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Research Article

Incidence and Morphologic Characteristics of Aberrant Subclavian Arteries: A Retrospective Cross-Sectional Study

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Abstract

Aim: The aim of this study to determine the incidence of aberrant right subclavian artery (ARSA) and aberrant left subclavian artery (ALSA), their diameter, angle at their point of origin, distance between them.The cases included in the study were also examined for atrial septal defect (ASD), aneurysm, Kommerell's diverticulum, dysphagia, dyspnea, atherosclerotic heart disease, and hypertension.
Material and Method: This study is a retrospective cross-sectional study conducted at Inonu University Faculty of Medicine Turgut Özal Medical Center. Within the scope of the study, The images of 2365 patients who applied to the Department of Radiology for contrast-enhanced thoracic CT arterial phase imaging were examined. As a result of the review, 52 cases (20 men and 32 women) with ARSA and ALSA were identified and included in the study.
Results: Among the examined images, ARSA was detected in 46 (1.9%) patients, while ALSA was detected in 6 (0.2%) patients. In ARSA cases, ASD and aneurysm were each found in 3 cases. Kommerell's diverticulum was not found in ARSA cases. In ALSA cases, aneurysm was found in 1 case, while Kommerell's diverticulum was found in 5 patients (83.3%). No evidence of ASD was found in ALSA cases. At the origin points, the average diameter of ARSA was 11.7 mm and ALSA was 12.55 mm, with average angles were 76.39° and 60.27°, respectively. The average distance between the right subclavian artery and the left subclavian artery in ARSA cases was 7.27 mm. In ALSA cases, the average distance between the left subclavian artery and the truncus brachiocephalicus was 10.9 mm.
Conclusion: The incidence of ARSA and ALSA in the studied population was 1.9% and 0.2%, respectively. The detailed anatomical characteristics provided in this study can aid in the planning and execution of vascular surgeries involving subclavian arteries.

Keywords: Aberrant subclavian artery; right aortic arch, Kommerell's diverticulum, vascular surgery, anatomical variation

INTRODUCTION

Anomalies and variations of the aortae can be found with many congenital heart diseases (1). In our study, we aimed to draw attention to the importance of these anomalies and variations in terms of prognosis and treatment of diseases.

ARSA is the most common congenital variant of the aortic arch and can occur in 0.4-2% of individuals (2). ARSA arises directly from the aortae, just distal to the left subclavian artery (3). 80% of ARSA cases are retro-esophageal,15% are between the trachea and esophagus and 5% are anterior to the trachea (3,4).

ALSA; It is a rarer anomaly in society (0.05%-0.1%) (5). ALSA, a branch of the right aorta, is located distal to the right subclavian artery as the first branch of the ascending aorta and usually passes behind the esophagus (6,7).

Kommerell's diverticulum is a rare condition seen together with ARSA and ALSA (5). This diverticulum was named by the German radiologist Burkhard Friedrich Kommerell. Kommerell described this diverticulum as a primitive remnant of the right dorsal aorta. He reported that this anomaly may be a dilatation of the descending aortae (8). ARSA or Kommerell's diverticulum can compress the esophagus or trachea (9). In cases with ARSA, problems occur in the perfusion of the right axillary artery to the right

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carotid artery. Therefore, it is necessary to pay attention to ARSA (9,10).

Congenital anomalies in the aortic arch are caused by branching or position differences. Of these, right-sided aortic arch (RAA) can be seen as three subtypes: RAA with ALSA or rarely RAA with mirror-image branching, RAA with isolated left subclavian artery .These subtypes occur due to different branching of the supra aortic arteries. In isolated left subclavian artery cases, the ALSA is not connected to the arch, but instead to the pulmonary trunk via a patent arterial duct (6).

In our study; we aimed to draw attention to the importance of these anomalies in regional surgical procedures.

MATERIAL AND METHOD

Study Design and Ethical Considerations:

This study is a retrospective cross-sectional study conducted with the permission of İnönü University Health Sciences Non-Interventional Clinical Research Ethics Committee with decision number 2021/2414.

Population and Sample

This study is a retrospective cross-sectional study covering the period January 2015-January 2020 and was conducted at İnönü University Faculty of Medicine Turgut Özal Medical Center.

A total of 25.472 patients who underwent contrast-enhanced thoracic computed tomography (CT) in the Radiology department were identified through a screening of the Hospital Information Management System. Out of these, 2.365 cases were randomly selected for the examination of vascular structures and variations. As a result of arterial phase imaging, 52 cases (20 males and 32 females) with ARSA and ALSA were identified and included in the study.

Imaging Method

The cases were imaged using a new generation 256-slice CT scanner with a stellar detector system (SOMATOM® Definition Flash, Siemens Healthcare, Forchheim, Germany). For each patient, planning images were initially taken for subsequent dynamic imaging positioning. After setting the scan position, 70 ml of iodinated contrast agent (Opaxol 300mg/ml) was administered intravenously through an 18-gauge catheter using an automatic injector at a flow rate of 4-5 ml/sec via the antecubital vein. Post-contrast images were obtained using the following scan parameters: tube voltage 80 kVp, tube current 100 mAs, number of scans 26, scan time 1.5 sec, gantry rotation time 0.28 sec, and detector configuration 128 mm x 0.6 mm. Using the obtained baseline images, reconstructions were performed with slice thicknesses of 2.5 mm and 5 mm.

Evaluation of Images

The data obtained from the imaging were evaluated using the PACS Sectra imaging system (Picture Archiving & Communications System, Sweden). To facilitate vascular assessment, the images scanned with a slice thickness of 0.625 mm were reconstructed using MIP (Maximum Intensity Projection) to create axial, coronal, and sagittal planes. Angle measurements on the reconstructed images in the PACS system were performed at the level where ARSA and ALSA originate from the aorta, between the aorta and the aberrant vascular structure orifices. The drawings for the angle measurement placed the apex of the angle at the level of the orifice as the vascular structures run parallel to the lumen. Vascular diameter measurements were taken approximately 1 cm distal to the ARSA and ALSA orifices to exclude any narrowing and dilation seen distally.

After the angle and diameter measurements, in cases where ARSA was detected, the distance between the origin of the ARSA and the origin of the left subclavian artery was measured. Similarly, in cases where ALSA was detected, the distance between the origin of the ALSA and the origin of the truncus brachiocephalicus was measured. However, measurement could not be made in a case where the right and left subclavian arteries originated from the same root. Therefore, this case was excluded from the study.

Our study is a retrospective study. Dysphagia, dyspnea, cardiac pathology, vascular aneurysm and atherosclerotic heart disease have been identified as indications. The aim was to evaluate the presence of vascular pathology as a result of the imaging.In addition to measurements, cases with ASD, Kommerell's diverticulum, and aneurysm were identified during the radiological evaluation. Additionally, patient notes, epicrisis report, test results and discharge summaries, from the Hospital Information Management System were evaluated. The number of cases with dysphagia, dyspnea, atherosclerotic heart disease and hypertension were determined from patient files.

To minimize contrast artifacts, the evaluation was performed on the extremity opposite to the one that received the contrast.

Biostatistical Data Analysis

Qualitative data from the variables included in the study were summarized with number (percentage). Compliance of quantitative data with normal distribution was evaluated by Shapiro-Wilk test. Quantitative data that did not show normal distribution were summarized with median (minimum-maximum), while quantitative data that showed normal distribution were summarized with mean± standard deviation. In statistical analyses, categorical variables were compared using Fisher's exact chi-square test. For quantitative variables, Mann Whitney U test and Independent sample t test were used for comparisons between two independent groups where appropriate. A value of $p<0.05$ was considered statistically significant in the applied statistical analyses. All analyses were performed using IBM SPSS Statistics 26.0 for Windows (New York; USA).

RESULTS

The study involved two groups ARSA (n=46) and ALSA (n=6) (Table 1,2). In our study, we made measurements of the diameter, angle and distance of ARSA and ALSA (Table 3). Among the cases, there was one ARSA and ALSA variation originating from the same root. This case was excluded from the scope of the study because measurements could not be made. There were no other cases in the study in which ARSA and ALSA were seen together.

Table 1. Distribution of clinical characteristics in ARSA and ALSA groups

Variables*		ARSA (n=46)	ALSA (n=6)
Gender [n (%)]	Male	17 (37)	3 (50)
	Female	29 (63)	3 (50)
Atrial septal defect [n (%)]	No	43 (93.5)	6 (100)
	Yes	3 (6.5)	0 (0)
Aneurysm [n (%)]	No	43 (93.5)	5 (83.3)
	Yes	3 (6.5)	1 (16.7)
Kommerell's diverticulum [n (%)]	No	46 (100)	1 (16.7)
	Yes	0 (0)	5 (83.3)

*Variables are expressed in numbers and percentages

Table 2. Descriptive statistics for the clinical findings of the variation types by gender

Variables			Atrial septal defect		Aneurysm		Kommerell's diverticulum	
			No	Yes	No	Yes	No	Yes
ARSA (n=46)	Gender [n (%)]	Male	16 (94.12)	1 (5.88)	17 (100.00)	0 (0.00)	17 (100.00)	0 (0.00)
		Female	27 (93.10)	2 (6.90)	26 (89.66)	3 (10.34)	29 (100.00)	0 (0.00)
	p*		1.0		0.286		-	
ALSA (n=6)	Gender [n (%)]	Male	3 (100)	0 (0)	3 (100)	0 (0)	1 (33.33)	2(66.67)
		Female	3 (100)	0 (0)	2 (66.67)	1 (33.33)	0 (0)	3 (100)
	p*		-		1.0		1.0	

*: Fisher's exact chi-square test

Table 3. Descriptive statistics for the diameter, angle and distance of the variation types

Variables	ARSA (n=46)		ALSA (n=6)		p*
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	
Diameter	11.7±3.13	11.3 (4-27)	12.55±2.03	12.7 (10.3-16)	0.289
Angle	76.39±25.49	72.05 (36.2-133)	60.27±11.97	62.95 (45.5-76)	0.197
Distance	7.27±4.24	6.2 (0-23.3)	10.9±10.7	7.25 (3.1-32.4)	0.448

SD: standard deviation, Min: minimum, Max: maximum; *: Mann Whitney U test

Within the scope of the study, cases were also examined in terms of ASD, aneurysm, Kommerell's diverticulum, dysphagia, dyspnea, atherosclerotic heart disease, and hypertension.

ARSA was observed in a total of 46 (1.9%) of 2365 patients included in the study (Figure 1).

Figure 1. Arrow: aberrant right subclavian artery; ARSA is seen coming out of the aortic arc

Considering Table 1; the gender distribution in the ARSA group was 37% male (17 individuals) and 63% female (29 individuals). Within the scope of our study ALSA was observed in 6 (0.2%) of 2365 patients (Figure 2,3). In the ALSA group, the distribution was equal, with 50% male (3 individuals) and 50% female (3 individuals). Regarding the presence of an ASD, 93.5% of the ARSA group (43 individuals) did not have an ASD, while 6.5% (3 individuals) did (Figure 4). In the ALSA group, none of the individuals (100%) had an ASD .

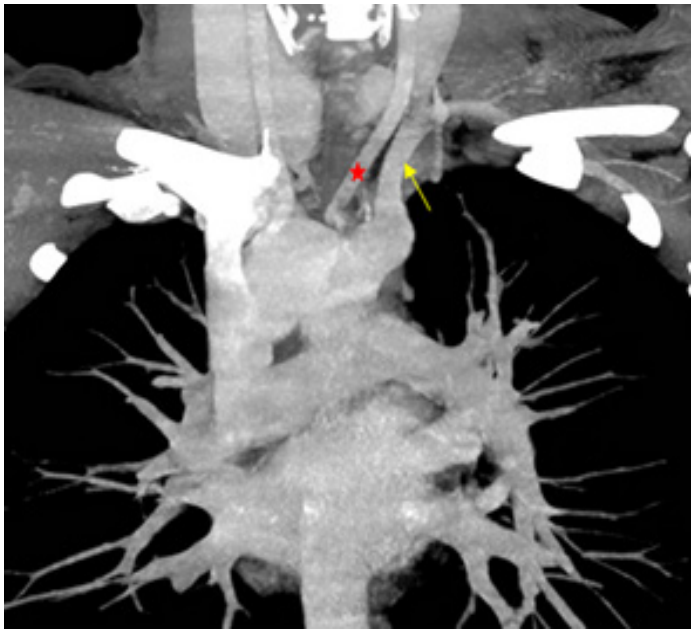

Figure 2. Arrow: Aberrant left subclavian artery; ALSA is seen coming out of the right aortic arc. The left common carotid artery is shown with a red star

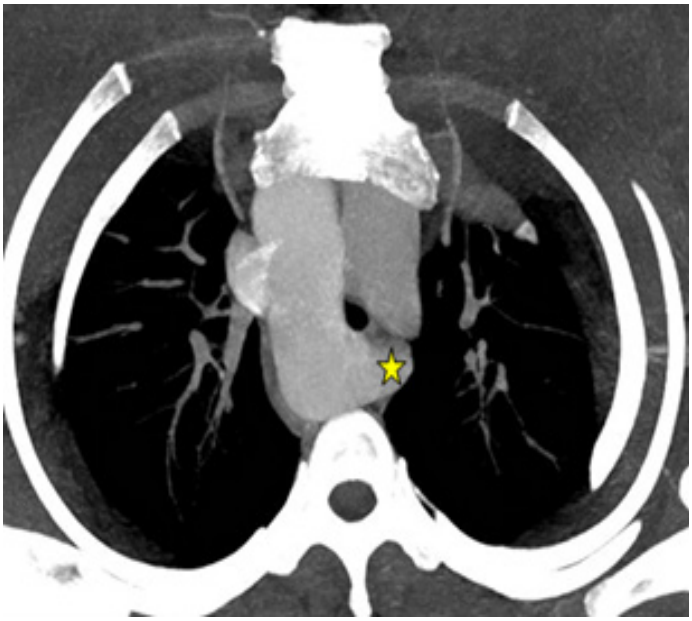

Figure 3. The aberrant left subclavian artery originating from the right aortic arch is indicated by a yellow star

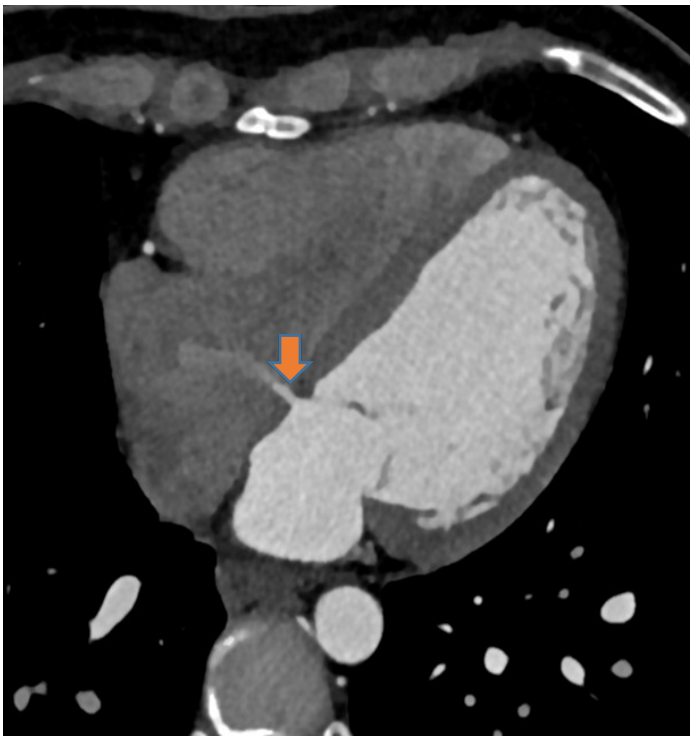

Figure 4. Arrow: Atrial septal defect. In addition to ASD observed at the level of the left and right atrium, passage of contrast material to the right atrium is demonstrated.

When looking at aneurysm occurrence, 93.5% of the ARSA group (43 individuals) had no aneurysm, while 6.5% (3 individuals) had an aneurysm. In the ALSA group, 83.3% (5 individuals) did not have an aneurysm, whereas 16.7% (1 individual) did. For the presence of Kommerell's diverticulum, all individuals in the ARSA group (100%) did not have this condition. In contrast, 16.7% of the ALSA group (1 individual) did not have Kommerell's diverticulum, while 83.3% (5 individuals) did (Figure 5).

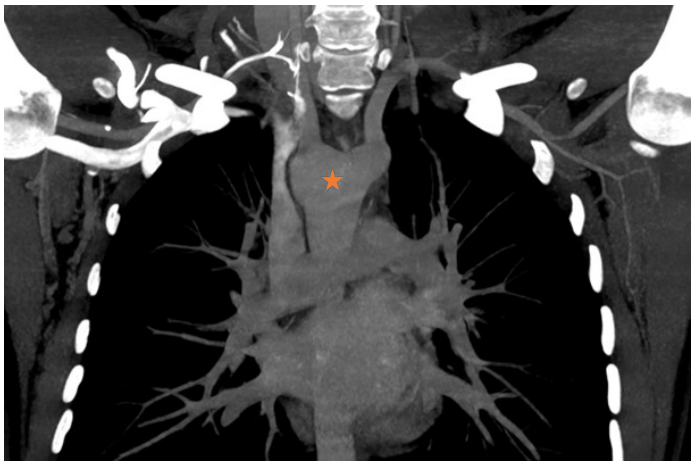

Figure 5. Kommerell's diverticulum (★) is seen

The Table 2 presents the distribution of ASD, aneurysm, and Kommerell's diverticulum in ARSA (n=46) and ALSA (n=6) groups, analyzed by gender.

ARSA Group:

ASD: Among males, 94.12% (16 individuals) did not have ASD, while 5.88% (1 individual) did. Among females, 93.10% (27 individuals) were without ASD, while 6.90% (2 individuals) had it. The p-value for gender difference was 1.0, indicating no significant difference.

Aneurysm: All males (100%, 17 individuals) did not have an aneurysm. Among females, 89.66% (26 individuals) were without an aneurysm, while 10.34% (3 individuals) had it. The p-value was 0.286, showing no statistically significant difference between genders.

Kommerell's diverticulum: In the ARSA group, neither males nor females had Kommerell's diverticulum (100%).

We detected the following clinical symptoms in our ARSA cases: Dyspnea 33 (71.7%), hypertension 21 (45.6%), atherosclerotic heart disease 12 (26%), dysphagia lusoria 8 (17.4%).

ALSA Group:

ASD: Both males and females (100%) in the ALSA group did not have ASD.

Aneurysm: Among males, all (100%) did not have an aneurysm. In females, 66.67% (2 individuals) did not have an aneurysm, while 33.33% (1 individual) had it. The p-value was 1.0, indicating no significant gender difference.

Kommerell's diverticulum: In the ALSA group, 33.33% of males (1 individual) did not have Kommerell's diverticulum, while 66.67% (2 individuals) had it. 100% of females (3 individual) had Kommerell's diverticulum. The p-value was 1.0, showing no significant difference between genders.

Other clinical symptoms accompanying ALSA cases were: Dyspnea 3 (50%), hypertension 3 (50%), atherosclerotic heart disease 4 (66.6%). Dysphagia was not observed in the ALSA cases in our study.

The Table 3 shows descriptive statistics for the diameter, angle, and distance of two variation types: ARSA and ALSA.

The mean diameter for ARSA was 11.7±3.13 mm with a median of 11.3 mm (ranging from 4 to 27 mm). For ALSA, the mean diameter was 12.55±2.03 mm with a median of 12.7 mm (ranging from 10.3 to 16 mm). The difference between the two groups was not statistically significant (p=0.289). The mean angle for ARSA was 76.39±25.49 degrees, with a median of 72.05 degrees (ranging from 36.2 to 133 degrees). For ALSA, the mean angle was 60.27±11.97 degrees with a median of 62.95 degrees (ranging from 45.5 to 76 degrees). The difference between the two groups was not statistically significant (p=0.197).

The mean distance for ARSA was 7.27±4.24 mm, with a median of 6.2 mm (ranging from 0 to 23.3 mm). For ALSA, the mean distance was 10.9±10.7 mm, with a median of 7.25 mm (ranging from 3.1 to 32.4 mm). The difference between the two groups was also not statistically (p=0.448).

In all cases of ARSA and ALSA the arteries passed posterior to the esophagus. In none of the cases did the arteries pass between the esophagus and trachea or anterior to the trachea.

DISCUSSION

Within the scope of our study, ARSA was detected in 46 (1.9%) cases and ALSA was detected in 6 (0.2%) cases out of 2365 tomography images. The detected ARSA and ALSA cases were evaluated in terms of ASD, aneurysm, Kommerell's diverticulum, dysphagia, dyspnea, atherosclerotic heart disease, and hypertension. Additionally, diameter, angle and distance measurements were taken in ARSA and ALSA cases.

In a previous study, diameter and angle measurements of the arteria subclavia arteria subclavia were made (11). However, in this study; no information was given about the diameter and angle of ARSA and ALSA. That's why we carried out this study, including ARSA and ALSA measurements.

Additionally, we measured the distances of ARSA cases to the arteria subclavia. In ALSA cases, we measured the distance with the truncus brachiocephalicus. We also evaluated ASD, aneurysm, and Kommerell's diverticulum radiologically. We searched hospital data processing records for dysphagia, dyspnea, atherosclerotic heart disease and hypertension.

Variations of aortic arch diverticula; they are the left aortic arch with ARSA and the RAA with ALSA. The most common congenital anomaly of the aortic arch is the left aortic arch with an ARSA, which occurs in 0.4% to 2.0% of the population (2). Although the incidence of ARSA in our study is slightly higher than the average, it is compatible with the literature. The incidence of ALSA and RAA, which are less common, is 0.05-0.1% (5). The incidence rate we found regarding ALSA is slightly higher than the literature.

Previous study has reported that the co-occurrence of ARSA and aneurysm is rare. Although aneurysm is low in

ARSA, mortality due to rupture (50%) is very high (12,13). In our study, rupture were not observed in ARSA cases. The ARSA case with aneurysm that we found in our study confirms the literature with its low rate.

Although ARSA is asymptomatic in most patients, it causes a type of dysphagia called dysphagia lusoria in 10% of patients due to esophageal compression (14-16). In one study in the literature, the dysphagia rate was stated as 30% (17). The dysphagia rate in our study is compatible with the average of literature studies. The coexistence of ARSA and dyspnea was found to be 23% in the literature. However, the dyspnea rate we found was much higher than the literature. In the same study, it was stated that the rate of coexistence of atherosclerotic heart disease with ARSA was 20-30% (17). The rate of atherosclerotic heart disease in our study is also consistent with the literature. In this study hypertension was found to be (45.6%). However, no study reporting the relationship between ARSA and hypertension has been found in the literature.

In the study of Cina et al. (18), Kommerell's diverticulum was reported in patients with ARSA or ALSA. They have reported that 19% of the asymptomatic Kommerell's diverticulum cases had spontaneous ruptures. Knowing the association of these structures is important to prevent complications. There is literature study showing the association of ARSA with Kommerell's diverticulum at a rate of 15-30% (14). However, in our study, there was no Kommerell's diverticulum or rupture in any of the ARSA cases.

There is literature reporting a 28% association of ARSA with ASD (19). The association of ARSA and ASD we found in our study is quite low.

Studies show that the left subclavian artery connects to the pulmonary artery via the patent ductus arteriosus or ligamentum arteriosum. It has been suggested that it is important to know this variant because it may cause subclavian steal syndrome and vertebrobasilar insufficiency (13).

It was stated that the association of ALSA with RAA and Kommerell's diverticulum is rare (5,20). As an important result in terms of literature, in this study, Kommerell's diverticulum was not seen in any ARSA cases, while it was present in 83% of ALSA cases. Therefore, the relationship of ALSA with Kommerell's diverticulum should be taken into consideration in treatment procedures. Kommerell's diverticulum is thought to be a remnant of the ARSA and ALSA resulting from the developmental anomaly of the fourth dorsal aortic arch during embryological development (21,22). It can be thought that the high prevalence of Kommerell's diverticulum in ALSA cases is due to embryological developmental disorder.

It has been reported in the literature that the association of ALSA and RAA aneurysma is rare (23). The low association of ALSA and aneurysm in our study also confirms the literature.

The association of ALSA with ASD syndrome has been reported in study (24). However, none of the ALSA cases in our study had ASD syndrome (Table 1,2).

In the ALSA cases dysphagia (34%) and dyspnea (25%) has been confirmed in the literature (7). However, in this study ALSA cases, dysphagia was not observed at all, while dyspnea was observed at a rate of 50%. The rate of dyspnea in ALSA cases was found to be twice that of the literature.

In this study, atherosclerotic heart disease (66.6%) and hypertension (50%) were seen with ALSA cases. No study has been found in the literature regarding the clinical findings of atherosclerotic heart disease and hypertension in ALSA cases. We think that the results we found will serve as a resource for future studies.

It has been reported in the literature that isolated left subclavian artery and RAA are rare (0.08%). In the literature, congenital heart diseases associated with isolated left subclavian artery are shown as tetralogy of fallot, right-sided patent ductus arteriosus, large ventricular septal defect, and dextro-transposition of the great arteries (25). None of our cases had isolated left subclavian artery.

The single-center and retrospective study design created a limitation. Multicenter and current studies are needed.

CONCLUSION

Peripheral arterial access is of great importance in ascending and arcus aortic aneurysm surgery and in the surgical treatment of acute aortic dissection. The most commonly used arteries are the right axillary and right subclavian artery. When the lower extremity circulation is stopped by cannulation of these arteries, cerebral perfusion is provided through these arteries. During aortic surgery, the right subclavian artery is cannulated to provide cerebral blood supply. In rare cases, when there is an ARSA, the perfusion given from here will go directly to the descending aortae and will not reach the brain. As a result, brain blood flow will stop. The associated mortality and morbidity rate can be very high. Therefore, this anomaly should be kept in mind while evaluating preoperative tomography images in such cases. And when this anomaly is detected, alternative cannulation sites should be identified and cerebral perfusion should be provided safely. Sometimes the ARSA may be complicated by dissection in the descending region from which the ARSA opens. In these cases, revascularization of the ARSA may be overlooked while treating the dissection of the descending aorta. In this situation, determining the appropriate treatment options is of great importance for the patient to receive a healthy treatment. For this important reasons, we investigated the cases of ARSA.

Our literature review showed that studies investigating variations in the subclavian arteries were not measured the angle, diameter and distance between ARSA and ALSA at the point of exit from the aortic arch. Therefore, we performed the said measurements to provide guidance for the surgical procedures.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *This study is a retrospective cross-sectional study conducted with the permission of İnönü University Health Sciences Non-Interventional Clinical Research Ethics Committee with decision number 2021/2414.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Using Deep Learning Algorithms to Predict Dental Implant Brands from Panoramic Radiographs

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Abstract

Aim: The aim of this study is to predict dental implant brands from panoramic radiographs using deep learning algorithms.
Material and Method: Panoramic radiographs of patients previously undergoing dental implant procedures were retrospectively screened. Radiographs were grouped into three different implant brands, with a minimum of 250 dental implants from each brand. The obtained radiographs were divided into three groups: training, validation, and test sets, with an equal distribution of implant brands in each group. 70% of the implants were used for training, 20% for validation, and 10% for the test dataset. Trained models were tested on the previously separated test set that was not used in the deep learning model training to determine the implant brand.
Results: A total of 882 implants were evaluated in 220 panoramic radiographs. The study found that the accuracy of the implants tested in the deep learning model was 75% and the sensitivity was 78.26%. The accuracy of the model was 94.73%. The F1 score, which is a parameter frequently used in comparing artificial intelligence models with each other, was found to be 85.71%.
Conclusion: The results of this study show that implants can be identified from panoramic radiographic images using deep learning algorithms. However, to use this system routinely in clinical practice, it is necessary to create libraries by conducting studies that include many different implant systems and a large number of images.

Keywords: Deep learning, dental implant, artificial intelligence

INTRODUCTION

Dental implants began to be used in the 1980s for the treatment of missing teeth and are now frequently used worldwide for patients with tooth loss (1). Implants, which play a significant role in the treatment of dental deficiencies, are used both in fixed prosthetic restorations and as support for removable prostheses, significantly improving patients' quality of life (2,3). Today, implant treatment has become one of the classical treatment methods for both practitioners and patients (4). Although implants have been used in clinical applications successfully for years, their complications, such as peri-implantitis and peri-implant mucositis in implants and various types of complications in implant-supported prostheses have been frequently reported (5,6). It has been reported that the technical complication rate in dental implants used for more than 5 years varies between 10% and 15% (7). When implants used for 10 years are evaluated, this rate varies between 25% and 32% (8). Additional prosthetic, periodontal, or surgical treatments are needed to resolve these issues. While performing these treatments, detailed information about the previously applied implant, including the implant's brand, length, diameter, and the type of abutment used, may be required. If the patient has previously been treated at the same clinic, this information can be easily obtained from the patient's medical records. However, if the treatment was performed at another clinic and the patient cannot communicate with the previously treated clinic, obtaining this information could be difficult or impossible (9). Some patients experiencing problems

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with their implants may seek treatment at other clinics due to various reasons, such as moving to a different city or country or the closure of the clinics where they were previously treated. In these cases, dentists try to identify the implants previously applied to the patient by asking the patient or evaluating radiographs with limited data. Specifically, identifying the brand of the implant is necessary to perform additional treatments. Despite the long history of dental implant systems, there are relatively few studies and techniques available for identifying the specific systems used (10). With thousands of implant brands now available and widely applied by practitioners, determining the brand of an implant in a patient has become increasingly challenging. This highlights the need for specialized programs or systems to aid in identification (9).

Deep learning technology has been applied in various fields today, bringing significant conveniences in many areas. In deep learning technology, various methods are used in alignment with the task (11). In medicine, deep learning has been utilized in areas such as medical diagnosis, statistics, and human biology (12,13). As one of the artificial intelligence technologies, the deep learning method is suitable for tasks such as prediction, object detection, classification, and other similar tasks. In dentistry, issues such as the diagnosis of dental diseases using radiographic images, treatment predictions, classification, statistical analysis of research data, and other topics have been addressed using the deep learning method (9,14-16). Notably, there has been an increase in studies focused on disease diagnosis using deep learning, with deep learning-based object detection algorithms commonly used for this task (17,18). The capability of diagnostic systems using deep learning is currently close to or superior to that of humans (19). The use of these systems will help reduce the risk of errors by preventing dentists from overlooking various diseases and pathologies. If this system can also be applied to identify implant brands using radiographic images, it will assist both dentists and patients in resolving complications and problems related to implants. In this study, we aim to predict dental implant brands from panoramic radiographs using deep learning algorithms.

MATERIAL AND METHOD

Ethical approval for this study was obtained from the Medical Research Ethics Committee of Karamanoğlu Mehmetbey University Medical Faculty (Decision Number: 01-2024/14). The panoramic radiographs used in our study were obtained from the periodontology and oral and maxillofacial surgery departments at the Ahmet Keleşoğlu Faculty of Dentistry, Karamanoğlu Mehmetbey University, where implants had previously been applied, and control radiographs that met the criteria were available. These images were acquired using two different panoramic radiography devices, Myray 3D Ready (Cefla, Imola, Italy) and Vatech PCH-2500 (Vatech, Hwaseong, South Korea), following the manufacturer's instructions. Radiographs meeting the criteria from three different implant brands were grouped. Portions of the radiographic images containing patient information were cropped out. The inclusion criteria for the radiographs were “individuals over 18 years old,” “having Medentica, Osstem, or Nucleoss brand implants placed,” and “not having radiographic imaging errors.” The resolution of the radiographs ranged from 2868x1504 to 2505x1515. These radiographs contained a total of 882 implants. The marking process to indicate the brand and boundaries of the implants in the radiographs was carried out using Roboflow software (Figure 1). The resolution of these radiographs is relatively high for artificial intelligence training. To accelerate the AI training process and increase success, all implants were cropped to stay within the image's long edge and then resized to a resolution of 640x640. Approximately 70% of the 220 radiographs were allocated for training, 20% for validation, and 10% for testing. The exact distribution of the radiographs and implants is provided in Table 1. No image preprocessing procedures other than resizing were applied to the radiographs. The prepared dataset was trained using the Roboflow 3.0 Instance Segmentation (Fast) AI model.

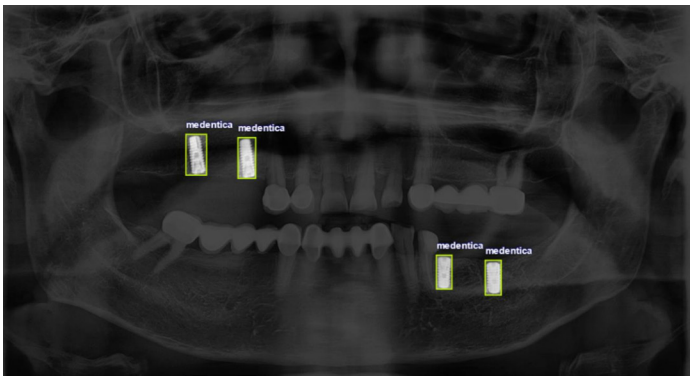

Figure 1. Labeling the implants on the radiograph as Medentica and marking the region of interest (ROI) of the implants

Table 1. Distribution of 220 radiographs and the implants in these radiographs according to brands and artificial intelligence training datasets

Implant brands	Radiographs				Implants			
	Training	Validation	Test	Total	Training	Validation	Test	Total
Medentica	51	18	7	76	192	65	26	283
Osstem	55	17	8	80	215	85	26	326
Nucleoss	48	9	7	64	214	40	19	273
Total	154	44	22	220	621	190	71	882

RESULTS

The success of the trained artificial intelligence model in identifying the implant brand was tested on the radiographs allocated for the test dataset (Figure 2). Correctly predicting the implant brand was considered a true positive (TP), incorrectly predicting the implant brand was considered a false positive (FP), and making no inference about the implant was considered a false negative (FN). Using these parameters, accuracy, sensitivity, precision, and the F1 score (the harmonic mean of precision and sensitivity) were calculated.

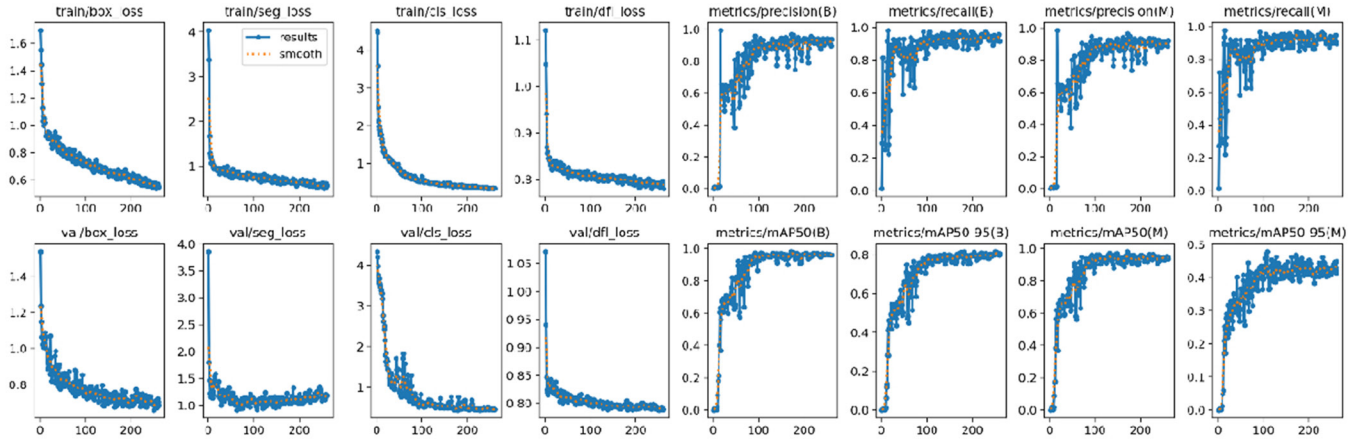

Figure 2. Metrics in the artificial intelligence training process

Of the total of 882 implants, 621 were used for training, 190 for validation, and 71 for testing. The 71 implants we tested were present on 22 radiographs. The brands of 54 of the 71 implants were correctly predicted (TP), 3 were incorrectly predicted (FP), and no implant brand was predicted for 15 (FN). Based on this data, the model's accuracy was found to be 75%, and its sensitivity was 78.26%. The precision of the model was relatively high at 94.73%. The F1 score, a parameter frequently used for comparing AI models, was 85.71%.

DISCUSSION

In recent years, with the development of artificial intelligence, deep learning technologies have begun to be used in many areas within the healthcare field (20). Specifically, deep learning-based neural networks have been successfully employed in dental applications, including cephalometric film analysis, segmentation of anatomical structures, detection and classification of various pathological formations, and detection of dental caries (21). Similarly, deep learning algorithms have been used in the field of implantology to identify the type and brand of implants since 2020 and most studies have demonstrated accuracy and reliability performance above 70% (10,20,22).

Images from periapical radiographs, panoramic radiographs, and computed tomography can be used to identify dental implants from radiographic images. It is thought that the deep learning algorithm identifies implants based on their unique features, such as shape, thread structure, and design, as well as the specific design of the implants in the apical third. The quality of training images is also important for the detailed recognition of implants in this manner (9). Most studies have used panoramic radiographic images (23). The advantage of using panoramic radiographs is that they are standardized to a certain level, independent of the patient, and the shapes of the implants in the images are also standardized. The drawback is that implants may not be visible when overlapping anatomical structures like the maxillary sinus floor, or when they are too short or overly curved, which can reduce image clarity. In such cases, this can lead to misperceptions and incorrect interpretations.

In our study, we also utilized panoramic radiograph records. In previous studies, before feeding the images into deep learning algorithms, the portions of the images containing implants were cropped in various ways. While one study cropped only the area surrounding the implant, in all other studies, rectangular or square areas encompassing the entire implant were cropped from the images (23,24). It has been reported that when the cropped area is not a standard shape, such as a square or rectangle, the quality of the dataset decreases (23). Therefore, in our study, we cropped rectangular areas that included the entire implants and fed these into the deep learning algorithms.

A review of studies utilizing deep learning algorithms to identify implant types and brands shows a reported minimum accuracy rate of 70%, demonstrating that deep learning-based AI technology has potential as a tool to assist in clinical decision-making (23). In our study, we achieved an accuracy rate of 75% when analyzing three different implant brands.

In our study, the F1 score was found to be 85.71%. The F1 score is a performance metric commonly used in deep learning, particularly for classification tasks and object detection to measure a model's accuracy. It provides a balance between precision and recall, which are two important aspects of classification performance (25).

CBCT images are frequently used in the field of dental implantology because they have less distortion and can obtain three-dimensional images with CBCT, while two-dimensional images can be displayed in panoramic radiographs (26). However, there are not many studies using deep learning and CBCT images in predicting implant brands (23). Therefore, it would be useful to conduct future studies using CBCT images along with panoramic radiographs in the detection of implant brands using deep learning.

CONCLUSION

Although studies on identifying implant brands from panoramic radiographs using deep learning algorithms are still very new and limited, both our study and previous studies have demonstrated high levels of accuracy and reliability. To increase the learning performance and to apply this system more widely in clinical practice, higher quality and more implant images and images of many different types and brands of implants will be needed in future studies.

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Research Article

Evaluation of the Relationship Between Vitamin D Deficiency and Epicondylitis

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Abstract

Aim: Though there is strong evidence connecting vitamin D deficiency to several health problems, such as diabetes mellitus, infections, autoimmune and endocrine diseases, cancer, and increased cardiovascular mortality and morbidity, studies examining the connection between vitamin D deficiency and epicondylitis are rare. The purpose of this study was to see if low vitamin D levels and epicondylitis were linked.
Material and Method: A total of 410 patients presented with the complaint of elbow pain and whose 25-hydroxycholecalciferol (25(OH) D) levels were evaluated. The files of 205 patients diagnosed with medial or lateral epicondylitis by physical examination and 205 controls not considered to have medial or lateral epicondylitis were reviewed retrospectively. Vitamin D levels were measured using 25(OH)D levels.
Results: Vitamin D levels were considerably lower (p<.001) in the epicondylitis group.
Conclusion: It is unclear precisely what causes epicondylitis, but the fact that our study's participants had much lower vitamin D levels raises the possibility that low vitamin D is one of the causes. More research is needed to understand how vitamin D levels may contribute to the etiology of epicondylitis in general.

Keywords: Elbow tendinopathy, Vitamin D deficiency, pain

INTRODUCTION

Elbow pain is most commonly caused by epicondylitis (1). Epicondylitis comes in two varieties: lateral epicondylitis, also referred to as tennis elbow, and medial epicondylitis, also known as golfer's elbow. It is most common between the ages of 40 and 60. It rarely occurs before the age of 30. It is more prevalent in women than in men. Medial epicondylitis is less common and has a milder course than lateral epicondylitis. In the general population, medial epicondylitis is more common in males (0.3-0.6%) and females (0.3-1.1%), but lateral epicondylitis is more common in males (1.0-1.3%) and females (1.1-4.0%). The annual incidence is estimated to be 0.3–1.1 and 0.1 per 100 individuals for lateral and medial epicondylitis, respectively (2). Epicondylitis is rarely bilateral and is more common in the dominant extremity (3).

Tennis elbow is thought to be caused by lesions at the lateral epicondyle of the humerus of the extensor carpi radialis brevis tendon, whereas golfer's elbow is thought to be caused by musculotendinous lesions at the medial epicondyle of the humerus of the common flexor tendon. Although it has the suffix -itis in its name, local inflammation is not frequently observed (1). Age is an essential factor in the formation of epicondylitis, and changes in the collagen content in the enthesis region decrease the number of cells and increase adipose tissue with aging, creating a predisposition. A history of overuse and repetitive and demanding activities increases the risk of developing epicondylitis (4).

A physical examination and history are used to diagnose epicondylitis. Radiologic and electrodiagnostic tests may be performed to exclude other possible diagnoses. Epicondylitis usually has an insidious and spontaneous

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onset. Pain is localized to the medial and lateral epicondyles but may radiate upward or downward. On physical examination, there is tenderness with pressure on the epicondyles. There is usually no swelling, and the elbow range of motion is normal (4). In lateral epicondylitis, an increase in pain is observed with resistant wrist extension or forearm supination. In medial epicondylitis, an increase in pain is observed with resistant wrist flexion or forearm pronation.

Calciferol, another name for vitamin D, is a fat-soluble vitamin. It comes in D2 and D3 variants. While vitamin D2 (ergocalciferol) is gained through diet, vitamin D3 (cholecalciferol) can also be generated in the skin by ultraviolet-B (UV-B) radiation from 7-dehydrocholesterol (5). Vitamins D2 and D3 are hydroxylated in the liver to form 25-hydroxycholecalciferol (25(OH)D). 25(OH)D is the result of the hydroxylation of vitamins D2 and D3 in the liver. The active form of vitamin D, 1.25-dihydroxycholecalciferol (1.25(OH)2D), is ultimately produced by the kidneys by hydroxylation (6). The level of 25(OH)D, which is the total of the amounts of 25(OH)D2 and 25(OH)D3, often indicates the amount of vitamin D present (7). Vitamin D is necessary for the health of the musculoskeletal system as well as the metabolism of calcium and phosphorus. Research has also linked vitamin D deficiency and insufficiency to a host of health issues, such as diabetes mellitus, autoimmune diseases, infections, cancer, endocrine diseases, and elevated cardiovascular mortality and morbidity (8-11). Additionally, studies have demonstrated vitamin D's neuroprotective, anti-inflammatory, and anti-proliferative properties (12). In this study, we looked into the potential link between vitamin D deficiency and epicondylitis.

MATERIAL AND METHOD

Research and Publication Ethics

The levels of 25(OH)D in a total of 410 patients with elbow pain, including 205 patients with medial or lateral epicondylitis by physical examination and 205 controls who were not considered to have medial or lateral epicondylitis, were retrospectively analyzed between January 2021 and November 2022 with the approval of Erzurum City Hospital Ethics Committee (decision no. 18-173 dated November 24, 2022). The exclusion criteria were trauma history, neoplasia, enfectious and rheumatological diseases.

Measurement of the Level of vitamin D

Every patient's venous blood was tested for vitamin D, and the results were assessed. Using the Atellica IM Analyzer, a total of 25(OH)D in human serum and plasma was quantitatively measured. Under 30 ng/ml of 25(OH)D was regarded as a vitamin D deficiency.

Statistical Analysis

IBM SPSS 26 was utilized for the analysis of the data. Analyses were first conducted to ascertain the distribution of normalcy. As a result, it was discovered that the Kolmogorov-Smirnov test findings were $p<.05$. These numbers explain the normal distribution of the data. Consequently, one of the parametric tests, the independent group T-test, was applied in the analysis. The statistical analysis of the descriptive data employed the values of the highest, lowest, median, mean, and standard deviation. The chi-square test was employed to analyze independent qualitative data.

RESULTS

A total of 205 patients had lateral or medial epicondylitis. There were 143 female patients and 62 male patients. The mean vitamin D level was 16.5±9.9 (2.92-69.70), and the mean age was 46.1±10 years. The results for 20 patients were normal. The vitamin D levels of 185 patients were low. Two hundred-five did not have lateral epicondylitis or medial epicondylitis. There were 140 females and 65 males among them. 49.3±16.5 years was the mean age, and 21.3±11.9 (6.1-72.3) was the mean level of vitamin D. 38 patients had normal results. It was found that 167 people had a deficit of vitamin D. Table 1 displays each patient's sociodemographic traits and 25(OH)D levels.

Table 1. Descriptive data on gender, age, 25(OH)D* vitamin levels and 25(OH)D* vitamin grades of the groups

Group	N	Gender		Age					25(OH)D* vitamin level			25(OH)D* vitamin grade	
		Women	Men	Mean	Median	SD	Min	Max	Mean	Median	SD	<30	>30
Epicondylitis (+)	205	143	62	46.11	45.00	10.08	16	76	16.50	13.70	9.99	185	20
Epicondylitis (-)	205	140	65	49.30	50.00	16.50	17	88	21.30	17.90	11.90	167	38

*25(OH)D: 25-hydroxycholecalciferol

Compared to the epicondylitis (-) group, the epicondylitis (+) group's patient age was considerably ($p=.019$) lower. There was no significant difference observed in the gender distribution between the epicondylitis (+) and epicondylitis (-) groups ($p=.831$). It was found that the vitamin D levels in patients with epicondylitis (X=16.54, SD=9.99) were lower than in individuals without epicondylitis (X=21.34, SD=11.90). An independent sample t-test was applied to determine whether the difference was significant. Consequently, patients with epicondylitis had considerably decreased vitamin D levels [$t(408)=-4.421$, $p<.001$] (Table 2).

Table 2. 25(OH)D* vitamin levels of the groups

	Group	N	Mean	SD	t	p
25(OH)D* vitamin level	Epicondylitis (+)	205	16.5498	9.99491	-4.421	<.001
	Epicondylitis (-)	205	21.3495	11.90550		

*25(OH)D: 25-hydroxycholecalciferol

DISCUSSION

Our investigation explored the possible connection between low serum vitamin D levels and epicondylitis. Furthermore, it was discovered that up to 85.7% of people (n=347) had vitamin D deficiency. According to studies, Türkiye and other developing nations have significant rates of vitamin D deficiency (13,14). There was no noticeable variation in gender distribution across the groups in our investigation. The group with epicondylitis had a substantial gender difference that favored the females. As in our study, epicondylitis has been reported in the literature as more common in females (2). Moreover, research indicates that vitamin D deficiency is more common in women than in men (13). To ensure that the study's findings are unaffected, it is crucial that there be no discernible variation in the groups' gender distribution.

Insufficient sun exposure, poor dietary intake, or absorption issues can all lead to vitamin D deficiency. It is important to test the level of 25(OH)D, which comprises both endogenous and dietary vitamin D and has a half-life of two to three weeks for vitamin D in the individual. The active biological form of 1.25(OH)2D is unsuitable for measurement. Because its circulating levels are 1000 times lower than 25(OH)D, and its half-life is 4-6 hours. Studies have been conducted to determine the normal range for 25(OH)D levels as well as to define vitamin D insufficiency and deficiency. These studies have led to the definition of vitamin D deficiency, which is now known as vitamin D insufficiency if the 25(OH)D level is between 21 and 29 ng/mL, normal if it is above 30 ng/mL (desired range: 30 to 60 ng/mL), and vitamin D intoxication if it is above 150 ng/mL (15,16).

The etiopathology of epicondylitis is not known precisely. Histologic investigations have not shown the presence of inflammatory cells in the tissue, such as neutrophils, lymphocytes, or macrophages. Histopathologic findings such as microfractures, periostitis, fibrinoid degeneration, immature collagen tissue, hyaline degeneration, radio-humeral joint disease, radial nerve entrapment, and annular ligament lesions have been reported in a few chronic cases. Ischemic stress may be significant in the etiology because the tenoperiosteal junction and the surrounding tendon are relatively avascular. These findings have been considered to be lateral elbow tendinosis by researchers. The term tendinosis describes a degenerative process characterized by vascular hyperplasia of fibroblasts and the dense presence of immature collagen in the area. The terms tendinosis or tendinopathy indicate the absence of chemical inflammation, but the pathology is painful. In most cases, the cause of pain is musculotendinous lesions that develop at or around the insertion site of the common extensor tendon to the lateral epicondyle (4).

Although water makes up 70% of typical tendon tissue, type I collagen accounts for most of the dry weight (17,18). The primary component of the extracellular matrix is type I collagen; this protein's quality and quantity significantly impact the mechanical and structural characteristics of tendon tissue (17). Tenocytes regulate type I collagen to preserve the integrity of the extracellular matrix. In contrast, tenoblasts produce extracellular matrix components, particularly type I collagen (17,19). The impact of vitamin D on tenocytes was examined by Min et al. (20). They demonstrated that in tenocytes treated with dexamethasone, the expression of tenomodulin, tenascin, type I, and type III collagen genes dropped. However, when vitamin D was administered, the expression of tenomodulin and type I collagen was restored to normal, and the quantity of reactive oxygen species decreased. In conclusion, they reported that vitamin D benefits tendons, bones, and muscles. According to Chen et al., inhibiting tumor necrosis factor-α (TNF-α) may protect against tendon degeneration (21). Vitamin D has been shown to reduce inflammation at the cellular level with its effects on macrophages, TNF-α, and interleukin and to have a protective effect on cell functions (8). Because of its interaction with muscle receptors, vitamin D has been shown to improve muscle growth and strength through protein synthesis. However, a loss in muscle tone and strength has been linked to vitamin D deficiency (22). In addition, another study reported low vitamin D levels in patients with lateral epicondylitis, similar to our study (23).

There are several restrictions on our investigation. The study's data were retrospectively gathered from file records. Our findings could have been impacted by the fact that each patient's vitamin D level was not assessed at the same time or season. A low vitamin D level may also be linked to several musculoskeletal issues. In patients with epicondylitis, the complaint change after vitamin D replacement could not be determined. Therefore, prospective studies are needed to determine the improvement in complaints after vitamin D replacement in these patients.

CONCLUSION

Patients with epicondylitis had significantly low vitamin D levels, suggesting a link between low vitamin D levels and epicondylitis. We believe this association may also apply to tendons in other regions of the musculoskeletal

system, not just the epicondylitis that was the subject of our investigation. The fact that some people with epicondylitis have normal vitamin D levels indicates that various elements, including anatomical, biomechanical, and occupational components, are involved in the genesis of the disease and that vitamin D deficiency is neither the sole nor the most significant cause. More research will shed light on the connection between epicondylitis and vitamin D.

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MEDICAL RECORDS-International Medical Journal

Research Article

Does Increased Cortical Screw Adhesion on the Far Cortex Result in Higher Resistance against Pull-Out?

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Abstract

Aim: Cortical screws exert compression on the fracture line by applying pressure to the surrounding cortex, while the screw moves within the bone structure through the threads as a result of cyclic movement. To achieve this compression, the cortical screw threads must adhere to the far cortex. The aim of this biomechanical study was to biomechanically evaluate the effect of varying degrees of contact with the far cortex on the resistance against pull-out and to determine the ideal amount of cortical adhesion.
Material and Method: A biomechanical study was conducted on the diaphyseal portions of 12 synthetic femur bones without the formation of any fracture models. The synthetic bones were initially divided into three groups, as follows: partial contact with the far cortex, full contact with the far cortex, and passed through the far cortex. The prepared models were subjected to testing, and after the bone was affixed within the compression device, the head of the screw on the bone was grasped with the aid of a tool, and a tensile force was applied to the cortical screw head until pull-out (load to failure).
Results: A significant difference was observed when the pull-out strengths were compared between groups (p=0.021). Post-hoc analyses revealed that this statistical difference was due to the group in which at least three threads passed through the far cortex.
Conclusion: When choosing the cortical screw length, a stronger pull-out resistance can be expected with a longer cortical screw length and passing the distal end through the far cortex. However, this should be decided taking into account the characteristics of the anatomical region to be treated, the nearby neurovascular structures, and the risk of tendon-soft tissue irritation.

Keywords: Biomechanical study, cortical screw, far cortex adhesion, fixation strength, pull-out

INTRODUCTION

Screws are a versatile and reliable choice for fixation in the field of orthopaedics and traumatology due to their ability to convert rotational force applied to them into linear motion through the use of threads. They can be classified according to the external diameter of their threads (cortical-cancellous), according to the existence of threads in the screw head (locking screws), or according to their applications (plate screws, lag screws, position screws, polar screws, etc.) (1-3). Cortical screws are one of the most commonly utilized screws in the field of traumatology. Through the threads, the screw head exerts compression on the fracture line by applying pressure to the surrounding cortex, while the screw moves within the bone structure as a result of cyclic movement. To achieve this compression, the cortical screw threads must adhere to the far cortex (4). This adhesion can be achieved to varying degrees with different screw lengths. Depending on the preferred screw length, compressive strength can be achieved with varying degrees of contact with the far cortex or with screws long enough to pass through the far cortex. It is essential that adequate compression strength is achieved for fracture healing, as inadequate retention may result in pull-out (screw retraction and loss of fixation).

It is regrettable that the desired screw lengths may not always be available due to limitations such as material supply issues or patient anatomical differences. Furthermore, the passage of the screw through the far cortex may give rise to soft tissue complications. To date, to the best of our knowledge, several studies in the

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literature have investigated cortical screw pull-out risk factors (5-9). However, no studies have investigated the relationship between varying degrees of contact to the far cortex and resistance against pull-out.

The aim of our study was to biomechanically evaluate the effect of varying degrees of contact with the far cortex on the resistance against pull-out and to determine the ideal amount of cortical adhesion.

MATERIAL AND METHOD

A biomechanical study was conducted on the diaphyseal portions of 12 synthetic femur bones without the formation of any fracture models (Third Generation Composite Left Femur; Selbones, Kayseri, Türkiye). The synthetic bones were initially divided into three groups, as follows: partial contact (Group 1), full contact (Group 2), and passed through (Group 3). The bones in Group 1 were inserted with cortical screws to achieve partial contact with the far cortex. In Group 2, cortical screws were inserted to achieve full contact with the far cortex. In the final group (Group 3), cortical screws were inserted with a length that ensured at least three threads at the distal end of the screw passed through the far cortex and exited from the opposite side (Figure 1). All synthetic bones were pre-drilled with a 3.2 mm cortical screw drill and then fixed to the bone with a 4.5 mm fully threaded cortical screw (TST Orthopedics®, TST Medical Tools®, İstanbul, Türkiye). The screws were 40 mm, 42 mm, and 44 mm in length, respectively, and were fixed in place with a screwdriver. All drilling and screwing procedures were conducted in the same anatomical location of the synthetic bone, in the midline of the diaphyseal region.

The prepared models were subjected to testing in the Marmara University Department of Mechanical Engineering (İstanbul, Türkiye) testing laboratory, utilizing the axial compression device (Shimadzu MWG-50 kNA Tensile Testing Machine, Shimadzu Company®, Kyoto, Japan). With the installed system (Figure 2), the bone was affixed within the device, the head of the screw on the bone was grasped with the aid of a tool, and a tensile force was applied to the cortical screw head until pull-out (load to failure). The applied forces were recorded in real time using the device's integrated software. In calculating the pull-out strength, the initial pull-out was defined as the moment when the resistance was first broken and the force-displacement curve first changed direction (Figure 3). Secondary resistances that may occur due to remaining threads in the cortex after the initial pull-out of the screw were not considered in this analysis. The experiment was repeated for each bone model in sequence, with the results recorded.

The data were analyzed statistically using the SPSS software. The conformity of the data to a normal distribution was assessed both visually (histogram and probability plots) and analytically (Kolmogorov-Smirnov test). Given that the data were skewed distributed, a Kruskal-Wallis test was employed for three-group comparisons and a Mann-Whitney U test for post-hoc pairwise analyses. The median and minimum-maximum range values were used for descriptive statistics. Statistical significance was defined as a P value less than 0.05.

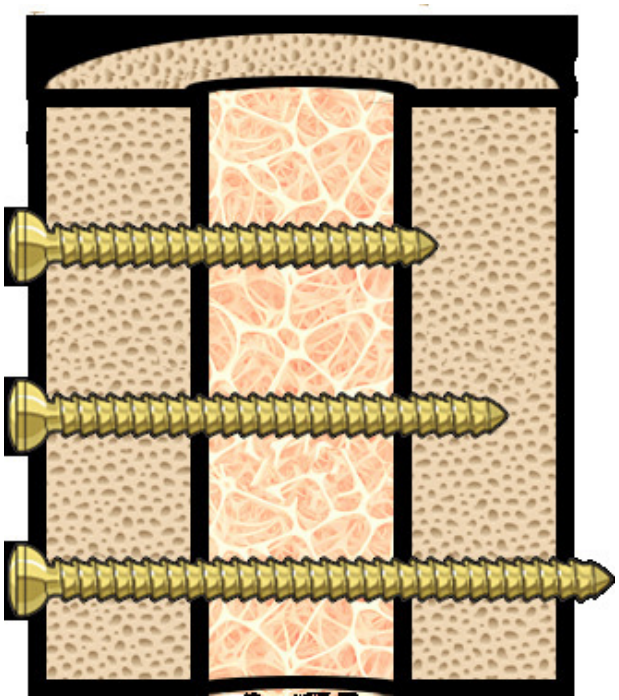

Figure 1. The illustration depicting the configuration of experiment groups. The upper screw represents Group 1, which demonstrates partial contact with the far cortex. The middle screw represents Group 2, which demonstrates full contact with the far cortex. The lower screw represents Group 3, which demonstrates at least three drilled threads passed through the far cortex

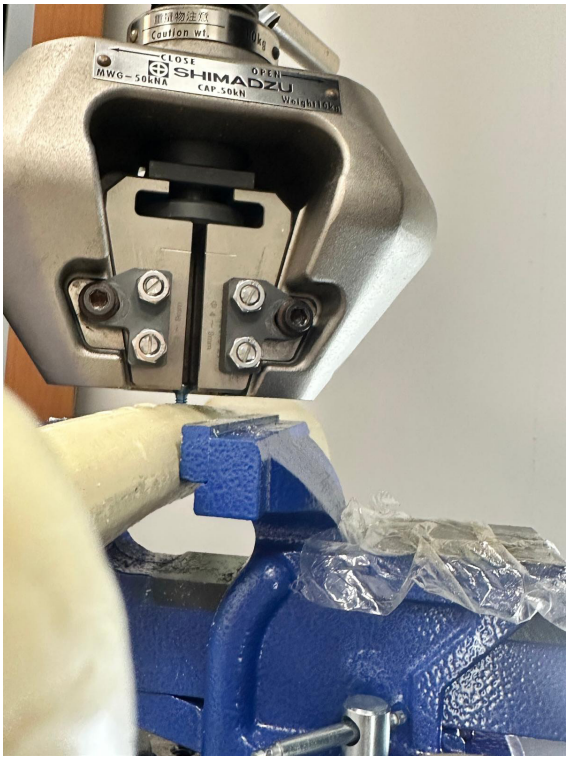

Figure 2. The installed system to test the prepared models. While the synthetic femur was affixed within the device, the head of the screw on the bone was grasped with the aid of a tool, and a tensile force was applied to the cortical screw head until pull-out (load to failure)

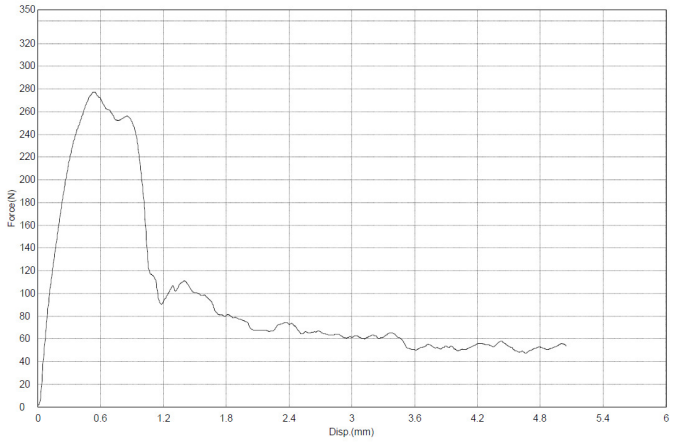

Figure 3. The force-displacement graph was constructed based on the data obtained from the experiment. In calculating the pull-out strength, the initial pull-out was defined as the moment when the resistance was first broken and the force-displacement curve first changed direction

RESULTS

It was ascertained that no synthetic bones were broken or lost during the preparation process prior to the measurement. The results demonstrated that the pull-out strength of the screws with partial contact to the far cortex ranged from 155 to 277 N, while the pull-out strength of the screws with full contact to the far cortex ranged from 178 to 256 N. In contrast, the pull-out strength in the group with at least three threads passed through the far cortex ranged from 322 to 540 N (Table 1).

A significant difference was observed in the triple comparison (p=0.021) when the pull-out strengths were compared between groups. Post-hoc analyses demonstrated that this was due to Group 3, with the pull-out strength in the group with at least three threads passed through the far cortex being significantly higher than in the other two groups (Table 2).

Table 1. Descriptive statistics of the experiment groups

Pull-out force	Group 1 (Partial contact)	Group 2 (Full contact)	Group 3 (Passed through)
Median (N)	185	235.5	401
Interquartile range	103	61	178
Minimum force (N)	155	178	322
Maximum force (N)	277	256	540

Table 2. Post-hoc analysis of the pull-out strength presenting a pairwise comparison of the groups in a cross-table format

	Group 1 (Partial contact)	Group 2 (Full contact)	Group 3 (Passed through)
Group 1 (Partial contact)	N/A	0.486	**0.029**
Group 2 (Full contact)	0.486	N/A	**0.029**
Group 3 (Passed through)	**0.029**	**0.029**	N/A

DISCUSSION

Screw systems are the most commonly utilized implants in traumatology. It is therefore imperative that healthcare professionals possess an in-depth understanding of their biomechanical properties and advantages, in order to ensure optimal fixation and prevent potential complications. It is generally accepted that cortical screws must make contact with both cortices (the near and far cortex) in order to achieve the desired compression force (1-4). On the other hand, there is a paucity of literature providing clear guidance on the extent to which the far cortex should be adhered. It is important to note that the far cortex may not always be adhered at the desired rate due to anatomical differences between patients or material supply issues. The aim of our study was to demonstrate the biomechanical superiority of partial and full contact and screw penetration of the far cortex. The most significant finding was that there was no difference in pull-out resistance between partial and full contact with the far cortex when using cortical screws. However, pull-out strength increased significantly when at least three threads were passed through the far cortex.

The value of utilizing longer screws in fracture fixation has been well documented in the scientific literature (10,11). In a study published in 2019, Fletcher et al. demonstrated that longer screws are associated with a reduced risk of cut-outs in proximal humerus fractures (11). In the case of cortical screws, the importance of screw length is further amplified, given that bicortical screw placement is crucial for achieving compression force. In contrast, the literature offers no clear explanation regarding the partial or complete adhesion of the far cortex in the context of bicortical application. From an engineering and geometrical perspective, it can be postulated that

increased adherence of the far cortex will result in enhanced compression strength. Furthermore, even in instances where the far cortex is pierced, the holding and pull-out strengths will be augmented. The findings of our study provide partial support for this hypothesis. The pull-out strength was significantly increased in the group that crossed at least three threads of the far cortex, whereas no significant difference was detected between partial and complete contacts of the far cortex. This result may be interpreted as indicating that contact between the distal end of the cortical screw and the far cortex is sufficient for minimum force, but that the holding force increases after the screw threads penetrate the far cortex. However, further biomechanical and finite element studies are needed for a more comprehensive analysis of the subject.

The results of our study demonstrated that the pull-out strength of Group 3 (the group in which at least three threads of the far cortex were passed) was the highest, and that the strongest fixation was obtained with this screw application. It is also important to note that a significant limitation of biomechanical studies is the inability to consider soft tissue as a parameter. Despite the observation that the pull-out strength of Group 3 was the highest in our study, the recommendation for the routine use of this application does not align with clinical practice. It is therefore necessary to consider the balance between stability and the potential for soft tissue complications. A review of the literature reveals numerous reports emphasizing the importance of achieving a balance in this regard (12,13). In 2020, van Dijk et al. emphasized the importance of achieving an equilibrium between optimizing pull-out strength and preventing cortical penetration and soft tissue complications (14). In conclusion, the primary objective of orthopaedic surgeons is to achieve fixation strength and prevent pull-out. However, this is not the sole objective, as preventing potential irritations and soft tissue complications and preserving the patient's biological processes are also vital for fracture healing.

It should be noted that, in the course of our study, 12 reinforced third-generation composite synthetic left femur models with a resistance against up to 1533 N in mechanical tests were employed. The synthetic femur models were prepared for biomechanical testing at the actual load quality that the human bone can withstand. Conversely, it is not possible to create a synthetic bone that precisely resembles the human bone, given that the quality of human bone is influenced by a multitude of factors, including age, gender, degree of movement, and mineral density. It is therefore unfeasible to develop a synthetic model that exhibits all of the same biomechanical properties as human bone. Furthermore, synthetic models lack soft tissue support, which is a crucial component of the mechanical system in humans. Nevertheless, our comparative experiment was conducted because the synthetic bone models were prepared to withstand the actual load quality that the human bone can withstand, have similar biomechanical properties with each other and have been previously validated in the literature (15,16).

It is important to acknowledge that our study is not without limitations. The principal limitation of the study is the relatively small number of subjects. Additionally, the study's reliance on synthetic bone models, its exclusive focus on a single anatomical structure type, and the exclusion of soft tissue as a factor due to the biomechanical nature of the study may affect the generalizability of the results. Moreover, the assessment of pull-out force in the direction of screw advancement, without consideration of motion vectors, represents another limitation. Finally, the use of screws in without plates, and the absence of a fracture model in the experimental process, represent important limitations. These limitations can be addressed through comprehensive studies that incorporate finite element analysis and clinical projections on the subject.

CONCLUSION

In conclusion, screw length and far cortical adhesion are critical parameters in obtaining ideal fixation strength in traumatology. When choosing the cortical screw length, a stronger pull-out resistance can be expected with a longer cortical screw length and passing the distal end through the far cortex. However, this should be decided taking into account the characteristics of the anatomical region to be treated, the nearby neurovascular structures, and the risk of tendon-soft tissue irritation.

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MEDICAL RECORDS-International Medical Journal

Research Article

Clinical Characteristics of Cases Developing Neonatal Pneumothorax: 10 Years of Experience

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Abstract

Aim: Pneumothorax is a serious emergency condition that increases mortality and morbidity due to the accumulation of air between the visceral and parietal pleura layers. Neonatal pneumothorax is more frequently encountered in neonates admitted to neonatal intensive care units. It is known that the most important risk factors are prematurity and ventilation with a bag mask.
Material and Method: Forty-two pneumothorax cases followed in the neonatal intensive care unit (NICU) were included in our study. The characteristics, risk factors, treatment methods and prognoses of the cases were retrospectively analyzed.
Results: Twenty eight of the cases (66.67%) were male, and Pneumothorax developed within the first 3 days of life in 41 cases (97.61%). Nineteen cases (45.24%) were premature, 16 cases (38.10%) underwent resuscitation at birth, and 15 cases (35.71%) received surfactant therapy. An intercostal chest tube was placed for treatment in 34 cases (80.95%), and invasive mechanical ventilation was required in 33 cases (78.57%). Thirty six cases (85.71%) were regained the health, while those who passed away were found to be more premature.
Conclusion: In our study, prematurity, resuscitation at birth, and surfactant therapy were identified as risk factors for neonatal pneumothorax. Newborns with these risk factors should be closely monitored, and neonatal pneumothorax should be kept in mind if respiratory distress develops.

Keywords: Neonatal pneumothorax, prematurity, resuscitation

INTRODUCTION

Pneumothorax is a serious emergency condition that increases mortality and morbidity due to the accumulation of air between the visceral and parietal pleura layers. The increase in intrathoracic pressure can lead to decreased venous return, hypoxia, and hypercarbia, which can be life-threatening (1). Neonatal pneumothorax occurs in 1-2% of neonates admitted to neonatal intensive care units, but this rate exceeds 40% in the presence of respiratory distress syndrome (RDS) (2). It is more common within the first 3 days of life. The most important risk factors are prematurity and ventilation with a bag-valv mask. Other known risk factors include male gender, low APGAR score, low birth weight, hyaline membrane disease, transient tachypnea of the newborn, meconium aspiration syndrome, and pulmonary hypoplasia (3,4). Although small pneumothorax may be asymptomatic, as the size of the pneumothorax increases, symptoms such as respiratory distress, tachypnea, apnea, cyanosis, and bradycardia can occur (5). While computed tomography (CT) is the gold standard for diagnosis, it is rarely used due to the high risk of ionizing radiation. In neonates, chest radiography and transillumination are the most commonly used methods for diagnosing pneumothorax. However, detecting small pneumothoraces, especially in premature and low birth weight infants, can be challenging. Due to the thin skin and narrow thorax of neonates, lung ultrasound can be used with high accuracy and reliability for diagnosis (6). The treatment of pneumothorax varies depending on the patient's symptoms and the size of the pneumothorax. Patients with asymptomatic and small pneumothorax can be monitored with non-invasive mechanical ventilation

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and positioning the affected side down. However, in life-threatening situations, needle aspiration with thoracentesis should be performed, or a intercostal chest tube should be placed (7).

In this study, we aimed to retrospectively analyze neonatal cases that developed pneumothorax in our hospital since 2014, to determine their clinical characteristics and predisposing factors.

MATERIAL AND METHOD

The study included 42 cases of pneumothorax that were followed and treated in the Neonatal Clinic of Düzce University Faculty of Medicine Training and Research Hospital between 2014 and 2024. All cases were diagnosed with anteroposterior chest radiography. In cases where it was deemed necessary, confirmation was made with lateral or decubitus position chest radiography. The cases were retrospectively evaluated for gestational age, birth weight, types of delivery, postnatal day of pneumothorax occurrence, gender, side of pneumothorax, need for postnatal resuscitation, meconium-stained birth, underlying primary lung disease, respiratory support, treatment method, and prognosis.

Cases with major congenital anomalies and those who had a thoracic tube placed due to thoracic surgery were excluded from the study.

Before inclusion in the study, the parents of the participants were informed about the content, purpose, and implementation of the study, and written consent was obtained.

This research involving human subjects complied with all relevant national regulations and institutional policies and was conducted in accordance with the tenets of the Helsinki Declaration. This study was approved by Düzce University Faculty of Medicine Ethics Committee (Decision no: 2024/94, Approval Date: 06.05.2024).

Statistical Analysis

In the statistical analysis of the study, descriptive statistics for numerical data were presented as mean±sd, if not normally distributed, median (IQR25-75) used, while categorical data were given as numbers and percentages.

In the statistical analysis of the study, descriptive statistics for numerical data were presented as mean+-std, if not normally distributed, median (IQR25-75) used, while categorical data were given as numbers and percentages. The distribution of numerical data was evaluated using histogram graphs. For the comparison of numerical data between two groups, the Student's t-test and Mann-Whitney U test were used. The chi-square test was employed for the comparison of categorical data. A p-value of <0.05 was considered statistically significant. The analyses were conducted using the SPSS 23.0 software package.

RESULTS

A total of 42 infants were included in the study. The mean age of the mothers of the infants in the study was found to be 29.21±6.18 years. The mean gestational age of the infants was 35.86±3.36 weeks. The median birth weight of the infants was 2892.50 grams (min=780; max=4770). Of the cases, 66.67% (n=28) were male. Pneumothorax developed on the 6th day of life in one case. In the other cases, pneumothorax developed within the first 3 days of life. Some demographic data of the patients are shown in Table 1.

Table 1. The parameters of maternal age, gestational age, birth weights, and the day of pneumothorax onset in the cases

Maternal age (year)*	29.21±6.18
Gestational age (week)**	36 (4)
Pneumothorax time(day)**	2 (5)
Birth weight (gr)*	2,861.79±778.82

* mean±SD, **median (IQR)

The majority of the cases, 85.71% (n=36), were delivered via cesarean section. Pneumothorax was predominantly unilateral, with a higher incidence on the right side. It was observed that 21.43% (n=9) of the cases developed bilateral pneumothorax. When comparing bilateral and unilateral pneumothorax cases, a significant difference was found only in the presence of preeclampsia in the mother. Bilateral pneumothorax was detected in both newborns whose mothers developed preeclampsia (p=0.006). Invasive mechanical ventilation was required in 33 (78.57%) cases (Table 2).

Table 2. Types of delivery, side of pneumothorax, and need for respiratory support in the newborns

		n	%
Types of delivery	**C/S**	36	85.7
	NSVD	6	14.3
Side of pneumothorax	**Right**	18	42.8
	Left	15	35.7
	Bilateral	9	21.5
Respiratory support	**Oxigen hood**	4	9.6
	CPAP	5	11.9
	Intubation	33	78.5

C/S: caeserian section, NSVD: normal spontaneous vaginal delivery

Comorbid conditions associated with pneumothorax development in the cases were evaluated in Table 3. Prematurity was present in 45.24% (n=19) of the cases. The rate of resuscitation at birth was found to be 38.10% (n=16). Surfactant was administered to 35.71% (n=15) of the cases. As a result, 14.29% (n=6) of the cases resulted in death. Other comorbid conditions are listed in Table 3.

Table 3. Comorbid conditions associated with the development of pneumothorax in newborns

	n	%
Prematurity	19	45.24
Necrotizing enterocolitis	1	2.38
Extremely low birth weight baby (<1000 g)	2	4.76
Intrauterine growth retardation	1	2.38
Premature membrane rupture	1	2.38
Preeclampsia	2	4.76
Hypoxic ischemic encephalopathy	1	2.38
Congenital heart disease	2	4.76
Neonatal transient tachypnea	1	2.38
Congenital pneumonia	3	7.14
Sepsis	1	2.38
Congenital diaphragmatic hernia	1	2.38
Neural tube defect	1	2.38
Gestational diabetes	3	7.14
Acute kidney failure	1	2.38
Chest tube insertion	34	80.95
Respiratory distress syndrome	12	28.57
Meconium aspiration	1	2.38
Resuscitation at birth	16	38.10
Surfactant replacement therapy	15	35.71
Exitus	6	14.29

g: gram

The numerical data of the cases and their mothers were evaluated according to the exitus status. No significant differences were observed in maternal age, gestational week, day of pneumothorax development and birth weight according to the exitus status of the patients (p>0.05). However, it was observed that the cases who were exitus had lower gestational weeks (Table 4).

Table 4. Evaluation of numerical data of the cases and their mothers according to exitus status

	Exitus	Recovering the health
Mother age (year) *	26.17±4.44	29.72±6.33
Gestation age (week) **	35(12)	37(12)
Pneumothorax time (day) **	1(2)	2(5)
Birth weight (gr) *	2272.50±1513.40	2960.00±560.10

*mean±SD, **median (IQR)

It was observed that the majority of the cases who used surfactant required the insertion of an intercostal chest tube; however, no significant difference was found between surfactant use and the need for chest tube insertion (p=0.128) (Table 5).

Table 5. The relationship between surfactant use and the need for chest tube insertion

	Surfactant therapy		p
	Yes	No	
Spontaneously resolved	1	7	0.128
Chest tube insertion	14	20	

DISCUSSION

In our retrospective study evaluating neonatal pneumothorax cases, we identified the most important risk factors as prematurity, the need for resuscitation at birth, surfactant administration, and RDS. Pneumothorax cases were more commonly observed in male infants. Most cases developed unilateral pneumothorax and additionally, most patients required invasive mechanical ventilation support for their treatment. In the majority of cases, a chest tube was inserted as part of the treatment.

In a study conducted in Türkiye by Tandırcıoğlu et al., the most frequently identified risk factor for neonatal pneumothorax was RDS, observed in 47.5% of cases (8). In our study, RDS was detected in 28.57% of cases. In Tandırcıoğlu's study, 42% of the cases were born before 34 weeks of gestation, and 30% were born between 34-37 weeks, all of whom were premature infants. Additionally, 68% of the cases born before 34 weeks were administered surfactant, and it was reported that the need for surfactant decreased as gestational age increased. In our study, 12% of the cases were born before 34 weeks, and 38% were born between 34-37 weeks. The lower rate of RDS in our study may be attributed to the lower proportion of premature infants born before 34 weeks. Consequently, the rate of surfactant administration was also found to be lower.

Many studies have reported that male sex is a risk factor for pneumothorax. Jovandarić et al. also reported that 67.6% of their cases were male (9). In our study, 66.6% of the cases were male as well. Ishak et al. investigated the male disadvantage in respiratory morbidity and mortality in preterm births using a preterm lamb model. They found that female lamb fetuses had higher lecithin/sphingomyelin ratios and higher saturated phosphatidylcholine ratios in amniotic fluid, indicating that female fetuses have a developmental advantage over males in terms of lung maturity (10).

Aly et al. reported that pneumothorax occurring in term or near-term infants had a better prognosis and required less mechanical ventilation (11). Boo et al. studied 505 cases of neonatal pneumothorax and found that pneumothorax was more common in infants with low birth weight and small gestational age. They also reported that mortality was higher the more premature the infant and the lower the birth weight (12). In our study, the gestational age and birth weight of the exitus cases were found to be lower compared to the discharged infants. However, no significant difference was observed between them. The low number of cases in our study may have contributed to the lack of a significant difference.

Smith et al. reported that in their study of infants with neonatal pneumothorax and a gestational age >36 weeks, 29% of the cases required intercostal tube drainage (13). Okumuş et al. found that in a cohort of 124 premature neonates, approximately 95.9% required intercostal tube drainage (14). These studies indicate that more premature infants have a higher need for intercostal tube drainage. In our study, intercostal tube drainage was performed in 80.9% of the cases.

Bhatia et al. reported that the earlier in life neonatal pneumothorax occurs, the higher the mortality rate (15). In our study, the timing of pneumothorax development in exitus cases was earlier compared to discharged infants, but no significant difference was observed.

Significant progress has been made in the care of premature infants with the introduction of surfactant therapy. It is well known that in the pre-surfactant era, pneumothorax developed much later in premature infants compared to term cases. However, after the introduction of surfactant therapy, it has been reported that approximately 20% of preterm infants develop pneumothorax within the first 48 hours (16). This suggests that surfactant therapy is a risk factor for pneumothorax. Studies have reported that newborns may require high distension pressures for ventilation. During the recovery phase of RDS, lung compliance can improve rapidly, which may lead to pneumothorax due to high pressures (17). It is known that surfactant administration is effective in this recovery process. To prevent pneumothorax, it is important to closely monitor the mechanical ventilator pressure settings in infants who have received surfactant. In our study, pneumothorax in infants who received surfactant was found to be more severe, with spontaneous resolution being less common and a greater need for chest tube insertion. However, these differences were not statistically significant. This is likely attributable to the limited number of patients in our study.

CONCLUSION

In our study examining neonatal pneumothorax cases, the most common comorbid conditions associated with pneumothorax were found to be prematurity, resuscitation at birth, and surfactant therapy. Most cases improved with appropriate timing and treatment. Correct identification of risk factors in neonatal pneumothorax and proper management of cases with respiratory distress leads to favorable outcomes.

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Research Article

The Treatment of Interphalangeal Joint Fracture Dislocations with the Pin and Rubber Method

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Abstract

Aim: This study aimed to evaluate the clinical and radiological results of interphalangeal joint injuries treated with the pin-and-rubber method and to determine the effectiveness of this treatment method.
Material and Method: Patients aged 18 years or older who presented with injuries of the interphalangeal joints of the hand and were treated with the pin-and-rubber method were included in the study. Patients with open fractures, multiple finger injuries, or those who underwent open surgery were excluded. Total of 32 interphalangeal joint injuries were evaluated retrospectively. Eight of those patients declined to participate in the study and the final analysis included 24 fingers of a total of 24 patients. Age, sex, injured finger, type of injury, and time until treatment were recorded for all patients. Union was evaluated based on joint radiographs from patients final follow-up appointments. For the evaluation of functional results, joint range of motion was measured with a finger goniometer and Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and visual analog scale (VAS) scores were evaluated.
Results: The median age of the analyzed patients was 30 (18-69) years. The most frequent mechanism of injury was fall (52.4%) and the most frequent injured finger was the fourth. The median follow-up duration for these patients was 25 (16.25-31.75) months. The median DASH score was 4.16 (0.00-7.50) and the median VAS score was 4 (0.00-8.00). The median range of motion of the proximal interphalangeal joint was 90° (80.00-98.75°), while that of the distal interphalangeal joint was 55° (36.25-80.00°). Union was achieved in all cases. Condylar fractures were observed in two patients over the course of follow-up.
Conclusion: The treatment of interphalangeal joint fractures or fracture dislocations by the pin-and-rubber method was confirmed to be an easily applicable and effective treatment method that does not cause a significant loss range of motion.

Keywords: Finger fracture, hand surgery, pin and rubber

INTRODUCTION

Although hand injuries are commonly experienced in society, fracture dislocations and comminuted fractures of the fingers are relatively less common. The prognosis of intraarticular fractures, comminuted fractures, and fracture dislocations is generally worse. These types of fractures can result in significant pain, joint stiffness, and limitation in range of motion (1-6).

There is no consensus on the ideal treatment modality for fracture dislocations of the fingers (5,7). Prolonged immobilization can cause stiffness in the affected joints (8), while open surgical methods may entail excessive soft tissue stripping, resulting in stiffness and loss of motion (9).

In these cases, the main goal of treatment is to obtain a finger that is free of pain without functional limitation (5,10,11). Many relevant treatment methods have been described in the literature, such as conservative, closed, and open surgical fixation or dynamic external fixator and joint reconstruction methods (5,10,12).

The aim of this study was to evaluate the clinical and radiological results of patients with interphalangeal joint fractures or fracture dislocations who were treated with the pin-and-rubber method and to compare those results with the previous literature. This study hypothesized that the pin-and-rubber method is a reliable approach for eligible patients with interphalangeal injuries because it allows for early movement and does not impair biological healing.

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MATERIAL AND METHOD

Patient Selection

This study was designed as a retrospective case series. Approval was obtained from the relevant clinical ethics committee before the research began.

The patients applied for interphalangeal joint fracture or fracture dislocation between 2015 to 2020 were included. For patients applying to our clinic with interphalangeal joint fractures or fracture dislocations, conservative treatment was preferred in cases in which there was no displacement, the fractured part accounted for less than 30% of the total joint, and the fracture was stable. Surgery was performed for patients for whom joint alignment and stability could not be achieved with conservative treatment. In the event of ongoing joint dislocation, joint malalignment, or sagittal or coronal plane malreduction in patients for whom a traction system was utilized during surgery, open reduction and internal fixation was added.

The inclusion criteria of the study were as follows: 1) being 18 years of age or older, 2) being diagnosed with acute interphalangeal fracture or fracture dislocation (i.e., within 21 days after the initial trauma), 3) having a fracture or fracture dislocation not suitable for conservative treatment and 4) having a minimum of 1 year of follow-up after surgery. 1) Patients with open fractures, 2) multiple finger injuries and 3) fractures or fracture dislocations that required open surgery for reduction were excluded. Accordingly, 32 interphalangeal joint injuries were retrospectively examined. Eight of those patients declined to participate in the study and the final analysis included 24 fingers of a total of 24 patients.

Surgical Technique

All surgical interventions and postoperative follow-up examinations were conducted by the same surgical team. Patients were operated on in the supine position under general or local anesthesia. After the necessary surgical preparations, a 1.2-mm Kirschner (K) wire was applied proximally to the joint, passing the head of the proximal phalanx from the center in the sagittal plane. Pliers were used to bend the wire 90° some distance from the skin. The K-wire was then bent again distally 3 cm past the fingertip and the axial traction pin was prepared (Figure 1).

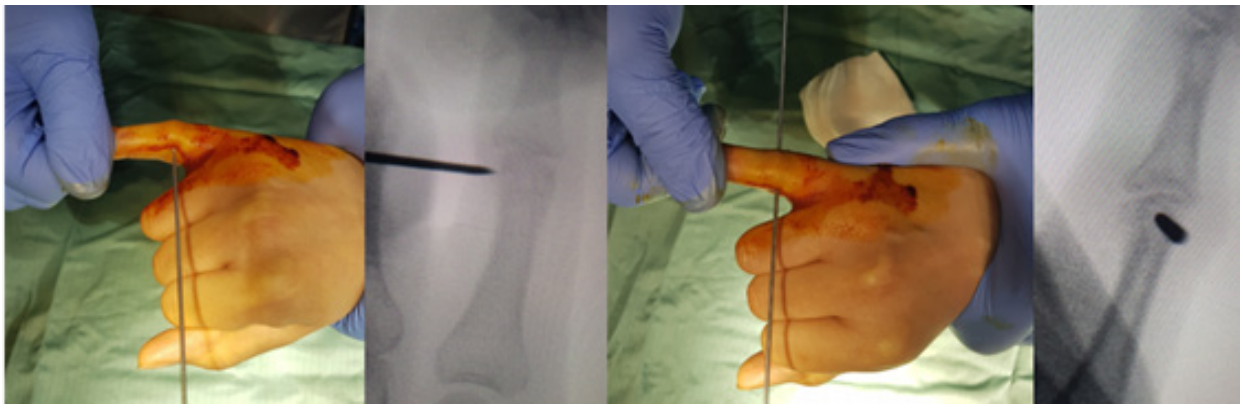

Figure 1. Application of the axial traction pin

A 1-mm K-wire (1 mm) was applied transversely to the fracture, distal to the middle phalanx. It was bent immediately above the skin with the help of pliers and the hook pin was prepared. For patients with dislocation, a 1-mm K-wire was applied to serve as a reduction pin just distal to the fracture and as close to the volar aspect of the phalanx as possible (Figure 2).

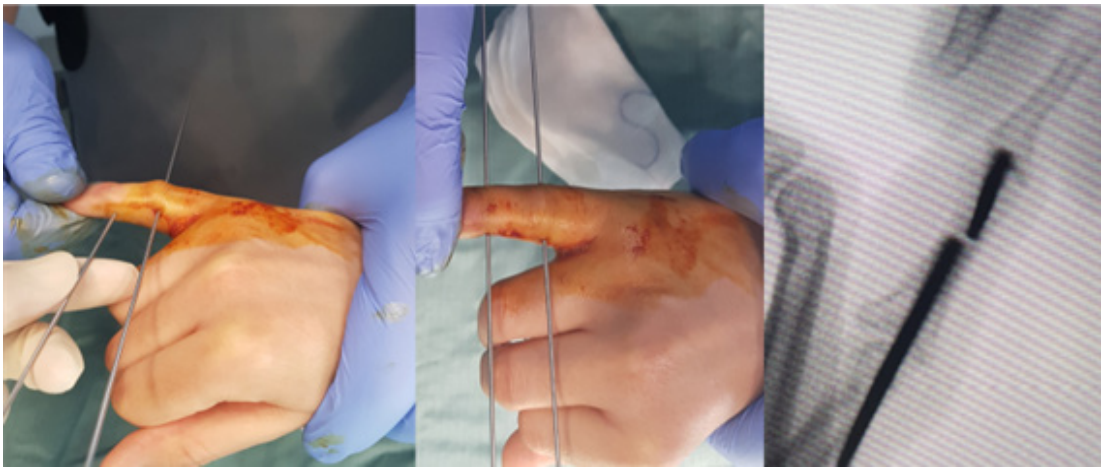

Figure 2. Application of the hook pin

Two rubber bands were subsequently added to the pin-and-rubber traction system and the achievement of appropriate reduction was checked under fluoroscopy considering the tension of the rubber bands. The tension and/or number of the bands was increased if necessary to achieve the appropriate reduction. When appropriate reduction was confirmed by fluoroscopy, the mobility of the finger was checked and the operation was terminated (Figure 3).

Figure 3. The bending of wires and the setup of the traction system

Postoperative Follow-up

Patients began routine postoperative movement immediately after leaving the operating room. After patients were discharged, they were called for weekly follow-up appointments to monitor the reduction. During these follow-up appointments, reduction was monitored via direct radiography and the joint movements of the patients were evaluated. For patients found to have experienced a loss of reduction in follow-up, reduction was regained by adjusting the tension of the rubber bands. The pin-and-rubber traction systems were routinely removed in the postoperative 6th week. After the removal of the traction system, patients were shown active finger movements to practice at home. Patients were then called for follow-up visits once a month for the first six months and every three months thereafter.

Patient Evaluations

The demographic data of all patients (age, sex, injured finger, type of injury, time until treatment) were recorded before surgery.

Joint range of motion (ROM) was examined for all patients at the final follow-up visit and X-rays were obtained. The functional status of the patients was evaluated with the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) score, while the presence and amount of pain was evaluated with a visual analog scale (VAS) with possible scores ranging from 0 to 100. Finger joint range of motion was measured with a finger goniometer and recorded.

RESULTS

The median age of the 24 patients included in this study was 30.0 (18-69) years, and 17 (70.8%) of these patients were male while 7 (29.2%) were female. Their injuries most often occurred after a fall (54.2%) and the fourth finger was most commonly injured (54.2%). The median time between the injury and surgical intervention was 3 (1.2-5.7) days. The median follow-up period was 25 (16.25-31.75) months. Demographic details of the study population were presented in Table 1.

Table 1. Demographic data of the patients included in the study

Variables	Values
Sex, n (%)	
Male	17 (70.8)
Female	7 (29.2)
Age, years	
X±SD	32.5±14.6
M (min-max)	30.0 (18.0-69.0)
Injured side, n (%)	
Right	12 (50)
Left	12 (50)
Injured finger, n (%)	
Second	1 (4.2)
Third	5 (20.8)
Fourth	13 (54.2)
Fifth	5 (20.8)
Affected joint, n (%)	
DIP	2 (8.3)
PIP	22 (91.4)
Mechanism of injury, n (%)	
Fall	13 (54.2)
Door closing on finger	3 (12.5)
Contact with a ball	2 (8.3)
Traffic accident	1 (4.2)
Injured while punching	5 (20.8)
Time interval between injury and treatment, days	
M (Q1-Q3)	3.0 (1.2-5.7)

The patients functional results were provided in Table 2. The median proximal interphalangeal (PIP) joint ROM was 90° (80.00-98.75°), while that of the distal interphalangeal (DIP) joint ROM was 55° (36.25-80.00°). The median DASH score was 4.16 (0.00-7.50) and the median VAS score was 4 (0.00-8.00).

Table 2. Functional scores

Functional scores	
M (Q1-Q3)	
DASH	4.16 (0.00-7.50)
VAS	4 (0.00-8.00)
PIP ROM (degrees)	90 (80.00-98.75)
DIP ROM (degrees)	55 (36.25-80.00)

M: median, Q1: first quartile, Q3: third quartile, DASH: disabilities of the arm, shoulder, and hand questionnaire, VAS: visual analog scale, PIP ROM: proximal interphalangeal joint range of motion, DIP ROM: distal interphalangeal joint range of motion

Union was observed to have occurred in all cases. No cases of coronal plane deformity were observed. Condylar fractures were observed during follow-up in two patients (8%), one occurring in the condyle of the middle phalanx and the other in the condyle of the proximal phalanx. The condylar fracture of the middle phalanx was observed the third week after surgery. The patient refused surgical treatment, and so the pin-and-rubber system was removed and no further surgical intervention was performed. The condylar fracture of the proximal phalanx was observed the fourth week after surgery. The patient had no fracture displacement and was therefore treated with a finger splint for two weeks, restricting active movement after the pin-and-rubber system had been removed. In three cases (13%), infection was observed at the base of a pin. In all three cases, the infection occurred at the base of the axial traction pin and these patients were treated with oral antibiotics; pin removal was not required. None of the patients developed osteomyelitis.

DISCUSSION

Interphalangeal joint fractures and fracture dislocations are complex injuries that most frequently occur in the PIP joint (13,14). Fractures accompanied by intraarticular fragments and dislocations may have extremely poor prognosis (1-4,6). In the literature, many treatment methods have been described for finger joint fractures and fracture dislocations (5,10,12). The most important finding of this study is that satisfactory joint range of motion was achieved in the long-term follow-up of patients with interphalangeal joint fractures or fracture dislocations following treatment with the pin-and-rubber traction system.

Capsuloligamentotaxis forms the basis of dynamic traction in the treatment of these injuries (1,8,15). The movement that occurs with the application of traction to the joint is a biological process. Ensuring fracture reduction and preventing the shortening of the ligaments around the joint facilitates the protection and healing of the articular surfaces (1,8,16).

Keramidas et al. reported reported 11 patients treated by Suzuki frame with PIP joint injuries, and after a mean follow-up period of 18 months, the mean active range of motion of the PIP joint was found to be 84° (17). In the study conducted by De Smet et al., which included 8 PIP joint fracture dislocations and had a mean follow-up period of 16.5 months, the mean total active joint range of motion was found to be 82° (16). Debus et al. found the mean active range of motion of the PIP joint to be 56° while that of the DIP joint was 39.6° (18). The study conducted by Agarwal et al. had a mean follow-up period of 12.8 months and the mean active range of motion of the PIP joint was found to be 67.2° while that of the DIP joint was 40.7° (19). In the present study, the median follow-up period was 25 months and the median values of total active range of motion were 90° for the PIP joint and 55° for the DIP joint. Compared to other studies in the literature in terms of follow-up, the present study is seen to have a relatively long follow-up period. Furthermore, compared to previous findings in the literature, the ranges of motion obtained in this study for both the PIP and DIP joints are higher. This may be due to the fact that previous studies involving the pin-and-rubber traction system also included patients who had undergone open reduction.

Ellis et al. retrospectively evaluated 14 patients, the mean VAS score was reported as 2.5 (0-10) (20). The study conducted by Finsen included 18 patients and the mean VAS score was 5.5 (0-10) (21). In the present study, the median VAS score was 4 (0-100). Thus, compared to the literature, the final pain levels reported in this study are quite low. This may be due to the present study's long duration of follow-up and the fact that appropriate closed reduction was achieved in all cases.

In the literature review conducted by Gianakos et al., it was stated that DASH scores were reported in 22% of the evaluated studies on the treatment of interphalangeal joint fracture dislocations, and the mean DASH score of patients in studies using dynamic external fixators was 9.2 (22). In the present study, the median DASH score was found to be 4.16. The lower DASH scores obtained in this study compared to the literature, reflecting a lower level of disability, may be attributed to the fact that most patients in this study had injuries of the fourth or fifth finger. These fingers have a relatively limited impact on overall DASH function scores.

Considering the frequency of postsurgical infections among patients treated with dynamic external fixators, Elatta et al. reported the occurrence of 5 superficial infections among a total of 36 patients, and those infections were treated with oral antibiotics without removal of the traction systems (23). In the study conducted by Agarwal et al., pin site infections were observed in 7 cases (28%) and were again treated with antibiotics without removal of the systems (19). Debus et

al. detected superficial infections in 3 patients who were accordingly treated with oral antibiotics, while one patient underwent surgical curettage due to osteomyelitis (18). In the study conducted by Kiral et al., no signs of infection were found in any patient (24). Infection at the pin site was observed in three patients in the present study. They were treated with oral antibiotics and removal of the pin-and-rubber system was not necessary. No patients developed osteomyelitis.

Regarding the possible complications of finger joint injuries treated with dynamic external fixators, nonunion, osteoarthritis, osteomyelitis, coronal and sagittal plane deformity, and osteolysis have been reported in the literature (16,19,20,25,26). In contrast, in the present study, only condylar fractures due to falls were encountered as complications in two cases, with one occurring in the middle phalanx and the other in the proximal phalanx. This finding may be attributed to the occurrence of osteolysis in bone area through which K-wires pass, with fractures due to trauma occurring more easily in those areas due to the effect of active movement.

The present study has several limitations that should be acknowledged. First, retrospective nature of the study may cause bias. Second, lack of control group prevents to compare the presented data with other treatment options. Third, relatively shorter follow up time may cause underestimating some complications that can present in long term such as osteoarthtiris. Also patient populations is not enough to demonstrate risk factors for complications.

CONCLUSION

In conclusion, good functional results can be achieved with the pin-and-rubber method in selected cases of interphalangeal joint injuries, as this method allows for early movement and does not disrupt the fracture biology. Although the complication rates of this method are relatively low, it should be kept in mind that condylar fractures may occur, especially due to osteolysis.

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MEDICAL RECORDS-International Medical Journal

Research Article

Comparative Analysis of Lateral Radiography and Magnetic Resonance Imaging in the Diagnosis of Lumbar Disc Herniation

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Abstract

Aim: This article investigates the use of X-ray as a cost-effective and feasible alternative to magnetic resonance imaging (MRI) for diagnosing lumbar disc herniation (LDH), a common condition with significant economic impact.

Material and Method: We assessed the diagnostic efficacy of lumbar lateral radiography (LLR) in identifying LDH. The study cohort formed from patients, presenting with lumbalgia or lumbosciatalgia. Participants who gave consent and had both MRI and LLR within a one-month period were included. Data normality was evaluated, employing the Kolmogorov-Smirnov test for nonparametric data. Variables were represented as means ± standard deviation, analyzed using the Wilcoxon test, with a p-value of less than 0.05 indicating statistical significance.

Results: The study involved 436 patients, 56.8% female and 43.2% male, ranging in age from 18 to 75 years. No significant gender, age, or Body Mass Index (BMI)-related differences were observed in the presence of LDH on radiographs. However, significant differences were noted at the L5-S1 and L4-L5 levels. The LLR showed a sensitivity of 94%, specificity of 95%, and a high agreement of 96.7% among evaluators.

Conclusion: Study concludes that LLR achieves a diagnostic success rate comparable to Lumbar MRI for most LDH cases. Notably, it is crucial to employ LLR even in patients presenting with "red flag" signs. LLR stands out as a cost-effective and rapid diagnostic alternative in the assessment of LDH. Nonetheless, it is important to acknowledge that MRI continues to be indispensable in more complex cases or for patients exhibiting specific clinical symptoms.

Keywords: Lumbar lateral radiography, lumbar disc herniation, lumbar magnetic resonance imaging, comparative analysis

INTRODUCTION

Lumbar disc herniation (LDH) is a prevalent condition, ranking as the second most common reason for medical consultations and hospitalizations (1,2). It accounts for 15% of all workforce losses and is the leading cause of disability in individuals under 45 years old (1). Given its impact, financial investments in diagnosing and treating LDH hold significant economic importance (3). In 2020, according to data from the Social Security Institution in our country, there were 86,386 new cases of LDH (3). The expenditure on surgical treatments for these cases was approximately 127 million Turkish Liras, representing only about 2% of the disease's total cost (3). This figure does not include investments in healthcare facilities or the indirect costs of workforce losses (3,4).

Currently, magnetic resonance imaging (MRI) is the most commonly utilized diagnostic tool for LDH, primarily due to its evidence-based effectiveness (5). Despite being the gold standard for etiological diagnosis, MRI has notable limitations, including long waiting times for appointments and high costs associated with installation, maintenance, and staffing (3). Additionally, MRI is not suitable for patients with certain medical devices or conditions such as pacemakers, stents, metallic fixators, or claustrophobia (6).

In contrast, X-ray, a simpler and less expensive imaging modality, is underutilized in neurosurgery training and practice, although it plays a crucial role in diagnosing bone pathologies (7,8). While not typically employed for diagnosing LDH, lumbar lateral radiography (LLR) is instrumental in surgical level determination, investigating

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muscle spasm etiology, assessing spinal alignment, and identifying various pathologies, including congenital/acquired anatomical disorders, tuberculosis or brucella spondylitis, and trauma-related injuries (7-9). Over the years, we have noticed during patient examinations that it is possible to observe disc traces in LLR. The advent of digital X-ray technology, with its adjustable dosing capabilities, has further facilitated this observation (9).

It is important to note that early diagnostic interventions using advanced technology do not necessarily contribute to the natural healing process of LDH (6). While a small subset of patients requires surgical intervention, a significant portion undergoes MRI due to legal and social reasons, despite the potential for diagnosis through X-ray (3,5,7-9). This overreliance on MRI has prompted a reevaluation of whether LLR could serve as a cost-effective alternative to alleviate the financial burden of more expensive imaging modalities.

This study aims to explore the feasibility of substituting lumbar MRI (LMRI) with LLR for diagnosing LDH. Given the financial burden of MRI on the health system and its widespread use (3,5), this research seeks to determine whether LLR, being cheaper, easier, and faster, could be a viable alternative under specific conditions.

MATERIAL AND METHOD

From March 2022 to August 2023, a research study was conducted at the Niğde Ömer Halisdemir University Faculty of Medicine Training and Research Hospital, Department of Neurosurgery. This study aimed to evaluate the effectiveness of LLR in diagnosing LDH. Eligible patients included those who visited the clinic with lumbalgia/lumbosciatalgia symptoms and met the following criteria:

- Aged between 18 and 85 years.
- Gave consent to participate in the study.
- Underwent both LMRI and LLR within a one-month interval.
  - Had both LMRI and LLR records available in the Hospital's PACS (Picture archiving and communication system) system.
  - Experienced persistent back pain unresponsive to treatment or developed neurological deficits, and subsequently underwent an LMRI.
  - Were new patients previously treated with an LMRI, unresponsive to pain treatment, scheduled for surgery, and had an LLR to determine the surgical level.

The study did not involve additional tests beyond those indicated for patients' existing conditions. Thus, existing LMRIs and LLRs were analyzed. Also, demographic data were collected and anonymized.

Patients were excluded from the study if they had contraindications for MRI (e.g., metal implants, claustrophobia, pacemakers) or X-ray (e.g., pregnancy), or if they had undergone previous lumbar surgeries, suffered from lumbar vertebral fractures, had congenital or acquired lumbar spinal stenosis, lumbar scoliosis greater than 10 degrees, lumbar spondylolisthesis, Paget's disease, were undergoing long-term steroid therapy, had renal colic, or presented with inadequate or inappropriate imaging.

For adequate LLR, criteria ensured:

- Comprehensive visibility of the lumbar spine from T12/L1 to L5/S1.
- Clear display of superimposed structures including the greater sciatic notches, superior articulating facets, and both superior and inferior endplates.
- Adequate image penetration and contrast, emphasizing trabecular and cortical bones of lumbar vertebral bodies.

Anonymized LLRs were independently evaluated by two authors, focusing on disc findings between L2-3 and L5-S1, due to their clinical importance (10). Patients were grouped into three age categories (18-40, 41-65, 66-85 years), and further divided based on Body Mass Index (BMI) into three subgroups (<24.9, 25-29.9, >30), creating nine evaluation groups. Disc herniations were classified into five types: natural, bulging, protrusion, extrusion, and sequestration. Disc findings on LMRI were analyzed and compared with disagreements considered inaccurate (Figure 1).

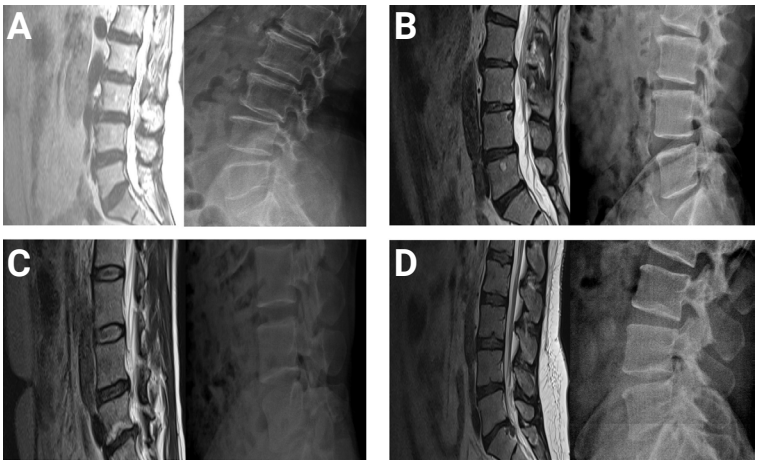

Figure 1. LMRI and LLR comparative examples of different types of disc herniation at various levels; although active digital dosing cannot be performed on the images following shows: **A.** LMRI and LLR showing bulging at L3-L4 and other natural levels; **B.** LMRI and LLR showing protrusion at L2-L3, bulging at L4-L5, and other natural levels; **C.** LMRI and LLR showing extrusion at L5-S1 and other natural levels; **D.** LMRI and LLR showing sequestration at L5-S1 and other natural levels

In LLRs, we classified and assessed slight bulging as "bulging", further protrusion as "protrusion", sagging without detachment from the disk space either superiorly or inferiorly as "extrusion", and the separation of the fragment as "sequestration" (Figure 1).

LMRIs were conducted using a 1.5-Tesla device (Magnetom Aera, Siemens, Germany), and LLRs with a digital X-ray device (Jumong, Sghealthcare, South Korea). Radiological measurements were utilized with the KarMed PACS. Data analysis was performed using SPSS (ver: 22.0) and Microsoft Excel (version 17), with Photoshop CS3 and Microsoft PowerPoint (version 17) for image editing.

Statistical Analysis

The study began with demographic data distribution analyses. LLRs effectiveness was evaluated through specificity, sensitivity, positive and negative predictive values, and test validity calculations. Data normality was assessed, and variables were presented as means±standard deviation. Nonparametric tests like the Kolmogorov–Smirnov and Wilcoxon tests were used. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

In this study, 436 patients were evaluated, consisting of 248 females (56.8%) and 188 males (43.2%). The analysis revealed no significant correlation between gender and the presence of disc findings in LLRs or across BMI groups (p>0.05).

The age distribution of the patients ranged from 18 to 75 years. The median age was 44, with an average age of 44.69 and a standard deviation of 13.44 (Figure 2). Statistical analysis showed no significant correlation between age and the presence of disc findings in LLRs or BMI groups (p>0.05).

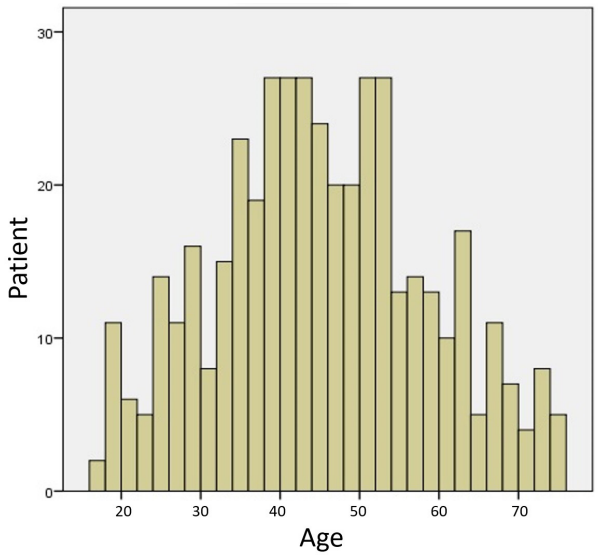

Figure 2. Age distribution histogram

The BMI of the patients varied from 14.69 to 48.89, with an average BMI of 27.77 and a median of 27.61. There was no significant correlation found between BMI and the presence of disc findings in LLRs (p>0.05).

In the cohort, a total of 1744 spinal levels were examined. The findings indicated that 1124 levels (70.18%) showed no pathologic disc involvement, while 520 levels (29.81%) exhibited pathologic disc findings. The breakdown of these findings was as follows: 40 levels (2.29%) at L2-L3, 96 levels (5.50%) at L3-L4, 214 levels (12.21%) at L4-L5, and 171 levels (9.80%) at L5-S1. Of these, 45 cases (2.58%) were identified as requiring surgical intervention for LDH (Table 1). Notably, a significant correlation was observed at the L5-S1 level and a lesser correlation at the L4-L5 level for inaccurate or inadequate disc findings in LLRs (p<0.05) (Table 2).

Table 1. Table showing the distribution of the examined levels according to the investigated factors.

	BMI* ≤24.9		BMI 25-29.9		BMI ≥30		Overall	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Pathological discs with L2-L3 level**	7	1.39%	19	2.81%	14	2.47%	40	2.29%
Pathological discs with L3-L4 level**	24	4.77%	37	5.47%	35	6.19%	96	5.50%
Pathological discs with L4-L5 level**	58	11.53%	83	12.27%	72	12.74%	214	12.21%
Pathological discs with L5-S1 level**	53	10.53%	68	10.05%	50	8.84%	171	9.80%
Levels requiring surgery***	16	3.18%	13	1.92%	16	2.83%	45	2.58%
All levels observed with LDH******	142	28.23%	207	30.62%	171	30.26%	520	29.81%
All levels without LDH	361	71.76%	469	69.38%	394	69.73%	1224	70.18%
All levels examined	503	28.84%	676	38.76%	565	32.39%	1744	100%

*Body mass index; ** Disk herniations at this level include bulging, protrusion, extrusion, and sequestration; *** Disk herniations at every level including extrusions and sequestrations require surgery; **** Disk herniations at every level include bulging, protrusion, extrusion, and sequestration; LDH: lumbar disc herniation

Table 2. Statistics results*

BMI**	L2-L3 level	L3-L4 level	L4-L5 level	L5-S1 level
≤24.9	0.157	1.000	0.751	0.105
25-29.9	0.141	0.785	0.050	0.009
≥30	1.000	0.180	0.129	0.176
Overall	0.071	0.476	0.021	0.002

* Samples related to the study were analyzed using the Wilcoxon signed-rank test, one of the nonparametric tests; the significance level for the test values was set at p<0.05, with a confidence interval of 95%; ** Body mass index

Among the levels assessed, 70.18% showed no pathologic disc changes, 14.63% exhibited bulging, 11.75% exhibited protrusion, 2.52% exhibited extrusion, and 0.91% exhibited sequestration. Accuracy rates in identifying these conditions were 97.78% in levels with no pathologic disc findings, 94.34% in bulging, 89.76% in protrusion, 79.1% in extrusion, and 76.25% in sequestration.

The overall diagnostic performance of LLR was evaluated, revealing a sensitivity of 94%, specificity of 95%, a positive predictive value of 88%, a negative predictive value of 97%, and an overall test validity of 94% (Table 3).

Table 3. Evaluation of LLR* in the diagnosis of LDH**

	BMI*** ≤24.9	BMI 25-29.9	BMI ≥30	Overall
Sensitivity	93%	94%	94%	94%
Specificity	95%	94%	95%	95%
Positive predictive value	88%	86%	90%	88%
Negative predictive value	97%	97%	97%	97%
Test validity	95%	94%	95%	94%

* Lumbar lateral radiography, ** Lumbar disc herniation, *** Body mass index

Additionally, there was a high degree of agreement between evaluators in analyzing LLRs, with a concordance rate of 96.7% across 1687 spinal levels from a total of 1744.

DISCUSSION

LDH is a multifactorial condition influenced by genetic, inflammatory, traumatic, and nutritional factors (6). Affecting primarily the 20-40 age group worldwide, it is increasingly observed in younger individuals due to paravertebral muscle weakness and weight gain as a result of a sedentary lifestyle brought about by technological advancements (11,12). In fact, LDH accounts for two-thirds of all general practitioner consultations for ambulatory patients (8). These conditions pose significant economic challenges due to lost work hours and the costs associated with diagnosis and treatment (3,13). In this study we conducted a comparative analysis to determine the extent to which LLR could fulfill a significant portion of the needs typically addressed by the more costly LMRIs. Apart from three articles that did not directly investigate this specific issue, there is no other study in the literature addressing this comparison (7-9).

Our findings indicated that the gender distribution in our study mirrors the general population (14), with a slight female predominance. This aligned with previous researches (15-18) suggesting that women may experience low back pain more intensely. However, gender did not significantly influence the need for surgical intervention (p>0.05).

The age distribution of our study population aligned with general epidemiological data (Figure 2) (11,12). The absence of a significant correlation between age, and disc findings in LLRs, or BMI groups may be attributed to our selection criteria, which excluded many age-related conditions like previous lumbar surgeries, lumbar vertebral fractures, acquired lumbar spinal stenosis, lumbar scoliosis more than >10 degrees, lumbar spondylolisthesis, long-term steroid therapy. Yet, these exclusions should not substantially affect our findings, as these conditions represent a small portion of the general population requiring more detailed investigations than X-ray.

One notable finding was the minimal impact of BMI on the diagnosis of LDH from LLRs. Despite X-ray imaging quality typically decreasing with increased tissue thickness, modern X-ray devices with automatic dosing and digital enhancements allowed for successful imaging across all BMI groups.

On the contrary, a drop in LLR accuracy rate was observed at certain spinal levels, particularly at the L5-S1 and, to a lesser extent, L4-L5 levels. This was mainly due to the overlapping shadow of the iliac wings. Hence physicians must be alert to artifacts from superimposed tissues and spinal axis disorders, which result from the two-dimensional structure of X-rays.

When we shift our focus to the types of LDH, we found that the distribution of herniation types were consistent with that in the general population (19). Although detecting sequestered and extruded herniations on LLR was more challenging, most of these cases were located at the L4-L5 and L5-S1 levels, where the iliac wings often obscure imaging. Even so, the rate of detecting these herniations on LLRs was not less than 76.25%. When the factor of level is excluded, the predictive accuracy of LLR was in the 90th percentile (Table 3). Given the relatively low prevalence of these types of LDH, their presence did not significantly diminish the utility of LLR (Table 3). Additionally, the clinical severity and high likelihood of neurological deficits in these patients generally necessitate more advanced diagnostic tools. Therefore, greater caution should be exercised in complex cases.

In our comparative analysis between LLRs and LMRI, we observed high success rates. reliability of the study was further enhanced by the fact that both evaluators provided highly similar results, and the mismatched results were scrutinized among the inaccurate levels.

According to the literature and our data, although LDH is a financially burdensome disease that diminishes quality of life (1,2,13), it is inherently prone to spontaneous regression (6), rarely leads to morbidity, and seldom requires surgery (3,6,13). As demonstrated in our study, LLRs are capable of diagnosing the vast majority of patients. In their detailed analysis, Jarvik and Deyo revealed that 95% of lower back pain originates from benign processes (20). They stated that only 0.7% of patients presenting to primary healthcare with a diagnosis of lumbago had undiagnosed metastatic neoplasms, 0.01% had pyogenic and granulomatous discitis, epidural abscess, or viral processes including spinal infections, and 0.3% suffered from non-infectious inflammatory spondyloarthropathies such as ankylosing spondylitis (20). They also found that osteoporotic compression fractures were identified as the most common etiological factor in only 4% of cases (20). The authors emphasized that the vast majority of these patients indeed recovered, many had musculoskeletal injuries or sprains, and up to 85% of patients had nonspecific degenerative phenomena for which no definitive diagnosis can be made (20).

At this stage, we need to mention the usage habits of advanced imaging techniques. Even when patients are examined using advanced imaging techniques, there is no evidence that these results lead to improved outcomes (21). Most spinal imaging is generally unnecessary and does not contribute to patient assessment, as our data also proved (21). Gilbert and colleagues' research highlighted the importance of using advanced imaging techniques such as Computed tomography (CT) or MRI in patients presenting with back pain only when there is a clear clinical indication (21). Similarly, Chou and his team concluded that LMRI does not improve clinical outcomes unless there are symptoms of a serious underlying condition for back pain (22). Carragee and colleagues conducted LMRI tests on asymptomatic individuals engaged in physically demanding jobs with a risk of back and leg pain and followed these patients periodically for five years (23). During this period, a second LMRI was performed when a subgroup of these subjects presented to the clinic with complaints of acute back or leg pain (23). However, less than 5% of the LMRIs performed for acute back or leg pain revealed clinically significant new findings (23). The authors emphasized that the degree of functional disability resulting from back and/or leg pain is a better indicator than morphological imaging results (23). For clinicians and patients, the value of advanced imaging techniques like MRI and CT emerges only when they facilitate the diagnostic process, rule out certain malignant conditions, or provide opportunities for evidence-based therapeutic interventions (24). These techniques can play a critical role in elucidating complex medical conditions and in developing treatment plans for specific diseases (23). Especially in cases where diagnosis is challenging and specific treatment strategies need to be determined, the use of these techniques is particularly valuable (23). These findings underscore the importance of preventing unnecessary imaging in the treatment of back pain.

Finally, in today's digital X-ray technology, radiation exposure has been significantly reduced (25). Even its contraindications have become relative (25). Moreover, X-ray imaging cost is incomparably lower than any other medical imaging technique (8). Through the use of advanced digital X-ray devices and appropriate techniques, we have achieved comparable results in our clinical practice, as evidenced by our data.

During our studies, we have gained significant experience related to the topic, which also we would like to share. X-ray imaging offers a broader perspective than MRI, enabling us to quickly and economically make accurate decisions. There are important cases on the subject. Firstly, although it does not provide information about disc spaces because of angles, it is indispensable in diagnosing and monitoring scoliosis. X-ray images are also extremely useful in demonstrating degeneration. Similarly, they are essential in the follow-up of ankylosing spondylitis. Also evaluating metallic implants, X-ray images are the most important modality. Even though LLR does not directly provide side information about LDH, it is possible to infer the side based on the bending caused by muscle spasms observed in anterior-posterior radiographs and through physical examination.

In light of all this information, our paper concludes that, except for patients with contraindications, an LLR should first be performed in every case. For patients without red flag signs (6) (Table 4) and no additional pathology found in the LLR, we recommend management with appropriate muscle relaxant medical therapy, rest, and psychosocial support. For patients without red flag signs (6) (Table 4)

and pathology found in the LLR, we recommend continuing follow-up and treatment according to the pathology and physical examination findings. In patients with red flag signs (6) (Table 4), advancement to further investigation is recommended based on LLR and physical examination findings. For those managed with muscle relaxant medical therapy, rest, and psychosocial support who do not respond to treatment, it is advised first to check treatment compliance and then, if compliance is confirmed, proceed to further investigation if not ensure treatment compliance. In those who have contraindications to X-ray imaging, if there are red flag signs (6) (Table 4) according to the current follow-up and treatment protocol (6), further investigation and treatment is required according to physical examination findings if not appropriate muscle relaxant medical therapy, rest, and psychosocial support should be provided. For those managed with muscle relaxant medical therapy, rest, and psychosocial support who do not respond to treatment, it is advised first to check treatment compliance and then, if compliance is confirmed, proceed to further investigation if not ensure treatment compliance. Current practice suggests monitoring patients without red flag signs (6) (Table 4), for about a month (Figure 3) (6). Although sources indicate that this does not lead to significant time loss (8), diagnosing many pathologies without delay using an inexpensive imaging method like LLR is not only cost-effective but also undeniably beneficial for patients.

Table 4. Table showing "Red flags" (5) for patients with low back problems

Condition	Red flags
Cancer or infection	Age>50 or <20 years
	History of cancer
	Unexplained weight loss
	Immunosuppression
	Urinary tract infection, intravenous drug abuse, fever, or chills
	Back pain has not been improved with rest
Spinal fracture	History of significant trauma
	Prolonged use of steroids
	Age>70 years
Cauda equina syndrome or severe neurologic compromise	Acute onset of urinary retention or overflow incontinence
	Fecal incontinence or loss of anal sphincter tone
	Saddle anesthesia
	Global or progressive weakness in the lower extremities

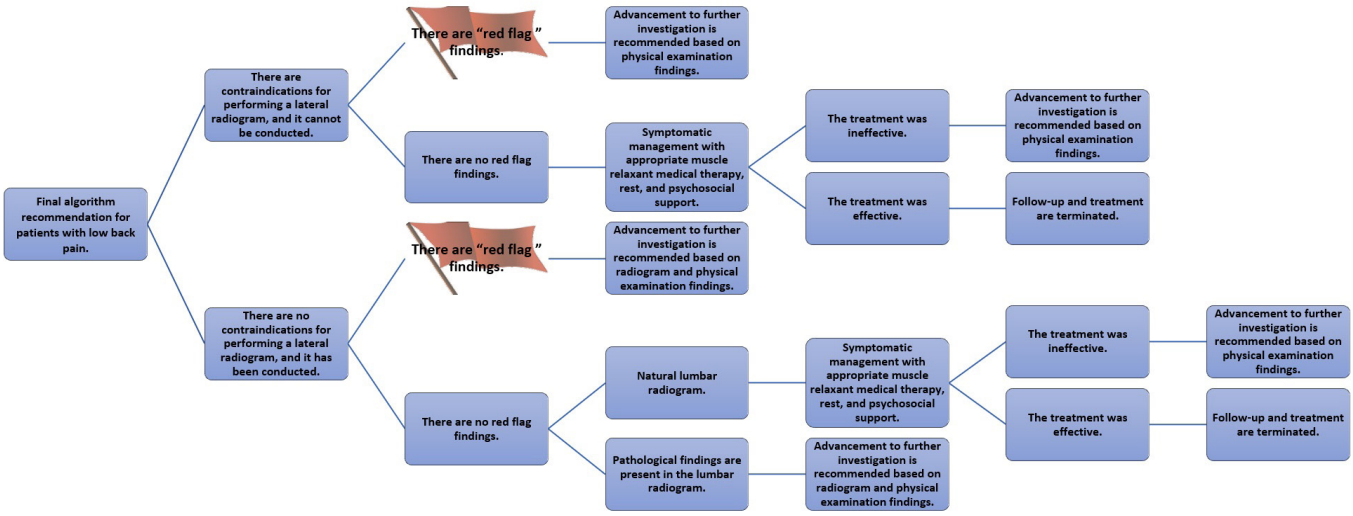

Figure 3. Final algorithm

CONCLUSION

Overall, our study concludes that LLR achieves a diagnostic success rate comparable to LMRI for most LDH cases. Notably, it is crucial to employ LLR even in patients presenting with "red flag" signs. This practice enables a prompt transition to more comprehensive investigations if needed. LLR stands out as a cost-effective and rapid diagnostic alternative in the assessment of LDH. Nonetheless, it is important to acknowledge that MRI continues to be indispensable in more complex cases or for patients exhibiting specific clinical symptoms.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Study was conducted in accordance with the Helsinki Declaration of 1975 (as revised in 2004 and 2008). Patient consent forms were archived at Niğde Ömer Halisdemir University Hospital. The study received approval from the institutional non-interventional clinical research ethics committee (2022-21).*

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MEDICAL RECORDS-International Medical Journal

Research Article

Comparison of Mid-Long Term Results of Cervical Cage and Cervical Disc Prosthesis in Patients with Single Level Cervical Disc Herniation

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Abstract

Aim: Continuous advancements in technology have facilitated the maintenance of spinal biomechanical properties, emphasizing the preservation of functional spinal segments. Therefore, this study focuses on comparing the mid- to long-term outcomes of cervical cage and cervical disc prosthesis (CDP) in patients with single-level cervical disc herniation.
Material and Method: This study included 51 patients diagnosed with cervical disc herniation. Among these, 25 underwent CDP, while 26 received a cervical cage. The mean follow-up period was 7.3 years. All surgeries were performed between 2021 and 2022 at a hospital in Türkiye. It was ensured that none of the patients had a prior history of spinal surgery. The demographics of the two groups were comparable. Radiographic evaluations and clinical outcomes were assessed, focusing on degenerative changes, cervical spine motion, and radicular pain in both groups.
Results: The mean age in the CDP group was 46 years, compared to 43 years in the cervical cage group. Recurrent cervical pain was observed in only one patient in the CDP group, whereas it was reported in eight patients in the cervical cage group over the 7.3-year follow-up period.
Conclusion: In conclusion, CDP was found to be a more effective treatment compared to cervical cage in patients with cervical disc herniation.

Keywords: Cervical cage, cervical disc prosthesis, cervical disc herniation, cervical pain

INTRODUCTION

Cervical disc herniation (CDH) is a common condition which is caused due to the rupture of a disc in a weak spinal area that results in pain and impacts the quality of life due to neurological defect (1). This can be caused due to age, continuous movements or sudden injury (2). The symptoms linked to this disease are neck pain, muscle weakness, numbness (3).

Treatment of CDH depends upon the severity of the disease. The treatment leads to surgery or else there are two other options; cervical disc prostheses (CDP) or cervical cage implants (4). It is highly prevalent in Eurasian Region (Europe and Asia) where doctors are struggling to rule out surgical options (5). The choice in choosing either cervical cage implant or CDP depends upon the age of the patient, degree of injury, and surgical goals.

Comparing the mid-long term results of surgical treatments of CDH patients is essential in addressing the pain relief and improvement seen in patients post-surgery along with that segment alignment is also monitored (6). Comparison of cost effectiveness helps analyze the procedure's cost and identify ways to perform these procedures more cost-effectively (7).

Cervical cage implants and CDH both procedures offer benefits to patients including improved movement and pain relief but at the same time these procedures have their own challenges for which understanding of regional disparities, patients preference and social and economic

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factors is essential to provide effective care. Ongoing medical research opens the way to advancements in technology all the stakeholders should collectively design strategies in order to face these challenges and provide care to patients with CDH across the region. Proper monitoring and comparison of the two procedures helps clinicians in drawing a review that which procedure works best under which circumstance ultimately providing quality life to patients. The current study will undergo a review which can help doctors in taking decisions regarding surgery for patients with this condition.

MATERIAL AND METHOD

The study was planned as a retrospective comparative study. Ethics committee approval for the study was received from Istinye University human research ethics committee with the date and issue number 24-157. The 8-year postoperative follow-up data of 51 patients who underwent surgery for CDH, including 25 cases of CDP and 26 cases of anterior cervical discectomy and fusion, were retrospectively analyzed. In these file scans, the patients' ages, genders, levels of CDH, and neurological examinations at 8-year postoperative follow-up are included.

Inclusion criteria

- Individuals diagnosed with cervical disc degenerative disease.
- There were no signs of myelopathy in the participants who had radiating pain.
- Patients who had not undergone cervical surgery in the past.
- Patients who are experiencing symptoms of individual or multiple-level diseases.
- Considering the similar demographics observed between the groups, it is probable that gender and age were taken into account.
- Patient candidates who may undergo anterior cervical discectomy with cage implantation or artificial CDP insertion (Prestige II).

Exclusion criteria

- Myelopathy symptoms present.
- Past surgical procedures involving the cervical region.
- Cervical disc replacement and cage implantation are not appropriate procedures for certain individuals.
- Surgical procedures or research results might be compromised in patients with co-morbidities or other serious health issues.
- Lack of competency to offer informed permission.
- Patients whose structural or anatomical anomalies might affect the success or failure of the surgical operations.

During each operation, the single surgeon carried out the procedures in the identical manner. Patients who had not undergone cervical surgery in the past and who were suffering from symptomatic single or multiple level illnesses were eligible to participate in the trial. A total of twenty-five patients were assigned to the Prestige II group, whereas twenty-six patients were assigned to the arthrodesis (control) group. Comparable demographics were found among the cohorts. In each and every one of the patients, the standard right anterior cervical approach was utilized (8,9). In three patients, two-level procedures were conducted, and the disc was removed. This was followed by the placement of a prosthesis of the same size. A similar method was utilized in six patients who were part of the cage group. In order to make a comparison between the therapy groups, standardized clinical outcome measures and radiographic tests were utilized at the required post-operative intervals. The evaluation of each patient included the utilization of static and dynamic cervical spine radiographs, in addition to magnetic resonance imaging (MRI) where it was deemed required. The visual analogue scale for neck and arm discomfort, the neck disability index, and the 36-Item Short Form Health Survey (SF-36) were all components of the clinical examination carried out. The specifics of any difficulties and subsequent surgeries were also taken into consideration.

Statistical Analysis

Power analysis of the study: In our power analysis, it was calculated that the required number of patients should be 52 for the effect size to be 0.70, alpha 0.05, and the power to be 80%. (G*Power 3.1.9.7). Statistical method used in the study: Statistical analysis was carried out using IBM SPSS 19 package program (IBM Software, New York, USA), and the results were expressed as mean±standard deviation for continuous variables, after the normal distribution of continuous variables was confirmed with the Kolmogorov Smirnov test, and Wilcoxon signed rank test was used for dependent continuous variables. The statistical significance level was accepted as 0.05 for all tests.

RESULTS

For this study, the mid-long term results are compared within the context of cervical cage and CDP in patients with single level CDH. For this purpose, two groups of patients, with single level CDH, were taken into account for this purpose. Group 1 included the patients (25 individuals), treated with CDP, while group 2 (26 individuals) included the patients with cervical cage. The mean age of the patients within the CDP group was found to be 46 years, ranging from 30 to 62 years, while the mean age within the cage group was found to be 43 years, ranging from 31 to 61 years.

Distribution of Sex

Table 1 shows the distribution of sex among the included patients for both CDP and cervical cage. For this study, a total of 51 patients with single level CDH were taken into account. 25 of these patients were included in CDP,

incorporating 8 male individuals and 17 female individuals, while cervical cage group included a total of 26 patients, integrating 10 male individuals and 16 female individuals.

Table 1. Distribution of sex

Sex	CDP (n=25)	Cervical cage (n=26)
M	8	10
F	17	16

Patient Distribution in CDP Group

Within the context of CDP, 20 patients were presented with paresthesia as well as "unilateral radicular pain (URP)." However, three patients were presented with "bilateral radicular pain" and 9 were presented with deficits of "pre-operative focal motor." Table 2 shows that 19 of the cases within the context of CDP group had "single level disc herniation" as shown by MRI, while three of the patients had "two level disc herniation," incorporating 2 consecutive levels. However, three of the patients were also investigated before the operation with discography to ensure the disc as pain pathology.

Table 2. Patient no. and distribution in CDP and cervical cage group

Level	CDP	Cervical cage
C4-C5	1	
C5-C6	8	10
C6-C7	10	10
C4-C5 & C5-C6	3	2
C5-C6 & C6-C7	3	4

Patient Distribution in Cervical Cage Group

For cervical cage group, all incorporated patients were presented with paresthesia and radicular pain, without any motor neurological deficiencies. In this regard, "single level disc herniation," was observed in 20 cases via MRI, while "two level disc herniation," was observed in 6 cases as shown in Table 2.

Mean hospital stay of the patients was found to be 2.6 days within both groups. However, one of the patients in CDP group had "transient recurrent nerve paralysis," which was recovered in a 3-week period.

Follow-Up Results

Figures 1 and 2 show cage placement and disc space within the context of the patient from the associated CDP and cervical cage groups. In 18 cases, restoration was observed in cervical movements within the CDP group within four weeks as shown in Figures 3 and 4. After three months of surgery within 21 patients, the movements range was found to be similar as that of the pre-operative period. However, only 18 cases were capable to engage in their duties at a follow-up of two months. Two of the cases within the CDP group, lost mobility as observed in their follow-up period. One of this case experienced anterior osteophytes after eight months of the surgery while the other case lost mobility at seven months of operation. Contrarily, the patients of this group had effective neck movement (Figure 5). During the second year of follow-up, degeneration was observed in radiological findings of one case at upper disc level, incorporating refractory pain to the traditional treatment. This case also went through prosthesis removal, following the fixation of C4-C6 and bone graft fusion, whereas, no difference was observed between cases with one or two levels within the CDP group.

Figure 1. Intraoperative cage placement

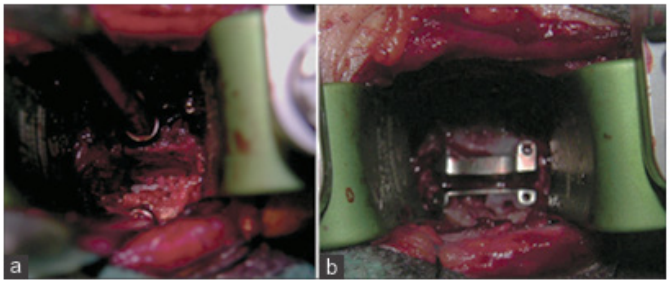

Figure 2. a. Intra-operative disc space after removal of disc, **b.** artificial disc within place

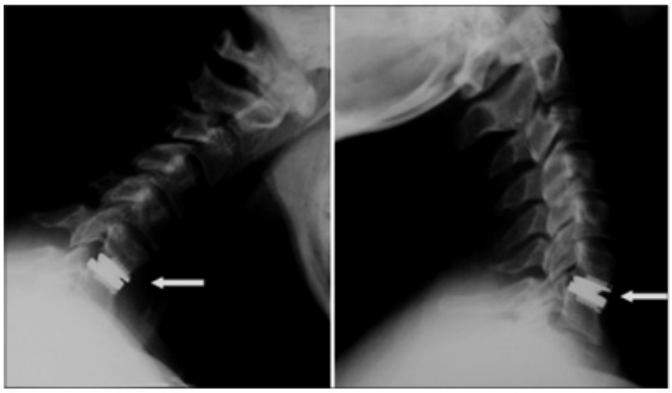

Figure 3. X-ray of cervical presenting "artificial cervical disc" movements

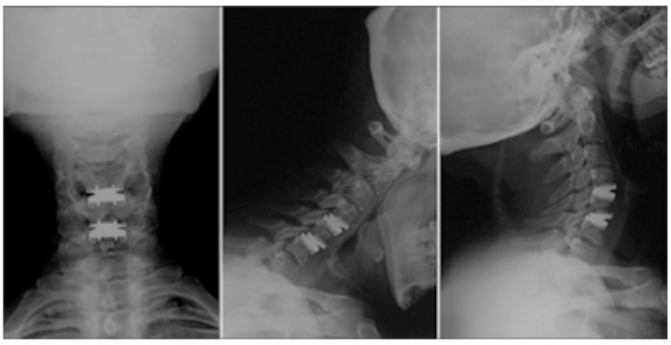

Figure 4. X-ray of cervical, presenting "artificial cervical disc" movements within the patient, incorporating disease at two level

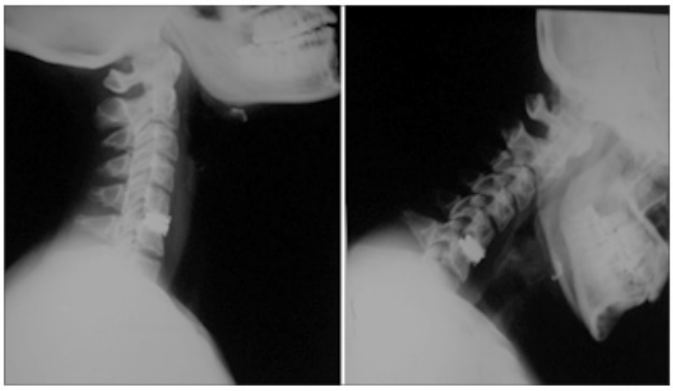

Figure 5. Follow-up shows that patients in cervical cage group, experienced seven time more recurrent pain as compared to CDP group

However, three of the patients who had CDP at multiple levels, had a follow-up of more than eighty months and they were found to have good mobility, as same as that of single-level CDP. However, in cervical cage group, one of the patients established arm pain which worsened over time. Within this context, neurological deficit was also observed because of the lesion of root nerve which took place during the surgery. For this purpose, analgesics were used for treating the pain. One of the patients from this group experienced nerve paralysis which was observed during the 4-week period after the surgery.

One of the patients with discectomy at double level, experienced wound hematoma which was needed to be evacuated urgently. Three of the patients had recurrent cervical pain, requiring local infiltration within a period of 3 to 6 months. Moreover, at 9 months, one of the patients went through rhizotomy in order to deal with consistent cervical pain. After cage removal is one of the patients, he was again operated after one year of surgery, leading to the application of circumferential arthrodesis at the center during the follow-up. In addition, during the follow-up, four patients for the cage group showed cervical degeneration, which later changed over a period of four years. In a follow-up period of 7.3 years, degenerative changes were observed at other cervical spine level in one of the patients from CDP group, while such changes were observed in seven patients from the cervical cage group (Figure 5).

DISCUSSION

Discussion revealed that individuals with single level CDH have their mid-long term results examined in relation to the cervical cage and CDP. A total of two patient groups with single-level CDH were considered for this purpose. Patients receiving CDP treatment and that receiving cervical cage treatment were categorized into two groups, with patients with paresthesia and URP seen in CDP settings. Some patients had pre-operative focal motor deficits and some patients had bilateral radicular pain. It demonstrates that, different cases in the CDP group had single level disc herniation, whereas some of the patients had two level disc herniation.

To confirm that the disc was the source of the discomfort, discography was used to examine the patients before the procedure. The cervical cage group patients experienced paresthesia and radicular discomfort without any motor or neurological system impairments (10). Cage location and disc space was evaluated in patients from both the CDP and cervical cage groups. Recovery of cervical motion was noted in the CDP group within four weeks. Three months after surgery, the range of motion for patients was determined to be comparable to the pre-operative period. The patients, however, remained able to perform their tasks after a two-month follow-up. Some patients in the CDP group experienced loss of mobility due to complications such as osteophyte formation. After eight months of surgery, one patient developed anterior osteophytes, and seven months after the procedure, the other patient lost movement (11). In contrast, the patients in this group were able to move their necks well. Degeneration was noted in one case's radiological results at the upper disc level during the second year of follow-up, adding refractory pain to the conventional therapy. After fixation and bone graft fusion, this patient also underwent prosthesis removal; nevertheless, within the CDP group, there was no distinction between cases with one or two levels (12). Nevertheless, after a follow-up of more than eighty months, the patients with multiple levels of CDP were found to have good mobility, comparable to that of single-level CDP. Patient in the cervical cage group, however, started experiencing arm discomfort that got worse with time. In this setting, a neurological impairment was also noted as a result of the root nerve damage that occurred during the surgical procedure (13). Analgesics were utilised to relieve the pain for this reason. During the four weeks following surgery, one of the patients in this group had nerve paralysis. One of the patients undergoing a double-level discectomy developed a wound hematoma that required immediate evacuation. Within three to six months, patients required local anesthetic injections due to persistent cervical discomfort. Patients underwent another operation a year after removing their cage, resulting in circumferential arthrodesis. Cage group patients experienced cervical deterioration, while CDP group patients experienced degenerative changes. Seven patients from cage group also experienced these changes.

Implications

Within the context of the Turkish healthcare system, the exploration regarding mid-long term results in patients with single-level CDH undergoing either CDP or cervical cage interventions has important implications. With regard to clinical practitioners, it provides valuable insights in order to guide them to enhance the quality of patient care need to follow the most effective and patient friendly intervention. Following the economic constraints, the study's findings have the potential influence regarding the decisions of resource allocations which postulates that which one is more cost-effective and yields superior outcomes so that resource distribution can optimize patient care and allocate resources efficiently. Furthermore, implications

intricate with surgical intervention trends in Türkiye. Based on the relative effectiveness of these treatments, surgeons may change their preferences which might have an effect on national training in specialization. The findings of the study may have a wider use in the development of health protocols and policies pertaining to the treatment of CDH in Türkiye. Based on these findings, national healthcare guidelines may be modified by incorporating comparisons of mid- to long-term outcomes of cervical cages and CDP that surpass prompt clinical decision making in Türkiye's healthcare system.

Limitations

A retrospective, single-center, cross-sectional study comparing the mid-term and long-term outcomes of cervical cage and CDP in patients with single-level CDH has valuable findings, but its authenticity and reliability are limited due to the fact that the primary data collection was from specific groups of people. Therefore, it was quite difficult to obtain the necessary data. In addition, since the current study focused on data from Türkiye, its results may not be representative of cervical cage and CDP in other world economies. The retrospective and observational design of the study precludes us from drawing any conclusions about causality. Future studies should consider other sources to compare with major world economies. In addition, the current study focused on two groups of patients with single-level CDH. There are also various other factors that may have a major impact on these groups and may affect the sample by understanding it. However, it is not possible to evaluate the impact of all important factors in a single study.

CONCLUSION

A total of 51 cases were included in this study. 26 had cervical cage surgery and 25 had CDP. For this investigation, a mean follow-up time of 7.3 years was taken into consideration. None of the participants in this study had a history of prior surgery. Clinical results and radiographic evaluations in both groups examined degenerative changes, cervical spine mobility, and radicular discomfort. Only one patient in the CDP group experienced recurrent cervical discomfort, whereas eight people in the cage group did so over a mean of 7.3 years which suggest that for patients with CDH, CDP was a more successful therapy than cervical cage.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Comparison of Tourniquet and Non-Tourniquet Use in Total Knee Arthroplasty: Impact on Postoperative Hemoglobin Changes and Surgical Time

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Abstract

Aim: This study aimed to evaluate the impact of pneumatic tourniquet use on postoperative hemoglobin (Hb) and hematocrit (Hct) levels, changes in Hb/Hct, and surgery duration in total knee arthroplasty (TKA) by comparing outcomes between patients who underwent the procedure with and without tourniquet application.

Material and Method: A retrospective cohort study was conducted on 130 patients with Kellgren-Lawrence grade 3-4 gonarthrosis who underwent TKA. Patients were divided into two groups, each with 65 patients, based on tourniquet use. Preoperative and postoperative day 1 Hb/Hct values, ΔHb/ΔHct, and surgery duration were compared. Patients with comorbidities and significant perioperative complications were excluded.

Results: No significant differences were found between the tourniquet and non-tourniquet groups for preoperative or postoperative Hb and Hct levels ($p>0.05$). Both groups experienced significant reductions in hemoglobin and hematocrit levels postoperatively. The non-tourniquet group had a slightly greater decrease in hemoglobin and hematocrit, although this difference was not statistically significant ($p>0.05$). The tourniquet group demonstrated a significantly shorter operation duration ($p=0.004$).

Conclusion: Tourniquet use in TKA reduces surgical time without significantly affecting blood loss. The comparable outcomes in both groups suggest that the use of a tourniquet may offer practical advantages, in terms of procedural efficiency in reducing surgical time, but its influence on postoperative Hb and Hct changes is minimal.

Keywords: Total knee arthroplasty, tourniquet use, hemoglobin change, hematocrit change, blood loss, surgical time

INTRODUCTION

Total knee arthroplasty (TKA) is widely regarded as the most successful intervention for alleviating pain, correcting deformities, and improving mobility in severe knee osteoarthritis, making it one of the most frequently performed orthopedic procedures globally (1-3). However, it is not without complications, including significant blood loss (3,4), periprosthetic joint infection (5,6), and periprosthetic fractures (7).

Various methods have been developed to address the complication of blood loss, including the use of pneumatic tourniquets and suction drains, advancements in surgical techniques, the administration of tranexamic acid, and local infusion with norepinephrine, among others (3,8). The tourniquet is a commonly employed method to address these complications to achieve hemostasis in clinical practice, demonstrating high efficacy in minimizing intraoperative bleeding. Beyond reducing blood loss, it also aids in maintaining a clear and unobstructed surgical field (2,9). However, it is also not without complications, including skin abrasions and blistering, wound hematomas, wound oozing and healing problems, muscle injury, rhabdomyolysis, nerve palsy,

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postoperative stiffness and pain, deep vein thrombosis (DVT), pulmonary embolism (PE), and infections (4,10,11).

Despite this, meta-analysis results in the literature also indicate that while the use of a tourniquet reduces intraoperative bleeding, it may increase the total blood loss postoperatively (4,12,13). We hypothesized that the use of a tourniquet during TKA would result in a comparable decrease in hemoglobin (Hb) and hematocrit (Hct) levels postoperatively, while also shortening the operation duration compared to surgeries performed without a tourniquet. Therefore, performing the surgery without a tourniquet may not only provide similar blood loss outcomes but also avoid the potential complications associated with tourniquet use. This study aims to assess the impact of tourniquet use on postoperative Hb and Hct levels, the changes in Hb/Hct from pre- to postoperative periods, and the duration of the surgical procedure in TKA, by comparing outcomes between patients with and without tourniquet application.

MATERIAL AND METHOD

Within this retrospective cohort study, a total of 130 patients who underwent TKA were included in the analysis. These patients were divided into two groups depending on whether a tourniquet was used during their procedure: one group had tourniquets applied, while the other did not. In the study, patients with Kellgren-Lawrence grade 3-4 gonarthrosis who underwent TKA, with no known hematologic disorders, preoperative Hb and Hct levels above 10/30, and no significant abnormalities in preoperative complete blood count were randomly included. Patients with cruciate-retaining prostheses were included in the study. This ensured that prosthesis selection did not introduce any confounding factors that could affect the study outcomes. The use of a tourniquet was random, and the surgeons were experienced in performing the surgery both with and without a tourniquet. Patients for whom preoperative and postoperative day 1 Hb/Hct values and surgery duration were accessible through the hospital system were included in the study. Patients with a history of tumors or tumor surgery, a history of infections, rheumatological conditions (to avoid bleeding complications related to vasculitis), those on regular corticosteroid therapy, patients with diabetes mellitus, morbid obesity, those who had undergone previous surgery in the same area, and those with known renal, hepatic, cerebrovascular, cardiovascular, peripheral vascular diseases, chronic obstructive pulmonary disease (COPD), hyperlipidemia, a history of thromboembolic events, anemia, or coagulation disorders, patients who required blood transfusions during surgery or experienced substantial blood loss (more than 500 mL) during the procedure, cases with incomplete medical records or missing postoperative Hb and Hct data were excluded from the study. Demographic data, including age, sex, and relevant medical history, were obtained from patient records. Hb and Hct levels were measured preoperatively, within 24 hours before surgery, and postoperatively, within 24 hours after surgery. Additional surgical information, such as whether a tourniquet was used and the length of the operation, was also recorded. Changes in hemoglobin (ΔHb) and hematocrit (ΔHct) were calculated by subtracting the postoperative values from the preoperative values for each patient. All patient data were anonymized to maintain confidentiality.

Before the incision, the tourniquets placed around the proximal thigh were inflated to 250-300 mmHg, depending on the patient's mean arterial pressure. The surgical procedure utilized a medial parapatellar approach, with patellar eversion and lateral dislocation. The menisci and anterior cruciate ligament were excised, and cruciate-retaining prostheses were implanted. Standard knee arthroplasty techniques were employed for the femoral and tibial cuts, with an intramedullary guide for the femoral cuts and an extramedullary guide for the tibial cuts. All prostheses were cemented in place. Postoperatively, patients were monitored in the ward, where follow-up hematologic tests were performed, and thromboembolism prophylaxis was administered.

The study protocol was approved by the İstanbul University-Cerrahpaşa Rectorate Clinical Research Ethics Committee under protocol number E-83045809-604.01-1058935 on August 7, 2024, and all procedures were conducted in compliance with good clinical practice and the principles of the Declaration of Helsinki.

Statistical Methods

In the context of this study, the sample size was determined through the power analysis. Using G*Power (Version 3.1.9.6), the analysis indicated a 95% confidence level, an effect size of 0.50, and a power value of 0.80. Based on these parameters, the minimum required sample size was calculated to be 126 participants, with at least 63 individuals in each group. For the analysis and statistical evaluation of the data, IBM SPSS Statistics version 26.0 was utilized, with a 95% confidence level. To determine whether the measurements followed a normal distribution, skewness and kurtosis coefficients were examined. Skewness and kurtosis values between +3 and -3 are considered indicative of a normal distribution (14). Since the skewness and kurtosis values derived from the measurements fell within the range of +3 to -3, the assumption of normality was met, allowing the use of parametric test techniques in our analyses (Table 1). The difference in measurements based on tourniquet use was analyzed using an independent samples t-test. The relationship between tourniquet uses and age was examined using a Chi-square test. Pre- and post-intervention changes with respect to tourniquet use were analyzed using a paired samples t-test.

Table 1. Since the skewness and kurtosis values obtained from the variables fall within the range of +3 to -3, the assumption of normality has been satisfied

Normality test	n	Skewness	Kurtosis
Age	130	0.011	0.809
Preoperative Hb	130	0.321	-0.474
Postoperative Hb	130	0.494	-0.468
Delta Hb	130	1.065	2.022
Preoperative Hct	130	0.218	0.366
Postoperative Hct	130	0.446	-0.264
Delta Hct	130	0.684	1.590
Operation duration	130	0.035	-1.449

RESULTS

In the group where a tourniquet was used, 80% were female and 20% were male, while in the group without tourniquet use, 75.4% were female and 24.6% were male. Overall, females accounted for 77.7%, and males made up 22.3% of the total sample. The Chi-square test revealed no significant relationship between gender and tourniquet use (p=0.674) (Table 2). The mean age in the group using a tourniquet was 65.51±8.67, while in the group without tourniquet use, the mean age was 64.86±8.17. The overall mean age was 65.18±8.39. The t-test showed no significant difference between age and tourniquet use (p=0.663) (Table 2).

Table 2. Analysis of gender and age in relation to tourniquet use

		Tourniquet use			p
		+	-	Total	
		n (%)	n (%)	n (%)	
***Gender**	**Female**	52 (80)	49 (75.4)	101 (77.7)	0.674
	Male	13 (20)	16 (24.6)	29 (22.3)	
****Age (mean±SD)**		65.51±8.67	64.86±8.17	65.18±8.39	0.663

*Chi-Square Test, **t-Test

The mean preoperative Hb in the group using a tourniquet was 12.86±1.31, while it was 12.84±1.33 in the group not using a tourniquet. The t-test results indicated no significant difference between tourniquet use and preoperative Hb (p=0.926). The mean postoperative Hb was 11.46±1.51 in the tourniquet group, compared to 11.09±1.45 in the non-tourniquet group. The t-test revealed no significant difference between tourniquet use and postoperative Hb (p=0.151). The mean DELTA Hb was 1.4±0.85 in the tourniquet group, while it was 1.75±1.53 in the non-tourniquet group. The t-test showed no significant difference between tourniquet use and DELTA Hb (p=0.107). The mean preoperative Hct was 37.76±3.9 in the tourniquet group, compared to 37.75±3.66 in the non-tourniquet group. The t-test indicated no significant difference between tourniquet use and preoperative Hct (p=0.987) (Table 3).

Table 3. Analysis of measurements in terms of tourniquet use

	Tourniquet use			p
	+	-	Total	
	mean±SD	mean±SD	mean±SD	
Preoperative Hb	12.86±1.31	12.84±1.33	12.85±1.31	0.926
Postoperative Hb	11.46±1.51	11.09±1.45	11.28±1.49	0.151
Delta Hb	1.4±0.85	1.75±1.53	1.57±1.25	0.107
Preoperative Hct	37.76±3.9	37.75±3.66	37.76±3.77	0.987
Postoperative Hct	33.89±4.33	33.17±4.22	33.53±4.28	0.340
Delta Hct	3.87±3.07	4.58±4.29	4.23±3.73	0.282
Operation duration	36.15±5.64	39.08±5.58	37.62±5.78	**0.004**

Independent t-Test

The mean postoperative Hct was 33.89±4.33 in the tourniquet group and 33.17±4.22 in the non-tourniquet group. The t-test found no significant difference between tourniquet use and postoperative Hct (p=0.340). The mean DELTA Hct was 3.87±3.07 in the tourniquet group, compared to 4.58±4.29 in the non-tourniquet group. The t-test showed no significant difference between tourniquet use and DELTA Hct (p=0.282). The mean operation duration was significantly shorter in the tourniquet group (36.15±5.64 minutes) compared to the non-tourniquet group (39.08±5.58 minutes). The t-test results indicated a significant difference between tourniquet use and operation duration (p=0.004) (Table 3).

In patients where a tourniquet was used, the average preoperative Hb level decreased from 12.86±1.31 to 11.46±1.51 postoperatively. This reduction was statistically significant according to the paired samples t-test (p=0.0001), with a decrease of 1.4 g/dL in Hb levels observed in this group. In patients where no tourniquet was used, the average preoperative Hb level dropped from 12.84±1.33 to 11.09±1.45 postoperatively. This difference was also statistically significant according to the paired samples t-test (p=0.0001), with a 1.75 g/dL decrease in Hb levels noted in the non-tourniquet group. In the tourniquet group, the average preoperative Hct level decreased from 37.76±3.9 to 33.89±4.33 postoperatively. This reduction was found to be statistically significant by the paired samples t-test (p=0.0001), with a 3.87 unit decrease in Hct levels. In the non-tourniquet group, the average preoperative Hct level fell from 37.75±3.66 to 33.17±4.22 postoperatively. This change was also statistically significant according to the paired samples t-test (p=0.0001), with a 4.58 unit decrease in Hct levels observed (Table 4).

Table 4. Analysis of preoperative, and postoperative changes in hb and hct values based on tourniquet use

	Tourniquet use					
	+			-		
	Pre	Post	p	Pre	Post	p
	mean±SD	mean±SD		mean±SD	mean±SD	
Hb	12.86±1.31	11.46±1.51	**0.0001**	12.84±1.33	11.09±1.45	**0.0001**
Hct	37.76±3.9	33.89±4.33	**0.0001**	37.75±3.66	33.17±4.22	**0.0001**

The paired samples t-test

The reduction in Hb was greater in the non-tourniquet group (1.75 g/dL) compared to the tourniquet group (1.4 g/dL). Similarly, the decrease in Hct was more pronounced in the non-tourniquet group (4.58 units) compared to the tourniquet group (3.87 units) (Table 3). Although both groups experienced significant reductions in Hb and Hct levels, the decreases were slightly more substantial in the non-tourniquet group (Figures 1,2).

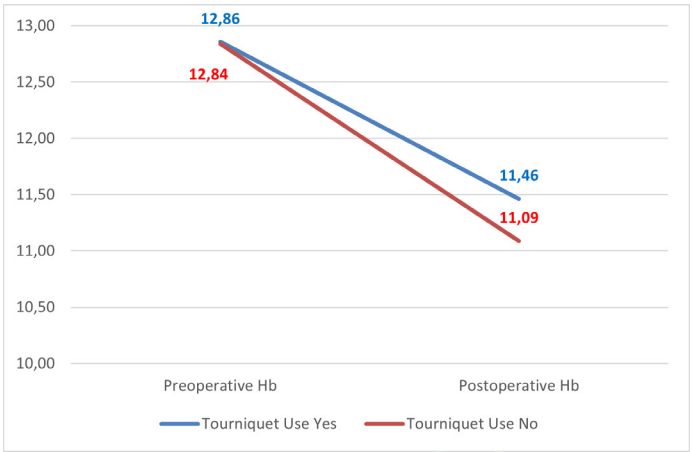

Figure 1. Preoperative and postoperative Hb levels in patients undergoing TKA with or without tourniquet use; the blue line represents patients where a tourniquet was used, and the red line represents patients where a tourniquet was not used; both groups show a decrease in Hb levels postoperatively, with slightly less reduction in the tourniquet group

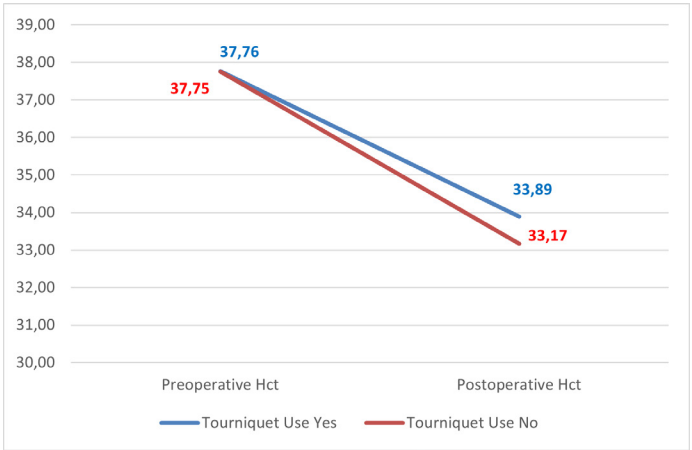

Figure 2. Preoperative and postoperative Hct levels in patients undergoing TKA with or without tourniquet use; the blue line represents patients where a tourniquet was used, and the red line represents patients where a tourniquet was not used; both groups show a decrease in Hct levels postoperatively, with the tourniquet group demonstrating a marginally smaller reduction

DISCUSSION

TKA remains one of the most effective treatments for severe osteoarthritis, but the role of tourniquet use continues to be debated due to its potential benefits and risks. In this study, we aimed to evaluate the impact of tourniquet use on postoperative Hb and Hct levels, as well as surgical time. The main findings of this study

revealed that both tourniquet and non-tourniquet groups experienced significant reductions in Hb and Hct levels postoperatively. However, the decrease in both Hb and Hct was slightly greater in the non-tourniquet group compared to the tourniquet group, though the difference was not statistically significant. Additionally, the operation duration was significantly shorter in the tourniquet group. These findings suggest that while the use of a tourniquet may reduce surgical time, its effect on blood loss is comparable to non-tourniquet use. The use of a tourniquet has traditionally been recommended to minimize blood loss. However, numerous studies have compared TKA procedures performed with and without a tourniquet, and the findings remain inconclusive (15). These results align with the ongoing debate in the literature regarding the benefits and drawbacks of tourniquet use in TKA.

Albayrak et al. found that while tourniquet use in TKA may not significantly reduce blood loss and can cause temporary extremity pain, it is beneficial for patients without comorbidities. Tourniquet use creates a bloodless environment during cementing, improving prosthesis longevity and potentially avoiding revision surgeries. The study recommends using tourniquets in patients without comorbidities, provided these are clearly documented before surgery (2). In our study, we included only patients without comorbidities in both groups, thus eliminating the potential effects of comorbidities on the outcomes. In both groups, similar Hb/Hct reductions were observed, as found in this study.

The literature reveals a range of outcomes regarding tourniquet application in TKA. Arthur et al.'s review also showed that several studies have examined the effectiveness of limited-use tourniquets, with mixed outcomes (15). Ishii and Matsuda's prospective randomized controlled trial (RCT) found that releasing the tourniquet before wound closure resulted in significantly higher total blood loss compared to releasing it after closure, though no significant difference in transfusion rates was noted between the two groups. Furthermore, Ishii and Matsuda, in another RCT, evaluated the impact of different tourniquet pressures, finding no significant differences in blood loss or transfusion requirements when comparing higher and lower tourniquet pressures (16,17). Similarly, Huang et al. conducted a systematic review and meta-analysis, concluding that early tourniquet release led to higher intraoperative blood loss (18). On the other hand, Rama et al. found that while total blood loss was higher in the early release group, the late release group experienced significantly more complications requiring return to the operating room (19). Contrary to these findings, Schnettler et al. observed a paradoxical increase in total blood loss with the use of a limited tourniquet. Their retrospective cohort study demonstrated that using a tourniquet during cementation resulted in greater blood loss compared to the use of tranexamic acid (TXA) alone. The authors proposed that tourniquet use restricted the delivery of TXA to tissues, leading to hidden blood loss (20). In the light of his literature review Arthur et al. prefer using a tourniquet inflated to 300 mm Hg until cementing is complete, followed by deflation. Before deflation, they inject a periarticular analgesic mixture containing ropivacaine, epinephrine, morphine, and ketorolac. They also administer 1,000 mg of TXA before inflation and another 1,000 mg after deflation. Tourniquet time is limited to 120 minutes, with adjustments made for longer surgeries or patients with vascular conditions. In cases of peripheral arterial bypass grafts, the tourniquet is avoided entirely (15).

Conversely, Zhang et al. conclude that TKA without a tourniquet is superior in reducing thromboembolic events and related complications, without significant differences in actual blood loss between groups. They also suggest that using a tourniquet may hinder early postoperative rehabilitation exercises (10). Tirumala et al. found that while omitting the tourniquet in revision TKA increased perioperative blood loss, it did not significantly affect transfusion rates. Additionally, patients who underwent revision TKA without a tourniquet experienced shorter postoperative hospital stays, fewer 30-day readmissions, and improved range of flexion (21). In the metaanalysis of Cai et al., the authors concluded that using a tourniquet in TKA significantly reduces intraoperative blood loss, calculated blood loss, and operation time, but it does not have a notable impact on reducing the rate of transfusion or DVT (22). Similarly, Yi et al. suggested that while tourniquet use can reduce surgical time, intraoperative, and total blood loss, it also leads to an increase in postoperative total blood loss. Additionally, they observed a higher incidence of postoperative complications such as DVT and surgical site infections in the tourniquet group (12). Other studies, like those by Zak et al., suggested that while tourniquet use does not influence the average cement penetration depth, it increases the chances of achieving optimal cement penetration during the procedure (23).

In terms of recovery and complications, Huang et al. concluded that tourniquet use during TKA significantly increases total blood loss without reducing postoperative transfusion rates. Furthermore, it worsens early postoperative hypercoagulable conditions and leads to a higher incidence of asymptomatic below-knee DVT, as detected by conventional coagulation tests, thromboelastography, and ultrasonic Doppler (24). In contrast, Pavao et al. found that using an optimized tourniquet in primary TKA resulted in clinical outcomes similar to surgery without a tourniquet and did not raise the risk of postoperative complications. The tourniquet provided the advantage of a clean and dry surgical field without increasing procedure-related comorbidities (25). However, Johnsen et al. concluded that tourniquet use significantly alters angiogenic gene expression, which may contribute to postoperative interstitial edema, increased pain, and decreased muscle strength. These factors could delay rehabilitation and ultimately reduce patient

satisfaction after TKA. (26). Xie et al. also concluded that the meta-analysis results indicate tourniquet application may increase the incidence of postoperative DVT and worsen postoperative pain and swelling in the short term (27).

On top of these, Nicolaiciuc et al. concluded that there was no significant correlation between tourniquet use and postoperative pain or range of motion (ROM) improvement (28). Smith et al. found in their systematic review no benefit to using a tourniquet in knee replacement surgery for reducing transfusion requirements (29). Tan et al. concluded that tourniquet use in TKA does not shorten surgery time or reduce blood loss, but it does lead to an increase in local complications (4). Joufflineau et al. concluded that using a low-pressure tourniquet in TKA reduces total blood loss compared to no tourniquet, without significantly increasing hidden blood loss and does not exhibit superior functional outcomes (30). Zan et al. concluded that releasing the tourniquet before wound closure increases perioperative blood loss but significantly reduces the risk of complications (31). Kim et al. stated that inflating the tourniquet to 120 mmHg above systolic blood pressure (SBP) is an effective method for use during TKA (32). Hung et al. concluded that performing TKA without a tourniquet preserves better quadriceps muscle function, leading to faster recovery and reduced need for transfusions, while also avoiding tourniquet-related complications (33). Xu et al. found that the use of a tourniquet in routine primary TKA was associated with a higher transfusion rate and a longer postoperative length of stay (PLOS) (34). Andrade et al. concluded that there were no significant differences in functional outcomes or cementation quality between two different tourniquet protocols in TKA. Whether the tourniquet was used throughout the entire procedure or only during skin incision and cementation, no differences were observed in visual pain scale (VAS), Oxford knee scores, range of motion, or radiolucent line analysis. Thus, both techniques appeared to provide similar clinical outcomes (35).

Limitations

This study was conducted at a single institution, which may introduce bias related to the specific surgical techniques, postoperative care protocols, and patient demographics of that center, potentially limiting the generalizability of the findings. Additionally, while the study focused on Hb and Hct changes, it did not assess other important postoperative outcomes such as pain, functional recovery, DVT, or wound complications, which are critical when evaluating tourniquet use. The non-blinded design may have further introduced performance or response bias, potentially influencing subjective outcomes like pain scores and rehabilitation progress. Future studies should incorporate a more comprehensive evaluation of these outcomes to provide a holistic view of the effects of tourniquet application in TKA.

CONCLUSION

This study provides valuable insights into the impact of tourniquet use on Hb, Hct levels, and surgical time in TKA. While both tourniquet and non-tourniquet groups experienced similar reductions in these parameters, tourniquet use resulted in shorter operative times without significantly affecting blood loss. Although the study did not explore postoperative complications like thromboembolic events and delayed rehabilitation, the literature suggests that tourniquet use may be associated with such risks. Future research should address these limitations by incorporating a broader evaluation of functional outcomes and complications to better guide clinical decision-making in TKA.

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MEDICAL RECORDS-International Medical Journal

Research Article

The Relationship Between the Activity of the Meibomian Gland and Pupil Diameter

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Abstract

Aim: The meibomian glands are modified sebaceous glands that line the inner surface of the eyelids. The aim of this study was to investigate the relationship between the autonomic nervous system and meibomian gland activity based on pupil diameter values.
Material and Method: 55 volunteers (27 patients and 28 controls) aged 16-41 years participated in the study. Patients with dry eye and a visual acuity of 10/10 according to the Snellen visual threshold were included in the study. Participants underwent static measurements at different light intensities and dynamic measurements to measure the rate of pupil dilation.
Results: Static measurements (scotopic, mesopic ve photopic) in the patient group averaged 5.93±1.21, 4.70±0.86 and 3.99±0.97 mm, while measurements in the control group averaged 5.82±0.99, 4.87±0.83 and 3.87±0.90 mm. Pupillary velocity was 0.14±0.04 in the patient group and 0.12±0.03 mm/sec in the control group.
Conclusion: This is the first study to investigate the relationship between meibomian gland function and pupillary function. The present study contributed to the literature by showing that there is no relationship between meibomian gland function and pupillary function.

Keywords: Dry eye, meibomian gland, pupillometry, pupil diameter

INTRODUCTION

The meibomian glands (glandula tarsales) are modified sebaceous glands with a tubuloacinar structure and holocrine function, arranged in a single row between the conjunctiva and the tarsus on the inner surface of the eyelids. These glands can be seen as elevations under the conjunctiva when the eyelids are rotated (1,2). There are 25 to 40 meibomian glands on the upper eyelids and 20 to 30 on the lower eyelids (3). The meibomian glands, which are located in the furrows on the inner sides of the tarsus, are arranged as diverticula around a single excretory duct that opens into the limbus posterior palpebrae of the eyelids (1,2). These glands are largely parasympathetically innervated. The source of the parasympathetic fibers is the pterygopalatine ganglion. The sympathetic fibers of the glands, which also contain sympathetic and sensory fibers, originate from the superior cervical ganglion and the sensory fibers from the trigeminal ganglion (4).

The tarsal glandules in the upper and lower eyelids release lipid secretions, the so-called meibum, to the ocular surface. These lipids, which they secrete, form the outermost layer of the tear film and protect the tear from evaporation (5). Reduced or absent meibomian secretion impairs tear film formation, leading to rapid evaporation of tears and thus evaporative dry eye disease (EDE). Although the factors causing meibomian gland dysfunction (MGD) are not well understood, it is reported to be influenced by hormonal, microbial, environmental and metabolic causes. MGD is the leading cause of dry eye disease (DED) worldwide (4). In epidemiologic studies conducted worldwide, the prevalence of DED is reported at rates between 5% and 50%. Studies have shown that up to 87% of DED is caused by MGD (5,6). There are two forms of DED, one with low tear production (lack of water) and the other with rapid evaporation of tears. Of these, underproduction of tears is related to the lacrimal gland (which accounts for a small proportion of DED), while EDE is related to the meibomian

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glands (the main cause of DED) (5-7). MGD, which causes rapid evaporation of tears, can be detected in clinics by a tear break-up test (8).

Pupil dilation and constriction as well as pupillary function are controlled by the autonomic nervous system. Pupil dilation (mydriasis) is caused by dilator pupils, which are innervated by sympathetic nerve fibers, while constriction (myosis) is caused by sphincter pupils, which are innervated by parasympathetic nerve fibers. Some data obtained from the pupil (pupillary reflex, pupillary symmetry, pupil size, shape and diameter) provide information used in the diagnosis of neuro-ophthalmologic diseases and intracranial pathologies. Since pupillary changes provide important information about diseases, they are used among the objective measurement methods. In recent years, pupillary functions have been objectively measured with devices and the data obtained from these measurements have been evaluated with the data of diseases such as COVID-19, diabetes, oculomotor nerve palsy, bipolar disorder and pseudoexfoliation syndrome (9-11).

In this study, we aimed to investigate the relationship between meibomian gland activity and pupil width, which is automatically measured and provides information about the autonomic nervous system. In addition, this study will be the first to reveal whether there is an autonomic nervous system-related cause in the etiology of MGD according to the literature review. According to the literature review, this is the first study to show the relationship between the meibomian glands and pupil diameter, which provides information about the autonomic nervous system.

MATERIAL AND METHOD

Fifty-five volunteers aged 16-41 years (27 patients and 28 control subjects), who were admitted to the Department of Ophthalmology at Niğde Ömer Halisdemir University Training and Research Hospital, participated in the study. The control group consisted of patients who came to the ophthalmology outpatient clinic for routine check-ups and had no eye disease other than myopia and hyperopia of less than 3 diopters and astigmatic refractive error of less than 1 diopter. The patient group consisted of patients who came to the outpatient clinic and were diagnosed with evaporative dry eye. Patients with a visual acuity of 10/10 according to the Snellen visual threshold and those with evaporative dry eye were included in the study. Patients with systemic diseases, pregnant and breastfeeding women, patients with myopia and hyperopia of more than 3 diopters and astigmatism of more than 1 diopter, patients with a history of heart disease, trauma, eye diseases other than refractive error and dry eye, patients with a history of eye surgery, smokers and alcohol or chronic drug users were excluded. Pupillary parameters and tear refraction times were determined using Sirius Topography (CSO, Firenze, Italy). The study was approved by the Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee with protocol number 2023/17.

Data Collection Tools

The pupillometry device automatically evaluates and measures the pupil diameter at different light intensities. The device performs pupil measurements in two ways: statically and dynamically. Static measurements are performed scotopically, mesopically and photopically at three different light intensities. Scotopic measurements were calculated at a light intensity of 0.4 lx from the LED light source in the pupillometry device, mesopic measurements at a light intensity of 4 lx and photopic measurements at an ambient light intensity of 40 lx. Dynamic measurements were then carried out at an illuminance of 500 lx. In the dynamic measurements, the speed of pupil dilation was measured. For this purpose, the pupil widths were calculated at 0 and 18 seconds at a light intensity of 500 lx. The pupil speed was then calculated by dividing the difference between the values at 0 and 18 seconds by 18. As the participants had the longest adaptation time of 18 seconds, the data were analyzed during this period. Measurements were taken at the same time of day (09:00-10:00) by the same researchers to minimize pupil effects. Measurements were taken after a 5-minute adaptation period to the dark environment. Subjects were asked to abstain from caffeinated food and drink 24 hours prior to the measurements.

Data Analysis

The Shapiro-Wilk test was used to check whether the variables correspond to a normal distribution. Numerical variables were summarised with mean±standard deviation and minimum-maximum values. The independent t-test was used for comparisons between two groups. Analyses were performed using IBM SPSS version 22 (SPSS, Inc., Chicago, IL, USA). $p<0.05$ was accepted as the statistical significance level.

RESULTS

Fifty-five subjects (27 patients and 28 controls) with a mean age of 29.78±8.34 years participated in this study. Of all participants, 60% were female and 40% were male. Mean±standard deviation and minimum-maximum values of the parameters of all participants are shown in Table 1.

Table 1. Descriptive statistics of the parameters of the whole study group

	N	Mean±Sd	Min-Max
Age (year)	55	29.78±8.34	16-41
TBUT (sec)	55	9.07±6.42	1.20-17.00
TBUT Average (sec)	55	10.31±5.49	2.70-17.00
Scotopic (mm)	55	5.87±1.10	4.07-8.24
Mesopic (mm)	55	4.79±0.84	3.18-6.66
Photopic (mm)	55	3.93±0.93	2.43-6.70
Dynamic 0th second (mm)	55	3.73±0.81	2.46-5.86
Dynamic 18th second (mm)	55	6.09±0.94	3.95-8.21
Pupilla speed (mm/sec)	55	0.13±0.04	0.040-0.193

N: number of participants, SD: standard deviation, Min: minimum, Max: maximum, TBUT: tear film breakup time

Table 2 shows that the mean age of patients with EDE was 29.33±8.80 years and 30.21±8.01 years in the control group. The mean tear film break-up time (TBUT) and TBUT were 3.10±1.43 and 5.14±1.45 seconds, respectively, in EDE, while the same parameters were 14.81±3.27 and 15.29±2.43 seconds, respectively, in the control group. The difference between these two parameters was statistically significant (p<0.001 for both parameters). The static measurements (scotopic, mesopic and photopic) were 5.93±1.21, 4.70±0.86 and 3.99±0.97 mm in the subjects with EDE, while they were 5.82±0.99, 4.87±0.83 and 3.87±0.90 mm in the control group. When analyzing the dynamic measurements, the pupil aperture at 0 and 18 seconds was 3.66±0.77 and 6.17±0.95 mm, respectively, in EDE, while these data were 3.79±0.85 and 6.02±0.94 mm, respectively, in the control groups. Pupillary velocity was 0.14±0.04 mm/sec in the EDE group and 0.12±0.03 mm/sec in the control group. No statistically significant difference was found when comparing the static, dynamic and pupillary velocity parameters between the patient and control groups (p>0.05).

Tablo 2. Comparison of patient and control group data

	EDE	N	Mean±SD	Min-Max	p
Age (year)	Patient	27	29.33±8.80	16-41	0.699
	Control	28	30.21±8.01	20-40	
TBUT (sec)	Patient	27	3.10±1.43	1.20-5.70	<0.001
	Control	28	14.81±3.27	6.20-17.00	
TBUT Mean (sec)	Patient	27	5.14±1.45	2.70-8.70	<0.001
	Control	28	15.29±2.43	10.30-17.00	
Scotopic (mm)	Patient	27	5.93±1.21	4.16-7.77	0.708
	Control	28	5.82±0.99	4.07-8.24	
Mesopic (mm)	Patient	27	4.70±0.86	3.27-6.37	0.464
	Control	28	4.87±0.83	3.18-6.66	
Photopic (mm)	Patient	27	3.99±0.97	2.56-6.70	0.635
	Control	28	3.87±0.90	2.43-5.89	
Dynamic 0th second (mm)	Patient	27	3.66±0.77	2.46-5.86	0.530
	Control	28	3.79±0.85	2.51-5.44	
Dynamic 18th second (mm)	Patient	27	6.17±0.95	4.30-7.51	0.563
	Control	28	6.02±0.94	3.95-8.21	
Pupilla speed (mm/sec)	Patient	27	0.14±0.04	0.04-0.189	0.121
	Control	28	0.12±0.03	0.072-0.193	

EDE: evaporative dry eye disease, N: number of participants, SD: standard deviation, Min: minimum, Max: maximum, TBUT: tear film breakup time

DISCUSSION

DED is a corneal surface disease that results in damage to the cornea and conjunctiva caused by the absence or rapid evaporation of tears. DED is aggravated by advanced age, gender, medication, wearing contact lenses, low humidity environments, prolonged reading or screen time (e.g. phones, tablets, computers). Phones, tablets, computers), smoke, windy environments, Asian ethnicity, air-conditioned rooms, rheumatoid arthritis, sarcoidosis, Many factors such as Sjögren's syndrome, Parkinson's disease, thyroid abnormalities, bell's palsy, hepatitis C infections, rosacea, seasonal or persistent allergies, allergic conjunctivitis caused by Demodex mites, diabetes, and eye surgery or trauma can cause DED (7,12-16). There are two forms of DED, categorised as low tear production (aqueous deficiency) and rapid tear evaporation (7). In EDE, rapid evaporation of the tear film occurs in the absence or deficiency of meibum secretion (4). The diagnosis of EDE can be made by evaluating the TBUT parameter (8). TBUT is calculated as the time interval between the first dry area that appears in the tear film after complete eye closure (17). Deterioration of the tear film below 10 seconds is considered abnormal (18). In our study, the TBUT value in patients with EDE was calculated as 3.10±1.43 seconds, while the TBUT parameter in the healthy control group was calculated as 14.81±3.27 seconds.

The pupil is the hole in the center of the iris. Its task is to regulate the amount of light that reaches the retina. Midriasis means dilation of the pupil and miosis means constriction. These functions are carried out with the help of smooth

muscles. While the dilator pupils dilate the pupil under the action of the sympathetic nervous system, the sphincter pupils constrict it under the action of the parasympathetic nervous system (1,2). A device that measures pupil function under different light sources is called a pupillometry device. Pupillometry measures pupil diameter non-invasively and provides important information about the sympathetic and parasympathetic nervous system. It also measures pupil diameter statically and dynamically under different light intensities and provides quantitative and objective results on pupil functions (9-11). The relationship between pupillometry, which has become increasingly important in recent years, and diseases such as COVID-19, diabetes, oculomotor nerve palsy, bipolar disorder, pseudoexfoliation, depression, autism, Graves' disease, sepsis-related encephalopathy, pain classification, Alzheimer's disease and Chagas' disease has been investigated (9-11,19-23). In this study, patients with dry eye and MGD were compared with healthy individuals in terms of pupillary function. According to the literature review, this study was the first to find a correlation between meibomian gland function and pupil diameter. In this study, pupil functions of healthy subjects were calculated as follows: scotopic 5.82±0.99 mm, mesopic 4.87±0.83 mm, photopic 3.87±0.90 mm, dynamic 0th second 3.79±0.85 mm, dynamic 18th second 6.02±0.94 mm and pupillary velocity 0.12±0.03 mm/sec. In a study conducted on 30 healthy subjects aged 19-40 years, pupil functions were scotopic 5.63±0.459 mm, mesopic 4.47±0.574 mm, photopic 3.47±0.519 mm, dynamic 0th second 3.68±0.661 and pupil velocity 0.128±0.029 mm/sec. These data are consistent with the data we measured in healthy volunteers. In our study, no statistically significant difference was found between the measurements we made between the healthy and patient groups.

Limitations of the Study

This study has some limitations. Our study only covers one region and the number of participants is relatively small. Studies with a larger number of participants are needed.

CONCLUSION

Therefore, the relationship between meibomian gland function and pupillary function was discussed in this study and it is the first study to investigate this. The present study contributed to the literature by showing that there is no relationship between meibomian gland function and pupillary function.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *The study was approved by the Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee with protocol number 2023/17.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Evolution of Thoracic Outlet Syndrome Research: A Detailed Bibliometric Study

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Abstract

Aim: Thoracic outlet syndrome (TOS) is a complex clinical condition caused by the compression of neurovascular structures in the thoracic outlet. Over the past few decades, research on TOS has expanded significantly. This study aims to analyze the literature on TOS using bibliometric methods to identify critical trends, influential authors, prominent themes, and emerging topics in the field.
Material and Method: A comprehensive literature search was conducted using the Web of Science (WoS) database for articles on TOS published between 1980 and 2023, employing the keyword 'thoracic outlet syndrome.' The collected data were analyzed using bibliometric methods. VOSviewer software was utilized to visualize bibliometric networks and map critical findings. Citation analysis was performed to identify influential journals and significant articles in the field. Additionally, keyword clustering and trend analyses were conducted to explore the thematic landscape of TOS research.
Results: In a literature search on TOS, 2248 publications were found, with 1509 journal articles (67.13%) included in the bibliometric summary. The most common research area was surgery (633 articles, 41.94%), and the United States had the highest publication productivity (684 articles, 45.32%). The University of California System had the highest number of publications among institutions (62 articles, 4.1%). These 1509 articles received 7831 citations (6596 excluding self-citations), averaging 13.1 citations per article and with an h-index of 57. 'Annals of Vascular Surgery' published the most articles (71, 4.7%), while 'Journal of Vascular Surgery' had the highest number of cited articles (65, 4.3%), accumulating 2563 citations.
Conclusion: This bibliometric analysis provides valuable insights into the evolution and trends of research on TOS. The keyword analysis offers a roadmap for researchers to design new studies. Additionally, the study highlights the influence of economic size and development levels on academic productivity in TOS, underscoring the importance of promoting multidisciplinary studies, especially in less developed countries.

Keywords: Thoracic outlet syndrome, bibliometric analysis, citation analysis, Web of Science, VOSviewer

INTRODUCTION

Thoracic Outlet Syndrome (TOS) is characterized by conditions where bony, muscular, or fibrous structures compress the neurovascular bundle in the thoracic outlet, leading to various symptoms (1). Peet et al. introduced the term "thoracic outlet syndrome" in 1956, and it has since become well-established (2).

TOS is divided into three subcategories based on the compressed anatomical structure and clinical symptoms. These categories include neurogenic TOS, which involves brachial plexus compression; arterial TOS, characterized by subclavian artery compression; and venous TOS, involving subclavian vein compression (3). It is worth noting that neurogenic TOS is the most prevalent, accounting for approximately 90% of cases (4).

Compression in TOS typically occurs in the interscalene triangle, costoclavicular space, or coracopectoral tunnel (5,6). The interscalene triangle, a narrow area between the anterior and middle scalene muscles and the first rib, is particularly prone to compression due to fibrous and muscular abnormalities (6-8). Contributing factors include trauma, tumors, clavicle fractures, fibromuscular bands, and rib anomalies (9).

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The exact number of cases of TOS is uncertain, but it is estimated to range from 2.5 to 4.0 cases per 100,000 people annually in the United States of America (USA) (10,11). Diagnosing TOS is challenging because there are no definitive neurodiagnostic tests or objective criteria (4). While treating arterial and venous TOS is straightforward, treating neurogenic TOS remains controversial, with no consensus on surgical timing or approach (12-16).

TOS is addressed by various surgical specialties, such as thoracic, vascular, orthopedic, neurosurgery, and plastic surgery (17). Misdiagnosis and complications are frequent, potentially leading to severe outcomes (18). A multidisciplinary approach is often beneficial for patients (17).

Given the ongoing debates and complexities surrounding TOS, conducting a bibliometric analysis can offer valuable insights into research trends and developments in this field. Our study aims to provide a quantitative description of the current status and trends in TOS research, identify influential publications, journals, researchers, and countries, and offer a reliable overview of the state of TOS research to guide future investigations.

MATERIAL AND METHOD

Data Sources

The literature review utilized the Web of Science (WoS) database to gather relevant studies. WoS database is a comprehensive indexing resource provided by Clarivate Analytics in Philadelphia, Pennsylvania. This database includes the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), Conference Proceedings Citation Index (CPCI), and other relevant sources. WoS is recognized globally as a multidisciplinary resource, providing access to numerous influential, high-quality academic journals. Leveraging WoS's built-in functions, we could delve into publication trends, geographical distribution, research areas, active organizations, journals, authors, trending topics, and citation counts (19). These robust features make the WoS database an ideal resource for conducting comprehensive bibliometric analyses of research related to TOS. Ethical approval was not required as the search utilized publicly available databases. Data collection was completed on May 17, 2024, ensuring the inclusion of all relevant publications up to that date.

Search Strategy

The search strategy was carefully crafted to explore the "Thoracic Outlet Syndrome". Only original articles were included in the search, while other document types such as reviews, meeting abstracts, proceedings papers, editorial materials, and letters were deliberately excluded. The search period was defined to span from 1980 to 2023 to capture a comprehensive range of literature. Raw data from the WoS database was meticulously extracted in plain text format to facilitate in-depth bibliometric analysis.

Data Extraction and Collection

We carefully retrieved relevant data from the WoS, manually excluding unrelated literature. Two authors independently browsed and extracted data from the selected articles. The information obtained from the articles included titles, authors, affiliations, publication year, contributing nations, journals, keywords, references, citation frequency, average citations per item, and h-index. We used Microsoft Office Excel 2017 for data entry and management. We conducted a thorough and meticulous process to gather relevant data from the WoS, carefully filtering out any unrelated literature by hand.

Bibliometric and Visualized Analysis

The world map was generated using GunnMap2 (http://lert.co.nz/map/), and bibliometric network and density visualizations were created with VOSviewer software (version 1.6.13, Van Eck and Waltman, Leiden University, The Netherlands) (20). In the network visualization map, larger circles indicated more significant contributions, and thick, closely positioned lines signified strong relationships. The density visualization map used a color scale from blue to red, with red representing areas with more items and greater weight of neighboring items.

Statistical Analysis

Statistical analyses were conducted using SPSS (Version 21.0, IBM Corp., Armonk, NY). The Kolmogorov-Smirnov test assessed data distribution normality, while Spearman's correlation analyzed the relationship between publications per country and GDP per capita (United et al., 2022) and HDI (United Nations, 2022). Linear regression was applied to predict future publication trends (2024-2034), with statistical significance set at $p<0.05$.

RESULTS

Quantity of Global Publications

The literature search resulted in 2248 publications. Of these, 1509 (67.13%) were journal articles, 227 (10.10%) were review articles, 205 (9.12%) were meeting abstracts, 135 (6.01%) were editorial materials, 113 (5.03%) were letters, 29 (1.29%) were proceedings papers, 23 (1.02%) were notes, 5 (0.21%) were corrections, 1 (0.04%) was early access, and 1 (0.04%) was a reprint. In total, 1509 articles were analyzed bibliometrically in this study. The most common languages of publication were English (n=1365; 91%), German (n=55), French (n=53), Spanish (n=13), Turkish (n=8), Korean (n=6), Japanese (n=3), Portuguese (n=3), Polish (n=2), and Czech (n=1). These 1509 articles received 7831 citations (6596 excluding self-citations), with a mean of 13.1 citations per article. The total h-index for all included journal articles was 57.

Active Research Areas

The research landscape is diverse, with surgery being the most common focus area, comprising 41.94% of published articles. Following closely behind are peripheral vascular disease (20.41%), orthopedics (13.18%), and clinical neurology (11.99%).

The research articles span a wide range of fields, with general internal medicine (165), radiology, nuclear medicine, and medical imaging (115), sports sciences (92), and rehabilitation (91) being the most prominent. Additionally, significant contributions were made in the areas of cardiac and cardiovascular systems (88), neurosciences (72), and the respiratory system (57). The research also extended to pediatrics (40), anatomy and morphology (37), anesthesiology (27), and rheumatology (22), among others. It is important to note that some articles were labeled in more than one field, reflecting the interdisciplinary nature of research.

Annual Publication Production

The graphical representation in Figure 1 illustrates the distribution of the number of articles by year. Notably, there was a substantial surge in the number of articles focusing on TOS in 2021 compared to previous years. Additionally, Figure 1 visually represents the projected number of publications for the next ten years using regression analysis, accompanied by 95% confidence intervals (CI). The regression analysis forecasts that 70 journal articles [95% CI: 51-89] are anticipated to be published in 2024, increasing to 84 [95% CI: 65-103] by 2033.

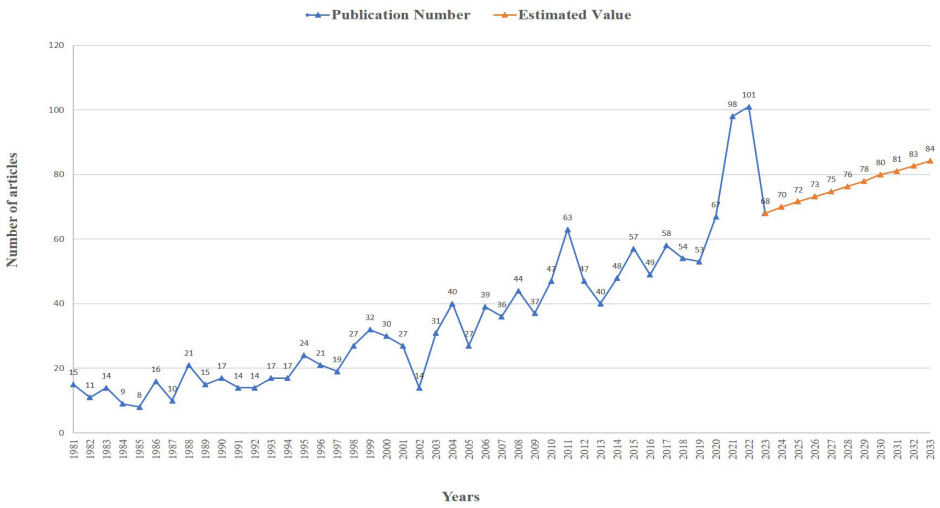

Figure 1. Trends in the number of annual publications by year

Active Countries

The productivity of countries in terms of published articles is as follows: The USA leads with 684 publications (45.32%), followed by France with 117, England with 73, Germany with 68, Türkiye with 67, Italy with 56, India with 48, Japan with 44, Canada with 37, Netherlands with 36, South Korea with 34, China with 31, Switzerland with 26, Belgium with 22, Finland with 21, Australia with 20, Spain with 19, Austria with 18, Brazil with 16, Sweden with 14, Poland with 11, and other countries contributing 152 publications (Figure 2). The corresponding authors indicate that the USA is the most productive country in the field related to TOS, as shown in Figure 3, with most publications originating from the USA.

Thirty-three countries contributed articles to the published articles. Figure 4 illustrates the map displaying the international collaboration networks among countries that have jointly published at least five articles.

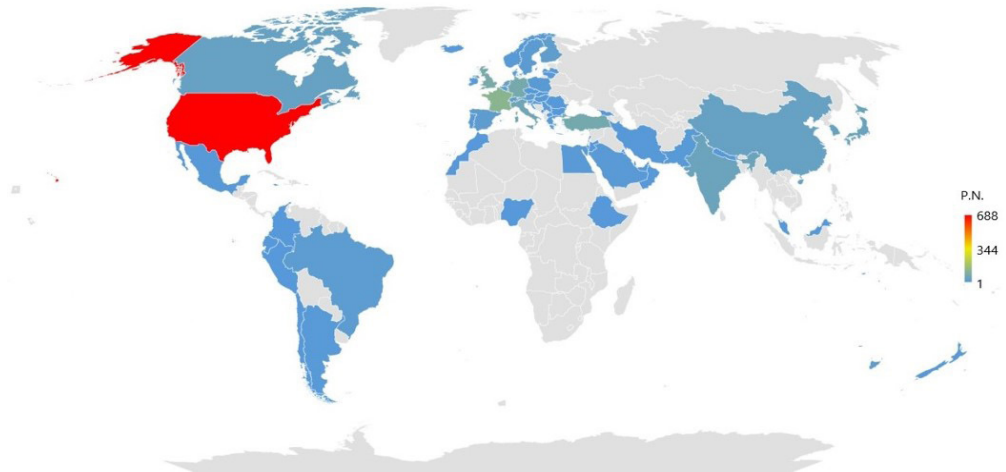

Figure 2. World map depicting publication productivity in the field of TOS by country (P.N.: Publication Number); Productivity is color-coded on a scale from blue (low) to orange (high)

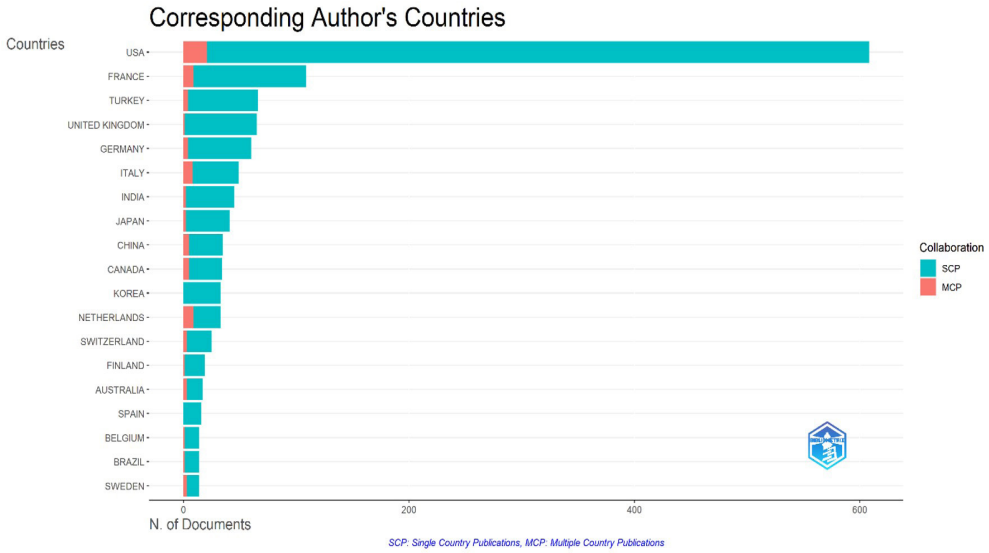

Figure 3. The most productive countries in the TOS-related field (MCP: multiple corresponding author publication; SCP: single corresponding author publication)

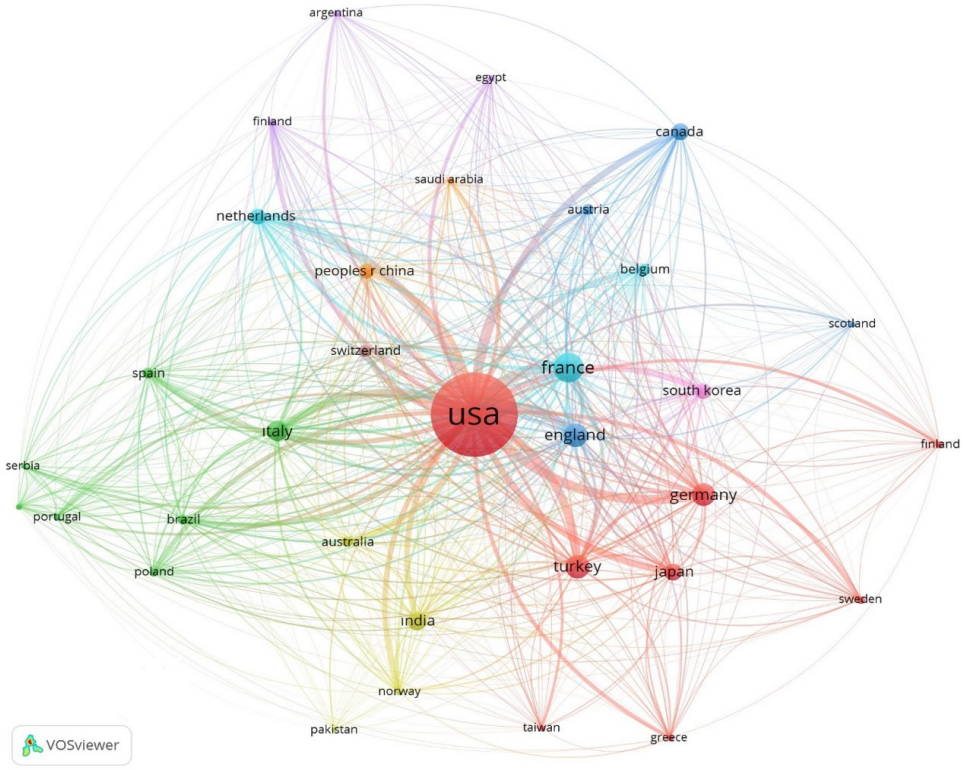

Figure 4. Network visualization map for international collaborations on TOS. (The sizes of the circles represent the number of publications, the colors indicate clusters of collaborations, and the thickness of the lines indicates the strength of collaborations)

Factors Associated with the Numbers of Publications

The analysis revealed a statistically significant correlation ($p<0.01$) between the number of publications on TOS and both GDP per capita ($r=0.36$) and HDI ($r=0.43$).

Active Journals

A comprehensive analysis revealed that 1509 articles were published across 558 distinct journals. Specific journals stood out for their exceptional frequency of publications and citations on TOS. These standout journals, which had each published a minimum of 10 articles, are detailed in Table 1. Annals of Vascular Surgery boasted the highest number of articles (71 articles, 4.7%), while the Journal of Vascular Surgery garnered the most citations (65 articles, 2,563 citations). The table also provides insights into the number of publications and citations per article. Furthermore, Figure 5 showcases a visually compelling citation network visualization map highlighting the most active journals.

Table 1. Journals with the highest frequency of publications and citations on TOS

Journal	Publications (n)	Citations
Annals of Vascular Surgery	71	1078
Journal of Vascular Surgery	65	2563
Journal of Vascular Surgery: Venous and Lymphatic Disorders	16	132
Annals of Thoracic Surgery	15	384
Vascular and Endovascular Surgery	19	191
Diagnostics	13	114
Thoracic Surgery Clinics	11	53
Muscle & Nerve	21	720
Hand Clinics	24	501
European Journal of Vascular and Endovascular Surgery	10	174
Journal of Hand Surgery - American Volume	16	294
American Journal of Surgery	12	411
Vascular	13	115
American Surgeon	10	173
Clinical Orthopaedics and Related Research	12	165
Vasa - Journal of Vascular Diseases	14	61
Surgical and Radiologic Anatomy	10	73
Archives of Physical Medicine and Rehabilitation	11	189
Journal des Maladies Vasculaires	10	63
Cureus Journal of Medical Science	12	44

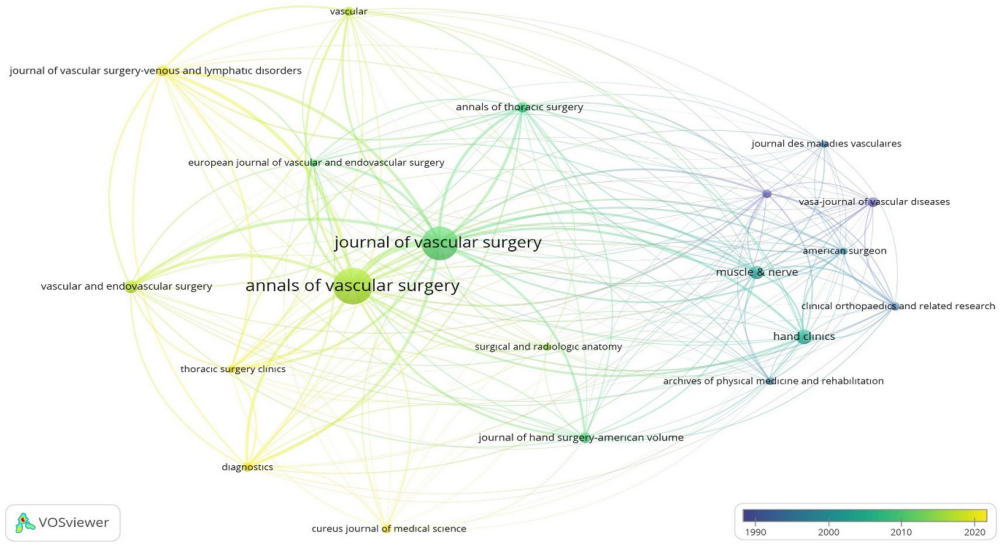

Figure 5. A network visualization map illustrating the citation analysis of the most active journals in the field of TOS. (The size of the circles indicates the frequency of each journal, while the thickness of the lines reflects the strength of the relationships)

Active Authors and Organizations

The following individuals were the most active authors in the field: Thompson RW (30 publications), Freischlag JA (29 publications), Gelabert HA (16 publications), Ozcakar L (15 publications), Teijink JAW (14 publications), Sanders R (14 publications), Abraham P (14 publications), Lum YW (12 publications), Henni S (12 publications), Pesser N (11 publications), Illig KA (11 publications), Hersant J (11 publications), and Donahue DM (11 publications). In addition, Figure 6 highlights the most active organizations in TOS research. The University of California System led 62 publications, followed by Harvard University and Johns Hopkins University with 53 publications.

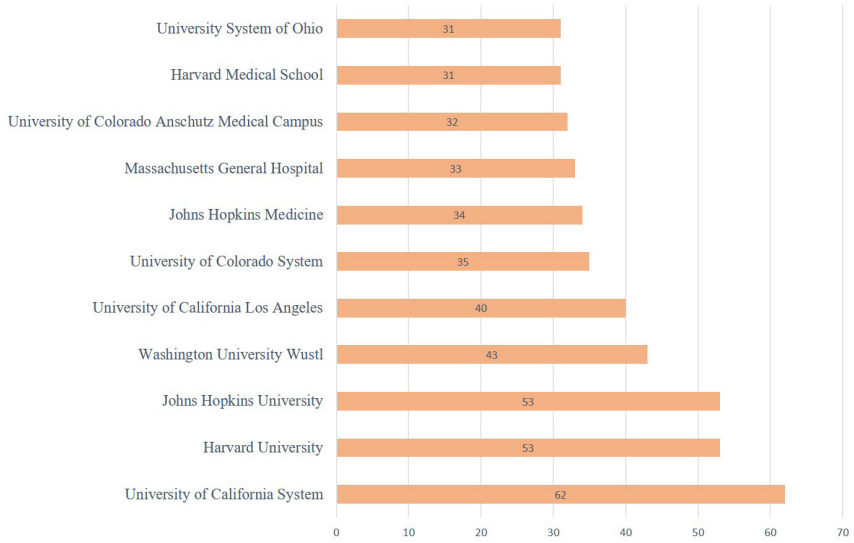

Figure 6. The most productive organizations are in the TOS-related field

Citation Analysis

Table 2 provides a comprehensive overview of the ten most extensively cited articles, including their total citation counts and average citations per year. Notably, all of these articles have amassed more than 100 citations each. The article by Sanders RJ et al. stands out with the highest number of citations, totaling 252, and was published in the Journal of Vascular Surgery in 2007 (21).

Table 2. The 10 most cited manuscripts on TOS

No	Article	Author (s)	Journal	PY	AC	TC
1	Diagnosis of thoracic outlet syndrome	Sanders RJ, Hammond SL and Rao NM	Journal of Vascular Surgery	2007	14	252
2	Ectopic sensory discharges and paresthesia in patients with disorders of peripheral-nerves, dorsal roots and dorsal columns	Nordin M, Nystrom B, Wallin U and Hagbarth KE	Pain	1984	5.41	222
3	Surveillance case definitions for work related upper limb pain syndromes	Harrington JM, Carter JT, Birrell L and Gompertz D	Occupational and Environmental Medicine	1998	7.22	195
4	Guidance for the treatment of deep vein thrombosis and pulmonary embolism	Streiff MB and et al.	Journal of Thrombosis and Thrombolysis	2016	21.56	194
5	Nonunion of the clavicle - associated complications and surgical- management	Jupiter JB and Leffert RD	Journal of Bone and Joint Surgery-American Volume	1987	4.68	178
6	Outcomes of surgery in 1019 brachial plexus lesions treated at Louisiana State University Health Sciences Center	Kim DH, Cho YJ, Tiel RL and Kline DG	Journal of Neurosurgery	2003	7.36	162
7	Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome	Illig KA and et al.	Journal of Vascular Surgery	2016	15.78	142
8	Imaging assessment of thoracic outlet syndrome	Demondion, X and et al.	Radiographics	2006	6.74	128
9	The place for scalenectomy and 1st-rib resection in thoracic outlet syndrome	Roos DB	Surgery	1982	2.93	126
10	The treatment of thoracic outlet syndrome - a comparison of different operations	Sanders RJ and Pearce WH	Surgery	1989	3.47	125

PY: publication year, AC: average citations per year, TC: total citation

Keyword Analysis

In scholarly publications, keywords are crucial as they provide essential information about the main themes and ongoing research trends. The frequency of specific keywords used during a particular period can offer valuable insights into the primary focus areas and critical research trends related to TOS. Figure 7A provides a detailed breakdown of the most frequently used keywords in TOS-related literature. 'Thoracic outlet syndrome' is the most commonly used keyword, appearing 250 times, followed by 'management' (216), 'diagnosis' (203), 'surgery' (120), and 'compression' (112).

Furthermore, analyzing the co-occurrence of keywords provides a comprehensive understanding of the research hotspots within the field. This analysis reveals the frequency with which a group of keywords appears in the same publications, forming a co-occurrence network that highlights their connections. To conduct this analysis on publications spanning from 1980 to 2023, we utilized VOSviewer. Figure 7B illustrates the change in the frequency of keywords over time, with "thoracic outlet syndrome" remaining the most prominent keyword, appearing 250 times. Figures 7C and 7D present detailed visual representations of the co-occurrence network of keywords, illustrating the relationships between frequently used terms in the analyzed literature. Each node in Figure 7C represents a keyword, with the node's size corresponding to the frequency of co-occurrence. Keywords of the same color belong to the same cluster. Notably, in Figure 7C, we have categorized all the keywords into twelve clusters, with the largest cluster containing 20 keywords, including "brachial plexus". This categorization provides a detailed insight into the interconnectedness of the keywords within the TOS-related literature.

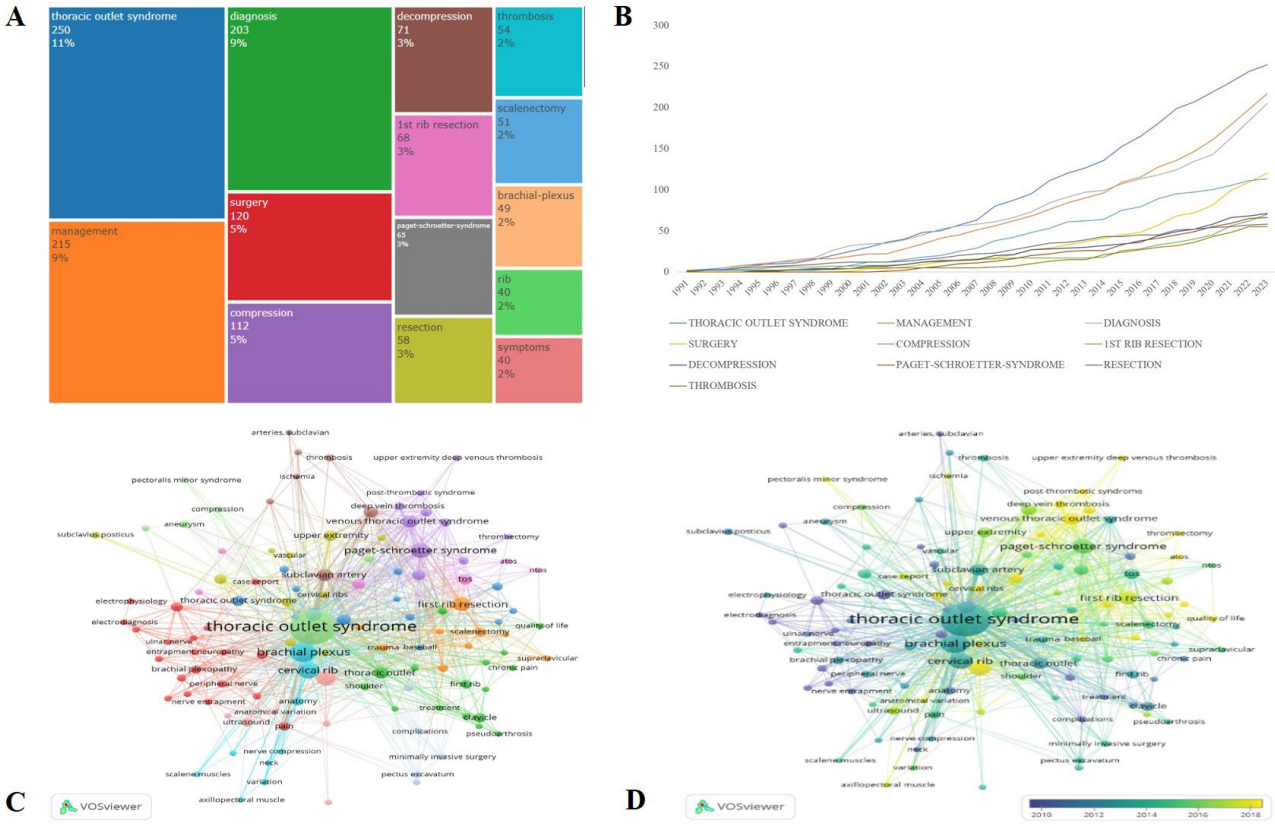

Figure 7. Keyword analysis of the TOS-related publications; **A.** Tree Map of the top 117 high-frequency keywords used, **B.** Keyword frequency over time, **C.** Co-occurring network of keywords, **D.** Co-occurring network of keywords in overlay visualization

DISCUSSION

This comprehensive study presents a detailed overview of the current status and global trends in TOS research. Over the years, there has been a consistent rise in the annual number of publications in this field, indicating a growing interest and focus on TOS. Our analysis has identified vital researchers, institutions, and countries involved in TOS research and their collaborative networks, shedding light on influential and highly cited publications. We have provided valuable insights into the landscape of TOS research through extensive bibliometric analyses, including keyword analysis and citation analysis of articles and journals, as well as an examination of international collaborations. This study is the first to conduct in-depth analyses, covering many articles on TOS and offering significant contributions to the knowledge base for researchers and practitioners in this field.

Growth of TOS Research

Research on TOS has grown significantly over the past four decades. The number of publications on TOS surged after

2021, which could be attributed to increased awareness, advancements in diagnostic techniques, and the findings of other studies (e.g., Illig et al., 2021). This increase in research activities may also signify the growing recognition of TOS as a significant clinical issue that demands more focused investigation and intervention.

Academic Influence and Key Contributors

The USA has a global academic influence, which is evident in its many publications and citations. These statistics support previous research highlighting the USA's prominent role in medical research, attributed to its substantial investment in healthcare and research infrastructure (Martín-Martín et al., 2021). The University of California System is the most active academic institution, fostering collaborative relationships with research organizations worldwide. This institution's prominence can be attributed to its extensive network of medical centers and its dedicated focus on multidisciplinary research.

Impact of Economic and Developmental Factors

Previous research has demonstrated a strong connection between a nation's economic strength, development indices, and publication productivity (22,23). Our study further substantiates this link by identifying specific correlations between certain economic and developmental indicators. It is evident that countries with higher wealth and more advanced healthcare systems are better positioned to allocate resources for research and produce high-impact studies, as evidenced by the research of Peet et al. in 1956 and Hooper et al. in 2010. These findings emphasize the critical role of resource allocation in driving scientific advancements and the importance of economic and developmental factors in shaping publication productivity.

Leading Journals in TOS Research

Two prominent journals greatly support the field of TOS research. The Annals of Vascular Surgery stands out with the most publications in TOS-related research and is the second most cited journal in this specialized area. On the other hand, the Journal of Vascular Surgery takes the lead regarding citations and holds the second position in the number of publications. These journals are renowned for their extensive readership and primary focus on vascular conditions, which naturally encompasses TOS. This underscores the multidisciplinary approach to TOS management, with a particular emphasis on the role of vascular surgeons. Researchers interested in TOS are strongly encouraged to prioritize these journals to stay updated on the latest developments and findings in the field.

Citation Trends and Influential Articles

Most of the top 10 most cited articles were published before 2010, suggesting that older studies have more time to accumulate citations than recent publications. These earlier works mainly focused on the diagnosis and treatment of TOS. The most frequently cited report, written by Sanders RJ in 2007, explores the diagnostic process for TOS, emphasizing the lasting impact of foundational studies on current understanding and practices.

Keyword Analysis and Research Hotspots

Keywords play a critical role in scholarly publications by offering valuable insights into the central themes and prevailing research trends in TOS. In TOS-related literature, some of the most frequently used keywords include "thoracic outlet syndrome", "management", "diagnosis", "surgery", and "compression". These keywords reveal interconnected research hotspots through co-occurrence analysis, forming networks that illustrate their associations. An analysis using VOSviewer to study publications from 1980 to 2023 highlighted "thoracic outlet syndrome" as the most prominent keyword. Additionally, the analysis showcased the grouping of keywords into clusters, with the largest cluster encompassing significant terms such as "brachial plexus". These clusters indicate concentrated research endeavors and evolving interests within the TOS field.

Limitations

While a bibliometric analysis can provide valuable insights into the publication data within a specific scientific field, it is essential to address the limitations of our study:

- Our selection was limited to the WoSCC database, meaning that other significant databases, such as PubMed and Scopus, were not included in our analysis.
- We only focused on English-language publications, potentially overlooking relevant studies published in other languages. It is crucial to note that the frequency of citations does not necessarily indicate the quality of a publication, which means that some high-quality studies with fewer citations might have been excluded from our analysis.
- Our study only included publications with sufficient data, which might have excluded more recent studies.

It is essential to recognize that research findings are subject to change over time. Lastly, our conclusions are based on database records, which may only partially represent the real-world scenario. This limitation is standard in all bibliometric studies.

Strengths and Innovations

Our research has significant strengths, notably its comprehensive coverage of the topic and the utilization of advanced bibliometric methods. No other study has conducted such extensive analyses within the field of TOS research, making our work a valuable and unprecedented resource for guiding future investigations in this area.

Future Research Directions

Future research could expand upon these findings by incorporating additional databases, such as PubMed and Scopus, offering a more comprehensive understanding of the subject. Including non-English publications may also reveal significant studies that should have been included

in this analysis. Additionally, longitudinal studies could be valuable in tracking changing trends in TOS research and its impact on clinical practices.

CONCLUSION

In this study, we used bibliometric and visualized analyses to identify current trends in research and collaborative relationships among countries, authors, and institutions. We also reviewed key scientific works to provide researchers with a comprehensive overview of the academic landscape in TOS research. Over the past forty years, there has been significant growth in TOS research, with the USA emerging as the leading contributor. The University of California System has been particularly active in this field. The Annals of Vascular Surgery and the Journal of Vascular Surgery have been identified as the most influential journals in this study area.

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Ethical approval: *As this study did not examine human subjects, it was exempt from institutional review board approval.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Investigation of Gender-Related Changes of Craniocervical Region Variables on MRI in Adults with Reduced Cervical Lordosis Angle

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Abstract

Aim: In the present study, the aim has been to evaluate the variables related to the craniocervical region on magnetic resonance imaging (MRI) of individuals with reduced cervical lordosis angle and to reveal the differences between genders.
Material and Method: Totally, 9 variables have been measured on the cervical vertebrae images of 120 individuals. The variables measured are as follows: Dens height (DH), dens anteroposterior distance (APDD), dens apical ligament length (LALD), foramen magnum sagittal diameter (SDFM), spinal canal anteroposterior diameter (APCSD), retropharyngeal space length (LRS), dens anteroposterior distance (ASDD), total cervical vertebrae length (TCVL) and dens angle (DA). Statistical analyses of the variables were performed with Minitab® 21.2 (64-bit) and R program.
Results: The study's results were as follows, men and women, respectively: DH: 31.5±2.8, 30.1±2.6, ASDD: 36.1, 34.2, TCVL: 116.2±7.2, 107.7±6.1. According to the analysis, the differences in DH, ASDD and TCVL variables between men and women were found to be statistically significant.
Conclusion: The study, which used MRI of the cervical region, found that gender was effective in the variables on the craniocervical region in individuals with reduced cervical lordosis angle and morphometric data related to the population were obtained.

Keywords: Gender, cervical vertebrae, lordosis, morphology, magnetic resonance imaging

INTRODUCTION

The craniocervical junction, formed by the atlantooccipital and atlantoaxial joints, is the complex transition zone between the cervical vertebrae and the skull and includes the neurovascular structures from the skull base to the second cervical vertebrae (1). Approximately one-third of all pathologies of the cervical spine are encountered at the craniocervical junction, which is rich in structure and function and can be caused by aging, degeneration or trauma (2). As the craniocervical junction contains many vital structures that are in close relationship with each other, the neurological system and musculoskeletal system are affected in pathologic conditions involving this region (3). A decrease in the cervical lordosis angle is popularly known as neck flattening and radiographs constitute the first step in the evaluation (2,3). Nevertheless, computed tomography and magnetic resonance imaging (MRI) can be used for detailed evaluations such as the degree and level of lordosis and its effect on surrounding structures (4,5). A lordotic angle of 20-35 degrees between C2-C7 vertebrae is considered physiologic. This angle may decrease due to pathologies in the muscle, intervertebral disc, bone tissue or adjacent segments, head position, injuries or accidents (6). Furthermore, a recent study reported that age and gender also play a role in the reduction of the lordosis angle (6,7). Thus, it is important to consider age and gender in diagnostic and therapeutic approaches and to prevent complications in surgery and to know the anatomical features of the region well (8). The purpose of this study has been to evaluate the variables related to the craniocervical region in adult individuals with decreased cervical lordosis angle and to present the differences between genders to the literature.

CITATION
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MATERIAL AND METHOD

Research has been started with the approval decision numbered 2023/230 from the Clinical Research Ethics Committee. In the study, MRI (1.5 Tesla MRI Device (Siemens-Magneton Symphony, Erlangen, Germany) of 120 individuals (60 women, 60 men) aged 25-55 years with reduced cervical lordosis angle randomly selected from the Picture Archiving and Communication Systems (PACS) archive of Bolu Abant Izzet Baysal University Training and Research Hospital has been used. The images taken from the system in Dicom format have been transferred to a personal workstation Radiant Dicom Viewer (RDV) program. After the determination of decreased cervical lordosis angle has been made by an orthopedic and traumatology specialist, the following parameters were measured. The following variables have been measured: Dens height (DH), anteroposterior distance of dens (APDD), length of apical ligament of dens (LALD), sagittal diameter of foramen magnum (SDFM), anteroposterior diameter of spinal canal (APCSD), length of retropharyngeal space (LRS), anteroposterior distance of dens (ASDD), total cervical vertebrae length (TCVL) and dens angle (DA). The demonstration of the measured variables is given in Figure 1.

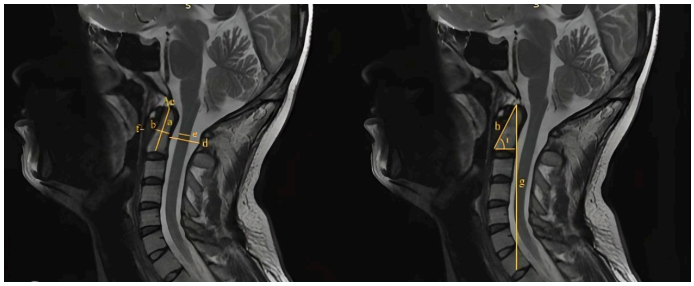

Figure 1. Demonstrations of the variables; a- DH, b- APDD, c- LALD, d- SDFM, e- APCSD, f- LRS, h- ASDD, g- TCVL, ı- DA; DH: dens height, APDD: anteroposterior distance of dens, LALD: length of apical ligament of dens, SDFM: sagittal diameter of foramen magnum, APCSD: anteroposterior diameter of spinal canal, LRS: length of retropharyngeal space, ASDD: anteroposterior distance of dens, TCVL: total cervical vertebrae length, DA: dens angle

Statistical Analysis

Statistical analysis have been performed with Minitab® 21.2 (64-bit) package program and R version 4.2.3 (2023-03-15 ucrt). The compatibility of the variables with normal distribution has been tested with Anderson Darling Test. The mean and standard deviation (sd) values of parametric variables and median (med), minimum (min) and maximum (max) values of nonparametric variables were calculated. To analyze the difference between genders, Two Simple T Test has been used for parametric tests and Mann Whitney U Test for nonparametric variables. Logarithmic transformation was performed for nonparametric variables. In the Anderson Darling Test performed as a result of logarithmic transformation, 95% confidence intervals have been calculated for variables that fit the normal distribution. P<0.05 has been accepted as significant.

RESULTS

Following the analysis, med, min and max values have been given for age, APDD, SDFM, APCSD, LRS and ASDD variables because they have not been normally distributed, and mean and sd values have been given for DH, DA and TCVL variables because they have been normally distributed. Log transformation has been applied for the LALD variable and mean and 95% confidence intervals have been included (Table 1). As a result of the analysis, the differences between men and women in DH, ASDD and TCVL variables have been found statistically significant. Descriptive statistics, Mann Whitney U Test results and Two Simple T Test results of the variables have been presented in Table 1.

Table 1. The descriptive statistics of the variables, Two Simple T and Mann Whitney Test results

Variable	M (n=60)	F (n=60)	p-value
Age	48 (24-64)*	45.5 (20-59)	0.388
DH (cm)	31.5±2.8**	30.1±2.6	0.007#
APDD (cm)	10.2 (8.1-16.5)	10.0 (7.3-14.3)	0.079
ASDD (cm)	36.1 (28.5-48.8)	34.2 (33.5-40)	<0.001
DA (°)	64.8±5.3	63.9±4.3	0.318#
LALD (cm)	7.2 (6.6-7.7)***	6.5 (6.1-6.8)***	0.077#
TCVL (cm)	116.2±7.2	107.7±6.1	<0.001#
LRS (mm)	3 (1-6.4)	3.6 (2-5.9)	0.220
APCSD (mm)	15.6±1.6	15.8±1.7	0.662#
SDFM (cm)	6.9 (3.1-8.3)	7.3 (4.5-8.8)	0.131

DH: dens height, APDD: anteroposterior distance of dens, ASDD: anteroposterior distance of dens, DA: dens angle, LALD: length of apical ligament of dens, TCVL: total cervical vertebrae length, LRS: length of retropharyngeal space, APCSD: anteroposterior diameter of spinal canal, SDFM: sagittal diameter of foramen magnum, M: male, F: female, : the p value of the Mann whitney u test result, #: the p-value of the Two Simple T Test, *: med (min-max), **: mean±sd, ***: the means and 95% confidence intervals after logarithmic transformation

The boxplot graph of age, DH, TCVL, ASDD variables has been presented in Figure 2.

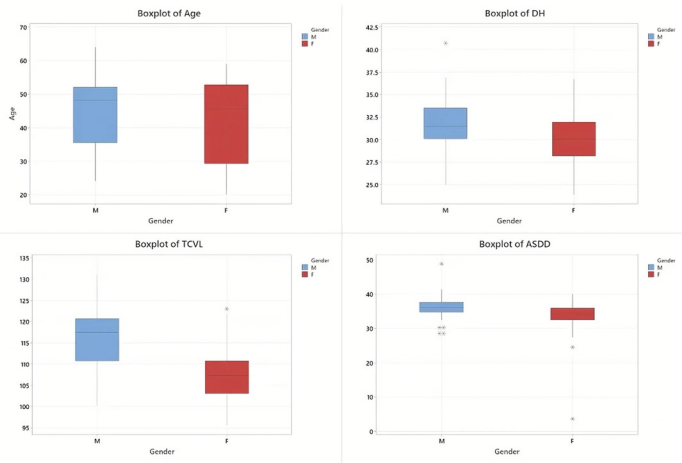

Figure 2. The boxplot graph of age, DH, TCVL, ASDD variables. DH: dens height, TCVL: total cervical vertebrae length, ASDD: anteroposterior distance of dens, M: male, F: female

DISCUSSION

Age and gender both have an impact on the deformities and degenerative changes that occur in the vertebrae of the craniocervical area, which cause variations in the cervical lordosis angle throughout time. Finding the anatomical-morphometric characteristics that contributed to the changes in this region has been the objective of the current investigation.

In the current study, MRIs of individuals with reduced cervical lordosis angles aged 25 to 55 were used to examine changes in the gender-related variables of DH, ASDD, TCVL, APDD, DA, LALD, LRS, APCSD, and SDFM. The results showed that the variables related to the craniocervical region, including DH, ASDD, TCVL, APDD, DA, LALD, LRS, APCSD, and SDFM, had statistically significant levels.

According to the literature review, this is the first study to determine the impacted anatomical parameters and investigate gender-related modifications of the craniocervical region in Turkish individuals who have reduced cervical lordosis. We think that the anatomical parameters that were examined in the study and found to be changed will make pre- and post-operative procedures easier. Several studies have been published in the literature that highlight the significance of cervical lordosis in terms of function, surgery, and therapeutic management (9-12). Very few studies have investigated at how it relates to anatomical parameters.

A study that evaluated the anatomical parameters of cervical lordosis and how it affect gender and age investigated at 1020 individuals, 424 of whom were male and 596 of whom were female, ranging in age from 7 to 95. Cervical lordosis and intervertebral disc compression have been shown to increases significantly with age, with a greater increase in males than in women. Vertebral body compression has been demonstrated to have a smaller effect on C2-C7 cervical lordosis than disc compression. The morphological characteristics of sagittal compression of the intervertebral discs and vertebral bodies in the cervical spine are thoroughly investigated in this study, which is the largest investigation of this type reported in the literature (13). Cervical lordosis increases with aging, according to earlier research in the literature (14-17).

The effect of age and gender on cervical lordosis in lateral cervical radiographs of a total of 197 patients ranging in age from 6 to 50 years has been investigated in two groups: a juvenile group (76 children aged 6-19 years; 48 males and 28 females) and an adult group (121 adults aged 20-50 years; 61 males and 60 females). Consequently, it was found that children showed a considerably more significant gender difference than adults (7).

An examination of 120 adults' cervical lateral roentgenograms compared the corpus of the cervical vertebrae biometrically. It has been reported that the vertebral body of C2, especially its anteroposterior diameter value, is the best indicator of age independent of individual and external variables (18).

A total of 1,230 asymptomatic individuals have been studied for age-related changes in the bony anatomy, alignment and range of motion of the cervical spine on antero-posterior (AP), lateral, flexion and extension radiographs of the cervical spine. The antero-posterior diameter of the spinal canal, vertebral body and vertebral disc has been measured at all levels from C2 to C7. It has been found that with increasing age, both the AP diameter of the spinal canal and the disc height gradually decrease. There has been a significant difference between men and women in terms of C2-C7 alignment and range of motion (19).

It is also reported in the literature that neck pain and neck flattening due to nerve root irritations at the level of the foramen intervertebrale as a result of decreased cervical lordosis angle (20-24).

The present study has several limitations. The sample size is relatively limited, which is the first constraint. The second is that different spondylotic changes that can be observed at older ages have been omitted from the study because the participants under examination ranged in age from 25 to 55. Third, ethnic differences could not be taken into account because the study was single-centered. Another drawback is that, as it was a retrospective study, none of the cases that were studied at presented any clinical symptoms.

CONCLUSION

In terms of normal values for comparison in clinical practice, it is thought that the study's data, which identify the anatomical parameters that are significantly determined among people with reduced cervical lordosis angle, may be helpful. Furthermore, based on an overview of the findings from this study and the literature, we believe that future research should investigate into the clinical consequences of anatomical features.

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MEDICAL RECORDS-International Medical Journal

Research Article

The Effect of Fasting During Ramadan on Acute Metabolic Complications of Diabetes

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Abstract

Aim: Ramadan fasting involves abstaining from eating and drinking from dawn to sunset for 29–30 days, causing significant lifestyle changes. These changes can increase the risk of acute metabolic complications in individuals with diabetes. This study investigates the impact of fasting during Ramadan on the frequency and clinical course of such complications.
Material and Method: This retrospective cross-sectional study included diabetic patients aged 18 years or older who presented to the emergency department (ED) of a tertiary care hospital between 2020 and 2024. Patients were grouped as fasting (≥10 days during Ramadan) or non-fasting. Key diagnoses included diabetic ketoacidosis (DKA), hyperglycemia, and hypoglycemia.
Results: Of the 229 patients (mean age 57.8 years; 56.3% female), 114 were in the fasting group. Both groups were predominantly diagnosed with Type 2 diabetes (85.1% vs. 86.1%). Hypoglycemia accounted for 42.1% of admissions in the fasting group, whereas hyperglycemia was predominant (93%) in the non-fasting group ($p<0.001$). No significant differences were found in in-hospital mortality or mechanical ventilation needs. However, fasting was associated with lower blood glucose levels in Type 2 diabetes patients ($p<0.001$).
Conclusion: Pre-fasting education is essential for effective diabetes management during Ramadan. Continuous education programs supported by updated evidence-based guidelines can mitigate risks and improve outcomes for fasting diabetic patients.

Keywords: Diabetes, emergency, fasting, Ramadan

INTRODUCTION

Diabetes Mellitus (DM) is a chronic systemic pathology characterized by hyperglycemia, resulting from varying degrees of insulin deficiency or resistance to insulin in peripheral tissues (1). The World Health Organization reports that there are currently 422 million people living with DM worldwide, and 1.5 million deaths annually are attributed to DM-related complications (2). The treatment and prevention of DM, a significant global public health issue, are of critical importance. To address this, numerous local and global guidelines on DM management and treatment have been published. These guidelines emphasize not only medical therapy but also lifestyle modifications and dietary habits as integral components of DM prevention and treatment (1,3).

Muslims constitute approximately one-quarter of the global population, with an estimated 1.6 billion Muslims worldwide as of 2010 (4). Ramadan, a sacred month in Islam, corresponds to the ninth month of the lunar Hijri calendar and lasts for 29–30 days. The length of Ramadan is determined based on the lunar calendar, which comprises 354 days per year. Due to the structure of the Hijri calendar, Ramadan cycles through all four seasons over approximately 33 years (5,6). Fasting during the month of Ramadan is obligatory for every healthy adult Muslim according to Islamic teachings (7). This practice involves abstaining from all food and drink from dawn to sunset for approximately 29–30 days. The duration of fasting varies depending on geographical location and season, extending up to 20 hours in some regions. Throughout Ramadan, meals are generally limited to two

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main occasions: Suhoor, the pre-dawn meal, and Iftar, the meal taken immediately after breaking the fast at sunset (4,8). Fasting during Ramadan leads to significant lifestyle changes in individuals, including alterations in sleep-wake cycles, meal frequency and quantity, and physical activity levels. As a result, there may be an increased risk of complications in diabetic patients. Among the acute metabolic complications of diabetes, hypoglycemia, dehydration, hyperglycemia, diabetic ketoacidosis (DKA), and hyperosmolar hyperglycemic state are potential health risks for diabetic individuals observing fasting during Ramadan (4,9,10). Although fasting is one of the five pillars of Islam, in cases where fasting could significantly affect an individual's health or in certain medical conditions, Islam exempts the person from the fasting obligation. Nevertheless, many patients continue to fast despite the permissions of religious authorities and the recommendations of their doctors (8). According to the 2001 Epidemiology of Diabetes and Ramadan (EPIDIAR) study conducted across 13 countries, the percentage of Type 1 DM patients who fasted for at least 15 days during Ramadan was 42.8%, while for Type 2 DM patients, it was 78.7%. In the same study, it was found that 57.8% of Type 2 diabetes patients in Türkiye fasted for at least 15 days. Additionally, the average number of fasting days in Türkiye was 18.1 days for Type 1 DM and 23.9 days for Type 2 DM (11). Therefore, the aim of our study is to investigate the impact of fasting during Ramadan on the frequency and clinical course of acute metabolic complications in diabetes.

MATERIAL AND METHOD

Study Design and Select of Participants

This is a cross-sectional study conducted retrospectively with approval from the local ethics committee (22.04.2024/ Decision No: 2024/82) at a tertiary care hospital between January 1, 2020, and January 1, 2024.

Patients aged 18 and older, who were previously diagnosed with DM and presented to the emergency department between the specified dates with diagnoses of DKA, hyperglycemia, or hypoglycemia, were included in the study. Patients under 18 years of age, those identified as pregnant, and those with missing data in their medical records were excluded from the study.

Patients who met the inclusion and exclusion criteria were divided into two groups based on their fasting status. Those who presented between 01.01.2020 and 01.01.2024 during the Ramadan period, reported fasting for at least 10 days, and adhered to the rituals of fasting such as suhoor and iftar, were categorized into the Fasting group. These patients took their diabetic medications during the suhoor and iftar times. Patients who presented outside of the Ramadan period were included in the Non-fasting group. Within this group, patients were randomly selected from months other than the two months before and after Ramadan, as dietary habits among Muslims tend to differ during those periods.

Hypoglycemia is defined as a blood glucose level of less than 70 mg/dL.

The diagnosis of DKA was made based on the following criteria:

1. **Hyperglycemia:** Blood glucose level >250 mg/dL
2. **Ketosis:** Presence of ketones in the urine or blood
3. **Acidosis:** Arterial pH <7.3 or bicarbonate level <18 mEq/L

The diagnosis of hyperglycemia refers to hyperglycemic conditions that require hospitalization but do not meet the criteria for DKA.

Data Collection

The data collection form included demographic information such as age and gender from the patients' medical records; vital signs at the time of emergency department presentation; laboratory values from blood samples including white blood cell count (WBC, cells/ mm^3), glucose levels (g/dL), creatinine levels (mg/ dL), blood urea (mg/dL), blood gas parameters, lactate (mmol/L), and ketone levels in urine tests.

The patients' hospitalization status (ward/intensive care unit (ICU)), admission diagnoses (hypoglycemia, DKA, hyperglycemia), length of hospital stay, need for mechanical ventilation, and in-hospital mortality were evaluated and recorded on the data collection form.

Statistical Analysis

Statistical analysis was performed using the SPSS V.26 software. The normality of the data was assessed using both analytical and visual methods. Descriptive statistics were presented as mean±standard deviation, median (25th and 75th percentiles), and frequency (%). The analysis of categorical variables was conducted using the Chi-square test. The analysis of continuous and categorical variables was performed using the Mann-Whitney U test and independent T-test, depending on the normality of the distribution. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 229 patients were included in the study, with 114 in the fasting group and 115 in the non-fasting group. The average age of the patients was 57.77±16.80, with 56.3% (n=129) of the patients being female. The majority of participants were diagnosed with Type 2 DM (85.6%). In both groups, patients with Type 2 DM were the majority, and their distribution was similar (85.1% in the fasting group and 86.1% in the non-fasting group). No statistically significant difference was found between the vital signs of the two groups (p>0.05). The median glucose level in the fasting group was significantly lower compared to the non-fasting group (p<0.001). The admission diagnoses differed between the two groups. In the non-fasting group, hyperglycemia was the most common admission diagnosis (93%), while no patients were admitted with

hypoglycemia. In the fasting group, 35.1% of patients were admitted due to hypoglycemia. A statistically significant difference was found between the groups in terms of admission diagnoses (p<0.001). In-hospital mortality and the need for mechanical ventilation were similar in both groups, with no statistically significant relationship found (p-values of 0.543 and 0.993, respectively). The demographic characteristics, clinical, and laboratory findings of the patients in the two groups are shown in Table 1.

Table 1. Relationship between fasting and patient demographic characteristics, clinical and laboratory findings

		Fasting status		
		Non-fasting (n=115)	Fasting (n=114)	p values
Sex; n (%)	Male	51 (44.3%)	49 (43.0%)	0.835*
	Female	64 (55.7%)	65 (57.0%)	
Type of diabetes; n (%)	Type 1 DM	16 (13.9%)	17 (14.9%)	0.830*
	Type 2 DM	99 (86.1%)	97 (85.1%)	
Age (year)		59 (45-68)	60 (47-71.25)	0.555[u]
SBP (mmHg)		134.14±25.23	131.79±23.47	0.466[t]
DBP (mmHg)		77.6±13.57	74.18±15.31	0.075[t]
MAP (mmHg)		96.33 (83.33-106.67)	90 (83.33-100.33)	0.067[u]
Pulse rate (beats/min)		87.49±14.5	85.97±11.04	0.375[t]
WBC count (cells/mm^3)		9.6±3.79	10.32±4.76	0.209[t]
Glucose (mg/dl)		463 (375-561)	339.5 (60.75-502)	**<0.001[u]**
Urea (mg/dl)		23.9±20.45	24.01±16.58	0.966[t]
Creatinine (mg/dl)		1.16±0.67	1.21±0.99	0.662[t]
Sodium (mEq/L)		132.9±5.93	134.55±5.38	**0.029[t]**
Potassium (mEq/L)		4.65±0.6	4.94±4.79	0.510[t]
Chloride (mEq/L)		98.91±5.46	100.83±7.25	**0.025[t]**
pH		7.38±0.07	7.35±0.09	**0.023[t]**
PCO2 (mmHg)		41.66±7.42	41.62±9.35	0.976[t]
PO2 (mmHg)		34.34±15.78	35.88±13.73	0.432[t]
Bicarbonate (mEq/L)		24.23±4.43	23.04±6.2	0.095[t]
Base excess (mEq/L)		-0.86±3.72	-2.09±6.3	0.074[t]
Lactate (mmol/L)		1.97±1.09	2.6±2.75	**0.025[t]**
Keton (Dipstick); n (%)	Negative	93 (80.9%)	100 (87.7%)	**0.015***
	Trace amouth	6 (5.2%)	0 (0%)	
	1 Positive	2 (1.7%)	0 (0%)	
	2 Positive	12 (10.4%)	7 (6.1%)	
	3 Positive	2 (1.7%)	7 (6.1%)	
Hospital admission status; n (%)	Ward	102 (88.7%)	95 (83.3%)	0.242*
	ICU	13 (11.3%)	19 (16.7%)	
Diagnosis on admission to hospital; n (%)	Hypoglycemia	0 (0.0%)	40 (35.1%)	**<0.001***
	Hyperglycemia	107 (93.0%)	60 (52.6%)	
	DKA	8 (7.0%)	14 (12.3%)	
Need for MV; n (%)	No	110 (95.7%)	107 (93.9%)	0.543*
	Yes	5 (4.3%)	7 (6.1%)	
In-hospital mortality; n (%)	No	113 (98.3%)	112 (98.2%)	0.993*
	Yes	2 (1.7%)	2 (1.8%)	

*Chi-Square, [t]Student t test, [u]Mann-Whitney U Test; Values are presented as mean±SD, median (25th and 75th quartile), or n (%); DBP: diastolic blood pressure, DM: diabetes mellitus, ICU: intensive care unit, MAP: mean arteriel pressure, MV: mechanic ventilation, SBP: systolic blood pressure, SD: standart deviation, WBC: white blood cells

A total of 33 patients with Type 1 DM were included in the study, with 17 in the fasting group, while 206 patients had Type 2 DM, of which 97 were in the fasting group. In patients with Type 2 DM, blood glucose levels were significantly lower in the fasting group compared to the non-fasting group (p<0.001). However, in patients with Type 1 DM, there was no statistically significant difference in blood glucose levels between the groups (p=0.081). The demographic characteristics, clinical, and laboratory findings of patients in the two groups for both Type 1 and Type 2 DM are shown in Tables 2 and 3.

Table 2. Relationship between fasting and patient demographic characteristics, clinical and laboratory findings according type 1 diabetes

		Fasting status		
		Non-fasting (n=16)	Fasting (n=17)	p values
Sex; n (%)	Male	8 (50.0%)	10 (58.8%)	0.611*
	Female	8 (50.0%)	7 (41.2%)	
Age (year)		50.5 (35.5-72.25)	44 (29-66.5)	0.763ᵘ
SBP (mmHg)		110 (100-136.75)	129 (120-140)	0.063ᵘ
DBP (mmHg)		70 (62.5-80)	70 (60-78.5)	0.510ᵘ
MAP (mmHg)		83.33 (75-98.33)	86.67 (80.83-93.83)	0.657ᵘ
Pulse rate (beats/min)		85 (71.25-103.5)	90 (84.5-97.5)	0.402ᵘ
WBC count (cells/mm³)		9.875 (6.41-14.1325)	12.11 (9.415-18.56)	0.074ᵘ
Glucose (mg/dl)		514.5 (439-666.75)	417 (282-610.5)	0.081ᵘ
Urea (mg/dl)		25.06±13.29	23.88±13.45	0.802ᵗ
Creatinine (mg/dl)		1.43±1.15	1.41±0.94	0.945ᵗ
Sodium (mEq/L)		131.5 (125.5-135)	132 (127.5-137.5)	0.929ᵘ
Potassium (mEq/L)		4.9 (4.05-5.175)	4.9 (4.4-5.45)	0.683ᵘ
Chloride (mEq/L)		97 (95-100.5)	98 (94-102.5)	0.683ᵘ
pH		7.36 (7.3225-7.38)	7.33 (7.115-7.39)	0.657ᵘ
PCO2 (mmHg)		40 (31.75-44)	41 (27.2-42.8)	0.533ᵘ
PO2 (mmHg)		29.5 (21.25-38.75)	40 (31-54.1)	**0.049ᵘ**
Bicarbonate (mEq/L)		20.7±6.49	18.64±8.92	0.451ᵗ
Base excess (mEq/L)		-0.1 (-8.75-1.5)	-2.2 (-16.5-1.5)	0.423ᵘ
Lactate (mmol/L)		1.75 (1.525-2.475)	1.7 (1.4-2.7)	0.873ᵘ
Keton (Dipstick); n (%)	Negative	3 (18.8%)	9 (52.9%)	**0.010***
	Trace amouth	0 (0%)	0 (0.0%)	
	1 Positive	2 (12.5%)	0 (0.0%)	
	2 Positive	9 (56.3%)	2 (11.8%)	
	3 Positive	2 (12.5%)	6 (35.3%)	
Hospital admission status; n (%)	Ward	8 (50.0%)	12 (70.6%)	0.226*
	ICU	8 (50.0%)	5 (29.4%)	
Diagnosis on admission to hospital; n (%)	Hypoglycemia	0 (0.0%)	3 (17.6%)	0.119*
	Hyperglycemia	10 (62.5%)	6 (35.3%)	
	DKA	6 (37.5%)	8 (47.1%)	
Need for MV; n (%)	No	14 (87.5%)	14 (82.4%)	0.680*
	Yes	2 (12.5%)	3 (17.6%)	
In-hospital mortality; n (%)	No	16 (100.0%)	16 (94.1%)	0.325*
	Yes	0 (0.0%)	1 (5.9%)	

*Chi-Square, ᵗStudent t test, ᵘMann-Whitney U Test; Values are presented as mean±SD, median (25th and 75th quartile), or n (%); DBP: diastolic blood pressure, DM: diabetes mellitus, ICU: intensive care unit, MAP: mean arteriel pressure, MV: mechanic ventilation, SBP: systolic blood pressure, SD: standart deviation, WBC: white blood cells

Table 3. Relationship between fasting and patient demographic characteristics, clinical and laboratory findings according to type 2 diabetes

		Fasting status		
		Non-fasting (n=99)	Fasting (n=97)	p values
Sex; n (%)	Male	43 (43.4%)	39 (40.2%)	0.647*
	Female	56 (56.6%)	58 (59.8%)	
Age (year)		59 (49-68)	62 (48.5-71.5)	0.270[u]
SBP (mmHg)		136.77±24.95	132.78±24.86	0.264[t]
DBP (mmHg)		78.35±13.48	75.19±15.83	0.133[t]
MAP (mmHg)		96.67 (86.67-110)	93.33 (83.33-103.33)	0.054[u]
Pulse rate (beats/min)		85 (78-97)	85 (79-91)	0.627[u]
WBC count (cells/mm^3)		9.52±3.68	9.73±4.42	0.713[t]
Glucose (mg/dl)		462 (363-542)	318 (59.9-459.5)	**<0.001[u]**
Urea (mg/dl)		23.72±21.43	24.03±17.13	0.910[t]
Creatinine (mg/dl)		1.12±0.55	1.18±1	0.614[t]
Sodium (mEq/L)		133.07±5.76	134.93±5	**0.017[t]**
Potassium (mEq/L)		4.64±0.57	4.94±5.18	0.565[t]
Chloride (mEq/L)		99.1±5.54	101.3±7.17	**0.017[t]**
pH		7.38±0.06	7.36±0.07	**0.036[t]**
PCO2 (mmHg)		42.13±6.94	42.51±8.97	0.744[t]
PO2 (mmHg)		30 (23-42)	34 (25.15-43.2)	0.385[u]
Bicarbonate (mEq/L)		24.81±3.74	23.81±5.29	0.128[t]
Base excess (mEq/L)		-0.39±2.46	-1.19±5	0.157[t]
Lactate (mmol/L)		1.97±1.11	2.46±2.33	0.061[t]
Keton (Dipstick); n (%)	Negative	90 (90.9%)	91 (93.8%)	0.058*
	Trace amouth	6 (6.1%)	0 (0.0%)	
	1 Positive	0 (0.0%)	0 (0%)	
	2 Positive	3 (3.0%)	5 (5.2%)	
	3 Positive	0 (0.0%)	1 (1.0%)	
Hospital admission status; n (%)	Ward	94 (94.9%)	83 (85.6%)	**0.026***
	ICU	5 (5.1%)	14 (14.4%)	
Diagnosis on admission to hospital; n (%)	Hypoglycemia	0 (0.0%)	37 (38.1%)	**<0.001***
	Hyperglycemia	97 (98%)	54 (55.7%)	
	DKA	2 (2.0%)	6 (6.2%)	
Need for MV; n (%)	No	96 (97.0%)	93 (95.9%)	0.680*
	Yes	3 (3.0%)	4 (4.1%)	
In-hospital mortality; n (%)	No	97 (98.0%)	96 (99.0%)	0.573*
	Yes	2 (2.0%)	1 (1.0%)	

*Chi-Square, [t]Student t test, [u]Mann-Whitney U Test; Values are presented as mean±SD, median (25th and 75th quartile), or n (%); DBP: diastolic blood pressure, DM: diabetes mellitus, ICU: intensive care unit, MAP: mean arteriel pressure, MV: mechanic ventilation, SBP: systolic blood pressure, SD: standart deviation, WBC: white blood cells

DISCUSSION

EPIDIAR study was conducted in 2001. A total of 12,243 individuals from 13 countries were analyzed for this study. Of these, 8.7% had type 1 diabetes, and 91.3% had type 2 diabetes. The countries involved in the study were Algeria, Bangladesh, India, Egypt, Malaysia, Indonesia, Lebanon, Jordan, Pakistan, Morocco, Tunisia, Saudi Arabia, and Türkiye. EPIDIAR study conducted in 13 countries in 2001 highlighted the need for pre-fasting education and awareness, leading to increased awareness among

relevant clinicians (11). This global awareness is of great importance for our country as well. However, in our country, where a large proportion of the population is Muslim, education and efforts regarding diabetes management during Ramadan are not sufficient. Therefore, in our study, we decided to investigate the impact of fasting during Ramadan on the frequency and clinical course of acute metabolic complications of diabetes, with the aim of emphasizing the importance of necessary pre-fasting education and raising awareness.

DM has emerged as a significant public health issue, with a notable increase in its prevalence in recent years. A review of the literature shows that globally, approximately 90% of diabetes cases are classified as Type 2 and 10% as Type 1 (12). The distribution of diabetes mellitus types among the 229 patients included in our study is consistent with this global trend.

It is estimated that hypoglycemia is responsible for 2-4% of mortality in patients with Type 1 diabetes. Although a reliable estimate is not available for patients with Type 2 diabetes, it is known to be a rare cause of death. Comparing the rates of hypoglycemia, they are several times lower in patients with Type 2 diabetes compared to those with Type 1 diabetes. Reduced food intake is known to be a strong risk factor for hypoglycemia, particularly in patients with diabetes (13). The duration of fasting during Ramadan, where no food is consumed, constitutes a significant factor in this context. The largest dataset on this topic is the EPIDIAR study, which shows that fasting during Ramadan increases the risk of hypoglycemia by 4.7 times in patients with Type 1 diabetes and by 7.5 times in patients with Type 2 diabetes (12). In our study, the fact that 7% of patients in the non-fasting group and 42.1% of patients in the fasting group were admitted to the hospital due to hypoglycemia is consistent with the information in the literature.

In the experimental study conducted by Perk and colleagues, no significant difference was found in blood pressure measurements before and during Ramadan. The study concluded that it is safe for patients who are taking antihypertensive medication to fast while continuing their current treatment (14). The literature on this topic is consistent, and no negative effects of fasting on blood pressure have been demonstrated. In our study, in accordance with the literature, no significant differences were found in vital signs between the two groups.

Prolonged fasting, changes in patients' diets, and dehydration during fasting are thought to increase the risk of DKA in individuals with diabetes. However, in a study conducted by Beshyah and colleagues, data from 283 patients over a 10-year period were analyzed, and no increase in the incidence of DKA during Ramadan fasting was observed (15). In our study, no significant difference was found between the fasting and non-fasting groups regarding DKA, and therefore, our results are consistent with the literature.

Proper education for diabetic patients before Ramadan plays a critical role in achieving successful disease management. Given the complexity of diabetes management, the challenges of maintaining blood glucose balance during fasting, and individual differences, it is essential for healthcare professionals to maintain regular and informative communication with patients. As healthcare providers, we must thoroughly communicate personalized treatment plans to minimize the risks patients may face during fasting and raise awareness about the potential dangers of fasting when necessary. This educational process will not only help maintain health throughout Ramadan but also make a lasting impact on patients' overall health management.

This study has certain limitations. First, it was conducted as a single-center, retrospective study, which may have introduced selection bias. Due to the retrospective design of the study, the antidiabetic medications used by the patients were not recorded, and therefore, their effects could not be evaluated. Additionally, the small sample size poses limitations on the generalizability of the results. Furthermore, hyperosmolar hyperglycemic states were not separately analyzed among hyperglycemic conditions.

Future studies should consider analyzing hyperosmolar hyperglycemic states as a separate category and increasing the sample size to expand the scope of the research. Moreover, conducting multicenter and prospective studies could help eliminate potential biases. Recording the antidiabetic medications used by patients would enable the evaluation of their effects. Consequently, more comprehensive and objective studies could be conducted.

CONCLUSION

In line with this approach, ensuring the continuity of educational programs for diabetic patients and supporting them with annually updated scientific data will remain one of the primary responsibilities of healthcare professionals.

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Research Article

Relationship between Serum Fetuin-B Level and Metabolic Parameters in Patients with Newly Diagnosed Type 2 Diabetes Mellitus

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Abstract

Aim: Fetuin-B, which is part of the fetuin family, has been demonstrated to be related with the emergence of insulin resistance. Here, we examined the relationship between metabolic parameters in treatment-naive patients with diabetes and fetuin B levels in serum.
Material and Method: Individuals aged 30-65 years old who were diagnosed with newly diagnosed diabetes mellitus, had no chronic disease history, and provided informed consent were enrolled in the study. The clinical parameters were examined.
Results: Forty recently diagnosed type 2 diabetic individuals and 43 controls were analyzed in this study. A significant difference was displayed for waist circumference, serum high-density lipoprotein, low-density lipoprotein, alanine transaminase, homeostatic model assessment for insulin resistance, high-sensitivity C-reactive protein, and carotid intima-media thickness (CIMT) between the two groups. The level of serum fetuin-B was determined to be statistically significantly reduced in diabetic patients compared to that in the serum of the controls. In the diabetic group, we showed a negative correlation between CIMT and fetuin-B (p=0.035).
Conclusion: Fetuin-B levels were considerably lower in recently diagnosed type 2 diabetics as equated with those in the control group who had normal glucose levels. Additionally, an inverse association between CIMT and fetuin-B levels among individuals with recently diagnosed type 2 diabetes mellitus.

Keywords: Carotid intima-media thickness, fetuin-B, metabolic parameters, type 2 diabetes mellitus

INTRODUCTION

Diabetes mellitus (DM) has become a pandemic, with a rapidly increasing prevalence worldwide and it is a critical risk factor for cardiac and vascular diseases, making it one of the most significant contributors to this health issue (1). The Framingham study showed that after 20 years of follow-up, the rate of development of atherosclerotic cardiovascular disease increased 2–3 times in diabetic patients compared with non-diabetic individuals (2). Therefore, diabetes is considered to be a cardiovascular disease.

Diabetic individuals are believed to be at a higher risk of cardiac and vascular complications due to the impact of accelerated atherosclerosis. Coronary artery disease (CAD) in diabetic patients occurs at an earlier age, has a more severe prognosis than non-diabetic individuals, and can cause silent myocardial infarction and premature death (1). Therefore, early diagnosis is important for preventing mortality and morbidity. Noninvasive, dependable, and readily evaluation of the carotid arteries by ultrasound is a valuable diagnostic tool. Information regarding the carotid artery can be obtained using this method, which is a characteristic feature of this technique. Various guidelines suggest that carotid intima-media thickness should be considered for individuals with no history of peripheral artery disease, cerebrovascular disease, or CAD, and whose Framingham risk score falls between 10-20% (3,4).

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Fetuins are cysteine protease inhibitors of low molecular weight that are members of the cystatin family (5). Fetuins, the major proteins in fetal life with decreased serum levels in the postnatal period, serve as key proteins in many metabolic pathways (6). They are mainly synthesized in the livers of adults. Human and animal studies showed that they have a role in many pathways, such as their contribution to growth and development through their effect on osteogenesis-bone resorption, their impact in the pathogenesis type 2 DM (T2DM) through the interference with the insulin receptor's intrinsic tyrosine kinase activity, inhibition of the attaching of hepatic growth factor to its receptor in the liver, and the opsonization of cationic molecules which deactivate macrophages and their involvement in the acute phase response of systemic inflammation (7-10). Many studies have indicated a relationship between T2DM, fetuin-B, and fetuin-A (11,12). In our prospective study, we wanted to study the relevance between serum fetuin-B levels, carotid intima-media thickness, and metabolic factors in subjects with recently diagnosed T2DM.

MATERIAL AND METHOD

Patient Selection

Patients diagnosed with diabetes mellitus for the first time and who attended outpatient clinics in internal medicine and endocrinology from August to October 2015. Forty patients with diabetes were selected, and written informed consent was acquired from all the patients. Forty-three normoglycemic individuals who were eligible for the study protocol were included in the control group. This study was conducted using a case-controlled, cross-sectional design. The inclusion criteria for the study were newly diagnosed diabetes, voluntary participation, and age between 30 and 65 years. The exclusion criteria were a history of malignancy, use of chronic medications, renal or hepatic disease, and pregnancy.

Data Collection

Demographic features (age, gender, measurements of the circumference of the waist and hip, and body mass index values) were included for the entire study group. The body mass index (BMI) was determined by dividing the body weight in kilograms by the height in meters squared. A measuring tape was used to measure waist and hip circumferences. The patient's blood pressure was assessed at the brachial artery using an Erka blood pressure monitor following a minimum of 10 min of rest. Insulin resistance was determined based on the Homeostasis Model Assessment (HOMA-IR), which is calculated by multiplying fasting serum insulin (in microunits per milliliter) by fasting serum glucose (in millimoles per liter) and then dividing the result by 22.5. Diabetes mellitus was characterized by a fasting plasma glucose level ≥126 mg/dL, a 2-hour glucose level ≥200 mg/dL during a 75-g oral glucose tolerance test, or HbA1c level ≥6.5% (13). In both the study and control groups, to evaluate glycemic index, HbA1c, fasting, and postprandial plasma glucose tests were used. In addition, fasting serum insulin, serum lipid tests, and kidney and liver function tests (urea, creatinine, AST, ALT) were also performed to evaluate the function of pancreatic β cells. Furthermore, blood samples from study participants were collected and analyzed to determine their hemogram, serum electrolyte, high-sensitivity C-reactive protein (hs-CRP), and thyroid function test levels. An additional 10 cc of blood was drawn to measure the serum fetuin-B level.

Biochemical Assessment

Blood samples were tested at our clinic's laboratory. Blood samples were collected from both groups using vacuum tubes that had a gel separator after an average fasting period of 10 h. Following a 30-minute waiting period to allow the blood samples to clot, they were spun at 3000 rpm for 10 minutes at room temperature. A portion of the collected serum was used for standard biochemical analysis. Standard methods were used to perform routine biochemical tests using a commercially available kit on an automated biochemical. The remaining serum was collected and kept at a temperature of -80 °C until its Human Fetuin B (FETU-B) levels were measured. A commercially available kit (Sunred, Republic of China) utilizing the sandwich ELISA method was employed to measure the serum levels of fetuin-B. Spectrophotometric measurements were obtained using a Multiskan GO ELISA reader (Thermo Scientific, Finland) at a wavelength of 450 nm. The concentrations of fetuin-B in the samples were determined using a standard curve that was constructed by measuring the absorbance of diluted standard solutions. The results were quantified in nanograms per milliliter (ng/ml).

Carotid Ultrasonography

The carotid intima-media thickness (CIMT) was determined using a HITACHI ultrasound device at our hospital's Radiology Clinic. The measurements were conducted by the same clinician to ensure consistency and standardization. During the CIMT evaluation, the patient was positioned in a supine posture. The patient's neck was extended slightly, and their head faced away from the side. Grayscale analysis was initiated using transverse projection. The assessment covered the entire cervical carotid artery. Measurements were conducted on both the carotid arteries in our study. The intima-media thickness is the measurement of the area between the lumen-intima boundary and the media-adventitia boundary. The thickness of the intima-media layer was evaluated at the most substantial portion of both carotid arteries. The means of the measured values were documented.

Statistical Analysis

All analyses were carried out using the Statistical Package for the Social Sciences software (version 18.0; SPSS Inc., Chicago, USA). The Kolmogorov-Smirnov test was employed

to evaluate the dispersion of continuous variables (Fetuin-B distribution was not normally distributed). The results of continuous variables were given as mean±standard error or median (percentage range), according to the distribution. The analysis of laboratory and demographic data for diabetic individuals and controls was conducted using the independent t-test or Mann-Whitney U test. The Spearman correlation analysis was used to correlate Fetuin-B with other laboratory and demographic data. A multiple linear regression model was used to analyze the independent association between fetuin-B levels and HOMA-IR. In our study, p<0.05 was taken into account statistically significant.

Local ethics approval was obtained upon decision of 18.08.2015 No: 2 from the Non-Interventional Clinical Research Ethics Committee of İzmir Bozyaka Training and Research Hospital.

RESULTS

This research comprised 40 cases diagnosed with type 2 diabetes mellitus recently (nT2DM) and 43 healthy individuals without diabetes. Table 1 displays the clinical and demographic features of cases with nT2DM and those in the control group. There were no statistically significant differences in terms of age, sex, and body mass indeks (BMI) between the two groups.

Waist circumference, HOMA-IR, serum ALT, LDL, fasting serum glucose, hs-CRP and insulin levels, and CIMT showed statistically significant increases in the nT2DM group (p=0.013, p=0.025, p=0.036, p<0.001, p=0.033, p=0.004, p=0.033, and p<0,001, respectively). The level of HDL cholesterol serum in individuals with diabetes was noticeably lower (p=0.003) than that of the control group (Table 1).

Table 1. Demographic and clinical characteristics of type 2 diabetic patients and control group

Variables	T2DM n=40	Controls n=43	p
Age, years	52.30±6.72	50.60±8.91	0.329
BMI, kg/m^2	28.75±3.53	28.25±3.01	0.489
Waist circumference, cm	101.05±10.86	95.09±10.37	0.013
Hip circumference, cm	108.10±9.25	104.22±8.22	0.051
Systolic blood pressure, mmHg	119.50±19.47	122.09±19.49	0.546
Diastolic blood pressure, mmHg	78.70±12.10	78.48±12.27	0.937
Serum glucose, mg/dl	190.57±74.56	91.72±8.89	<0.001*
OGTT 2.h, mg/dl	228.00±33.11	118.28±14.07	0.004*
Serum Insulin, µIU/ml	9.30±4.37	6.90±2.52	0.004*
HbA1C %	8.92±2.68	5.36±0.28	<0.001*
Serum urea, mg/dL	27.68±6.37	27.45±6.84	0.875
Serum creatinine, mg/dl	0.82±0.13	0.88±0.18	0.088
AST U/L	21.80±10.89	20.26±3.85	0.403
ALT U/L	26.11±14.38	20.47±6.82	0.025*
TSH, uIU/mL	1.49±0.89	1.73±1.09	0.267
Serum total cholesterol, mg/dl	227.95±42.64	220.72±39.69	0.374
Serum total triglycerides, mg/dl	169.70±75.32	141.53±53.94	0.056
Serum LDL-C, mg/dl	158.70±34.14	140.93±41.74	0.036*
Serum HDL-C, mg/dl	46.65±9.49	62.48±32.21	0.003*
Serum hs-CRP mg/l	4.98±3.56	3.31±2.45	0.033*
HOMA-IR	3.57±2.06	1.98±1.08	<0.001*
CIMT, mm	0.72±0.10	0.67±0.13	0.033*
Serum Fetuin-B, ng/ml	297.00 (283.50-346.75)	318.00 (291.00-592.00)	0.022*

Data are presented as mean±standard deviation or median (interquartile range); *p<0.05 was considered statistically significant; ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, BMI: body mass index, CIMT: carotid intima-media thickness, hs-CRP: high-sensitivity C-reactive protein, HbA1C: hemoglobin A1C, HDL-C: high-density lipoprotein-cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low-density lipoprotein-cholesterol, OGTT: oral glucose tolerance test, TSH: thyroid stimulating hormone

Table 2 shows a substantial negative correlation between serum fetuin-B level and many factors such as BMI, waist circumference, serum insulin level, fasting blood glucose level, and insulin resistance. Additionally, a significant negative association was observed between the levels of fetuin-B and hs-CRP, an inflammatory marker, and CIMT, which indicates cardiovascular risk in two groups. No relevant statistical variations were detected between other variables and the levels of serum fetuin-B. After accounting for other variables, a negative correlation was demonstrated between fetuin-B levels and HOMA-IR, as shown in Table 3.

Table 2. Correlation analysis between fetuin-B and metabolic variables

	Fetuin-B			
	T2DM		Control	
	r	p	r	p
Age	0.124	0.163	0.116	0.256
BMI	-0.241	0.039*	-0.142	0.045*
Waist circumference	-0.267	0.033*	0.167	0.042*
Systolic blood pressure	0.136	0.353	0.223	0.456
Diastolic blood pressure	0.216	0.237	0.178	0.325
CIMT	-0.244	0.035*	-0.131	0.041*
Insulin	-0.285	0.009*	-0.141	0.040*
FBG	-0.148	0.021*	-0.112	0.045*
HOMA-IR	-0.218	0.015*	-0.133	0.042*
hs-CRP	-0.352	0.007*	-0.191	0.011*
Total cholesterol	0.218	0.236	0.103	0.238
LDL-C	0.105	0.215	0.112	0.176
HDL-C	0.112	0.213	0.103	0.143
Triglycerides	0.203	0.239	0.127	0.562

*p<0.05 was considered statistically significant; BMI: body mass index, CIMT: carotid intima-media thickness, hs-CRP: high sensitivity C-reactive protein, HDL-C: high-density lipoprotein-cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low-density lipoprotein-cholesterol

Table 3. The multiple-linear regression analysis of the relationship between fetuin-B and HOMA-IR

	β	95% CI		P
		Lower	Upper	
Fetuin-B	-0.305	-0.398	-0.212	0.011*
Fetuin-B + age + BMI	-0.296	-0.357	-0.235	0.014*
Fetuin-B + age + BMI + hs-CRP	-0.279	-0.335	-0.223	0.016*
Fetuin-B + age + BMI + hs-CRP + lipids	-0.278	-0.335	-0.221	0.016*

*p<0.05 was considered statistically significant; BMI: body mass index, hs-CRP: high sensitivity C-reactive protein

DISCUSSION

In our study, we demonstrated lower serum levels of fetuin-B levels in subjects with nT2DM than the healthy subjects. Our multiple linear regression analysis demonstrated that lower fetuin-B levels served as a risk factor for insulin resistance independently. Our findings contradict to those of some articles, which have demonstrated that increased levels of serum fetuin-B are linked to insulin resistance (12,14-17). Moreover, in another research article, plasma fetuin-B levels exhibited a positive correlation with newly diagnosed T2DM (18). Various studies have displayed a notable association between increased serum fetuin-B levels and non-alcoholic fatty liver disease (NAFLD) (19-21). In one of these studies, after controlling for metabolic syndrome, the authors indicated that fetuin-B level was not an independent predictor of T2DM (21). The demonstrated pathophysiological mechanism was that NAFLD caused an elevation in serum fetuin-B levels, indicating that NAFLD was the main independent risk factor for developing type 2 DM. As a result, it can be stated that fetuin-B is a bridging component which is affected by other pathological conditions, increasing insulin resistance and causes hyperglycemia, but is not a main etiological factor in the development of DM.

In the current study, hs-CRP levels were notably greater in the nT2DM group than in the healthy individuals. Fetuin-B has been first described by Olivier et al. and the researchers discovered that levels of fetuin-B messenger RNA in the livers of rats decreased in response to systemic acute-phase inflammation (5). In agreement with the literature, lower fetuin-B levels in nT2DM may be attributed to the newly developed inflammation caused by hyperglycemia in our study. Similarly, Yakout et al. stated fetuin-B level was not associated with insulin resistance parameters in pregnant women with gestational DM, which might be a result of inflammation caused by pregnancy interfering with alterations in fetuin-B levels (22).

In the literature, only two studies were performed to investigate the connection between atherosclerosis and fetuin-B levels. The first one included 1140 obese individuals, and the authors showed a relationship between brachial ankle pulse wave velocity and fetuin-B level (23). However, this significance disappeared after adjusting for insulin resistance. Moreover, the relationship between

ankle-brachial index and fetuin-B levels was insignificant in the same study. In contrast, in a different study, the plasma protein profiles of subjects with restenosis inside the stents were compared to patients without restenosis, and fetuin-B was discovered to be significantly higher in individuals with in-stent restenosis in the latter study (24). In disagreement with these limited reports, we demonstrated an inverse correlation between CIMT and fetuin-B levels in both nT2DM and healthy subjects. As previously mentioned, the possible mechanism for this outcome is the compensatory decrease in fetuin-B as a stress response to recently developed hyperglycemia in the nT2DM group or any other factor inducing atherosclerosis in the controls.

The modest size of the sample in the current research is considered a limitation. Our study was planned as a pilot study due to the absence of data on the effects of fetuin-B during the period this investigation was conducted. Nevertheless, many original articles which included larger sample sizes have been reported within the prolonged period between data collection and the construction of the manuscript. In short, our limited sample size might be a possible reason for the conflicting outcomes of our study compared to the majority of recent literature data. On the other hand, the strength of this research is its prospective nature and the situation that carotid ultrasonography was performed by the same radiologist during the whole study period.

CONCLUSION

In conclusion, a significant lesser degree of fetuin-B levels was demonstrated in individuals with nT2DM than the controls who had normal blood sugar levels. Our logistic regression analysis indicated low fetuin-B levels were an independent risk factor for developing insulin resistance. Moreover, there existed a substantially inverse association between CIMT and fetuin-B levels in both groups. Future prospective studies are required to evaluate the proposed compensatory mechanism, which is the decrease in serum fetuin-B levels in individuals with nT2DM and the elevation of fetuin-B levels through the development of advanced DM and cardiometabolic complications.

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MEDICAL RECORDS-International Medical Journal

Research Article

Evaluation of Third Molars According to the Operative Difficulty Score

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Abstract

Aim: Third molars (M3) are the most common type of impacted tooth, and the prevalence of impaction varies between 27% and 68.8%. The aim of this study was to evaluate M3 according to their operative difficulty score and angulation.

Material and Method: A total of 1000 patients who returned to our clinic for M3 extraction were included in the study. Preoperative clinical and radiological operative difficulty scores (ODS) and angulations were evaluated from 0 to 6. Descriptive statistics were performed.

Results: When M3 were evaluated according to ODS, 343 (34.3%) were ODS 1, 106 (10.6%) were ODS 3, 327 (32.7%) were ODS 4, 188 (18.8%) were ODS 5 and 36 (3.6%) were ODS 6. When evaluated according to their angulations, 621 (62.1%) M3 were found in the vertical position, 184 (18.4%) in the mesioangular position, 70 (7%) in the horizontal position, 104 (10.4%) in the distoangular position, and 21 (2.1%) in the buccolingual-palatal position.

Conclusion: This study will allow the evaluation of the level of difficulty before the operation in the surgery of the M3 and the creation of a better treatment plan. Thus, perioperative and postoperative complications can be minimized.

Keywords: Classification, oral surgery, third molar

INTRODUCTION

Among the molar teeth located on the maxilla and mandible, the Third molars (M3) are the teeth that are the most diverse in terms of morphology and location (1). For this reason, M3 tooth extraction is important in routine oral surgery procedures performed by oral surgeons (2). Molar teeth may also remain impacted for local and systemic reasons, such as inadequate growth, inadequate mandibular distance for tooth eruption, adverse growth direction, early completion of physical maturation, hormonal activity disorders, various syndromes and sometimes high bone density (3). M3, which can be found in the mouth as erupted or impacted, can cause conditions such as infection, decay, and periodontal damage to neighboring teeth and can also pose an obstacle to prosthetic and orthodontic procedures (4). According to the literature, the most commonly impacted teeth, impacted M3, can also cause pericoronitis, osteomyelitis, cysts and atypical pain (5). The most common postoperative complications after M3 extraction are alveolar osteitis and local infection, but severe pain, swelling, trismus, secondary bleeding, and paresthesia of the inferior alveolaris n. may also occur. To prevent possible complications or to treat complications with minimal damage, the level of difficulty of extraction must be carefully evaluated in each patient (6).

The principal radiographic tools are periapical and panoramic radiographs, and the small size of periapical radiographic images can make it difficult for the practitioner to visualize M3 that are deeply positioned in the jaws. This can cause discomfort to the patient or result in incomplete visualization of the anatomy of the tooth during exposure (7). Radiographic variables such as the size and shape of the crown of the tooth; the number, size and curvature of the roots; the position and condition of the impacted tooth; and the presence or absence of the periodontal ligament and its relationships with adjacent structures can be analyzed with an Ortopantomography (OPG) (8). In all cases, preoperative determination of the level of surgical difficulty is important for proper treatment planning.

CITATION

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This will enable the preparation of the correct materials, determination of the surgical access point, selection of the appropriate technique and type of anesthesia, and determination of whether the operator's experience and abilities are compatible with the extraction to be performed (6). This study aims to evaluate the angulation of the M3, the operative difficulty scores (ODS), and the jaw where the patient is located, using demographic data such as age and sex, along with panoramic radiography data that are easily used in clinical practice.

MATERIAL AND METHOD

Data Collection

Our study used retrospective data of M3 molars obtained from 1000 patients who presented at our clinic with complaints of M3 between September 2017 and July 2024. Before the study, approval was obtained from the Eskişehir Osmangazi University Non-Interventional Clinical Research Ethics Committee (Decision Date: 23.07.2024/ Decision Number: 30), and the study was conducted in accordance with the Helsinki Declaration of Human Rights. While male and female patients with M3 were included in the study, patients without M3 due to genetic, syndromic or congenital reasons were excluded from the study.Before M3 surgery, panoramic radiographs were taken from all patients, and the M3 were divided into different groups according to their angularities: vertical, mesioangular, distoangular, horizontal, buccolingual or buccopalatinal. M3s were also classified according to the ODS in the study by Lang et al. (9) This classification was performed by a single surgeon after both clinical and radiological examinations before surgery, and an ODS value from 0 to 6 was determined for each M3. The ODS scores were as follows: 0: no extraction needed, 1: nonsurgical erupted, 2: surgical erupted, 3: impact on soft tissue, 4: partial impact on the bone, 5: complete impact on the bone, and 6: complete impact on the bone but in a difficult position to reach (complicated or difficult). The ODS value for each M3 was determined from 1 (erupted without surgery) to 6 (completely impacted in bone and difficult to extract). The ODS scoring was prepared based on Saruhan's study (10).

Statistical Analysis

The data were recorded in a spreadsheet (Excel 2010; Microsoft, USA) and then analyzed via SPSS version 22.0. The jaw location of M3, sex, angulation and ODS were correlated and are shown as frequencies and percentages. Quantitative variables are shown as the minimum, maximum and mean.

RESULTS

The patients who underwent tooth extraction were between 16 and 79 years old, and the average age was 28.58±9.87 years. Among the 1000 patients who underwent tooth extraction, 608 were female (60.8%), and 392 were male (39.2%). The age range of the female patients was between 16 and 70 years, and the average age was 26.9±8.97 years. The age range of the male patients was between 18 and 79 years, and the average age was 31.18±10.62 years. When the extracted teeth were evaluated according to their jaw location, 459 (45.9%) lower M3 were extracted, whereas 541 (54.1%) upper M3 were extracted. When the M3 were evaluated according to their angulation, 621 (62.1%) M3s were found in the vertical position, 184 (18.4%) in the mesioangular position, 70 (7%) in the horizontal position, 104 (10.4%) in the distoangular position, and 21 (2.1%) in the buccolingual-palatinal position. According to the ODS, 343 (34.3%) of the M3s included in the study were ODS 1, 106 (10.6%) were ODS 3, 327 (32.7%) were ODS 4, 188 (18.8%) were ODS 5, and 36 (3.6%) were ODS 6.

The angulations of the teeth according to sex are shown in Table 1. In male and female patients, most teeth were in the vertical position, whereas the fewest teeth were in the buccolingual position. The ODS scores by sex are also shown in Table 2. For both genders, most tooth extractions were performed on teeth with ODS 1. The ODS scores by jaw localization are shown in Table 3. According to the table, the most extracted tooth in the maxilla was ODS 1, whereas in the mandible, ODS 4 was found.

Table 1. Descriptive statistics of tooth position by gender

		Frequency (N)	Percent (%)
Female	Vertical	381	62.7
	Mesioangular	115	18.9
	Horizontal	27	4.4
	Distoangular	73	12
	Buccolingual-palatinal	12	2
	Total	608	100
Male	Vertical	240	61.2
	Mesioangular	69	17.6
	Horizontal	43	11
	Distoangular	31	7.9
	Buccolingual-palatinal	9	2.3
	Total	392	100

Table 2. Descriptive statistics of ODS by gender

		Frequency (N)	Percent (%)
Female	ODS 1	198	32.6
	ODS 2	-	-
	ODS 3	64	10.5
	ODS 4	197	32.4
	ODS 5	126	20.7
	ODS 6	23	3.8
	Total	608	100
Male	ODS 1	145	37
	ODS 2	-	-
	ODS 3	42	10.7
	ODS 4	130	33.2
	ODS 5	62	15.8
	ODS 6	13	3.3
	Total	392	100

Table 3. Descriptive statistics of ODS according to jaw location			
		Frequency (N)	Percent (%)
Maxilla	ODS 1	257	56
	ODS 2	-	-
	ODS 3	47	10.2
	ODS 4	62	13.5
	ODS 5	62	13.5
	ODS 6	31	6.8
	Total	459	100
Mandible	ODS 1	86	15.9
	ODS 2	-	-
	ODS 3	59	10.9
	ODS 4	265	49
	ODS 5	126	23.3
	ODS 6	5	0.9
	Total	541	100

DISCUSSION

It has been reported in the literature that M3 may reach normal occlusion partially or completely or may remain partially or completely impacted in the maxillary or mandibular arch (11). There are several theories about the cause of impaction; insufficient space and mechanical obstacles (cysts, tumors, tissue hyperplasia, local infections, etc.), as well as local and systemic factors such as trauma, vitamin deficiencies, malnutrition, hormonal disorders and some syndromes, may cause this situation (12). M3s are the most frequently impacted teeth in the oral cavity, followed by impacted canine teeth (13). Surgical extraction of M3s is one of the most common surgical procedures performed in oral, dental and maxillofacial surgery clinics (10). In clinical practice, M3s frequently cause problems such as the risk of recurrent pericoronitis, swelling, caries formation in adjacent teeth, root resorption and dysfunction, facial and referred pain of unknown cause, periodontal, prosthetic and orthodontic conditions, and pathological lesions such as cysts and tumors (14,15). Preoperative evaluation of the degree of difficulty of M3 surgery is one of the important factors to consider (16). Many factors affect the difficulty of surgical extraction of M3s. Age, body mass index (BMI), body surface area, race, surgeon experience, extraction method, number of teeth extracted, depth of impaction, ramal relationship, tooth angle, root development, root curvature, relationship to the mandibular canal, root width, patient anxiety, and other factors are thought to affect the difficulty of extraction, but researchers do not agree on the relative effects of these factors (17,18). In their study of 2978 patients, Lang et al. (9) classified the M3s according to the ODS, with 4 M3s in each patient, as upper-lower and right-left, and evaluated the ODS value between 0–6 and determined the ODS value between 0–24, with a score of 4*6 for each patient. They extracted an average of 3.2 teeth from each patient and evaluated the total ODS in the jaw, finding a total score of 12±6.5. They also reported a relationship between gender and ODS. Saruhan (10) reported that 27 (22.5%) of the M3s were ODS 3, 29 (24.2%) were ODS 4, 53 (44.2%) were ODS 5, and 11 (9.1%) were ODS 6 according to the ODS. The author also evaluated the M3s according to their angulation. The author reported that 65 (54.2%) impacted teeth were in the vertical position, 28 (23.3%) were in the mesioangular position, 10 (8.3%) were in the distoangular position, 14 (11.7%) were in the horizontal position, and 3 (2.5%) were in the buccolingual-palatal position. When the ODS was evaluated according to age ranges, the average age was found to be 25,09±8,3. Author reported that the difficulty level of extractions was high in young patients in the population he evaluated by finding the highest score of 5 in the ODS evaluation (10). In his study, Gümrükçü et al. (19) also listed the tooth positions of 684 patients according to the Winter classification. He reported that there were 369 teeth in the vertical position, 249 in the mesioangular position, 45 in the horizontal position, 10 in the distoangular position, and 11 in the buccolingual position. Mahdey et al. (20) evaluated panoramic radiographs of 1249 patients aged between 20 and 44 years. They reported that the operative difficulty score was greater in female patients than in male patients. In our study, the teeth to be surgically extracted were evaluated according to their operative difficulty scores and angulations. In our study, the tooth in the vertical position was the most common tooth, and in the comparison between genders, the tooth in the vertical position was the most common tooth in male and female patients. ODS is different from the literature, whereas ODS 1 is the most common in extracted teeth, when evaluated according to jaw localization, teeth with ODS 4 were extracted in the mandible. Although the average age of the patients in our study is similar to the average age found by Saruhan (10), we can say that more complicated extractions can occur at younger ages by finding ODS 4.In addition, ODS was evaluated not as the total ODS in the patient's jaw but as each ODS in the extracted teeth. In M3 surgery, preoperative radiographic examination is very important to guide the surgical procedure for different types of impacted M3. The type of impacted tooth is routinely evaluated easily and frequently via the OPG. The magnification ratio of the OPG is lower, and the reliability is higher when the correct position of the head is provided. Therefore, the data obtained via OPGs can provide reliable measurement values before M3 surgery. In light of this information, the evaluation of the impacted type of tooth and the measurement via OPGs can be used as standard and reliable methods in oral and maxillofacial surgery/ radiology (19,21). We used the OPG, which is the gold standard, in the evaluations in our study.

CONCLUSION

The degree of difficulty of extracting teeth from the lower jaw was greater than that from the upper jaw, and no significant difference was found between the sexes. Estimating the difficulty index in M3 surgery before surgery will be an important practice in preventing or minimizing postoperative complications by ensuring that the dentist is prepared for complications that may be encountered during surgery.

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MEDICAL RECORDS-International Medical Journal

Research Article

Demographic Characteristics of Patients who Underwent Dual-Energy X-Ray Absorptiometry According to Age and Clinical Department

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Abstract

Aim: The aim of this study was to retrospectively assess the bone dual-energy x-ray absorptiometry (DXA) with the prolongation of human living all over the world results taken over a year along with the demographic characteristics of the patients.
Material and Method: This study was performed at the Department of Radiology, Harran University Hospital between January 1, 2022 and January 1, 2023. Bone DXA examinations requested from all clinical departments within a one-year period were investigated. Osteoporosis (OP) was evaluated considering clinical department-based six groups and age-based four groups.
Results: A total of 1366 patients from all clinical departments such as physical medicine and rehabilitation (PMR), orthopedics, neurology, endocrine, obstetrics and other branches who requested bone DXA were included in the study. Of these, 1166 (85.36%) were women and 200 (14.64%) were men. The PMR was the most frequently prompted clinical department with 721 (52.78%) patients. The OP frequency was highest in the group aged 65 years and older. The lowest OP frequency was seen in the group aged 64 years and younger.
Conclusion: The prevalence of osteoporosis increases with age and the prevalence of OP is higher in women. More than half of DXA requests belong to the PMR department. The PMR department have an important role in the diagnosis and treatment of OP.

Keywords: Osteoporosis, physical medicine and rehabilitation, dual-energy x-ray absorptiometry, age

INTRODUCTION

Osteoporosis (OP) is defined as a systemic bone disease characterized by microarchitectural deterioration in bone tissue, decrease in bone mineral tissue, and consequently increased bone fracture risk (1). It is a common disease in postmenopausal women. It is estimated that one in five men and one in three women over the age of 50 will experience an OP-related fracture, resulting in pain, limitations in quality of life, morbidity, and increased mortality. The clinical manifestation of OP is the fragility fracture, and approximately 80% of all fractures are associated with OP (2,3).

Although fragility fractures cause many problems, OP is still insufficiently diagnosed and untreated. The most common bone measurement test used to scan the OP is dual-energy x-ray absorptiometry (DXA); other screening tests include peripheral DXA and quantitative ultrasound. The central DXA measures bone mineral density (BMD) in the hip and lumbar spine. While the diagnosis of OP with the presence of a fragile fracture is considered universal, BMD measurement by DXA can accurately diagnose OP before the fracture occurs (3-5).

With the increase in life expectancy worldwide and the increase in the elderly population, there is a parallel increase in chronic diseases. Today, it is estimated that more than 200 million people have osteoporotic. In Türkiye, OP stands out as an important health problem due to the aging of the population (6).

The aim of this study was to retrospectively evaluate that how much the bone DXA taken in an university hospital for a year are requested from which departments and how much of their results are compatible with OP, together with the demographic characteristics of the patients.

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MATERIAL AND METHOD

The study was carried out in the Department of Radiology at Harran University Hospital. In the radiology department, bone DXA examinations requested from all clinical departments during the one-year period between 01-01-2022 and 01-01-2023 were examined. The results of adult patients aged 18 and over were evaluated in the study. Harran University Rectorate Clinical Research Ethics Committee approved the study protocol (decision number: HRÜ/23.11.29, decision date: 19 June 2023). In accordance with the comments of the Declaration of Helsinki, the study was planned, performed and completed.

Interpretation of BMD Results

All anthropometric measurements of the patients were evaluated and recorded. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height in meters. The BMD measurement was performed using the Hologic QDR 4500 DXA scanner device (Bedford, Boston, MA, USA). Measurements included the femoral neck and the lumbar spine regions.

According to the WHO diagnostic classification including DXA results, OP is defined by T-score, which is an indicator of BMD, at the hip or lumbar spine regions equal to or less than -2.5 standard deviations relative to the mean T-score of the young adult reference population. If the BMD value is between -1.0 and -2.5 as a result of bone DXA measurement, it is defined as osteopenia or low bone mass. If the BMD value is -1.0 or higher, it is defined as normal (7).

Statistical Analyses

In the present study, all statistics and measurements were made using IBM SPSS 27 Statistics version. The data were presented as number (persentage) or mean±SD (min.-max.).

RESULTS

A total of 1366 patients from all clinical departments (PMR, orthopedics, neurology, endocrine, obstetrics and other branches) who requested bone DXA were included in this study. Of these, 1166 (85.36%) were women and 200 (14.64%) were men. The PMR was the most frequently prompted department with 721 (52.78%) patients. This was followed by the orthopedics department with a request of 369 (27.01%) patients. Gender distributions in the clinical department-based groups is given in Table 1. In terms of gender distributions, there was a majority of women in all groups.

Table 1. Gender distributions in the clinical department-based groups

	1 (n=721)	2 (n=369)	3 (n=93)	4 (n=70)	5 (n=40)	6 (n=73)	7 (n=1366)
Gender							
Female	621 (86.13%)	329 (89.16%)	75 (80.65%)	70 (100.0%)	21 (52.50%)	50 (68.49%)	1166 (85.36%)
Male	100 (13.87%)	40 (10.84%)	18 (19.35%)	0 (0.0%)	19 (47.50%)	23 (31.51%)	200 (14.64%)
Total	721 (52.78%)	369 (27.01%)	93 (6.80%)	70 (5.12%)	40 (2.94%)	73 (5.35%)	1366 (100%)

1: physical medicine and rehabilitation, 2: orthopedics and traumatology, 3: endocrinology, 4: gynecology and obstetrics, 5: neurology, 6: other departments [gastroenterology (21)+infectious diseases (21)+algology (17)+internal medicine (10)+family medicine (2)+surgical oncology (1)+urology (1)], 7: all cases

The average age of the patients at the time of admission was 59.32±12.8 (distribution between 18-99 years) years. The patients were divided into 4 groups according to age-based groups. When we look at the age-based groups; 896 (65.6%) were in the 18-64 age group, 470 (34.4%) were in the 65-year-old and older group, and 1064 (77.9%) were in the 50-year-old group. The frequency of females in the age-based groups was prominently higher.

The mean BMI values of the patients according to age-based groups were slightly fat. The total BMI values were 31.64±6.3 kg/m² (16.2-54.7). Age, BMI, and gender scores in the age-based groups are given in Table 2.

Table 2. Age, BMI, and gender scores in the age-based groups

	1: ≤64 years (n=896)	2: ≥65 years (n=470)	3: >50 years (n=1064)	4: All years (n=1366)
Age, yrs	72.41±9.63 (18-64)	72.49±6.0 (65-99)	64.35±8.76 (51-99)	59.32±12.81 (18-99)
BMI, kg/m²	31.49±6.23 (16.22-54.67)	31.91±6.31 (16.65-53.83)	32.35±6.07 (16.65-54.67)	31.64±6.26 (16.22-54.67)
Gender				
Female	772 (86.16%)	394 (83.83%)	922 (86.65%)	1166 (85.36%)
Male	124 (13.84%)	76 (6.17%)	142 (13.35%)	200 (14.64%)

According to BMD value, the frequency of OP in the lumbar spine and femoral neck was highest in the group aged 65 years and older. The lowest OP frequency in the lumbar spine and femur neck regions was seen in the group aged 64 years and younger. The lumbar spine and femur neck regions OP frequencies in the age-based groups are shown in Table 3.

Table 3. Lumbar spine and femur neck OP frequency in the age-based groups				
	1: ≤64 years (n=896)	2: ≥65 years (n=470)	3: >50 years (n=1064)	4: All years (n=1366)
Lumbar spine				
Normal	263 (29.35%)	95 (20.22%)	241 (22.65%)	358 (26.21%)
Osteopeni	388 (43.31%)	186 (39.57%)	442 (41.54%)	574 (42.02%)
Osteoporosis	245 (27.34%)	189 (40.21%)	381 (35.81%)	434 (31.77%)
Femur neck				
Normal	700 (78.13%)	229 (48.72%)	684 (64.29%)	929 (68.01%)
Osteopeni	177 (19.75%)	200 (42.55%)	325 (30.54%)	377 (27.60%)
Osteoporosis	19 (2.12%)	41 (8.72%)	55 (5.17%)	60 (4.39%)

DISCUSSION

Despite having a younger population and OP rates compared to European countries, there has been an increase in the incidence of OP disease in the last 20 years in Türkiye. The diagnosis and follow-up of patients with OP is mainly administered by PMR, endocrinology, rheumatology, internal medicine, orthopedics and gynecology specialists (8). In current study, it was seen that the bone DXA was requested by PMR (52.8%), orthopedics (27%), endocrinology (6.8%), gynecology (5.1%) and neurology (2.9%) in order of frequency. Since the rheumatology department was not in the hospital, it did not make any DXA requests.

A recent comprehensive systematic review and meta-analysis presented the prevalence of OP in the world and by continents. According to this study, Asia (16.7%), Europe (18.6%), America (12.4%), Africa (39.5%), Australia (13.5%) between continents. Accordingly, the highest prevalence of OP was reported in Africa with 39.5%. In this study, it was reported that the prevalence of OP in the world was 18.3%. The prevalence of OP in women around the world was 23.1% and the prevalence of OP was reported as 11.7% in men (9). In current study, the prevalence of OP was 33.1%. Again, in our study, the prevalence of OP in women was 33.6% and 30.0% in men. The reason why the OP rate is high in male patients may be the low number of DXA required from male patients.

In another study, the prevalence of OP was evaulated in various industrialized countries (USA, Australia, Canada, Japan and five European countries) with people aged 50 and over. According to the study, the incidence of OP in the spine and hip region was found to be the most common in Japan at 26.3%, in the USA at 21%, in Germany at 14.3% and the least in Australia at 2% (9,10). The present study showed that the frequence of OP in patients over the age of 50 was 35.8% and 5.2% in the in the spine and hip, respectively; the frequence of OP in patients under the age of 65 was 27.3% and 2.1% in the spine and hip, respectively. Finally, the frequence of OP in patients 65 years and older was 40.2% and 8.7% in the spine and hip, respectively. According to the study conducted earlier on 26424 Turkish citizens over the age of 50, the prevalence of femur neck OP was estimated to be 7.5% in men and 33.3% in women. The prevalence of OP is increasing with age, and the general prevalence in men and women aged 50 and over is calculated as 22.2% and 27.2% for Türkiye, respectively. A newly published prevalence study identified 4,253,039 OP patients, corresponding to 4.9% of Türkiye's country's population. In addition, when viewed throughout the country, a prevalence of 0.8% was obtained in Şanlıurfa, 6.1% in the southeast (11-13). The present study was conducted in Şanlıurfa, and in all patients looked at, 32.3% in the lumbar was 4.3% in the lumbar, while in men, 29.0% in the femor neck were 5.0% in the lumbar. According to our findings, while the OP rate was low in the femur neck, the OP rate was found to be high in the lumbar region.

Study Limitations

The results of this study may be misleading regarding the prevalence of OP since it is not known whether the DXA examination was performed for the first time or for follow-up purposes. Because bone DXA scores in patients receiving OP treatment may show lower prevalence of OP due to improvement. Therefore, it would be more realistic to perform prevalence analysis in patients not receiving OP treatment. Another limitation may be that a standard OP cut-off values were used for all age groups. Since the evaluation was retrospective, the demographic data of the patients and secondary causes of OP could not be assessed completely.In addition, since the study was conducted in only one hospital, the results cannot be generalized to the entire region and country. Despite these limitations, this study can be a source for future studies in the literature.

CONCLUSION

Today, due to the aging population, the number of OP patients increases over the years. The prevalence of osteoporosis increases with age and the prevalence of OP is higher in women. The increase in OP causes an increase in both the disability rate and treatment costs due to OP fractures. In this study, more than half of DXA requests belong to the PMR department. The PMR department have an important role in the diagnosis and treatment of OP. In the future, OP should have an important place in the assistant training, especially in PMR department, in terms of health policies.

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MEDICAL RECORDS-International Medical Journal

Research Article

Readability Analysis of Web Pages Providing Information on the Relationship Between Gingival Diseases and Heart Health

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Abstract

Aim: This study aimed to evaluate the readability of Turkish-language texts that provide information about the relationship between gingival diseases and heart health on the internet.
Material and Method: The keywords "gingival diseases and heart health relationship" were entered into the Google search engine. As a result of the search, the first 60 pages with Turkish content that provided patient information on the subject and could be accessed directly without any membership requirement were included in the study. Repeated web pages, academic publications, images, video content, and sites for advertising commercial products were not included in the study. The texts obtained were evaluated according to the Ateşman Readability Index.
Results: Forty-six of the first 60 sites found in the search met the inclusion criteria. When the texts included in the study were examined according to their sources, it was found that 43.5% were pages of dental clinics, 26.1% of private hospitals, 10.9% of university hospitals, 10.9% of media news pages, 4.3% of professional organizations, 2.2% of cardiology clinics and 2.2% of state hospitals. It was determined that 60.87% of the texts on the pages were at "medium" and 39.13% were at "difficult" readability level.
Conclusion: According to the results of the study, it was determined that the informative texts about "The relationship between gingival disease and heart health" published on Turkish websites have medium and difficult readability levels. In order to make such informative texts easier and comprehensible to read, it would be useful to adjust the language level of the text by using readability tools by the author before publication.

Keywords: Readability, internet, gingival diseases, heart health, heart diseases

INTRODUCTION

Internet usage is increasing every year in the world and in Türkiye. According to the results of the "Household Information Technology Usage Survey" conducted by the Turkish Statistical Institute (TÜİK) in 2023, the proportion of households with access to the internet increased to 95.5% and the internet usage rate of individuals aged 16-74 increased to 87.1% (1). According to another survey conducted by TÜİK in 2019, 69.3% of internet users use the internet to obtain information on health-related issues (2). People increasingly turn to the internet to obtain health-related information every year (3). Therefore, websites that provide health-related information should, first of all, be easy to read and understand by people (4). Having reliable and accurate information content is another important dimension.

Readability refers to the degree of ease or difficulty of understanding the text written in any language by the reader (5). Various formulas and indices have been developed to evaluate readability according to objective criteria. For example, while formulas such as SMOG measurement value, Gunning Fog value, Automatic Readability Index, Fresch Reading Ease Score, Flesch-Kincaid Grade Level are frequently used for English, the Ateşman readability formula developed by Ender Ateşman is used for Turkish (6). Ateşman studied texts of different difficulty levels and belonging to different fields and determined an index to classify them according to the level of ease-difficulty for the reader. According to Ateşman's readability index, texts with a score of 90-100 are classified as very easy; 70-89 as easy; 50-69 as medium difficulty; 30-49 as difficult; and 1-29 as very difficult (7) (Table 1). This index is based on

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average word and sentence length. The index is calculated with this formula : 198,825 - (40,175 x Average Word Length) - (2,610 x Average Sentence Length).

Table 1. Readability classification according to the Ateşman readability index range

Ateşman readability classification	
Very easy	90-100
Easy	70-89
Medium difficult	50-69
Difficult	30-49
Very difficult	1-29

The degree of ease and difficulty of a text depends, of course, on the level of education of the reader. The higher the level of education, the higher the degree of comprehension of difficult texts. Flesch's Ease of Reading classification is used in this regard. Ateşman took this classification as a basis when he created his own readability classification. According to this classification, the text is scored between 1 and 100 to determine the level of education at which it is easily comprehensible. A score of 100 indicates that the text is easily comprehensible even by individuals with the lowest level of education and therefore has a high readability (Table 2) (8). As the readability level of a text decreases, the effectiveness of the information and directions on the web page will also decrease (9).

Table 2. Readability classification according to the Flesch readability index range

Flesch readability classification	
Grade 4 and below	90-100
5-6. grade	80-89
7-8. grade	70-79
9-10. grade	60-69
11-12. grade	50-59
Associate degree	40-49
Bachelor's degree	30-39
Postgraduate	1-29

Periodontal diseases are chronic or acute inflammatory destructive diseases affecting the teeth and their supporting tissues. It is highly prevalent worldwide, with an estimated prevalence of 20%-50%, increasing with age (10). Since it is an infectious, inflammatory disease, inflammatory mediators and other disease-causing agents that spread throughout the body through blood and saliva during the disease have the potential to spread to many different parts of the body and directly or indirectly cause disease in other organs. Scientific studies have shown that periodontal diseases are associated with many systemic diseases (11-14). One of these is cardiovascular diseases (CVD). CVD is one of the leading causes of death worldwide (15,16). Apart from known risk factors, there is evidence that inflammation plays an important role in the development of CVD, suggesting that periodontal diseases, which have an inflammatory character, may be associated with the development of CVD (17,18). In many studies examining the relationship between periodontal diseases and CVD, it has been reported that advanced periodontal disease poses a 25-90% risk of CVD (19,20). Based on a review of large-scale studies on the subject, the American Heart Association has evaluated periodontal diseases as a risk factor for atherosclerotic vascular diseases independent of other risk factors. Studies on the direct or indirect effects of pathogenic bacteria causing periodontal diseases and the inflammatory response caused by them on CVD formation are ongoing (14).

Today, when the relationship between periodontal diseases and CVD is becoming clearer and stronger with scientific studies, informing the public about this issue is of great importance in terms of protecting public health. In the report published by Scannopieceo et al. on the prevention of periodontal diseases in 2020, the importance of informing the public on the subject was pointed out in terms of protecting periodontal health (21). Today, one of the most practical and preferred ways of accessing information is the internet. Many people, in order to obtain information about the subjects they are curious about, search for the subject in search engines and utilize the information on the web pages they come across. Of course, the accuracy of this information as well as its comprehensibility, i.e. readability, is of great importance. It should not be ignored that people from all levels of education can access this information on the internet. In order for this tool, which is widely used to deliver information to the society, to be used correctly and effectively, texts containing information should be as easy to read as possible. This will be more efficient in terms of social benefit, as it will ensure that the text is understandable by all segments of society.

Since periodontal diseases are commonly referred to as “gum disease”, we preferred the expression “gum disease” when searching in the search engine. Similarly, since “cardiovascular diseases”, which is a general expression that includes many diseases, is not an expression used among the public, we preferred the expression “heart health”, which is a more common and general expression among the public. Since the shortest and most general expressions are preferred when searching in search engines, we made our search as “gum disease and heart health relationship”. We think that by analyzing the readability of the texts with information content as a result of such a search, we will contribute to the texts to be created on the subject to reach their purpose more effectively.

MATERIAL AND METHOD

Since publicly available information was used in this study, ethics committee approval was not required.

In order to access informative texts on the internet about the relationship between gingival disease and heart health, a search was performed by a researcher by typing the keywords in Turkish 'Dişeti hastalıkları ve kalp sağlığı ilişkisi' into the Google search engine in June 2024. Academic publications, images, video content, sites for advertising commercial products, forum sites, and sites requiring membership were not included in the study. Turkish websites containing texts for patient information and education about the relationship between gingival disease and heart health were included. The texts were classified according to their sources as private hospitals, university hospitals, public hospitals, private dental clinics, cardiology clinics, professional organizations and media news pages. To determine readability levels, text content was transferred to a free online readability calculator using the Ateşman readability formula (http://okunabilirlikindeksi.com). The data obtained were exported to Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA).

Statistical Analysis

The data obtained in the study were evaluated using the SPSS 26 (SPSS Inc., Chicago, IL, ABD) package program. Descriptive statistical methods were used in the evaluation of the data obtained. Data were expressed as percentage (%), arithmetic mean, standard deviation, minimum and maximum. Readability index values were classified according to Ateşman readability classification.

RESULTS

After typing keywords into the search engine, 46 of the first 60 web pages that met the criteria were used in the study. When the texts included in the study were examined according to their sources, it was found that 43.5% were pages of dental clinics, 26.1% of private hospitals, 10.9% of university hospitals, 10.9% of media news pages, 4.3% of professional organizations, 2.2% of cardiology clinics and 2.2% of state hospitals (Table 3). Descriptive statistics of the texts in terms of language are given in Table 4.

Table 3. Distribution of web pages according to text source

	n	%
Dental clinics	20	43.5
Private hospitals	12	26.1
Media news pages	5	10.9
University hospitals	5	10.9
Professional organizations	2	4.3
Cardiology clinics	1	2.2
State hospitals	1	2.2

Table 4. Descriptive statistics of the texts in terms of language

	Mean	Standard deviation	Minimum	Maximum
Number of words	667.43	393.00	218	2234
Number of characters	5264.24	3226.26	1819	18996
Number of difficult words	660.33	391.68	215	2221
Unique words	398.61	202.71	145	1156
Number of short words	144.46	82.75	40	411
Characters without spaces	4579.20	2825.86	1591	16693
Number of sentences	54.85	38.18	12	217
Number of paragraphs	23.96	19.30	4	91
Average word length	2.77	0.13	3	3
Average sentence length	13.27	3.33	8	20
Ateşman readability index	52.86	9.68	32	70

The mean Ateşman readability index was 52.86±9.68. The percentage distribution diagram of the readability level of the web pages according to the Ateşman readability index values is shown in Figure 1 based on Ateşman readability classification (Table 1). According to the available data, 60.87% of the websites were found to be at medium and 39.13% at difficult readability level. The Ateşman readability levels of the web pages according to the sources are shown in Table 5, and according to the Flesch classification (Table 2).

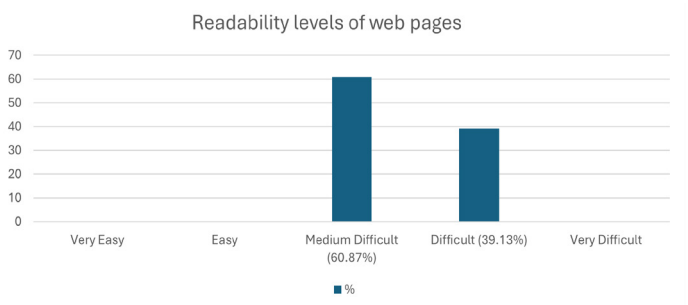

Figure 1. Distribution diagram of readability level of web pages

Table 5. Ateşman readability levels according to sources

	Very easy	Easy	Medium difficult	Difficult	Very difficult	Total
State hospitals	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Cardiology clinics	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Media news pages	0.00%	0.00%	80.00%	20.00%	0.00%	100.00%
Professional organizations	0.00%	0.00%	50.00%	50.00%	0.00%	100.00%
Dental clinics	0.00%	0.00%	55.00%	45.00%	0.00%	100.00%
Private hospitals	0.00%	0.00%	91.70%	8.30%	0.00%	100.00%
University hospitals	0.00%	0.00%	40.00%	60.00%	0.00%	100.00%

DISCUSSION

Nowadays, with the widespread use of the internet, when people experience a health problem, they first research about the subject on the internet. In recent years, the number of publications in both print and visual media expressing the relationship between gingival diseases and general body health has been increasing. Especially the relationship between gingival diseases and cardiovascular diseases, which has been increasing in recent years, and the public awareness of this relationship is important for public health. This study is the first study to investigate the level of readability of information about the relationship between gingival diseases and heart health on Turkish websites. In the literature, there is only one study evaluating Turkish information texts about "gingival disease" (22,23).

While searching on the subject; the search engine was searched by typing the simplest expressions that the public would use. Since Google is the most widely used search engine in Türkiye, Google search engine was preferred in our study (24,25). The readability levels of the resulting texts were found to be at the level of medium difficult and difficult. In the readability analysis study on "Gum disease" previously available in the literature, it was determined that the texts were of medium difficulty. In order for the general public to understand the subject easily, it is recommended that the readability should be at the "easy" level and not higher than the 6th-8th grade level (24). In our study, no text sources were identified that fit this range. 39.13% of the texts were difficult and 60.87% were of medium difficulty. It was observed that the sentence and word lengths were higher than the average values determined by Ateşman for Turkish and the amount of difficult words was also high. According to Ateşman, the definition of difficult words refers to words other than the 3000 most frequently used words in Turkish (7). According to TÜİK data, the average duration of education in Türkiye in 2023 is 9.3 years. Only 48.3% of the population has secondary education and above (26). Therefore, the readability level of the texts subject to our research shows that the texts are not fully comprehensible by almost half of the population. Moreover, 39.13% of the texts are difficult to read. In order for these texts to be fully understood, education at associate's and bachelor's level is required. However, according to the same data, the rate of people with higher education in our country is 24.6% (26). In other words, the texts in question are fully comprehensible by only 24.6% of the population. Therefore, in our study, it has been determined that the language of the texts should be simplified in order for the texts in question to fully achieve their goals and to be understandable by all segments of the public.

CONCLUSION

It was observed that the readability level of the web pages providing information on the relationship between gingival diseases and heart health was at the "moderately difficult" and "difficult" level. It is important that such informative web pages are easily understandable by large segments of the public in order to achieve the informative purpose. In such issues that directly concern public health, it is important that the texts prepared should be as simple and clear as possible. In our study, we concluded that these texts do not fully serve their purpose in their current form. We believe that it would be much more efficient and effective in terms of informing the public and thus public health if those who prepare articles on such issues, which are very important for public health, make use of readability tools that are available free of charge on the internet.

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MEDICAL RECORDS-International Medical Journal

Research Article

Comparison of Clinical Outcomes of Conservative Treatment, Percutaneous Intralaminar Stabilization of Pars Defect, and Posterolateral Fusion with Interbody Fusion in Spondylolysis

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Abstract

Aim: This study aimed to compare the clinical efficacy of posterior lumbar interbody fusion (PLIF), percutaneous intralaminar screw pars stabilization (PS), and conservative treatment (CT) for symptomatic spondylolysis (SL).

Material and Method: A retrospective randomized study was conducted on 45 patients, with 15 in each group (PLIF, PS, and CT), who underwent bilateral L5 SL and were treated between 2017 and 2022. Surgical indications included low back pain lasting >6 months that was unresponsive to CT and without sciatica. The CT group comprised patients with similar pain profiles. Clinical outcomes were measured using the visual analog scale (VAS), Oswestry Disability Index (ODI), and Short Form 36 (SF-36) scores at 0, 1, 3, 6, and 12 months.

Results: The study included 65% female patients with a mean age of 52 (PLIF), 44 (PS), and 46 (CT) years. Both the PS and PLIF groups showed significant clinical improvement compared with the CT group ($p<0.05$). No intraoperative complications were observed. The mean hospital stay was shorter in the PS group (2.7±1.3 days) than in the PLIF group (5.4±1.8 days). The operation time was 40±15 minutes for PS and 168±41 minutes for PLIF, with blood loss of 50±15 cc for PS and 350±170 cc for PLIF.

Conclusion: PS and PLIF resulted in better clinical outcomes than CT for L5 spondylolysis. PS is a minimally invasive and safe option with less muscle and soft tissue disruption; however, the final follow-up scores did not differ significantly between the PS and PLIF groups.

Keywords: Spondylolysis, pars stabilization, isthmic defect, intralaminar screw, conservative treatment

INTRODUCTION

The term spondylolysis (SL) originates from the Greek words spondylo (vertebra) and lysis (separation) and is defined as the separation or defect of the pars interarticularis (1-3). Repetitive hyperextension and rotation of the spine in SL causes microtrauma in the pars interarticularis and leads to stress fractures (4-6). It is a common cause of low back pain, particularly in athletic adolescents and young adults (2,7). Its prevalence is approximately 6-8%, and it is most commonly seen at the L5 level, followed by L4, and less frequently at the upper levels (8). It is mostly asymptomatic and becomes symptomatic after repeated lumbosacral strain during heavy physical labor. Mild or moderate low back pain, which increases with activity and resolves with rest, and complaints of tension in the hamstring muscles are common. Clear neurological deficits or radicular findings are very rare. Anteroposterior, lateral, and oblique direct radiographs of the lumbosacral region are the first steps in diagnosis. Computed tomography is the technique that best demonstrates the bony architecture of the pars; however, it should be chosen with caution, especially in young people, because of the risk of ionizing radiation. Magnetic resonance imaging (MRI) is the first choice for complaints of sciatica, young patients, and neurological deficits and is the gold standard for the detection of stress reactions (9). Initial treatment in symptomatic patients includes rest, use of a lumbar corset, and physiotherapy for 4-6 weeks. Regular daily activities are gradually increased as symptoms decrease. Surgery may be performed in patients in whom symptoms persist or who are unresponsive to conservative treatment (CT). Surgical fusion is an effective method for stabilizing the spine during lumbar spondylolysis and is preferred for reducing

CITATION

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chronic back pain and disability. In the surgical treatment of SL, many surgical techniques ranging from percutaneous screw fixation of the pars defect with percutaneous technique to posterolateral segmental fusion are applied according to the patient's and physician's decision, and a success rate of 60-90% has been reported (4,10). The aim of this study was to evaluate and compare operative factors and the visual analog scale (VAS), Oswestry Disability Index (ODI), and Short Form 36 (SF-36) clinical scores of patients with SL who were followed up with conservative methods, those who underwent percutaneous intralaminar screw pars defect fixation (PS), and those who underwent posterior lumbar interbody fusion (PLIF) with open surgery to determine which method was more effective.

MATERIAL AND METHOD

Ethical Approval

This study protocol was approved by the University of Health Sciences Kanuni Sultan Süleyman Training and Research Hospital Ethical Review Board (Subject No: KAEK/2022.02.38; approval date: 10/02/2022). All the procedures were performed in accordance with the principles of the Declaration of Helsinki.

Study Characteristics and Patient Population

Between 2017 and 2022, patients with single-level L5 spondylolysis who were treated either conservatively or surgically and followed up were randomly included in the study. A total of 45 patients (15 in each group) treated with percutaneous intralaminar stabilization, posterolateral interbody fusion and stabilization, or conservative methods were included in this retrospective, randomized study. The inclusion criteria were L5 bilateral spondylolysis, listhesis <3 mm, posterior opening >5°, and no neurological deficits. The exclusion criteria were spondylolisthesis, concomitant spinal disorders (scoliosis, trauma, infection, and tumor), and osteoporosis.

All patients were diagnosed with spondylolysis by dynamic imaging, computed tomography, and MRI within normal limits and had listhesis <3 mm, which is considered normal according to many studies (9).

The main complaint of all the patients was low back pain without sciatica. For clinical outcomes, the VAS was used to measure pain level, the ODI to assess functional limitations in activities of daily living, and the SF-36 to assess general health and quality of life at admission and at 1, 3, 6, and 12 months follow-up. Changes over time and differences between the conservative and surgical groups were analyzed. The duration of hospital stay, duration of surgery, amount of bleeding, and use of drains were analyzed.

Conservative Treatment Method (CT)

Patients were followed up with analgesics, activity restriction, exercises focusing on the deep abdominal musculature and lumbar multifidus muscles, daily life modification, and lumbosacral bracing for 4-6 weeks. Patients were allowed to start limited activities 4 weeks after the start of treatment (Figure 1).

Figure 1. In patient 8 in the conservative treatment group, lumbar T2 sequence midsagital MRI (**a**), right pars defect (white arrow) (**b**), left pars defect (white arrow) (**c**) in parasagittal section image of lumbar computed tomography

Percutaneous Intralaminar Screw Stabilization Method (PS)

Using the percutaneous technique, with the help of two anteroposterior and lateral scopes and after a 2 cm sacral skin incision, a Jamshidi needle was inserted inferiorly caudal to the L5 lamina, close to the facet joint. A guidewire was advanced through the lamina, pars defect, defective pars neck, and pedicle using a high-speed drill with the help of a guidewire through a Jamshidi needle. A working cannula was inserted under the guidance of a guidewire, with the guidewire remaining in place. With the help of the guidewire, the lamina and pars defect were drilled with a 3 mm diameter drill, the cannulated screw was placed to terminate near the superior cortex of the pedicle, and the guidewire was removed. The mean screw diameter was 4-4.5 mm and length was 3.5-4 cm. The pars defect was debrided using an ultrasonic bone microshaver through the same working cannula under scopic visualization. Intralaminar screw fixation of the contralateral pars defect was performed using the same incision, and the skin was sutured (Figure 2).

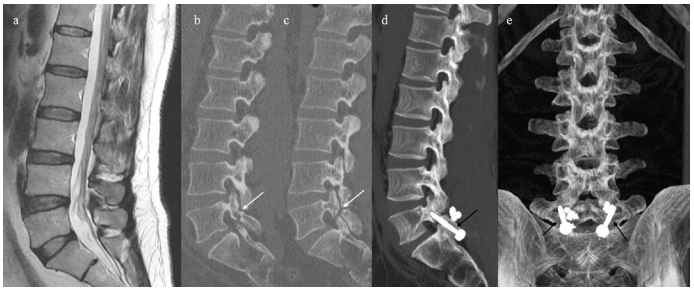

Figure 2. In the 10th patient in the pars stabilization group, lumbar T2 sequence midsagital MRI (**a**), right pars defect (white arrow) (**b**), left pars defect (white arrow) (**c**) in parasagittal section image in lumbar computed tomography, L5 pars screw (black arrow) in sagittal image (**d**), right and left pars screws (black arrow) (**e**) in coronal image with 3D reconstruction in lumbar computed tomography

Posterolateral Interbody Fusion and Fixation Method (PLIF)

After L5-S1 midline skin incision, subcutaneous and fascia incision, and paravertebral blunt dissection with conventional surgery, bilateral pedicle screws were inserted into the L5 and S1 pedicles under scopic control.

After partial medial facetectomy and hemilaminectomy, microdiscectomy was performed and a bone graft and/or cage was placed in the disc space. A bone graft was placed on the screw and rod edges. After controlling the bleeding, the muscle and fascia were closed anatomically, and the skin was sutured (Figure 3).

Figure 3. In the 15th patient in the posterolateral interbody fusion group, right pars defect (white arrow) (**a**), left pars defect (white arrow) (**b**) on lumbar computed tomography parasagittal image, preoperative lumbar T2 sequence midsagital MRI (**c**), postoperative lumbar magnetic resonance sagittal section image with plif (thick white arrow) (**d**)

Statistical Analysis

IBM SPSS statistical software (version 23.0, IBM Corp., Armonk, NY, USA) was used for statistical analysis. The study data were analyzed using descriptive statistical methods (mean, standard deviation [SD], median, quartile range, frequency, and proportion) and box plots. Conformity to normal distribution was analyzed using the Shapiro-Wilk test. Repeated measures analysis of variance (ANOVA) was used to examine within-group and between-time changes in normally distributed data. Two-way repeated measures ANOVA (treatment group and time factors) was used to determine the differences between treatment groups. In cases in which the data did not conform to a normal distribution, the Kruskal-Wallis test was used to evaluate the differences between groups, and Dunn's test was applied for post-hoc analyses. All analyses were performed with a 95% confidence interval (CI) and a significance level of $p<0.05$.

RESULTS

In the CT group, the mean age was 46±15 years (range, 21–68 years), with eight females and seven males. In the PS group, the mean age was 44±13 years (range, 23–59), with 10 females and 5 males. In the PLIF group, the mean age was 52±8 years (range, 29–64 years), with nine females and six males. The mean operative time was significantly shorter in the PS group compared with the PLIF group (PS group: 40±15 minutes; PLIF group: 168±41 minutes, $p<0.001$). Similarly, intraoperative blood loss was significantly lower in the PS group (PS group: 50±15 ml; PLIF group: 350±170 ml, $p<0.001$). The hospital stay was also significantly shorter in the PS group compared with the PLIF group (PS group: 2.7±1.3 days; PLIF group: 5.4±1.8 days, $p=0.03$). No blood transfusions were required in either group. Four patients in the PLIF group required surgical drainage, and one patient developed a surgical wound infection.

Neuropathic pain developed in two patients in the PLIF group and one patient in the PS group; however, the pain improved significantly by the 4th day of gabapentin treatment, after which the medication was discontinued. Upon admission, VAS scores were 7.6±1.4 in the CT group, 8.2±1.5 in the PS group, and 8.1±1.4 in the PLIF group, with no significant difference between the groups ($p>0.05$). ODI scores at admission were 43±3.5 in the CT group, 55±5.6 in the PS group, and 49±2.6 in the PLIF group. There was a significant difference between the CT and PS groups ($p=0.004$) and between the CT and PLIF groups ($p=0.003$) in terms of ODI scores at admission, whereas no significant difference was found between the PS and PLIF groups ($p=0.910$).

The SF-36 Mental Health (MH) scores were 49±4.2, 49±7.0, and 45±6.2 in the CT, PS, and PLIF groups, respectively, with no statistically significant difference between the groups ($p>0.05$). Similarly, the SF-36 Physical Health (PH) scores were 49±3.3, 49±3.7, and 48±3.6 in the CT, PS, and PLIF groups, respectively, with no significant differences ($p>0.05$). At 12 months, VAS scores decreased by 3.9, 6.2, and 6.8 points in the CT, PS, and PLIF groups, respectively ($p<0.05$). Statistically significant differences were found between the CT and PS groups ($p=0.023$) and between the CT and PLIF groups ($p=0.004$) at 12 months; however, no significant difference was observed between the PS and PLIF groups ($p=0.170$).

The ODI scores decreased by 18 points in the CT group, 45 points in the PS group, and 38 points in the PLIF group at 12 months compared with those at admission ($p<0.05$). Significant decreases were found between the CT and PS groups as well as between the CT and PLIF groups ($p<0.001$), with no significant difference between the PS and PLIF groups ($p=0.623$). The SF-36 MH scores increased by 3, 6, and 12 points in the CT, PS, and PLIF groups, respectively, at 12 months ($p<0.05$). A statistically significant difference was found between the CT and PLIF groups ($p=0.004$), whereas no significant difference was observed between the CT and PS groups ($p=0.064$) or between the PS and PLIF groups ($p=0.910$). The SF-36 PH scores increased by 4, 13, and 12 points in the CT, PS, and PLIF groups, respectively, at 12 months ($p<0.05$). Significant differences were found between the CT and PS groups ($p=0.009$) and between the CT and PLIF groups ($p=0.014$), with no significant difference between the PS and PLIF groups ($p=0.473$).

In all three groups, there was a significant decrease in the VAS and ODI scores and an increase in the SF-36 MH and SF-36 PH scores at the last follow-up compared with baseline ($p<0.0001$). Improvement in the CT group was less pronounced than that in the other groups. Overall, the VAS, ODI, SF-36 MH, and SF-36 PH scores for low back pain improved significantly in all three groups at follow-up ($p<0.05$). The PS and PLIF groups achieved better clinical

results than the CT group (p<0.05) (Figure 4). No patients in the CT group underwent surgery. In the postoperative period, a skin infection in one patient in the PS group was treated with topical antibiotics. In the PLIF group, two patients were treated with an iliolumbar trigger point injection.

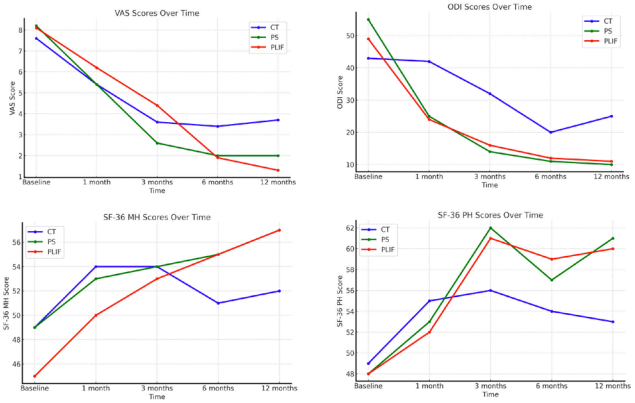

Figure 4. Results of VAS, SF-36 and oswestry disability index scores

DISCUSSION

SL is a neural vertebral arch defect that most commonly occurs at the L5 level and is usually asymptomatic (4). The cause of defect development is fatigue fracture of the pars (1). Two-way oblique direct radiography is the first choice for visualizing pars defects. While MRI is a sensitive method to reveal stress fractures and bone edema, computed tomography shows bone architecture in detail. Conservative methods are largely successful for treating symptomatic SL, but surgical intervention is required in 9-15% of cases (11). Classical or percutaneous surgical techniques are used for symptomatic patients. Many surgical techniques such as pars screwing, screw-wire, screw-rod, screw-hook techniques, posterolateral stabilization and interbody fusion and/or a mixture of these techniques are applied according to the decision of the surgeon and the patient, but there is no gold standard surgical technique. The PS technique provides minimally invasive rigid fixation of the pars defect with the help of percutaneous working cannulas, restoring impaired intrasegmental abnormal motion (4,9,12-15).

However, the PLIF approach provides direct decompression of the compressed neural elements through unilateral or bilateral access to the disc space after partial facetectomy and provides bony fusion of the posterior neural arch, but it impairs segmental motion.

Our results showed that neither surgical technique was superior in terms of pain or functional outcomes at the most recent follow-up; however, the clinical scores were better than those in the CT group. PS showed a significant reduction in surgical time and intraoperative blood loss compared with PLIF (p<0.001). No blood transfusion was required in either group, but surgical drainage was required in four patients who underwent PLIF. No minor intraoperative complications were observed. PLIF has been associated with a longer operative time, as in our case, and PS provides a shorter recovery time and earlier return to daily life. Adjacent segment development may be a significant problem in PLIF; however, adjacent segment development has not been reported using the PS method. Percutaneous and minimally invasive procedures are associated with rapid recovery time and low perioperative blood loss rate. Our study found that the hospital stay was significantly shorter in PS patients (4.7±2.3 days) compared with PLIF patients (6.4±2.8 days) (p=0.03). Surgical treatment should be considered in the absence of impressive improvement in symptoms after conservative treatment for 4-6 months on several occasions (16,17). Confirmatory testing of the pars defect with an anesthetic block should be performed before surgery for a differential diagnosis (4,18,19). Treatment options are classically divided into direct repair of the pars defect and spinal fusion. The choice of the most appropriate surgical intervention is largely determined by the severity of SL and the patient's clinical goals and perspective. Segmental fusion shows significant efficacy in reducing pain, and up to 70% of the patients with terminal SL experience significant pain relief (20,21). L5/S1 fusion with an autogenous iliac bone graft is often the first-line surgical treatment for adult patients with symptomatic L5 SL. In younger or more active patients, one of many different techniques, such as intralaminar screw fixation of the pars defect, V-rod technique, screw hook, and screw tape, may be preferred. Minimally invasive methods are preferred when muscle damage is undesirable in athletes or young individuals. In PS, segmental spinal motion is directly restored with pars defect repair and is generally preferred in adolescents and young adults if the intervertebral disc is intact (16,20,22). Direct repair is often recommended as the first-line surgical treatment for young athletes and patients with active lifestyles to prioritize functionality and accelerate their return to sports (23,24). Direct repair methods, including single-screw fixation (i.e., Buck's), hook screw fixation, pedicle screw band fixation, and robot-assisted direct repair, may vary according to the surgeon's experience and patient preference. Percutaneous intralaminar screw fixation may be preferred in pars injection-positive patients, patients with slippage of <3 mm, normal disc structure, and no radiculopathy (4,12,25). In our study, blood loss and length of hospital stay were lower with direct percutaneous pars screw fixation, but the learning curve was challenging. PLIF is the preferred surgical method for terminal-stage SL. The clinical scores were better in the two surgical groups than in the CT group. The main outcome measured was disability; when compared with the preoperative value, the difference between the PS and PLIF surgical groups in the final ODI assessment at 12 months after surgery was 10 points, and no screw malposition or fracture was detected in the PS group. The operative time was shorter for percutaneous PS (40 min) and longer for PLIF (3 h). Surgeons may favor open surgical methods in cases of abnormal laminar anatomy or pseudarthrosis, which may result in more heterogeneous studies (2,26). The primary limitation of our study is its retrospective design, which may introduce a potential bias in patient selection, despite adherence to standard

criteria. Additionally, the small sample size and single-center setting limits the generalizability of the findings, even though the patient groups were homogeneous. Furthermore, the ultimate goal of all these procedures is to achieve sound arthrodesis. Although all operations were performed by the same surgeon, ensuring consistency, the study's limitations could be addressed through larger-scale, long-term, prospective randomized trials to provide more comprehensive evaluations and reliable results. Future research may more clearly define the appropriate indications for PLIF and PS for which a minimally invasive or open approach should be used. The fact that there was no difference in the short-term results between PS and PLIF may indicate that the selection bias was low. The current study could be conducted as a randomized prospective study involving different groups.

CONCLUSION

There was no significant difference in the clinical outcomes between intralaminar pars stabilization and posterolateral interbody fusion. The PS method showed superior results in terms of operative time, estimated blood loss, and length of hospital stay. To our knowledge, this is the first study to compare the clinical outcomes of percutaneous intralaminar screw pars fixation and posterolateral lumbar interbody fusion with conservative treatment in SL; further prospective, multicenter studies are required to confirm these findings.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *This study protocol was approved by theUniversity of Health Sciences Kanuni Sultan Süleyman Training and Research Hospital Clinical Research Ethics Committee (Subject No: KAEK/2022.02.38; approval date: 10/02/2022). All the procedures were performed in accordance with the principles of the Declaration of Helsinki.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Global Outlook for Disability Adjusted Life Years: Brain and Central Nervous System Cancers

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Abstract

Aim: In 2019, brain and central nervous system cancers were listed among the top 5 causes of death in men and women by absolute Disability Adjusted Life Years (DALY) burden globally. In this respect, it is important to define the current global status of deaths from neurological disorders and brain and central nervous system cancers. In this study, we aimed to examine the burden of disease metrics of deaths from neurological disorders and brain and central nervous system cancers in 204 different countries/regions by categorizing the countries.

Material and Method: Brain and central nervous system cancer DALYs, motor neuron disease deaths and multiple sclerosis deaths of 204 different countries were obtained from the "GBD Compare" tool of the Institute for Health Metrics and Evaluation. The k-means clustering algorithm, also known as unsupervised machine learning algorithm, was used to categorize the countries. The number of clusters was determined by the Silhouette score (s). The statistical difference between the medians of two independent groups was analyzed by Mann-Whitney U Test.

Results: According to the silhouette score obtained using the K-Means algorithm, the number of clusters was determined as 2 (s=0.684). Cluster I included 135 countries (African and Asian countries) and Cluster II included 65 countries (European and North American countries). The median (min; max) values of Cluster II countries for brain and central nervous system cancer DALYs, Multiple Sclerosis deaths and Motor Neuron Disease deaths variables were 201.77 (147.65;375.16), 0.62 (0.00;2.21), 1.13 (0.00;4.65), while the median (min; max) values of Cluster I countries are 64.50 (6.29;134.99), 0.04 (0.00;0.67), 0.00 (0.00;2.36), respectively ($p<0.001$).

Conclusion: The group of developed countries in Europe and North America has been found to have more deaths from neurological diseases and more DALYs from brain and central nervous system cancers. When the countries in the groups are evaluated, it is concluded that the geographical proximity and development level of the countries have a significant effect on the variables used in the grouping.

Keywords: Brain neoplasms, cluster analysis, disability adjusted life years, global burden of disease

INTRODUCTION

Brain tumors constitute an important disease group in neurosurgery. They cause many neurological, cognitive and psychosocial problems. The incidence of malignant and benign brain tumors is higher, especially in industrialized regions of Australia, Europe and North America (1). In the UK, the incidence of glioblastoma, one of the age-standardized tumor subtypes, increased from 3.27 and 2.00 per 100,000 population in 1995 in men and women, respectively, to 7.34 and 4.45 in 2013 (2). In the United States, the incidence of brain tumors, which are among the top four cancers in young adults, is 7.10 per 100,000 in the 20-24 age group and 15.5 in the 34-39 age group (3). In summary, brain and central nervous system cancer was listed among the top 5 causes in women and men according to absolute Disability Adjusted Life Years (DALY) burden globally in 2019 (4).

While many factors pose a risk for brain cancer, these factors can be classified as environmental, demographic, genetic and socioeconomic factors (5). These factors are also closely related to neurological disorders. In general, neurological disorders are defined as Alzheimer's and other dementias, Parkinson's, idiopathic epilepsy, multiple sclerosis, motor neuron disease, headache disorders (6). While epidemiologic studies have found a significant inverse association between Alzheimer's

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disease and cancer, increasing evidence has shown a higher risk of melanoma and brain cancer in Parkinson's patients (7,8). Research on the pathological relationship between epilepsy and brain tumors has reported epileptic symptoms attributed to intracranial tumors (9). Although the assessment of brain tumor formation in multiple sclerosis patients is complex, multiple sclerosis has been recognized as the primary pathology that often results in the development of brain gliomas (10). The best-known form of motor neuron disease is amyotrophic lateral sclerosis, and the level of evidence for carcinogenesis is low with few studies available (11). Although there are more than 600 diseases affecting the neurological system, the most well-known ones are the neurological disorders and brain tumors described above (12).

Cluster analysis has been widely used in the health literature for image segmentation, human genetic clustering, recommendation systems, data reduction, classification and prediction using stroke, diabetes, Alzheimer's data (13). For example, cluster analysis studies have been conducted using social, economic and health metrics together or alone to shed light on policies to be created to control a disease of specific interest (14). From identifying subgroups of brain tumors affecting the neurological system (15) to identifying distinct patterns in gene studies (16), cluster analyses have also found widespread use specifically in neurology. Cluster analysis is also widely used to group countries using various health outcome metrics. Many metrics such as COVID-19 case data, quality of life data, standardized mortality data have been used to classify countries through cluster analyses (17-19). In this context, our study aimed to group countries using multiple sclerosis disease, motor neuron disease mortality data and brain and central nervous system cancer DALY numbers, which are considered as neurological disorders, and clustering algorithm was used in grouping. Since our study aims to identify subgroups of countries that are different from each other among clusters, the study analyses were carried out with a country-centered approach. As a result of this study, it was aimed to show that the loss of healthy life years due to neurological disorders and brain cancer is not homogeneous in terms of the countries of the world.

MATERIAL AND METHOD

Data Set Selection and Definition of Parameters

Brain and central nervous system cancer DALYs (per 100,000 population), motor neuron disease deaths (per 100,000 population) and multiple sclerosis deaths (per 100,000 population) in 204 different countries, including Türkiye, constitute the variables for the statistical analysis of this study. Since disability-adjusted life-year data specific to motor neuron and multiple sclerosis disease are still insufficient, mortality data were used for these two variables. The data set for the variables was obtained from the "GBD Compare" tool of the Institute for Health Metrics and Evaluation (IHME), which allows comparison of diseases, deaths and risk factors at various levels (regional, gender, age, etc.) (IHME, 2024). As a result of the International Classification of Diseases 10th Revision (ICD-10) and the COVID-19 pandemic, diseases for the Global Burden of Disease are categorized into four main groups in the GBD Compare tool: Communicable Diseases (Group A), Non-Communicable Diseases (Group B), Injuries (Group C), Other Consequences of the COVID-19 Pandemic (Group D). Brain and central nervous system cancer DALYs for this study were compiled from the "Neoplasms" subgroup of the non-communicable diseases group. Data on variables related to the number of deaths were obtained from the "Neurological Disorders" subgroup of the noncommunicable diseases group (6).

DALY is a measure used especially in global burden of disease studies beyond crude mortality rates. In summary, a DALY represents the loss of one full healthy year. As given in Equation 1, DALY is the sum of years of life lost to premature death (YLLs) and years of life lost to disability due to illness or injury (YLDs) (20).

$$DALY = YLLs + YLDs \quad (1)$$

When calculating YLDs, health conditions are assigned a disability weight ranging between 0 and 1 (0: no disability; 1: loss equivalent to death). YLDs is obtained by multiplying the assigned disability weight by the time (years) spent in the disease. In the calculation of YLLs, the years of life lost due to premature death based on the reference life expectancy gives the value of YLLs (21).

All variables in the study dataset belong to 2021 and represent all age groups.

Methods for Study Analysis

The classification of countries according to the variables showing the number of deaths related to neurological disorders and the number of brain and central nervous system cancer DALYs was made with the k-means clustering method. Clustering analysis is based on the separation of data in a variable set into groups according to distance and proximity criteria or according to the differences or similarities between variables. The aim of clustering analysis is to achieve high similarity within clusters and low similarity between clusters (22). In this study, the variables Brain and central nervous system cancer DALY (Per 100,000 population), Multiple Sclerosis (Deaths per 100,000 population), and Motor Neuron Disease (Deaths per 100,000 population) were used together for similarity-based clustering. Clustering, also known as unsupervised machine learning algorithm, which is used in data mining, divides an unlabeled dataset of size N*D (N is the number of samples, D is the data size) into k groups with the same similarity (23).

Clustering algorithms are divided into two main groups: hierarchical clustering and partitioned clustering algorithms (24). While hierarchical clustering algorithms cluster data objects using either a bottom-up additive approach or a top-down divisive approach, partitioned clustering algorithms use combinatorial search of all possible values to obtain the optimum value, resulting in different k values (25). There are many clustering algorithms in the literature such as DBSCAN, CURE, Chameleon. However, the K-means clustering algorithm has been widely used in the literature as one of the most effective algorithms (26).

K-means, one of the unsupervised algorithms, calculates the distance between the center points and all data points in the space using randomly fixed starting/center (k) points and then assigns the data points to the nearest center point (27). Although this process can be done according to different distance measures, the Euclidean distance measure is used in this study. The Euclidean distance measure is calculated as in Equation 2.

$$d\left(x,c\right) = \sqrt{\sum_{i=1}^{D}\left(x_i - c_i\right)^2} \qquad (2)$$

In the equation, x represents the data point, c the center, D represents the total number of data points in space. The average distances of the center and data points are iterated until there is no change in the center and the calculated average, and the center is repositioned according to the average position. The formula used to assign the center after the repeated process is given in equation 3.

$$v_{ij} = \frac{1}{N_i}\sum_{k=0}^{N_i} X_{kj} \qquad (3)$$

Where v_{ij}: is the average centroid in cluster ith for the jth variable; N_i: is the number of members in cluster i; X_{kj}: is the k data values for variable j in the cluster.

Silhouette score was used to determine the most appropriate cluster number from the cluster numbers obtained. The Silhouette score, which provides insight into cluster quality by measuring the cohesion within clusters, represents how well each data point is classified, and indicates whether there is a reasonable level of separation between clusters, varies between -1 and +1 (28). A score of 0.6 and higher indicates an acceptable separation between clusters (29).

The difference between the averages of the sample group clustered as a result of the K-means algorithm for each variable was evaluated with an independent sample test to ensure the clustering analysis. Mann-Whitney U hypothesis test was used to compare continuous data groups. The relationship between the variables was analyzed with Spearman's rank correlation coefficient. Spearman's rank correlation coefficient ranging from $-1 \le r_s \le 1$ indicates that the strength of the relationship decreases as it approaches 0, while the strength of the relationship increases when it approaches 1 in absolute value in both directions.

For this study, clustering analysis was performed in Orange Data Mining (Version: 3.32.0) and independent sample test and correlation analysis were performed in IBM SPSS Statistic 22.0.

RESULTS

Descriptive Statistics

Within the scope of this research, descriptive statistics of the variables included in the clustering analysis before clustering analysis of 204 different countries/regions are presented in Table 1.

Table 1. Descriptive statistics of variables

Variables	Label	Median (Min-Max)
Brain and central nervous system cancer DALY *(Per 100,000 population)*	BCNSC_DALYs	91.54 (6.29-375.16)
Multiple sclerosis *(Deaths per 100,000 population)*	MS	0.09 (0-2.21)
Motor neuron disease *(Deaths per 100,000 population)*	MND	0.04 (0-4.65)

Since the data related to the variables do not show normal distribution, median, minimum and maximum values are presented as descriptive statistics. BCNSC_DALYs per 100,000 population ranged between 6.29 and 375.16, with a median of 91.54. The median of MS and MND deaths per 100,000 population classified as neurological disorders is 0.09 and 0.04, respectively. According to the results of the Spearman's rank correlation coefficient (rs) analysis, there is a significant and positive relationship between all variables ($p<0.001$). There was a moderate and positive relationship between BCNSC_DALYs and MS (rs=0.72), a moderate and positive relationship between BCNSC_DALYs and MND (rs=0.67), and finally a moderate and positive relationship between MS and MND (rs=0.72). Spearman's rank correlation coefficients, scatter plots and histogram plots of variables are given in the correlogram in Figure 1. When the histogram plots were analyzed, it was determined that especially MS and MND variables showed a right-skewed (positive) distribution (Figure 1).

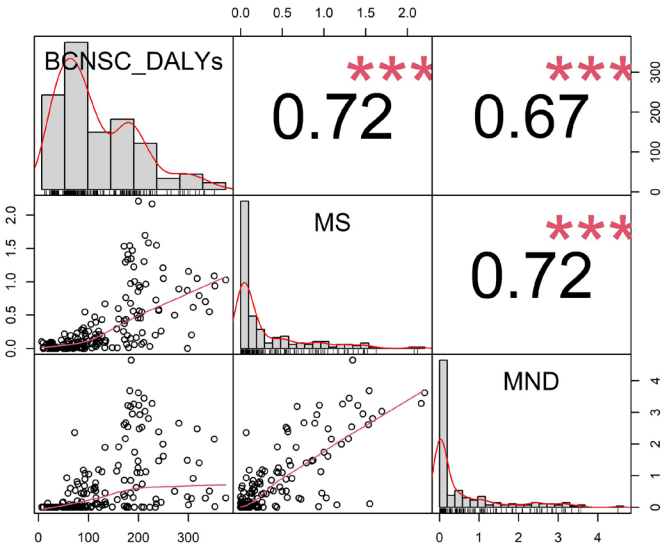

Figure 1. Correlogram graph for variables

Clustering Results

Using the k-means algorithm and Euclidean distance measure, the number of clusters was estimated by Silhouette coefficient for grouping countries in terms of brain and central nervous system cancer DALYs and two variables related to neurological disorders (MS, MND). When the Silhouette coefficients calculated up to 8 clusters were analyzed, it was determined that the best cluster number was k=2 (Figure 2). When the number of clusters was k=2, the Silhouette score was 0.684; when k=3, 0.663; when k=4, 0.559. The optimal number of clusters or Silhouette score, whose graphical analysis is presented in Figure 2, is the highest when the number of clusters is 2.

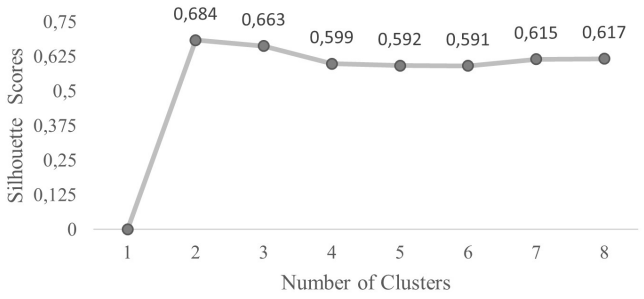

Figure 2. Silhouette scores for different cluster numbers

After the number of clusters determined as k=2 according to the Silhouette score, countries were grouped as shown in Table 2. According to the k-means algorithm, there were 135 countries/regions in Cluster 1 and 69 countries/regions in Cluster 2. The clusters of countries/regions are visualized and presented in Figure 3. The countries in Cluster I are colored in blue and Cluster II countries are colored in red. In Cluster I, countries in Africa and Asia are generally clustered, while in Cluster II, countries in Europe and North America are clustered.

Table 2. Country groups as a result of k-means algorithm

Cluster	Countries*
1 (n=135)	AFG, AGO, ARE, ARG, ASM, ATG, BDI, BEN, BFA, BGD, BHR, BHS, BLZ, BOL, BRB, BRN, BTN, BWA, CAF, CHL, CIV, CMR, COG, COK, COL, COM, CPV, CRI, DJI, DMA, DOM, DRC, DZA, ECU, ERI, ETH, FJI, FSM, GAB, GHA, GIN, GMB, GNB, GNQ, GRD, GTM, GUM, GUY, HND, HTI, IDN, IND, JAM, JOR, JPN, KAZ, KEN, KGZ, KHM, KIR, KNA, KOR, KWT, LAO, LBN, LBR, LCA, LKA, LSO, MAR, MDG, MDV, MEX, MHL, MLI, MMR, MNG, MNP, MOZ, MRT, MUS, MWI, MYS, NAM, NER, NGA, NIC, NIU, NPL, NRU, OMN, PAK, PAN, PER, PHL, PLW, PNG, PRI, PRK, PRY, QAT, RWA, SAU, SDN, SEN, SGP, SLB, SLE, SLV, SOM, SSD, STP, SWZ, TCD, TGO, THA, TKL, TLS, TON, TTO, TUN, TUV, TWN, TZA, UGA, VCT, VEN, VIR, VNM, VUT, WSM, YEM, ZAF, ZMB, ZWE
2 (n=69)	ALB, AND, ARM, AUS, AUT, AZE, BEL, BGR, BIH, BLR, BMU, BRA, CAN, CHE, CHN, CUB, CYP, CZE, DEU, DNK, EGY, ESP, EST, FIN, FRA, GBR, GEO, GRC, GRL, HRV, HUN, IRL, IRN, IRQ, ISL, ISR, ITA, LBY, LTU, LUX, LVA, MCO, MDA, MKD, MLT, MNE, NLD, NOR, NZL, POL, PRT, PSE, ROU, RUS, SMR, SRB, SUR, SVK, SVN, SWE, SYC, SYR, TJK, TJM, TUR, UKR, URY, USA, UZB

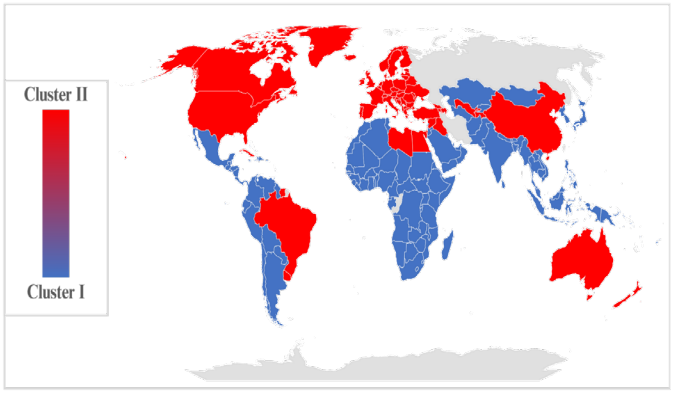

Figure 3. Clusters of countries in the k-means algorithm

The Silhouette score for each country included in the analysis is presented in Figure 4. The Silhouette scores of the countries in Cluster I range between 0.72 and 0.57, while the Silhouette scores of the countries in Cluster II range between 0.70 and 0.52.

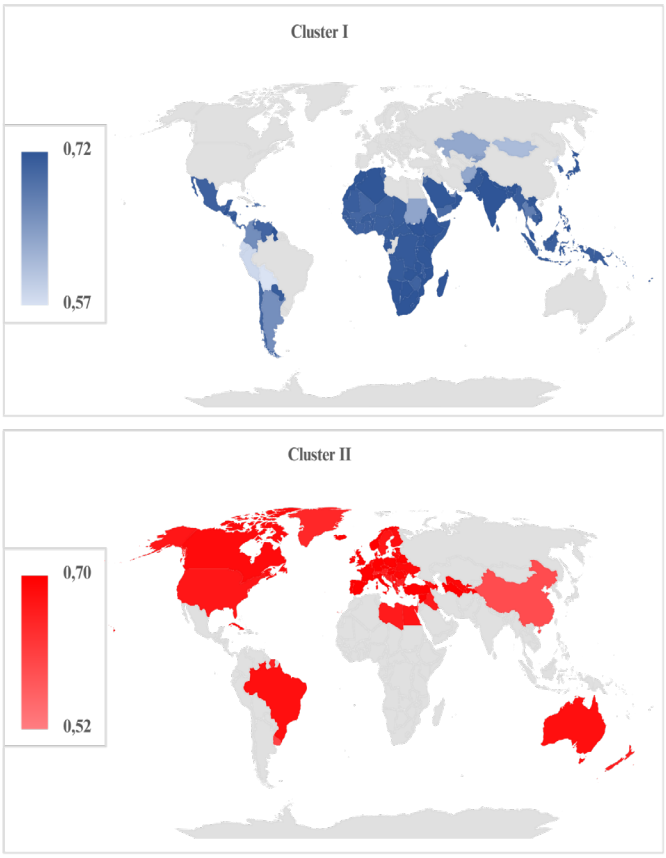

Figure 4. Silhouette scores of countries by cluster

Table 3 presents the test results of the differences between country groups in terms of health outcome variables. According to the Mann-Whitney U test results, there is a statistically significant difference between the rank means of the clusters in terms of all three variables (BCNSC_DALYs: U=0.00; MS: U=912; MND: U=1512; p<0.001). In terms of BCNSC_DALYs, MS and MND health outcome variables, Cluster II countries have higher rank means than Cluster I countries.

Table 3. Comparison of country clusters in terms of variables

	BCNSC_DALYs	MS	MND
	Median (Min;Max)	Median (Min;Max)	Median (Min;Max)
Cluster I	64.50 (6.29;134.99)	0.04 (0.00;0.67)	0.00 (0.00;2.36)
Cluster II	201.77(147.65;375.16)	0.62 (0.00;2.21)	1.13 (0.00;4.65)
Cluster I vs Cluster II	U=0.00; p<0.001	U=912; p<0.001	U=1512; p<0.001

*U =Mann-Whitney U Test U score

DISCUSSION

As a result of the clustering analysis, 204 countries/regions were grouped into two different clusters according to MS, MND mortality and brain and central nervous system cancer DALY data. Cluster I included 135 countries, while Cluster II included 69 countries. In Cluster I, African and Asian countries are grouped in general. Cluster II includes countries from Europe and North America. When the countries in the clusters are analyzed, it is seen that countries with geographical proximity are mostly grouped in the same cluster. Cluster I countries are better in terms of mortality data and brain tumor DALYs. However, this is thought to be related to the fact that tumor registry coverage is lowest in Southeast Asia and Africa (30). The level of data evidence is also known to be low in Africa, Central and South America and most countries in Asia (31). Again, in terms of protocols for determining death according to brain death/neurological criteria, it is thought that some African, South American and South Asian countries do not have national protocols and therefore cannot provide reliable information (32). In this respect, the fact that the health outcome variables of the countries in Cluster I seem to be in better condition compared to the other cluster may be associated with the low level of data reliability reported.

In terms of the health system, countries that provide adequate preventive and curative health services and are in better condition in terms of human resources and physical health infrastructure were included in Cluster II. For example, while the number of doctors (per 1000 people) in the European region in Cluster II is 4.3, this number is 0.2 in Sub-Saharan Africa countries in Cluster I. It is thought that this situation may be related to the fact that the countries in Cluster II have more diagnostic equipment such as Computed Tomography and Magnetic Resonance and a relatively higher number of neurologists, as well as accurate and timely diagnosis (33). When health human resources are evaluated in terms of minimum labor intensity, researchers have reported that physician intensity is the lowest in Sub-Saharan Africa, South Asia and North Africa (34).

Access to care and availability of health services have been reported in previous studies to be important factors influencing the burden of disease and mortality used in the study for countries in both clusters. (35). As a matter of fact, easy access to health institutions enables the recording of diseases and causes of death in the right number and in the right category.

According to the findings of our study, countries that exhibit a similar outlook according to their income levels are grouped in the same cluster. The fact that especially low-income countries are in Cluster I is related to data quality and more importantly data availability (35). As a result of our study, it is known that life expectancy at birth and urbanization are high in countries in cluster II (36). In this respect, it is thought that the high life expectancy at birth causes the disease burden of brain and central nervous system cancer to be higher in direct proportion. In a study investigating the incidence of brain tumors in high-income and middle-income countries, it was found that the incidence rates of tumors were significantly higher in high-income countries (37). The incidence of brain and other central nervous system tumors in childhood and adolescence is also reported to be highest in high-income countries (38). In addition, increased risk for brain and central nervous system tumors is associated with increasing socioeconomic status (39). In summary, the grouping of developed countries in the same group is closely related to the use of advanced diagnostic techniques, the higher proportion of the elderly population and the high prevalence of health screenings. The fact that dietary type, alcohol/tobacco use, and occupational exposures differ according to the development and geographical proximity of the countries is thought to affect the health outcome variables used in the grouping. In this respect, as a result of the clustering analysis used in our study, the grouping of high- and middle-income countries in one cluster and low-income countries in the other cluster is consistent with other studies in the literature.

CONCLUSION

As a result of our study, countries with geographical proximity and approximately similar levels of development as known from previous studies are grouped in the same clusters. European and North American countries were found to have higher mortality rates from MS and MND affecting the individual's neurological system and higher loss of healthy life years due to brain tumor cancer compared to the rest of the globe. In addition, countries with high life expectancy at birth have the highest mortality rates from central nervous system diseases.

For future studies, it is recommended that the regional differences in neurological disorders reported in our study should be evaluated from different perspectives such as the level of neurologists/neurosurgeons, the income level of countries and socioeconomic level.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Since secondary data were used in this study, ethics committee approval was not obtained.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Does Ramadan Fasting Improve Echocardiographically Assessed Tei Index in Patients With Coronary Artery Disease?

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Abstract

Aim: Ramadan fasting (RF) can affect the health status of patients with coronary artery disease or risk factors. The aim of this study is to evaluate echocardiographic functions and tei index according to ramadan fasting status in patients followed for clinically existing coronary artery disease.

Material and Method: This single-centre, cross-sectional study included 49 patients who were being followed up with a diagnosis of coronary artery disease. The patients were separated into 2 groups as those who were fasting during the month of Ramadan (RF (+), n=24) and those who were not (RF (-), n=25). Detailed echocardiographic evaluations were made. Analyses of the study data were performed using MedCalc software.

Results: The demographic and echocardiographic characteristics of the patients in both groups were similar at the start of the study. When the fasting and non-fasting groups were compared separately, a statistically significant decrease was determined in the tei index value in the ramadan fasting (+) group after 1 month of fasting (0.44±0.14 vs. 0.40±0.12) (p: 0.025).

Conclusion: In this study, the effects of RF on cardiac functions were investigated in patients with coronary artery disease and a previous stent procedure. The results of the echocardiographic evaluation after one month of fasting showed a statistically significant decrease in the tei index in the patient group fasting for Ramadan. This finding demonstrated positive effects of RF on cardiac functions.

Keywords: Ramadan fasting, Tei index, myocardial performance index, echocardigraphy, coronary artery disease

INTRODUCTION

The month of Ramadan is a period of intermittent fasting in which most Muslims around the world abstain from eating and drinking between sunrise and sunset each day, according to the Islamic calendar. This period lasts about 30 days every year according to the Islamic calendar. Those who fast during Ramadan make a temporary change to their lifestyle, affecting their eating patterns, sleep duration, physical activity and smoking habits (1). These lifestyle changes can affect the health status of patients with cardiovascular diseases or cardiovascular risk factors (hypertension, diabetes and dyslipidemia) (2). Many studies have been conducted in recent years to investigate the effects of Ramadan fasting (RF) on physiological and cardiac performance in the body. Previous studies have found that RF is closely associated with longer life expectancy due to its positive effects on healthy living and aging (3). In a previous study, RF was associated with numerous positive cardiac effects, including a reduction in cardiac risk factors (4). Studies conducted with patients with coronary artery disease revealed that there was no increase in cardiac morbidity and mortality after RF in patients diagnosed with chronic coronary syndrome. Moreover, an improvement in cardiac symptoms and anginal symptoms was found after RF in approximately about one of third patients (5,6). Although an echocardiography study who investigated effect of intermitant fasting on cardiac function in rats has been counducted, to the best knowledge, there is no literature in terms of non invasive asssesment of cardiac function in human population with intermitans fasting-including RF (7).

The main aim of this study was to evaluate the echocardiographic functions according to RF status in individuals followed up for clinical coronary artery disease (CAD). The effect of RF on cardiac functions in patients with CAD was examined by evaluating echocardiographic parameters before and after the month of fasting in groups fasting and not fasting for the month of Ramadan.

CITATION

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MATERIAL AND METHOD

Data Collection

This single-centre, cross-sectional study included patients who presented at the Cardiology Polyclinic between February 2023 and March 2023, and had undergone coronary angiography and complete revascularization with stent placement at least one year previously because of chronic coronary syndrome. The study exclusion criteria were defined as i) a coronary intervention made again within the last year, ii) the presence of symptoms thought to be of cardiac origin (palpitations, angina, dyspnea), iii) the use of a new drug or dose titration within the last month, iv) the presence of uncontrolled diabetes or another metabolic disease, v) the presence of arrhythmia that would cause suboptimal echocardiographic evaluation, and vi) incomplete revascularization. After the implementation of the exclusion criteria, a total of 74 patients were seen to be eligible for the study. Those 74 patients were divided into two groups; those who planned to fast and those who would not fast for the month of Ramadan.

The patients were given detailed information about the study, and written informed consent was provided by all the patients included. A record was made for each patient of demographic data, clinical findings and the drugs used. In the 72-hour period before the start of Ramadan on 23 March 2023, a detailed two-dimensional (2D) transthoracic echocardiographic (TTE) evaluation was performed for all the patients. The patients who intended to fast continuously for the 30 days of Ramadan were identified. A total of 25 patients were excluded as they did not fast regularly for the 30 days, or did not attend follow-up appointments, or had recently started new drug treatment. Finally, 49 patients were included in the analyses, separated into two groups as 24 patients who were fasting (RF (+)) and 25 patients who were not fasting (RF (-)) (Figure 1).

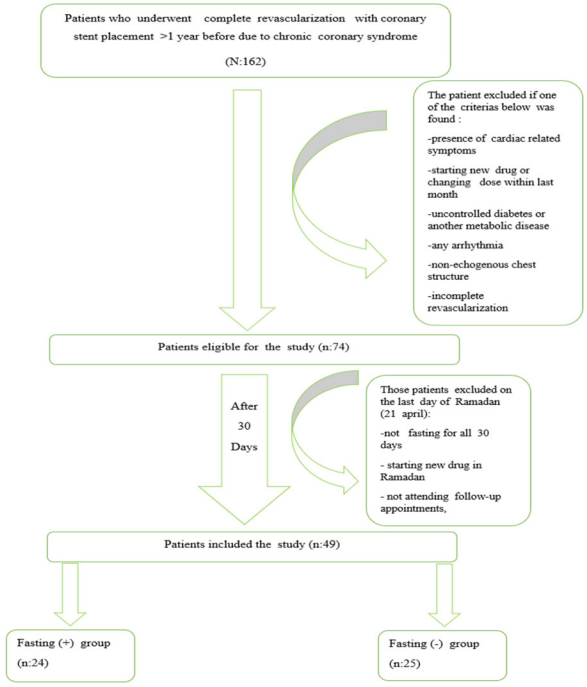

Figure 1. Flowchart of the study population

Echocardiographic Evaluation

The 2D TTE procedure was performed by an experienced echocardiography specialist who was blinded to the clinical characteristics of the patients. An Epiq 7c Ultrasound System device with a 3.5 MHz transducer (Philips Medical System, Andover, MA, USA) was used in the procedure. In the measurement of the left ventricle parameters, the recommendations of the American Society of Echocardiography Committee were taken into consideration (8). The left ventricle ejection fraction (LVEF) and left ventricle end diastolic volume (LVEDV) values were measured with the modified Simpson method. The Tei index was calculated as the total of the isovolumetric contraction time and relaxation time divided by the left ventricle (LV) ejection time (9). For the measurement of basal S', the average was taken of the S' waves measured with tissue Doppler pulse wave echocardiography in septum, lateral, anterior, and inferior wall basal segments in apical 2 chamber and apical 4 chamber windows.

For the LV global longitudinal strain (GLS) procedure, Automated Cardiac Motion Quantification (aCMQ) software was used (Qlab 10; Philips Medical System, Andover, MA, USA). The digital cineloop images were recorded on frame rate 55 from the R wave peak at the end of expirium, on the apical 2 chamber, apical 3 chamber, and apical 4 chamber window images, respectively. Care was taken that the difference in heart rate between the loop recordings was <10%. Then, reference points were placed manually first on the mitral valve leaflet insertion, left ventricle outflow tract (LVOT), and apex endocardium of the apical 3 chamber recording, then on the left and right mitral valve leaflet insertion and apex endocardium of the apical 2 chamber and apical 4 chamber loop recordings (10). After the placement of the reference points on each loop recording, the region of iterest (ROI) was formed automatically by the software drawing endocardial borders. If any regions were incompatible between the line drawn and the endocardial border, they were corrected manually. The GLS score was obtained as the average of 3 strain scores obtained automatically by the software from each ROI on the final recordings. Three measurements were taken for each patient and the average of the measurements was calculated. The same measurements of all the patients in the study were taken again by the same echocardiography specialist within 24 hours of 21 April, which was the date of the end of the month of Ramadan according to the Islamic calendar.

Statistical Analysis

Data obtained in the study were analyzed statistically using MedCalc Version 20.014 software (MedCalc Software Ltd,Ostend, Belgium). Conformity of the data to normal distribution was assessed with the Kolmogorov-Smirnov test. Continuous data were stated as mean±standard deviation values if distribution was normal and as median and interquartile range (IQR 25th-75th) values if not showing normal distribution. Categorical data were stated as number (n) and percentage (%). Comparisons between the two groups (RF+/RF-) were made using the Independent

Samples t-test for continuous variables with normal distribution and the Mann Whitney U-test when distribution was not normal, and categorical variables were compared using the Chi-square test. Comparisons of the basal and final values of the echocardiographic parameters were made using the Paired Samples t-test (normal distribution of data) or the Wilcoxon test (non-normal distribution of data). To evaluate observer agreement of the LVEF, tei index, and GLS measurements, the root mean square method was used with the Intraclass Coefficient test on 10 patients selected at random. In all the tests, a value of $p<0.05$ was accepted as statistically significant.

The minimum number of patients required for this study, with an effect size of 0.5, 95% confidence interval and 80% power, was found to be 27.

Ethical Statements

All the procedures in this study including human participants were applied in compliance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and subsequent revisions or comparable ethical standards. No animals were used in this study. Approval for the study was granted by the Local Ethics Committee [Protocol Code: 2024-TBEK 2024/10-12].

RESULTS

Evaluation was made of 49 patients, comprising 37 (75.5%) males and 12 (24.5%) females with a mean age of 62.8±7.9 years. No statistically significant difference was determined between the fasting and non-fasting patients in respect of age, gender, body mass index (BMI), smoking status, hypertension, diabetes mellitus, drugs used, laboratory values, residual syntax scores, and basal GLS values. Comparison of fasting and non-fasting groups is shown in Table 1. Additionally, in Table 2, echocardiographic parameters are compared between the groups that fasted and did not fast during Ramadan at the beginning and end of Ramadan. A significant difference was found in echocardiographic parameters between the groups with RF (+) and RF (-) at baseline, only in inferior S' values evaluated with tissue doppler (p: 0.013). No significant difference was detected between other parameters. When echocardiographic parameters were compared at the end of Ramadan, a significant difference was detected in septal E' values (p: 0.028) evaluated with tissue Doppler. No significant difference was detected in other echocardiographic parameters at the end of Ramadan.

Table 1. The baseline characteristics and laboratory investigations of all patients

		All patient (n: 49)	RF (-) (n: 25)	RF (+) (n: 24)	P value
Demographic characteristics	Age, mean±SD	62.8±7.9	63.5 ±7.3	62.2±8.5	0.543
	Male, n (%)	37 (75.5)	16 (64.0)	21 (87.5)	0.056
	Baseline BMI, mean±SD	31.1±6.9	30.6±8.5	31.66 ±4.9	0.606
	Δ BMI, mean±SD	-0.25±1.4	-0.02±1.4	-0.5±1.5	0.279
Comorbidities	Diabetes, n (%)	17 (34.7)	11 (44.0)	6 (25.0)	0.162
	Hypertension, n (%)	33 (67.3)	17 (68.0)	16 (66.7)	0.921
	Smoking, n (%)	10 (20.4)	7 (28.0)	3 (12.5)	0.178
Medications	ASA use, n (%)	39 (79.5)	19 (76.0)	20 (83.3)	0.524
	Clopidogrel use, n (%)	17 (34.6)	11 (44.0)	6 (25.0)	0.162
	Beta Blocker use, n (%)	45 (91.8)	22 (88.0)	23 (95.8)	0.609
	ACE inh/ARB use, n (%)	40 (81.6)	20 (80.0)	20 (83.3)	0.763
	Statin use, n (%)	43 (87.7)	21 (84.0)	22 (91.7)	0.667
Laboratory assessment	Wbc, × 10^9/l, mean±SD	8.2±1.6	8.3±1.7	8.1±1.6	0.558
	Hemoglobin g/dl, mean±SD	13.9±1.5	13.9±1.6	13.8±1.3	0.793
	Creatinine mg/dL, mean±SD	0.9±0.2	0.9±0.2	0.8±0.1	0.082
	TSH mIU/L, median (25th-75th)	1.1 (0.6-1.9)	1.0 (0.5-1.9)	1.1 (0.7-1.9)	0.719
	LDL-C mg/dl, mean±SD	119.5±41.0	115.4±44.3	123.9±37.6	0.476
	Triglycerides, mg/dL, mean±SD	185.1±96.4	197.2±101.7	172.6±91.0	0.377
	HDL-C, mg/dL, mean±SD	45.9±9.7	46.5±11.1	45.2±8.1	0.656
	rSS median (25th-75th)	2 (0-4)	2 (0-5)	1.5 (0-3)	0.537
	Baseline GLS %, mean±SD	15.2±2.1	15.1±2.4	15.4±1.7	0.590

Data are presented as median (interquartile range) or number (percentage) of patients; ASA: asetilsalisilic asid, BMI: body mass index, ACE: angiotensin converting enzyme, ARB: angiotensin receptor blockers, GLS: global longitudinal strain, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, RF: ramadan fasting, rSS: residual syntax score, SD: standard deviation, TSH: thyroid stimulating hormone, Wbc: white blood cells

Table 2. Echocardiographic parameters of all patients and groups

	Baseline paramaters				Follow-up paramaters			
	All patients (n=49)	Fasting (-) (n=25)	Fasting (+) (n=24)	P value	All patients (n=49)	Fasting (-) (n=25)	Fasting (+) (n=24)	P value
LVEDD mm, mean±SD	48.5±5.1	48.5±5.2	48.4±5.0	0.979	48.0±3.9	48.1±4.4	47.9±3.2	0.884
LVEDV ml, mean±SD	111.0±26.3	111.3±30.1	110.7±22.1	0.936	107.4±23.3	109.6±28.5	105.1±16.6	0.509
LVEF %, mean±SD	61.4±5.6	61.1±6.0	61.7±5.2	0.743	61.7±5.5	60.7±5.9	62.7±5.0	0.210
RV mm, mean±SD	34.7±5.5	33.6±5.8	35.9±5.0	0.151	35.1±5.1	34.4±5.5	36.0±4.6	0.205
E/A, mean±SD	0.9±0.2	0.9±0,3	0.8±0.2	0.439	0.9±0.2	0.9±0.3	0.9±0.1	0.464
EDT ms, mean±SD	220.5±37.0	216.4±41.7	224.8±31.7	0.434	215.0±31.1	210.8±35.9	219.4±25.1	0.338
Septal E' cm/s, mean±SD	6.8±1.4	6.5±1.5	7.1±1.2	0.108	7.0±1.2	6.7±1.3	7.4±0.9	0.028
Septal S' cm/s, mean±SD	7.0±1.4	6.9±1.4	7.1± 1.2	0.484	7.1±1.1	6.9±1.3	7.2±0.9	0.432
Lateral S' cm/s, mean±SD	8.1±1.5	7.8±1.5	8.4±1.5	0.171	8.1±1.4	7.9±1.5	8.2±1.2	0.293
Inferior S' cm/s, mean±SD	7.6±1.5	7.1±1.4	8.1±1.4	0.013	7.6±1.1	7.3±1.2	7.8±0.9	0.109
Anterior S' cm/s, mean±SD	7.3±1.6	7.1±1.4	7.6±1.6	0.316	7.4±1.2	7.2±1.2	7.5±1.3	0.496
Tei index, mean±SD	0.44±0.16	0.43±0.17	0.44±0.14	0.873	0.42±0.13	0.43±0.14	0.40±0.12	0.447
GLS %, mean±SD	-15.2±2.1	-15.1±2.5	-15.4±1.7	0.590	-15.4±2.4	- 14.9±2.3	- 16.1±2.4	0.051

EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

The BMI values of the RF (+) group were similar at baseline and at the end of the fasting month (31.8±4.9 vs 31.3±4.9 kg/m^2, p: 0.145). The intraobserver intraclass coefficients were calculated as 0.85 (0.43-0.96) for LVEF, 0.95 (0.78-0.98) for the tei index, and 0.94 (0.75-0.98) for GLS. No statistically significant difference was determined between the baseline values and the values at the end of Ramadan of the echocardiographic parameters of all the patients (Table 3).

Table 3. Comparison of the initial values of echocardiographic parameters of all patients and their values after ramadan fasting

Variable	Baseline	Follow up	P value
LVEDD mm, mean±SD	48.4±5.1	48.0±3.9	0.379
LVEDV ml, mean±SD	111.0±26.2	107.4±23.3	0.132
LVEF %, mean±SD	61.4±5.6	61.7±5.5	0.529
RV mm, mean±SD	34.7±5.5	35.1±5.1	0.121
E/A, mean±SD	0.9±0.2	0.9±0.2	0.826
EDT ms, mean±SD	220.5±37.0	215.0±31.1	0.071
Septal E' cm/s, mean±SD	6.8±1.4	7.0±1.1	0.097
Septal S' cm/s, mean±SD	7.0±1.3	7.1±1.1	0.390
Lateral S' cm/s, mean±SD	8.1±1.5	8.1±1.4	0.736
Inferior S' cm/s, mean±SD	7.6±1.5	7.6±1.1	0.699
Anterior S' cm/s, mean±SD	7.4±1.5	7.4±1.2	0.940
Tei index, mean±SD	0.44±0.1	0.42±0.1	0.104
GLS %, mean±SD	-15.2±2.1	-15.4±2.4	0.522

EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

When all the patients were evaluated together, there were determined to be no significant changes in the echocardiographic diameter measurements, tissue Doppler evaluations, tei index values, and GLS values throughout the fasting month. When the fasting and non-fasting groups were compared separately, no significant change in the echocardiographic parameters was determined in the RF (-) group. In the RF (+) group, a statistically significant decrease was determined in the tei index value after 1 month of fasting (0.44±0.14 vs. 0.40±0.12, p: 0.025). No significant change was determined in the other echocardiographic parameters in this group (Table 4).

Table 4. Separate comparison of the patients' echocardiographic parameters with their baseline values and values after the ramadan fasting month

	Ramadan fasting (-) group			Ramadan fasting (+) group		
Variable	**Baseline**	**Follow up**	**P value**	**Baseline**	**Follow up**	**P value**
LVEDD mm, mean±SD	48.5±5.2	48.1±4.4	0.603	48.4±5.0	47.9±3.2	0.474
LVEDV ml, mean±SD	111.3±30.1	109.6±28.5	0.592	110.7±22.1	105.1±16.6	0.126
LVEF %, mean±SD	61.1±6.0	60.7±5.9	0.438	61.7±5.2	62.7±5.0	0.154
RV mm, mean±SD	33.6±5.8	34.4±5.5	0.119	35.9±5.0	36.0±4.6	0.597
E/A, mean±SD	0.9±0,3	0.9±0.3	0.990	0.8±0.2	0.9±0.1	0.748
EDT ms, mean±SD	216.4±41.7	210.8±35.9	0.143	224.8±31.7	219.4±25.1	0.271
Septal E' cm/s, mean±SD	6.5±1.5	6.7±1.3	0.359	7.1±1.2	7.4±0.9	0.145
Septal S' cm/s, mean±SD	6.9±1.4	6.9±1.3	0.484	7.1±1.2	7.2±0.9	0.615
Lateral S' cm/s, mean±SD	7.8±1.5	7.9±1.5	0.851	8.4±1.5	8.2±1.2	0.565
Inferior S' cm/s, mean±SD	7.1±1.4	7.3±1.2	0.253	8.1±1.4	7.8±0.9	0.068
Anterior S' cm/s, mean±SD	7.1±1,4	7.2±1.2	0.602	7.6±1.6	7.5±1.3	0.580
Tei index, mean± SD	0.43±0.17	0.43±0.14	0.960	0.44±0.14	0.40±0.12	0.025
GLS %, mean±SD	-15.1±2.5	-14.7±2.3	0.276	-15.4±1.7	-16.1±2.4	0.083

Data are presented as median (interquartile range) or number (percentage) of patients; EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

DISCUSSION

The aim of this study was to investigate the effects of fasting during the month of Ramadan on cardiac functions in patients with coronary artery disease who had previously undergone complete revascularization with stent procedure. Although there is sufficient evidence on the safety of RF in patients after percutaneous coronary intervention (PCI), there is no study showing that cardiac functions are positively affected noninvasively in this population (11). Due to the lack of data in this area, we prefer only the PCI patient population. We excluded patients with CAD and incomplete/non revascularization because ongoing ischemia might be a co-founded factor which could affect echocardiographic parameters. Another limitation of the study was that no functional non-invasive test was implemented following PCI in order to determine residual ischemia.

The results of the echocardiographic evaluation after the fasting period showed a significant decrease in the tei index in the patients who fasted for the month of Ramadan. This shows that Ramadan fasting could have positive effects on cardiac functions. To the best of our knowledge, this is the first study in literature to have investigated the effect of Ramadan fasting on cardiac functions.

When all the patients were evaluated at the end of the study, there was observed to be no significant change in the BMI values in both groups. There was expected to be a decrease in BMI in the RF (+) group as they had no food or water intake for the whole day. In previous studies on this subject, decreases in BMI values have been observed after RF (12). However, in other studies it has been shown that patients could gain weight after RF (13). That these values remained stable in the current study was thought to be due to weight gain being triggered by the wish to eat more because of the high level of hunger and thirst when breaking the fast and going to sleep after eating in the early hours at the start of the fast.

The Tei index (Myocardial Performance Index - MPI), which includes both systolic and diastolic time intervals in the cardiac cycle, was first used to evaluate global cardiac dysfunction by Tei et al. in 1995 (14). Tei index can be measured using continuous wave Doppler in routine echocardiographic evaluation, and repeated measurements can be easily performed in patients. This index can be easily used to evaluate right and left heart function and provides easy estimation of combined systolic and diastolic functions of the heart. It has been documented in many studies that the Tei index, which can be measured in routine echocardiographic evaluation in patients in the supine position, is independent of arterial pressure, heart rate, ventricular geometry, valve pathologies, afterload and preload, and therefore standardization of this value is not necessary and is reproducible (14-17). In previous studies on the Tei index, significant relationships were detected between the prolongation of the time measured by this index and the long-term adverse cardiac outcomes. Especially in a study by Kishore et al., the probability of end-stage heart failure and death occurring in a 2-year follow-up period was determined to be 5-fold greater in patients with Tei index >1.4, independently of all other causes (18).

When the two groups in the current study who were fasting and not fasting during Ramadan were compared, the echocardiographic parameters were determined to be similar. A significant difference was determined only in the tei index between the patients. In the patients who

were fasting during Ramadan, a significant decrease was determined in the tei index after 1 month of fasting. A previous study conducted with a drug that had an effect on energy metabolism, showed that the tei index values were significantly decreased during the follow up of patients who were taking the drug (19). This drug made changes in the energy metabolism by affecting fatty acid oxidation within the cell. Therefore, the changes in enegy metabolism occurring in the fasting group, the decrease in body fat ratio and the positive changes occurring in body composition (20) are thought to be responsible for the decrease in the tei index in this group.

There is no study in the literature evaluating the effect of RF on noninvasive echocardiographic parameters in patients with coronary heart disease and coronary stents. According to the results of this study, it was determined that there was a significant decrease in the Tei index of the patients after RF. Therefore, with this study, it can be thought that improvement in cardiac functions was observed in patients after RF and that it will shed light on future studies aiming to reduce the risk of side effects.

CONCLUSION

In this study, the effects of RF on cardiac functions were investigated in patients with coronary artery disease and a previous complet revascularization with stent procedure. The results of the echocardiograph evaluation after one month of fasting showed a statistically significant decrease in the tei index in the patient group fasting for Ramadan. This finding demonstrated that RF could have positive effects on cardiac functions. To the best of our knowledge, this is the first study to have evaluated the effect of RF on cardiac functions.

Study Limitations

As the study had to be conducted within the short period of the month of Ramadan, a greater number of patients could not be included. Despite the low number of patients, the study can be considered to make a very important mark. It was shown that the cardiac functions of patients improved with RF, which is a religious obligation undertaken by a significant proportion of Muslims. Additionally, echocardiographic parameters of the patients could not be monitored after Ramadan. For this reason, the stability of the results found and whether the effects achieved were reversible could not be evaluated. However, it is stated in the literature that after intermittent feeding is stopped, the effects at the cellular level will continue for a few weeks (21). It is also stated that stopping intermittent feeding does not increase metabolic risks (21). However, this study was conducted on mice and human studies are needed on this subject. This study can be of guidance for further larger scale studies on this subject. In addition, right ventricular functions, which have previously been shown to be affected by volume overload, were not evaluated in this study. The reason for this is that the devices in our hospital do not have the features required for right ventricular strain measurement.

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Ethical approval: *All the procedures in this study including human participants were applied in compliance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and subsequent revisions or comparable ethical standards. No animals were used in this study. Approval for the study was granted by the Local Ethics Committee [Protocol Code: 2024-TBEK 2024/10-12].*

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Research Article

Evaluation of Common Diagnostic Errors in Panoramic Radiographs and Interobserver Agreement in Error Identification

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Abstract

Aim: Panoramic radiography is frequently used in dental practice as an imaging technique that provides an extensive view of facial anatomical structures. Achieving high-quality radiographic images requires precise positioning and technique. This study aims to evaluate the quality of panoramic radiographs, to identify common errors that compromise diagnostic adequacy, and to analyze interobserver agreement levels concerning these errors.

Material and Method: A study analyzed 947 panoramic radiographs from the archive of Ordu University based on nine specific error criteria. Four research assistants evaluated the diagnostic quality of each image, classifying them as "excellent," "diagnostically acceptable," or "unacceptable." Inter-observer agreement was measured with kappa statistics, and overall agreement was evaluated using the Fleiss κ test.

Results: The rate of incorrect radiographs was 66.1% to 78.8%, with the most common error criterion differing for each observer. The least common error was the chin tipped too low for observers 1 and 2, and the patient positioned forward for observers 3 and 4. The highest inter-observer agreement was observed regarding the presence of foreign objects on the radiographs, while the lowest agreement occurred in cases where the patient was positioned too far back. Overall, the diagnostic quality of the panoramic radiographs was rated as "acceptable," with scores ranging from 60.5% to 69.5%. The Fleiss Kappa analysis indicated fair agreement among the four observers in assessing radiographic quality (k=0.252).

Conclusion: This study demonstrates that errors in panoramic radiography significantly impact image quality and diagnostic accuracy, highlighting the need for standardization, the use of various imaging models, and enhanced training in radiographic education.

Keywords: Panoramic radiography, quality control, oral radiology, radiographic errors

INTRODUCTION

Panoramic radiography is widely utilized in dentistry. It provides a broad view of facial structures, including the maxillary and mandibular arches and their supporting anatomy. This technique has several advantages, such as a relatively low radiation dose, patient comfort, procedural simplicity, and short acquisition time, making it a valuable tool in clinical practice (1,2).

The diagnostic utility of panoramic radiography is diminished when image quality is suboptimal. Poor-quality radiographs increase the risk of misinterpretation, potentially leading to inaccurate diagnoses and suboptimal treatment planning (3,4).

Technical and processing errors are primary contributors to poor-quality images in panoramic radiography (5). Therefore, careful attention to patient positioning and each step of the imaging process is essential. According to the literature, the most frequently observed errors are positioning-related, followed by issues with exposure settings, artifacts, and other technical errors, in decreasing order of occurrence (3,6,7).

The quality of every X-ray depends on careful positioning of the patient and on the technique and processing of the image (2). Proper patient positioning in panoramic radiography requires alignment with four key anatomical planes: the median sagittal plane, the canine-meatus plane, the ala-tragus plane, and the orbital-meatus plane (Frankfort plane). The recommended positioning technique involves extending the neck, relaxing the shoulders, maintaining

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an upright back, and keeping the feet together and slightly forward relative to the torso. Patients should be instructed to bite on the bite block, close their lips, and press their tongue against the roof of the mouth. Additionally, a lead apron should be placed over the areas of the patient's body below the head and neck to minimize radiation exposure, and care should be taken to ensure that no foreign objects are present in the head and neck region that might appear within the imaging field (5).

The primary objective of radiation protection is to produce high-quality radiographs suitable for diagnostic and treatment purposes while minimizing the patient's exposure to radiation (8). Consequently, reducing errors is essential to limit the number of suboptimal radiographs, prevent unnecessary radiation exposure, and reduce examination time (3,9-11).

This study aimed to assess the quality of panoramic radiography, identify specific errors contributing to diagnostically inadequate images, and analyze the interobserver agreement regarding these errors.

MATERIAL AND METHOD

This study was approved by the Clinical Research Ethics Committee of Ordu University (Decision No: 2024/155) and was conducted in accordance with the Declaration of Helsinki.

This retrospective study analyzed panoramic radiographs obtained in the Department of Oral and Maxillofacial Radiology at Ordu University between November 2021 and February 2022.

Panoramic radiographs were obtained using Planmeca Promax 2D S3 device (Planmeca, Helsinki, Finland) with the following parameters: 66 kVp, 8 mA, and 15.8 s. In the study in which we evaluated positioning errors, 128 panoramic films with technical errors out of a total of 1075 panoramic radiographs were excluded from the study. The 947 panoramic radiographs were evaluated according to the following nine error criteria (6).

1. The chin tipped too low,
2. The chin tipped too high,
3. Absence of tongue and palate contact,
4. A slumped position,
5. The patient positioned forward,
6. The patient positioned backward,
7. The head tilted,
8. The head turned to one side,
9. Foreign bodies (metallic partial dentures, earrings, necklaces, piercings, glasses, hair clips, etc.).

All radiographs were evaluated by four dentomaxillofacial radiology research assistants with one year of experience. Finally, the observers rated the diagnostic acceptability of each radiograph as "excellent," "diagnostically acceptable," or "unacceptable." The term "excellent" was applicable when there were no errors. While radiographs with a maximum of two errors were recorded "diagnostic acceptable." In cases, it was categorized as "unacceptable" when there were three or more errors, and radiography was found to be non-diagnostic and needs to be repeated.

The data collected were entered into a computer and analyzed using Microsoft Excel and the Statistical Package for Social Sciences (SPSS®) software (version 20, SPSS®, Inc., Chicago, IL, USA). Inter-observer agreement was quantified using kappa statistics. Kappa values>0.75 were defined as "excellent" reproducibility, those between 0.40 and 0.75 as "fair to good" reproducibility and those <0.40 as "moderate to poor" reproducibility (12).

We used the Fleiss κ test to measure the overall agreement in the assessment of quality in panoramic radiography among the four observers.

RESULTS

The rate of radiographs considered incorrect by observers was between 66.1% and 78.8% (kappa values between 0.224 and 0.379).

The most common error criterion differed for each observer. The least common error was the chin tipped too low for observers 1 and 2, and the patient positioned forward for observers 3 and 4. The relative frequency of different errors as observed by the four observers is presented in Table 1 and illustrated in Figure 1 using a bar diagram.

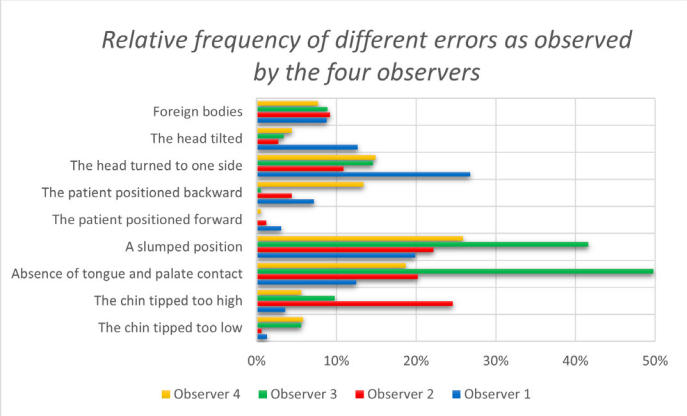

Figure 1. A bar diagram representing the frequency of errors as observed by four observers

The error criterion with the highest agreement between observers was the presence of foreign bodies on the panoramic radiography (kappa values between 0.577 and 0.852). The error criterion with the least agreement was that the patient positioned backward (kappa values between 0.020 and 0.232). Pairwise kappa values among the observers are presented in Table 2.

Based on the predefined criteria, the total counts of diagnostically acceptable, unacceptable, and excellent radiographs as assessed by the four observers are summarized in Table 3. According to the observers, the quality of the radiographs was "diagnostically acceptable," with a range of 60.5%-69.5%. Overall agreement among the four observers in assessing radiographic quality was classified as fair, with a Fleiss Kappa value of k=0.252.

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Table 1. Relative frequency of different errors as observed by the four observers

Errors	Observer 1		Observer 2		Observer 3		Observer 4	
	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)
Presence of error	292 (30.8)	655 (69.2)	267 (28.2)	680 (71.8)	201 (28.2)	746 (78.8)	321 (33.9)	626 (66.1)
The chin tipped too low	935 (98.7)	12 (1.3)	941 (99.4)	6 (0.6)	894 (94.4)	53 (5.6)	892 (94.2)	55 (5.8)
The chin tipped too high	913 (96.4)	34 (3.6)	714 (75.4)	233 (24.6)	853 (90.1)	93 (9.8)	894 (94.4)	53 (5.6)
Absence of tongue and palate contact	829 (87.5)	118 (12.5)	756 (79.8)	191 (20.2)	475 (50.2)	472 (49.8)	770 (81.3)	177 (18.7)
A slumped position	759 (80.1)	188 (19.9)	737 (77.8)	210 (22.2)	553 (58.4)	394 (41.6)	702 (74.1)	245 (25.9)
The patient positioned forward	918 (96.9)	29 (3.1)	936 (98.8)	11 (1.2)	947 (100)	(0)	942 (99.5)	5 (0.5)
The patient positioned backward	879 (92.8)	68 (7.2)	905 (95.6)	42 (4.4)	942 (99.5)	5 (0.5)	820 (86.6)	127 (13.4)
The head turned to one side	693 (73.2)	254 (26.8)	844 (89.1)	103 (10.9)	809 (85.4)	138 (14.6)	806 (85.1)	141 (14.9)
The head tilted	827 (87.3)	120 (12.7)	921 (97.3)	26 (2.7)	915 (96.6)	32 (3.4)	905 (95.6)	42 (4.4)
Foreign bodies	864 (91.2)	83 (8.8)	860 (90.8)	87 (9.2)	863 (91.1)	84 (8.9)	874 (92.3)	74 (7.7)

Table 2. Interobserver reproducibility expressed by kappa values for observers pairwise

Errors	Observer 1 vs 2	Observer 1 vs 3	Observer 1 vs 4	Observer 2 vs 3	Observer 2 vs 4	Observer 3 vs 4
Fault-free	0.379	0.309	0.246	0.346	0.224	0.352
The chin tipped too low	0.328	0.262	0.101	0.160	0.088	0.175
The chin tipped too high	0.133	0.176	0.171	0.263	0.030	0.143
Absence of tongue and palate contact	0.384	0.200	0.127	0.257	0.137	0.164
A slumped position	**0.511**	**0.413**	0.306	**0.408**	0.304	0.336
The patient positioned forward	0.339	-	0.110	-	0.245	-
The patient positioned backward	0.231	0.101	0.112	0.076	0.055	0.020
The head turned to one side	0.181	0.233	0.164	**0.417**	0.166	0.147
The head tilted	0.225	0.222	0.088	0.289	0.178	0.129
Foreign bodies	**0.819**	**0.796**	**0.595**	**0.852**	**0.577**	**0.632**

Table 3. Observations made by the four observers regarding the quality of radiographs

Quality	Observer 1 N (%)	Observer 2 N (%)	Observer 3 N (%)	Observer 4 N (%)
Excellent	291 (30.7)	263 (27.8)	193 (20.4)	320 (33.8)
Diagnostically acceptable	631 (66.6)	658 (69.5)	647 (68.4)	573 (60.5)
Unacceptable	25 (2.6)	26 (2.7)	107 (11.3)	54 (5.7)

DISCUSSION

The focal trough in a panoramic X-ray unit is a three-dimensional curved zone where anatomical structures are most clearly visualized. Due to the limited dimensions of the focal trough, even minor positioning errors can lead to distortions. Structures positioned outside this zone may appear blurred, magnified, reduced in size, or otherwise distorted. Thus, proper patient preparation and precise head positioning within the focal trough are critical for obtaining diagnostically valuable panoramic radiographs (13).

Dental radiography quality standards are established by recommendations on radiology standards, which also define the phrases “excellent”, “diagnostically acceptable”, and “unacceptable”. Guidelines recommend that the rate of “unacceptable” radiographs should not exceed 10%, while at least 70% of radiographs should be classified as “excellent” or fault-free (14). However, achieving these quality standards can be challenging in practice. In previous studies, the error rate of radiographs was reported to range from 62.4% to 93% (6,9,13,15-17). In the current study, the rate of erroneous radiographs was observed between 66.1% and 78.8% according to the observers.

In a study by Dhillon et al. evaluating 1,782 radiographs, 24.9% were classified as “diagnostically unacceptable” (9). Similar studies by Brezden et al. and Kumar et al. reported rates of 18.2% and 13.2%, respectively (4,18). In the present study, the rate of diagnostic unacceptable radiographs ranged from 2.6% to 11.3% according to the observers. The variation in this rate compared to similar studies may stem from differences in the observers' undergraduate education across countries as well as variations in their levels of experience.

All observers in this study were research assistants of dentomaxillofacial radiology with one year of experience. Kappa statistics indicated low interobserver reproducibility for most parameters, with the exception of foreign body detection, which showed excellent agreement among all observer pairs. This variability may be attributable to differences in the observers’ educational backgrounds, as they completed their undergraduate studies at different dental faculties, and their limited experience in this specialty. Overall agreement on panoramic radiograph quality, as measured by Fleiss Kappa, was fair, suggesting that while observers were consistent in their overall quality ratings, their assessments of specific error types varied. In a comparable study by Khator et al., 500 radiographs were assessed by three observers—a postgraduate student, a lecturer, and a professor, showing that observations from the lecturer and professor were more closely aligned. This finding underscores the potential impact of radiological experience on error evaluation (19).

Observer 1 identified the most frequent error as the patient’s head being turned to one side. Similarly, studies by Bissoon et al. and Kaviani et al. reported head rotation as the most common error (20,21) When patients turn their heads, it results in overlapping of proximal surfaces, the teeth on one side appear wider and the teeth on the other side appear narrower. This misalignment also causes inconsistencies in the horizontal magnification of anatomical structures, complicating diagnostic interpretation (5).

Observer 2 noted that the most frequent error was the patient’s chin positioned too high. Recognized indicators for identifying an excessively elevated chin position include the flattening of the occlusal plane and distortion of the maxillary anterior tooth apices. This type of positioning error can lead to significant distortion of the maxillary anterior residual ridge, potentially compromising diagnostic interpretation of this area to such an extent that accurate evaluation may no longer be feasible (22).

According to Observer 3, the most common error observed was absence of tongue and palate contact. This has also been found to be the most common error in many other studies (6,7,9,10,13,16,23,24). This error results in a radiolucent shadow over the apices of the maxillary teeth, which complicates interpretation of the periapical region. Consequently, it can lead to missed diagnoses of periapical pathology, root resorption, and both odontogenic and non-odontogenic lesions around the maxillary tooth apices (6). Ensuring patient cooperation is essential to minimize this error.

Observer 4 reported that the most common error was a slumped posture, which was also observed as the most frequent error in studies by Belgin et al. and Fairozekhan et al. (15,25). This positioning issue results in a ghost image of the cervical spine being superimposed on the anterior region (20). Factors contributing to this error may include advanced age, postural abnormalities, or obesity, which can make optimal positioning challenging. To prevent this, the operator should ensure that the patient’s spine is straight, and the neck properly extended.

The occurrence of errors can be significantly minimized by double-checking patient positioning and providing clear, concise instructions (26). However, errors may still occur in patients with facial asymmetry, short or heavy necks, severe obesity, extreme height, or those unable to follow directions, which may be beyond the operator's control (13). In such cases, the operator must exercise caution during positioning. Additionally, to enhance radiographic quality, periodic random audits should be conducted.

Education for technicians, dentists, and dental students is crucial in minimizing errors in panoramic radiography. In a study by Wenzel et al., it was found that computer-assisted learning and training with a phantom in a simulated clinical environment enhanced dental students' ability to identify panoramic errors and improve their patient positioning skills (27).

In recent years, various artificial intelligence-based software programs have been developed to enhance image quality by correcting errors in panoramic radiography. Du et al. utilized a convolutional neural network (CNN)-based architecture designed to eliminate image blurring caused

by patient positioning errors. The results demonstrated that the CNN effectively estimated the positioning error of the patient's dental arch, followed by the reconstruction of the corrected panoramic image, which successfully reduced the blur (28).

CONCLUSION

In conclusion, the evaluation of panoramic radiographic errors in this study, which had a substantial impact on image quality and diagnostic value, varied across observers. Standardization of radiography education is essential, along with the implementation of diverse educational models and the support of both theoretical and practical periodic training. Looking ahead, the widespread adoption of artificial intelligence-supported programs has the potential to automatically correct panoramic errors, thereby ensuring the production of high-quality images.

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Research Article

A New Approach: Generative Artificial Intelligence in Physiatry Resident Education

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Abstract

Aim: This study assessed the effectiveness of ChatGPT-4o, an artificial intelligence (AI) platform, in creating a therapeutic exercises presentation for physiatry residents' education. The aim was to compare the quality of content created by ChatGPT-4o with that of an expert, exploring the potential of AI in healthcare education.
Material and Method: Both an expert and AI created 24 PowerPoint slides across six topics, using same reputable sources. Two other experts assessed these slides according to CLEAR criteria: completeness, lack of false information, appropriateness, and relevance and scored as excellent, 5; very good=4, good=3, satisfactory/fair=2, or poor, 1.
Results: Interrater reliability was confirmed. Average scores (calculated from the two raters' scores) for each topic were significantly lower for AI than for the expert, although whole presentation scores did not differ between the two. Overall scores (calculated from the average scores of all items) for each topic were good to excellent for AI, excellent for the expert. The overall score for whole presentation was good for AI, excellent for the expert. Highest ranks for individual criteria was relevance for AI, lack of false information for the expert. Some AI-generated elements were later integrated into the expert work, enhancing the content.
Conclusion: ChatGPT-4o can generate effective educational content, though expert outperforms it, highlighting the need for professional oversight. Collaboration between humans and AI may further enhance educational outcomes.

Keywords: Healthcare education, physiatry residency, therapeutic exercises, ChatGPT, generative AI

INTRODUCTION

Residency education in medicine is a period of specialized training that takes place between graduating from medical school and becoming a certified independent specialist. Unlike basic medical education, it is shaped by specific healthcare settings and needs, and serves as a bridge between academic learning and real-world medical practice (1). Structured training programs that prioritize skill building and formal education are essential for supporting junior doctors and ensuring their competence (2).

When determining educational strategies, it is essential to consider institutional preferences, target populations, and learning style. A variety of methods are widely used, including simulation-based approaches, scenarios, standardized patients, research, mentoring, journal clubs, seminars, lectures, case discussions, bedside discussions, courses, games, and portfolios (3). In physiatry clinics, educational sessions such as seminars, lectures, case discussions, and journal reviews are designed for postgraduate physiatry residents and practicing physiatrists. While these programs also include bedside discussions, direct patient care, and invasive procedures, the knowledge gained from lectures and seminars serves as the basis for effective real-time practice.

In Türkiye, the Medical Specialty Regulation defines the curriculum, planning, programming, and implementation principles for each specialty (4). 'Therapeutic exercises' is one of the topics that is generally included in the curriculum of Physical Medicine and Rehabilitation programs. This topic involves movements prescribed to correct impairments, restore muscular and skeletal functions, and maintain a state of well-being in patients. They are beneficial for quality of life, and overall health (5).

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Generative artificial intelligence (AI) platforms are systems that can generate relevant responses by drawing on vast amounts of knowledge and information and mimicking human-like conversations. They can be applied in numerous medical fields, including image analysis, clinical diagnostics, drug development, patient assistance and education, remote monitoring, tailored treatment plans, administrative functions, and medical documentation (6).

A prominent example of generative AIs is ChatGPT created by OpenAI (7). ChatGPT can be used to prepare medical letters, imaging reports, and patient discharge documents (8). It can also play a role in summarizing drug labeling documents and creating safety protocols for invasive procedures (9,10). ChatGPT-4o is one of the fastest and most developed versions of the ChatGPT.

As generative AIs have been successful in various medical fields and are able to write, summarize, and create medical texts, thats very possible that they can also summarize articles or texts and create educational slides out of them.

In this research, we aimed to evaluate the effectiveness of ChatGPT-4o in creating PowerPoint slides by comparing its slides with those prepared by a physiatrist. Both sets of slides were developed using the same reputable sources to ensure consistency. Our approach consisted of two steps: first, a physiatrist and ChatGPT-4o created 35 slides for a presentation on therapeutic exercises using relevant articles; then, two additional physiatry experts reviewed and scored both slide sets for completeness, lack of false information, appropriateness, and relevance.

The objective of this study is to evaluate ChatGPT-4o's effectiveness in preparing a therapeutic exercises presentation for an educational session for physiatry residents.

Our research has two hypotheses. The effectiveness hypothesis suggests that ChatGPT-4o will prepare a presentation rated above moderate effectiveness. The null hypothesis for this asserts that ChatGPT-4o will not effectively prepare the presentation and that it will be rated below moderate. The performance hypothesis predicts that the expert, based on subject knowledge, will outperform ChatGPT-4o. The null hypothesis states that there will be no variation in performance between the expert and ChatGPT-4o.

These hypotheses emphasize the necessity of evaluating the effectiveness of AI tools in contributing to lecture hours to meet the growing demands of health education.

MATERIAL AND METHOD

Study Design

This study integrated qualitative and quantitative components, categorizing it as a mixed-methods study. It is reported according to METRICS checklist that involves model used and its settings, evaluation approach, timing, transparency, range of tested topics, randomization, individual factors and interrater reliability, count of requests, and specificity of the prompts and language used (11). Since the study did not involve human participation and centered on engagements with conversational AI systems, ethical approval was not necessary.

Model Used and its Exact Setting

ChatGPT is a conversational AI system powered by large language models. We chose the 4o version created by OpenAI due to its status as one of the most advanced versions available at the time of our search (7). The system was assessed using standard default configurations to ensure consistent replication of the generated content. Since ChatGPT-4o does not remember information from prior interactions, each conversation begins without any reference to previous questions or answers, thereby eliminating the possibility of learning or feedback loops. However, all slide requests for each topic were made using a new session, and the regenerate button was not utilized.

Evaluation Approach for the Generated Content

The physiatry specialist initially created a presentation based on information from six selected articles about therapeutic exercises (12-17). Subsequently, the same six articles were submitted to ChatGPT-4o and it was tasked with generating an equivalent number of slides suitable for a PowerPoint presentation. Once both sets of slides were ready, the specialist anonymized them by assigning letter codes, making it impossible to tell which set was AI-generated and which was expert-made. Then, two other physiatry specialists, who had previously reviewed the articles, independently evaluated both sets of slides without knowing their sources. To maintain objectivity, the raters were also unaware of each other's scores during the assessment.

Given that the presentations shared the same underlying material, we focused on the C (Completeness of the Content), L (Lack of False Information), A (Appropriateness of the Content), and R (Relevance) elements of the CLEAR scoring system. The "E" component, which evaluates evidence supporting content, was deemed less distinct between the two presentations due to the uniformity of the sources used. By concentrating on the remaining CLEAR criteria, we aimed to provide a comprehensive analysis of how each presentation utilized shared evidence and conveyed information effectively to the audience. In this tool, items are scored as follows: excellent, 5; very good=4, good=3, satisfactory/fair=2, or poor, 1 (18).

Timing of Testing and Transparency of the Data

AI model was tested on September 21, 2024, at local time 12:20-12.35, in Istanbul zone. The conversations have been recorded in the public data archive Zenodo (19).

Range of Tested Topics and Randomization

The authors selected a specialized issue of a reputable local journal, published in Turkish, that focused on

therapeutic exercises. This issue included a range of relevant topics, such as joint range of motion exercises, stretching exercises, peripheral joint mobilization and manipulation, muscle performance exercises, aerobic exercises, aquatic exercises, posture exercises, and relaxation exercises (12-17). Articles that were not aligned with the focus of the study were excluded. For example, the article entitled "Exercise for Healthy Living and Prevention of Chronic Diseases" was omitted because of its emphasis on preventive rather than therapeutic interventions. Likewise, specialized discussions on exercises for specific conditions, such as soft tissue injuries, orthopedic surgeries, and respiratory issues, were left out to keep the core content general. Since all six essential therapeutic exercise topics were covered, randomization was deemed unnecessary.

Individual Factors in Selecting the Topic and Interrater Reliability

Therapeutic exercises subject is a foundational component of the first-year curriculum for resident physiatrists. To ensure thorough training, the authors concentrated on general therapeutic exercises for initial learning, reserving more specialized topics for subsequent sessions. The use of a reputable journal known for its thorough coverage of essential physiatry subjects ensured that personal preferences or biases did not influence the selection of topics, leading to a comprehensive introduction ideal for newly trained physicians.

To enhance objectivity in the assessment process, two independent raters, physiatrists working in an outpatient clinic and rehabilitation service, evaluated the content. Statistical measures indicated significant agreement between the raters. The inter-rater reliability confirmed that the assessments were consistent and had minimal influence from individual biases, thereby enhancing the validity of the study's findings.

Count of Slides Requested from the Model

Of the six topics selected, ten slides were requested for the first, as it was more comprehensive, while five slides were requested for each of the remaining five topics. The topics of the articles used by the physician and AI to prepare the training outline are presented in Table 1.

Table 1. Topics of the articles used in preparation of educational slide content

Therapeutic exercises	
1	Joint range of motion exercises, stretching exercises, peripheral joint mobilization and manipulation
2	Muscle performance exercises
3	Aerobic exercises
4	Aquatic exercises
5	Posture and posture exercises
6	Relaxation exercises

Specificity of the Prompts and Language Used

The questions followed a consistent methodology, using the following prompt (in Turkish): 'I plan to prepare a PowerPoint presentation on "..." for assistant doctors who are in the first year of their specialty training in the Physical Medicine and Rehabilitation Department. This presentation will be used during an educational hour. Please take the provided text and create a detailed PowerPoint presentation consisting of ... slides formatted in Turkish. Each slide should contain complete, cohesive content that I can read directly to an audience without headings.

I specifically want the slides to be organized in a listing pattern with bullet points or numbered lists to enhance readability and fit well into the PowerPoint slide format. The slides should cover essential aspects and explanations for each section, reflecting the key points suitable for a physiatry seminar. I want to clarify that I want the slides to be prepared according to the content of the text I will be loading. Please wait for the text to be loaded before starting to create the slides.' We deliberately crafted this request to resemble that of a physician. This strategy aimed to reflect professional tone of a professional requesting assistance for an upcoming educational mission. By doing so, we aimed to make our interactions with the AI platform similar to a genuine academic scenario, making the generated content more relevant to actual needs. The prompt was designed according to the recommendations of Meskó B (20).

Statistics and Data Analysis

Data analysis was carried out utilizing IBM SPSS Statistics for Windows version 29.0.2.0 (IBM Corp., Armonk, NY), with a significance level set at $p < 0.050$. Two physiatrists independently evaluated the presentations, referred to as rater 1 and rater 2.

The strength and direction of the association between the two ordinal variables were measured using Kendall's tau-b statistic. Kendall's Tau-b values are categorized as follows: 0.00 to ±0.10: very weak or no correlation, ±0.11 to ±0.30: weak correlation, ±0.31 to ±0.50: moderate correlation, ±0.51 to ±0.70: strong correlation, ±0.71 to ±1.00: very strong correlation. Kendall's tau-b values ranged from -1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 indicating no association (21).

Agreement between the two independent evaluators was assessed utilizing Cohen's kappa method. Cohen's Kappa quantifies inter-rater agreement for categorical data. The categorization of Cohen's kappa values is as follows: values below 0.20 indicate poor agreement, 0.21-0.40 signify fair agreement, 0.41-0.60 reflect moderate agreement, 0.61-0.80 represent substantial agreement, and 0.81-1.00 indicate nearly perfect agreement (22).

After measuring inter-rater reliability, the scores for each topic from both evaluators were totalled and divided by two. These results were accepted as 'average scores.' For example, the C score for topic 1 from evaluator 1 and the C score for topic 1 from evaluater 2 were summed and then divided by two, resulting in the 'average C score' for topic 1. Next, the average scores of the four CLEAR items for each topic were totalled and divided by four, with the resulting value accepted as the 'overall score' for each topic. For instance, the C, L, A, and R average scores for topic 1 were summed and divided by four, resulting in the 'overall score' for topic 1.

Additionally, the raters evaluated the entire presentation, considering all slides collectively, to provide 'average scores' and 'overall scores' for the whole presentation. The overall scores were organized into the following categories: scores of 1-1.79 as "poor", 1.80-2.59 as "satisfactory", 2.60-3.39 as "good", 3.40-4.19 as "very good", and 4.20-5.00 as "excellent" (18).

A paired samples t-test was used to compare average scores, as the Shapiro-Wilk test confirmed normality. For the entire presentation scores, the Wilcoxon signed-rank test was applied, as the data did not meet the normality assumption. Further analysis assessed performance on CLEAR items (excluding E) by examining within-model variability.

RESULTS

The results of the inter-rater correlation indicated a very strong correlation for the AI-generated content and a moderate correlation for the expert-generated content according to Kendall's Tau-b statistics. Similarly, the results of the inter-rater agreement indicated substantial agreement for the AI-generated content and fair agreement for the expert-generated content according to Cohen's Kappa statistics. Notably, although the raters exhibited stronger agreement for the AI-generated slides than for the expert-generated slides, the p-values confirmed that the correlation and the agreements were statistically significant in both groups. Given this significance, it was appropriate to calculate the average of the two raters' scores, as utilizing these averaged values would provide a single, more reliable score for subsequent analyses. The results of these tests are presented in Table 2.

Table 2. Interrater correlation and agreement for ai and expert-generated presentations

	Kendall's Tau-b	p-value (Kendall's Tau-b)	Categorization (Kendall's Tau-b)	Cohen's Kappa	p-value (Cohen's Kappa)	Categorization (Cohen's Kappa)
AI	0.723	<0.001	Very strong correlation	0.514	<0.001	Substantial agreement
Expert	0.513	<0.001	Moderate correlation	0.401	0.016	Fair agreement

Table 3 presents descriptive statistics of the cumulative average scores (derived from the initial average scores) for the AI-generated and expert-prepared slides. The cumulative values were calculated from 24 average scores, with each of the six topics contributing four scores. For AI-generated slides, the cumulative score was 3.77. In contrast, expert-prepared slides achieved a higher cumumulative score of 4.52.

Table 3. Descriptive statistics for cumulative average scores of AI and expert-generated slides

	N	Min	Max	Mean	SD
Cumulative scores of AI-prepared slides	24	2.50	5.00	3.77	0.79
Cumulative scores of expert-prepared slides	24	3.50	5.00	4.52	0.48

N: number of scores, Min: minimum, Max: maximum, SD: standard deviation

Table 4 presents the descriptive statistics of the overall scores for each of the six topics and for the entire presentation. The overall scores of the AI-prepared slides were rated as good to excellent, whereas the expert-prepared slides were consistently rated as excellent. The expert presentations excelled in all categories, while the AI-generated content performed notably well in the "Aquatic Exercises" category. A comparison of overall scores of AI and Expert-generated content per each topic is presented in Figure 1.

Table 4. Descriptive statistics for overall scores of AI and expert-generated slides

Therapeutic exercises subheadings	Prepared by	Min	Max	Mean	SD	Category
JRME, SE, PJMM	AI	3.00	4.00	3.25	0.50	Good
	Expert	4.00	5.00	4.75	0.50	Excellent
Muscle Performance E	AI	2.50	5.00	3.50	1.08	Very Good
	Expert	4.00	5.00	4.38	0.48	Excellent
Aerobic E	AI	3.00	4.00	3.63	0.48	Very Good
	Expert	4.00	5.00	4.50	0.41	Excellent
Aquatic E	AI	4.00	5.00	4.50	0.41	Excellent
	Expert	3.50	5.00	4.50	0.71	Excellent
Posture and Posture E	AI	3.00	4.50	3.63	0.75	Very Good
	Expert	4.00	5.00	4.50	0.58	Excellent
Relaxation E	AI	3.00	5.00	4.13	1.03	Very Good
	Expert	4.00	5.00	4.50	0.41	Excellent
Whole Presentation	AI	3.00	4.00	3.38	0.48	Good
	Expert	4.00	4.50	4.25	0.29	Excellent

JRME, SE, PJMM: joint range of motion exercises, stretching exercises, peripheral joint mobilization and manipulation, E: exercises, Min: minimum, Max: maximum, SD: standard deviation

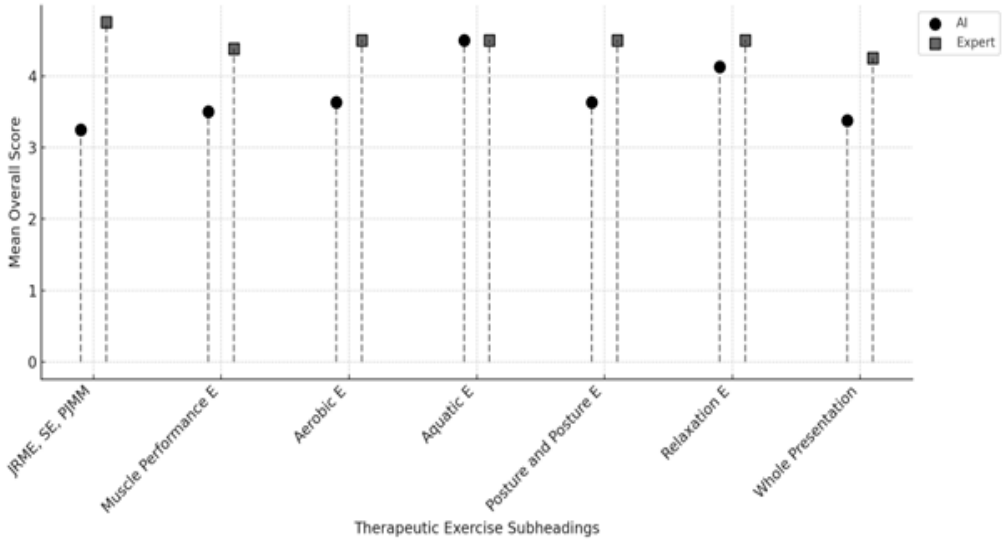

Figure 1. Comparison of overall scores of AI and expert-generated content per each topic

After demographic statistics, we planned to compare the average scores of AI-generated and expert-generated slides. Before the comparison, the normality distribution was tested using the Shapiro-Wilk test. The results showed no significant deviation from normality ($W(24)=0.924$, $p=0.071$; $W(24)=0.924$, $p=0.071$), indicating that conducting a parametric test was suitable. The paired-samples t-test revealed a statistically significant difference between the

average scores of AI and expert-prepared slides (p<0.001). The negative mean difference indicates that the AI-made slides' scores were significantly lower than those of human-made slides'. Furthermore, the effect size was large (Cohen's d=-0.998), highlighting a large difference between the groups (Table 5).

Table 5. Comparison of mean of average scores of ai and expert presentations

Measure	Mean difference	SD	SEM	95% CI Lower	95% CI Upper	t	df	p-value (two-sided)	Cohen's d (effect size)
AI - expert	-0.75	0.75	0.15	-1.07	-0.43	-4.89	23	< 0.01	-0.998

SD: standard deviation, SEM: standars error mean, CI: confidence interval

Later, we planned to compare the average scores of the whole presentation of AI and expert. The cumulative score for the expert-prepared entire presentation (4.25) was higher than AI-generated presentation (3.38). Before the comparison, the normality distribution of the scores was tested using the Shapiro-Wilk test. The results showed a significant deviation from normality (W=0.630, p=0.001; W=0.630, p=0.001). Therefore, we performed a nonparametric test, the Wilcoxon signed-rank test, for the scores of the entire presentation. The results of this test indicated a test statistic (Z) of -1.890, based on negative ranks. The asymptotic significance (2-tailed p-value) was 0.059. This p-value suggested that the difference in scores was not statistically significant at the conventional alpha level of 0.05.

Table 6 presents the final analysis of performance for each CLEAR item, examining within-model variability. The Friedman test revealed a statistically significant difference in ranks across the four CLEAR items for both AI-prepared content ($\chi^2(3)=10.39$, p=0.016) and expert-prepared content ($\chi^2(3)=11.70$, p=0.008). For AI-prepared slides, "relevance" and "lack of false information" received higher ranks, while for expert-prepared slides, "lack of false information" and "appropriateness" were ranked higher. "Completeness" had the lowest rank in both AI and expert presentations. The within-model variability in AI and expert mean ranks across the items is presented in Figure 2.

Table 6. Within-model variability in mean ranks and statistical results across CLEAR items for AI and expert-generated content

	Mean Rank (AI)	Mean Rank (Expert)
C	1.50	1.17
L	3.00	3.42
A	2.00	2.75
R	3.50	2.67
Chi-Square (χ^2)	10.39	11.70
p-value	0.016	0.008

C: Completeness of the Content, L: Lack of False Information, A: Appropriateness of the Content, and R: Relevance

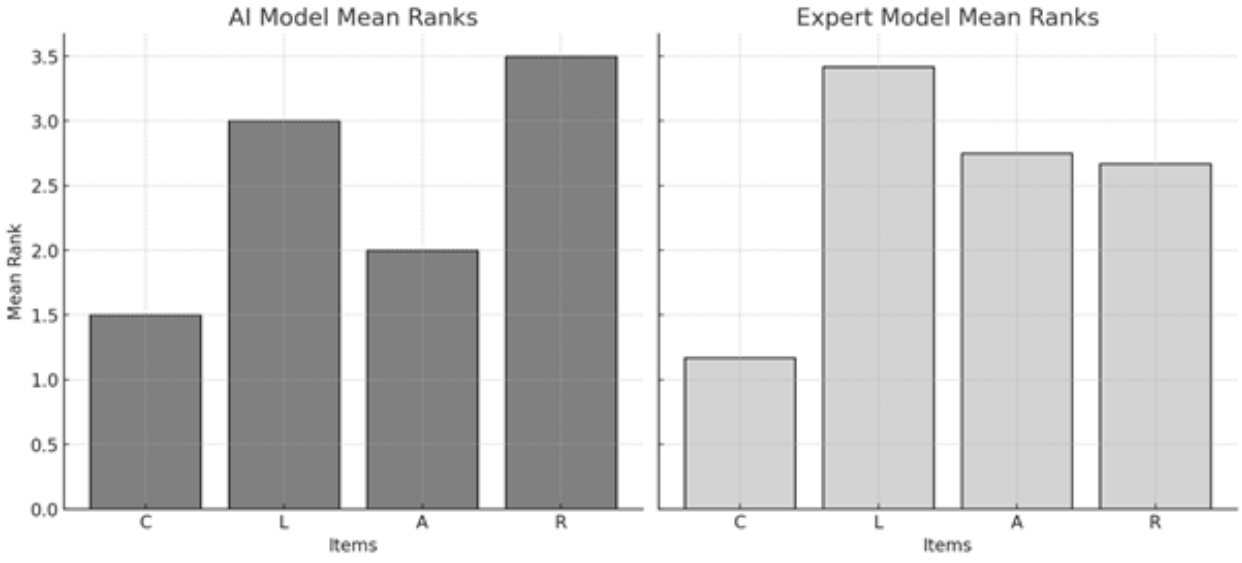

Figure 2. Within-Model Variability in Mean Ranks Across CLEAR Items for AI- and Expert-generated; C: completeness of the content, L: lack of false information, A: appropriateness of the content, and R: relevance

DISCUSSION

This study explored a novel approach to preparing educational presentations aimed at enhancing the educational hours of physiatry residents. Specifically, it evaluated the effectiveness of ChatGPT-4o in creating PowerPoint slides for therapeutic exercises. Presentations generated by both AI and the expert were assessed by blinded evaluators.

In this study, the cumulative average score for AI-generated presentations was 3.77 out of 5, while expert-prepared presentations achieved a higher mean score of 4.52 out of 5, indicating superior performance of the expert. Notably, the cumulative scores for the expert-prepared slides were significantly higher than those for the AI slides ($p<0.001$). However, when the presentations were assessed as a whole, no statistically significant difference was found between the cumulative scores ($p=0.059$).

Furthermore, the overall scores for individual topics indicated that the AI's performance ranged from good to excellent, whereas the expert received excellent ratings across all topics. When considering the entire presentation, the AI received a score of 3.38 out of 5, classified as "good", while the expert received a score of 4.25 out of 5, classified as "excellent".

These findings support both our hypotheses, suggesting that ChatGPT-4o would prepare a presentation rated above moderate and that the physiatrist would outperform ChatGPT-4o because of expertise.

As far as we know, this study is the first to investigate the capability of an AI system to create PowerPoint slides for a presentation based on medical texts. It represents a pioneering effort to evaluate the effectiveness of AI in preparing educational materials for residency programs.

To contextualize these findings, it is important to consider the existing literature on the use of AI in medicine and healthcare.

Previous studies have suggested that conversational AI platforms can enhance healthcare by reducing the daily burden on professionals. For example, ChatGPT has demonstrated its capability as an effective tool for improving medical documentation, such as clinical letters, imaging reports, and discharge reports (8). In a simulated case study, ChatGPT reviewed a conversation between a patient and a doctor, generated medical records, suggested differential diagnoses, and provided treatment recommendations; the results closely aligned with the physician's summaries (23). Likewise, ChatGPT was employed to facilitate the process of writing clinical letters for prior authorization requests from insurance providers. This innovative approach was noted to potentially save physicians considerable time, enabling them to concentrate more on patient care and clinical decision-making (24). Our findings support these results, demonstrating that the 4o version of ChatGPT can contribute to preparing medical content, even though expert performed better.

Literature also suggests that AI systems can play a beneficial role in health education initiatives. A systematic review pointed out that ChatGPT has promising uses in healthcare education, research, and practice, including improving scientific writing, streamlining workflows, and enhancing personalized learning (25). Munaf et al. recommended that resident doctors use ChatGPT for generating reports, creating mnemonics, and simulating clinical scenarios, thereby reducing administrative tasks, enhancing learning, and improving patient interaction as it streamlines workflows and presents information clearly (26). It has been shown that AI tools like ChatGPT can aid in content creation, support learning, and offer new opportunities for assessment and research in medical and postgraduate education (27). AI serves multiple roles in medical education, including enhancing clinical specialty training, facilitating personalized and adaptive learning, and improving decision-making through advanced data analysis. Additionally, AI integration promotes increased efficiency and accuracy in educational processes, driving the modernization and diversification of medical curricula (28). Our research supports these findings on educational effectiveness, as the AI-generated slides in our study were rated from good to excellent. This suggests that ChatGPT-4o could effectively reduce the workload for educator physicians, allowing them more time for other tasks.

Nonetheless a systematic review highlighted that ChatGPT only achieved moderate or 'passing' performance across various tests, deeming it unreliable for clinical deployment due to its nonclinical design (29). In line with this, our study highlighted the need for professional support when managing AI-generated content, as the expert's performance consistently surpassed that of the AI on cumulative and overall. This suggests two potential approaches: implementing professional oversight of AI-generated drafts or fostering collaboration between AI and experts.

Additionally, the use of AI in educational contexts is not without challenges. There are critical concerns regarding the potential for inaccurate information, inherent biases, and the necessity for robust privacy and security measures (26). Bajwa et al. asserted that attention must be given to ensuring ethical access to data, possessing the necessary expertise in medical fields, having sufficient computing power, and addressing the challenges associated with implementing AI in real-world settings (30). Moreover, ChatGPT should also be used with caution due to ethical, copyright, transparency, and legal issues, as well as risks of bias, plagiarism, lack of originality, inaccurate content with hallucination risks, limited knowledge, incorrect citations, cybersecurity concerns, and the potential for infodemics (25). Besides inaccuracies and misinformation, there may also be risks of over-reliance on AI for medical purposes (31).

In our study, there were no inaccuracies or misinformation present in the AI-prepared content. However completeness and appropriateness of the content received lower ranks.

Additionally, we did not encounter any inherent biases in the AI-generated slides, as the material was derived from reputable sources. Given that no sensitive information was included, privacy and data protection were also not a concern. Furthermore, the author utilizing the AI system had the necessary expertise, which mitigated potential challenges related to implementation. We did not observe any cases of hallucination in the generated content. While there is a possibility of limited knowledge in AI outputs, this was addressed by ensuring that the content was reviewed by an expert prior to use. Additionally, we provided the citations ourselves, as this was part of the study design, further ensuring the reliability of the information presented

Even though the raters did not identify the mentioned problems they claimed that there was a notable distinction in the presentation style. After completing the statistical analysis and being informed about the group assignments the raters remarked that the AI-generated slides appeared more mechanical, whereas the human-generated slides conveyed a friendlier tone.

Another notable observation in our study was that 'relevance' was highest in the AI-made presentation, while 'lack of false information' was highest in the expert-made presentation. The high relevance in the AI presentation likely resulted from its ability to efficiently process and filter large datasets, effectively aligning content with specific objectives or keywords. In contrast, the expert's superior performance in ensuring the lack of false information suggests a strong emphasis on content reliability, which can be attributed to extensive domain knowledge, critical thinking skills, and experience in fact-checking.

Additionally, both AI and expert presentations scored lowest in completeness, indicating challenges faced by each in fully addressing all necessary details. For the AI, this limitation likely arisen from the inherent constraints of its training data and algorithms, which may not capture the depth and breadth of a topic as comprehensively as a human could. On the other hand, the expert's completeness might be affected by assumptions about the audience's prior knowledge particularly since they are first-year residents or by practical constraints such as limited time in educational settings.

Looking forward, advancements in artificial intelligence are likely to address some of the challenges currently faced. As AI systems continue to evolve, there will be an increase in their potential benefits, leading to higher accuracy in their outputs. A research suggests that in the coming decade, AI will become increasingly advanced, enabling healthcare to move away from a one-size-fits-all model toward a more personalized, preventive, and data-driven approach. These changes could improve patient outcomes and clinical experiences while also reducing costs, resulting in a more efficient and tailored healthcare system (30).

Finally, based on our findings, we recommend requiring specialist oversight when using AI-generated material, as expert-prepared presentations outperformed AI-generated one. Additionally, we propose that collaboration between experts and AI could yield more refined results by leveraging their respective strengths.

Integration of AI in Educational Preparation

After completion of the study, we aimed to integrate the AI-generated presentation into the expert-made presentation. To achieve this, the AI-generated slides were meticulously reviewed and some necessary information were selectively included in the expert-made slides. This approach resulted in an enriched content, but also increased the time required for the presentation. Nevertheless, the resulting presentation was stored for use in the upcoming education hour for physiatry residents (19). This experience provided us with a unique opportunity to combine AI and human efforts to achieve better education material and to incorporate AI-generated insights into practical educational settings.

Limitations of the Study

The study has several limitations. First, the number of presentations could have been greater; however, the existing presentation covered the six most important topics related to therapeutic exercises, with each topic scored separately. While increasing the number of raters could have provided more varied feedback, both raters were experienced physiatrists, and their agreement was confirmed. Additionally, while it would have been beneficial for assistant doctors in the residency program to participate in the scoring, this was not feasible since they were in their first year of specialization and lacked sufficient knowledge on the subject. As new learners, they would have likely evaluated aspects such as fluency and clarity rather than the content itself. Lastly, although evaluating a larger number of slides could have enriched the analysis, the presentation was designed to simulate a real training session, which was intended to last approximately 40 minutes.

CONCLUSION

This study demonstrated that ChatGPT-4o can generate educational slide content on therapeutic exercises at a level above moderate for physiatry residents. However, the expert consistently outperformed the AI due to their specialization. This indicates that generative AI tools can be valuable for creating educational materials, but they should complement rather than replace human expertise. Careful integration of AI-generated health education content with professional oversight is essential to ensure the accuracy and appropriateness of the information presented.

There is a continued need for ongoing research and awareness of the practical challenges associated with integrating AI into healthcare education. Future studies should explore strategies to enhance AI's performance in its weaker areas and investigate how collaboration between AI and experts can be optimized to improve educational outcomes.

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Ethical approval: *Since the study did not involve human participation and centered on engagements with conversational AI systems, ethical approval was not necessary.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Examining the Attitudes and Experiences of Nurses Working in a High Security Forensic Psychiatry Unit from a Psychiatric Perspective

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Abstract

Aim: This study aims to examine the approaches, attitudes, and experiences of nurses working in a High Security Forensic Psychiatry Unit (HSFPU) towards psychiatric disorders, conditions, and treatments and to reveal the associated factors.
Material and Method: This cross-sectional study was conducted with nurses working at Elazığ Fethi Sekin City Hospital HSFPU who agreed to participate in the study. The participants filled out the Nurses' Attitudes Towards Forensic Psychiatric Patients Scale (NAFPPS) along with a questionnaire including various variables.
Results: Thirty-two nurses (22 females (68.80%), 10 males (31.20%)) were included in the study. Twenty-two nurses (31.20%) did not have sufficient knowledge of the Penal Code of Türkiye 32 (PCT 32). The psychiatric disorder that nurses found easiest to predict was bipolar spectrum disorder (43.80%), while the one that nurses found most difficult to predict was schizophrenia spectrum disorder (62.50%). The illicit substance that caused the most difficulty in nursing care was methamphetamine for 19 nurses (59.40%). Nurses' command of psychiatric terminology was not at the desired level. Twenty-three nurses (71.90%) thought that antidepressants caused addiction. Almost all of the nurses (96.90%) thought that antisocial and borderline personality traits make nursing care difficult. According to regression analysis, working duration in HFSPU predicts NAFPPS willingness to provide care subscale (constant $p<0.001$; working duration in HFSPU $p=0.039$), while NAFPPS willingness to provide care subscale predicts routine learning of psychiatric diagnosis in nursing care (constant $p=0.048$, NAFPPS willingness to provide care $p=0.037$).
Conclusion: This study demonstrated that nurses' knowledge and experience levels regarding psychiatric treatment practices were quite high, but not at the desired level regarding forensic and psychiatric terminology. It was suggested that the necessary improvements would be provided through in-service training including psychiatric nursing, forensic psychiatric nursing, psychiatry, psychology, and social services.

Keywords: Nurse, nursing care, forensic nursing, psychiatric nursing, forensic psychiatry

INTRODUCTION

In Türkiye, cases who were diagnosed with a psychiatric disorder or were thought to have a psychiatric disorder and were involved in a crime were hospitalized in forensic psychiatry inpatient units within mental health and disease hospitals in the past. In 2005, within the framework of European Union harmonization laws, it was decided that the judicial procedures and, if necessary, the treatment of cases diagnosed with psychiatric disorders involved in crime would be carried out in High Security Forensic Psychiatry Units (HSFPU). As of 2015, HSFPUs started to provide services under the City Hospitals (1,2).

Cases are accepted within the scope of articles 32 of the Penal Code of Türkiye (PCT 32), 57 of the Penal Code of Türkiye (PCT 57) or 74 of the Code of Criminal Procedure (CCP 74) in HSFPUs. PCT 32 is about mental disorders. A penalty shall not be imposed on a person who, due to mental disorder, cannot comprehend the legal meaning and consequences of the act he has committed, or if, in respect of such act, his ability to control his own behaviour was significantly diminished. However, security measures shall be imposed for such persons. PCT 57 includes "Security

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Measures Specific to Mental Cases". It evaluates the hospitalization for treatment purposes (PCT 32/1 or PCT 32/2), discharge and post-discharge process of cases who were mentally ill at the time of involvement in a crime. The case must admit to HSFPUs for follow-up and treatment to be checked at certain intervals. The duration of this follow-up is determined by the health board. Cases where the necessary decision cannot be determined within the scope of PCT 32 are observed. CCP 74 includes "Stationary Mental Examination". If strong indications of suspicion are present, which tend to show that the suspect or the accused committed the criminal conduct; then in order to clarify whether the suspect or the accused is mentally ill, and if so, the duration of the illness, and whether this affected his actions, the Justice of the Peace in Criminal Matters during the investigation phase, and the trial court during the prosecution phase, may order the suspect or the accused to be stationed in a public medical centre upon the proposal of the expert, after hearing both the public prosecutor and the defence counsel. The period of the stationary mental examination shall not exceed three weeks. If this period is not sufficient, upon the motion of the public medical centre, a ruling may be made and the additional terms not exceeding three weeks each may be given; the sum of the terms shall not exceed three months. The purpose of keeping the case under observation is to determine whether there is criminal liability within the scope of PCT 32. Although rare, involuntary, also known as compulsory, hospitalizations are carried out in HSFPUs. Article 432 of the Turkish Civil Code (TCC 432-437) includes the "Involuntary Hospitalization Decision" (1).

Nurses play a role in the care and treatment processes of forensic psychiatry cases in HSFPUs. There is no standardization in terms of treatment and care services in these units and nurses who are defined/specialized as forensic psychiatric nurses are not assigned. Therefore, the treatment and care services for forensic psychiatric patients are carried out by nurses who have received almost no training in forensic psychiatric nursing. Lack of forensic psychiatric training is reflected in the practices of nurses working in these units and affects their attitudes towards cases (3-5). Our aim in this study is to examine the approaches, attitudes and experiences of nurses working in a HSFPU towards psychiatric disorders and treatments and to reveal the associated factors.

MATERIAL AND METHOD

This cross-sectional and descriptive study was conducted at Health Sciences University Elazığ Fethi Sekin City Hospital HSFPU between 15/09/2024 and 15/10/2024. The universe of the study consisted of 38 nurses working in this unit. The study was conducted with 32 nurses who agreed to participate in the study, excluding those who were absent from their institutions due to reasons such as leave, illness, and change of place of duty for training purposes. The inpatient capacity of Elazığ Fethi Sekin City Hospital HSFPU is 100.

The survey draft was created by researcher with six years of experience in psychiatry practice. The survey was administered face to face. Leading and sensitive questions were avoided. The survey language is Turkish. The Nurses' Attitudes Towards Forensic Psychiatric Patients Scale (NAFPPS) was administered to all participants.

NAFPPS was developed by Baysan-Arabacı and Çam (3) in 2009 to determine the attitudes of nurses towards forensic psychiatric patients. It consists of 25 items: positive (items 3, 4, 7, 10, 14, 15, 16, 17, 20) and negative (items 1, 2, 5, 6, 8, 9, 11, 12, 13, 18, 19, 21, 22, 23, 24, 25). In the validity and reliability study of the scale, the content validity index was found to be 0.69, the Cronbach Alpha internal consistency coefficient was 0.86, the intra-cluster correlation coefficient was 0.86, and the stability coefficient determining the consistency between pre-test and re-test was 0.69. In the factor analysis, it was determined that the scale consisted of four sub-dimensions: "social distance (items 14, 15, 16 and 17)", "willingness to provide care (items 7, 10, 11, 12, 13, 19 and 20)", "trust (items 8, 9, 18, 21, 22, 23, 24 and 25)" and "feeling threatened (items 1, 2, 3, 4, 5 and 6)". NAFPPS was prepared as a five-point Likert-type scale. According to the nurses' agreement or disagreement with each statement, each positive item is scored from 1 to 5 from "completely disagree" to "completely agree", and the negative items are scored vice versa. The highest score that can be obtained from the scale is 125, and the lowest score is 25. A high score indicates a positive attitude towards forensic psychiatric patients.

There was no age or gender limit. The participants answered all questions completely and harmoniously. Therefore, no data were excluded from the study. According to the sample size analysis (population size 300; population proportion 99%), 15 or more measurements/surveys are needed to have a confidence level of 95% that the real value is within ±5% (margin of error) of the measured/surveyed value.

Ethical approval was obtained from the Fırat University Non-invasive Research Ethics Committee and the 1964 Declaration of Helsinki was complied with (Clinical Trial Number: 2024/12-16; Date: 11/09/2024). All participants provided informed consent.

All analyses were performed using IBM SPSS Statistics version 26.0. Descriptive statistics and continuous variables were given as mean±standard deviation and categorical variables were given as frequency and percentage. The Chi-square test and Fisher's exact test were used to compare the categorical data between the groups and genders. Compliance with normal distribution was determined by the Kolmogorov-Smirnov test and Mann-Whitney U test was used for non-normally distributed variables. Linear regression analysis, binary logistic regression analysis and Spearman correlation analysis were used. A p value of less than 0.05 was set as statistical significance.

RESULTS

Sociodemographic, Training, and Psychometric Scale Characteristics of Nurses

Thirty-two nurses (22 females (68.80%), 10 males (31.20%)) were included in the study. Mean age was 37.53±6.57 years (minimum 29 years, maximum 54 years; 25th 32.00 years; median 37.00 years; 75th 43.00 years). Twenty-nine nurses (90.60%) were university graduates, while three nurses (9.40%) were high school graduates. Nursing duration was 15.37±7.55 years (minimum 6 years, maximum 36 years; 25th 10.00 years; median 14.00 years; 75th 20.00 years); mean working duration in the psychiatric inpatient unit was 5.31±2.71 years (minimum 1 years, maximum 14 years; 25th 3.00 years; median 5.00 years; 75th 6.75 years); mean working duration in HSFPU was 4.37±1.66 years (minimum 1 years, maximum 7 years; 25th 3.00 years; median 5.00 years; 75th 6.00 years). There was only one male nurse (3.10%) with a master's degree in psychiatric nursing. There were no nurses with a master's degree in forensic psychiatric nursing. While four nurses (12.50%) were working in day shift, 28 nurses (87.50%) were working in night shift. There were no nurses with first-degree relatives who had a severe mental disorder (SMD). There were three nurses (9.40%) with second-degree relatives who had a SMD. In total (n=32), NAFPPS total was determined as 64.56±11.82 (minimum 44.00, maximum 86.00; 25th 55.00; median 60.00; 75th 77.25), NAFPPS social distance as 8.68±3.49 (minimum 4.00, maximum 15.00; 25th 6.00; median 8.00; 75th 12.00), NAFPPS willingness to provide care as 24.65±5.03 (minimum 16.00, maximum 35.00; 25th 21.00; median 24.00; 75th 28.75), NAFPPS trust as 16.12±4.10 (minimum 10.00, maximum 22.00; 25th 12.00; median 16.00; 75th 20.00) and NAFPPS feeling threatened as 15.09±2.17 (minimum 10.00, maximum 21.00; 25th 14.00; median 14.00; 75th 16.00) (Table 1).

Table 1. Sociodemographic, training, and psychometric scale characteristics of nurses

Parameters	Female (n=22) mean±SD (mean rank) & n	Male (n=10) mean±SD & n	p
Age (years)	38.63±6.10 (18.50)	35.10±7.23 (12.10)	0.199[a]
Education (university/high school)	21/1	8/2	0.164[b]
Nursing duration (years)	16.90±6.73 (18.89)	12.00±8.51 (11.25)	0.129[a]
Working duration in the psychiatry (years)	5.13±3.02 (15.61)	5.70±1.94 (18.45)	0.533[a]
Working duration in the HSFPU (years)	4.09±1.84 (15.20)	5.00±0.94 (19.35)	0.076[a]
Shift (day shift/night shift)	4/18	0/10	0.149[b]
Second-degree relatives with SMD (yes/no)	1/21	2/8	0.164[b]
NAFPPS total	63.13±12.39 (15.18)	67.70±10.34 (19.40)	0.290[a]
NAFPPS social distance	8.04±3.53 (14.70)	10.10±3.10 (20.45)	0.113[a]
NAFPPS willingness to provide care	24.40±5.52 (15.80)	25.20±3.96 (18.05)	0.650[a]
NAFPPS trust	15.40±4.22 (14.82)	17.70±3.49 (20.20)	0.123[a]
NAFPPS feeling threatened	15.27±2.07 (16.75)	14.70±2.45 (15.95)	0.531[a]

*p<0.05; Mann-Whitney U testa and Fisher's exact testb were used in statistical analysis; SD: standard deviation, HSFPU: high security forensic psychiatry unit, SMD: severe mental disorder, NAFPPS: nurses' attitudes towards forensic psychiatric patients scale

Nurses' Experiences and Attitudes on HSFPU Processes and Procedures

There were 25 nurses (78.10%) with sufficient knowledge regarding CCP 74, 27 nurses (84.40%) with sufficient knowledge regarding PCT 57, 22 nurses (68.80%) with sufficient knowledge regarding PCT 32, and 12 nurses (37.50%) with sufficient knowledge regarding TCC 432-437.

All of the nurses accompanied the psychiatrists on visits. All of the nurses were familiar with the forensic hospitalization processes of the cases. However, 14 nurses (43.80%) did not routinely learn the psychiatric diagnosis of the case during nursing care.

There were 20 nurses (62.50%) who thought that the nurse-to-patient ratio was adequate. There was only one female nurse who was not happy working at HSFPU (Table 2).

Table 2. Experiences and attitudes of nurses on HSFPU processes and procedures

Parameters	Female (n=22)	Male (n=10)	p
Is the nurse-to-patient ratio adequate? (yes/no)	14/8	6/4	0.844[a]
Sufficient knowledge regarding CCP 74 (yes/no)	15/7	10/0	0.044*[a]
Sufficient knowledge regarding PCT 57 (yes/no)	17/5	10/0	0.101[a]
Sufficient knowledge regarding PCT 32 (yes/no)	14/8	8/2	0.355[a]

*p<0.05, Fisher's exact testa were used in statistical analysis; HSFPU: high security forensic psychiatry unit, SD: standard deviation, CCP: code of criminal procedure, PCT: penal code of Türkiye

Nurses' Experiences and Attitudes Regarding Psychiatric Conditions, Disorders, and Treatments

The psychiatric diagnosis that caused the most difficulties in nursing care was schizophrenia spectrum disorder for 11 nurses (34.40%) and bipolar spectrum disorder for seven nurses (21.9%). The psychiatric disorder that the 20 nurses (62.50%) had the most experience in nursing care was bipolar spectrum disorder. The most common psychiatric disorder accompanying insomnia was bipolar spectrum disorder for 16 nurses (50.00%) and schizophrenia spectrum disorder for 10 nurses (31.30%). The most common psychiatric disorder accompanying agitation was schizophrenia spectrum disorder for 13 nurses (40.60%) and bipolar spectrum disorder for eight nurses (25.00%). Based on nursing observations, the most easily predicted psychiatric disorder diagnosis was bipolar spectrum disorder for 14 nurses (43.80%) and schizophrenia spectrum disorder for eight nurses (25.00%). Based on nursing observations, the most difficult psychiatric disorder diagnosis to predict was schizophrenia spectrum disorder for 20 nurses (62.50%). The illicit substance that caused the most difficulty in nursing care was methamphetamine for 19 nurses (59.40%). There were 25 nurses (78.10%) with experience in nursing care of methamphetamine psychosis. Twenty-six nurses (81.30%) did not know what extrapyramidal system side effects meant. Twenty-eight nurses (87.50%) knew what delusion meant, while all of the nurses (100.00%) had sufficient knowledge about hallucination. Eleven nurses (34.40%) did not know what hypomania/mania meant. Twenty-three nurses (71.90%) thought that antidepressants caused addiction. The most common antidepressant side effect experienced by ten nurses (31.30%) was sedation. All nurses (n=32) knew that benzodiazepines cause addiction. Thirty-one nurses (96.90%) thought that antisocial and borderline personality traits made nursing care difficult. All nurses (n=32) had experience of restricting agitated patients, administering haloperidol, biperiden, chlorpromazine, zuclopenthixol acuphase, zuclopenthixol depot intramuscularly. All nurses (n=32) thought that patients with suicide and homicide phenomena should be closely monitored. Four of the nurses (12.50%) had experience of life-threatening psychiatric conditions (such as neuroleptic malignant syndrome, malignant catatonia) (Table 3 and 4).

The sociodemographic characteristics, attitudes and experiences of nurses who thought the nurse-to-patient ratio was adequate and those who did not were similar (p>0.05).

The sociodemographic characteristics, attitudes and experiences of nurses with and without sufficient knowledge regarding PCT 32 were compared. Those with sufficient knowledge of PCT 32 had higher working duration in the psychiatry (p=0.001) and working duration in the HSFPU (p=0.002). Those who did not have sufficient knowledge regarding PCT 32 also did not have sufficient knowledge regarding CCP 74 (p=0.001), PCT 57 (p=0.001), and purpose of biperiden use (p=0.010). Those who did not have sufficient knowledge about PCT 32 (p=0.005) and mania/hypomania (p=0.017) were not willing to learn the psychiatric diagnoses of the cases they care for. Nursing duration was higher in those with experience in delirium nursing care (p=0.023).

The correlation between various variables was examined by controlling the effect of age. No significant correlation was found between nursing duration, working duration in psychiatry, working duration in HSFPU and NAFPPS total and subscales (p>0.05).

According to linear regression analysis, working duration in HFSPU predicts NAFPPS willingness to provide care (R=0.367, R square=0.134, Durbin-Watson=1.216, F=4.660, 95.0% CI=14.873-24.705; constant p<0.001; working duration in HFSPU p=0.039).

According to binary logistic regression analysis, NAFPPS willingness to provide care predicts routine learning of psychiatric diagnosis in nursing care (Beginning block, -2 log-likelihood=43.860[a], overall p=0.025; Block one, -2 log-likelihood=38.380[a]; Cox & Snell R^2=0.157; Nagelkerke R^2 0.211; Hosmer and Lemeshow Test p=0.297, constant p=0.048, NAFPPS willingness to provide care p=0.037).

The parameters that can be used to predict having sufficient knowledge about PCT 32 were examined using binary logical regression analysis. The significant variables were examined one by one using binary logistic regression analysis. After various modelling, a model was created using 'routine learning of psychiatric diagnosis in nursing care' and 'working duration in HFSPU' (Beginning block,

-2 log-likelihood=39.760[a], overall p=0.001; Block one, -2 log-likelihood=23.709[a]; Cox & Snell R^2=0.394; Nagelkerke R^2 0.554; Hosmer and Lemeshow Test p=0.485, constant p=0.079). The 'routine learning of psychiatric diagnosis in nursing care (p=0.023)' and 'working duration in HFSPU (p=0.018)' contributed significantly to the model.

Table 3. Experiences and attitudes of nurses regarding psychiatric disorders and conditions

Parameters	Female (n=22)	Male (n=10)	p
The most difficult psychiatric diagnosis for nursing care (bipolar spectrum disorder/ schizophrenia spectrum disorder/intellectual disability/personality disorder/substance use disorder)	3/8/5/4/2	4/3/1/0/2	0.255[a]
Having much experience in nursing care (bipolar spectrum disorder/schizophrenia spectrum disorder/intellectual disability/ substance use disorder)	14/5/1/2	6/3/1/0	0.706[a]
The most common psychiatric disorder accompanying insomnia (bipolar spectrum disorder/schizophrenia spectrum disorder/ personality disorder/substance use disorder/anxiety spectrum disorder/depression spectrum disorder)	10/8/0/2/1/1	6/2/1/1/0/0	0.550[a]
The most common psychiatric disorder accompanying agitation (bipolar spectrum disorder/schizophrenia spectrum disorder/personality disorder/substance use disorder)	6/10/3/3	2/3/1/4	0.422[a]
The most easily predicted psychiatric disorder (bipolar spectrum disorder/ schizophrenia spectrum disorder/anxiety spectrum disorder/intellectual disability/ personality disorder/substance use disorder)	10/6/1/3/0/2	4/2/0/3/1/0	0.449[a]
The most difficult psychiatric disorder to predict (bipolar spectrum disorder/ schizophrenia spectrum disorder/anxiety spectrum disorder/ personality disorder/ substance use disorder)	1/13/1/3/2	1/7/0/2/0	0.714[a]
The most difficult illicit substance for nursing care (no experience/methamphetamine/ cannabis/heroin)	7/11/2/2	2/8/0/0	0.362[a]
Experience in nursing care of methamphetamine-induced psychotic disorder (yes/no)	16/6	9/1	0.273[a]
Sufficient knowledge regarding delusion (yes/no)	18/4	10/0	0.149[a]
Sufficient knowledge regarding mania/hypomania (yes/no)	15/7	6/4	0.652[a]
Experience of nursing care of delirium (yes/no)	15/7	3/7	0.044*[a]

*p<0.05, Fisher's exact testa were used in statistical analysis

Table 4. Experiences and attitudes of nurses regarding psychotropic medications and side effects

Parameters	Female (n=22)	Male (n=10)	p
Sufficient knowledge regarding EPS side effect (yes/no)	5/17	1/9	0.393
Most frequent EPS side effect experience (no experience/tardive dyskinesia/ akathisia/dystonia)	17/2/2/1	9/0/0/1	0.516
Do antidepressants cause addiction? (yes/no)	18/4	5/5	0.064
The most common psychotropic side effect according to nurses' observations (sedation/constipation/nausea/dry mouth/sialorrhea/dystonia/palpitations/tremor)	7/0/1/6/4/2/1/1	3/4/0/1/0/1/1/0	0.077
Sufficient knowledge regarding the purpose of use of biperiden (yes/no)	12/10	8/2	0.168
It is recommended that the first dose of PP1M be administered to the deltoid muscle, and the second dose on day eight. Did you know this? (I have administration experience and I knew it/I have administration experience but I didn't know it)	3/19	0/10	0.220
PP3M needs to be shaken for 15 seconds before administration. Did you know this? (I don't have any administration experience/I have administration experience and I knew it/I have administration experience but I didn't know it)	19/2/1	9/1/0	0.790

*p<0.05, Fisher's exact testa were used in statistical analysis; EPS: extrapyramidal system; PP1M: paliperidone palmitate once-monthly injection; PP3M: paliperidone palmitate three-monthly injection

DISCUSSION

This study examined the experiences and attitudes of nurses working in a HSFPU regarding psychiatric disorders, treatment, and judicial procedures, and yielded important findings. It was shown that the nurses' knowledge of judicial procedures (e.g., CCP 74, PCT 57, PCT 32, TCC 432-437), psychiatric terminology, and psychotropic medications was not at the desired level. It was determined that the nurses' experiences regarding psychiatric disorders were consistent with the HSFPU characteristics. It was also concluded that the nurses' attitudes and experiences were not generally related to gender.

In Türkiye, hospitalizations under TCC 432-437 are mostly carried out in centres such as mental health hospitals (6). However, in rare cases where observation is carried out under CCP 74 and a PCT 57 decision is applied to the court, hospitalization may be required until the PCT 57 decision is reached (1). These hospitalizations are carried out involuntarily under TCC 432-437 (6). In other words, hospitalizations under TCC 432-437 are relatively rare in HSFPUs. It is thought that this is the most important reason why nurses are less familiar with the concept of TCC 432-437 compared to other judicial procedures including CCP 74, PCT 57, and PCT 32. It is also a striking finding that approximately one-fourth of the nurses do not have knowledge of CCP 74, PCT 57, and PCT 32 despite working in an HSFPU. The parameters associated with having sufficient knowledge about judicial processes were also investigated in this study. Those who had sufficient knowledge about PCT 32 were found to have longer working duration in psychiatry and HSFPU. Those who did not have sufficient knowledge regarding judicial processes and mania/hypomania were not willing to learn the psychiatric diagnoses of the cases.

Mood disorders and psychotic disorders are among the psychiatric disorders most frequently hospitalized in HSFPUs due to involvement in crime (7). In the study conducted by Yıldız et al. (7) in the same clinic as this present study, Elazığ Fethi Sekin City Hospital HSFPU, between May 15, 2021 and June 30, 2021, it was shown that 61.8% of the cases were in the psychotic disorder spectrum, and 30.9% were in the mood disorder spectrum. Again, in the study by Kazgan-Kılıçaslan et al. (8), who examined the data of the same unit, Elazığ Fethi Sekin City Hospital HSFPU, between September 20, 2021 and October 20, 2021, it was shown that 45.3% of the cases were in the psychotic disorder spectrum, and 44.4% were in the mood disorder spectrum. It is seen that psychiatric disorder diagnoses other than mood disorders and psychotic disorders are relatively rare (~10.0%) and inpatient profile is also clearly reflected in the attitudes and experiences of the nurses. It was determined that the psychiatric disorders that the nurses have the most nursing care experience are bipolar spectrum disorder and schizophrenia spectrum disorder. Again, it was shown that the psychiatric disorders that nurses have the most difficulty in nursing care are these disorders. Half of the nurses stated that the psychiatric disorder in which insomnia is most common is bipolar spectrum disorder. Indeed, insomnia constitutes one of the diagnostic criteria in manic and hypomanic episodes of bipolar disorder (9). It is also seen that the nurses' experiences on agitation are consistent with the literature. Agitation is common in schizophrenia and bipolar spectrum disorders and disrupts the patient's treatment compliance (10). The nurses reported that they more easily predict the diagnosis of bipolar spectrum disorder, while it is more difficult to predict the diagnosis of schizophrenia spectrum disorder. Psychomotor agitation, insomnia, inflated self-esteem, grandiosity, increased amount of speech, laxity in associations, goal-directed activity, distractibility, and excessive involvement in activities probably make it easier to predict bipolar spectrum disorders. Negative symptoms in schizophrenia spectrum disorders including slow movement, lack of motivation, poor grooming, difficulty planning, reduced range of emotions, and becoming withdrawn make diagnostic prediction difficult (9). The increasing use of methamphetamine all over the world in recent years is also reflected in our findings. According to the 2023 World Drug Report, 36 million of the 296 million drug users in 2021 were methamphetamine users (11). It is known that approximately 40% of methamphetamine users have psychotic symptoms. These psychotic symptoms may be transient or permanent. Psychotic disorders due to methamphetamine use are associated with increased aggression (12,13). The judicial processes of these cases, who tend to violence and engage in crime, are also carried out in HSFPUs. This results in nurses encountering more users of methamphetamine than other illicit substances. Four out of five nurses included in this study had been involved in the nursing care of a patient diagnosed with methamphetamine-related psychotic disorder at least once, and three out of five reported that the substance they had the most problems with in nursing care was methamphetamine.

Nurses' command of psychiatric terminology and conditions is also one of the subjects of this study. It was observed that all nurses had sufficient knowledge about hallucination. It was thought that the widespread use of the concept of hallucination in the normal population was related to this result. Although bipolar spectrum disorder is one of the most frequently followed psychiatric disorders in HSFPUs, it was determined that the nurses' knowledge about mania/hypomania was not sufficient. Another important finding of this study was that two-thirds of the nurses thought that antidepressants caused addiction. It was observed that nurses had good experience with intramuscular injections, which are frequently used in psychiatry practice. In the study conducted by Baysan-Arabacı and Çam (3) on nurses working in psychiatry inpatient units, the NAFPPS total score was reported as 69.07±12.46. In this sense, the NAFPPS scores determined in this present study were found to be consistent with the data in the literature.

Additionally, a significant relationship was found between NAFPPS willingness to provide care and 'routine learning of psychiatric diagnosis in nursing care' and working duration in HFSPU.

In health services, individuals who do not have serious medical problems, exhibit nonspecific complaints and psychosomatic symptoms, are coercive, demanding, aggressive, and seek secondary gains are defined as 'difficult', 'heart sink', or 'hateful' patients. Antisocial and borderline personality traits are the most frequently detected personality patterns in these patients (14). The nurses who participated in this study also stated that antisocial and borderline personality traits made the process difficult during nursing care.

As of 2021, there are six HSFPUs in the provinces of Adana, Kayseri, Elazığ, Eskişehir, Bursa, and Ankara (1). The exact number of nurses working in these units is not known, but based on the number of nurses working in Elazığ Fethi Sekin City Hospital HSFPU, it is estimated to be around 250-300. The most important strength of this study is that it has examined for the first time the approaches of nurses working in HSFPUs regarding forensic cases, psychiatric disorders and conditions, psychotropic medications, and side effects. The limitation of this study is that it has addressed only one of the six HSFPUs. Its cross-sectional nature is another limitation. Longitudinal studies with larger samples are needed. Studies with larger samples may increase the generalizability of the results.

CONCLUSION

This study has demonstrated that nurses' knowledge and experience levels regarding psychiatric treatment practices are quite good, but not at the desired level regarding forensic and psychiatric terminology. It is suggested that the necessary progress will be made in this regard through in-service training in psychiatry. It is anticipated that the cooperation of units such as psychiatric nursing, forensic psychiatric nursing, psychiatry, psychology, and social services will maximize the benefit to be obtained from these in-service trainings.

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Research Article

Examination of the Relationship Between the Comfort Levels and the Mother to Infant Bonding Levels of Women in the Postpartum Period

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Abstract

Aim: The research was conducted to establish the relationship between the comfort levels of mothers in the postpartum period and mother-infant bonding.
Material and Method: The research is of descriptive type. The sample of the study consisted of 257 women who had just given birth in the Gynecology and Obstetrics service of a public hospital in Türkiye and voluntarily participated in the research between February and April 2023. Personal information questionnaire, postpartum comfort scale, and mother to infant bonding scale were used to collect the data of the study.
Results: The average total score women received from the postpartum comfort scale in the postpartum period was 97.45±15.22. A statistically significant difference was found between the postpartum comfort scale total score average according to the women's working status, number of postpartum days, postpartum care requirement and number of patients in the room (p<.05). Additionally, there was a difference between the mean physical comfort scores of women according to their income level (p<.05). The mean total score of the mother to infant bonding scale was 14.30±2.92. No significant relationship was found between women's postpartum comfort and mother-to-infant bonding levels.
Conclusion: The research findings indicated that women in the postpartum phase exhibited a moderate degree of comfort and maternal-infant bonding, with no statistically significant correlation between the two variables. To enhance postpartum comfort and foster stronger maternal-infant bonds, it is advisable for healthcare providers to assess mothers' needs and expectations comprehensively and deliver high-quality care accordingly.

Keywords: Parturition, woman, comfort, mother-infant interaction

INTRODUCTION

The postpartum phase represents a unique journey for families, playing a crucial role in safeguarding the well-being and growth of both the mother and baby, while also nurturing family health. During this period, the family balances change and regeneration is experienced, and the stress and anxiety of both the family and the mother increase while adapting to the changes experienced (1). In addition, this period is a period that requires giving baby care and creating a safe environment, communicating with the baby and overcoming the problems that arise. Prolonged labor, intense pain during labor and possible complications cause mothers to feel tired and exhausted. In this period of physical and emotional intensity, the mother has to adapt to this new process in order to meet the needs of her baby and to continue her daily life, while trying to meet her self-care and cope with the problems she experiences (2,3). The care and support to be received at the hospital in adapting to this new process is important for the positive maintenance of the postpartum comfort of the mothers. The word “comfort” is defined in

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the dictionary as relaxation that facilitates daily life (4). The notion of comfort has remained central to nursing practice since the time of Florence Nightingale, serving as the ultimate objective in the provision of nursing care (5). The concept of comfort in nursing; It is defined as diagnosing the comfort needs of the individual, family and society being cared for, planning the nursing care for these needs and then evaluating the comfort level (4,6,7). According to the comfort theory developed by Kolcaba, comfort; it is explained as meeting the problems that arise in physical, sociocultural, psychospiritual and environmental dimensions at three levels as relief, relaxation and overcoming problems (4).

In the postpartum period, women experience changes in physical, sociocultural, psychospiritual and environmental areas, and their comfort level is also affected. With the inclusion of a new individual in the family, there are changes in feelings, thoughts and relationships. The first minutes after birth are important in terms of ensuring the adaptation of the mother and the baby to this new situation, and mother to infant bonding (8).

Bonding, as a concept, refers to the connection that develops between an infant and their primary caregiver, fostering the infant's trust (9). Mother-to-infant bonding is a relationship that initiates with the baby's growth and movements within the mother's womb, and it is anticipated to mature gradually over time (10). This connection between the mother and the infant plays a crucial role in shaping the mother's role and ensuring its ongoing fulfillment (11). In the first days after birth, which forms the basis of the mother-infant relationship, mother-infant interaction begins, mothers need social and psychological support, and this support is mostly received from members of the family (12). Supporting the care of the baby, helping the mother to meet her care needs, creating time for sleep and rest, and the support of the spouse positively affect the bonding between the mother and the infant. As a result of relieving pain and bleeding in the postpartum period, ensuring hygiene, nutrition and mobilization, and supporting infant care, the mother will feel sufficient and will be stronger in coping with problems. In this period, ensuring the harmony of the mother who receives holistic care, starting and continuing breast milk early, ensuring the recovery in a short time, preventing the risk factors that may occur and the care to be given to the mother and the baby will provide both postpartum comfort and strengthening the mother's bond with the baby. Midwives and nurses have important responsibilities in providing postpartum care, improving comfort and strengthening the mother's bond with the baby (8,13-15,16-21). Based on this information, the study aimed to determine the relationship between women's comfort levels in the postpartum period and maternal bonds with their newborns.

Research Question and Hypothesis

Is there a relationship between women's comfort levels in the postpartum period and mother-infant bonding?

MATERIAL AND METHOD

Type of Research

The research is a descriptive correlational study conducted to elucidate the relationship between the comfort levels of mothers and mother-infant bonding in the postpartum period.

Population and Sample of the Research

In this research, the G-power 3.1.9.4 statistical software was utilized to determine the appropriate sample size. To establish the sample size, we referenced a prior study by Engin and Ayyıldız (n=368) that explored factors associated with maternal bonding to infants. Employing a Type I error level of 0.01, a Type II error level of 0.01 (resulting in a power of 0.99), and an effect size of 0.3, our analysis yielded a calculated sample size of 205 participants (21). Consequently, the research included 257 female participants who met the criteria of free will and acceptance. The acceptance criteria for the study included being 18 years and older, having given birth either vaginally or via cesarean section, being in the postpartum period (between 1 and 40 days), having given birth to one or more babies, having at least primary education, being able to read and understand Turkish, and expressing a willingness to participate in the study. Additionally, individuals who had experienced baby loss during the postpartum period, those who did not have their babies with them, and those diagnosed with postpartum depression or using psychiatric medication were excluded from the study.

Data Collection

The researchers gathered research data through in-person interviews conducted with mothers who had recently given birth (within the postpartum period of 1-40 days) and were under the care of the obstetrics service. Before proceeding with data collection, mothers were presented with comprehensive details regarding the study's purpose. They were then given the opportunity to provide informed consent should they decide to take part. It was made explicitly clear that they had the autonomy to withdraw from the study at any stage, underscoring the voluntary nature of their participation. Furthermore, it was emphasized that mothers would not be subject to any costs or fees associated with their involvement in the research.

Data Collection Tools

Personal information form, postpartum comfort scale and mother to infant bonding scale were used to collect the data of the study.

Personal information form: The questionnaire comprises inquiries related to socio-demographic and obstetric attributes (12-15,19-21). It encompasses a range of questions, including but not limited to the woman's age, educational background, employment status, family structure, income level, pregnancy intention, infant's gender, method of delivery, any complications during childbirth, the occupancy of the room (number of patients), and the necessity for postpartum care.

Postpartum Comfort Scale (PCS): Karakaplan and Yıldız devised this tool for assessing postpartum comfort, as documented in their work (22). The scale, consisting of a total of 24 items, is in a 5-point Likert format. It encompasses three dimensions that investigate the physical, psychospiritual, and sociocultural aspects. Scores on the scale can range from a minimum of 34 to a maximum of 170, with a higher score indicating an increased level of postpartum comfort. The reliability of the data obtained from the scale was assessed using the Cronbach's Alpha test, resulting in a coefficient of 0.78 (22).

Mother to Infant Bonding Scale (MIBS): The scale under consideration assesses the relationship between the maternal-infant bond and the mother's initial emotional state. It can be effectively administered as early as the day following childbirth and was originally developed by Taylor and colleagues (23). Aydemir and Alparslan conducted a study with a sample of Turkish mothers to ensure the validity and reliability of the scale's Turkish version. The study included a translation and cultural adaptation process to ensure the suitability of the scale for Turkish culture. The translated scale was then administered to a group of mothers, and data were collected to assess its psychometric properties. The validity of the scale was evaluated using various methods, including content validity, construct validity, and criterion validity. Content validity was established by having experts in the fields of mother-infant attachment and emotional well-being review the scale items and provide feedback on their relevance and clarity. Construct validity was examined by analyzing the relationships between scale scores and other measurements of mother-infant attachment and emotional well-being. Criterion validity was established by comparing scale scores with established measures of mother-infant attachment and emotional well-being. The scale, consisting of a total of 8 items, is in a 4-point Likert format. Responses are scored between 0-3. The score that can be obtained from the scale is 0-24. As the score obtained from the scale increases, it is considered an indicator of mother-infant attachment problems. The reliability of the scale was assessed using Cronbach's alpha coefficient, which measures the internal consistency of scale items. The coefficient was calculated for the first day after birth and the 8-12 weeks postpartum period. The reported values of 0.69 and 0.68 indicate that the scale has acceptable internal consistency (24).

Statistics of Data

The research data underwent analysis using Statistical Package for the Social Sciences (SPSS) 25.0 software. To assess the socio-demographic and obstetric characteristics of the mothers, descriptive statistics were employed, encompassing figures, percentages, arithmetic means, and standard deviations. For data associated with the PCS and MIBS, various statistical parameters were computed, including arithmetic means, standard deviations, medians, as well as minimum and maximum values. The distribution of the data was evaluated using the Shapiro-Wilk normality test. The choice between the Kruskal-Wallis H test and the Mann-Whitney U test depended on the number of variables considered. To explore relationships within the data, the Spearman correlation coefficient was utilized, with Spearman rank correlation coefficient (rho, ρ) values categorized as very weak (0.00-0.25), weak (0.26-0.49), moderate (0.50-0.69), high (0.70-0.89), and very high (0.90-1.00) correlations (25). Throughout the study, a significance level (α) of .05 was established, with any p-value less than .05 regarded as statistically significant (26).

Ethics of Research

Ethics committee approval (dated 5.12.2022 and number 11-2022/09) and institutional permission (2/09.01.2023) were obtained to conduct the research. The research's objectives were conveyed to the willing mothers who expressed their willingness to participate, and their informed consent was duly obtained. It was explicitly emphasized that participation in the study was entirely voluntary, and strict measures were in place to safeguard the confidentiality of the collected data.

RESULTS

The study revealed that the average age of the participating mothers was 28.45 years, with a standard deviation of 5.01. In terms of educational background, 31.5% (n=81) had completed middle school. A significant portion of the participants, specifically 74.7% (n=192), were unemployed, and 65.4% (n=168) reported having an income that matched their expenses. The majority, at 82.9% (n=213), belonged to nuclear families. Regarding pregnancy, a substantial 88.7% (n=228) of the mothers stated that their pregnancies were voluntary. In terms of childbirth, 59.1% (n=152) underwent cesarean sections, and 59.9% (n=154) gave birth within the first day postpartum. Furthermore, 90.7% of the women (n=233) expressed a need for postpartum care. Notably, the primary care requirement identified among them was the need for breastfeeding support, accounting for 45.5% (n=117) of the responses (Table 1).

Table 1. Socio-Demographic and obstetric characteristics of the mothers (n=257)		
Characteristic	**Mean**	**SD**
Age	28.45	5.01
	n	**%**
Education level		
Primary school	27	10.5
Middle school	81	31.5
High school	71	27.6
University and above	78	30.4
Employment status		
Yes	65	25.3
No	192	74.7
Income status		
Income less than expenditure	60	23.3
Income equal to expenditure	168	65.4
Income more than expenditure	29	11.3
Family type		
Nuclear family	213	82.9
Extented family	44	17.1
Desirability of pregnancy		
Yes	228	88.7
No	29	11.5
Sex of the baby		
Girl	132	51.4
Male	125	48.6
Mode of delivery		
Normal/vaginal delivery	105	40.9
Caesarean section	152	59.1
How many days after the end of labor		
Day 1	154	59.9
Day 2 and above	103	40.1
Complications in childbirth		
Yes	17	6.6
No	240	93.4
Regular prenatal check-ups		
Yes	247	96.1
No	10	3.9
Need for postnatal care		
Yes	233	90.7
No	24	9.3
Initial postnatal care needs		
Breastfeeding	117	45.5
Mobilization	71	27.6
Self-care	26	10.1
Baby care	19	7.4
Number of patients in the patient room		
1 patient	134	52.1
2 patients	123	47.9
	Mean	**SD**
Number of births	1.99	0.96
Number of Abortions/Curettage	0.33	0.61

The mean scores of the mothers were 38.33±6.16 in the physical comfort subscale, 26.92±7.31 in the psychospiritual comfort subscale, 32.19±6.50 in the socio-cultural comfort subscale and 97.45±15.22 in the total scale (Table 2). In the evaluation of the comfort level of the mothers participating in the study, it was found that the physical comfort sub-dimension was 2.73 points, the psychospiritual comfort sub-dimension was 2.69 points, the Socio-cultural Comfort sub-dimension was 3.21 points and the total scale was 2.86 points. The mean total score of the MIBS was 14.30±2.92 (Table 2).

Table 2. Mean, median distributions and Cronbach's alpha values of mothers' Postpartum Comfort Scale and Mother to Infant Bonding Scale subscale and total scores (n=257)		
	Mean±SD*	**Min-Max**
Postpartum Comfort Scale		
Physical comfort	38.33±6.16	39.00 (14.00-54.00)
Psychospiritual comfort	26.92±7.31	29.00 (10.00-43.00)
Socio-cultural comfort	32.19±6.50	34.00 (10.00-44.00)
Total scale score	97.45±15.22	101.00 (40.00-123.00)
Mother to Infant Bonding Scale	14.30±2.92	15.00 (3.00-21.00)

*SD: standard deviation

There were no statistically significant variations observed in the mean scores, encompassing both the total scores and sub-dimension scores of both the PCS and the MIBS. These findings held true across various factors, including the mothers' age, educational background, family structure, pregnancy intention, infant gender, delivery method, occurrence of birth complications, consistent attendance at prenatal check-ups, parity, history of abortions or curettage, and the initial postnatal needs of the women ($p>.05$). Significant statistical differences were identified in the study's findings. Firstly, in relation to the employment status of the women, a notable difference emerged in the mean scores of the psychospiritual comfort sub-dimension ($U=5194.000$, $p=.043$) and the total score ($U=5173.500$, $p=.039$) of the PCS. Furthermore, when examining income status, a disparity was observed in the mean scores of women's Physical Comfort ($KW=8.009$, $p=.018$). As a result of the conducted research, it has been determined that the source of the observed difference primarily arises from variations between groups with income levels exceeding their expenses and those not exceeding their expenses ($U=567.000$, $p=.008$). Moreover, a significant difference has also been found between the group with income exceeding their expenses and the group with income equal to their expenses. Additionally, it can be observed that the sub-dimensions of Physical Comfort and Psychospiritual Comfort, as well as the total scores of the PCS, vary according to the postpartum care requirement, the number of days postpartum, and the number of patients in the room ($p<.05$) (Table 3).

Table 3. Mean total and subscale scores of the Postpartum Comfort Scale and mean total scores of the Mother to Infant Bonding Scale according to socio-demographic and obstetric characteristics of mothers

Features		Postpartum Comfort Scale				Mother to Infant Bonding Scale
		Physical Comfort	Psychospiritual Comfort	Socio-cultural Comfort	Total Score	
Age		ρ*=0.053 p=0.397	ρ=-0.002 p=0.974	ρ=-0.113 p=0.071	ρ=-0.028 p=0.660	ρ=0.029 p=0.644
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Education status	Primary school	40.00±6.17	27.85±5.69	34.44±4.75	102.29±6.74	13.88±3.30
	Middle school	38.04±5.79	28.39±7.02	32.77±6.13	99.22±13.84	14.41±2.70
	High school	38.01±6.25	26.19±7.57	31.52±7.05	95.73±17.23	14.29±2.60
	University and above	38.35±6.48	25.74±7.67	31.41±6.73	95.51±16.36	14.34±3.31
		KW=3.387, p=0.336	KW=5.287, p=0.152	KW=5.567, p=0.135	KW=2.665, p=0.446	KW=0.731, p=0.866
Employment status	Yes	37.72±6.37	25.50±7.84	31.23±6.88	94.46±15.89	14.09±3.39
	No	38.54±6.10	27.40±7.08	32.51±6.35	98.46±14.89	14.38±2.76
		U=5808.500, p=0.404	U=5194.000, p=0.043**	U=5544.000, p=0.178	U=5173.500, p=0.039**	U=6223.000, p=0.972
Income status	Income less than expenditure	39.20±5.98	27.28±7.15	32.95±5.79	99.43±12.60	14.46±2.61
	Income equal to expenditure	38.50±6.18	27.03±7.07	32.15±6.63	97.69±15.46	14.13±3.18
	Income more than expenditure	35.62±5.90	25.55±8.94	30.82±7.07	92.00±17.84	14.96±1.70
		KW=8.009, p=0.018**	KW=0.237, p=0.888	KW=1.996, p=0.369	KW=4.267, p=0.118	KW=0.609, p=0.738
Family type	Nuclear family	38.35±6.28	26.52±7.33	32.05±6.62	96.93±15.36	14.29±2.85
	Extended family	38.25±5.62	28.88±6.94	32.84±5.89	99.97±14.41	14.38±3.28
		U=4559.500, p=0.778	U=4042.000, p=0.151	U=4518.500, p=0.708	U=4125.000, p=0.294	U=4455.500, p=0.589
Desirability of pregnancy	Yes	38.25±6.15	26.89±7.22	32.07±6.49	97.23±15.23	14.36±2.86
	No	39.00±6.36	27.137±8.07	33.06±6.57	99.20±15.29	13.86±3.45
		U=3103.500, p=0.591	U=3250.000, p=0.882	U=2860.000, p=0.236	U=2984.500, p=0.393	U=3086.000, p=0.539
Sex of the baby	Girl	38.15±6.49	26.81±7.57	32.63±6.44	97.59±15.85	14.34±2.86
	Male	38.53±5.82	27.04±7.05	31.72±6.55	97.30±14.58	14.26±3.00
		U=8049.500, p=0.736	U=7988.000, p=0.659	U=7405.500, p=0.155	U=8094.000, p=0.793	U=8217.000, p=0.953

*ρ=Spearman correlation test, **p<0.05

Table 3. Mean total and subscale scores of the Postpartum Comfort Scale and mean total scores of the Mother to Infant Bonding Scale according to socio-demographic and obstetric characteristics of mothers

Features		Postpartum Comfort Scale				Mother to Infant Bonding Scale
		Physical Comfort	Psychospiritual Comfort	Socio-cultural Comfort	Total Score	
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Mode of delivery	Normal/vaginal delivery	38.00±5.87	26.67±7.28	32.57±6.35	97.24±14.40	14.20±2.73
	Caesarean section	38.57±6.37	27.09±7.34	31.92±6.60	97.59±15.80	14.34±3.06
		U=7470.000, p=0.383	U=7583.500, p=0.498	U=7280.000, p=0.231	U=7558.000, p=0.471	U=7400.000, p=0.297
How many days after the end of labor	Day 1	37.50±6.63	25.36±7.77	31.53±7.14	94.40±17.00	14.38±2.79
	Day 2 and above	39.58±5.18	29.26±5.85	33.17±5.28	102.01±10.61	14.18±3.12
		U=6273.500, p=0.004**	U=5645.000, p=0.000**	U=7185.000, p=0.200	U=5768.000, p=0.000**	U=7920.500, p=0.985
Complications in childbirth	Yes	39.35±4.06	27.94±6.90	34.52±4.71	101.82±10.35	13.11±14.39
	No	38.26±6.29	26.85±7.34	32.02±6.58	97.14±15.47	3.12±2.90
		U=1845.000, p=0.509	U=1959.500, p=0.785	U=1472.000, p=0.055	U=1736.000, p=0.304	U=1516.500, p=0.063
Regular prenatal check-ups	Yes	38.38±6.17	26.85±7.38	32.12±6.52	97.36±15.31	14.37±2.85
	No	37.20±6.30	28.80±5.05	33.80±5.94	99.80±13.14	12.60±4.14
		U=1119.500, p=0.616	U=1098.500, p=0.553	U=1006.000, p=0.319	U=1150.000, p=0.712	U=928.000, p=0.161
Need for postnatal care	Yes	38.71±5.92	27.41±7.13	32.49±6.18	98.63±14.20	14.31±2.98
	No	34.66±7.35	22.16±7.48	29.20±8.62	86.04±19.80	14.25±2.38
		U=1814.500, p=0.005**	U=1650.500, p=0.001**	U=2288.500, p=0.142	U=1740.500, p=0.002**	U=2534.500, p=0.427
Initial postnatal care needs	Breastfeeding	38.52±5.45	28.29±6.83	33.15±5.68	99.97±13.01	14.27±2.90
	Mobilization	38.90±6.27	26.53±7.35	32.16±6.53	97.60±15.36	14.30±2.98
	Self-care	40.50±7.02	27.00±7.18	31.80±6.92	99.30±14.74	13.92±3.34
	Baby care	36.73±5.45	25.89±7.83	30.63±6.63	93.26±15.60	15.10±3.03
		KW=4.314, p=0.229	KW=3.532, p=0.317	KW=3.035, p=0.386	KW=5.698, p=0.127	KW=1.640, p=0.650
Number of patients in the patient room	1 patient	39.02±6.26	28.21±6.62	32.58±5.38	99.82±13.57	14.36±3.21
	2 patients	37.58±5.99	25.52±7.78	31.76±7.53	94.86±16.49	14.24±2.59
		U=6922.000, p=0.026**	U=6630.500, p=0.007**	U=8100.000, p=0.812	U=6774.000, p=0.014**	U=7503.500, p=0.192
Number of births		ρ=-0.036, p=0.562	ρ=-0.043, p=0.490	ρ=-0.101, p=0.107	ρ=-0.079, p=0.209	ρ=0.080, p=0.203
Number of abortions/curettage		ρ=-0.031, p=0.622	ρ=0.063, p=0.317	ρ=0.032, p=0.612	ρ=0.031, p=0.619	ρ=0.075, p=0.232

*ρ=Spearman correlation test, **p<0.05

No significant differences were found in the scores obtained from the MIBS based on the socio-demographic and obstetric characteristics of the mothers included in the study in the difference analysis (p>.05) (Table 3).

The relationship between the scores obtained from the MIBS and the sub-dimension scores of the PCS, as well as the total scores of the PCS, was examined through correlation analysis, and no significant relationship was found between the specified variables (Table 4).

Table 4. The relationship between Mothers' Postpartum Comfort Scale sub-dimension and total mean scores and Mother to Infant Bonding Scale total mean scores (n=257)

Postpartum Comfort Scale	Mother to Infant Bonding Scale
Physical comfort	ρ*=-0.032, p=0.615
Psychospiritual comfort	ρ=-0.029, p=0.639
Socio-cultural comfort	ρ=-0.119, p=0.057
Total scale score	ρ=-0.078, p=0.215

*ρ=Spearman correlation coefficient

DISCUSSION

The aim of the research is to examine the relationship between mothers' comfort levels and the level of bonding with their babies during the postpartum period. The postpartum period is marked by a cascade of physiological, psychological, and social changes, coupled with the assumption of new parental roles and responsibilities. Factors like shifting family dynamics, sleep disturbances, fatigue, difficulties in meeting infant-related needs, and problem-solving challenges can intensify stress levels among women during this period, potentially disrupting their adaptation and comfort levels, leading to a crisis situation (27,28). Consequently, assessing the comfort levels of postpartum women holds significant importance as it aids in recognizing the challenges they face, facilitating appropriate care planning and implementation (29). In this study, the mean total score for the participating mothers was 97, with the scale ranging from a minimum score of 34 to a maximum of 170. Comparable research reported postpartum comfort scores for mothers falling within the range of 82 to 131 (27-31), aligning with the findings of this study, indicating that mothers' postpartum comfort levels tend to be moderate.

According to the findings obtained in the research, the PCS scale had a level of 38.33 (SD 6.16) for the physical comfort subscale, 26.92 (SD 7.31) for the psychospiritual comfort subscale, and 32.19 (SD 6.50) for the socio-cultural comfort subscale. To provide context, a study conducted by Akgün and Aksoy (2020) reported mean scores in their research as follows: physical comfort sub-dimension at 46.27 (SD 7.66), psychospiritual comfort sub-dimension at 43.48 (SD 5.10), and socio-cultural comfort sub-dimension at 33.09 (SD 6.59) (32). In a similar fashion to the obtained results, Kaya et al., (2024) found in their study that the PCS scale had mean levels of 44.55 (SD 7.96) for the Physical Comfort subscale, 42.06 (SD 6.69) for the Psychospiritual Comfort subscale, and 32.75 (SD 6.43) for the Socio-cultural Comfort subscale (14). Kartal et al. (2018), the mothers' mean scores were 46.20 (SD 7.82) for the physical comfort subscale, 40.58 (SD 4.50) for the psychospiritual comfort subscale, and 31.27 (SD 5.80) for the socio-cultural comfort subscale (30). These findings collectively suggest that mothers typically confront the challenges of the postpartum period at a moderate level, and their overall postpartum comfort levels align with this moderate trend, consistent with existing literature.

It was determined that women whose income level was less than expenses had better physical comfort than those whose income level was equal to expenses and whose income level was more than expenses. In the study of Birgili et al. (2020) also, which was conducted to investigate the postpartum comfort levels of laboring women and the factors affecting them, it was found that the physical comfort of women with low income level was better, which was same from our study (15). It can be thought that women with middle and high income levels may have more expectations and the service provided may not meet their needs and hospital conditions may cause them to feel uncomfortable, and therefore their comfort may be negatively affected.

It was observed that comfort levels of non-working women were better than working women. In Birgili study, it was found that the mean total score of PCS of non-working women was higher than that of working women (15). The majority of the women who participated in the study were not working. The absence of work-related stress factors may have caused women to feel more comfortable and have better comfort levels.

The study results have shown that as the number of days spent in the hospital after childbirth increases, women's comfort levels also increase. As the problems arising from the adaptation period of the postpartum mothers decrease, an increase in mothers' comfort and comfort levels is observed.

An interesting finding of the study was that women who needed postnatal care had higher comfort levels. The first postpartum care need was breastfeeding support. The most common health problems experienced after childbirth are breastfeeding and breast problems. The support of health personnel and relatives is important in terms of comfort and trust (33). The decrease in the problems of women in need of care in the postpartum period with the fulfillment of their care needs may have increased the comfort of mothers.

In the study, it was determined that the comfort levels of those who were left alone in the hospital room were higher. In another research on the subject, it was concluded that

staying alone in the hospital after childbirth, having one's spouse as a companion, receiving visits from relatives, and being able to benefit from the hospital's facilities increased the level of comfort (34). Furthermore, in another study, it was observed that staying alone in the room had a positive impact on privacy and meeting expectations, thus enhancing satisfaction with the childbirth experience (35). The fact that there were no other patients in the room after the birth of the women who participated in our study may have led the women to be comfortable in the room where they were lying, to ensure that the room was suitable for their needs and that they were with their family, and as a result, the hospital facilities were at a level that could meet their needs, which may have led to a high level of comfort. These results show that privacy and hospital environment should be considered as an important factor on comfort and that their comfort can be increased by ensuring that they stay in single and clean rooms as much as possible, especially in the postpartum period for the adaptation of mother and baby.

In the first moments of the postpartum period, a deep bond between mothers and their babies is said to form immediately during their initial encounter, and the mother-infant bond that begins during pregnancy continues until the postpartum period. The first few days after birth represent a crucial and sensitive period for the development of the bond between the mother and the baby (8,36). In our research, we observed that the bond between the mother and the baby was at a moderate level, and we found no significant relationship between postpartum comfort and the level of the bond between the mother and the baby. Specifically, while our results were consistent with a moderate level of bonding between the mother and the baby, some other studies using the Mother to Infant Bonding Scale have reported higher levels of bonding between the mother and the baby compared to our findings (8,36,37). The reason for this moderate level of bonding in our study may be the early postpartum period, which could potentially hinder women from fully adapting to their maternal roles. Therefore, further evidence-based research with larger sample groups that examines the relationship between postpartum comfort and the bond between the mother and the baby in more detail is needed.

CONCLUSION

The study's findings indicated that women who had recently given birth reported a moderate level of comfort. Furthermore, factors such as employment status, the number of days postpartum, the requirement for postpartum care, and the number of patients sharing the room had an impact on the total score of the PCS. Additionally, income status influenced the level of physical comfort experienced by mothers. In terms of mother-to-infant bonding, the study revealed a moderate level, with no significant relationship identified between postpartum comfort and the level of mother-to-infant bonding. It is advisable that nurses and midwives closely monitor women during the postpartum period, assessing their postpartum comfort and mother-to-infant bonding. In cases where issues or challenges are detected within the mother, baby, or any family member, appropriate counseling and guidance should be provided.

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Research Article

Investigation of the Bifid Mandibular Canal Prevalence in the Central Anatolian Population: A Retrospective CBCT Study

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Abstract

Aim: This study aims to retrospectively examine cone beam computed tomography (CBCT) images obtained for various reasons to determine the prevalence of bifid mandibular canal (BMC) in the Central Anatolian population.
Material and Method: A total of 518 mandibular canals (right and left sides evaluated separately) from 259 CBCT images (145 female, 114 male) that met the inclusion criteria were included in the study. BMCs were categorized as retromolar canal, forward canal, dental canal, and buccolingual canal. Individuals were grouped into age ranges of 15-34, 35-54, and 55-75 years. Statistical analysis was performed using IBM SPSS version 25.0. The data were then compared based on side (right/left), gender, and age.
Results: BMC was observed in 35.9% of the total participants. The most common subtype was the forward canal (Type 3) at a rate of 41.9%, followed by the retromolar canal at 35.4%, the dental canal at 31.1%, and the buccolingual canal at 26.8%. While there was no significant difference in BMC prevalence by gender, the prevalence was found to be higher in the second age group.
Conclusion: In conclusion, regardless of subtype, determining the presence of BMC in patients undergoing mandibular procedures is extremely important for informing the clinician, especially to avoid complications such as local anesthesia failure, postoperative paresthesia, or bleeding. If present, it should be noted in the CBCT report.

Keywords: Bifid mandibular canal, cone-beam computed tomography, mandibular anatomy

INTRODUCTION

The mandibular canal, which extends bilaterally from the mandibular foramen in a downward and forward direction towards the mental foramen and lingual foramen in the anterior region, is an anatomical curve that carries the mandibular artery, vein, and nerve bundle, providing innervation and vascularization to the mandible (1). Radiographically, the mandibular canal is typically observed as a linear radiolucency accompanied by a thin cortical bone opacity on the inferior and superior sides. Identifying variations of the mandibular canal is critical in reducing and preventing complications in procedures such as impacted third molar extractions, implant placements, and orthognathic surgeries in this region. These complications may include paresthesia, iatrogenic nerve damage, local anesthesia failure, and unexpected intraoperative bleeding (2).

Among the variations of the mandibular canal, the bifid mandibular canal (BMC) is a commonly observed condition. The term "bifid" originates from Latin and refers to a structure divided into two branches or parts. In 1996, Chávez-Lomeli et al. (3) conducted a study on cadaveric hemi-mandibles. They found that the mandibular canal could be observed as three distinct canals corresponding to the anterior, premolar, and molar teeth, respectively. They further noted that these canals later fused into one or two branches, and in cases where fusion was incomplete, bifid or even trifid canal variations could be observed.

Since the first case was described in the 1970s (4), numerous studies have been conducted on the prevalence and classification of BMC. Although some studies have utilized panoramic radiography, its limitations in assessing BMC prevalence have been noted due to the two-dimensional nature of panoramic radiography. These limitations include insufficient cross-sectional information, high magnification values, and anatomical superimpositions such as the pharyngeal airway, uvula, and soft palate (5). In contrast, cone beam computed

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tomography (CBCT), which is frequently used in preoperative imaging for dentomaxillofacial surgeries, has been commonly employed in BMC research due to its ability to provide high-resolution volumetric images with a significantly lower radiation dose compared to medical computed tomography (6-8).

This study aims to retrospectively examine CBCT images obtained for various reasons to determine the prevalence of BMC in the Central Anatolian population. This study contributes significantly to identifying anatomical variations in the mandibular canal, particularly BMC. Accurately defining the type and morphological variations of the mandibular canal is critical for preventing complications that may arise during procedures such as impacted tooth extractions, implant placements, and other surgical interventions in the mandibular region.

Considering the limitations of panoramic radiography, using three-dimensional, high-resolution imaging techniques like CBCT enables more reliable and precise evaluations. The significance of this study lies in its investigation of BMC prevalence in the Central Anatolian population using the detailed data provided by CBCT, thereby elucidating the impact of these anatomical variations on surgical and dental treatment planning. These findings are expected to contribute to developing safer and more effective treatment protocols for dentists and surgeons.

MATERIAL AND METHOD

This study was approved by the Local Scientific Medical Research Ethics Committee of Karamanoğlu Mehmetbey University Faculty of Medicine with decision number 01-2024/09 and was conducted by the principles of the Helsinki Declaration.

Sample Group and Study Design

Within the scope of the study, CBCT images obtained for various purposes between August 2022 and August 2024 at Karamanoğlu Mehmetbey University Faculty of Dentistry were retrospectively and randomly reviewed. From the 400 CBCT images evaluated, images of individuals with a history of trauma, surgery, or pathology in the maxillofacial region, craniofacial anomalies, or images with artifacts that hindered radiological assessment (such as metallic artifacts or artifacts due to patient movement), and CBCT images in which the mandibular canal could not be traced, as well as those not meeting diagnostic criteria, were excluded from the study. Consequently, 518 mandibular canals (evaluated separately for the right and left sides) from 259 CBCT images (145 females, 114 males) that met the inclusion criteria were included in the study. The participants were grouped by age into the following categories: 15-34, 35-54, and 55-75 years.

The mandibular canals examined for BMC prevalence were classified according to the classification system proposed by Naitoh et al. (9) based on this classification:

- **Type 1 Retromolar Canal:** A branch that exits the mandibular canal and reaches the retromolar region.
- **Type 2 Dental Canal:** A branch that exits the main canal and terminates at the roots of the molar teeth.
- **Type 3 Forward (Anterior) Canal:** A canal originating from the mandibular canal's upper wall. The forward canal has two subtypes based on whether it merges with the main mandibular canal:
  - ***Without confluence:*** A forward canal that diverges from the main mandibular canal in the mandibular ramus region and advances towards the second molar region.
  - ***With confluence:*** This type of forward canal separates from the mandibular canal and advances anteriorly, later merging with the main mandibular canal.
- **Type 4 Buccolingual Canal:** This canal branches off the main mandibular canal's buccal or lingual wall. There are two variations of the buccolingual canal:
  - ***Buccal Canal:*** A canal type that separates from the mandibular canal in the mandibular ramus and advances bucco-inferiorly.
  - ***Lingual Canal:*** A canal that separates from the mandibular canal in the mandibular ramus, advances in the lingual direction, and then perforates the lingual cortical bone (Figure 1).

Figure 1. A. Type 1 retromolar canal; **B.** Type 2 dental canal; **C.** Type 3 forward canal (with confluence); **D.** Type 4 buccal canal; **E.** Type 4 lingual canal

Imaging Protocol

All CBCT images were obtained using Kavo OP 3D Pro (PaloDEx Group Oy, Tuusula, Finland) with 90 kVp, 8 mA dose setting, 4.5 seconds irradiation time, and 8x15 cm imaging area exposure parameters.

A computer with a 21.5-inch flat panel color screen (Lenovo ThinkVision S22e-20), 8 GB RAM, Windows 10 Professional operating system, 3.10 GHz Intel 10th generation i5 processor, and 1920×1080-pixel resolution was used to examine the obtained CBCT images.

All radiologic examinations were performed in a standardized observation room under fixed imaging protocols by an observer (M.G.) with 8 years of radiology experience. For consistency of the examinations, 20% of

the total measurements were recalculated by the same observer at least 14 days after the initial measurements, and intraobserver agreement was evaluated with the data obtained.

Statistical Analysis

All statistical analyses were conducted using SPSS version 25 (IBM SPSS Statistics v25.0, IBM Corp. Released 2017, Chicago, IL, USA). Continuous variables are presented as mean±standard deviation (X±SD), while categorical variables are reported as frequency and percentage (%). The relationship between gender and BMI was evaluated using the chi-square test. To measure effect size, Cramer's V coefficient was calculated and interpreted. Results with a p-value of less than 0.05 were considered statistically significant.

RESULTS

In this study, CBCT images obtained from a total of 259 individuals aged 15 to 75 were retrospectively analyzed. The Intraclass Correlation Coefficient (ICC) value used to assess intra-observer agreement was found to be excellent, with a value of 0.948.

Table 1 presents the sociodemographic information of the participants and the distribution of BMC and other canal types. The mean age of participants was 43.72±15.61 years. The largest age group, comprising 41.3% of participants, was those aged 35-54. This was followed by the 55-75 age group at 35.1% and the 15-34 age group at 23.6%. This distribution indicates a greater representation of middle-aged and older individuals in the study. Of the participants, 56% were female (145 individuals), and 44% were male (114 individuals), indicating a higher representation of females in the study.

BMC was observed in 35.9% of the total participants. It was most frequently found on the right side (15.8%), followed by the left side at 12.7% and bilaterally at 7.3%, indicating that BMC is more prevalent on the right side. Retromolar canals were absent in 87.3% of participants, with bilateral presence being quite low at 1.2%. The frequency of occurrence of the canal was equal on both sides (5.8%). Dental canals were absent in 88.8% of participants. The most frequently observed variation of dental canals was at the level of the first molar on the right side (3.1%) and at the level of the second molar on the left side (2.3%), indicating that dental canals are more common at the levels of the first and second molars.

In 93.4% of participants, no forward canals were found on the right side; however, types of forward canals merging with the main mandibular canal were identified in 6.6% on the left side and 5.4% on the right side. Non-merging types were very rarely observed (1.2% on the right, 1.9% on the left). Buccal and lingual canals were also rarely seen. Buccal canals were absent in 95% of participants, with only 3.9% on the right and 1.2% on the left showing buccal canals. Lingual canals were absent in 95.4% of cases, while they were found in 2.7% on the right and 1.9% on the left.

No significant difference was found in the presence of BMC between genders (p=0.781). BMC was observed in 35.2% of females and 36.8% of males.

Table 1. Sociodemographic data of participants

Variable	X±SD / n (%)
Age (years)	43.72±15.61
Gender	
Male	114 (44.0)
Female	145 (56)
Age range	
15-34	61 (23.6)
35-54	107 (41.3)
55-75	91 (35.1)
Bifid mandibular canal	
Absent	166 (64.1)
Right	41 (15.8)
Left	33 (12.7)
Bilateral	19 (7.3)
Type 1 retromolar canal	
Absent	226 (87.3)
Right	15 (5.8)
Left	15 (5.8)
Bilateral	3 (1.2)
Type 2 dental canal	
Absent	230 (88.8)
1st molar right	8 (3.1)
1st molar left	4 (1.5)
2nd molar right	7 (2.7)
2nd molar left	6 (2.3)
3rd molar right	2 (0.8)
3rd molar left	0
Other	
Type 3 forward canal right	
Absent	242 (93.4)
With confluence	14 (5.4)
Without confluence	3 (1.2)
Type 3 forward canal left	
Absent	234 (90.3)
With confluence	17 (6.6)
Without confluence	5 (1.9)
Type 4 buccal canal	
Absent	246 (95.0)
Right	10 (3.9)
Left	3 (1.2)
Type 4 lingual canal	
Absent	247 (95.4)
Right	7 (2.7)
Left	5 (1.9)

X: mean, SD: standard deviation, n: frequency, %: percentage

Table 2 illustrates the relationships between age groups and the presence of BMC and other mandibular canal variations. A significant difference was found in the presence of BMC among age groups (p=0.004). Notably, the prevalence of BMC is higher in the 35-54 age group (47.7%). The Cramér's V value is 0.206, indicating a weak yet significant relationship.

A significant difference was also identified in the presence of Type 1 retromolar canal among age groups (p=0.021). Retromolar canals are more frequently observed in the 35-54 age group (18.7%), while this rate is notably low in the 55-75 age group (5.5%). The Cramér's V value of 0.173 suggests a weak relationship.

No significant difference was found in the presence of Type 2 dental canals among age groups (p=0.139). However, it is noteworthy that the dental canal is more frequently observed in the 35-54 age group compared to other age groups (15%).

A significant difference was found regarding the Type 3 forward canal among age groups (p=0.046). The presence of forward canals is particularly higher in the 35-54 age group (18.7%), indicating a greater prevalence in this age group compared to others. The Cramér's V value of 0.154 also shows a weak relationship.

No significant differences were found in the presence of Type 4 buccal and lingual canals among age groups (p>0.05). However, the presence of buccal canals is higher in the 35-54 age group (18.7%).

Table 2. Relationship between age group and variations of subtypes

Age groups	15-34	35-54	55-75	p	Cramer' V
Bifid mandibular canal					
Absent	44 (72.1%)	56 (52.3%)	66 (72.5%)	**0.004***	0.206
Present	17 (27.9%)	51 (47.7%)	25 (27.5%)		
Type 1 retromolar canal					
Absent	53 (86.9%)	87 (81.3%)	86 (94.5%)	**0.021***	0.173
Present	8 (13.1%)	20 (18.7%)	5 (5.5%)		
Type 2 dental canal					
Absent	58 (95.1%)	91 (85%)	81 (89%)	0.139	0.123
Present	3 (4.9%)	16 (15%)	10 (11%)		
Type 3 forward canal					
Absent	57 (93.4%)	87 (81.3%)	82 (90.1%)	**0.046***	0.154
Present	4 (6.6%)	20 (18.7%)	9 (9.9%)		
Type 4 buccal canal					
Absent	60 (98.4%)	87 (81.3%)	82 (90.1%)	0.363	0.088
Present	1 (1.6%)	20 (18.7%)	9 (9.9%)		
Type 4 lingual canal					
Absent	59 (96.7%)	100 (93.5%)	88 (96.7%)	0.472	0.076
Present	2 (3.3%)	7 (6.5%)	3 (3.3%)		

p<0.05, Chi-square, n: frequency, %: percentage

DISCUSSION

Determining the type and shape of mandibular canal variations is crucial for preventing potential complications during planned surgical procedures in the relevant areas and for providing patients with the most effective treatment options. Various imaging protocols, including panoramic radiography, computed tomography, and CBCT, have been utilized in studies examining the mandibular canal. It has been reported that the dense trabeculation observed around the mandibular canal in panoramic radiography may lead to misinterpretations, highlighting that prevalence studies planned with CBCT would be more reliable (9).

In a study conducted in our country in 2010 (6), it was reported that BMC was detected in 161 out of 242 individuals aged between 17 and 83 years (66.5%), with the most observed BMC variation being the forward canal (17.8%). It was determined that the non-merging type of the forward canal was more frequently encountered than the merging type. According to the findings of this study, the lingual canal was found to occur more regularly than the buccal canal. In contrast, the most common dental canal type was identified as the canal reaching the level of the third molar.

In another study examining 1933 individuals, BMC was detected in only 198 individuals (10.2%), with the most

common type being Type 1 retromolar canal (52.5%). It was noted that the non-merging type of the forward canal was more prevalent (2).

Naitoh et al. (9) conducted a study involving the CBCT images of 9,122 individuals to determine the prevalence of BMC. They found it in 65% of the subjects, identifying the most common type as the type 3 forward canal. They emphasized that CBCT examinations have advantages over panoramic radiography.

In their 2017 study, Serindere et al. (10) reported a BMC prevalence of 3.05%, with the most frequently observed type being the Type 1 retromolar canal. Elnadoury et al. (11) examined CBCT images from 278 patients, revealing BMC in 181 canals (34%) and trifid canal in 46 canals (8.7%).

Rashsuren et al. (12) reported a prevalence of bifid canals at 22.6%, with the most observed subtype being retromolar canal (71.3%), followed by dental canal (18.8%), trifid canal (5.8%), and forward canal (4.1). They indicated that the merging type of the forward canal was more commonly found than the non-merging type, and they did not encounter any cases of the buccolingual canal type. In a recent study, Alali et al. (13) reported that the retromolar canal is the most observed type, and no significant differences were found based on gender and age. In their research, Dumanlı et al. (14) attempted to determine the prevalence of BMC in 300 patients using CBCT images, stating that they did not identify any trifid canals, while the most frequently observed subtype was the merging forward canal.

In this study focusing on the Central Anatolian population, the prevalence of BMC was calculated to be 35.9% (n=93), with the most common subtype being Type 3 forward canal (41.9%). This was followed by the retromolar canal (35.4%), the dental canal (31.1%), and the buccolingual canal (26.8%). The most prevalent subtype of dental canal was the one reaching the level of the second molar, while the most common type of forward canal was the subtype merging with the main mandibular canal. The most frequently observed subtype of the buccolingual canal was the buccal canal type. As noted above, while there are studies in the literature that are similar to the findings of our study, differences in sample sizes, variations in the radiographic techniques employed, and the diversity of the populations included can lead to differing results in other studies.

A meta-analysis conducted in 2023 indicated that geographic location, classification, gender, and the voxel size of the CBCT device all influence the prevalence of BMC. The study, which reviewed a total of 40 articles, reported a high level of heterogeneity and bias while also noting that most of the studies were conducted in Europe and that the prevalence of BMC was higher in males and on the right side (15). In another study that examined CBCT images of 558 patients from different ethnic backgrounds, it was reported that gender and ethnicity did not impact the prevalence of BMC (16). This study found that the prevalence of BMC did not differ significantly between genders; however, similar to findings in the literature (7,17), it was observed to be more common on the right side. Recent studies have categorized individuals into age groups to examine the variations in BMC prevalence according to age. This research divided individuals into three age groups: 15-34, 35-54, and 55-75. It was noted that the presence of BMC was significantly higher in the second group. The retromolar and forward canal frequencies were also considerably higher when examining subtypes in this group. While other subtypes were not statistically significant, they were still found in greater numbers in the second group. Dumanlı et al. (14) reported no significant differences in BMC prevalence based on age or gender. On the other hand, Okumuş and Dumlu (7), in a study conducted with 500 individuals aged 14-79 years, reported that BMC was significantly less common in individuals younger than 25 years. These findings may stem from the higher representation of middle-aged and older individuals in the studied group, suggesting that future research should analyze BMC prevalence in age subgroups with equal patient numbers.

This study has some limitations. First, it focused solely on the Central Anatolian population, limiting the generalizability of the results to other populations. Research conducted in different geographic regions and ethnic groups could contribute to a more comprehensive understanding of BMC prevalence and variations. Additionally, the retrospective nature of the study means that control over data collection methods and purposes was not possible, which could affect the homogeneity of the obtained images and data. Studies with more balanced distributions of different age groups could yield more substantial results regarding BMC prevalence.

The CBCT method used in the study is a reliable technique for detecting BMC and other mandibular canal variations; however, the resolution of the CBCT device may limit the detection of canal variations in low-quality images. Factors such as metallic artifacts or patient movements can negatively impact image quality, potentially leading to unclear identification of canal variations in some individuals.

Considering these limitations, future prospective and comparative studies on larger populations are recommended to validate the findings. Advanced imaging techniques, particularly high-resolution methods like micro-CT, may allow for the detection of more complex canal variations. Furthermore, studies investigating the clinical implications of BMC on surgical complications and local anesthesia failures could clarify the role of these variations on clinical outcomes. It is also essential to conduct studies with large participant groups encompassing various age ranges to examine the relationship between age and BMC prevalence in more detail.

CONCLUSION

In conclusion, regardless of the subtype, it is crucial to determine the presence of BMC in patients undergoing procedures in the mandible to prevent complications such as local anesthesia failures, postoperative paresthesia,

or bleeding. This information should be included in the CBCT report to inform the treating physician adequately. In orthognathic surgery cases, the presence of a second neurovascular bundle complicates the surgical procedure and necessitates careful examination of the area to identify this variation, especially when harvesting bone grafts from the commonly used retromolar region. Additionally, in patients using complete dentures in the mandible who experience persistent pain or paresthesia, BMC variation should be considered, and treatment planning should be adjusted accordingly.

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MEDICAL RECORDS-International Medical Journal

Research Article

The Relationship Between Selective Motor Control and Trunk Control in Children With Spastic Cerebral Palsy

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Abstract

Aim: Cerebral palsy (CP) can cause a variety of musculoskeletal issues that impact everyday functioning and activities, including reduced muscle tone and selective motor control. Appropriate evaluation of these problems and determination of their interrelationships are important in treatment planning. The aim of this study was to investigate the correlation between control of the trunk and selectivity of the lower limbs in children with CP.

Material and Method: Sixty-eight children and adolescents with spastic CP, categorized as GMFCS levels I to III and aged between five and seventeen years, were enrolled in the present study. The Trunk Control Measurement Scale (TCMS) was utilized to evaluate the trunk control. The Selective Control Assessment of the Lower Extremity (SCALE) was performed to measure the selectivity of the lower extremity. Groups with varying GMFCS levels were analyzed using the Kruskal-Wallis test. For the relationship analysis, the Spearman rank correlation test was employed.

Results: Significant differences in total SCALE scores between levels of the GMFCS were found in the group comparisons (Kruskal-Wallis H test: 44.145, p<0.001). SCALE scores and TCMS scores showed a substantial high association for dynamic sitting balance (rho:0.743, p<0.001), selective movement control (rho: 0.739, p<0.001), and overall TCMS scores (rho: 0.767, p<0.001). TCMS dynamic reaching (rho: 0.676) and static sitting balance (rho: 0.690) had a moderate positive correlation with SCALE score (p<0.001).

Conclusion: The SCALE test, which is simple to administer in a clinical setting, may provide insight into the level of trunk control. To improve selectivity of the lower limbs, physiotherapy programs may include interventions related to trunk control.

Keywords: Cerebral palsy, evaluation tool, selective motor control, trunk control measurement scale

INTRODUCTION

One of the most prevalent motor diseases affecting posture and gait in childhood is cerebral palsy (CP) (1). Children with CP commonly experience neuromuscular deficits, including spasticity, weakness and loss of selectivity. Depending on where and how the brain gets affected, varying degrees of positive and negative motor signs may manifest (2). Reduced muscle activity and selective motor control are characteristics of negative motor signs, whereas increased muscle tone is present in positive motor signs (3).

Selective motor control refers to the capacity to carry out a desired movement in isolation. Selective motor control plays a pivotal role in normal human movement, providing rapid and voluntary control over joint mobility (4). The lateral corticospinal tract is responsible for directing and generating the force of voluntary movements. Injury to this tract can disrupt the speed, timing, and strength of these movements (5). Damage to the periventricular white matter's lateral corticospinal pathway is linked to motor dysfunction in CP. One of these motor deficits, the selective loss of motor control, may lead to the emergence of synergistic movement patterns (6).

Selective motor control in the daily activities can be difficult for children with CP (7). Inadequate selectivity is a typical problem in CP (8). Research has shown that

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problems with the selective lower limb motor control in children with CP can lead to problems with walking (9). In addition, functional exercise capacity has been reported to be affected by difficulties with the lower extremities's selectivity (10).

Postural control is defined as ensuring proper positioning of the body in space and maintaining body alignment and stability by keeping the center of gravity within the support surface (11). Trunk control is important in achieving postural control. The core part of the body is the trunk and plays crucial role in the function of the limbs (11). Children with CP often struggle with maintaining trunk control, leading to challenges in to carry out activities of daily living (11). Deficits in motor functions and a significant limitation in walking capacity are consequences of impaired control of the trunk in children with CP (12,13). There is a connection between impairments in lower extremity tone and trunk control in CP. Impaired trunk control can negatively affect walking parameters (14). In other words, the more severe the tone abnormality in the lower extremities is, the more compromised the trunk control. Nevertheless, not enough research has been done on the association between trunk control and lower extremity selectivity. Thus, the purpose of this study was to investigate the relationship between lower extremity selectivity and trunk control in children with CP.

MATERIAL AND METHOD

Study design

The Karadeniz Technical University's Ethics Committee for Scientific Research in the Health Sciences approved this study. Children and adolescents aged 5-18 (mean age: 10±4) diagnosed with CP were enrolled to this study. Prior to the child's participation in the study, the consent of both the child and the parents was obtained. This study recruited children and adolescents with Gross Motor Functional Classification System (GMFCS) levels I, II and III who could sit for at least 45 minutes with or without assistance. Children who had received botox injection in the previous 6 months in the lower extremities, had undergone orthopaedic surgery, or had mental problems that prevented them from understanding the instructions given were excluded from this study. The study evaluated a total of 72 children. Four children excluded because they did not meet eligibility criteria (2 had botox injection for 6 months, and 2 did not complete the assessment), and the study was completed with 68 children with CP. Between January and September 2023, the children in the study were examined.

Evaluations

Trunk Control Measurement Scale

This scale has been used to evaluate the control of the trunk in children. There are fifteen items in the TCMS. It evaluates sitting balance both dynamically and statically. These are the two primary parts of trunk control, including static sitting balance (SSB) and dynamic sitting balance (DSB), the two subscales that make up the TCMS. Dynamic reaching (DR) and selective movement control (SMC) constitute the two components of a DSB. The total score ranges from 0 to 58. High scores reflect excellent performance (15). The Turkish form of the TCMS was utilized in this study. Özal et al. conducted a reliability and validity study of the scale (16). Their findings confirmed that the Turkish TCMS has strong intrarater (intraclass correlation coefficient (ICC): 0.98) and interrater (ICC: 0.88) reliability as well as validity (correlation with gross motor functional measure (GMFM) r: 0.827), similar to the original form. In an assessment room with the right amount of light, sound and temperature, two physiotherapists - one with 12 years' experience and the other with 5 - carried out the trunk assessment. The assessment took approximately 20–30 minutes.

Selective Control Assessment of Lower Extremity

This scale evaluates the toe, subtalar, ankle, knee, and hip joints separately for selective movements. These joints are assessed as bilateral. On a three-point ordinal scale, each joint's selective motor control is assessed as "unable" (0 points), "impaired" (1 point), or "normal" (2 points). A participant received a "normal" score if they were able to effectively execute the specified movement sequence within the verbal count without moving the ipsilateral or contralateral lower limb joint that was not being assessed. The motion was classified as "impaired" if the participant isolated it but committed any of the following errors: only one direction of movement was made, the movement was completed less than 50% of the time, a non-tested joint (including mirror motions) was moved, or the verbal count was more than three seconds. A "unable" rating was assigned if the subject failed to initiate the intended movement or displayed a synergistic pattern of flexing or extending muscles (17). The scale was scored by 2 physiotherapists with 10 years of experience. In this study, the SCALE's Turkish version was utilized. The validity and reliability of the Turkish SCALE in children with spastic CP were examined by Tuncdemir et al (18). They found that the SCALE is valid and reliable when used with the Turkish population. SCALE assessment was performed in the same room where the trunk assessment was performed. All the evaluated joints were video recorded and evaluated. The SCALE assessment took approximately 10–15 minutes. Patients included in this study were evaluated at the Karadeniz Technical University Farabi Hospital Risky Infant Follow-up Unit or the Gazi University Faculty of Health Sciences Pediatric Rehabilitation Unit.

Statistical analysis

IBM SPSS Statistics version 25 was used to evaluate the data gathered for the study. To figure out whether or not the data are regularly distributed, analytical and visual techniques are employed. For regularly distributed data, descriptive statistics are shown as means and standard deviations; for nonnormally distributed data, they are shown as medians and interquartile ranges. Descriptive statistics are presented as frequencies and percentages for qualitative variables. The Kruskal-Wallis test was

applied to compare groups with varying GMFCS levels. For pairwise comparisons, the Mann-Whitney U test was used. The Bonferroni adjustment was carried out. Correlation coefficients were calculated via Spearman correlation coefficients. The interpretation of Spearman's rank correlation is 0.70 + strong, 0.40 - 0.69 moderate, and 0.10 - 0.39 weak (19). P values considered statistically significant were less than 0.05. G*Power version 3.1 (Düsseldorf, Germany) was used for sample size calculation. In this study the number of participants was determined as 58, with a correlation effect size of 0.4, 90% power and a 0.05 error rate, according to the Yun et al. study (20).

RESULTS

This study included sixty-eight children and adolescents with spastic CP (median age at enrollment: 10 years, interquartile range: 7-12 years, GMFCS levels I (n=25, 36.8%], II (n=22, 32.4%), and III (n=21, 30.8%). Table 1 displays the participants' characteristics. The median TCMS score was 46, and the median SCALE score was 4 (Table 1).

Table 1. Characteristics of participants

n	68
Age	10 (7-12)
Gender (male/female)	36/32
Height (cm)	122 (110-130)
Weight (kg)	25 (20-35)
BMI (kg/m²)	18.2 (15.3-20.4)
GMFCS level I	25 (36.8%)
GMFCS level II	22 (32.4%)
GMFCS level III	21 (30.8%)
Unilateral CP	30 (44.1%)
Bilateral CP	38 (55.9%)
SCALE total	4 (2-7)
TCMS SSB	20 (14-20)
TCMS DSB	28 (13-34)
Selective movement control	18 (8-24)
Dynamic reaching	10 (5-10)
TCMS total	46 (30-54)

Data are presented as the median (interquartile range) or frequency (percentage); BMI: body mass index, CP: cerebral palsy, GMFCS: Gross Motor Function Classification System, SCALE: Selective Control Assessment of the Lower Extremity, TCMS-SSB: Trunk Control Measurement Scale-Static Sitting Balance, TCMS-DSB: Trunk Control Measurement Scale-Dynamic Sitting Balance

Significant differences in SCALE total scores between GMFCS levels were found in the group comparisons (Kruskal-Wallis H: 44.145, p<0.001) (Figure 1). SCALE total scores differed significantly between GMFCS I and II (u: 151.50, p: 0.008), between GMFCS I and III (u: 5.00, p<0.001) and between GMFCS II and III (u: 12.00, p<0.001) when pairwise comparisons were performed with Bonferroni correction.

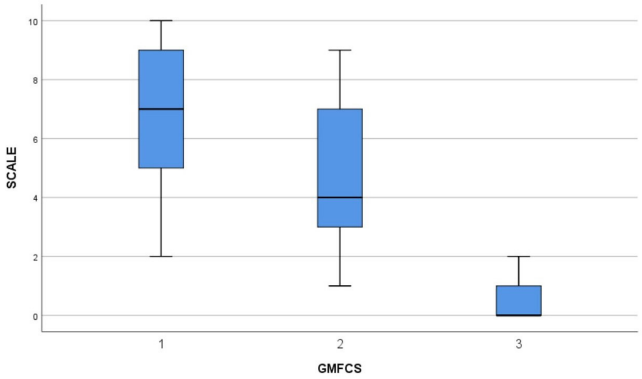

Figure 1. SCALE total score by GMFCS levels; GMFCS: Gross Motor Function Classification System, SCALE: Selective Control Assessment of the Lower Extremity

The SCALE scores and the TCMS scores were strongly correlated with the dynamic sitting balance, the selective movement control and the total TCMS score (p<0.001). There was a moderate correlation between TCMS static sitting balance and dynamic reaching and SCALE (p<0.001) (Table 2).

Table 2. Correlation analyses of the Selective Control Assessment of the Lower Extremity (SCALE) in relation to trunk control

SCALE	Spearman's rank correlation coefficient	
	rho	p
TCMS SSB	0.690	p<0.001
TCMS DSB	0.743	p<0.001
Selective movement control	0.739	p<0.001
Dynamic reaching	0.676	p<0.001
Total TCMS	0.767	p<0.001

TCMS: Trunk Control Measurement Scale, TCMS-SSB: Trunk Control Measurement Scale-Static Sitting Balance, TCMS-DSB: Trunk Control Measurement Scale-Dynamic Sitting Balance, SCALE: Selective Control Assessment of the Lower Extremity

DISCUSSION

The objective of this study was to explore the association between trunk control and selective motor control in ambulatory children with CP. The results of the study showed that children with spastic CP had a general trunk control deficit that was associated with lower limb selectivity. The TCMS total score and sub-scores and the SCALE score have been demonstrated to be significantly correlated. This can be the first study that examines at the association between Turkish children with CP's TCMS and SCALE scores. A previous study found that the control of the trunk was correlated with the selectivity in Korean children with CP (6). Similar studies on the impact of poor selective motor control have been reported in most cases, indicating that selectivity impacts balance, motor function and gait parameters in children with CP (9,20-22). In addition to these existing studies in the literature, our study revealed that loss of selective motor control was also associated with trunk control.

The results of our study showed that there was a difference between the SCALE score according to the GMFCS levels. Additionally, pairwise comparisons showed that GMFCS levels I–II, I–III, and II–III differed significantly in SCALE ratings. This finding revealed that as the GMFCS score increased, the SCALE score decreased. In other words, as the severity of the motor impairment increased, there was a decrease in the ability to move selectively in children with CP. Our study's findings are consistent with those of earlier research in the literature (3,18). Tuncdemir et al. reported a significant difference between levels I-II, I-III and II-III, similar to our study (18). Children with GMFCS levels I and II had significantly different SCALE scores than those reported by Balzer et al., whereas children with GMFCS levels II and III did not significantly differ in their SCALE scores (3). In contrast to our research, Balzer's study revealed no significant distinction between levels II and III. In this study, it was stated by the authors that the small number of patients in level 2 may affect the results of the study. Numerous CP-related problems, including weakness, a lack of reciprocal inhibition, and hyperreflexia, may be explained by central nervous system (CNS) damage (9). The more severe the damage to the CNS is, the more problems there are. This may explain the strong correlation between the GMFCS levels, a marker of the severity of motor impairment, and selective movements. Increasing the severity of impairment may lead to a decrease in the loss of selective movement in these children. Therefore, we believe that selective movements should also be evaluated in children with all levels of motor impairment.

The study findings showed that there was a moderate to strong association between the sub scores and total scores on the TCMS and SCALE. This result revealed that good lower limb selective control was associated with good trunk control. Our results were similar to those of Lim et al. (6). Their findings demonstrated a strong connection between the Korean-TCMS scores and the SCALE score. Trunk control impairment affects functional ability, according to Panibatla et al. (23). The control of the trunk and the ability to balance show that the trunk control is an essential part of the functional ability of the CP (23). Their findings indicated that trunk stability during upper and lower extremity movements influences one's capacity to perform functional tasks. Furthermore, a trunk-focused intervention to increase the TCMS score has been demonstrated to enhance balance performance and gross motor function (23). As can be understood from this study, the trunk is the basis for all limb movements and balance and daily performance. The results of our study additionally show that the trunk is strongly associated with lower limb selectivity. In this way, we can also obtain important information about the trunk with SCALE, which is an easier and time-saving assessment tool.

The TCMS static and dynamic sitting balance items were related to the total SCALE score in this study. This is consistent with early research by Balzer et al and Lim et al, who reported a significant relationship between the SCALE and TCMS (6,10). The TCMS dynamics revealed a strong relationship with SCALE. The dynamic reach parameter is a part that can be used alone in terms of balance assessment (15). This result shows that SCALE assessment can also provide insight into the balance of children with CP.

This study has a number of limitations. First, participants in this study included all children with GMFCS levels I, II and III who were able to sit independently for at least 45 minutes; those who were unable to do so were excluded. In addition, as this study only included children with spastic CP, the results cannot be extrapolated to other children with CP. We believe that future studies with different types of CP will contribute to the results of our study.

CONCLUSION

To summarize, this study investigated the relationship between selective lower limb control and trunk control in spastic CP. TCMS scores and overall SCALE scores were significantly positively associated. This study implies that trunk control is necessary for lower limb function and selective movement, and that trunk control is the basis of lower limb selective control. Therefore, a trunk control examination and intervention should be considered while attempting to enhance the selective control of a CP's lower extremities.

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MEDICAL RECORDS-International Medical Journal

Research Article

Traumatic Amputations in Military Personnel: From The Perspective of Forensic Medicine

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Abstract

Aim: Traumatic amputations are devastating injuries that occur suddenly and unexpectedly, resulting in the loss of a body part. This study was aimed at evaluating cases of traumatic amputations from a medico-legal perspective.
Material and Method: The forensic reports prepared by the Department of Forensic Medicine, Gülhane Training and Research Hospital (fka; Gülhane Military Medical Academy), between January 1, 2011, and December 31, 2014 were examined retrospectively and the cases who had traumatic amputations analyzed in depth.
Results: All of the cases (n=72) were male, and the mean age at the time of the injury was 24.2 (±4.3) years. Almost all the cases (97.2%) were soldiers. It was determined that the most common cause of trauma among all cases was work accident (51.5%), followed by explosion injuries (26.4%). Traumatic amputations were mostly seen in the upper extremity (83.3%), followed by lower the extremity (12.5%) and both upper and lower extremities (4.2%). The most common cause of upper extremity amputations was work accidents, while lower extremity amputations were mostly caused by blast injuries. While 58.3% of the amputations were minor (fingers only), 41.7% were major. It was determined that psychiatric disorders developed in 19.4% of the cases after traumatic amputation.
Conclusion: Traumatic amputations are among the issues that need to be carefully examined because they occur especially at the young age group and cause disabilities in the affected people. It is necessary to reduce trauma, which is one of the important causes of amputations, to take precautions by using personal protective equipment, and to not neglect treatment and follow-up. The majority of patients in developing nations, like Türkiye, struggle to receive pre-hospital care, which proves to be a major challenge for trauma care, especially in military cases. It is of great importance that psychiatric follow-up of people is carried out in the early and late periods after amputation and that social support and appropriate treatments are not neglected.

Keywords: Amputation, trauma, forensic medicine, military personnel

INTRODUCTION

The word “amputation” means a total or partial removal of any organ in the form of a protrusion of the body (especially the extremities) by surgery. While the etiology of amputation may be alterable depending on the cultural and geopolitical conditions of countries, the most common causes are diseases, traffic accidents, occupational-work accidents, and combat-related injuries like gunshot injuries and explosions (1-5).

Approximately 185,000 amputations are performed annually in the United States, and it is reported that 16% of these are related to trauma (6-8). Traumatic amputation is one of the most disturbing and devastating wounds of conflict. It occurs suddenly and unexpectedly, and there is not any adaptation time, contrary to the disease-related amputations. Therefore, traumatic amputees need complete health care services, including psychological support.

The purpose of this retrospective study was to analyze the forensic cases with traumatic amputation (s) who applied to the Gülhane Training and Research Hospital (fka: Gülhane Military Medical Academy), and reveal the characteristics of military amputees and traumatic extremity amputations among military personnel.

MATERIAL AND METHOD

The forensic reports prepared by the Gülhane Training and Research Hospital (Gülhane Military Medical Academy),

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between January 1, 2011, and December 31, 2014, were examined retrospectively. The cases who had traumatic amputation (s) were analyzed in detail, including the parameters like age and sex of amputees, the etiology of amputation, amputation levels, replantation operations, life-threatening situations due to amputation, the disability of extremities due to amputation, and psychiatric disorders due to amputation.

The data obtained from the cases were analyzed with Microsoft Office-Excel 2010 and IBM SPSS Statistics version 23.0 (IBM SPSS Statistics for Windows, IBM Corp, Armonk, New York, USA). Descriptive statistics included number (%) and mean standard deviation for continuous variables.

Ethics committee approval is received for this research from Ethics Committee of Gülhane Military Medical Academy (05.05.2015, 08/227).

RESULTS

There were a total of 2472 forensic reports in four years, and 72 (2.9%) of the cases had traumatic amputation(s). The cases were sent to the Department of Forensic Medicine to prepare forensic reports for extremity disability ratio calculation (n=54, 75%), action for compensation (n=10, 13.9%), criminal action (n=6, 8.3%), and the Turkish Armed Forces Assistance Fund Law (n=2, 28%).

All of the amputees were male, with the mean age at injury date being 24.2 (±4.3) years, ranging from 20 to 35 years. Almost all cases were military personnel (n=70, 97.2%) and the ranks of the cases were as follows: 53 (73.6%) private, 10 (13.9%) specialist sergeant, 3 (4.2%) noncommissioned officer, 4 (5.6%) commissioned officer, and 2 (2.8%) civilian. Traumatic amputation mostly occurred in May (n=11, 15.3%) and in the spring season (n=25, 34.7%). The seasonal evaluation of the traumatic amputation rate of incidence is stated in Figure 1.

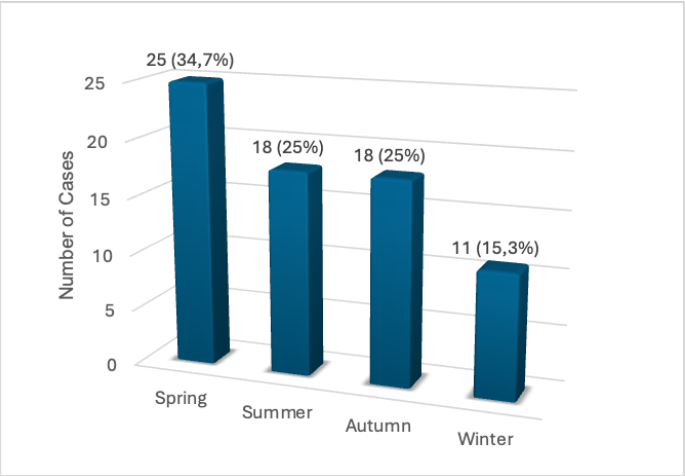

Figure 1. Seasonal evaluation of traumatic amputation rate of incidence

Amputations due to work-related (occupational) injuries were the most common cause of traumatic amputations (n=37, 51.4%), followed by explosion injuries (n=19, 26.4%) and gunshot injuries (n=9, 12.5%). Among the work-related injury group, jamming of body parts (in the door, gun mechanism, etc.) accounted for 21 cases, and machine accidents (lawn mower, meat grinder, etc.) accounted for 16 cases. The distribution of causes of amputations and amputation levels is stated in Table 1.

Sixty-four (88.9%) cases had amputation of one extremity (upper or lower), while 8 (11.1%) cases had multiple extremity amputations. Six (8.3%) cases had amputations involving two extremities, and 2 (2.8%) cases had amputations involving three extremities (Table 1).

Traumatic amputation was mostly seen in the upper extremity (n=60, 83.3%), followed by the lower extremity (n=9, 12.5%) and both upper and lower extremities (n=3, 4.2%). There was no difference in the number of amputees between the right and left upper extremities; besides, amputation was more frequently seen at the left lower extremity than the right lower extremity. Also, there were 4 (5.6%) cases with bilateral upper extremity amputations and 1 (1.4%) case with bilateral lower extremity amputations (Table 1).

Work-related (occupational) injuries (n=35, 62.5%) were the most common cause of traumatic upper extremity amputations, followed by explosion injuries (n=9, 15.2%) and gunshot injuries (n=6, 11.7%). Among lower extremity amputations, explosion injuries and work-related injuries (each n=3, 37.5%) were the most common cause. And also explosion injuries (n=7, 87.5%) were the most common cause of multiple extremity amputations.

"Toes and fingers (digits)" are considered as minor amputations, while "any upper level of metacarpophalangeal/metatarsophalangeal articulation" is considered as major amputations (i.e., partial hand/foot, wrist, trans-radial, elbow, trans-humeral, shoulder, hip, trans-femoral, knee, trans-tibial, ankle). In this research, of the 72 amputees, 42 (58.3%) had minor amputations (only fingers and/or toes) and 30 (41.7%) had major amputations. While isolated partial hand amputations (n=11, 36.6%) were the most common among the major amputations, finger amputations (n=39, 54.2%) were the most common among the minor amputations (Table 1 and 2).

Partial hand amputation was the most frequent amputation level among all trauma types, except electrical injuries and traffic accidents. The traumatic cause was explosion wounds in 3 cases, who had both upper and lower extremity amputations (Table 2).

There were a total of 110 amputations among 54 partial hand amputees, and the left hand (n=29, 53.7%) was more dominant than the right hand (n=25, 46.3%). Of the 54 amputees who had partial hand amputations, 34 (62.9%) had only one finger involving amputations, while 20 (37.1%) had more than one finger amputations. Distal phalanges level (30.9%), metacarpophalangeal joint level (17.3%), and proximal phalanges level (15.4%) were the most frequent amputation levels. The distribution of amputation levels and amputation numbers of 54 partial hand amputees is stated in Table 3.

Replantation operation was performed only on 4 (5.6%) of the amputees: left second and third proximal phalanges level in 1 case, right third mid phalanges level in 1 case, and right elbow level in 2 cases. There were eburnation and movement restriction sequels at the distal levels of replantation in replanted amputees.

Eighteen (25%) amputees overcame a life-threatening situation due to amputation injury, and 14 (19.4%) amputees had a psychiatric disorder after trauma. The distribution of psychiatric disorders after traumatic amputation is stated at Figure 2. The rate of psychiatric disorders was found to be 15.6% (n=13) in upper extremity amputations, 28.2% (n=11) in lower extremity amputations, and 50% (n=2) in both extremity (upper and lower) amputations. The incidence of psychiatric disorders after traumatic amputation was most frequently observed in explosion injuries (37.2%) and gunshot injuries (28.6%).

While the rate of psychiatric disorders was 29.8% (n=17) in major amputations, this rate was only 13% (n=9) in minor amputations. It was determined that the most common type of psychiatric disorder in both types of amputations was anxiety disorder.

Twenty-four (33.3%) amputees had a continuous failure of extremity function, while 22 (30.6%) amputees had a loss of extremity function due to amputation.

Table 1. The distribution of amputation causes and amputation levels of the amputees

	Explosion injuries	Work-related injuries	Gunshot injuries	Electricity injuries	Stab wounds	Traffic Accident	Total (%)
Upper extremity amputations							
Fingers	4	28	4	-	2	1	39 (54.2)
Partial hand	4	5	2	-	-	-	11 (15.3)
Wrist disarticulation	1	-	-	-	-	-	1 (1.4)
Trans-radial (below elbow)	-	-	-	1	-	-	1 (1.4)
Elbow disarticulation	-	2	-	-	-	-	2 (2.8)
Trans-humeral	-	-	-	-	-	2	2 (2.8)
Shoulder disarticulation	-	-	-	-	-	-	-
Subtotal upper extremity							56 (77.7)
Lower extremity amputations							
Toes	-	1	1	-	-	-	2 (2.8)
Partial foot (below ankle)	-	-	-	-	-	-	0
Ankle disarticulation	-	-	-	-	-	-	0
Trans-tibial (below knee)	2	-	1	1	-	-	4 (5.6)
Knee disarticulation	-	-	-	-	-	-	0
Trans-femoral (above knee)	-	-	1	-	-	-	1 (1.4)
Hip disarticulation	1	-	-	-	-	-	1 (1.4)
Subtotal lower extremity							8 (11.1)
Multiple extremity amputations							
Fingers + trans-femoral	2	-	-	-	-	-	2 (2.8)
Partial hand + partial foot	1	-	-	-	-	-	1 (1.4)
Knee disarticulation + trans-tibial	1	-	-	-	-	-	1 (1.4)
Bilateral hand fingers	-	1	-	-	-	-	1 (1.4)
Bilateral wrist disarticulation	3	-	-	-	-	-	3 (4.2)
Subtotal multiple extremity							8 (11.1)
Grand total (%)	**19 (26.4)**	**37 (51.4)**	**9 (12.5)**	**2 (2.8)**	**2 (2.8)**	**3 (4.2)**	**72 (100)**

Table 2. Extremity distributions of amputations

Amputation region	Number of cases	(%)
Right upper extremity	28	38.9
Left upper extremity	28	38.9
Bilateral upper extremity	4	5.6
Right lower extremity	1	1.4
Left lower extremity	7	9.7
Bilateral lower extremity	1	1.4
Upper and lower extremity	3	4.2
Total	**72**	**100**

Table 3. Amputation levels and numbers of 54 partial hand amputees

	Carpal bones	CMC joint	Metacarpal bones	MCP joint	Proximal phalanges	PIP joint	Mid phalanges	DIP joint	Distal phalanges	Total
Right hand	2	1	5	7	9	10	4	5	14	57
Left hand	-	1	3	12	8	1	6	2	20	53
Total (%)	2 (1.8)	2 (1.8)	8 (7.3)	19 (17.3)	17 (15.4)	11 (10)	10 (9.1)	7 (6.4)	34 (30.9)	110 (100)

CMC: Carpometacarpal, MCP: Metacarpophalangeal, PIP: Proximal Interphalangeal, DIP: Distal Interphalangeal

DISCUSSION

Amputations can be evaluated in two ways: traumatic and non-traumatic. Non-traumatic amputations depend on diseases (diabetes mellitus, peripheral vascular disease, malignancy, etc.) and frequently performed surgery treatment at hospitals. This kind of amputation is more acceptable for patients because they are preplanned operations, and patients have knowledge about their disease. But, on the contrary, traumatic amputations occur suddenly, without going through a pre-loss adaptation phase, and are the most severe injuries for a person, both physically and psychologically.

The etiology of amputation varies between countries and cities depending on cultural and geopolitical characteristics. In the United States, vascular diseases (Diabetes Mellitus, etc.) are the most frequent cause of amputations (9), while trauma is seen as the most frequent cause in Türkiye (1,3). To our knowledge, this is the first study that determines traumatic amputations among military personnel in Türkiye.

Military personnel are always at risk of trauma due to difficult conditions like conflicts, training, etc. This can also cause traumatic amputations. In this research, we examined 2472 forensic case reports of military personnel retrospectively and determined that 72 (2.9%) of them had traumatic amputation (s).

It is known that traumas and traumatic amputations are frequently seen in young men. All of our cases were male and in young age groups similar to the other studies (4) (1,2,10-14). It is thought that the fact that the cases in our study were mostly in the young age group and all were men was because all the cases included in the study were military personnel. This is consistent with the fact that traumatic amputations are generally caused by occupational injuries, especially in the military, heavy labor, when machinery is involved, and in youths and males.

When the etiology of traumatic amputations is examined, it varies depending on factors such as profession (civilian/security force), development level of the countries, terrorism, war, public order in the country, and the existence of a developed health system. While the majority of injuries, especially in the presence of war, are caused by explosions, outside of war, other causes other than explosions are more effective (15). When the literature was examined, although there were differences in the rates, it was seen that work accidents and explosions were the most common causes of amputations (1,3,16,13). The most common causes of traumatic amputation in our study were work-related injuries (51.4%) and explosion injuries (26,4%). The frequent occurrence of terrorist acts and military operations in our country between the years of the study led to an increase in explosions and explosion-related amputations. In addition, the study mainly involved soldiers, who often work with heavy machinery and are exposed to trauma-inducing scenarios like explosions; it was determined that work accidents and explosions were the leading causes of traumatic amputations.

Although amputations vary depending on the cause of trauma, they are mostly in only one extremity (upper or lower) in literature (2,17). In our study, most of the cases (88.9%) had amputation in only one extremity (upper or lower), while 11.1% had amputation in multiple (more than one) extremities. We were unable to locate any research on amputations involving only one or multiple limbs. The etiology of the trauma, the severity of the injury, and the affected body part are all factors that contribute to the number of extremities involved in traumatic amputations. Although primarily associated with severe trauma such as terrorist bombings and land mines, it can also develop in a singular extremity from relatively minor injuries like those sustained in work or traffic accidents. Since people injured in these minor injuries are focused on protecting themselves, it is thought that they try to protect their uninjured extremities to avoid amputation. We think that the fact that work-related injuries were the most common in the cases in our study caused amputations to occur mostly in only one extremity.

Although amputations occur in various parts of the body, they often occur in the upper extremity. In the study of Barmparas et al., it was reported that amputations were more common in the upper extremity (58.9%) (11). Similarly, other studies have found that traumatic amputations are most common in the upper extremity (68.6%) (17,18). In our study, it was determined that the majority of amputations (83.3%) were in the upper extremity, consistent with the literature. People frequently use their upper extremities in their daily lives. Especially in work accidents, traumas are frequently seen in the upper extremities, especially the fingers, and as a result, amputations occur. We think that the most common cause of trauma in our study is work-related, which causes upper extremity amputations to occur more frequently.

The most frequently affected areas by trauma are the distal parts of our body. In studies evaluating upper extremity amputations, it was reported that amputations were most frequently seen in the fingers (19,20). In a study conducted on American soldiers injured in Afghanistan and Iraq, it was

determined that amputations occurred more frequently at the distal ends of the body, upper extremity amputations were more common below the elbow, and lower extremity amputations were more common below the knee (21). Similar results were obtained in the study of Melcer T et al. (22). In our study, similar to the literature, it was determined that amputations were most common in the fingers of the upper extremity (54.2%, n=39) and in the distal parts of the lower extremity. This is just because people use their distal extremities for work or battle, and they get hurt frequently at distal extremities.

Amputations can be at different levels, major or minor, depending on the etiology of the trauma and the severity of the injury. When the literature is evaluated, there are differences regarding the level of traumatic amputations. These differences vary depending on the country where the study is conducted, the level of development of the health system, and the presence of war, such as the profession (civilian/security force). In a study conducted on American soldiers injured in Afghanistan and Iraq, it has been stated that the majority of traumatic amputations are major amputations, and this situation is caused by severe trauma such as terrorist bombings and antipersonnel land mines (23). In the study conducted by Dillingham et al. among civilians, it was reported that the most common amputations were minor amputations (70.1%), and among them, finger amputations (52.7%) were the most common. It was determined that the most common major amputation was hand amputation (11.5%) (18). In our study, 58.3% of the cases had minor amputations and were frequently seen in the fingers. In general, minor amputations are most common in civilians and non-traumatic amputations, while major amputations are common in military personnel at different rates. Amputations due to diseases (diabetes, cardiovascular diseases, etc.) are mostly in the distal parts, while in traumatic amputations, this situation varies according to the etiology of trauma. For example, major amputations are seen in high-energy traumas such as terrorist bombings and antipersonnel land mines, while minor amputations are more common in work-related traumatic amputations. Although the cases in our study were military personnel, the frequency of work-related traumatic amputations in the etiology of trauma explains the minority of amputations. In this case, we think that the presence of military doctors and the experience of military hospitals in this field are also effective, and the major level is prevented.

Amputations have not only physical but also psychological effects on people. The level of these effects may vary depending on the personality characteristics of the victim and the severity of the amputations. Many researchers reported that traumatic amputations are typically equated with the loss of a spouse, loss of one's perception of wholeness, symbolic castration, and even death (24) (25). In the study of Çopuroğlu et al., it was determined that 36% of the cases had psychiatric complaints in the early period after amputation, and post-traumatic stress disorder occurred in 77.2% in the late period (26). In a study conducted on military cases, it was reported that 38.3% of the cases had psychiatric complaints after traumatic amputation, and among these, post-traumatic stress disorder was the most common (17.9%) (27). Similar studies have also reported that there are varying rates of psychiatric complaints after amputation, and post-traumatic stress disorder is the most common among them (28,29). In our study, it was determined that an accompanying psychiatric disorder occurred in 19.4% (n=14) of the injuries resulting in amputation, and among these, anxiety disorder was the most common. In addition, it was determined that psychiatric disorders were more common in lower extremity amputations, and as the number of amputations increased, the rate of psychiatric disorders also increased. In a study conducted on war victims, it was found that patients with amputations were more frequently examined in psychiatric outpatient clinics, and psychiatric disorders were more common, especially in lower extremity amputations (22). Amputations are known to cause social discomfort and body image anxiety. This leads to activity limitation and psychiatric disorders such as post-traumatic stress disorder, depression, and anxiety. Since lower extremity amputations cause more social discomfort, psychiatric disorders were more common than upper extremity amputations. Similarly, we think that increasing the number of amputations causes psychiatric disorders for the same reason.

CONCLUSION

Trauma is one of the important causes of amputations. Traumatic amputations are among the issues that need to be carefully examined because they occur especially in the young age group and cause disabilities in the affected people. It is known that traumatic amputations are more common in soldiers and security forces, where situations such as explosions and gunshot wounds occur frequently in terrorist acts in our country and around the world. Amputations occur in the extremities and often in the distal regions, and this leads to significant effects on the person's post-event life. It is necessary to reduce trauma, which is one of the important causes of amputations, to take precautions by using personal protective equipment, and to not neglect treatment and follow-up. Trainings should be provided on common causes of trauma (work-related injury, explosion, etc.) to prevent the occurrence of amputations.

The majority of patients in developing nations, like Türkiye, struggle to receive pre-hospital care, which proves to be a major challenge for trauma care, especially in military cases. The prevention of amputations relies heavily on proper prehospital first aid interventions. Simple first aid information and training are essential for soldiers who often encounter traumatic amputations.

Psychological injuries may also occur in people with severe traumatic injuries such as amputation. Developing psychological injuries leads to significant effects on a person's life. It is of great importance that psychiatric follow-up of people is carried out in the early and late periods after amputation and that social support and appropriate treatments are not neglected.

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MEDICAL RECORDS-International Medical Journal

Research Article

Assessing the Performance of ChatGPT on Dentistry Specialization Exam Questions: A Comparative Study with DUS Examinees

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Abstract

Aim: This study aims to evaluate the performance of the ChatGPT-4.0 model in answering questions from the Turkish Dentistry Specialization Exam (DUS), comparing it with the performance of DUS examinees and exploring the model's clinical reasoning capabilities and its potential educational value in dental training. The objective is to identify the strengths and limitations of ChatGPT when tasked with responding to questions typically presented in this critical examination for dental professionals.
Material and Method: The study analyzed DUS questions from the years 2012 to 2017, focusing on the basic medical sciences and clinical sciences sections. ChatGPT's responses to these questions were compared with the average scores of DUS examinees, who had previously taken the exam. A statistical analysis was performed to assess the significance of the differences in performance between ChatGPT and the human examinees.
Results: ChatGPT significantly outperformed DUS examinees in both the basic medical sciences and clinical sciences sections across all years analyzed. The statistical analysis revealed that the differences in performance between ChatGPT and DUS examinees were statistically significant, with ChatGPT demonstrating superior accuracy in all years.
Conclusion: ChatGPT's performance on the DUS demonstrates its potential as a supplementary tool for dental education and exam preparation. However, future research should focus on integrating AI into practical dental training, particularly in assessing its real-world applicability. The limitations of AI in replicating hands-on clinical decision-making in unpredictable environments must also be considered.

Keywords: Artificial intelligence in dentistry, clinical decision support, chatgpt in medical education, dental exam performance

INTRODUCTION

Specialization in dentistry requires extensive and deep knowledge in both basic medical sciences and advanced clinical practices. In Türkiye, the Dentistry Specialization Examination (DUS) is one of the most critical exam for dental professionals who wish to pursue specialist training. Administered by the Evaluation Selection and Placement Center (ÖSYM), the DUS is a rigorous examination that consists of 120 questions divided into basic medical sciences and clinical sciences sections. These sections test the knowledge and clinical competence of examinees (1). Success in this examination is crucial for dental professionals looking to advance in their careers, as it determines eligibility for specialist education in Türkiye's competitive healthcare environment.

In recent years, advancements in artificial intelligence (AI) have sparked considerable interest in its potential applications in medical and dental education (2). One of the most notable innovations in AI is the development of large language models (LLMs) like ChatGPT by OpenAI. These models have been shown to perform comparably to human examinees in various standardized tests, including medical licensure exams such as the United States Medical Licensing Examination (USMLE) (3-5).

LLMs like ChatGPT have also been used for various educational purposes, such as assisting with scientific writing, conducting literature reviews, and formulating research questions (6). The potential of these models to complement traditional educational methods by providing personalized learning experiences is becoming increasingly

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apparent (7). In particular, studies have suggested that AI models can offer a significant advantage in preparing for critical exams by providing real-time feedback and simulating exam conditions (6,8).

However, while AI has proven to be effective in standardized testing environments, there is still much to learn about its potential to support clinical decision-making and practical skill development in fields such as dentistry (5,6). This study systematically evaluates the performance of ChatGPT in answering questions from the Turkish DUS, focusing on its clinical reasoning capabilities and reliability as an educational tool. The study compares ChatGPT's performance to that of actual DUS examinees who took the exam between 2012 and 2017, with the goal of assessing the strengths and limitations of AI in this specific context. Additionally, the research explores the potential role of AI in enhancing dental education, especially in preparing for specialized exams like the DUS.

MATERIAL AND METHOD

Study Design

This study was designed as a retrospective analysis aimed at evaluating the performance of the ChatGPT-4.0 model in answering multiple-choice questions from the Turkish DUS. The study compares ChatGPT's performance to that of DUS examinees who took the exam between 2012 and 2017. The analysis focused on net correct answers and considered the basic medical sciences and clinical sciences sections separately, as these sections encompass different areas of knowledge and testing formats.

Data Collection

Data was gathered from six DUS exams administered between 2012 and 2017. The exams were made publicly available by ÖSYM, and only those that provided full performance data and allowed open access were included in the study (https://www.osym.gov.tr/TR,25704/2023.html). Any exams with missing numerical data or restricted access were excluded from the analysis. The study utilized 120 multiple-choice questions from each DUS exam, covering both basic medical sciences and clinical sciences. Each exam consisted of 40 questions from the basic medical sciences and 80 questions from the clinical sciences, providing a comprehensive evaluation of the dental knowledge required for specialization.

Performance data for the DUS examinees were obtained from official ÖSYM reports. The net scores for each examinee were calculated using the standard scoring method, where one point was subtracted for every four incorrect answers from the total number of correct answers. This calculation method was applied consistently across all years to ensure comparability of the data.

AI Model

The ChatGPT-4.0 model, developed by OpenAI, was utilized to answer the DUS questions. Each question was presented to the model via screen recordings, with the model selecting one of the multiple-choice answers for each question. The model's performance was evaluated based on the accuracy of its selected answers compared to the correct responses. The analysis aimed to identify how well ChatGPT could perform on specialized dental exams and to compare its accuracy with that of human examinees.

RESULTS

The performance data comparing ChatGPT and DUS examinees across the years 2012 to 2017 is summarized. (Table 1).

Table 1. Descriptive statistics of performance (net correct answers)

Year	DUS examinees medical basic science	ChatGPT medical basic science	DUS examinees clinical science	ChatGPT clinical science
2012	15.42	40.00	41.08	67.50
2013	16.23	35.50	48.90	60.25
2014	19.88	40.00	43.52	62.50
2015	16.86	40.00	49.56	65.50
2016	14.04	36.25	50.46	66.25
2017	19.55	40.00	46.72	65.00

Figure 1 highlights that ChatGPT consistently outperformed the DUS examinees in both basic medical sciences and clinical sciences sections across all years. The most significant differences were observed in the basic medical sciences, where ChatGPT achieved near-perfect scores in several years, while the DUS examinees' scores were substantially lower. Even in the clinical sciences, which tend to require more complex reasoning and application of knowledge, ChatGPT consistently outscored the human examinees.

Figure 1 presents the success rates of ChatGPT and DUS examinees as a percentage of the total number of questions answered correctly in both the basic medical sciences and clinical sciences sections. As shown in the figure, ChatGPT's success rates were consistently high across all years and far exceeded those of the DUS examinees in both sections. ChatGPT's success rates in the basic medical sciences were particularly impressive, often exceeding 90%, while the DUS examinees' success rates were generally below 50%.

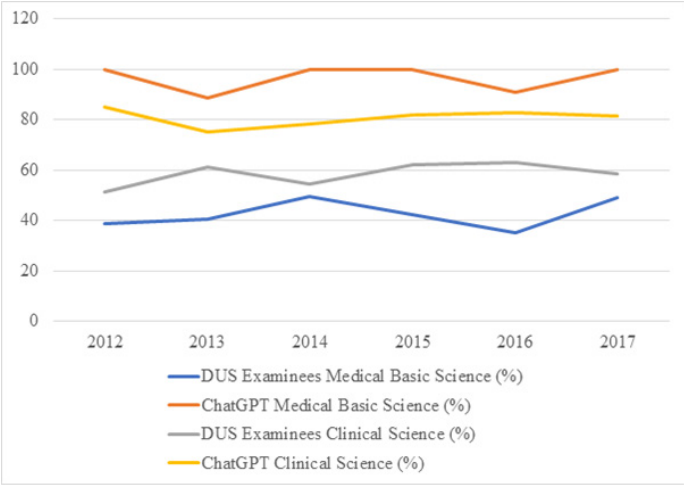

Figure 1. Success rates: DUS examinees vs. ChatGPT (medical basic science and clinical science)

A paired t-test was conducted to compare the average performance of ChatGPT and DUS examinees in both the basic medical sciences and clinical sciences sections. The results of the t-test indicated a statistically significant difference ($p<0.05$) in both sections. ChatGPT's mean score in the basic medical sciences was 38.63, compared to the DUS examinees' mean score of 16.66. In the clinical sciences, ChatGPT's mean score was 64.83, compared to the DUS examinees' mean score of 46.87 (Figure 2). These results demonstrate a substantial performance gap in favor of ChatGPT.

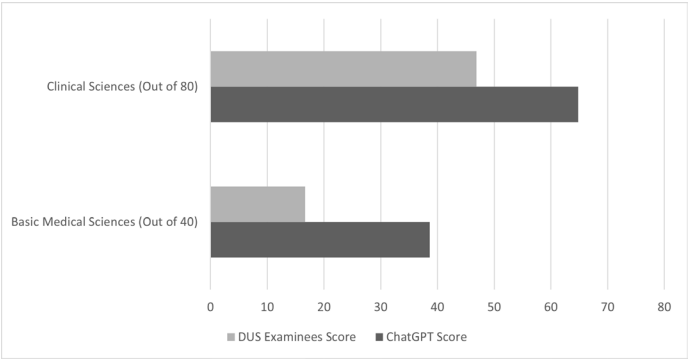

Figure 2. Comparison of mean net scores (absolute out of 40 for basic, 80 for clinical): ChatGPT vs DUS examinees

DISCUSSION

The results of this study indicate that ChatGPT consistently outperformed DUS examinees in both the basic medical sciences and clinical sciences sections of the exam. These findings highlight the growing potential of AI in medical and dental education, specifically in specialized exams like the DUS. Large language models such as ChatGPT are highly capable of processing vast amounts of information quickly and accurately, making them particularly suitable for answering questions that rely on recall. This is consistent with the findings of Brown et al., who stated that language models are effective in tasks that require memory-based knowledge (2).

One explanation for ChatGPT's superior performance may be that the exams are structured as multiple choice; these exams rely heavily on recall rather than critical thinking or clinical judgment. ChatGPT excels at providing accurate answers because it can access a vast repository of information and process it with incredible speed. This is consistent with research by Cascella et al., which shows that AI models such as ChatGPT are particularly suitable for tasks that require retrieving specified facts from a knowledge database (5).

In contrast, although test examinees may be knowledgeable, they may be affected by factors such as cognitive limitations, test anxiety, or variability in test preparation methods, which may lead to lower performance according to the AI model (6). Additionally, humans face the natural limitations of information processing speed and working memory, which can lead to errors, especially under time constraints. The variability in performance among DUS examinees over the years may also be attributed to changes in the difficulty of the exam questions, external pressures, and differing levels of preparedness among candidates (9).

ChatGPT's strong performance in the clinical sciences division was particularly notable. Clinical exams that require decision-making by synthesizing knowledge are often considered a challenging aspect of medical and dental examinations (10,11). Although ChatGPT's success in such exams is impressive, the fact that the exam consists of multiple-choice questions plays an important role in this success. However, as Davenport et all point out, AI systems may struggle in real-world clinical scenarios where decisions rely on the incorporation of uncertain or incomplete information (12). This suggests that ChatGPT's success in exams does not necessarily translate into practical clinical decision-making.

In the basic medical sciences section, ChatGPT achieved a success rate of 97.39%, while the average success rate for DUS examinees was only 42.49%. This significant difference in performance may be attributed to the nature of the questions in the basic sciences. Subjects like anatomy, histology, and pharmacology rely on well-documented and relatively stable knowledge bases, which are readily available in public databases. ChatGPT, being trained on vast amounts of such data, can quickly retrieve and accurately process this information. Moreover, the questions in these areas often have definitive answers (13-15). This is likely why ChatGPT achieved near-perfect scores in these sections, compared to the success rates of the DUS examinees.

However, it is important to acknowledge that clinical knowledge differs significantly from basic science knowledge, as it requires the practical application of skills acquired through experience (16). Dentists and other healthcare professionals, when encountering clinical cases, must go beyond abstract information and make patient-specific decisions. The complexity of managing diverse patient scenarios, especially in high-pressure clinical environments, requires a type of reasoning that goes beyond what AI models can currently replicate. Clinical

decisions often involve interpreting subtle patient cues, integrating hands-on experience, and considering patient preferences, all of which are difficult for AI to simulate accurately (16-18). In this study, ChatGPT demonstrated a 80.21% success rate in clinical sciences, compared to 58.36% for DUS examinees. Although ChatGPT's performance was still superior, the smaller margin of success suggests that clinical questions particularly those involving diagnostic reasoning or patient management may pose greater challenges for AI models.

Moreover, while ChatGPT demonstrated exceptional proficiency in the theoretical aspects of clinical sciences, it is essential to recognize that true clinical competence involves more than just answering questions correctly (19). Effective clinical decision-making requires the ability to weigh multiple factors simultaneously, to exercise judgment in the face of uncertainty, and to engage in hands-on procedures that require fine motor skills and the ability to adapt to real-time feedback (19-21). As such, while ChatGPT has proven to be a valuable tool for knowledge acquisition and standardized testing, its utility in real-world clinical practice remains limited by its inability to replicate these higher-order cognitive processes.

Despite these limitations, AI has significant potential as an educational tool. By integrating artificial intelligence into dental education, students can benefit from personalized learning experiences tailored to their individual strengths and weaknesses. AI-powered platforms can provide targeted learning materials and practice questions, helping students prepare more effectively for exams such as the DUS (22,23). In particular, AI systems can be used to identify areas where students struggle the most, enabling educators to offer more focused instruction in those areas. Furthermore, AI-driven assessments can give students an opportunity to test their knowledge in a simulated environment, providing feedback that can help them build confidence and improve their performance on future exams.

Additionally, AI can assist in enhancing the learning experience by providing detailed explanations for incorrect answers. This type of real-time feedback helps students understand their mistakes and develop better clinical reasoning skills over time. However, educators must be mindful of the risks associated with over-reliance on AI-generated answers. While AI can provide support in factual recall, it is crucial for students to cultivate their own problem-solving abilities and develop critical thinking skills, particularly in the context of clinical decision-making. As Davenport and Kalakota caution, AI should be viewed as a tool to complement, rather than replace, traditional learning methods (12).

Limitations of the Study

Despite the promising findings of this study, several limitations must be considered. First, the data used for this study were based on publicly available DUS exam results, and the performance of the DUS examinees may not be fully representative of the general population of dental students. Additionally, the ChatGPT model was developed primarily in English, which could have affected its performance when handling Turkish-language exam questions. This language discrepancy is a factor that must be considered when evaluating the model's accuracy and reliability in non-English exams. Future studies should explore the impact of language differences on AI performance, particularly in multilingual or non-English contexts.

Furthermore, while ChatGPT performed well in this study, it is important to remember that the model was evaluated in a controlled, multiple-choice exam environment. Real-world clinical practice is far more complex and dynamic, involving patient interactions, physical examinations, and hands-on procedures that cannot be easily replicated by AI (18,21,24). Therefore, future research should explore the use of AI in clinical practice settings to determine whether it can assist dental professionals in making accurate decisions when treating patients.

CONCLUSION

This study highlights the potential of AI, particularly large language models like ChatGPT, to support dental education by providing accurate knowledge recall and assisting in exam preparation. ChatGPT's superior performance on the DUS, particularly in the basic medical sciences and clinical sciences sections, demonstrates that AI can be a valuable tool for dental professionals preparing for critical exams. However, while AI shows promise in structured, fact-based testing environments, its limitations in real-world clinical practice, where situational judgment and hands-on skills are critical, must be acknowledged.

The future of dental education will likely involve integrating AI as a supplementary tool, enhancing students' ability to retain and recall knowledge while emphasizing the irreplaceable value of human clinical expertise. AI should be used to complement traditional learning methods, helping students build a solid foundation of knowledge that can be applied in practical, real-world scenarios. By embracing the potential of AI while recognizing its limitations, educators can help prepare the next generation of dental professionals for success in both academic and clinical settings.

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Ethical approval: *Ethical approval has been obtained from the Ethics Committee of İstanbul Medipol University (ethics committee approval number: 1135, issue number: E-10840098-202.3.02-7444).*

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Research Article

The Role of Prognostic Nutritional Index in Vascular Behçet's Syndrome

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Abstract

Aim: This study aimed to evaluate the levels of the Prognostic Nutritional Index (PNI) in vascular and non-vascular subtypes of Behçet's Syndrome (BS) and its potential utility in distinguishing vascular involvement.

Material and Method: This retrospective cohort study included 386 patients diagnosed with BS based on ISG criteria. Patients were categorized into vascular (n=100) and non-vascular (n=286) involvement groups. Subgroup analyses assessed organ-specific patterns of involvement. PNI values were calculated as 10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (/mm^3). Statistical analyses were performed to compare PNI levels between subgroups. Additionally, ROC curve analysis was conducted to evaluate the discriminatory ability of PNI for detecting vascular involvement.

Results: Patients with vascular involvement exhibited significantly lower mean PNI values (51.7±6.6) compared to the non-vascular group (56.9±4.4, p<0.001). Neuro-Behçet's disease was significantly more frequent in the vascular group (19.0%) than in the non-vascular group (2.4%, p<0.001). However, among patients with Neuro-Behçet's disease without vascular disease, PNI values were found to be similar to the rest of the cohort. ROC analysis demonstrated that PNI effectively differentiated vascular involvement, with an AUC of 0.76, sensitivity of 72.7%, and specificity of 71%. The optimal cutoff value for PNI was determined to be 55.

Conclusion: PNI is a potential marker for identifying vascular involvement in BS. The significantly lower PNI values observed in patients with vascular involvement, coupled with its moderate discriminatory ability, suggest that PNI could serve as a valuable tool in clinical practice. Low PNI values are associated with impaired nutritional and immunological status, which may contribute to or result from the systemic inflammatory burden seen in vascular disease. Further multicenter, prospective studies are warranted to validate these findings.

Keywords: Behçet's syndrome, vascular involvement, prognostic nutritional index

INTRODUCTION

Behçet's Syndrome (BS) is a chronic, multisystemic inflammatory disorder characterized by diverse clinical manifestations, ranging from mucocutaneous lesions to life-threatening vascular complications (1). The pathogenesis of this complex and multifactorial disease remains incompletely understood; however, infectious, genetic, epigenetic, and immunological factors are thought to play significant roles in its development (2). BS presents heterogeneously, with recurrent oral and genital aphthae, uveitis, skin manifestations (e.g., erythema nodosum or acneiform lesions), gastrointestinal involvement, neurological symptoms, vascular disease, and arthritis (3). This variability requires accurate classification of patients for optimal management and prognostication. Among the various manifestations, vascular involvement is particularly serious, contributing significantly to morbidity and mortality and requiring specific therapeutic approaches (4). There remains a critical need to identify clinical or biochemical markers that can help distinguish between vascular and non-vascular forms of the disease.

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The Prognostic Nutritional Index (PNI), initially developed to assess nutritional and immunological status in oncology, is calculated using serum albumin levels and total lymphocyte count (5). In particular, the PNI, a tool used to assess nutritional and immunologic status in oncology (5), has recently emerged as a potential biomarker in various inflammatory and vascular disorders. In inflammatory rheumatic diseases, PNI has been found to correlate with disease activity, emphasizing that it can be used as a biomarker for disease activity assessment (6-8). BS, particularly its vascular subtype, represents a unique context where systemic inflammation and immune dysregulation play a pivotal role. In this setting, while markers of disease activity remain crucial for evaluating the systemic burden of inflammation, the PNI may provide additional insights by distinguishing vascular BS from its non-vascular subtypes, thus expanding its diagnostic relevance beyond disease activity alone.

However, despite the dual inflammatory and immunological underpinnings of BS, PNI utility in BS has not been extensively studied. Considering the importance of classification of BS according to vascular involvement for the correct clinical and therapeutic approach, the aim of this study was to evaluate the levels of the PNI in vascular and non-vascular subtypes of BS and its potential utility in distinguishing vascular involvement.

MATERIAL AND METHOD

Study Design and Population

This retrospective cohort study analyzed hospital records from patients diagnosed with BS between 2018 and 2023 using International Classification of Diseases (ICD) codes. Patients who met the International Study Group (ISG) diagnostic criteria and had available laboratory data for PNI calculation at the time of diagnosis or relapse were included (9). Demographic, clinical, and laboratory data were retrospectively extracted from the electronic medical records. Patients younger than 18 years old, those with other inflammatory diseases or malignancies, and those without laboratory data at the time of diagnosis or relaps were excluded from the study.

Out of 590 patients identified based on ICD codes, 204 were excluded according to these criteria. The final analysis included the remaining cohort with complete relevant data. Patients were categorized into two main groups: those with vascular involvement and those without. The "non-vascular organ involvement" group comprised patients with isolated mucocutaneous manifestations, uveitis, arthritis, Entero-Behçet's disease, or Neuro-Behçet's disease. Subgroup analyses were conducted within both the vascular and non-vascular groups to assess specific patterns of organ involvement.

To evaluate the role of systemic inflammation and nutritional status in BS, we utilized the PNI, calculated as 10×serum albumin (g/dL)+0.005×total lymphocyte/mm3. The primary focus was on comparing PNI values between vascular and non-vascular groups to assess differences and determine whether PNI could distinguish vascular involvement.

In addition, we investigated whether the observed differences in PNI values were driven by vascular involvement itself or by variations in specific organ involvements within the non-vascular group. This secondary analysis aimed to ensure that the predictive utility of PNI was not confounded by other patterns of organ involvement.

Finally, the discriminative capacity of PNI for vascular involvement was evaluated using Receiver Operating Characteristic (ROC) curve analysis. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to assess the diagnostic performance of PNI in distinguishing patients with vascular involvement from those without.

The study protocol was approved by Ankara City Hospital Clinical Researches Ethics Committee (Date: 2023, Decision No: E1-23-4368).

Statistical Analyses

Statistical analyses were conducted using Jamovi Software v2.3 (10). Normality was tested using the Shapiro-Wilk test, along with assessments of skewness and kurtosis to characterize the distribution of each variable. Continuous variables were expressed as mean values with standard deviations (SD), while categorical data were summarized as absolute frequencies and percentages.

Group comparisons for PNI levels were conducted using the Student's t-test. The discriminative ability of PNI for vascular involvement was assessed via ROC curve analysis, with the area under the curve (AUC) calculated to evaluate its predictive accuracy. Optimal cutoff values for PNI were determined using Youden's Index. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated for each index. All statistical analyses were performed at a significance level of $p<0.05$.

RESULTS

The study cohort consisted of 386 patients diagnosed with BS. The mean age of the cohort was 43.0±11.3 years, ranging from 19 to 76 years, with males constituting 50.0% of the population. Clinical manifestations were distributed as follows: vascular involvement (25.9%), isolated mucocutaneous involvement (37.8%), musculoskeletal symptoms (19.4%), ocular involvement (28.2%), Entero-Behçet (2.1%), and Neuro-Behçet (6.7%). Targeted treatments, including TNF inhibitors, cyclophosphamide, and IVIG, were used in 22.0% of cases. The overall mean PNI was 55.5±5.5, ranging between 31.0 and 74.5 (Table 1).

Table 1. Baseline characteristics of patients with Behçet's Syndrome

Characteristic	Overall (N=386)
Age	
Mean (SD)	43.0 (11.3)
Range	19.0–76.0
Sex	
Male, n (%)	193 (50.0)
Clinical manifestations	
Vascular, n (%)	100 (25.9)
Mucocutaneous, n (%)	146 (37.8)
Musculoskeletal, n (%)	75 (19.4)
Eye involvement, n (%)	109 (28.2)
Entero-Behçet, n (%)	8 (2.1)
Neuro-Behçet, n (%)	26 (6.7)
Treatment	
Targeted therapies (e.g., TNF inhibitors, cyclophosphamide, IVIG), n (%)	85 (22.0)
Prognostic Nutritional Index (PNI)	
Mean (SD)	55.5 (5.5)
Range	31.0-74.5

Patients were stratified into vascular (N=100) and non-vascular (N=286) subgroups to evaluate differences in clinical and demographic parameters:

Patients with vascular involvement were older (Mean: 45.2±10.8) compared to the non-vascular group (Mean: 42.3±11.4) (p=0.028). A higher proportion of males was observed in the vascular group (69.0%) compared to the non-vascular group (43.4%) (p<0.001).

51% of the patients in non vascular groups had only Mucocutaneous involvement. Musculoskeletal involvement was more frequent in the non-vascular group (22.0%) compared to the vascular group (12.0%), p=0.029. No significant difference was noted in ocular or Entero-Behçet involvement between groups (p=0.749 and p=0.953, respectively). Neuro-Behçet was significantly more common in the vascular group (19.0%) compared to the non-vascular group (2.4%) (p<0.001). Targeted therapies were more commonly used in the vascular group (37.0%) compared to the non-vascular group (16.8%) (p<0.001). The mean PNI was significantly lower in the vascular group (51.7±6.6) compared to the non-vascular group (56.9±4.4) (p<0.001) (Figure 1).

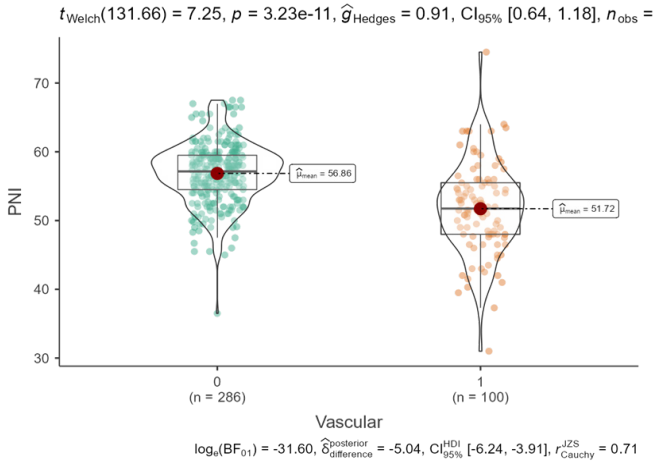

Figure 1. Distribution of Prognostic Nutritional Index (PNI) values among patients with and without vascular involvement in Behçet's Syndrome

Additionally, within the subset of patients with neurological involvement but no vascular involvement (n=7), the PNI was 59.3±7.3, which was not statistically significant from the rest (55.5±5.5, p=0.07) (Table 2).

Table 2. Comparison of characteristics between vascular and non-vascular Behçet's Syndrome groups

Characteristic	Non-vascular (N=286)	Vascular (N=100)	p-value
Age			0.028
Mean (SD)	42.3 (11.4)	45.2 (10.8)	
Range	19.0 – 76.0	20.0 – 70.0	
Sex (Male), n (%)	124 (43.4)	69 (69.0)	<0.001
Isolated Mucocutaneous Involvement, n (%)	146 (51.0)	0 (0.0)	<0.001
Musculoskeletal Involvement, n (%)	63 (22.0)	12 (12.0)	0.029
Eye Involvement, n (%)	82 (28.7)	27 (27.0)	0.749
Entero-Behçet, n (%)	6 (2.1)	2 (2.0)	0.953
Neuro-Behçet, n (%)	7 (2.4)	19 (19.0)	<0.001
Treatment (e.g., TNF inhibitors, cyclophosphamide, IVIG), n (%)	48 (16.8)	37 (37.0)	<0.001
Prognostic Nutritional Index (PNI)			<0.001
Mean (SD)	56.9 (4.4)	51.7 (6.6)	
Range	36.5-67.5	31.0-74.5	

Statistical analysis was conducted using Linear Model ANOVA and Pearson's Chi-squared test

The ROC curve analysis demonstrated that the PNI is a moderately effective tool for differentiating between vascular and non-vascular involvement in Behçet's Syndrome. The optimal cutoff value for PNI was determined to be 55, achieving an AUC of 0.76. At this threshold, the sensitivity was 72.7%, and the specificity was 87.8%, indicating moderate ability to correctly identify vascular cases (Figure 2). Additionally, the PPV was 87.8%, and the NPV was 47.7%, highlighting the stronger reliability of the test in defining vascular involvement.

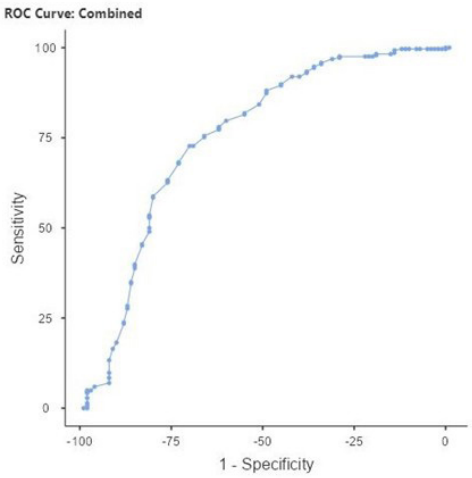

Figure 2. Receiver Operating Characteristic (ROC) curve for the use of Prognostic Nutritional Index (PNI) in distinguishing vascular from non-vascular involvement in Behçet's Syndrome. The optimal cutoff value of 55 achieved an Area Under the Curve (AUC) of 0.76, with a sensitivity of 72.7% and specificity of 71%"

DISCUSSION

This study underscores the utility of PNI as a distinguishing marker for vascular versus non-vascular involvement in BS. The observed association between low PNI values and impaired nutritional and immunological status suggests that these deficits may both drive and result from the systemic inflammatory burden characteristic of vascular disease. Importantly, our findings demonstrate that this difference in PNI values cannot be attributed solely to other organ involvements within the vascular group, such as Neuro-Behçet's disease, as evidenced by the comparable PNI values in patients with isolated neurological involvement but without vascular disease. Our study also underscores the clinical importance of vascular involvement in Behçet's Syndrome, with clear differences observed in demographic, clinical, and therapeutic parameters between vascular and non-vascular subgroups.

Vascular events develop in up to 40% of BS patients. Although vascular events can be observed at any stage of the disease, they usually develop in the early stages of the disease (11,12). The most common manifestations of vascular involvement, which mostly affect the male gender, are superficial vein thrombosis (SVT) and deep vein thrombosis (DVT), usually involving the upper or lower extremities (13,14). Vascular involvement is the main cause of morbidity and mortality (12). Early diagnosis and appropriate therapeutic intervention are critical in improving vascular BS prognosis. Regular monitoring becomes even more vital such cases. Thus, non-invasive biomarkers may play an essential role in identifying vascular involvement and facilitating timely and effective intervention.

Thrombogenesis in vascular BS results from immune-inflammatory dysfunction. In active BS, immune and inflammatory triggers cause endothelial cell damage, largely driven by activated neutrophils that congregate at these damaged sites. These neutrophils induce thrombo-inflammation, leading to platelet activation, endothelial dysfunction, and impaired fibrinolysis (14). Monocytes, the primary sources of pro-inflammatory and oxidative cytokines, further exacerbate these processes, leading to an increase in the number of monocytes and a decrease in lymphocytes (15). Systemic inflammation and abnormal immune responses then lead to significant changes in hematologic and biochemical markers.

Several studies have examined the link between these laboratory parameters and disease activity in BS. Active vascular involvement may trigger a more pronounced inflammatory response. Markers that predict immune-inflammatory response are likely to induce a more robust response in vascular involvement. However, the relationship between these markers and vascular involvement has been less extensively investigated. There are data suggesting that mean corpuscular hemoglobin concentration (MCHC) and mean platelet volume (MPV) may be predictive for vascular involvement (16-18). The Pan-Immune-Inflammation Value (PIV) has also been proposed as a predictive marker for vascular involvement in BS (19). Furthermore, studies have suggested that neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) are associated with vascular BS (20,21). However, there are also articles that found no association (22). Therefore, the predictive value of these indices for vascular BS remains limited and supports the need for further investigation of inflammatory indices.

The PNI was developed as an index of nutritional status to investigate the association of the risk of postoperative complications in gastrointestinal surgery patients with baseline nutritional status (23). The index was subsequently investigated in malignancy, chronic diseases, vascular diseases and rheumatic diseases in which chronic inflammation predominates and was found to be associated with both disease activity and mortality.

Previous studies have demonstrated that PNI is associated with disease activity in conditions such as rheumatoid arthritis and systemic lupus erythematosus, indicating its role as a marker of systemic inflammation (6,8,24,25). Additionally, in patients with antineutrophil cytoplasmic antibody-associated vasculitis (AAV), PNI has been identified as a useful tool at the time of diagnosis for assessing disease severity and predicting patient prognosis (7). These findings in the literature underscore the broader applicability of PNI as a marker of systemic inflammation and its potential relevance in evaluating

vascular involvement in BS. Our study adds to this growing body of evidence by highlighting PNI's utility as a differentiating index between vascular and non-vascular forms of BS.

The application of the PNI showed promising results, with a significantly lower mean PNI observed in the vascular group. ROC curve analysis further confirmed PNI as a moderately effective tool to discriminate vascular involvement with an AUC of 0.76. The PPV (87.0%) indicates that PNI may be useful in confirming vascular cases, while the moderate NPV (47.7%) highlights the need for complementary markers for ruling out vascular cases. Our study supports previous findings on the relevance of systemic inflammation markers in BS (20,21), but it uniquely highlights PNI's potential as a standalone index for vascular involvement. Unlike NLR and PLR, PNI captures both nutritional and immunological status, providing a more holistic measure of disease burden. Incorporating PNI into routine clinical practice may enhance the early detection of vascular involvement in BS, enabling timely therapeutic interventions and improved patient outcomes.

When organ involvement was compared between the groups, musculoskeletal involvement was more common in the non-vascular group, while the frequency of Entero-Behçet and uveitis was similar in both groups. In particular, Neuro-Behçet was significantly higher in the vascular group ($p<0.001$). Given that neurological involvement elicits a high inflammatory response, the question arose whether the lower PNI values observed in the vascular group could be influenced by the higher incidence of Neuro-Behçet. To address this, we specifically analyzed PNI values in the subset of patients with Neuro-Behçet but without vascular involvement and found that PNI values were higher and not significantly different from the rest of the patients ($p=0.396$). This suggests that the significantly lower PNI values observed in the vascular group cannot be attributed solely to the presence of Neuro-Behçet. The limited number of cases with isolated neuro-Behçet's syndrome in our study precludes definitive conclusions regarding the role of PNI in this subgroup. Nevertheless, our findings indicate that PNI values in neuro-Behçet's patients are comparable to those observed in the general Behçet's population and are numerically higher than those in patients with vascular involvement. Further research is required to elucidate the clinical significance of PNI in neuro-Behçet's syndrome. Thus, the reduced PNI value in the vascular group reflects a broader systemic inflammatory burden specific to vascular involvement in BS, emphasizing its utility as a marker for this particular subtype of the disease.

The study cohort was derived from a single center, which limits the generalizability of the findings. Furthermore, the cross-sectional design precludes establishing causality between PNI levels and vascular involvement. Additionally, the absence of longitudinal data and disease activity indices may limit the ability to assess the dynamic relationship between PNI levels, disease activity, and vascular involvement. Future studies with larger, multicenter cohorts and prospective designs are needed to confirm the findings and investigate the prognostic implications of PNI over time.

CONCLUSION

In conclusion, the PNI was notably lower in patients with vascular involvement, supporting its association with disease severity and systemic inflammation in BS. PNI has the potential to distinguish BS vascular involvement from non-vascular involvement. Integrating PNI into clinical practice alongside traditional clinical parameters may improve risk stratification and enhance patient follow-up outcomes by guiding personalized treatment strategies.

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Research Article

Evaluation of Polymethylmethacrylate (PMMA) Cement for Stabilizing Loosened Screws in Mandibular Angle Fracture Fixation: A Biomechanical Study

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Abstract

Aim: Mandibular angle fractures account for 23-42% of all mandibular fractures, with treatment options often debated due to the region's anatomical complexity. While single miniplate fixation has shown low complication rates, issues like screw loosening remain a challenge. Polymethylmethacrylate (PMMA) has been widely used in orthopedic surgery to improve screw stability. This study aimed to evaluate the effect of PMMA on the stability of loosened screws in mandibular angle fractures.

Material and Method: Twenty hemimandibles from sheep cadavers were divided into control and experimental groups. In the control group, standard 2.0 mm screws were inserted without PMMA augmentation. In the experimental group, a 1.6 mm pilot hole was used to simulate screw loosening, and PMMA was injected into the screw tracts before screw insertion. Both groups underwent vertical force testing using a hydraulic device, with displacement values measured at 50 N of force. Statistical analysis was performed using the Student t-test, with significance set at $p<0.05$.

Results: The mean maximum displacement in the control group was 5.60±2.22 mm, while in the experimental group it was 6.49±3.21 mm. There was no statistically significant difference between the two groups ($p=0.479$). The biomechanical behavior of both groups was similar, indicating that PMMA did not significantly affect displacement values under the tested conditions.

Conclusion: PMMA cement did not significantly improve the stability of loosened screws in mandibular angle fractures. Further research with different force applications and screw conditions may provide more insights into the potential benefits of PMMA augmentation.

Keywords: Mandibular angle fractures, polymethylmethacrylate, screw loosening, miniplate fixation, biomechanical stability

INTRODUCTION

Mandibular angle fractures account for approximately 23-42% of all mandibular fractures, making them a significant subset of facial trauma cases (1,2). Despite their frequency, the optimal treatment of mandibular angle fractures remains a topic of debate due to the unique anatomical and mechanical challenges presented by the region. The complex anatomical structures surrounding the mandibular angle, coupled with the technical difficulties in surgical manipulation, necessitate a range of treatment approaches. Internal fixation techniques, while commonly used, are associated with a relatively high risk of infection, particularly in the mandibular angle region. Additionally, these fractures are often complicated by high postoperative complication rates, which can make their management particularly challenging for surgeons (3-5).

A variety of miniplate configurations and screw positions have been evaluated in the literature to optimize fracture stabilization. Single miniplate fixation on the lateral aspect of the mandibular angle, acting as a tension band, has been shown to yield low complication rates, with reported figures between 12% and 16% (6,7). Proper adaptation of non-compression miniplates to the bone surface is critical for effective fracture treatment. The anatomical difficulty of the mandibular angle, exacerbated by limited access via the trans-oral route, further complicates the surgical

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approach. Non-compression miniplates must be correctly adapted to the bone to provide adequate stability; any maladaptation can generate torque forces that result in complications such as bone resorption, screw loosening, or impaired fracture healing (8-11).

During fixation, the thin cortical bone in the mandibular angle may suffer from additional microfractures as a result of drilling and screw insertion, further increasing the risk of damage to adjacent structures, including vessels, nerves, and tooth roots (11,12). Polymethylmethacrylate (PMMA), a material widely used in dentistry and orthopedic surgery, offers significant benefits due to its biocompatibility and ease of preparation both intraoperatively and preoperatively (13). In orthopedic surgery, the attachment of PMMA to bone is achieved through the retention forces generated by acrylic cement infiltration into the trabecular bone structure (14). Multiple orthopedic studies have demonstrated that augmenting pedicle screws with PMMA or similar cements can improve the fixation of screws to bone, increasing both stability and resistance to mechanical forces (15-17).

The objective of this study was to evaluate the efficacy of PMMA in improving the stability of loosened screws in mandibular angle fractures. While PMMA has been previously studied for use in miniplate fixation with non-loosened screws, (18). this study specifically explores its application in cases where screws have become loosened. We hypothesized that mandibular angle fractures treated with PMMA-augmented loosened screws would exhibit displacement values comparable to those observed in a control group with non-loosened screws, under hydraulic pressure forces.

MATERIAL AND METHOD

The study was conducted using 20 hemimandibles obtained from sheep cadavers, each of which had been fed under similar conditions and had an average weight of 40 kg. The hemimandibles were kept moist and refrigerated at 4°C until the experimental procedures commenced. To facilitate the experiment, all skin and muscle tissues were removed, and the coronoid processes and condyles were excised to ensure that the specimens conformed to the physical constraints of the experimental setup. Surgical pens were used to mark the angular fracture lines on each hemimandible before the samples were randomly assigned to one of two groups (n=10 per group).

In the control group, pilot holes were created using a 1.2 mm diameter drill bit, while the experimental group used a 1.6 mm diameter drill bit, both under 1500 rpm, with physiological saline irrigation for cooling and debris removal (Figure 1). Four-holed, non-compression, straight titanium miniplates (1 mm thickness, Medplates/Türkiye) were positioned at the angle region of the mandible, with the osteotomy line centered on the miniplate. Bicortical osteotomies were performed using a diamond-tipped saw, and to simulate mandibular angle fractures, chisels and hammers were used to complete the fracture line due to the relative weakness of sheep mandibles compared to human mandibles (Figure 2) (19).

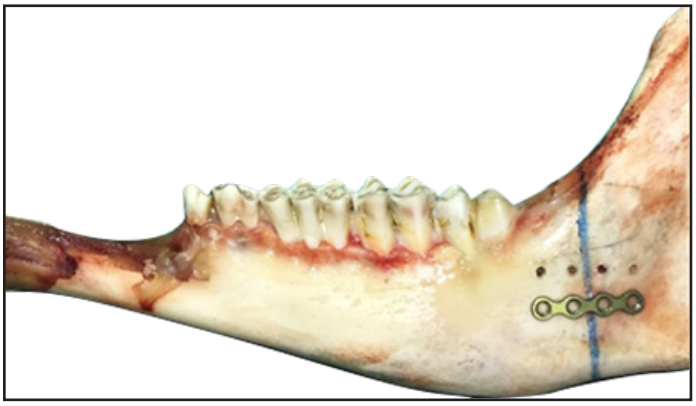

Figure 1. Preparetion of pilot holes and osteotomy line

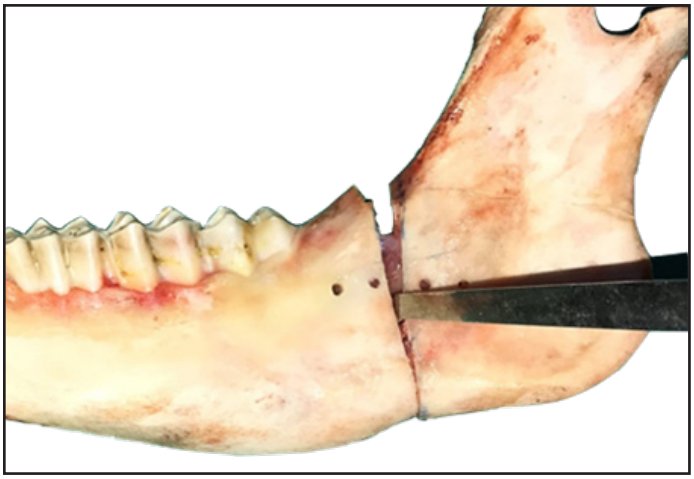

Figure 2. A chisel osteotome used for creating fracture site

In the experimental group, PMMA (Cemex, Tecrecs, Italy) was prepared and allowed to reach a toothpaste-like viscosity (approximately three minutes post-preparation). The PMMA was retrogradely injected into the 1.6 mm diameter screw tracts using a 10 ml syringe before screw placement (Figure 3). The screws (2.0 mm diameter, 11 mm length) were inserted into the PMMA-augmented tracts using a torque-controlled physiodispenser set to 40 Nm, simulating the clinical insertion of dental implants (Figure 4).

Figure 3. PMMA application using a 10 ml syringe

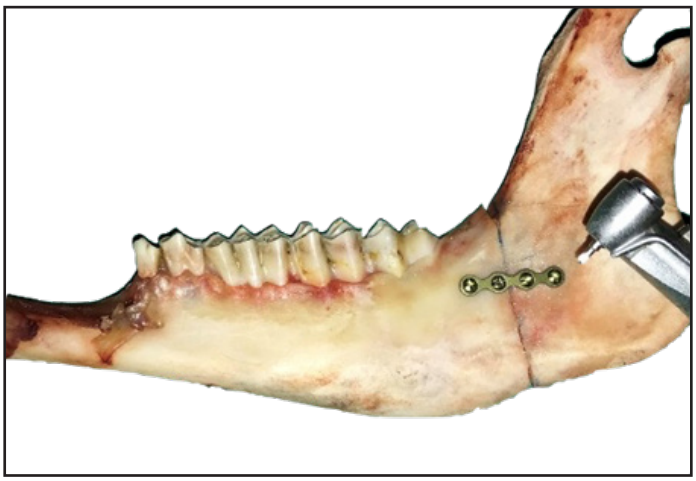

Figure 4. Insertion of screws using an electronic screw driver

Each hemimandible was secured in a custom L-shaped metal device, which provided stable fixation during biomechanical testing using a hydraulic test device (Universal Autograph AGS®, Shimadzu Scientific Instruments, Kyoto, Japan). A vertical progressive force was applied to the molar region, with force being measured via a sensor in the testing machine's headstock. The machine applied a maximum force of 50 N at a displacement speed of 5 mm/min, with the force being transmitted to the occlusal plane after calibration.

Statistical analyses were performed using IBM SPSS Statistics 22 (SPSS IBM, Türkiye). The normal distribution of the data was verified using the Shapiro-Wilk test, and a Student's t-test was employed to compare the two groups, with statistical significance set at $p<0.05$.

RESULTS

The displacement values and maximum displacement means (SD) for both groups under a force of 50 N are presented in Table 1 and Figure 5. There was no statistically significant difference between the maximum displacement values in the study and control groups (p: 0.479, p>0.05). However, slight differences in biomechanical behavior were observed in a few individual specimens across the two groups.

Table 1. Displacement values (mm) of control and experimental group at 50 N force.

Control group	Maximum displacement values in milimeters	Experimental group	Maximum displacement values in milimeters
C1	2.63120	**E1**	3.00970
C2	3.58770	**E2**	7.36940
C3	4.83117	**E3**	3.98627
C4	6.60770	**E4**	6.88127
C5	9.20647	**E5**	9.25287
C6	6.78773	**E6**	2.35607
C7	3.16280	**E7**	4.56293
C8	4.24957	**E8**	5.74287
C9	6.92790	**E9**	9.21117
C10	8.01130	**E10**	12.5765
Mean (SD)	5.60±2.22	**Mean (SD)**	6.49±3.21

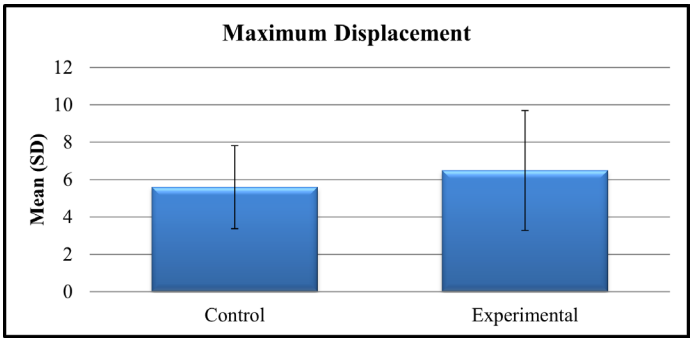

Figure 5. Graphical representation of mean (SD) displacement values of hemimandibles

DISCUSSION

This study sought to investigate whether PMMA cement could enhance the stability of loosened screws in mandibular angle fractures stabilized with miniplates. Most of the literature highlights the high incidence of mandibular angle fractures and the associated challenges of their management (20). Treatment approaches for these fractures remain controversial, with various fixation techniques being explored. Champy's introduction of miniplates revolutionized mandibular fracture management, as clinical studies demonstrated their efficacy in minimizing complications (21). A single miniplate secured with monocortical screws has been shown to offer reliable fixation with fewer complications than two-plate systems (6,7,8,20).

While resin mandible models are commonly used in fracture studies to standardize variables, such models may not accurately replicate the biomechanical properties of human bone. Fresh sheep mandibles, as used in our study, are widely accepted as a reliable alternative due to their similarity in size and cortical thickness to human mandibles (22).

Chewing forces in post-surgical mandibular fracture patients have been reported to reach 90 N within the first week after surgery, increasing to approximately 148 N by the sixth week (22). In our study, we applied a vertical force of 50 N, simulating the immediate post-fixation scenario

and assessing the stability of the screws under moderate load. This force is reflective of early postoperative conditions rather than maximum force endurance.

Previous studies have indicated no significant differences in stability between locking miniplates and standard titanium miniplates with diameters of 2 mm when subjected to forces up to 60 N (23). Based on these findings, we selected non-compression, four-holed miniplates with monocortical screws (2 mm diameter) to reflect routine clinical practice.

A larger pilot hole diameter has been associated with reduced screw holding power. Heidemann et al. recommend that pilot holes should not exceed 80% of the screw's external diameter to avoid weakening the screw's retention in the bone (24). In this study, we used a 1.6 mm pilot drill, which represents 80% of the external diameter of our 2.0 mm screws, to simulate screw loosening.

Several strategies have been proposed in the literature for increasing the retention strength of loosened screws, such as increasing screw diameter. However, this approach is often limited by anatomical constraints, and larger screws can increase the risk of cortical fracture (25-27). PMMA cement has been demonstrated in multiple orthopedic studies to be an effective means of augmenting screw fixation (16,17,28,29). The cement's biocompatibility, ease of use, and ability to form immediate bonds with cancellous bone make it a widely favored material (10,30-33). In this study, PMMA was used to augment loosened screws, reducing the displacement values in mandibular angle fractures.

One concern with the use of PMMA is its potential to leak into surrounding tissues, causing damage to nerves and blood vessels. The optimal quantity of PMMA to inject in mandibular fractures has not been well established. To minimize leakage, we employed a retrograde injection technique as described by Chang et al., (10). and ensured that the viscosity of the PMMA was appropriate for application.

In conclusion, this study demonstrates the potential of PMMA cement to stabilize loosened screws in mandibular angle fractures. Our findings suggest that PMMA augmentation offers a viable solution for increasing the retention strength of screws during fixation procedures. It also can stabilize a loosened screw during fixation of mandibular angle fractures, maintaining comparable biomechanical behavior to non-loosened screws without augmentation. Although there was no statistically significant difference between the experimental and control groups regarding displacement values, the application of PMMA provided enhanced fixation strength in cases of screw loosening, suggesting its potential utility in clinical settings where screw stability is compromised.

One of the key limitations of our study is the in vitro nature of the experiment. Sheep mandibles, while structurally similar to human mandibles, may not perfectly replicate the biomechanical properties of human bone, especially under clinical conditions. Moreover, the short-term nature of the mechanical testing did not allow us to evaluate long-term outcomes, such as screw loosening due to cyclic loading or potential bone resorption around the screws over time. Future studies should focus on long-term evaluation of PMMA augmentation in vivo, possibly incorporating finite element analysis to model stress distribution around augmented screws under dynamic loads.

Additionally, further research is required to optimize the quantity and viscosity of PMMA injected into the bone. While our study aimed for a toothpaste-like consistency of the PMMA cement, real-time monitoring of cement flow during screw placement—perhaps aided by imaging techniques like intraoperative computed tomography or 3D navigation—could significantly reduce the risk of cement leakage into soft tissues, nerves, or vascular structures. Furthermore, the exploration of novel screw designs, such as fenestrated screws, may provide even greater control over cement distribution and enhance fixation strength.

CONCLUSION

In conclusion, PMMA augmentation of loosened screws offers a promising solution for improving screw stability in the fixation of mandibular angle fractures. Although the technique requires careful attention to the quantity and handling of the cement to avoid complications such as leakage, it remains a valuable option in cases where screw retention strength is compromised. Future developments in cement application methods and screw design are likely to further enhance the efficacy and safety of this approach, providing oral and maxillofacial surgeons with an additional tool in the management of complex mandibular fractures.

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Research Article

The Impact of Clinical Rotation in Addiction Treatment Centers (AMATEM) on Attitudes and Behaviors of Psychiatry Residents Toward Individuals with Addiction

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Abstract

Aim: Psychiatry residents often feel unprepared and may exhibit negative attitudes toward individuals with substance use disorders, which can undermine treatment access and outcomes. This study examined the impact of a three-month Alcohol and Drug Treatment Center (AMATEM) rotation on residents' attitudes and explored factors influencing these attitudes.
Material and Method: Ninety-one psychiatry residents who applied for a three-month rotation training on addictions at Ankara Training and Research Hospital AMATEM Clinic completed a personal information form and the Attitudes and Behaviors Toward Substance Users Scale at the start and end of the rotation.
Results: Residents' stigmatizing attitudes significantly decreased post-rotation. Those who felt unsafe before the rotation reported higher stigma scores, and residents who believed they needed more education had fewer negative attitudes initially. Paradoxically, participants who anticipated referring patients to AMATEM due to insufficient training showed increased stigma after completion of the rotation.
Conclusion: Overall, structured, practical, and case-based training—delivered under experienced supervision—can reduce negative attitudes and help residents feel safer. Further research should clarify how specific training processes influence the knowledge, attitudes, and beliefs of future psychiatrists regarding substance use disorders.

Keywords: Addiction, psychiatry residents, addiction training, attitudes and stigma, healthcare education

INTRODUCTION

Attitudes and behaviors toward individuals with addictions have gone through various changes for centuries. Individuals with addiction were considered sinners or criminals in the 19th century. However, following scientific advancements and social reforms, the World Health Organization (WHO) first recognized them as patients in the early 1950s (1). In parallel with these developments, the American Psychiatric Association, through the DSM-III (Diagnostic and statistical manual of mental disorders), first acknowledged addiction as a disorder, moving away from the sociopathic personality emphasis present in previous editions of the DSM (2).

Despite these changes in the conceptualization of addiction over the years, the conflict between the moral addiction model and the medical chronic disease model persists to this day (3). According to the medical model, individuals seen as vulnerable and victimized by their illness should be protected and treated with the proactive involvement of professional healthcare workers (4,5). On the other hand, the moral model, which does not view addiction as a disease, holds individuals solely responsible for both their illness and its resolution (4). Resistance to shifting away from the moral model, which ignores the medical disease aspect of addiction, persists among a significant portion of society, including healthcare workers.

Addiction has consistently been regarded more negatively than other mental health conditions within society (6,7). People with substance addiction are often perceived as dangerous, lacking decision-making ability, and primarily responsible for their condition (7,8). Similar to this general societal perception, many studies have shown

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that healthcare workers feel insufficiently motivated when working with addicted patients, exhibit lower respect toward them, and frequently express dissatisfaction with working with such individuals (9-11).

The attitudes of healthcare professionals toward patients with substance use disorders (SUDs) have been explored across different disciplines and settings (12,13). A multicenter study found that healthcare personnel working in primary care settings exhibited more negative attitudes compared to those working in general psychiatry clinics and clinics specializing in addiction treatment (10). Another study demonstrated that anesthesiologists held more negative attitudes toward patients with substance use disorders than physicians who regularly dealt with such patients (14). Moreover, multiple studies have found that healthcare workers who directly work with individuals with substance addiction show more positive attitudes toward these patients (14-16).

Negative attitudes of healthcare workers toward individuals with substance use can adversely affect the delivery of healthcare services, leading to difficulties in accessing treatment and relapses (17,18). As stigma research shows, factors such as knowledge and experience can mitigate beliefs and attitudes associated with stigmatized conditions (19,20).

The impact of education and training on healthcare workers' attitudes toward patients with substance use disorders has been investigated in various studies. Generally, it has been determined that healthcare workers possess low levels of knowledge about substance use disorders and feel inadequate in providing care to this specific patient group (11,15,21). Numerous studies have demonstrated that education and training have positive effects on healthcare professionals' attitudes and motivation to work with patients with substance use disorders (14,22,23). In this context, various authors have emphasized the need to integrate addiction education into the general medical curriculum to address the lack of knowledge in the field (23,24).

According to a 2014 survey conducted by the World Health Organization, approximately 37% of 155 countries lacked adequate postgraduate training programs for treating substance use disorders, while over 80% of European countries now offer programs for psychiatry residents (25). In Türkiye, the necessity of including an education module on substance addiction and a rotation at Alcohol and Substance Addiction Treatment Centers (AMATEM) in the residency training curricula for adult and child psychiatrists was first mentioned in the 2015 Drug Combat Emergency Action Plan and Strategy Document (26). Child psychiatry residents undergo a one-month theoretical and practical training rotation in various AMATEM clinics in Türkiye, while adult psychiatry residents complete a three-month rotation.

This study aims to assess the attitudes of psychiatry residents toward individuals with addiction, the factors that may influence these attitudes, and the impact of completing an AMATEM rotation on related attitudes and behaviors.

MATERIAL AND METHOD

Study Sample

Before data collection, a power analysis was conducted, determining that the minimum sample size required was 64 participants. The power analysis was based on the following parameters: medium effect size (d=0.50), α=.05, 1-β=.80, and a two-tailed hypothesis. This analysis was performed using the G*Power software (version 3.1).

The study sample consisted of 91 psychiatry residents employed in various hospitals in Ankara province and attended a three-month addiction training rotation at the AMATEM clinic of Ankara Training and Research Hospital between 2023 and 2024. All participants provided informed consent to join the study.

Ethical Considerations

Before initiating the research, ethical approval was obtained from the Ankara Training and Research Hospital Scientific Research and Publication Ethics Committee (approval number E-23/1326, dated 12.10.2023). The study complied with the Declaration of Helsinki; all participants provided written informed consent.

Data Collection Instruments

1. ***Personal Information Form:*** The researchers developed this form to align with the study objectives. It collected sociodemographic data, such as age, gender, marital status, and length of residency. Additionally, it included 13 questions assessing participants' perceptions of their safety before the rotation, experiences of issues with patients suffering from alcohol/substance addiction, opinions on the effectiveness of AMATEM's addiction treatments, interest in addiction psychology, and views regarding the rotation.

2. ***Attitudes and Behaviors Toward Substance Users Scale:*** This scale, developed by Kaylı et al., consists of 27 items scored on a 5-point Likert scale (11). The response options range from "Strongly Agree" (1) to "Strongly Disagree" (5). Since the scale is unidimensional, the items are not divided into sub-dimensions. A higher total score indicates a more negative attitude toward individuals with substance use disorders. The items 7, 11, 12, 15, 19, and 20 are direct-coded and the other items are reverse-coded to calculate the total score. This scale was administered to residents at the beginning and end of their rotations.

Statistical Analysis

The data analysis involved descriptive statistics (frequencies and percentages), skewness and kurtosis statistics, paired sample t-tests, independent sample t-tests, one-way ANOVA, and simple linear correlation analysis. Analyses were conducted using SPSS software (version 25), with a significance level set at .05.

Skewness and kurtosis values were examined to assess the normality of the scale distributions in both measurements. Cronbach's alpha values were calculated to evaluate the reliability of the measurements. For the attitude scores (first measurement), the Skewness value is 0.34, the kurtosis value is 0.25, and Cronbach's α is .900. For the attitude scores (second measurement), the Skewness value is 0.18, the kurtosis value is -0.05, and Cronbach's α is .906. The skewness values for the attitude scale range from 0.18 to 0.34, while the kurtosis values range from -0.05 to 0.25. A skewness value within ±3.00 and a kurtosis value within ±10.00 indicate normal distribution (27). The reliability values (Cronbach's alpha) for the two measurements were .900 and .906, respectively. As reliability values above .70 are considered reasonable and values between .60 and .70 acceptable, the measurements demonstrated high internal consistency.

RESULTS

Descriptive Statistics

In line with the study's objective, data were collected from psychiatry residents twice: at the beginning of their AMATEM rotation and three months later at the end. A total of 91 residents voluntarily participated in the study. Descriptive statistics regarding the participants' sociodemographic variables are presented in Table 1.

An examination of Table 1 reveals that most participants were female. Regarding marital status, most residents were single and did not have children. Most worked in city hospitals, with the fewest participants from university hospitals. The mean age of the participants was approximately 29 years, and their average professional experience was 2.5 years.

Table 1. Frequencies and percentages of residents sociodemographic information

	Categorical variables		
Variables	**Levels**	**f**	**%**
Gender	**Female**	60	65.9
	Male	31	34.1
Marital Status	**Single/divorced/widowed**	57	62.6
	Married	34	37.4
Number of Children	**None**	81	89.0
	1	9	9.9
	2	1	1.1
Hospital Worked	**Training and Research Hospital**	24	26.4
	City Hospital	45	49.4
	University Hospital	22	24.2
Total		91	100.0
	Continuous variables		
	Min-Max	Mean	SD
Age	**25-35**	28.92	2.09
Length of residency	**1-4**	2.49	0.90

f: frequency, SD: standard deviation

After presenting the sociodemographic characteristics, descriptive statistics regarding various variables, particularly those related to addiction psychology and treatment, are shown in Table 2.

Table 2 shows that most residents reported having no prior issues with patients with alcohol or substance use disorder. Nearly all participants had colleagues who had completed an AMATEM rotation, but more than half found the information, which they got from their colleagues about the AMATEM system inadequate. Most participants expressed an interest in addiction psychology but did not have any patients or acquaintances who had undergone addiction treatment. Regarding the effectiveness of AMATEM, residents generally believed the clinics were moderately successful in treating alcohol use disorder but less effective for other types of substance use disorder. Approximately one-third of the participants felt insufficiently safe at the start of their rotation. Most participants had no specific plans when asked about managing a patient consultation during the rotation, while others indicated they would follow their standard examination routines. By the end of the rotation, most participants stated they would manage addiction cases themselves rather than refer them to AMATEM clinics.

Table 2. Frequencies and percentages of residents opinions on various variables before the AMATEM rotation			
Variables		**f**	**%**
Previous experience with alcohol/substance-dependent patients	**Yes**	35	38.5
	No	56	61.5
Having a colleague who previously did an AMATEM rotation	**Yes**	86	94.5
	No	5	5.5
Adequate knowledge of AMATEM working system	**Sufficient**	37	40.7
	Insufficient	54	59.3
Interest in addiction psychology	**Yes**	56	61.5
	No	35	38.5
Knowing someone who has experience with the treatment process	**Yes**	15	16.5
	No	76	83.5
Thoughts on the success rates of alcohol addiction treatment at AMATEM	**Low success**	5	38.5
	Medium success	45	49.5
	High success	11	12
Thoughts on the success rates of other addiction treatments (non-alcohol) at AMATEM	**Low success**	57	62.6
	Medium success	31	34.1
	High success	3	3.3
Feeling secure at the start of AMATEM rotation	**Do not feel secure**	34	37.4
	Feel secure	57	62.6
Thoughts on the effect of sports or spiritual counseling on addiction treatment	**Not effective alone**	66	72.5
	Effective in some patients	25	27.5
What type of treatment is most suitable and adequate for substance addiction?	**Only medication**	1	1.1
	Medication+psychotherapy	90	98.9
Perspective on the AMATEM rotation	**Should be completed as part of the curriculum**	26	28.6
	Need independent training	65	71.4
Plan for managing a dependent patient during an outpatient examination	**Routine examination duration**	36	39.6
	Longer than routine examination	6	6.6
	Shorter than routine examination	5	5.5
	No opinion	44	48.4
Thoughts on where the treatment for an addicted patient should take place after rotation	**Referral to AMATEM**	24	26.4
	Treat in my clinic	67	73.6
Total		91	100.0

Comparison of Attitude Scores Pre- and Post-Rotation

The attitudes of psychiatry residents toward substance users were assessed before and after the AMATEM rotation. The results are presented in Table 3.

As shown in Table 3, residents' attitude scores toward substance users differed significantly between the two measurements. Post-rotation scores were considerably lower than pre-rotation scores, indicating reduced negative attitudes after the rotation.

Table 3. Comparison of substance use attitude scores

	Measurement	N	Mean	SD	t	p	d
Attitude scores	Before rotation	91	80.51	13.65	4.31	.000	0.45
	After rotation	91	74.10	14.19			

N: number, SD: standard deviation

Analysis of Factors Influencing Attitude Scores

The differences in residents' attitude scores before and after the rotation based on various factors are presented in Tables 4 and 5.

Table 4 shows that pre-rotation attitude levels differed significantly based on the variable of perceived safety. Residents who reported feeling safe before the rotation had substantially lower (more positive) attitude scores than those who did not feel safe. This difference had a moderate practical effect. Additionally, pre-rotation attitude levels were significantly associated with residents' perceptions of the AMATEM rotation. However, post-rotation attitude scores did not vary considerably across variables, suggesting similar distributions after the rotation.

Table 5 highlights that pre-rotation attitude scores negatively correlate with residents' perceived safety levels before the rotation. A statistically significant relationship was also observed between pre- and post-rotation attitude scores and residents' perspectives on the AMATEM rotation, specifically regarding their training needs. After the rotation, a low-level but statistically significant negative correlation was found between residents' attitude scores and their plans for treatment management.

Table 4. Variations in pre-rotation attitude scores based on variables

Variables		N	Mean	SD	t/F	p	d
Alcohol treatment success	Low success	35	82.91	13.73	1.11	.334	–
	Medium success	45	78.40	12.89			
	High success	11	81.45	16.23			
Other substances treatment success	Low success	57	81.79	14.01	1.16	.247	–
	Medium success	34	78.35	12.94			
Interest in addiction psychology	Yes	56	80.05	13.79	0.40	.692	–
	No	35	81.23	13.58			
Perspective on AMATEM rotation	Part of the curriculum	26	85.50	11.23	2.26	.026	0.52
	Need for additional training	65	78.51	14.09			
Pre-rotation feel security	Not secure	34	86.12	14.62	3.18	.002	0.69
	Secure	57	77.16	11.96			
Having a relative with ASUD diagnosis	Yes	15	85.73	15.96	1.64	.105	–
	No	76	79.47	13.02			
History of conflict with a patient with ASUD	Yes	35	81.94	15.13	0.79	.430	–
	No	56	79.61	12.69			
Length of residency	2 years or less	47	79.51	11.00	0.72	.475	–
	2 years or more	44	81.57	16.07			
Post-rotation treatment	AMATEM	24	84.38	14.78	1.63	.106	–
	Self-treatment	67	79.12	13.06			
Gender	Female	60	82.83	14.52	2.32	.023	.51
	Male	31	76.00	10.59			

N: number, SD: standard deviation

Table 5. Correlation results

Questions	Attitude scores (Pre-rotation)	Attitude scores (After-rotation)
Alcohol treatment success	-.13	.01
Other substance addiction treatment success	-.12	-.01
Interest in addiction psychology	.07	.04
Perspective on AMATEM rotation	-.26*	-.21*
Pre-rotation security feeling	-.28*	-.09
Having a relative with an ASUD diagnosis	-.15	.14
History of conflict with a patient with ASUD	-.08	.07
Post-rotation treatment	-.14	-.23*
Gender	.26*	.19

*p<.05

Examination of Safety Perceptions

Given the identified negative correlation between pre-rotation attitude scores and perceived safety, as well as differences by gender, the relationship between perceived safety and various factors is presented in Table 6.

Table 6 shows that residents' perceived safety before the rotation varied significantly based on the quality of information received from colleagues and gender. Among those who received adequate information from colleagues, 81.1% felt safe, compared to only 50.0% of those who did not receive adequate information. Additionally, most participants who felt unsafe before the rotation were female, whereas most of those who felt safe were male. No significant differences in perceived safety based on other variables were found, as distributions were similar across groups.

Table 6. Comparison of residents security feelings based on various variables

Variables		Feel secure f (%)	Does not feel secure f (%)	χ^2	r_s
Post-rotation treatment	AMATEM	10 (41.7)	14 (58.3)	0.26 (p=.611)	.05 (p=.616)
	Self-treatment	24 (35.8)	43 (64.2)		
	Total	34 (100.0)	57 (100.0)		
Length of residency	2 years or less	14 (29.8)	33 (70.2)	2.38 (p=.123)	.16 (p=.125)
	2 years or more	20 (45.5)	24 (54.5)		
	Total	34 (100.0)	57 (100.0)		
Risky alcohol and drug use	Yes	15 (42.9)	20 (57.1)	0.73 (p=.392)	.09 (p=.397)
	No	19 (33.9)	37 (66.1)		
	Total	34 (100.0)	57 (100.0)		
Information from colleagues	Yes	32 (37.2)	54 (62.8)	0.02 (p=.900)	.01 (p=.902)
	No	2 (40.0)	3 (60.0)		
	Total	34 (100.0)	57 (100.0)		
Adequate information	Sufficient	7 (18.9)	30 (81.1)	9.06 (p=.003)	.32 (p=.002)
	Insufficient	27 (50.0)	27 (50.0)		
	Total	34 (100.0)	57 (100.0)		
Gender	Female	28 (46.7)	32 (53.3)	6.52 (p=.011)	.27 (p=.010)
	Male	6 (19.4)	25 (80.6)		
	Total	34 (100.0)	57 (100.0)		

r_s=Spearman correlation coefficient

DISCUSSION

Many studies have shown that doctors, medical students, and psychiatry residents often feel inadequate when working with patients diagnosed with substance use disorders (SUDs). They tend to be pessimistic about the benefits of evidence-based treatment and may avoid working with such patients altogether (28,29).

In our study, we found a negative correlation between psychiatry residents' pre-rotation attitudes toward individuals using substances and their sense of security. A qualitative study examining the negative attitudes of healthcare professionals toward patients with SUDs revealed that participants viewed these patients as prone to violence and highlighted the emotional challenges of working with them (30). Another study conducted among general practitioners demonstrated that patients with substance addictions were often perceived as unmotivated, manipulative, and aggressive (21). In our research, some residents with negative perceptions of individuals with addiction felt less secure before their rotations. However, after gaining experience working with patients during their rotations, their attitudes may have shifted in a more positive direction.

Approximately one-third of the residents in our study reported feeling insufficiently secure before their rotations. Variables such as the duration of their residency, gender, prior experiences with patients diagnosed with SUDs, or personal perceptions and attitudes toward such patients may have influenced their pre-rotation sense of security.

However, no relationship was found between residency duration, previous problems with patients with SUD, and the resident's sense of security. This could be explained by the fact that, in our country, physicians, regardless of their residency experience, are often exposed to direct interaction with individuals with substance use disorders for the first time during their rotations in AMATEM clinics. Additionally, residents who had experienced prior issues with patients who had SUD may have resolved those issues, which could have impacted their sense of security differently. A more likely explanation is that the majority of our sample, who had not reported previous problems with patients with SUD, might still perceive these patients as manipulative or violent —similar to findings in earlier studies— despite their lack of personal experience, leading to comparable high levels of negative attitudes.

Another notable finding of our study was that residents who received adequate information from colleagues who had previously completed rotations reported feeling more secure. Residents who gained comprehensive knowledge about the clinical training and treatment processes might have felt more prepared to face potential challenges, reducing their anxiety. Furthermore, hearing about the experiences of other residents may have normalized personal difficulties and made them feel less isolated in these challenges, thereby increasing their sense of security (29).

The literature on the relationship between gender and attitudes toward substance users has produced inconsistent results. While some studies indicate no significant differences in attitudes based on age or gender (31,32) others have found that women tend to evaluate substance use more negatively and exhibit less tolerant attitudes toward individuals with SUDs than men (11,33). In our study, female residents were found to have higher pre-rotation attitude scores and were more likely to report feeling insecure. Cultural expectations, power dynamics, and social norms in our country may have influenced these gender-based differences in risk perception, ultimately affecting their attitudes and sense of security toward individuals with addiction. However, the absence of these gender differences after the rotation suggests that training balanced residents' attitudes and sense of security.

Two systematic reviews highlighted that healthcare professionals, including psychiatry residents, generally have low levels of knowledge about substance use disorders and a clear need for further education. Additionally, healthcare professionals interested in working in the field of addiction often demonstrate less stigmatizing attitudes even before receiving formal training (34,35). In our study, most residents expressed a need for addiction education and showed more positive attitudes toward individuals with addiction, consistent with the literature. However, some residents may perceive addiction rotations as merely an obligatory duty and not feel the need for such training due to their negative attitudes toward individuals with SUDs. Notably, the reduction in negative attitudes after rotation training among this group highlights the potential of well-structured mandatory training programs to mitigate these attitudes.

Residents who believed their training would be insufficient and preferred to refer patients to AMATEM clinics after their rotations were found to have higher stigmatizing attitude scores post-rotation. A qualitative study involving 35 healthcare professionals revealed that most participants felt inadequate or unwilling to engage with patients diagnosed with SUDs, believing that these patients should only be treated by addiction specialists (11). Residents who doubted the adequacy of their training and preferred to transfer the care of addicted patients to specialized clinics might have psychologically distanced themselves from both the patients and the training content during the rotation, thereby reinforcing their preconceived notions. Additionally, negative experiences during the rotation, such as repeated treatment failures or inappropriate medication requests, may have further exacerbated these residents' negative attitudes.

The most significant finding of our study was the notable decrease in residents' post-rotation attitude scores compared to pre-rotation scores. Studies have shown that in-person or online education on addiction epidemiology, pathophysiology, and treatment can improve residents' knowledge and attitudes (36). For instance, an online training module for first-year psychiatry and internal

medicine residents demonstrated decreased stigmatizing attitudes after the program (37). Similarly, a study involving psychiatry residents who received motivational interviewing training found that participants developed more favorable attitudes toward the concept and treatment of addiction (38).

In addition to education, other factors might have contributed to developing more positive attitudes among residents in our study. Frequent interaction and increased contact with patients who are diagnosed with SUD correlate with more positive attitudes among healthcare professionals (14-16,23). In a study where senior psychiatry residents assumed a supervisory role for six months with patients experiencing both addiction and comorbid psychiatric disorders, residents reported gaining a better understanding of recovery experiences and developing shared human emotions with the patients (39). In our clinic, activities such as theoretical training sessions, morning rounds, and rehabilitation programs may have provided residents with opportunities to interact with individuals with addiction, fostering a more understanding and empathetic perspective.

Studies indicate that educational programs alone have limited influence on the attitudes and behaviors of healthcare professionals. The most critical factor for change is the nature of the work environment (9). In our study, the relatively positive attitudes and role modeling of addiction specialists and other healthcare professionals in our clinic may have influenced residents' attitudes. A comprehensive review of the determinants of practice change in addiction emphasized that training strategies are more effective when combined with contextual factors such as staff cohesion and communication (40).

To the best of our knowledge, this is the first study in Türkiye examining the impact of AMATEM rotation training on psychiatry residents' attitudes toward individuals with substance use disorders. However, our study has several limitations. First, while the sample size was adequate, the generalizability of our findings to the broader population of psychiatry residents is uncertain. During the design phase, confidentiality concerns led us to indirectly inquire about alcohol and substance use histories through questions about their relatives rather than directly questioning the residents. However, personal histories of alcohol or substance use may have influenced the residents' attitudes. Additionally, we did not assess the residents' religious beliefs or attitudes, which could morally influence their perspectives. Self-reported surveys are prone to social desirability bias, potentially affecting the reported attitude scores. Finally, it should be noted that residents might influence one another's perspectives and attitudes toward individuals with substance use disorders.

CONCLUSION

In conclusion, considering the increasing prevalence of psychoactive substance use among children and adolescents, we recommend reevaluating the current one-month limited rotation training on addiction offered in fields like child and adolescent psychiatry. Moreover, such education should not be confined to psychiatrists but should be integrated into all stages of medical education, albeit with varying durations. Viewing rotation training as merely a requirement and perceiving individuals with substance use disorders as unreliable may reinforce healthcare workers' negative attitudes towards this patient group and complicate treatment processes. Training programs should include practical applications and case studies that provide residents with opportunities to interact with individuals struggling with addiction under the guidance of experienced clinicians. This can help residents feel more confident and prepared. Furthermore, these programs should incorporate strategies to understand and mitigate the potential causes of stigmatizing attitudes. Further research is needed to better understand how factors related to training processes influence the attitudes, beliefs, and knowledge of resident physicians regarding addiction.

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Research Article

Knowledge Levels of Child Abuse and Neglect Among a Group of Turkish Dentistry Students

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Abstract

Aim: Dentists play an important role in identifying signs of child abuse and neglect and reporting them to the appropriate authorities. This study aims to evaluate the knowledge of a group of dental students in the Central Black Sea region about child abuse and neglect.
Material and Method: This cross-sectional study includes dental students from the Faculty of Dentistry at Tokat Gaziosmanpaşa University, enrolled during the 2023-2024 academic year. An online survey consisting of 28 questions was administered to dental students who agreed to participate, covering demographic information and assessing their knowledge level regarding child abuse and neglect. The data were analyzed using descriptive statistics and two-way ANOVA.
Results: A total of 266 (70.4%) students aged between 18 and 25 participated in this study. Among the dental students reported that 10.2% suspected child abuse and neglect, while 9.8% stated that they would prefer to report when they suspect such cases. While 58.6% of dental students believed that child abuse and neglect should be reported legally, 60.9% stated that they may not report suspected cases due to the possibility of making a misdiagnosis. While the impact of gender on dental students' knowledge levels regarding child abuse and neglect was not observed, the effect of academic year was significant ($p<.05$), with the lowest knowledge levels found among 1st grade students.
Conclusion: This study highlights the deficiencies in dental students' knowledge regarding the identifying of child abuse and neglect in dentistry, as well as their legal obligations. Therefore, it is recommended that all dental students receive education on child abuse and neglect.

Keywords: Child abuse, child neglect, student

INTRODUCTION

Child abuse and neglect are an important issue that needs to be considered comprehensively from medical, developmental, psycho-social and legal perspectives, which is based on complex causes and can have serious consequences (1). The World Health Organization (WHO) defines child abuse as 'all forms of physical and emotional ill-treatment, sexual abuse, neglect and exploitation that cause actual or potential harm to the health, development or dignity of the child (0-18 years)' (2). There are four main types of abuse: neglect, physical abuse, psychological abuse and sexual abuse. Abuse is defined as an act, whereas neglect is defined as an act of negligence that leads to potential or actual harm (2).

Child Protective Services (CPS) agencies in the United States report that 18 percent of the more than 2 million cases of suspected child abuse involve physical abuse, and that more than 1,500 child deaths per year are due to child abuse or neglect (3). In the United Kingdom, as of December 2023, 50780 children were on the child protection register, 49.3% of whom were reported to be child neglected (4). A study conducted in Saudi Arabia showed that 74.9% of all types of abuse involved psychological abuse, followed by physical abuse with 57.5%, neglect with 50.2% and sexual abuse with 14.0% (5). According to recent research on child abuse in Türkiye, a joint study conducted by UNICEF and the Ministry of Social Security found that 45% of children between the ages of 7 and 18 had experienced physical abuse, 50% had suffered emotional abuse, and 25% had been neglected (6).

The literature indicates that 50-77% of children subjected to physical abuse experience injuries in the oro-facial region and often seek medical attention due to dental trauma

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(7,8). In this context, dentists are in a unique position to help detect findings in the oro-facial region. In addition, since dentists see their patients and their parents at regular intervals, they have information about the general health status of the patient. These regular follow-up visits also allow them to detect any changes in behavior (9).

The studies conducted in the field of dentistry in Türkiye were analysed and Hazar Bodrumlu et al. (10) reveal that the roles and knowledge levels of dentistry faculty students in diagnosing suspected cases of child abuse are inadequate. In the study conducted by Özgür et al. (11) 70.3% of Turkish pediatric dentists reported being unaware of the legal sanctions for delaying or failing to report suspected cases. However, the role of dentists in child abuse and neglect is referred to as the "four 'R's of responsibility (recognize, record, report, and refer to protect)". In this context, they should recognize the risk factors and symptoms of child abuse, collect information, report suspicious cases to the judicial authorities and provide support to patients if necessary (12). In 2005, an amendment was made to Article 280 of the Turkish Penal Code, stipulating that healthcare professionals who fail to report or delay reporting signs of child abuse and neglect to the relevant authorities can be sentenced to up to one year in prison (13). Therefore, dentists should be well educated and equipped with skills to detect such possible suspicious cases.

This study aims to evaluate the knowledge of a group of dental students in the Central Black Sea region about child abuse and neglect. Accordingly, four research questions were formulated: a) What is the level of knowledge of dental students about child abuse and neglect?; b) What is the level of knowledge of dental students about the detection of child abuse and neglect in the clinic?; c) What is the level of knowledge of dental students about legal obligations regarding child abuse and neglect?; d) Which variables affect dental students' general knowledge about child abuse and neglect?

MATERIAL AND METHOD

Ethical Approval

The Clinical Research Ethics Committee of Tokat Gaziosmanpaşa University Faculty of Medicine approved this study (Approval No. 23-KAEK-152 and date 22.06.2023) before data collection. The study was conducted in accordance with the principles stated in the Declaration of Helsinki and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. A written informed consent form was obtained from all participants.

Sampling Framework and Sampling

The study population for this cross-sectional study consisted of 377 students at Tokat Gaziosmanpaşa University Faculty of Dentistry. The questionnaire was sent to all students, but 266 students voluntarily agreed to complete the questionnaire. The sample size for the study was 70.4% of the study population.

Participants

This study was conducted with the participation of volunteers from the 1st, 2nd, 3rd, 4th, and 5th-grade undergraduate students enrolled at the Faculty of Dentistry, Tokat Gaziosmanpaşa University, during the 2023-2024 academic year. The inclusion criteria for the study were being enrolled as a 1st, 2nd, 3rd, 4th, or 5th- grade student at the Faculty of Dentistry, Tokat Gaziosmanpaşa University, and completing the entire questionnaire.

Questionnaire and Measurements

The study questions consist of questionnaire questions taken from previously published studies on child abuse and neglect after a comprehensive literature review (11,14-16). Students who agreed to participate in the study were asked to answer an online questionnaire form (Google Form) consisting of 28 questions measuring demographic information and knowledge levels about child abuse and neglect.

The sections of the questionnaire are as follows:

a. The first six items include demographic information about the participants.
b. Items 7-14: These questions assess participants' general level of knowledge about child abuse and neglect.
c. Items 15-24: These questions assess participants' level of knowledge of the participants about the ability to detect child abuse and neglect in dentistry.
d. Items 25-27: These questions assess participants' level of knowledge of the participants about their legal obligations related to child abuse and neglect.
e. Item 28: This includes a multiple-choice question 'What/what could be your reasons for not reporting your suspicions of child abuse?'.

The questionnaire consists of 'yes', 'no', and 'I don't know' questions and multiple choice format question. While '1 point' was given for the correct answer, '0 point' was given for the wrong answer and don't know answer. Knowledge level scores were calculated based on the answers given to items 7-27 and participants can score minimum '0' and maximum '21'.

The reliability of the questionnaire was determined by Cronbach's α (α=0.821).

Statistical Analysis

Statistical evaluation was analysed using SPSS v26 (Chicago, IL, USA) software package. Descriptive statistics including frequency, percentage, mean and standard deviation were performed for all questions asked to evaluate the level of knowledge. A 2-way ANOVA was performed to analyse the effect of gender and students' academic years on the level of knowledge. A p-value of <.05 was considered statistically significant.

RESULTS

A total of 266 (70.4%) students aged between 18-25 years with an mean age of 21.92±1.93 years participated in the study. 63.9% of the students were female and 36.1% were male. While the lowest participation was obtained from 2nd grade students (14.7%), the highest participation was obtained from 3rd grade students (23.7%). Of the students who participated in our study, 6.4% received education on the identification and reporting of child abuse and neglect. 10.2% of the students reported that they suspected child abuse and 9.8% stated that they preferred to report in case of suspicion of child abuse and neglect (Table 1).

Table 1. Demographic data of the dental students

		Frequency (n)	Percentage (%)
Gender	**Female**	170	63.9
	Male	96	36.1
Academic year	**1st grade**	52	19.5
	2nd grade	39	14.7
	3rd grade	63	23.7
	4th grade	56	21.1
	5th grade	56	21.1
Have you ever suspected child abuse?	**Yes**	27	10.2
	No	239	89.8
Do you report suspected cases of child abuse and neglect?	**Yes**	240	90.2
	No	26	9.8
Have you ever received education on the identification and reporting of child abuse and neglect?	**Yes**	17	6.4
	No	249	93.6

Considering the multiple responses to the question 'What could be your reason/reasons for not reporting your suspicions of child abuse?', the highest response was the possibility of misdiagnosis with 60.9%. The second and third answers to this question were determined as being concerned about further harm to the child (39.1%) and not having information about the reporting protocol (38%), respectively. Fear of violence from parents/family (23.7%) followed these responses. The rate of participants who think that social services cannot be a solution to this situation is 18% (Table 2).

Table 2. Multiple responses to the question 'What/what could be your reasons for not reporting your suspicions of child abuse?

	Frequency (n)	Percentage (%)
Fear of violence from parents/family	63	23.7
The possibility of misdiagnosis	162	60.9
I didn't know I had a reporting obligation	30	11.3
I don't know about the reporting protocol	101	38.0
I may be concerned about further harm to the child	104	39.1
I do not want to be involved in legal proceedings	16	6.0
I am worried about damage to my professional life	25	9.4
I think that social services cannot be a solution to this situation	48	18.0
Total	549	206.4

61.7% of the participants stated that child abuse and neglect is an important cause of child deaths. The rate of participants who reported that abused children usually do not share the situation with someone else is 71.4%. 81.2% of the participants think that child abuse and neglect should be considered when there is a delay in the child receiving medical care after the trauma. 87.6% of the participants reported that the appearance of wounds with different healing periods on children's bodies may suggest child abuse and 89.5% of the participants reported that uncertainties in parents' expressions were important in confirming the suspicion. The rate of those who stated that the child was afraid of going home or approaching the parents as a sign of emotional and psychological abuse was 92.9%. 72.6% of the participants stated that children who were sexually abused hesitated to make eye contact and behaved more docile. The rate of those who think that child abuse is directly proportional to income level is 38% (Table 3).

Table 3. Evaluation of the general level of knowledge about child abuse and neglect

Questions	Correct response	Yes	No	I don't know
		n (%)	n (%)	n (%)
Child abuse and neglect is one of the most important causes of child deaths.	Yes	164 (61.7)	13 (4.9)	89 (33.5)
Children who have been abused usually tell someone about it.	No	24 (9.1)	190 (71.4)	52 (19.5)
If there is a delay in the child receiving medical care after the trauma, child abuse and neglect should be considered.	Yes	216 (81.2)	3 (1.1)	47 (17.7)
Frequent injuries of the child and the appearance of wounds with different healing periods on the body should suggest child abuse and neglect.	Yes	233 (87.6)	5 (1.9)	28 (10.5)
Uncertainty and time differences in parental expressions after the injury may be a sign of abuse.	Yes	238 (89.5)	1 (0.4)	27 (10.2)
Signs of emotional and psychological abuse may be that the child reports being afraid of going home or approaching the parents.	Yes	247 (92.9)	1 (0.4)	18 (6.8)
Children who have been sexually abused are reluctant to make eye contact and behave more submissive.	Yes	193 (72.6)	4 (1.5)	69 (25.9)
Child abuse is generally directly related to income level and is more common in low-income families.	No	101 (38.0)	63 (23.7)	102 (38.3)

80.8% of the participants think that dentists can detect child abuse and neglect in clinical practice. While 42.1% of the participants think that there is a strong linear relationship between dental neglect and physical neglect, 57.1% of the participants think that bite scars observed on the head and neck during dental examination/treatment are signs of abuse. While 61.3% of the participants stated that lacerations and haematomas on the inner lip surface observed in the clinical dental examination should suggest physical abuse, 51.1% of the participants stated that discolored or avulsed teeth due to repeated trauma could be a sign of child abuse. Bruises on the cheek could be the result of slapping or squeezing the face by 78.6% of the participants and an intercanine distance measured more than 3.0 cm is suspicious for an adult human bite by 39.8% of the participants. 69.5% of the participants thought that bruises, lichen or scars in the corner of the mouth could be a sign of oral plugging or forced sexual abuse. 47.4% of the participants stated that both oral and perioral gonorrhea infections may be indicators of sexual abuse in prepubertal children and unexplained injuries and petechiae on the palate may be evidence of sexual abuse (Table 4).

Table 4. Evaluation of the level of knowledge on the identification of child abuse and neglect in dentistry

Questions	Correct response	Yes	No	I don't know
		n (%)	n (%)	n (%)
Dentists can reveal child abuse and neglect during their clinical practice.	Yes	215 (80.8)	6 (2.3)	45 (16.9)
There is a strong linear relationship between dental neglect and physical neglect.	Yes	112 (42.1)	27 (10.2)	127 (47.7)
Bite scars observed on the head and neck during dental examination/ treatment are not a sign of abuse.	No	49 (18.4)	152 (57.1)	65 (24.4)
On examination, lacerations and haematomas on the inner lip surface should suggest physical abuse.	Yes	163 (61.3)	8 (3.0)	95 (35.7)
Discoloured or avulsed teeth as a result of repeated trauma may be considered as a sign of child abuse.	Yes	136 (51.1)	11 (4.1)	119 (44.7)
Bruises on the cheek are caused by slapping or squeezing the face.	Yes	209 (78.6)	5 (1.9)	52 (19.5)
An intercanine distance (linear distance between the central point of the cusps) measured more than 3.0 cm is suspicious for an adult human bite.	Yes	106 (39.8)	3 (1.1)	157 (59.0)
Unexplained injuries and petechiae on the palate, especially at the junction of the hard and soft palate, may be evidence of sexual abuse.	Yes	126 (47.4)	11 (4.1)	129 (48.5)
Oral and perioral gonorrhea infections may be a pathognomonic indicator of sexual abuse in prepubertal children.	Yes	126 (47.4)	2 (0.8)	138 (51.9)
Bruises, lichen or scars in the corner of the mouth may be a sign of oral plugging or forced sexual abuse.	Yes	185 (69.5)	5 (1.9)	76 (28.6)

The rate of participants who stated that dentists in Türkiye have a legal obligation to report child abuse and neglect is 58.6%. To the question 'Where should child abuse and neglect cases be reported?', the most common answer was 'I don't know' (34.6%) and 17.3% of the participants stated that it should be reported to the Ministry of Family, Labour and Social Services. Participants were asked about the sanctions that a dentist who fails or delays to report child abuse and neglect cases according to the Turkish Penal Code and 86.5% of them answered 'I don't know'. Only 0.8% of participants stated that a person who does not report a crime in progress is punished with up to 1 year in prison (Table 5).

Table 5. Evaluation of the level of knowledge about legal obligations related to child abuse and neglect

		Frequency (n)	Percentage (%)
Dentists in Türkiye are legally obliged to report which of the following?	Only child abuse	8	3
	Child abuse and neglect	156	58.6
	I don't know	102	38.4
Where should cases of child abuse and neglect be reported?	Someone more authorised at the institution where I work	44	16.50
	To the closest hospital	1	0.4
	Police station	65	24.40
	Social services and child protection institution	11	4.10
	Ministry of Family, Labour and Social Services	46	17.30
	Public Prosecutor's Office	7	2.60
	I don't know	92	34.60
According to the Turkish Penal Code, a dentist who fails or delays in reporting suspected cases of child abuse and neglect faces which of the following punishments?	There are no legal obligations	10	3.8
	He/She will be reprimanded	6	2.3
	Suspension from the occupation	1	0.4
	A person who does not report a crime in progress is punished with up to 1 year in prison	2	0.8
	A public official who does not report a crime in progress is punished with up to 1 year in prison from 6 months to 2 years	12	4.5
	Health personnel who do not report an offence committed shall be punished with up to 1 year in prison	5	1.9
	I don't know	230	86.5

The main effects and interactions of gender and academic year on the knowledge level of dental students about child abuse and neglect are shown in Table 6. It is observed that the main effect of academic year is statistically significant and its effect on knowledge level is 12.5% (p<.001). Gender and gender- academic year interaction had no statistically significant effect on the level of knowledge (p>.05).

Table 6. The effect of gender and academic year on dental students' level of knowledge about child abuse and neglect

Source	Type III Sum of Squares	df	Mean square	F	Sig.	Partial Eta Squared
Gender	27.924	1	27.924	2.038	.155	0.008
Academic year	501.516	4	125.379	9.152	**.000**	0.125
Gender *Academic year	25.577	4	6.394	0.467	.760	0.007
R Squared=.141 (Adjusted R Squared=.111)						

The knowledge levels of 2nd, 3rd, 4th and 5th grade students about child abuse and neglect were similar, but the knowledge levels of 1st grade students were significantly lower compared to other academic years (p<.001). The highest level of knowledge about child abuse and neglect was observed in the 4th grade (12.9±4.3) followed by the 3rd grade (12.7±3.1), while the lowest was found in the 1st grade (9±3.7) (Table 7).

Table 7. Descriptive data on the effect of gender and academic year on dental students' level of knowledge about child abuse and neglect

Academic year	Gender		Total
	Female	Male	
1st grade	9.3±3.6	8.6±3.9	9±3.7[a]
2nd grade	13.1±3.4	11.3±2.7	12.5±3.2[b]
3rd grade	12.7±3.2	12.6±3.1	12.7±3.1[b]
4th grade	12.8±4.6	13±3.8	12.9±4.3[b]
5th grade	12.3±3.5	11.4±4.8	12±3.9[b]
Total	12±3.9	11.5±4	11.8±3.9

a,b there is no differences between groups with the same letter (Bonferrroni correction)

DISCUSSION

Child abuse and neglect is a significant public health issue, both medically and socially, that violates children's human rights and can lead to serious morbidity and mortality (17). The WHO emphasizes that identifying children who have been subjected to abuse and neglect, protecting these children through a holistic approach and interdisciplinary collaboration, and ensuring appropriate treatment conditions are among the responsibilities of healthcare professionals (2). Dentists, who are among the healthcare professionals, are in an appropriate position to identify, prevent and report cases in the head and neck region, which they routinely evaluate in their professional lives (18). In this way, this is the first and most important step in identifying child abuse, helping abused children and preventing deaths due to child abuse. In order to perform these responsibilities, health professionals should have adequate knowledge about the symptoms, signs and risks of child abuse and neglect (19). In this context, our study evaluates the knowledge of a group of dental students in the Central Black Sea region about child abuse and neglect.

The first documented evidence that dentists do not report child abuse was reported by the American Dental Association in 1967. Accordingly, none of the 416 cases of abuse in New York State at that time were reported by dentists (20). When the studies on child abuse and neglect in Türkiye are analysed, Özgür et al. (11) reported that although 43.9% of the participants suspected physical abuse, only 12.7% of the suspected participants reported the suspected child abuse in a study conducted with paediatric dentists. In a study conducted by Kural et al. with dentists, it was reported that although 32.7% of the participants suspected physical abuse, only 1% of the suspected participants reported the suspected child abuse (16). Similar to our study, in another study conducted among dental students, it was observed that 20.3% of the participants suspected child abuse and 5% ignored it (10). According to the present study, although 10.2% of dental students suspected physical abuse, from a general perspective, only 9.8% of all students stated that they would report in case of suspicion. Although this issue is of critical importance, the majority of dentists from the past to the present still do not have the right attitude towards suspected cases of abuse. When the reasons were analysed, the possibility of misdiagnosis (60.9%), concern that the child may be harmed more (39.1%) and lack of adequate knowledge about the notification protocol (38%) were among the most important reasons in our study in accordance with Hazar Bodrumlu et al. (10). Particularly in our study, major deficiencies were observed about the reporting protocol. This situation emphasises the importance of the knowledge on child abuse and neglect that should be obtained by dental students (93.6%) who have not received education on the topic in our study.

In the present study, when the students' knowledge about child abuse and neglect is evaluated, it is observed that there is a lack of knowledge among the students. For example, only 23.7% of the students are aware that child abuse and neglect is not related to income level and that it can also occur among people with high income. While dentists have an important role in the diagnosis of child abuse findings, 60.1% of the students could not confirm the finding of physical abuse in the head and neck region of an adult human bite. Furthermore, 52.6% of the participants were not aware that petechiae and unexplained injuries on the palate could be evidence of sexual abuse, while 52.7% did not know that oral and perioral gonorrhea infections were a pathognomonic indicator of sexual abuse in prepubertal children. Similar findings were reported in studies evaluating the knowledge about child abuse in the field of dentistry in the world and in Türkiye, and it was observed that there was a lack of knowledge about the physical and social symptoms of child abuse among all participants (10,11,15,21-23). It is revealed that dentistry students have insufficient knowledge about child abuse

and do not feel ready for their role in protecting children (24,25).

Child abuse and neglect should be considered as a whole. This situation does not only consist of physical or sexual abuse. Emotional abuse and neglect should not be ignored. In addition, dental neglect, which is a subtype of neglect, is a type of abuse that dentists can easily detect due to their professional position (15). However, in our study, only 42.1% of the students reported that there may be a relationship between dental neglect and physical neglect. Although there are legal sanctions in many countries, the legal basis for dental neglect in our country is relative (26). Although dental neglect is a component of child abuse and neglect, the effect of dental caries on the child should be examined, dental records should be kept, parental awareness should be raised with information and the willingness of the child should be increased. In this case, dentists should first provide information and correct guidance rather than the legal process (27).

In our study, in addition to descriptive data on child abuse and neglect, the total level of knowledge on child abuse and neglect was compared according to gender and the academic years in which the students were present. While the mean knowledge score of 11.8±3.9 did not differ between genders, the lowest knowledge score was observed in 1st grade students and the highest in 4th grade, and this difference was significant. Hazar Bodrumlu et al. (10) reported that 5th grade students had more knowledge about child abuse when compared with the results of 3rd and 4th grade students and concluded that upper grades were more interested in the subject. Similarly, Jordan et al. (22) investigated students' educational experiences and knowledge about child abuse and reported that students in more experienced years had more knowledge. The fact that 1st grade students had the lowest level of knowledge in our study is similar to the studies mentioned above (10,22). The observed highest level of knowledge among 4th grade students may be attributed to the specific emphasis placed on this topic, particularly in the differential diagnosis of child abuse and dental trauma findings. While lectures on child abuse and neglect are incorporated into the 2nd, 3rd, and 4th grade curricula, the absence of such lectures in the 5th grade might lead to a decline in knowledge levels due to the lack of continuous knowledge reinforcement and updating.

This study has certain limitations. Firstly, this cross-sectional study was conducted among dental students in a single city. The findings of this study cannot be generalised to other groups because the sample was small and homogeneous. Second, other independent variables (e.g., participants' cognitive and psychological state, anxiety, stress, trust) that may affect participants' perceptions were not investigated in this study.

The current study investigated previously unexplored relationships between knowledge and awareness of child abuse and neglect and various variables among a group of dental students in Türkiye. Therefore, the findings also provide non-descriptive information. Further studies should examine the effects of different independent variables on dental students' knowledge and perceptions of child abuse and neglect in different societies and cultures.

CONCLUSION

This study identified the lack of knowledge about child abuse and neglect among a group of dental students in the Central Black Sea region. Most of the students were not ready to identify, take action and report to the relevant authorities when faced with suspicion of child abuse and neglect. Differences in the knowledge of the students depending on the academic year they were in were identified. In order to complete these differences and deficiencies, lectures on child abuse and neglect should be included as part of the undergraduate education of students before starting the clinic and theoretical and practical education should be carried out regularly with updates.

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Research Article

A Morphometric Examination of The Orbita Structure in Schizophrenia Patients: A Retrospective Study

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Abstract

Aim: To compare the orbita anthropometric measurement values of individuals diagnosed with schizophrenia with those of a healthy control group.
Material and Method: The study included 156 participants as 75 schizophrenia patients and 81 healthy control subjects, all with previous cranial computed tomography imaging. The orbita morphometric values were calculated of all the participants. Statistical comparisons were made between the groups of the mean values of the measurements. The Kolmogorov-Smirnov test was used to evaluate the conformity of continuous variables to normal distribution. Paired groups were compared with the Student's t-test.
Results: Statistically significantly higher left orbita height was determined in the schizophrenia patient group compared to the control group (p=0.001), and the values of the right orbita lateral wall length (p=0.042), left lateral wall length (p=0.033), and left medial wall length (p=0.014) were statisically significantly lower. Female schizophrenia patients were found to have significantly lower values of right orbita height (p=0.031), right orbita width (p=0.022), left orbita height (p=0.007), left orbita width (p=0.002), right orbita area (p<0.001), left orbita area (p=0.023), bimalar width (p<0.001), left optic nerve-sheath width (p=0.021), and skull transverse diameter (p<0.001) compared to males. There was determined to be a significant positive correlation between age and the right orbita width and the interorbital width measurements (p=0.011, r=0.203; p=0.015, r=0.194, respectively).
Conclusion: These findings can be considered useful in respect of better undertanding the orbita structure of schizophrenia patients.

Keywords: Schizophrenia, orbita, morphometry, multislice computed tomography

INTRODUCTION

Schizophrenia is a chronic mental health disease that generally starts at a young age and disrupts the functionality of the individual with clinical symptoms seen such as problems in thoughts and perception, cognitive disorders, unwillingness and lack of interest, and motor abnormalities (1). Although neurodevelopmental, environmental, and genetic factors are among the causes, the disease etiology remains unclear (2). The importance of the role of genetic factorsin the pathogenesis of schizophrenia has been shown in recent research (3). It has also been reported that environmental factors and some structural changes in the brain caused by genes starting from the intrauterine period can cause the emergence of psychotic symptoms in later periods (4,5). It has been hypothesised that individuals with mental health disease have common phenotypical characteristics of the brain and facial structure exposed to similar effects in the embryological process (6). According to the neurodevelopmental model, developmental changes in the early period are caused by neuron dysfunctions which can explain the signs and symptoms in the premorbid stage of individuals who later develop schizophrenia (7). Anatomic measurements of the facial diameters suggest that dysmorphology concentrated in the craniofacial region orginates from neurodevelopmental disorders in schizophrenia patients (8,9). Although physical abnormalities are of limited value in explaining the disease-specific pathophysiology, certain anomalies in the craniofacial morphology could be informative about schizophrenia (10). It has been said that changes such as low ears and epicanthal eye folds in schizophrenia patients are due to anomalies in the first trimester (11).

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The development of the bulbus oculi, which is an important space located adjacent to various regions including formations related to sight and the brain, starts in the third week of intrauterine life, as it also does in the brain and face with typical devlopment (12). As the eyeball and orbita structure are most likely related to fetal anthropometric growth (13), the anatomy of these structures may be important in terms of neurodevelopmental diseases because of fetal growth abnormalities. From a scan of the literature, it was seen that previous morphometric studies of schizophrenia patients have been conducted (14,15). For example, it has been reported from anthropometric analyses that there is a development disorder in the mid section of the skull in schizophrenia patients (16). However, no study could be found that has evaluated the orbita structure of these patients. Therefore, the aim of this study was to evaluate the anthropometric measurements of the orbita structure in schizophrenia patients through comparisons of the measurements made on multi-slice computed tomography with those of a healthy control group.

MATERIAL AND METHOD

This study was approved by the Non-Interventional Research Ethics Committee of Fırat University (Decision no: 21853, Date: 02.02.2024). The medical records of individuals who attended the Fethi Sekin City Hospital from January 2020 to January 2024 were reviewed using the hospital registration system. Previous treatment and comorbidities of the patients were analyzed according to the data in the patient record system. The study included patients who presented within the defined date range. A retrospective evaluation was made of the images archived in the hospital Picture Archiving and Communication System (PACS). All the computed tomography (CT) scans were performed using a 128-slice CT scanner (Ingenuity Core 128; Philips Medical Systems, Best, the Netherlands). Non-contrast axial and coronal images were obtained at slice thickness of 0.5mm. The medical history, anamnesis and other systemic diseases of the patients were examined in detail from the hospital record system by a mental health and diseases specialist. The healthy control group comprised demographically matched individuals who had undergone a routine annual check-up at the hospital and had no known systemic or mental illness.

Exclusion criteria for the study were defined as age <18 years, poor quality CT scans, pathology determined in the orbital structures, or the presence of orbita fracture, tumour, or foreign body in this region. A total of 22 subjects were excluded; 15 schizophrenia patients and 7 healthy individuals with incomplete data. Thus, a total of 156 participants were included in the study analyses; 75 schizophrenia patients and a control group of 81 healthy individuals.

Orbita height was measured on coronal slices as the longest vertical distance between the midpoints of the supraorbital and infraorbital edges (Figure 1A) (17).

Orbita width was measured on coronal slices as the longest horizontal distance between the medial and lateral edges of the orbita at the surface level of the frontozygomatic suture (Figure 1A) (17).

Orbita depth: first the level of the optic nerve continuously observed on axial slices was determined. A line was drawn joining the lateral and medial walls of the trajectory. With another line descending vertically from the previous line to the midpoint of the optic canal, the orbita depth was determined (Figure 1B) (18).

Orbita medial and lateral wall lengths were measured on axial slices at the level continuously followed by the optic nerve and where the fissura orbitalis was seen. The medial wall length was measured as the distance between the anterior corner of this wall and the anteromedial point of the optic canal. The lateral wall length was measured as the distance between the anterior corner of this wall and the anterolateral edge of the fissura orbitalis superior (Figures 1C, D) (19).

Orbital aperture area was calculated bilaterally by following certain anatomic points on the orbita edges on coronal slices using the software of the hospital imaging system. These anatomic landmarks were the foramen supraorbitale, anterior edge of the fossa lacrimalis, frontozygomatic suture, and infraorbital edges. The area of the covered bone line drawn was calculated automatically by the software (Figure 1E) (20).

Bimalar (interzygomatic) width was measured as the distance between the most prominent anterior points of the right and left zygomatic bones (Figure 1F) (21).

Biorbital width was measured as the distance between the most prominent lateral points of the right and left orbita (Figure 1G) (21).

Interorbital width was measured as the distance between the two dacryon points at the medial edges of the orbital apertures (Figure 1H) (21).

Optic nerve-sheath width was measured on the axial slice where the optic nerve was widest and width was measured from the place where the optic nerve and sheath seemed to be the thickest (Figure 1I) (22).

Skull transverse diameter measurement was the distance between the furthest points of the skull transverse diameter on the axial slice where the transverse diameter was greatest (Figure 1J) (23).

The measurements were taken twice by the same expert and the average was calculated.

Statistical Analysis

Statistical analyses of the study data were performed using SPSS vn. 22 software (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL, USA). Descriptive statistics were stated as mean±standard deviation (SD) values for continuous variables and as number (n) and percentage (%) for categorical variables. Pearson chi-square analysis was applied in the comparisons of categorical variables between groups. The Kolmogorov-Smirnov test was used to evaluate the conformity of continuous variables to normal distribution. Paired groups were compared with the Student's t-test. To examine the relationships between continuous variables, Pearson correlation analysis was applied. Statistical significance was accepted as $p<0.05$.

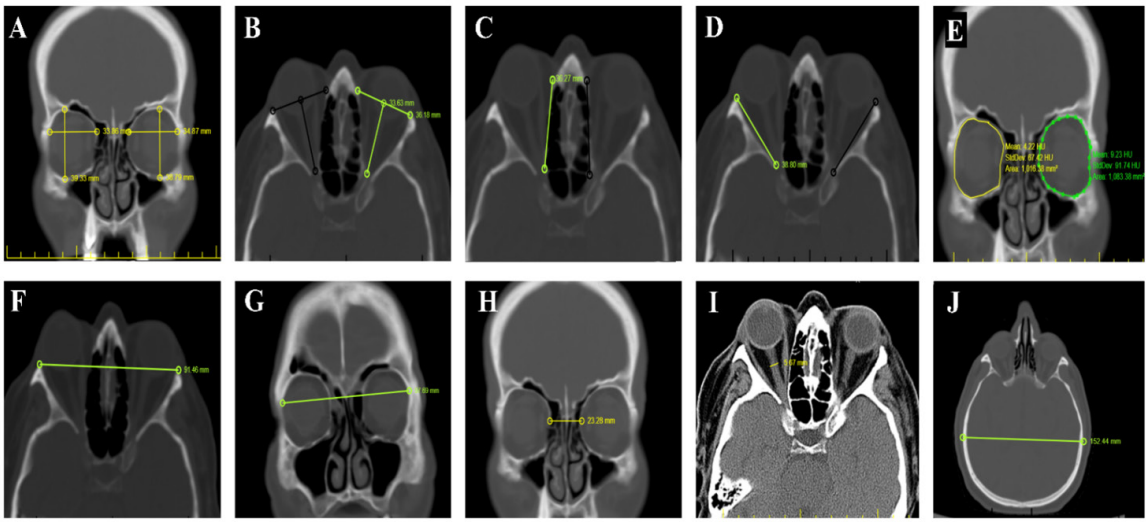

Figure 1. Morphometric evaluation of the orbita

RESULTS

Evaluation was made of a total of 156 participants, as 75 schizophrenia patients and 81 healthy control subjects. The patient group comprised males (65.3%) and females (34.7%) with a mean age of 53.7±16.4 years. The control group comprised males (63%) and females (37%) with a mean age of 53.1±16.4 years. There was no significant difference between the groups in terms of gender or age (p=0.758, p=0.810, respectively).

The height of the left orbita was determined to be statistically significantly higher in the schizophrenia patient group than in the control group (p=0.001), and the values of the right orbita lateral wall length (p=0.042), left orbita lateral wall length (p=0.033), and left orbita medial wall length (p=0.014) were significantly lower (Table 1).

Table 1. Comparisons of the demographic characteristics and tomographic measurements of the groups

		Patients (n=75)		Control (n=81)		p*
		n	%	n	%	
Gender	Female	26	34.7	30	37.0	0.758
	Male	49	65.3	51	63.0	
		Mean±SD		Mean±SD		p**
Age (years)		53.7±16.4 (19-70)		53.1±16.4 (21-68)		0.810
Right A		34.5±2.3		34.3±1.8		0.640
Right B		39.9±6.7		39.0±2.5		0.267
Right C		37.8±3.0		38.1±2.8		0.494
Left A		34.8±2.0		33.7±2.0		0.001
Left B		39.5±4.1		39.1±2.4		0.486
Left C		37.6±3.7		38.3±2.7		0.169
Right lateral		40.9±2.9		41.8±2.8		0.042
Right medial		41.4±3.8		42.5±3.9		0.066
Left lateral		40.4±3.2		41.5±3.0		0.033
Left medial		41.1±5.3		42.7±2.9		0.014
Right area		1086.7±99.3		1073.3±87.1		0.369
Left area		1073.5±135.1		1048.4±82.5		0.160
Bimalar		97.3±4.2		96.5±4.9		0.266
Biorbital		94.6±4.1		92.0±11.6		0.066
Interorbital		25.5±3.0		26.6±11.4		0.411
Right optic nerve		5.4±.7		5.3±.7		0.408
Left optic nerve		5.2±.8		5.3±.7		0.898
Tranverse diameter		140.3±8.7		139.0±6.5		0.289

*Chi-square analysis, **Student's t-test

In the female patients diagnosed with schizophrenia, the values of the right orbita height (p=0.031), right orbita width (p=0.022), left orbita height (p=0.007), left orbita width (p=0.002), right orbita area (p<0.001), left orbita area (p=0.023), bimalar width (p<0.001), left optic nerve-sheath width (p=0.021), and skull transverse diameter (p<0.001) were determined to be statistically significantly lower than those of male schizophrenia patients (Table 2).

A significant positive correlation was determined between age and the right orbita width and the interorbital width measurements (p=0.011, r=0.203; p=0.015, r=0.194, respectively) (Table 2).

Table 2. Relationships between the demographic characteristics and tomographic measurements

	Female (n=56)	Male (n=100)	p*	Age	
	Mean±SD	Mean±SD		r	p**
Right A	33.9±2.0	34.6±2.1	0.031	0.083	0.300
Right B	38.2±2.6	40.1±5.8	0.022	0.203	0.011
Right C	37.9±3.1	38.0±2.8	0.906	0.084	0.299
Left A	33.6±1.8	34.6±2.1	0.007	-0.025	0.757
Left B	38.2±1.9	39.9±3.8	0.002	0.027	0.735
Left C	37.4±3.3	38.3±3.2	0.090	0.054	0.502
Right lateral	41.1±2.8	41.5±2.9	0.381	0.038	0.638
Right medial	41.9±3.8	42.0±3.9	0.888	0.012	0.885
Left lateral	40.5±2.9	41.2±3.2	0.157	-0.009	0.914
Left medial	41.4±3.7	42.3±4.6	0.227	-0.014	0.859
Right area	1044.3±95.1	1099.6±86.2	<0.001	0.108	0.181
Left area	1033.5±76.4	1075.6±124.5	0.023	0.110	0.171
Bimalar	95.0±5.5	98.0±3.6	<0.001	0.055	0.492
Biorbital	91.5±9.8	94.3±8.2	0.056	-0.052	0.522
Interorbital	26.0±9.6	26.1±7.8	0.913	0.194	0.015
Right optic nerve	5.3±.6	5.5±.7	0.105	0.133	0.098
Left optic nerve	5.1±.7	5.4±.7	0.021	0.082	0.310
Tranverse diameter	136.2±6.7	141.5±7.5	<0.001	0.005	0.952

* Student's t-test, ** Pearson correlation analysis

DISCUSSION

Anthropometric measurements performed appropriate to certain standards provide a great amount of data about the human body anatomy. These measurements are taken in the framework of certain protocols and measurement techniques which are generally accepted worldwide. In addition to measurements taken with manual calipers, they can now be taken with imaging methods due to developments in technology. In this study, which aimed to compare the anthropometric measurements of the orbital structure in schizophrenia patients with measurements made on multi-slice CT and in the healthy control group, showed that the left and right orbital lateral edges and the left orbital medial wall were shorter in schizophrenia patients. The orbita structures of female schizophrenia patients were seen to be smaller than those of the male schizophrenia patients. It can also be said that the orbita measurements of schizophrenia patients show variability with age.

In terms of neurodevelopmental diseases, it has been reported that there are various physical malformations in patients with schizophrenia, especially in the craniofacial region (24). During the intrauterine period, the craniofacial region and the ventral section of the brain develop at similar times, so a disruption in the stage of formation of one renders the other structure prone to malformation (25,26). The anatomic or embryonic interaction between the face and the brain can also affect brain functions (27). The first psychotic attack of schizophrenia patients usually occurs in late adolescence or early adulthood, and when the preceding period has been examined, there have been observed to be small physical cranio-cerebral (ears, palate, head circumference), some oral anomalies (teeth measurements), temporomandibular, and palatal abnormalities (28). It has been reported that these patients have an increased frequency of abnormal head circumference, hypertelorism, conjoined earlobes, thick palate, epicanthus and finger anomalies (24). Orbita morphometry can be used for the early determination of some diseases (29). Technological methods have also been used recently to provide reliable reference values for clinicians and to facilitate the identification of normal and abnormal orbita anatomy (30). In a previous study of healthy individuals in Türkiye, the orbita height width and depth mean values were calculated to be 36.04±2.97 mm,

32.33±2.59 mm, and 38.35±3.32 mm, respectively on the right side and 35.79±3.18 mm, 32.29±2.67 mm, and 38.13±3.21 mm, respectively, on the left side (31).

A study in Iran examined orbita morphometry using 3-dimensional CT (3DCT) and the measurements were reported for the right and left sides as mean orbital height of 3.75±0.20 cm and 3.74±0.21 cm respectively, orbital width of 3.44 cm±0.17 cm and 3.46 cm±0.17 cm, and interorbital-biorbital width of 2.26 cm±0.26 cm and 9.55±0.41 cm. Orbital volume on both the left and right sides was found to be significantly greater in males compared to females, and a significant correlation was determined between age and the right and left orbital volume (32). The anthropometric examinations of the orbita of the current study schizophrenia patients were performed using multi-slice CT. It was observed that the right and left orbita lateral edges and the medial wall of the left orbita were shorter in the patients than in the healthy control subjects. These findings are promising in respect of being able to identify groups at risk of schizophrenia with imaging methods of the orbita morphometry, especially the left side, before disease symptoms emerge, and to therefore be able to make the early interventions required by these groups. From a scan of the literature, this study can be considered the first to have evaluated orbita morphometry in schizophrenia, which is important for early diagnosis and treatment.

The current study results revealed a difference in orbita structures between the genders, with the orbita anthropometric measurement values of females observed to be smaller than those of males. In addition, it was seen that the orbita measurements of schizophrenia patients showed variability with age. It has been previously reported that morphometric measurements can show differences due to age and gender (33,34). Erdem et al. reported that with the exception of vertical diameter, all the orbita measurement values were significantly greater in males than in females (30). In diseases such as Graves disease, there are also known to be changes in orbita lipid volume together with ageing (35). Although similar to the age of the control group, the higher mean age of the current study patients could have affected the orbita measurement values. Therefore, as the results could affect the evaluation of orbita anthropometry, there is a need for further studies of younger schizophrenia patients.

Limitations of this study can be said to be the single-centre, retrospective, cross-sectional design, the relatively small sample size, and that the severity of disease symptoms was not known.

CONCLUSION

In conclusion, as in all diseases, early diagnosis and treatment of mental health diseases is important in respect of morbidity and mortality. Based on the findings of the current study, the aim of which was to detect the disease in the prodromal period, the determination of reference measurement values of the orbita using advanced technology methods in a larger sample group could facilitate the early detection of mental health diseases by clinicians. Therefore, the findings of this study can be considered of guidance for further studies to be conducted in this field.

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MEDICAL RECORDS-International Medical Journal

Research Article

A Comparative Study on the Question-Answering Proficiency of Artificial Intelligence Models in Bladder-Related Conditions: An Evaluation of Gemini and ChatGPT 4.o

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Abstract

Aim: The rapid evolution of artificial intelligence (AI) has revolutionized medicine, with tools like ChatGPT and Google Gemini enhancing clinical decision-making. ChatGPT's advancements, particularly with GPT-4, show promise in diagnostics and education. However, variability in accuracy and limitations in complex scenarios emphasize the need for further evaluation of these models in medical applications. This study aimed to assess the accuracy and agreement between ChatGPT 4.o and Gemini AI in identifying bladder-related conditions, including neurogenic bladder, vesicoureteral reflux (VUR), and posterior urethral valve (PUV).
Material and Method: This study, conducted in October 2024, compared ChatGPT 4.o and Gemini AI's accuracy on 51 questions about neurogenic bladder, VUR, and PUV. Questions, randomly selected from pediatric surgery and urology materials, were evaluated using accuracy metrics and statistical analysis, highlighting AI models' performance and agreement.
Results: ChatGPT 4.o and Gemini AI demonstrated similar accuracy across neurogenic bladder, VUR, and PUV questions, with true response rates of 66.7% and 68.6%, respectively, and no statistically significant differences ($p>0.05$). Combined accuracy across all topics was 67.6%. Strong inter-rater reliability ($\kappa=0.87$) highlights their agreement.
Conclusion: This study highlights the comparable accuracy of ChatGPT-4.o and Gemini AI across key bladder-related conditions, with no significant differences in performance.

Keywords: ChatGPT, Gemini, articifial intelligence, bladder

INTRODUCTION

The rapid evolution of artificial intelligence (AI) has significantly reshaped multiple disciplines, including medicine and healthcare (1-5). Among the most prominent advancements in AI are large language models (LLMs) like ChatGPT 4.o and Google Gemini (2-4). ChatGPT, developed by OpenAI, employs state-of-the-art natural language processing to generate human-like responses (2-4). Initially launched with GPT-3.5 in November 2022 and succeeded by GPT-4 in March 2023, ChatGPT has demonstrated considerable promise in various fields, including medical diagnostics and education. Similarly, Google Gemini, a competitor, integrates advanced neural networks to interpret and respond to complex medical inquiries. These advancements position both platforms as potential tools for supporting clinical decision-making (5,6).

Prior studies have explored ChatGPT's accuracy in standardized medical exams, revealing its potential to complement traditional methods. For example, GPT-4 has outperformed its predecessor GPT-3.5 in answering medical licensing questions, emphasizing its growing accuracy and reliability (7).

Despite the advancements, concerns persist regarding the reliability and consistency of these tools (8,9). Studies comparing ChatGPT, Gemini, and other AI models in specific medical contexts highlight variability in diagnostic accuracy and comprehensiveness. ChatGPT has been noted for its higher accuracy in certain scenarios but has also demonstrated limitations in nuanced or ambiguous

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cases. Similarly, Gemini, while robust in specific areas, occasionally falters in providing context-sensitive responses, necessitating further evaluation (1).

This study aimed to assess the accuracy and agreement between ChatGPT 4.o and Gemini AI in identifying bladder-related conditions, including neurogenic bladder, vesicoureteral reflux (VUR), and posterior urethral valve (PUV).

MATERIAL AND METHOD

This study was conducted in October 2024. Since it involved an AI-based analysis, ethical approval was not required. The study focused on three primary bladder-related topics: VUR, PUV, and neurogenic bladder. A total of 51 questions were prepared, with 17 questions from each topic to ensure balanced representation across all areas. The questions were randomly selected from pediatric surgery and pediatric urology board examination study materials to reflect clinically relevant scenarios.

The prepared questions were simultaneously presented to both Gemini AI and ChatGPT 4.o models. Each model's responses were independently recorded and evaluated against a pre-determined answer key. The number of correct and incorrect answers provided by each model was calculated separately for each topic to assess their accuracy.

A text was prepared to train both artificial intelligence models in the question-and-answer format. This text was taught to both AI models and was as follows. "I am conducting a study to assess the diagnostic accuracy and agreement between ChatGPT and Gemini AI in identifying bladder-related conditions, including neurogenic bladder, VUR, and PUV. For this purpose, I will ask each of you a total of 51 questions, with 17 questions per topic. The questions will be the same for both models and are selected from the European board examination study materials in pediatric surgery and pediatric urology. Please answer these questions to the best of your ability. At the end, your correct and incorrect answers will be compared to the official answer key. And then, the results will be compared for a study." The responses provided by the models are presented in Figures 1 and 2. The questions asked to the AI were multiple choice questions (5 options) in a test format.

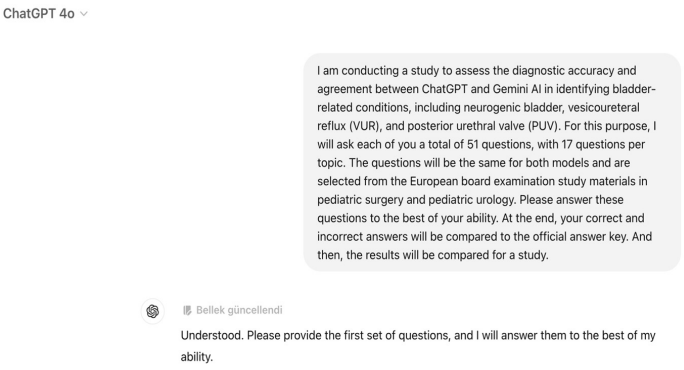

Figure 1. Instructions for AI model evaluation (for ChatGPT 4.o)

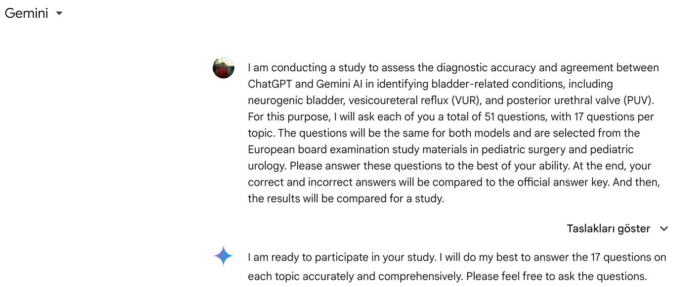

Figure 2. Instructions for AI model evaluation (for Gemini AI)

Statistical Analysis

For statistical analysis, the number of true and false responses for both AI models was compared for each topic using accuracy metrics and Cohen's Kappa to evaluate inter-model agreement. The categorical variables were compared with chi-square test. Univariate logistic regression analysis was performed to examine the factors associated with correct responses, using neurogenic bladder as the reference topic and ChatGPT 4.o as the reference AI model. Odds ratios (OR) and p-values were calculated to assess the statistical significance of the differences between the models and topics. Data visualization was achieved through a Sankey diagram to demonstrate the flow and distribution of correct and incorrect responses across topics and models. All statistical analyses were conducted using Jamovi software 2.4, with a significance threshold set at $p<0.05$.

RESULTS

For neurogenic bladder, ChatGPT 4.o correctly answered 11 questions (64.7%), while Gemini AI correctly answered 13 questions (76.5%), resulting in a combined true response rate of 70.6% (n=24). The false response rates were 35.3% for ChatGPT 4.o and 23.5% for Gemini AI, with a total false response rate of 29.4% (n=10). The difference in performance between the two AI models on neurogenic bladder-related questions was not statistically significant (p=0.452). Regarding VUR, ChatGPT 4.o and Gemini AI achieved true response rates of 64.7% (n=11) and 58.8% (n=10), respectively, with a total true response rate of 61.8% (n=21). The false response rates were 35.3% and 41.2% for ChatGPT 4.o and Gemini AI, respectively, contributing to a combined false response rate of 38.2% (n=13). The statistical comparison indicated no significant difference between the models on VUR-related questions (p=0.724). For PUV, both ChatGPT 4.o and Gemini AI performed identically, each with a true response rate of 70.6% (n=12) and a false response rate of 29.4% (n=5). The total response rates were identical across the models on PUV-related questions (p=1.000). Across all conditions, the combined true response rate was 66.7% for ChatGPT 4.o and 68.6% for Gemini AI, with a total true response rate of 67.6% (n=69). The combined false response rates were 33.3% for ChatGPT 4.o and 31.4% for Gemini AI, with a total false response rate of 32.4% (n=33). The overall performance comparison between the AI models showed no statistically significant difference (p=0.832) (Table 1).

Table 1. Accuracy between ChatGPT 4.o and Gemini AI

		ChatGPT 4.o	Gemini AI	Total	P-value
Neurogenic bladder	**True**	11 (64.7%)	13 (76.5%)	24 (70.6%)	0.452
	False	6 (35.3%)	4 (23.5%)	10 (29.4%)	
Vesicoureteral reflux	**True**	11 (64.7%)	10 (58.8%)	21 (61.8%)	0.724
	False	6 (35.3%)	7 (41.2%)	13 (38.2%)	
Posterior urethral valve	**True**	12 (70.6%)	12 (70.6%)	24 (70.6%)	1.000
	False	5 (29.4%)	5 (29.4%)	10 (29.4%)	
Total	**True**	34 (66.7%)	35 (68.6%)	69 (67.6%)	0.832
	False	17 (33.3%)	16 (31.4%)	33 (32.4%)	

A univariate logistic regression analysis was conducted to evaluate the factors associated with correct responses provided by the AI models. The analysis considered the topics (neurogenic bladder, VUR, and PUV) and the AI model used (ChatGPT 4.o vs. Gemini AI). For the topic, using neurogenic bladder as the reference category, the OR for VUR was 0.673 (p=0.443), indicating no statistically significant difference in the likelihood of correct responses between neurogenic bladder and VUR. Similarly, the OR for PUV was 1.000 (p=1.000), showing no difference in the probability of correct responses between neurogenic bladder and PUV. When comparing the AI models, using ChatGPT 4.o as the reference, the OR for Gemini AI was 1.09 (p=0.832) (Table 2).

Table 2. Univariate logistic regression analysis of AI model performance

	Univariate analysis	
	OR	**p-value**
Topic (ref: neurogenic bladder)		
VUR	0.673	0.443
PUV	1.000	1.000
AI-model (ref: ChatGPT 4.o)	1.09	0.832

The Cohen's kappa value for inter-rater reliability between ChatGPT 4.o and Gemini AI is 0.87, indicating a strong level of agreement (κ=0.87). The Sankey diagram demonstrates how each AI model's predictions distribute across topics and their respective accuracies (Figure 3).

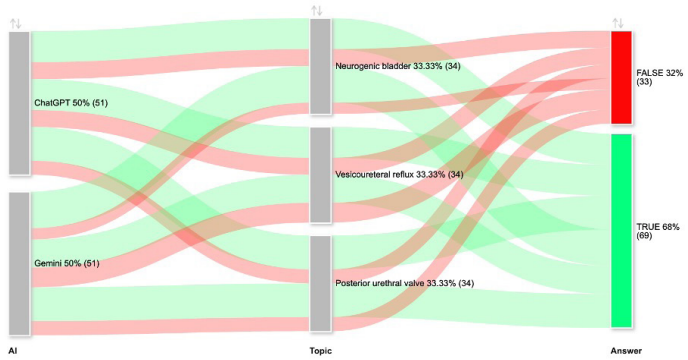

Figure 3. Sankey diagram

DISCUSSION

In our study, ChatGPT 4.o and Gemini AI showed comparable accuracy across neurogenic bladder, VUR, and PUV, with total true response rates of 66.7% and 68.6%, respectively, and no significant performance differences (p>0.05). Logistic regression confirmed no significant variability between topics or models. Strong inter-rater agreement (κ=0.87) highlights their potential as reliable tools.

The widespread adoption of artificial intelligence has significantly increased its use in various fields, including medicine (1-5,10). Numerous studies have been conducted in disciplines such as orthopedics, dermatology, and neurology to evaluate the accuracy of AI models in answering exam questions (11-14). While these studies have shown promising results, many also highlight the frequent occurrence of incorrect answers alongside correct ones. Furthermore, it has been emphasized that models like ChatGPT can occasionally produce misleading or incorrect responses, referred to as "hallucinations," underscoring the importance of being aware of such inaccuracies (15,16).

In this study, a total of 51 questions related to three key bladder conditions—neurogenic bladder, VUR, and PUV—were posed to both ChatGPT 4.o and Gemini AI, and their responses were compared. To minimize potential confounding factors, all questions were designed as multiple-choice. These questions were randomly selected from the European Board Examination study materials in pediatric surgery and pediatric urology. To the best of our knowledge, this is the first study to compare ChatGPT 4.o and Gemini AI models specifically for bladder-related conditions.

In a study on orthopedic and trauma surgery, the American and British equivalents of the French DES exam, the OITE (ABOS) and FRCS-Trauma and Orthopaedics, were tested. ChatGPT-4 generally performed well, approaching but not surpassing the residents' average scores (10). In another study, in the field of General Orthopedics, Ulus et al. reported GPT-4 achieving a higher success rate (75%) compared to GPT-3.5 (45%) (p=0.053) (17). In the

Traumatology domain, GPT-4 showed a notable success rate of 80%, significantly outperforming GPT-3.5 (p=0.010). Greif et al. found ChatGPT correctly identified the top diagnosis for 12 of 32 cases (37.5%), compared to 5 of 10 cases (50%) in their study (18). ChatGPT-3.5 included the correct diagnosis in 81% of cases, while ChatGPT-4 achieved 80%. These findings indicate ChatGPT-4 consistently outperforms its predecessor, GPT-3.5, as also demonstrated in the study by Azizoğlu et al (19). Furthermore, Demir et al. found ChatGPT 4.o provided more detailed and accurate answers to patient questions about keratoconus than Google Gemini and Microsoft Copilot, with 92% of responses rated as "agree" or "strongly agree" (1). Ronbinson et al highlight the potential of AI chatbots in addressing common urologic queries, particularly for benign prostatic hyperplasia (BPH) (20). Chatbot-generated responses demonstrated comparable accuracy, greater completeness, and higher perceived empathy compared to urologists' responses. However, patient trust and perception of AI remain challenges. They concluded that future studies should explore AI integration in broader urologic domains, address ethical concerns, and focus on improving patient confidence in AI-driven healthcare communications. In a meta-analysis of 193 studies, Zong et al. concluded that MedExamLLM is an open-source, freely accessible platform offering comprehensive performance evaluations and evidence on LLM capabilities in medical exams globally (21). It serves as a vital resource for educators, researchers, and developers in clinical medicine and AI. Despite its value, limitations include potential data source biases and exclusion of non-English studies, warranting future research to enhance LLM performance across diverse contexts. In our current study, we evaluated responses to bladder-related questions using ChatGPT 4.o and Gemini AI, assessing the accuracy and agreement of both AI tools. Our study found that ChatGPT 4.o and Gemini AI demonstrated comparable accuracy across conditions, with no significant performance differences, highlighting strong reliability.

Despite its strengths, this study has several limitations. First, the sample size of 51 questions may not comprehensively represent the complexity of bladder-related conditions. Additionally, the study relied on pre-determined answer keys, which may not account for nuanced clinical variations. Furthermore, the AI models were assessed using text-based questions, excluding imaging or laboratory data integration, which are critical in real-world diagnostics. The absence of clinical context in the questions may limit the applicability of findings to actual medical scenarios. Lastly, the models' outputs were evaluated in isolation, without considering collaborative human-AI interactions, potentially overlooking their full diagnostic potential.

CONCLUSION

In conclusion, this study highlights the comparable accuracy of ChatGPT 4.o and Gemini AI across key bladder-related conditions, with no significant differences in performance. These findings suggest the potential utility of AI tools in bladder-related conditions, emphasizing their reliability. However, further research is required to address limitations such as sample diversity and real-world applicability, ensuring these technologies can effectively complement clinical decision-making.

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MEDICAL RECORDS-International Medical Journal

Research Article

Morphological and Morphometric Examination of the Proximal and Distal Ends of the Radius

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Abstract

Aim: The radius, located on the lateral forearm, plays a key role in pronation and supination. Its proximal and distal ends contribute to the stability and motion of the elbow and wrist joints, making them susceptible to trauma, with fractures common, especially in the geriatric population. Understanding the morphological and morphometric features of these ends is crucial for surgical interventions, such as screwing techniques for complex fractures. This study aims to examine the morphological and morphometric characteristics of the proximal and distal ends of the human radius and provide clinically relevant data.
Material and Method: 70 radii (34 right and 36 left) from the collections of Necmettin Erbakan University and Acıbadem Mehmet Ali Aydınlar University were analyzed. Measurements were taken using digital calipers, an osteometric board, a tape measure, and the Image J program. Morphological classifications of the articular fovea and radial tuberosity were recorded. Morphometric analysis of the proximal and distal extremities was conducted, and data, analyzed using SPSS 21, were found to be normally distributed. Right-left comparisons were made using paired Student's t-tests, type differences with one-way ANOVA, and relationships with correlation tests.
Results: Among all radii, 97.1% of articular foveae were elliptical, while 54.3% of radial tuberosities were single roughened (Type b). No significant differences were found in the morphology of the articular fovea or radial tuberosity between the right and left sides ($p>0.05$). The medial thickness of the radial head (RH-mt) and the anterior lenght of the ulnar notch (UN-al) were significantly larger on the right side ($p<0.05$). Larger circumferences, diameters, and inclination angles were observed in double roughened (Type c) radial tuberosities ($p<0.05$). This was observed for the medial and lateral sides, as well as for the neck and head regions.
Conclusion: The data obtained from our study might be useful as a reference in post-traumatic reconstruction, prosthesis design and orthopaedic surgical procedures in adults.

Keywords: Radius, radial tuberosity, the articular fovea of the radius, inclination angle

INTRODUCTION

The radius is a long bone situated laterally to the forearm and plays a critical role in the rotation around the ulna during pronation and supination movements of the forearm. The proximal and distal ends of the radius join the elbow and wrist joints, thereby providing movement and stability to these joints (1,2). A disruption to any of the components of these joints can result in a considerable reduction in the range of supination-pronation movement, thus resulting in a notable impairment of limb functionality (3). The proximal and distal ends of the radius are particularly susceptible to trauma and fractures, with injuries occurring in these regions often resulting in significant functional losses and requiring surgical intervention (4).

Approximately 20% of all fractures are distal radius fractures, which are particularly common in active children and elderly individuals with osteoporosis (4,5). These fractures typically impact the kinematics of the wrist, potentially leading to limitations in wrist movement and chronic pain (6). Approximately 70% of forearm fractures are proximal radius fractures, which typically result from a fall or direct trauma (7). These fractures can result in instability and limitation of movement in the elbow joint (8). Therefore, a comprehensive examination of the anatomical and morphometric characteristics of the radius bone is crucial for the management of such fractures and surgical procedures.

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A detailed examination of the proximal and distal ends of the radius is essential for the successful reconstruction and prosthesis design procedures that must be performed following iatrogenic injuries and trauma. Determining accurate morphometric parameters of the proximal and distal ends of the radius as well as its morphological appearance was the aim of our investigation.

MATERIAL AND METHOD

The study was conducted on 70 radii (34 right and 36 left) from an unknown sex in the bone collection of Necmettin Erbakan University and Acıbadem Mehmet Ali Aydınlar University, Faculty of Medicine Anatomy Laboratories. The Acıbadem University Medical Research Ethics Committee has reviewed and approved the research project numbered ATADEK/2024-18/696, focusing on the morphological and morphometric analysis of the radius bone, ensuring its compliance with ethical, scientific, and legal standards. In the present study, two groups were subjected to comprehensive morphological and morphometric assessments. In the morphological evaluations of the articular fovea of the radius, the classification proposed by Captier et al. was revised and used (9). Accordingly, Type 1 was classified as round, Type 2 as elliptical, and Type 3 as irregular (Figure 1). The radial tuberosity was evaluated using the classification described by Mazzocca et al. (10) as Type a: smooth, Type b: single roughened, and Type c: double roughened (10) (Figure 2).

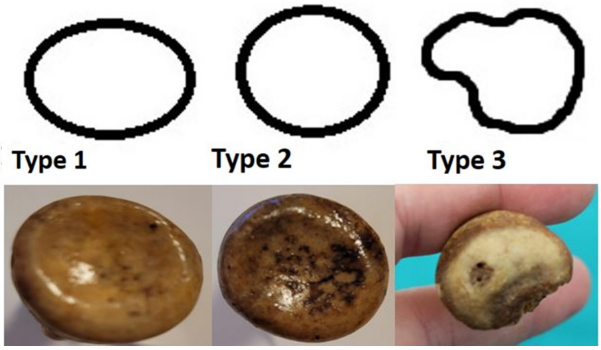

Figure 1. Morphological classification of the articular fovea of the radius (Type 1: Round, Type 2: Elliptical, Type 3: Irregular)

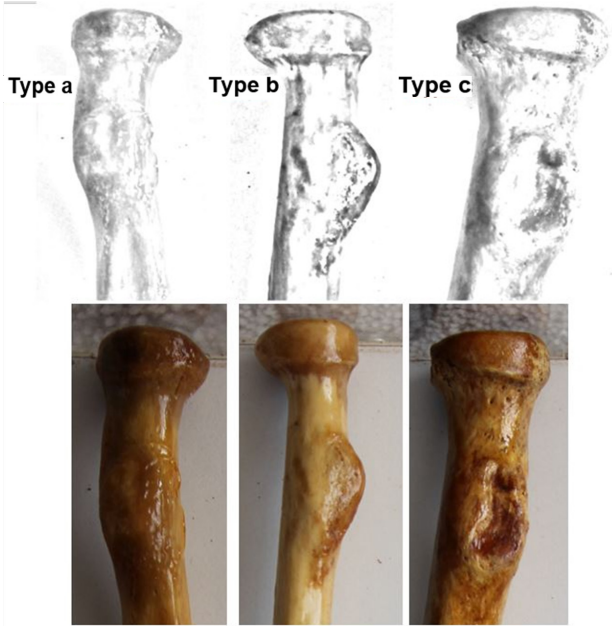

Figure 2. Morphometric classification of the radial tuberosity (Type a: Smooth, Type b: Single roughened, Type c: Double roughened)

All morphometric measurements were taken three times by an experienced anatomist using a digital caliper (INCA, DCLA-0605, 0.6-150 mm, USA), osteometric board, tape measure and Image J (NIH's National Institute of Mental Health, USA) software and the mean values were included in the study. All measurements were reported in millimetres (mm), while angle measurements were reported in degrees (°). Radii were photographed by placing them on an osteometric board with millimeter paper on them. The photographs of the radii were scanned into Image J software and were calibrated for the measurements. Morphometric measurements of the proximal and distal parts of the radius were then performed. The measurements were re-evaluated by three experienced anatomists at separate times. In case of differences between the measurements, the researchers met to discuss the matter and come to a consensus.

Lateral length of the radius (LLR): The length of the radius in the lateral direction.

Medial length of the radius (MLR): The length of the radius in the medial direction (Figure 3).

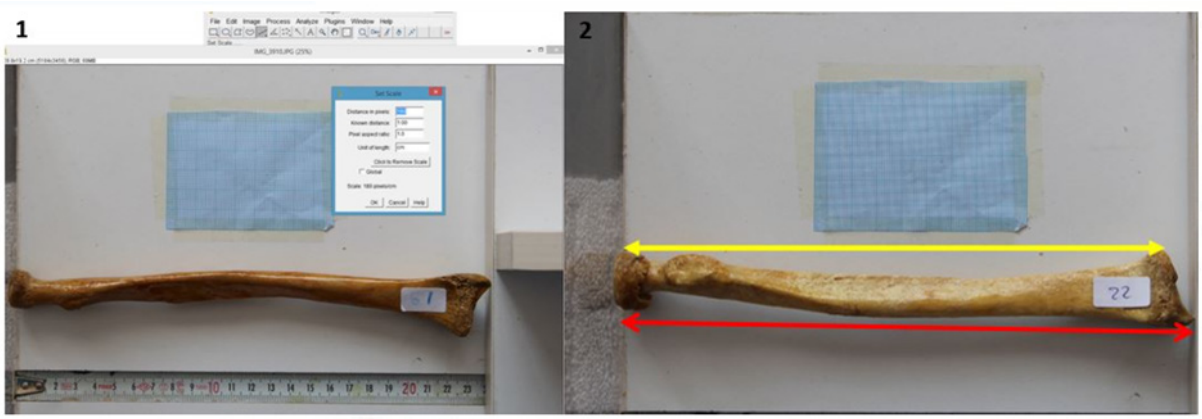

Figure 3. Morphometric measurements of the radius (1: measurement calibration with Image J, 2: medial length of the radius (yellow arrow), lateral length of the radius (red arrow))

Measurements of Proximal Radius

- ***Circumference of the articular surface of the radial neck (RN-CA):*** The circumference length of the articular surface at the neck of the radius.
- ***Circumference of the articular surface of the radial head (RH-CA):*** The circumference length of the articular surface at the radial head.
- ***Antero-posterior diameter of the radial head (RH-ap):*** The diameter of the radial head measured in the front-to-back (antero-posterior) direction.
- ***Medio-lateral diameter of the radial head (RH-ml):*** The diameter of the radial head measured in the side-to-side (medio-lateral) direction.
- ***Medial thickness of the radial head (RH-mt):*** Thickness of the radial head measured in the medial direction.
- ***Lateral thickness of the radial head (RH-lt):*** Thickness of the radial head measured in the lateral direction.
- ***Length of the radial tuberosity (RT-l):*** Measurement along the longest axis of the radial tuberosity.
- ***Width of the radial tuberosity (RT-w):*** Measurement along the widest axis of the radial tuberosity.
- ***Distance between the radial head and the radial tuberosity (RH-RT-d):*** The linear distance between the radial head and the radial tuberosity (Figure 4).

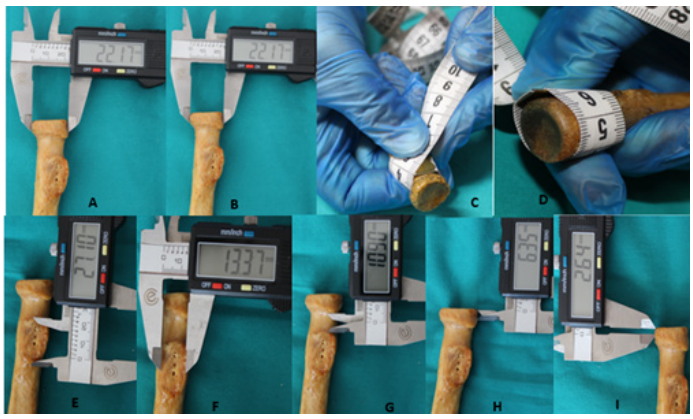

Figure 4. Morphometric measurements of the proximal radius; **A.** antero-posterior diameter of the radial head, **B.** medio-lateral diameter of radial head, **C.** medial thickness of the radial head, **D.** lateral thickness of the radial head, **E:** circumference of the articular surface of the radial neck, **F.** length of radial tuberosity, **G.** width of radial tuberosity, **H.** medial thickness of the radial head, I: lateral thickness of radial head

Measurement of Distal Radius

- ***Anterior length of the ulnar notch (UN-al):*** Length of the anterior surface of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Posterior length of the ulnar notch (UN-pl):*** Length of the posterior surface of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Width of the ulnar notch (UN-w):*** Width of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Length of the styloid process (SP-l):*** Length of the styloid process at the distal end of the radius.
- ***Radial inclination angle (RIA):*** Angle between the medial margin of the distal end of the radius and the axis of the styloid process (Figure 5).

Figure 5. Morphometric measurements of the distal extremities; **a.** anterior length of the ulnar notch, **b.** posterior length of the ulnar notch, **c.** width of the ulnar notch, **d.** radial inclination angle, **e.** length of the styloid process

Statistical Analysis

Version 21.0 of the Statistical Package for Social Sciences (SPSS) was used to analyze the data. All measurement data from the study were subjected to Skewness and Kurtosis tests. The skewness and kurtosis values between -3 and +3 indicated that the data exhibited a normal distribution (11) (Table 1).

The data were analyzed using both qualitative and quantitative methods. Qualitative methods included mean value, standard deviation (SD), maximum (max.) and minimum (min.) values, percentages (Chi-square), and quantitative methods included paired sample t-test to compare measurements between right and left bones, Pearson correlation, and One-Way ANOVA (with Post-Hoc Tukey test). Our results were evaluated according to a 95% confidence interval and a 0.05 margin of error, and differences at $p<0.05$ were considered statistically significant.

RESULTS

In the present study, comprehensive morphometric and morphological evaluations were conducted on a total of 70 radii (48.6% right; 51.4% left). The distribution of the morphological classifications of the articular fovea of the radius and radial tuberosity on the total, right, and left radius in the morphometric evaluations of our study are presented in Table 2.

The articular fovea of the radius was observed to be Type 2 in 97.1% of cases, Type 1 in 1.4% and Type 3 in 1.4% of all radii. The most common type was elliptical on the right and left sides, but the difference was not statistically significant between the left and right sides (χ^2: 2.003; p: 0.367). Radial tuberosity was most commonly seen as a

single roughened type. Similarly, the difference was not statistically significant between the left and right sides (χ^2: 0.610; p: 0.737) (Table 2).

The minimum, maximum, mean, and SD values of the morphometric parameters of the right and left radius bones and the right and left comparison statistical values are presented in Table 3. In the present study, the RH-mt and the UN-al of the right radius were found to be larger and statistically significant ($p<0.05$) compared to the corresponding measurements of the left radius (Table 3).

The mean and SD values of the measurement data obtained according to tuberosity typing, as well as the observed differences between the study groups, are presented in Table 4. For several parameters, statistically significant differences between the groups were found. These include the MLR, the LLR, the RN-CA, the RH-CA, the RH-ml, the RH-ap, the UN-w, the RIA measurements of the radius, along with the Type c tuberosity ($p<0.05$). Furthermore, the MLR and the LLR of the radius were significantly reduced in Type b tuberosity cases compared to Type c tuberosity cases (Table 4). Additionally, a comparison of the the RH-ml and the RH-ap and the RIA across the three types of tuberosities revealed that these values were larger in the tuberosities with Type c, and this difference was statistically significant (Table 4).

The results of the correlation analysis between the morphometric measurements of the radius are presented in Table 5. The analysis demonstrates that there are strong positive correlations across the measurements. The highest correlation was found between the RML and RMA parameters (r=0.901) (Table 5).

Table 1. Test of normality with Skewness and Kurtosis

Parameters	Min.	Max.	Mean	SD	Skewness	Kurtosis
MLR	17.35	25.65	21.69	2.14	0.8	-0.181
LLR	16.6	26.6	22.410	2.0674	.085	-.281
RN-CA	5.3	9.2	7.283	.7721	.272	.148
RH-CA	4.3	7.4	5.754	.5564	.300	.810
RH-ml	13.52	29.59	21.0254	3.25583	.027	-.114
RH-ap	10.81	25.46	19.6828	2.84789	-.387	.469
RH-mt	3.02	14.84	8.3696	2.58945	.220	-.053
RH-lt	1.79	12.01	6.2452	2.22677	.629	.255
RT-l	10.88	28.85	20.7381	3.79875	-.041	-.103
RT-w	5.47	19.03	12.5723	2.64334	-.085	.335
RH-RT-d	5.65	17.39	11.3113	2.36340	.018	.167
UN-al	2.05	12.26	7.3368	1.64224	.139	1.399
UN-pl	4.80	14.70	9.4493	1.92289	.305	.311
UN-w	7.14	19.72	14.5562	2.79631	-.815	.703
SP-l	2.57	9.09	5.1200	2.52816	1.089	1.096
RIA	15.32	39.45	22.4000	4.00000	-.810	.700

Morphometric data of the radius for the right and left sides included medial length of the radius (MLR), lateral length of the radius (LLR), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA)

Table 2. Distribution of the articular fovea of the radius and the radial tuberosity in total, right and left radius

		Total (n=70)		Right (n=34)		Left (n=36)			
		n	%	n	%	n	%	χ^2	p
Articular fovea of the radius	**Type 1**	1	1.4	0	0.0	1	2.8	2.003	0.367
	Type 2	68	97.1	33	97.1	35	97.2		
	Type 3	1	1.4	1	2.9	0	0.0		
Radial tuberosity	**Type a**	6	8.6	2	5.9	4	11.1	0.61	0.737
	Type b	38	54.3	19	55.9	19	52.8		
	Type c	26	37.1	13	38.2	13	36.1		

n: number of individuals, χ^2: chi-square test, Type 1: round, Type 2: elliptical, Type 3: irregular, Type a: smooth, Type b: single roughened, Type c: double roughened, p: significance value

Table 3. Minimum, maximum, mean, standard deviation values of morphometric data of radius according to right and left sides

Parameters		Right (n=34)		Left (n=36)		
		Min.-Max.	Mean±SD	Min.-Max.	Mean±SD	p
	MLR	17.35-25.65	21.69±2.14	18.8-26.79	21.4±1.85	0.543
	LLR	19-26.6	22.8±2.09	19.5-26.1	22.29±1.86	0.293
Proximal radius	RH-ml	14.29-29.59	21.27±3.53	13.52--26.99	20.81±3.01	0.564
	RH-ap	13.88-25.09	20.01±3.01	10.81-25.46	19.38±2.7	0.366
	RN-CA	68.9	7.38±0.8	5.3-9.2	7.2±0.74	0.343
	RH-CA	4.3-7.4	5.82±0.63	4.4-6.9	5.7±0.48	0.389
	RT-l	10.88-28.85	20.87±3.77	13.52-28.54	20.62±3.87	0.787
	RT-w	7-19.03	12.7±3.12	5.47-16.93	12.46±2.15	0.713
	RH-RT-d	5.65-16.58	11.45±2.6	6.66-17.39	11.19±2.15	0.651
	RH-mt	3.02-14.84	9.27±2.96	3.33-10.8	7.54±1.89	0.006*
	RH-lt	1.79-12.01	6.12±2.82	3.56-9.5	6.36±1.52	0.664
Distal radius	UN-al	4.45-12.26	8.12±1.62	2.05-8.96	6.62±1.32	0.000*
	UN-pl	5.75-14.7	9.89±1.97	4.8-12.57	9.04±1.81	0.069
	UN-w	7.14-19.72	14.85±3.14	7.87-19.11	14.29±2.46	0.413
	SP-l	2.57-11.9	8.25±2.17	3-10.8	7.87±1.69	0.424
	RIA	15.57-39.45	22.01±4.6	15.32--31.32	23.37±3.58	0.174

Morphometric data of the radius for the right and left sides included medial length of the radius (MLR), lateral length of the radius (LLR), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA), p<0.05 was considered statistically significant; Min.: minimum, Max.: maximum, SD: standard deviation

Table 4. Comparison of morphometric data of the radius of the right and left sides

		Type a (n=6)	Type b (n=38)	Type c (n=26)	p	GA
	MLR	20.9±1.20	20.80±1.04	22.30±1.80	0.010*	bc
	LLR	21.98±2.17	21.84±2.04	23.34±1.81	0.013*	bc
Proximal radius	RN-CA	6.68±0.43	7.21±0.77	7.52±0.75	0.037*	ac
	RH-CA	5.07±0.66	5.81±0.57	5.84±0.4	0.005*	ab.ac
	RH-ml	17.35±2.42	20.54±2.53	22.56±3.52	0.000*	ab,bc,ac
	RH-ap	17.49±3.01	19.71±2.72	21.15±2.87	0.0.17*	ab,bc,ac
	RH-mt	7.77±3.52	8.2±2.59	8.74±2.42	0.607	
	RH-lt	5.81±2.87	6.65±2.22	5.77±2.06	0.276	
	RT-l	18.77±6.64	20.53±3.42	21.48±3.46	0.791	
	RT-w	10.78±2.66	12.68±2.87	12.83±2.2	0.260	
	RH-RT-d	11.9±1.85	11.32±2.39	11.16±2.49	0.219	
Distal radius	UN-al	6.43±0.56	7.42±1.7	7.43±1.7	0.370	
	UN-pl	9.25±1.71	9.17±1.78	9.89±2.14	0.332	
	UN-w	12.04±3.59	15.05±2.07	14.44±3.26	0.046*	ab
	SP-l	3.57±1.41	5.83±0	6.32±3.92	0.681	
	RIA	20.01±4.00	21.09±1.02	22.50±1.20	0.030*	ab,bc,ac

Morphometric data of the radius for the right and left sides included medial length of the radius (MLr), lateral length of the radius (LLr), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA), Types of the articular fovea of the radius Type a: smooth, Type b: single roughened, Type c: double roughened GA refers to intergroup comparisons. p: significance value

Table 5. Pearson correlation coefficients (r) and statistical significance levels (p) between various morphometric measurements of radius bones

		RIA	SP-l	UN-w	UN-pl	RN-CA	RH-CA	RH-mt	RH-ap	RH-ml	RH-lt	RH-mt	RT-l	RT-w	UN-al	UN-pl	UN-w
UN-w	**r**	.098	**.452****	-.085	.125	**.446****	**.273***	**.516****	**.592****	**.469****	**.320****	.169	.214	**.484****	**.359****	**.364****	1
	p	.424	**.000**	.488	.306	**.000**	**.023**	**.000**	**.000**	**.000**	**.007**	.164	.078	**.000**	**.002**	**.002**	
UN-pl	**r**	.152	**.347****	.023	.216	**.329****	**.286***	**.303***	**.373****	**.333****	**.337****	-.136	**.376****	**.293***	**.471****	1	
	p	.213	**.003**	.855	.075	**.006**	**.017**	**.012**	**.002**	**.005**	**.005**	.265	**.001**	**.015**	**.000**		
UN-al	**r**	**.272***	**.293***	-.173	**.244***	**.342****	.230	.225	**.408****	**.364****	**.348****	.170	**.259***	**.313****	1		
	p	**.024**	**.015**	.158	**.044**	**.004**	.058	.063	**.001**	**.002**	**.003**	.164	**.032**	**.009**			
RT-w	**r**	.225	**.373****	-.070	.258*	**.561****	**.561****	**.507****	**.613****	**.506****	**.491****	.133	**.580****	1			
	p	.063	**.002**	.571	.032	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	.276	**.000**				
RT-l	**r**	**.315****	**.362****	.190	**.388****	**.567****	**.520****	**.464****	**.492****	**.342****	**.298***	.003	1				
	p	**.008**	**.002**	.121	**.001**	**.000**	**.000**	**.000**	**.000**	**.004**	**.013**	.977					
RH-mt	**r**	**.568****	.079	-.161	**.535****	.208	-.078	.165	**.329****	**.338****	.190	1					
	p	**.000**	.521	.191	**.000**	.086	.523	.176	**.006**	**.004**	.118						
RH-lt	**r**	.123	**.297***	-.039	.128	**.272***	**.299***	.102	**.441****	**.569****	1						
	p	.314	**.013**	.754	.296	**.024**	**.013**	.403	**.000**	**.000**							
RH-ml	**r**	**.263***	**.365****	-.066	**.298***	.450**	**.292***	**.357****	**.586****	1							
	p	**.029**	**.002**	.596	**.013**	.000	**.015**	**.003**	**.000**								
RH-ap	**r**	**.522****	**.429****	-.075	**.519****	**.789****	**.468****	**.783****	1								
	p	**.000**	**.000**	.542	**.000**	**.000**	**.000**	**.000**									
RH-mt	**r**	**.449****	**.360****	-.028	**.460****	**.781****	**.449****	1									
	p	**.000**	**.002**	.823	**.000**	**.000**	**.000**										
RH-CA	**r**	**.272***	.177	-.019	**.285***	**.578****	1										
	p	**.024**	.145	.875	**.018**	**.000**											
RN-CA	**r**	**.598****	**.337****	-.025	**.597****	1											
	p	**.000**	**.005**	.839	**.000**												
UN-pl	**r**	**.901****	.163	-.138	1												
	p	**.000**	.178	.258													
UN-w	**r**	-.205	**.389****	1													
	p	.092	**.001**														
SP-l	**r**	.084	1														
	p	.488															
RIA	**r**	1															
	p																

**correlation is significant at p <0.01, *correlation is significant at p <0.05. r: direction and magnitude of correlation, p: statistical significance of correlations, the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA)

DISCUSSION

In this study, morphometric analysis of the proximal and distal ends of 70 radius bones was performed and several important correlations between different anatomical parameters were revealed (Table 5). The data obtained should provide important clinical information that can be used in the management of injuries occurring in these regions. These findings may provide important data for the development of prosthetic design and surgical techniques, especially in the fields of orthopedic and reconstructive surgery.

The results of our study are consistent with similar studies in literature. For example, Samokhina et al. stated that proximal and distal radius measurements are important for the design of implants to be used in these regions (12). Another study emphasized the need for morphometric data for plate and screw placement in the treatment of distal radius fractures (13). These findings highlight the importance of the morphometric characteristics of the radial bone in post-traumatic reconstruction and prosthesis design.

When comparing the circumference of the RN-CA measurements with literature, we observed both similarities and differences. In one study, the RN-CA was reported as 4.64 cm on the right side and 4.62 cm on the left side, which is close to our findings (14). Another study reported 50.04 mm on the right side and 50.32 mm on the left side (15). In our study, we measured 7.38 cm was found on the right side and 7.20 mm on the left side.

In our study, we measured 5.82 cm on the right and 5.70 cm on the left, whereas Rayna et al. reported values of 6.3 cm on the right and 6.1 cm on the left for the RH-CA (14). We believe that measurements of RN-CA and RH-CA can be used to determine the methods to be used in the treatment of radial head and neck fractures.

The RH-ap and the RH-ml measurements of radial head obtained in our study were found to be consistent with other studies in literature. Captier et al. reported the mean of RH-ap as 21.6 mm (9), Kadel & Thapa, reported it as 2.09 cm (16), Puchwein et al. as 22.44 mm (17), Singh & Singh, as 20.50 mm (18), King et al., as 23.4 (19), and Gupta et al. as 1.91 cm on the right side (20). The result was determined to be 20.01 mm for the right radius and 19.38 mm for the left radius in our study. These differences may be due to biological variation between studied populations and the measurement methods used. For RH-ml, similar consistency with literature was observed. Captier et al. reported 21.0 mm (9), Ajit Singh et al. reported 19.53 mm (21), Puchwein et al. reported 23.15 mm (17), King et al., reported 23.6 mm (19), Gupta et al. reported 1.85 cm, and 23 mm (20), and Mazzocca et al. reported 23.0 mm (22). In our study, RH-ml was measured as 21.27 mm for the right radius and 20.81 mm for the left radius. The RH-ap and RH-ml measurements are important anatomical parameters for overall radial head stability and prosthetic fit. The RH-ap and RH-ml measurement provides guidance for proper sizing and placement of radial head prostheses (23). Consideration of this parameter in prosthetic surgery contributes to improved postoperative outcomes. They are also essential for fracture management (24) and overall assessment of elbow joint stability and function (25).

When comparing the measurements of the RH-mt with literature, varying results were found. Singh & Singh reported the RH-mt of 8.65 mm (18) whereas, Akshaya reported 0.92 mm on the right side and 0.82 mm on the left side (26). Ethiraj et al. found the RH-mt to be 0.86 cm on the right side and 0.95 cm on the left side (27). In our study, RH-mt was measured as 9.27 mm on the right side and 7.54 mm on the left side. For the RH-lt, Singh & Singh reported a measurement of 6.28 mm (18). Akshaya found it to be 0.84 mm on the right and 0.73 mm on the left (26), while Ethiraj et al. reported 0.73 cm on the right and 0.71 cm on the left (27). In our study, the RH-lt, was measured as 6.12 mm on the right side and 6.36 mm on the left side. These differences may be attributed to biological variations among populations and differences in measurement methods. The RH-mt and RH-lt are important considerations in surgical planning for procedures such as radial head arthroplasty, fracture reduction, fixation, and joint reconstruction. Precise measurements of these dimensions help to select appropriate implants and ensure optimal surgical outcomes (27,28).

The RT-l and the RT-w measurements in our study were found to be consistent with data reported in literature. RT-l, a prominent anatomical feature of the radius, has been the subject of several studies investigating its morphology, morphometry, and clinical implications. RT-l and RT-w are important parameters to be used in surgical procedures such as bicipital tendon reconstruction. In previous studies, Gupta et al. reported the RT-l as 2.02 cm on the right and 1.92 cm on the left (20), while Ethiraj et al. recorded it as 2.29 cm (27). Rayna et al. measured it at 3.36 cm on the right and 3.34 cm on the left (14), and Mazzocca et al. found it to be 22.3 mm (22). In our study, the RT-l was measured as 20.87 mm on the right side and 20.62 mm on the left side. These parameters are critical considerations for surgical planning and reconstruction involving the bicipital tendon. The RT-w was also measured in our study, and the findings were compared with literature. Mazzocca et al. reported the RT-w as 15.2 mm (22). Gupta et al. reported this length as 1.25 cm on the right and 1.21 cm on the left (20). In our study, the RT-w was measured as 12.7 mm on the right side and 12.46 mm on the left side. These measurements provide valuable insight into the structural features of the radial tuberosity and its relationship with reconstructive surgical procedures, elbow joint function and bone diseases. Additionally, we analyzed the types of radial tuberosity in our study. Mazzocca et al. classified these as smooth, single roughened and double roughened and reported the prevalence rates as 6%, 88% and 6%, respectively (22). When the single ridges were classified according to their size, reporting large, medium and small sizes in 12%, 47% and 41% cases, respectively. In the study conducted by Gupta et al. 36% of radial tuberosity was

classified as flat, 60% as single prominence, and 4% as double prominence (20). In our study, the classifications were as follows: Type a (5.9% on the right, 11% on the left), Type b (55.9% on the right, 52.8% on the left), Type c (38.2% on the right, 36.1% on the left). We also compared the shapes of the articular fovea, classifying them as Type 1, Type 2 and Type 3. Type 2 was observed in 97% of cases on both the right and left sides, while Type 1 on the right side and Type 3 on the left side were not observed. However, Captier et al. reported 57% of shapes as elliptical and 43% as flat (9). The high proportion of circular shapes in our study may indicate anatomical variations that differ from previous studies. This may require further investigation of population-specific characteristics or measurement methods.

Distance between the RH-RT-d is a critical anatomical measurement that plays an important role in orthopaedic practice. Studies have focused on the morphology and morphometry of the proximal end of the dry radius bones. Understanding this distance is essential for surgical planning, fracture management, and overall assessment of elbow joint function and stability, including radial head prosthesis implantation, biceps tendon reconstruction, and proximal radial trauma reconstruction (27).

In addition, research has also demonstrated that a larger radial tuberosity size is associated with an increased risk of distal biceps tendon rupture, highlighting the clinical importance of this anatomical feature (29). One study reported this measurement as 25 mm (22) whereas in our study, it was measured as 11.45 mm on the right side and 11.19 mm on the left side. In conclusion, the differences observed between studies may be due to methodological differences, population-specific anatomical variations, and the inherent complexity of human anatomy. Further studies that standardize measurement techniques and control for demographic factors are needed to clarify these discrepancies.

The ISP-l was also measured in our study with values of 8.25 mm on the right side and 7.87 mm on the left side. This result is in accordance with several studies that have investigated the dimensions of the styloid process and its clinical implications. For example, Rayna et al. reported a SP-l of 1.01 cm on the right and 1.0 cm on the left (14), while Prithishkumar et al. recorded lengths of 10.8 mm on the right and 11.0 mm on the left (30). Captier et al. found an SP-l measurement of 12.8 mm (9). Additionally, the clinical implications of styloid process length are significant noting that elongation can lead to complications such as Eagle syndrome (31). These studies highlight the importance of understanding variations in styloid process length, as they may have important implications for diagnosis and treatment in clinical practice.

In our study, anterior length of the UN-al was measured as 8.12 mm on the right side and 6.62 mm on the left side. This measurement is significant for understanding anatomy of the distal radius and its impact on joint stability and function. Literature on this topic is limited; however, one study reported UN-al measurements ranging from 4 to 7 mm (32).

Additionally, we measured the posterior length of the UN-pl and the UN-w in our study. These measurements ranged from 9.89 to 14.85 mm on the right side and 9.04 to 14.29 mm on the left side, respectively. The stability of the distal radioulnar joint is mainly provided by both the bony structure of the ulnar notch of the radial head and the surrounding soft tissues (33). In conclusion, the measurements of the UN-w in our study reveal the variations in the distal radius anatomy and its potential effects on joint stability. Given that soft tissues and bone structures provide joint stability, these results are somewhat compatible with previous studies. These measurements may contribute to a better understanding of joint function.

The length of the radius is crucial in the context of distal radius fractures and their treatment as it plays a key role in maintaining wrist stability and function. In our study, the LLR and the MLR were measured as 22.8 cm and 22.29 cm on the right side and 21.69 cm and 21.4 cm on the left side, respectively. Similarly, Rayna et al.reported these measurements as 23.7 cm on the right side and 22.5 cm on the left side (14). In other studies, the radius length was reported as 29.4 cm (9) and 23.39 cm in another study (34). It has been noted that loss of radial length, especially following distal radius fractures, is common in patient-reported complaints, indicating that proper alignment and length preservation are critical for optimal healing (35). Furthermore, the need for accurate measurements during surgical procedures has been emphasized, as any reduction in radial length can lead to complications such as malunion, impaired wrist function, and significant limitations in forearm rotation, affecting both pronation and supination (36,37).

The RIA was also measured in our study. RIA indicates the angle of inclination at the distal end of the radius and is important for wrist kinematics and distal radius prosthesis design (38). In our study, the RIA was measured as 22.01° on the right side and 23.37° on the left side. This measurement is important for understanding the anatomy of the distal radius and its effect on wrist stability and function. A review of relevant studies in literature revealed similar measurements. Prithishkumar et al. reported an RIA of 22.1°±2.9° on the right and 21.8°±2.5° on the left side (30). A study of distal radius morphometry found radial tilt angle of 21.85°±2.76° (39), while Ajit Singh et al.reported it as 25.1°±3.42° (21). In addition, Bilgin reported a mean radial tilt of 26.7°, highlighting variations across populations (40). Collectively, these studies underscore the clinical importance of measuring radial inclination as it plays a critical role in assessing wrist mechanics, guiding surgical intervention, and predicting functional outcomes after distal radius fractures. Accurate measurements of radial tilt are essential to optimize treatment strategies and improve patient care. Furthermore, the combined data on radial length and radial tilt angle contribute valuable insights for ensuring normal anatomical alignment and optimizing surgical procedures.

Our study has several limitations that should be acknowledged. First, the sample size of radius bones was limited, which may affect the generalizability of the results. Additionally, all the bones used in the study were only obtained from Türkiye, potentially limiting the applicability of the findings to other populations. Another significant limitation is that the gender of the bones is unknown. This factor could have considerable effects on the findings of the study. To address this, future studies should aim to include larger and more diverse sample sizes from different populations and ensure that the gender of the bones is identified.

CONCLUSION

The results of this study provide detailed morphometric analyses of the proximal and distal ends of the dry human radius, providing important information that can be used in clinical applications. The data demonstrates that various anatomical features of the radial bone play a critical role in post-traumatic reconstruction, prosthetic design, and orthopedic surgical planning. Comparisons with other studies in literature revealed differences in the morphometric measurements of the radius in the Turkish population, highlighting the impact of ethnic and biological diversity on bone structure. It is believed that these findings suggest that this dataset may serve as a valuable resource for understanding the effects of different ethnic and biological diversity on bone structures and may provide important contributions to future research and clinical applications.

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MEDICAL RECORDS-International Medical Journal

Research Article

Bacterial and Fungal Infections Among COVID-19 Patients in Intensive Care Unit

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Abstract

Aim: Secondary infections caused by bacteria or fungi are dangerous because they increase death rates, particularly in patients with COVID-19 who are receiving intensive care. In this study, hospital-associated secondary infections resulting from bacteria and fungi amid COVID-19 patients treated in intensive care units, as well as their distribution according to microbial agents, were investigated.
Material and Method: The study comprised 134 COVID-19 patients who were being treated in the Mersin City Hospital of the Ministry of Health intensive care unit between January 1, 2021, and April 30, 2021. The patients' demographics and clinical records, as well as bacterial and fungal infections in the blood, urine and deep tracheal aspirate samples, were analyzed retrospectively.
Results: The rate of secondary infection was found to be quite high in patients hospitalized in intensive care units for over 72 hours (91.4%). The majority of secondary infections were detected in blood samples (n=103, 15%). Secondary infection was detected in 61 (8.9%) deep tracheal aspirate specimens and 59 (8.5%) urine samples. The most common secondary infectious agents were *Candida spp.* (22.3%), *Acinetobacter baumannii* (16.8%). In addition, it was determined that ≥60 years and ≥3 days of mechanical ventilation independently increased the probability of developing secondary infection.
Conclusion: Our findings are emphasized that the concern of secondary infection due to *Candida spp., Acinetobacter baumanii and Stahylococcus epidermidis* agents. Evaluation of bacterial superinfections during the later waves of the pandemic may be critical, especially given the changes in the management of these patients, such as the routine use of corticosteroids and the raise of the different variants of the SARS-CoV-2.

Keywords: Corticosteroids, COVID-19, intensive care unit, secondary infection

INTRODUCTION

Following the reporting of the patients presenting with respiratory tract infections caused by a previously unidentified microbial agent in Wuhan, China; a new beta-coronavirus, the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), is defined as a causative pathogen of the disease in December, 2019 (1,2). The World Health Organization (WHO) later gave the illness the term coronavirus disease 2019 (COVID-19) (2). The virus that enters alveolar epithelial cells and multiplies quickly, in particular, can trigger a potent immune response. Intensive care unit (ICU) treatment is necessary for severe cases, and there are risks including cytokine storm-induced multiple organ failure or acute respiratory distress syndrome (ARDS) (3). To counteract this abnormal immune system activation, immunosuppressive medications, like glucocorticoids, are extensively used (4).

In hospitalized COVID-19 patients, infections from bacteria and fungi are frequent as with other viral pneumonias (5,6).

In COVID-19 patients, bacterial and fungal secondary infections are of great concern as they cause increased mortality rates, especially in ICU. Rapid and accurate identification of local flora or pathogenic bacterial or fungal organisms during COVID-19 should make up a vital component in the effective management of patients (7,8).

This study aimed to identify the distribution and prevalence of the microbes causing hospital-associated secondary infections caused by bacteria and fungi in COVID-19 patients admitted to the ICU.

CITATION
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MATERIAL AND METHOD

Ethical Permissions

The Scientific Research Platform of the General Directorate of Health Services of the Turkish Ministry of Health granted authorization for this research. This research was conducted with the permission of the Mersin University Clinical Research Ethics Committee (Decision No: 2021/480 and Date: 07/14/2021).

134 COVID-19 patients who were hospitalized in the intensive care unit of the Ministry of Health Mersin City Hospital between January 2021 and April 2021 were comprised in the study. Demographics, the clinic of the disease, and secondary infections resulting from bacteria or fungi of the patients followed in the ICU were determined retrospectively. All patients had been treated in the ICU for more than 72 hours and were older than 18 years. Patients who were monitored in the ICU were split up into two groups: those receiving glucocorticoids and those receiving no glucocorticoids. Data on age, gender, antibiotic therapy, time spent in the ICU, comorbidities, mechanical ventilation/intubation status, and treatment result (death/discharge) of these two groups were collected.

SARS-CoV-2 RT-PCR

Samples of the patients' nasal and oropharyngeal swabs were collected using the designated swab and inserted into the tubes containing the viral transport medium (VTM) or viral nucleic acid buffer (vNAT). COVID-19 laboratory diagnosis was performed by the real-time reverse transcription polymerase chain reaction (RT-PCR) assay of SARS-CoV-2 RNA from patient samples, using the Bio-speedy SARS-CoV-2 RT-PCR kits (Bioeksen, Türkiye).

Microbiological Culture

Initially, each patient admitted to the ICU had one urine and two blood culture specimens were taken. When patients in the ICU had fever, an elevated leukocyte count, or other symptoms that would suggest a secondary infection, blood and urine samples of the cultures were got. In addition, deep tracheal aspirate (DTA) specimens were got from patients if they were intubated, and if central venous catheter (CVP) was inserted, blood samples from CVP were collected for culture.

The specimens were collected and delivered immediately to the microbiology laboratory. The samples were cultured on 5% sheep blood agar, "Eosin-Methylene Blue" agar, chocolate agar, and "Sabouraud Dextrose" agar and incubated at 37°C for 24-72 hours for the conventional culture of bacterial and fungal agents. The BacT/Alert system from BioMérieux (France) was used to culture blood samples. Colonies formed on the media after incubation were identified by Gram staining, standard biochemical tests, and Vitek 2 (BioMérieux, France) system. The replicating agents were subjected to normal disk diffusion antimicrobial susceptibility testing under EUCAST criteria.

Statistical Analysis

All data collected in Microsoft Excel for analysis. Comparison of data from ICU inpatients was analyzed using SPSS version 22 (IBM, Chicago, USA). The Kolmogorov-Smirnov test was used to analyze the normality of the continuous variable distribution. The chi-square (χ^2) test was used to compare non-parametric data; Mann-Whitney U test was used for comparisons between non-normally distributed continuous variables and independent samples t-test was used for normally distributed continuous variables. Categorical variables were expressed as frequency or percentage, age and the time spent in the ICU is described as mean±standard deviation, $p \leq 0.05$ was considered significant.

RESULTS

Demographic Data

90 of the 134 COVID-19 patients included in our study were taking corticosteroids during their hospitalization besides the standard treatment specified in the T.C. Ministry of Health COVID-19 Outbreak Management and Study Guide (9). The patient group who did not take steroids comprised 44 people.

Of the patients, 63 were women and 71 were men, with a mean age of 68.3±15 for women and 65.1±12.7 for men. The mean age was 64.5±14.1 years in the group that received steroids, while it was 70.9±12.5 in the group that did not. The patients' average stay in the ICU was 19.9 days. When the distribution of hospitalization periods according to steroid treatment was evaluated, it was determined as 19.8±11.9 days in those who received steroid treatment and 18±12.4 days in those who did not. No difference exists between the patients that received steroid treatment and those who did not, in terms of length of stay. In the study, 106 patients died, 70 of whom received steroid therapy and 36 of those who did not.

Etiology in Secondary Infection

The rate of secondary infection was determined to be considerably high in patients hospitalized in the ICU for over 72 hours, regardless of corticosteroid use (n=115, %92). No significant difference between the patients received steroid treatment (82 individuals, 91.1%) and those who did not (40 people 90.9%) in terms of the presence of secondary infection. When the rate of multiple secondary infections during the hospitalization period in patients receiving steroid therapy was evaluated, it was found that patients with 2 or more secondary infections (46 people 56.1%) were significantly higher than those with a single secondary infection (36 people, 43.9%). The proportion of patients with a single secondary infection (n=20, 50%) and those with two or more secondary infections (n=20, 50%) who did not receive steroid treatment was the same. Bacterial and/or fungal growth was detected in 244 (31.6%) of 771 samples taken for microbiological

culture. *Candida species* were determined as the most common secondary infectious agent in COVID-19 patients hospitalized in ICUs included in the study (n=54, 22.1%). *Candida species* were followed in order of prevalence by *Acinetobacter baumanii* (n=41, 16.8%), *Staphylococcus epidermidis* (n=41, 16.8%), *Staphylococcus haemolyticus* (n=23, 9.4%) and *Klebsiella pneumoniae* (n=20, 8.2%) respectively (Table 1).

Table 1. Distribution of secondary infectious agents

Organisms	Blood	Deep tracheal aspirat	Urine	CVP catheter	Total
Candida spp.	12	13	27	2	54
Acinetobacter baumanii	12	21	4	4	41
Stahylococcus epidermidis	35	0	0	6	41
Stahylococcus haemolyticus	21	1	0	1	23
Klebsiella pneumoniae	2	10	6	2	20
Enterococcus spp	9	1	7	1	18
Eschericia coli	0	4	13	0	17
Stenotrophomonas maltophilia	8	3	0	3	14
Pseudomonas aeruginosa	1	7	0	1	9
Other GNBs	2	1	2	0	5
Pseudomonas putida	2	0	0	0	2
Total n/N (%)	104/771 (13.5)	61/771 (7.9)	59/771 (7.6)	20/771 (2.6)	244/771 (31.6)

The majority of secondary infections were detected in blood samples (n=104, 13.5%). The most frequently isolated agent in blood samples was *Staphylococcus epidermidis* (n=35,33.7%). *Candida species* were followed in order of prevalence by *Staphylococcus haemolyticus* (n=21, 20.2%), *Candida spp*. (n=12, 11.5%), *Acinetobacter baumanii* (n=12, 11.5) (Table 1). Secondary infection was most common in deep tracheal aspirat (DTA)samples after blood samples (n=61, 7.9%). The most commonly isolated agent in DTA samples was *Acinetobacter baumanii* (n=21, 34.4%), followed by *Candida species* (n=13, 21.5%). The most commonly isolated agent in DTA samples was *Acinetobacter baumanii* (n=21, 34.4%), followed respectively by *Candida species* (n=13, 21.5%), The most prevalent pathogens isolated in urine samples (n=59, 7.9%) were *Candida species* (n=27, 45.8%). The most prevalent cause of secondary infections detected in CVC samples (n=20, 2.6%) was *Staphylococcus epidermidis* (n=6, 30%), *Acinetobacter baumanii* (n=4, 20%).

Secondary infection was detected in 14.9% (n=73) of blood samples, 8.3% (n=41) of DTA samples, 7.3% (n=36) of urine samples and 3.1% (n=15) of CVC samples of the patients receiving steroid therapy.

In patients who did not receive steroid treatment, in 10% (n=28) of blood samples, 7.1% (n=20) of DTA samples, 8.2% (n=23) of urine specimens, and 1.8% of central venous catheter (CVC) samples (n=5) bacterial growth was detected. Bacterial or fungal secondary infectious agents were most commonly isolated from blood samples in those receiving steroid therapy (n=73, 14.9%). DTA (n=41, 8.3%), urine (n=36, 7.3%) and CVC (n=15, 3.1%) followed respectively in terms of secondary infection frequency in the samples. When infectious agents were evaluated in patients receiving steroid therapy, the most commonly isolated microorganisms from blood samples were *Staphylococcus epidermidis* (n=25) and *Staphylococcus haemolyticus* (n=16) (Table 2). *Acinetobacter baumanii* (n=14) was the most frequently isolated sample from DTA samples of patients receiving steroid therapy. The most frequently isolated agent in urine samples of the patients who received the corticosteroids during their stay in the ICU was comprised of the *Candida species* (n=19).

The frequency of bacterial and/or fungal secondary infections in patients who did not receive steroid treatment was similar in blood (n=28, 10%), urine (n=23, 8.2%) and DTA (n=20, 7.1%) samples. The most common agents detected in blood samples were *Staphylococcus epidermidis* (n=7), *Acinetobacter baumanii* (n=5), *Candida species* (n=5) and *Staphylococcus haemolyticus* (n=5). The most common agents detected in blood samples were Staphylococcus epidermidis (n=7), *Acinetobacter baumanii* (n=5), *Candida species* (n=5), and *Staphylococcus haemolyticus* (n=5). The most frequently isolated agents in the urine samples of the patients were *Eschericia coli* (n=9) and *Candida species* (n=8) (Table 2).

Table 2. Distribution of secondary infections in patients receiving and not receiving steroid therapy

Organisms	Blood Steroid+	Steroid-	Deep tracheal asp. Steroid+	Steroid-	Urine Steroid+	Steroid-	CVP catheter Steroid+	Steroid-	Total Steroid+	Steroid-
Candida spp.	7	5	9	4	19	8	1	1	36	18
Acinetobacter baumanii	7	5	14	7	4	0	2	2	27	14
Stahylococcus epidermidis	27	7	0	0	0	0	4	2	32	9
Stahylococcus haemolyticus	16	5	1	0	0	0	1	0	18	5
Klebsiella pneumoniae	1	1	7	3	3	3	2	0	13	7
Enterococcus	7	2	1	0	4	3	1	0	13	5
Eschericia coli	0	0	2	2	4	9	0	0	6	11
Stenotrophomonas maltophilia	5	3	3	0	0	0	3	0	11	3
Pseudomonas aeruginosa	1	0	3	4	0	0	1	0	5	4
Other GNBs	0	0	1	0	2	0	0	0	3	0
Pseudomonas putida	1	0	0	0	0	0	0	0	1	0
Total n/N (%)	73/491 (14.9) 28/280 (10)		41/491 (8.3) 20/280 (7.1)		34/491 (7.3) 23/280 (8.2)		15/491 (3.1) 5/280 (1.8)		165/491 (33.6) 76/280 (27.1)	

In the study, it was also determined that mechanical ventilation for over three days and age older than 60 years independently increased the probability of developing a secondary infection. The mortality rate among COVID-19 patients with secondary infection was 79.1% (106/134), 77.8% (70/90) in those that received steroid therapy, and 81.8% (36/44) in those who did not.

Infection was detected in 207 of the samples taken from the cases that resulted in mortality. The most common secondary infections were detected in blood samples at 44.4% (n=92). Secondary infections in the deep tracheal aspirate specimens were in the second rank with 26.1% (n=54), and urine samples were in the third row with 21.3%. The frequency of secondary infection was 8.2% (n=17) in the samples taken from the CVC. Among the patients who lost their lives, *Candida spp* with 21.7% (n=45) were the most frequent cause of secondary infections. *Acinetobacter baumanii* (n=33) was in second place with 15.9%, and *Staphylococcus epidermidis* was in the third row with 14% (n=29). These factors were followed by *Klebsiella pneumoniae* and *Enterococcus spp*, each with 7.7% (n=16).

DISCUSSION

It is well known that COVID-19 patients who get secondary infections have worse health outcomes (6,10). During the first few days after SARS-CoV-2 infection, lung dysbiosis or respiratory tract destruction in patients may develop, which may be converted into a secondary bacterial or fungal infection after a few weeks (11). According to recent studies, in less than 4% of COVID-19 patients, community-acquired bacterial co-infection was stated at admission. While, it has been reported that the prevalence of secondary bacterial infections has been raised to 3.7-21.9% after hospitalization (10,12). However, it has been reported that this rate varies between 7.2% and 58% in ICU patients (12-16). In our study, the rate of secondary infection in patients hospitalized in the ICU for over 72 hours was relatively high, 91.4%. This reasonably high rate is thought to be due to the time in which study samples were included covering the peak of the COVID-19 epidemic.

It has been emphasized that extensive, well-designed clinical trials are needed to determine the incidence, risk factors, and outcome of secondary pulmonary infections in hospitalized COVID-19 patients due to differences in the design of various studies (17).

In our study, it was aimed to reveal the frequency of detection of secondary bacterial and fungal agents and the distribution of the agents in COVID-19 patients who were followed up with steroid therapy in the ICU and were not treated with steroids. The microorganisms most frequently encountered as a secondary infection agent in COVID-19 patients hospitalized in ICUs were determined as *Candida spp*. (n=54, 22.1%), *Acinetobacter baumanii* (n=41, 16,8%), *Staphylococcus epidermidis* (n=41, 16.8%), *Staphylococcus haemolyticus* (n=23, 9.4%), *Klebsiella pneumoniae* (n=20, 8.2%), *Enterococcus spp*. (n=18, 7.4%), *Eschericia coli* (n=17, 7%), respectively. According to the reports of the Infection Control Committee of our hospital, the agents previously isolated from ICUs were reported as *Staphylococcus epidermidis*, *Staphylococcus haemolyticus*, *Staphylococcus saphrophyticus*, *Candida spp.*, *Klebsiella pneumoniae*, *Enterococcus faecalis*, *Proteus mirabilis*, *Acinetobacter baumanii*. Most of the factors detected in COVID-19 patients followed up in their follow-up period were associated with these bacteria. Most of the factors detected in COVID-19 patients followed up in their follow-up period were associated with these bacteria. In the study, the highest frequency of C. albicans, an opportunistic

colonization pathogen, as a cause of secondary infection in critically ill COVID-19 patients, may be explained by the fact that the immune system of the patients were suppressed due to viral sepsis.

In the study of Obata et al., bacterial infection (25% vs. 13.1%, p=0.041) and fungal infection (0.7% vs. 0.7%, p<0.001) in the group receiving steroid treatment compared to the group not receiving steroids have been reported to have a higher incidence (18). In our study, no significant difference was found between the patients who received steroid treatment (82 people, 91.1%) and those who did not (40 people 90.9%) while they were hospitalized in the ICU.

It has been reported that positive culture rates of respiratory tract bacterial pathogens from hospitalized COVID-19 patients ranged from 23% to 86.6% (9,13,19,20). In our study, bacterial secondary infection rate in respiratory tract samples was found to be 7.9%, similar to previous studies.

Streptococcus pneumoniae and *Staphylococcus aureus* have been reported frequently as causative agents in community-acquired co-infections in patients diagnosed with COVID-19 (12). On the other hand, the most frequently identified bacterial agents in respiratory tract cultures were reported as *Psoudomonas aeruginosa*, *Klebsiella spp.*, *Staphylococcus aureus*, *Eschericia coli*, and *Stenotrophomonas maltophilia*. *Aspergillus fumigatus* has been identified as the most common microorganism causing secondary fungal pulmonary infections (17).

In different studies, the most common agents found in respiratory tract samples of COVID-19 patients hospitalized in the ICU were *Acinetobacter baumanii* (21.8-90%) *Stenotrophomonas maltophilia* (9-15.6%), *Pseudomonas spp.* (4.8%-33%), *Klebsiella pneumoniae* (14.4-24.5%), and *Staphylococcus aureus* (10%-21%). These agents were followed by *Burkholderia cepacia* (18.8%), *Haemophilus influenza* (9%), *Enterobacter spp.* (7%), and *Eschericia coli* (7%) (6,8,10,14,19,20). It has been reported that *Aspergillus fumigatus* (9%) (14) and *Candida albicans* were also detected among fungal agents. (6.8%) (6). In a study conducted by Avan Mutlu and Bozok in our country, *Acinetobacter baumanii* (47.8%), *Klebsiella pneumoniae* (13.4%), *Psoudomonas aeruginosa* (12.0%), *Staphylococcus aureus* (4.5%) and *Enterococcus spp.* (2.1%) has been reported to be detected (21). In our study, the most common agents detected in the respiratory tract of critically ill COVID-19 patients hospitalized in ICUs were *Acinetobacter baumanii* (n=21, 34.4%), *Candida species* (n=13, 21.5%), *Klebsiella pneumoniae* (n=10, 16.3% and *Psoudomonas aeruginosa* (n=7, 11.5%). Since these microorganisms are hospital-acquired agents frequently defined in ICUs, it was difficult to distinguish colonization and infection, especially in respiratory tract samples.

In our study, unlike other researches, blood circulation and urinary tract infections were also evaluated besides respiratory tract infections. The rate of hospital-acquired bloodstream infection in COVID-19 patients followed in ICUs has been reported as 31-34% (14-16,22) in other studies. In our study, the most elevated rate of secondary infections was determined in blood samples of 13.5%. It has been concluded that one of the significant reasons underlying the high incidence of infection in blood samples is the use of intravenous catheters in patients treated in the ICU. Similarly, the widespread use of urinary catheters in the ICU is an important factor that can explain the frequency of urinary tract infections. Patients may be exposed to infectious agents due to application errors or deficiencies in antisepsis practice throughout respiratory support with nasal cannula, endotracheal tube, and similar devices during hospitalization (16).

The most common etiologic bacterial pathogens in secondary infections developing in the bloodstream were reported as *coagulase-negative Staphylococci* (34%), *Enterococcus spp.* (22%), *Psoudomonas aeruginosa* (8%), *Klebsiella spp.* (7%) and *Staphylococcus aureus* (7%) (10). In another study, the most common agents were determined as *Enterococcus spp.* (64%), *coagulase-negative staphylococci* (11%), *Psoudomonas aeruginosa* (7%), and *Staphylococcus aureus* (3.5%) (14). In our study, the most frequently isolated agents in the blood were *Staphylococcus epidermidis* (33.7%), *Staphylococcus haemolyticus* (20.2%), *Candida spp.* (11.5%), *Acinetobacter baumanii* (11.5%), *Enterococcus spp.* (8.7%) and *Stenotrophomonas maltophilia* (7.7%). With this aspect, our study reveals new findings on microorganisms that cause secondary infections in COVID-19 patients treated in the ICU.

Graselli et al. reported that the rate of catheter-related bloodstream infection represents 10% while Bardi et al. found the rate 25% (14,15). In our study, secondary infectious agents were determined at a rate of 2.6% in CVC samples. In our study, secondary infectious agents were determined at a rate of 2.6% in CVC samples and the detected pathogens were *Staphylococcus epidermidis* (30%), *Acinetobacter baumanii* (20%), *Stenotrophomonas maltophilia* (15%), *Candida spp.* (10%) and *Klebsiella pneumoniae* (10%). Similarly, in a study, *coagulase-negative staphylococci* (54%) were detected most frequently in CVC samples. The former were followed by *Enterococcus spp.* (25%), *Candida albicans* (17%) and *Staphylococcus aureus* (4%) (14). Since patients with severe COVID-19 and bloodstream infections may have a severe disease course, prolonged hospitalization, and poor clinical outcomes (19), prospective studies in which patients will be evaluated together with risk factors are required for good antimicrobial management of patients (19).

In our study, the secondary infection rate in urine samples was determined as 7.9%. The most common pathogens isolated from urine samples were *Candida species* (n=27, 45.8%), followed by *Eschericia coli* (n=13, 22%), *Enterococcus spp.* (n=7, 11.7%) and *Klebsiella pneumoniae* (n=6, 10.2%), respectively. Our study is compatible with the literature in this aspect. In the study of the Bardi et al., urinary tract infection rate was similarly reported as 8%. The most frequent agents detected in the urine were determined

as in this study *Enterococcus spp.* (72%), *Psoudomonas aeruginosa* (14%) and *Acinetobacter baumanii* (14%) (14).

It should be taken into account that the length of stay in the intensive-care unit may be prolonged if the patients are co-infected (19). Studies have shown that the average length of stay in the ICU of critically ill COVID-19 patients who develop secondary infections is 8-40 days (8,22). In our study, the average length of stay of the patients in the ICU was 19.9 days, and it was determined that those who received steroid treatment (21 days) were higher than those who did not (17 days) ($p<0.05$). When compared with other studies, it was observed that the length of stay in the ICUs of the patients was not long.

Secondary infections in hospitalized patients for COVID-19 may cause increased mortality (12,19). In various studies, mortality rates of critical COVID-19 patients during their stay in the ICU have been reported between 30%-95% (8,15,16,23). In our study, the mortality rate was reported to be quite high, as 79.1% in total. However, the mortality rate we found is consistent with the literature.

In the study of Obata et al., it was reported that steroid use did not affect mortality (18). In support of the result obtained in this study, it was revealed in our research that steroid administration during treatment in the ICU did not have an effect on the mortality rate of COVID-19 patients. In our study, the mortality rate was 91.1% in patients who received steroid therapy, while it was 90.9% in patients who did not receive steroid therapy. In addition, the mortality rate in patients aged ≥60 years was significantly higher than in patients aged 18-59 years, regardless of steroid treatment (86.9% vs. 70.5%). It was also determined that mechanical ventilation for ≥3 days independently increased the probability of developing secondary infection (94.3% vs. 64.8%).

One of the shortcomings of our study is that we could not compare our results with the incidence of secondary infections among patients without COVID-19. Another limitation of our study is that we conducted a single-center retrospective study with a relatively small sample size. More prospective multicenter studies are needed to be designed in the future to confirm our findings.

In our study, the incidence of secondary infection was found to be quite high, 91.4%, in patients with COVID-19 and hospitalized in the ICU for over 72 hours. Our findings emphasize the risk of secondary infection due to *Candida spp.*, and *A. Baumanii*. However, we found that there was no difference in the distribution of secondary infection in steroid users compared to non-users. Evaluation of bacterial superinfections during the later waves of the pandemic may be critical, substantially given the changes in the management of these patients, such as the routine use of corticosteroids and the emergence of new SARS-CoV-2 variants. Management of these infections is essential to ensure compliance with hospital infection control measures. In conclusion, it is of vast importance to focus on fungal and bacterial secondary infections and to have information about the distribution of these agents for the appropriate treatment of critical COVID-19 patients in ICUs.

CONCLUSION

In summary, it is of vast importance to focus on fungal and bacterial secondary infections and to have information about the distribution of these agents for the appropriate treatment of critical COVID-19 patients in ICUs.

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MEDICAL RECORDS-International Medical Journal

Research Article

The Immediate Effect of Graston Technique on Ankle Range of Motion and Vertical Jump Performance in Athletes

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Abstract

Aim: A limited number of studies have demonstrated the effects of Graston and static stretching on different muscle groups and sports performance. The study aimed to investigate the immediate effect of the Graston technique on vertical jump performance and ankle range of motion in athletes.
Material and Method: A quasi-experimental study included 30 participants aged 18-40 among active, licensed basketball players between January 2023 and May 2023. The 30 participants were divided into a graston group (n=15) and a static stretching group (n=15). A vertical jump test was performed for performance after the ankle joint range of motion was measured with a goniometer. Behind the first assessment session, a Graston or static stretching was applied to the groups. Thereafter, the vertical jump performance and goniometer measurement was repeated.
Results: Graston and static stretching had similar results in vertical jump performance ($p<0.05$). Graston on the gastrocnemius, soleus muscles and Achilles tendon was superior to static stretching, particularly in left foot dorsiflexion ($p<0.05$).
Conclusion: Graston application can be preferred to increase vertical jumping and ankle range of motion performance in athletes with similar and superior effects to static stretching. Including Graston and static stretching in the rehabilitation protocols can provide an effective range of motion and jumping performance.

Keywords: Athletes, instrument-assisted mobilization, jump, stretching

INTRODUCTION

Limitations in ankle range of motion (ROM) are essential in lower extremity injuries. In particular, limited ROM can lead to ankle re-injury (1). Ankle dorsiflexion (DF) may predispose to abnormal biomechanics during dynamic activities, which has been linked to the risk of knee injuries (2). Clinicians perform various interventions to increase ankle DF, such as manual therapy, stretching, ultrasound, electrotherapy and exercises. However, the intervention most effectively improves ankle DF has not yet been identified (1,3).

Stretching techniques are one of the treatments used to increase muscle extensibility to improve ROM. It can help prevent injury in sports, reduce muscle pain, and improve muscle capacity and athletic performance (4). Stretching increases joint flexibility and minimizes muscle-tendon junction stiffness, specifically during pre-exercise warm-up (5,6), thus ensuring optimum performance (7).

Passive stretching is a safe way to perform dynamic and static balance exercises (8). It can be used to regain both the joint's range of motion and the ability to balance on complex tasks in individuals returning from a previous injury. Sport-specifically, it proves that passive stretching can be performed before balance tasks, when necessary, without compromising their final performance (9).

One essential performance that requires balance in sports is the vertical jump. Vertical jump (VJ) is the difference between the height reached by standing and jumping (10). In basketball, VJ height and height are critical (11). One study stated that the gastrocnemius muscle is involved

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in powerful and rapid movements and plays an integral role in running and jumping by significantly participating in the plantar flexion (PF) of the foot (12). The amount of ankle DF plays a vital role in the cause of lower limb injuries. Restriction of DF may predispose to re-injury of the ankle. Clinicians perform various therapeutic interventions such as stretching, manual therapy, electrotherapy, ultrasound and exercises to increase ankle DF. However, the intervention or combination of interventions most effectively improves ankle DF has yet to be specified (1).

The Graston technique is an essential application that improves lower extremity range of motion and jump performance. Groston is an instrumented soft tissue mobilization technique. The stainless-steel instrument, designed to adapt to the curves and various tissues of the body, is used to detect and release scar tissue, adhesions and fascial restrictions. Graston was developed as an alternative to manual therapy for transverse friction. Graston acts like a diapason when in contact with fibrotic tissue. A reverberation within the device occurs at the moment of contact and is transmitted through the device to the physiotherapist's hands (13). Graston can improve ROM without affecting the mechanical and neurological properties of the muscles that are the focus of treatment (14).

The effectiveness of graston combined with stretching exercise has not been investigated so far. The objective of our study was to compare and contrast the relative merits of static stretching and the Graston technique and to examine the impact of both methods on ankle range of motion and vertical jump performance. The study's hypothesis was determined as follows: The Graston technique has a more immediate effect than static stretching in improving ankle range of motion and vertical jump performance.

MATERIAL AND METHOD

Participants and Setting

A quasi-experimental study was conducted between January 2023 and May 2023. Thirty participants aged 18-40 were selected among clients who applied to Athlete and Orthopedic Clinic “Fizyomove”. The study was carried out in accordance with the ethical principles and the Helsinki Declaration. Informed consents of the patients were obtained. The study protocol was approved by the ethics committee of Muğla Sıtkı Koçman University (No: “141”).

The inclusion criteria were as follows: (1) the participant was voluntary and had consented to participate in the study, (2) the participant was between the ages of 18 and 40, and (3) the participant was able to perform the squatting movement pattern. The exclusion criteria of the study were as follows: (1) the participant's trunk exhibited excessive stability, (2) the participant had a health condition that would significantly impair their mobility, (3) the participant had undergone a surgical procedure involving the ankle and knee within the previous six months, (4) the participant had sustained an ankle sprain and ligament injury within the previous six months, (5) the participant demonstrated kinesiophobia in squatting, (6) the participant had a neurological diagnosis, was pregnant, had sustained an acute lower extremity injury, or had metatarsal stress fractures.

Data collection

Demographic information (e.g., age, height, weight) and information such as license status, previous surgical operation, and sports branch of interest were obtained from the individuals who participated in our study. VJ performance and range of motion were evaluated before and after the intervention. The evaluations were performed face-to-face in the sports club and orthopaedic clinic environment.

Vertical Jump Test

VJ is a test with a high-reliability rate for determining the jumping power of the athlete. In this method, a tape measure is attached to the wall in the test. Participants stand upright with their feet shoulder-width apart and their dominant side against the wall. The highest point they can reach on the tape measure without lifting their feet off the floor is marked. When ready, they are asked to bend down by bending their hips and knees and using their arms and legs to mark the highest point they can reach with their hands. The distance difference between the point they reach and the point they jump is determined. The test is repeated thrice, and the best result is recorded in centimeters (15).

ROM Measurement

The range of motion of the ankle was quantified using a goniometer. The subject is positioned supine with the knee extended and the ankle hanging over the edge of the table. In goniometric measurement, the 90-degree right angle between the fifth metatarsal and fibula is accepted as the reference point for the measurement of ankle range of motion, with 0 degrees representing the neutral position for dorsi and plantar flexion. The goniometer is positioned with its pivot point on the lateral malleolus. The fixed arm is maintained in a parallel position to the lateral midline of the fibula. The movable arm is aligned with the lateral midline of the fifth metatarsal bone. It is imperative that the foot remains stationary throughout the measurement process, neither inverting nor everting.

In order to obtain measurements for inversion and eversion, the subject should assume a prone position with the knee flexed at 90 degrees. The pivot point of the goniometer is positioned at the midpoint of the calcaneus. The fixed arm is initially maintained in a parallel position with respect to the midline of the sole between the second and third toes, while ensuring that its parallelism with the ground is maintained at the outset of the movement. The movable arm is aligned with the midline of the sole and positioned between the third toes (16).

Intervention

Graston group

In the aforementioned application, the objective was to enhance the performance of the gastrocnemius and soleus muscles. To this end, the Graston technique was employed at an angle of 45° parallel to the muscle fibres for a duration of approximately 20 seconds. Subsequently, the device was applied to the muscles in a direction perpendicular to the same muscle fibres at a 45° angle with the Graston for 20 seconds (Figure 1). An increase in temperature and a relaxation of the dermal tonus were observed on the skin surface (17) (Figure 2).

Figure 1. Graston method application on gastrocnemius and soleus

Figure 2. Statical stretching application on gastrocnemius and soleus

Statical stretching group

Static stretching is a widely employed method that serves to elongate muscle tissue by means of autogenic inhibition, which in turn stimulates the Golgi tendon organ. This technique entails passively stretching a specific antagonist muscle by positioning it in a maximum stretch position and maintaining that position for an extended duration. The participant's ankle was positioned in a DF position, and the gastrocnemius, soleus and Achilles muscles were placed in the most stretched position. The measurement was repeated on four occasions, with a holding time of 30 seconds applied in each instance (18) (2). A bilateral application was performed.

Statistical Analysis

IBM Statistical Package for Social Sciences Version 22 statistical program was used for data analysis. Continuous variables were given as mean±standard deviation and qualitative variables as number and percentage (%). Paired samples t test (dependent paired sample t-test) was used before and after data comparisons, and $p<0.05$ was considered significant for all analyzes.

RESULTS

Of the 30 participants who voluntarily participated in the study, 28 (93.3%) were male, and 2 (6.7%) were female. The mean age of the Graston group was 19.33±4.62 (min: 18, max: 36) years. The mean age of the static stretching group was 18.8±4.05 years (min: 18, max: 26). The mean age of all groups was 19.4±3.74 years (min: 18, max: 36).

There was no significant difference between the graston and static stretching groups in terms of VJ performance ($p=0.86$). When we analyzed the ROMs according to the methods applied, a significant result was found between the groups in left DF ($p<0.48$). No significant difference was found in other ROMs ($p>0.05$) (Table 1).

Graston technique had a significant effect on VJ performance ($p=0.0001$). The effectiveness of Graston was also significant for right DF ($p=0.007$) and left DF ($p=0.0001$). Graston was not effective in right PF ($p=0.683$), right EV ($p=0.337$), and right IN ($p=0.068$). On the other hand, left PF ($p=0.512$), left EV ($p=1$), and left IN ($p=0.060$) were not significant for the efficacy of Graston (Table 2).

Static stretching technique had a significant effect on VJ performance ($p=0.002$). Static stretching technique had a significant effect on right and left DF ($p<0.05$). Static stretching technique had no significant effect on right and left PF ($p>0.05$). The effect of static stretching technique on right EV ($p=0.005$) and right IN was significant ($p=0.026$). On the other hand, static stretching technique was effective for left foot EV ($p=0.022$), while its effect on left IN was not significant ($p=0.270$) (Table 3).

Table 1. The post-intervention results between the Graston and stretching groups

	Graston group (n=15) Mean±SD	Stretching group (n=15) Mean±SD	p
VJ performance	0.46±0.09	0.45±0.16	0.862
DF-right	16.33±5.40	17.80±4.69	0.434
DF-left	19.73±4.33	16.33±4.65	**0.048**
PF-right	36.33±9.48	32.53±7.80	0.241
PF-left	35.87±13.40	33.07±7.11	0.481
EV-right	14.33±5.09	15.47±4.56	0.526
EV-left	14.00±4.76	13.80±4.37	0.906
IN-right	14.07±5.36	14.07±4.94	1.000
IN-left	14.60±5.28	12.80±3.98	0.301

n: the number of participants, SD: standard deviation

Table 2. The results of the Graston technique (in-group changes)

	Graston group (n=15) Change score (Mean±SD)	p
VJ performance	-0.46±0.28	**0.0001**
DF-right	-3.53±4.35	**0.007**
DF-left	-4.80±2.93	**0.0001**
PF-right	-0.46±4.34	0.683
PF-left	-1.40±8.06	0.512
EV-right	-1.20±4.67	0.337
EV-left	0.00±3.91	1.000
IN-right	-0.80±1.56	0.068
IN-left	-1.93±3.65	0.060

n: the number of participants, SD: standard deviation

Table 3. The results of the Stretching technique (in-group changes)

	Stretching group (n=15) Change score (Mean±SD)	p
VJ performance	-0.03±0.30	**0.002**
DF-right	-3.86±3.60	**0.0001**
DF-left	-2.73±3.45	**0.008**
PF-right	2.13±6.72	0.240
PF-left	-1.73±8.11	0.422
EV-right	-4.40±5.18	**0.005**
EV-left	-2.53±3.79	**0.022**
IN-right	-2.00±3.11	**0.026**
IN-left	-1.33±4.49	0.270

n: the number of participants, SD: standard deviation

DISCUSSION

This study aimed to investigate the immediate effects of the Graston technique and static stretching on ankle range of motion and VJ performance in athletes. The results proved that Graston and static stretching applied to the gastrocnemius, soleus muscles, and Achilles tendon had significantly similar effects on VJ performance. Graston application was superior to static stretching, especially in left foot DF.

Loss of ROM is a common functional impairment in physically active people. It is one of the causes of musculoskeletal injury. Factors such as low flexibility, previous injuries, and sedentary time can lead to loss of ROM. Studies have suggested that ankle DF ROM deficit is a factor that increases the likelihood of a wide range of lower extremity injuries (19). In addition, the methods used to assess ankle range of motion have differed significantly regardless of gender due to geographical and cultural differences based on individuals' activities of daily living (20). Ankle ROM varies as the significant muscles acting over the joint absorb shock or generate force during standing posture (21). Adequate flexibility and range of motion of the ankle joint are essential for performing activities that require balance, such as running and squatting (22). An ankle ROM impairment caused by muscle tension during gait can affect the ankle-foot complex and the rest of the joints of the lower extremities (23). Movement restriction in the DF direction also increases the risk of ankle sprains (24). Restricted DF in the ankle joint can lead to acute or chronic injuries in the ankle and knee (19). Therefore, our study aimed to provide the effect of soft tissue mobilization technique that might improve ankle range of motion and physical performance.

Clinicians use soft tissue mobilization techniques to restore fascial mobility and reduce pain by addressing myofascial restrictions within the triceps surae (19). Grieve et al. (2011), in their study of 20 healthy individuals (5 males and 15 females) with restricted ankle DF with an average age of 27.7±2.1 years, it was observed that DF range of motion increased by applying myofascial trigger point to the soleus muscle (25).

The current study examined the effect of Graston and static stretching on hamstring muscle extensibility and pain intensity in patients with low back pain were examined. Twenty-four patients, 12 in the Graston and 12 in the static stretching group, were included in the study. Hamstring extensibility was recorded using the sit and lie test, and a visual analog scale was used to measure pain intensity. The Graston technique group showed significantly more improvement in hamstring extensibility than the static stretching group (26).

A recent scoping review in 2024 states that Graston is effective for foot and ankle pathologies when combined with other therapeutic interventions but emphasizes that the limited number of studies reduces the level of evidence (27).

Since the early 1980s, static stretching has been widely promoted before performing physical activity to prevent injury and improve physical performance (28). It has become a prominent routine incorporated into the warm-up for exercise, as the slow, controlled movement is believed to allow stretching to be performed quickly and safely, with less risk of injury compared to other forms of stretching (29).

Some studies have shown that static stretching before exercise may increase the risk of injury (28). VJ capacity depends on lower limb muscle strength and is used as a standard test of strength performance and to estimate muscle fiber composition. A higher vertical velocity at take-off is required to improve VJ performance. This performance can be achieved by a higher contraction velocity or muscle strength of the trunk, hips and lower limbs extensor muscles. If the muscle becomes shortened and strained, it negatively affects VJ performance (10).

Studies on the effects of Graston and static stretching on different muscle groups and performance parameters are limited in the literature. In general, when the literature is reviewed, the study results show that Graston and static stretching have a performance-enhancing effect. When we investigated the superiority of static stretching and Graston to guide clinicians, we found that they similarly improved DS performance. There is also a difference in ankle DF. Since we worked on the gastrocnemius, soles muscles and Achilles tendon, the improvement in the range of motion of the DF was realized to the extent we expected.

Limitations

One of the limitations of our study may be that the number of participants was 30. A higher number of participants may strengthen the statistical results. We included all athletes in our study without homogeneity regardless of the sports branch, mainly basketball. Since each sport has specific positions, the dominant muscle group that should be used also differs. Future studies can be strengthened by diversifying the sports branch and homogeneous distribution. We think that our other limitations are gender and the presence of a license. The fact that 2 of our 30 participants were women and 3 of our 30 participants were unlicensed reduces the homogeneity of our study. Future studies can improve the literature by considering gender and license status.

CONCLUSION

The Graston technique increases DS performance and ankle range of motion. There is no superiority between Graston and static stretching in DS performance. In terms of the results of our study, it will benefit sports and health professionals who are engaged in team sports such as volleyball, basketball and soccer, where jump performance is essential and will contribute to the literature. Including Graston and static stretching in the treatment protocols for athletes, health rehabilitation will strengthen the treatment process. Regularly performing Graston or static stretching, even without injury, will strengthen the preventive rehabilitation modality. It will not only result in success for the physiotherapist but also increase the success of the coach, conditioning and doctor as a team.

Key Findings

The Graston technique increases DS performance and ankle range of motion. There is no superiority between Graston and static stretching in DS performance.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *The study was carried out in accordance with the ethical principles and the Helsinki Declaration. Written informed consents of the patients were obtained. The study protocol was approved by the ethics committee of Muğla Sıtkı Koçman University (No: 141).*

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MEDICAL RECORDS-International Medical Journal

Research Article

Investigation of the Effects of Lycopene Against Cisplatin-Induced Renal Damage in Rats: A Histopathological Study

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Abstract

Aim: This study aimed to investigate the protective effect of lycopene (LP) on kidney damage induced by cisplatin (CPT), which is used as a potent agent in chemotherapy, in rats.

Material and Method: A total of 35 female Wistar albino rats between 220-250 grams which were 2-4 months old were included in the study. The rats were divided into 5 equal groups as control (Cont) group, CPT group, CPT+LP group, LP group and Dimethyl sulfoxide (DMSO) (solvent) group. Cont group did not receive any treatment during the 7-day long experiment. Rats in the CPT group were administered a single dose of 7 mg/kg CPT intraperitoneally on the first day of the experiment. CPT+LP group was administered 5 mg/kg of LP dissolved in DMSO intraperitoneally every day for 7 days after CPT was administered at the mentioned dose and duration. LP and DMSO groups were intraperitoneally administered 5 mg/kg of LP dissolved in DMSO and 1 ml/kg 0.1% DMSO, respectively during the experiment. At the end of the experiment, kidney tissues taken from the rats were evaluated histopathologically.

Results: When the histopathological analyses were evaluated, it was found that glomerular shrinkage, tubular vacuolisation, desquamous epithelium and interstitial hemorrhage were statistically more intense in the CPT group when compared with the Cont, DMSO and LP groups. In the CPT+LP group, cellular organization in the renal tissue was found to be close to normal when compared with the CPT group and it was found that apart from other parameters, especially glomerular atrophy was minimised by LP ($p<0.01$).

Conclusion: In conclusion, it was shown that LP administration alleviated nephrotoxicity, which is one of the primary adverse effects of CPT in rats.

Keywords: Cisplatin, lycopene, nephrotoxicity, histopathology, rat

INTRODUCTION

As a chemotherapeutic agent in cancer treatment, cisplatin (CPT) is often administered intravenously as first-line chemotherapy for tumours of testis, breast, ovary, bladder, lung and various malignancies. In this context, after being absorbed by the cancer cell, CPT may show cytotoxic effect leading to inhibition of Deoxyribo Nucleic Acid (DNA) synthesis by interacting with cellular macromolecules (1). Although CPT is one of the widely used and potent chemotherapeutic drugs, its use may cause side effects such as nephrotoxicity in normal tissues and organs, especially in kidneys (2). This is the most important side effect limiting CPT use. Studies have shown that the pathogenesis of CPT induced renal damage is caused by decreased activity of antioxidant enzymes and increased reactive oxygen species in renal tissue (3,4). When the nephrotoxic effect of CPT was analysed molecularly and cellularly, it was found that it resulted in the damage and death of renal tubular cells (2). Renal proximal tubules, especially epithelial tubular cells of the S-3 segment, are the main sites where the toxic effects of CPT are seen (5). In addition, the inflammatory response caused by CPT damages the plexus in the kidney and causes ischemic damage, resulting in decreased glomerular filtration (2).

Lycopene (LP) is a carotenoid pigment found in red and orange fruit and vegetables (6). It has a high-capacity antioxidant effect due to its hydrophobic structure and the conjugated double bond it contains. While LP shows

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a strong antioxidant property in in vitro environments, in in vivo environments it has multi-targeted activities such as inducing apoptosis, decreasing DNA damage, preventing oxidative stress and decreasing metastasis (7,8). A large number of diseases are characterized by oxidative stress and chronic inflammation. In this context, studies are frequently planned with antioxidants to alleviate the side effects of CPT. LP can be used as a molecule that has synergic effects on cancer cells and that minimizes the undesirable effects mediated by CPT. LP, which is an important agent in oxidative damage and tissue healing due to its strong antioxidant activity, has been reported to reduce renal damage in a large number of renal damage models, to have dose-dependent beneficial effects and to maintain metabolic homeostasis in the kidney (9-11).

In the light of all this information, CPT is still used as an effective chemotherapeutic agent in various cancer types despite the nephrotoxicity it causes. In this context, the aim of the present study is to investigate the efficacy of LP, which was shown to have anti-apoptotic and antioxidant effects in previous studies, against CPT-induced kidney damage at histopathological level in the light of available information in the literature.

MATERIAL AND METHOD

Experimental Design

Experimental procedures of the study were carried out at Bolu Abant İzzet Baysal University Experimental Animals Application and Research Centre after obtaining the 02.08.2023 dated and 2023/22 numbered decision from Bolu Abant İzzet Baysal University Animal Research Local Ethics Committee. In this context, 35 female Wistar albino rats, each weighing 220-250 gram and 2-4 months old, obtained from the relevant centre were used in the study. The animals were kept at the centre in an environment with a constant temperature (24±2°C) and humidity (55±15%) in a 12-hour light-dark cycle. The rats were allowed access to ad libitum standard rat feed and water during the experiment. A power analysis test was conducted using Minitab software version 16 to determine the requisite number of animals in all groups. In this context, the subjects were randomly allocated to 5 groups, with 7 rats in each group:

Control (Cont) group: This group was not administered any treatment.

CPT group: Single dose 7 mg/kg CPT (12) was administered intraperitoneally on the first day of the experiment

CPT+LP group: Single dose 7 mg/kg CPT was administered intraperitoneally on the first day of the experiment. Following this, 5 mg/kg of LP (13). dissolved in dimethyl sulfoxide (DMSO) was administered intraperitoneally every day for 7 days.

LP group: 5 mg/kg of LP dissolved in DMSO was administered intraperitoneally every day for 7 days.

DMSO (Solvent) group: 1 ml/kg 0.1% DMSO was administered intraperitoneally during the 7-day long experiment.

Tissue Sampling

At the end of the 7-day long experiment, the kidney tissue was removed under 90 mg/kg ketamine (Ketalar®, Pfizer, İstanbul) and 10 mg/kg xylazine (Citanest®, AstraZeneca, İstanbul) anaesthesia and the animals were sacrificed. Kidney tissues taken for histopathological analyses were fixed in 10% buffered neutral formalin for two weeks.

Preparation of Tissue Samples and Histopathologic Analysis

Following the completion of two weeks fixation period, the kidney tissues were labelled appropriately and kept overnight in running water and formalin was removed from the tissue. The tissues kept in running water were dehydrated first through alcohol series (70%, 80%, 96%, 96%, 100%, 100%). Afterwards, the tissues made transparent with xylene were infiltrated with paraplast. The tissues taken from the hot paraffin were embedded in L-iron filled with paraffin and labelled. Thus, the tissue tracking process was completed. Using a rotary microtome (Leica RM2125RT) with 1/50 sampling in compliance with the systematic random sampling criteria, 3 µm thick sections were extracted from the paraffin embedded sections for light microscopic examinations. Sections from each group were later stored in an oven set to 58°C for the entire night in order to remove the paraplast for staining. Next, the sections were stained with Haematoxylin-Eosin for histological examination. Kidney tissues were evaluated histopathologically in terms of glomerular shrinkage, tubular vacuolization, desquamated epithelium and interstitial haemorrhage by using Nikon Eclipse 80i light photomicroscope with camera attachment. In this context, 10 different areas were examined in each section at X20 magnification and scored semi quantitatively from 0 to 3. According to this scoring, absence of pathology was scored as 0, the presence of mild pathology was scored as 1, the presence of moderate pathology was scored as 2 and the presence of severe pathology was scored as 3 (14). Quantitative results were obtained by making comparisons among groups. The same histologist assessed each parameter by randomly picking tissue samples from each group and without knowing which tissue sample belonged to which group (blind evaluation).

Statistical Analysis

Statistical analyses were performed with SPSS version 21.0 analysis program. Shapiro-Wilk test was used to evaluate whether the data of the subjects conformed to the assumption of normal distribution, and in the comparison of continuous variables, the data conforming to normal distribution were evaluated with One-Way ANOVA and Post-hoc Bonferroni tests. $P<0.05$ indicated statistically significant difference.

RESULTS

When the kidney sections stained with Hematoxylin-Eosin were examined histopathologically in terms of glomerular shrinkage, tubular vacuolization, interstitial hemorrhage and desquamous epithelium, it was observed that the interstitial tissue density surrounding the renal glomeruli, tubules and veins in Cont, DMSO and LP groups had normal morphology. In the CPT group, shrunken glomeruli were observed in places in the cortical labyrinth of the related tissue. Bowman's interval of the renal corpuscles whose glomeruli were degenerated in this way was wider compared to the Cont group. In addition, tubular dilatation and interstitial hemorrhage were found to be intense in this group. In the CPT+LP group, renal bodies had more normal morphology, tubule cell damage was lower, and tubule epithelial cell loss was significantly improved when compared with the CPT group (Figure 1). In this context, when the groups were evaluated semi-quantitatively, no statistical difference was found between the Cont, DMSO and LP groups ($p>0.05$). When a statistical difference of $p<0.01$ was found between Cont and CPT groups in terms of glomerular shrinkage, tubular vacuolization and desquamous epithelium, this difference was found to be at $p<0.05$ in the evaluation of interstitial haemorrhage. When CPT and CPT+LP groups were compared statistically, difference was found between groups in terms of tubular vacuolization, desquamous epithelium and interstitial hemorrhage ($p<0.05$). This difference was at $p<0.01$ in the parameter in which glomerular shrinkage was examined (Figure 2-5).

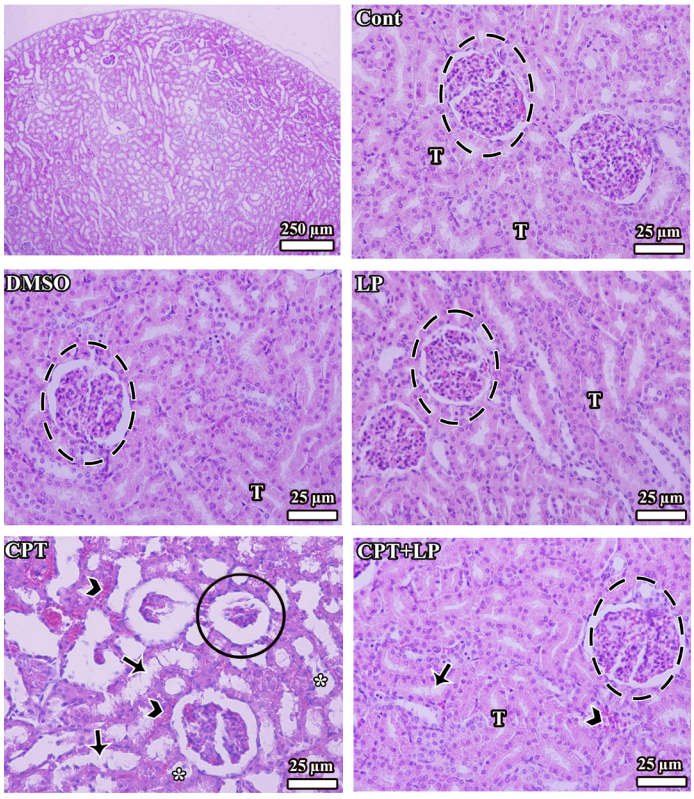

Figure 1. Light microscopic images obtained from the kidney of rats in all groups. The first image points out the panoramic view of the kidney (x5). **Arrow:** tubular vacuolation; **Arrowhead:** interstitial haemorrhage; **Star:** desquamous epithelium; **Circle:** glomerular shrinkage; **T:** healthy tubule; **Dashed circle:** healthy glomerulus;. Hematoxylin-Eosin staining. X20

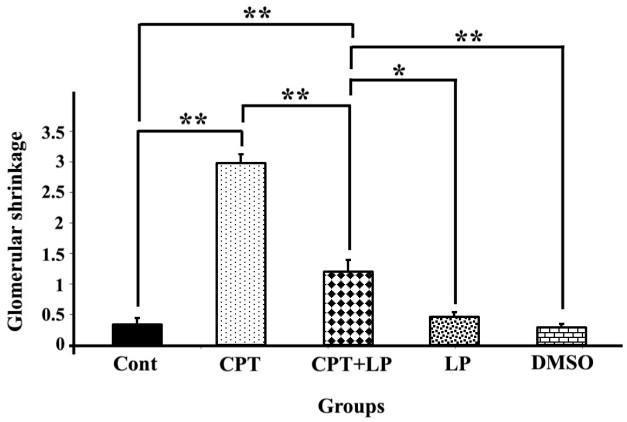

Figure 2. Semi-quantitative evaluation of glomerular shrinkage parameter in all groups. Differences at the level of $p<0.05$ were shown with "*" while differences at the level of $p<0.01$were pointed out by "**"

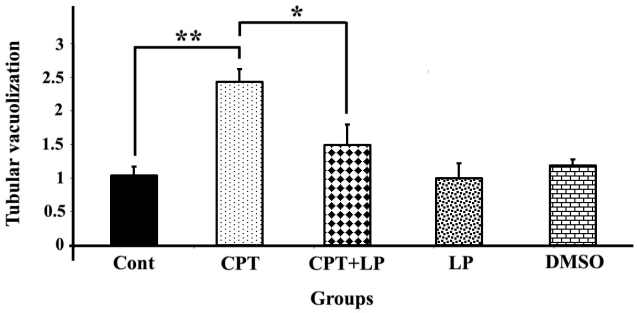

Figure 3. Semi-quantitative evaluation of tubular vacuolization parameter in all groups. Differences at the level of $p<0.05$ were shown with "*" while differences at the level of $p<0.01$were indicated by "**"

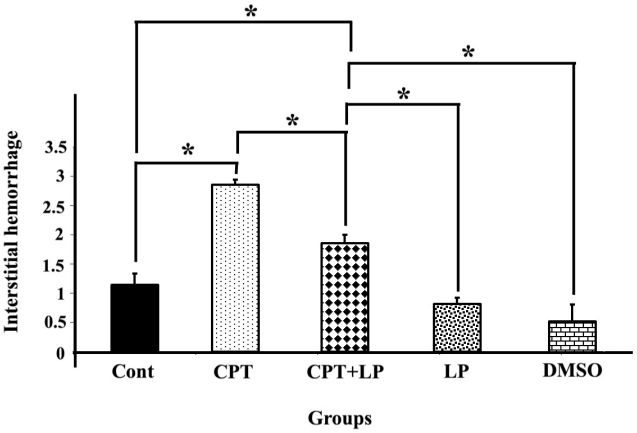

Figure 4. Semi-quantitative evaluation of interstitial hemorrhage parameter in all groups. Differences at the level of $p<0.05$ were shown with "*"

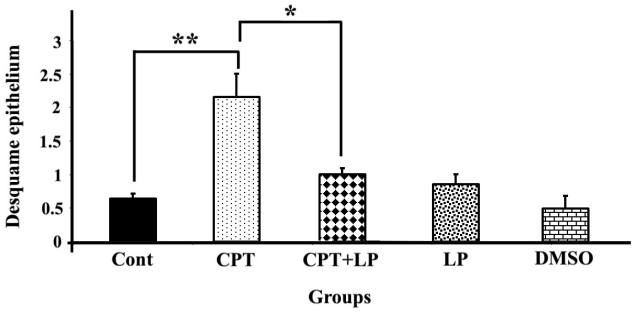

Figure 5. Semi-quantitative evaluation of desquame epithelium parameter in all groups. Differences at the level of $p<0.05$ were shown with "*" while differences at the level of $p<0.01$were displayed by "**"

DISCUSSION

Most of the chemotherapeutic drugs used in cancer treatment work by generating free radicals and reactive oxygen species (15). In this context, CPT is a chemotherapeutic agent used effectively in various cancer treatments that induce cell death by binding to DNA. This agent can show its antitumor mechanism in many ways, the most important of which is creating DNA damage. It may also cause cellular damage through stress on endoplasmic reticulum and mitochondria and activation of apoptotic pathway. According to the data obtained from the studies conducted, exposure to CPT has been shown to cause nephrotoxicity by causing damage to the proximal tubule S3 segment in the kidneys of mice, rats and humans (16). The result reported in a large number of studies that oxidative stress may cause nephrotoxicity was also found in our study as mediated by CPT. In clinical use, CPT nephrotoxicity is characterized by elevated serum creatinine, decreased serum potassium and magnesium levels, and low glomerular filtration rate days after treatment with CPT. There are also studies which show that it reduces renal filtration permanently in the long term (2). While nephrotoxicity was observed in 42% of the patients, it was found that CPT treatment was not completed in 7% due to renal toxicity (17). This is one of the primary problems leading to dose limitation in the use of CPT. CPT exposure causes the production of reactive oxygen species including hydroxyl radicals, oxidation of protein, lipid and nucleic acids and eventually damage to tubule epithelium cell membrane (18). In this case, inflammation may cause high nephrotoxicity potential through reactive oxygen species (ROS)-mediated endoplasmic reticulum (ER) stress and autophagy (19). Atrophic glomerular structure was observed in CPT-treated rats in histological examination of the kidney tissue in our study. We believe that the reason for this damage may be the ischemic effect caused by inflammation.

LP, which is a carotenoid, has many biological activities. These are stopping the growth of cancer cells by regulation of cell cycle proteins, regulating the immune function, and preventing oxidative DNA damage (15). LP is known to contribute to cell survival against oxidative damage by strengthening the antioxidant system like many antioxidant substances (20). In our study, it was found that 5 mg/kg LP reduced the CPT-mediated nephrotoxicity in the renal tubular cells. Open polyene chain in the structure of LP plays an effective role in neutralizing superoxide anions and free radicals. In this context, we think that in our study LP reversed the histopathological deterioration in the CPT+LP group by reducing oxidative stress and inflammation. Previous studies have reported that LP minimized cell swelling and organelle deformation and prevented cytoplasmic division and atrophy in renal cells (21). In our study, it was found that when compared with the CPT group, atrophy of glomeruli and deterioration in tubular structure decreased in the CPT+LP group. A study by Salari et al. showed that in lipopolysaccharide-induced renal injury, LP treatment improved NF-kB gene expression, TNFα, IL6, TLR4 levels. In other words, LP showed anti-inflammatory effect by attenuating TLR4 and NF-kB mediated inflammation and reduced nephrotoxicity by contributing to the repair of intracellular antioxidant mechanism through regulation of Nrf2 and HO-1 (20). In the present study, which evaluated whether the CPT-induced nephrotoxicity in rats can be prevented by using LP, our results showed that LP showed protective effects on tubular vacuolization, interstitial hemorrhage, glomerular atrophy, and epithelial changes that occur due to CPT. In a study conducted by Deng et al., it was shown that CPT caused acute kidney injury in many different ways such as CHOP-mediated endoplasmic reticulum stress, renal tubular damage by triggering inflammation and oxidative stress with ROS and TNF-a and IL6 mediated cytokines, direct apoptosis by caspase-3 and caspase-9 activation and mitochondrial dysfunction (16). In the light of literature, we believe that a large number of mechanisms such as endoplasmic reticulum stress are involved in the observed damage and LP provides protection by reducing reticulum stress. In this context, there is a need for molecular studies to elucidate the mechanism underlying the protective effect.

In a study conducted by Li et al., it was reported that the kidneys shrunk in the renal damage induced by using di (2-ethylhexyl) phthalate (DEHP) and that the kidney size returned to normal after using LP. In addition, histological examinations showed that the degradation of the brush edges, dilatation and damage in the tubular structure decreased after treatment (21). A study conducted by Doğukan et al. reported that LP treatment reduced lipid peroxidation against the nephrotoxic effect caused by CPT administered to mice (22). In addition, a study conducted by Pektaş et al. examined renal markers through blood samples in ischemia-reperfusion-induced renal damage, and it was shown that pathological biomarkers including malondialdehyde (MDA), glutathione and catalase were higher in the control group when compared with the LP administered group (23). In a study conducted by Saylan et al., it was shown that LP decreased tubular dilatation, tubular epithelial degeneration, glomerular shrinkage and desquamous epithelium amount significantly in ischemia-reperfusion induced renal damage (14). Another study conducted by Gori et al. showed that LP treatment minimised renal inflammatory changes due to adenine histopathologically, physiologically and biochemically (24). In this context, it was shown in our study that LP treatment reversed the histopathological deterioration of CPT-induced renal damage. In other words, it was found that LP protected renal tissue significantly against complications caused by CPT. In the light of these researches, by adding our results, we believe that LP has a protective effect in the nephrotoxic effect of CPT and with the increase in clinical research, CPT can be added in the diets of patients who receive chemotherapy and used as a protective factor.

CONCLUSION

Based on the histopathological examinations of the present study, it was found that LP use minimised the degree of damage in the rats which were administered CPT injection. It was shown that LP, which is a string antioxidant, prevented the nephrotoxicity caused by CPT by alleviating the destructive effects of oxidative stress in renal tissue, especially in tubule and glomerular structures. In this context, there is a need for further clinical research, especially at the molecular level, for the use of LP as an agent that reduces the side effects of LP in chemotherapy regimens. This way, it is certain that more comprehensive information using different animals, different laboratories, different periods of time and different methods will help to further improve clinical studies in the field.

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Ethical approval: *Ethical approval was taken from the local Ethics Committee of Bolu Abant İzzet Baysal University with the decision number 2023/22 dated 02.08.2023.*

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Research Article

Investigation of Age- and Gender-Related Changes in Anatomical Variables of the Cerebellum in Healthy Adults Using MR Imaging

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Abstract

Aim: The aging process and gender are thought to cause changes in anatomical regions of the brain. The present study was designed to present age- and gender-related changes in the morphometric characteristics of the cerebellum, which is known to be mainly responsible for the coordination of the skeletal system and balance.
Material and Method: Brain magnetic resonance (MR) images of healthy individuals aged 25-55 years were analyzed. MCRae line (MCL), Klaus index (KI), clivus length (LC), supraocciput length (LSO), diameter of the posterior cranial fossa (PDFC), height of the posterior cranial fossa (PHFC), lateral diameter of the cerebellum (LDC), cerebellum height (HCL), cerebellum width (WCL), cerebrum height (HC), anterior dural angle of the cerebellum (ADAC), angle of the cerebellar clivus (ACC), anteroposterior diameter of the right cerebellar hemisphere (RCHD) and anteroposterior diameter of the left cerebellar hemisphere (LCHD) variables were measured.
Results: It has been determined that the difference between the groups for age, MCL, LSO, PHFC, HCL variables is statistically significant. The difference between genders is statistically significant for KI, LC, PHFC, LDC, WCL, HC, RCHD, LCHD variables in the first group, MCL, KI, LDC, HC, LCHD variables in the second group, LC, LDC, HCL, WCL, HC, ACC, LCHD variables in the third group.
Conclusion: Overall, the results show that aging and gender cause changes in cerebellum morphometry in healthy individuals for the Bolu (Türkiye) population.

Keywords: Cerebellum, magnetic resonance imaging, morphometry, sex differences, brain

INTRODUCTION

The cerebellum, situated in the posterior cranial fossa behind the pons and bulbus, is separated from these structures by the fourth ventricle to the posterior aspect of the cerebral trunk by bundles of the nerve fibers called pedunculus (1,2). Although it occupies only 10% of the brain in total volume, it contains 80% of the neurons of the brain (3). Thanks to these neuromuscular networks, it maintains the coordination of agonist and antagonist muscles, thus movement, and ensures the maintenance of posture and balance (3,4). Furthermore, recent studies have emphasized that the cerebellum has several striking functional spectrums such as perception, language, working memory, cognitive control, and thus contributes to cognitive and social development (4-6). Numerous studies have reported that the morphometric structure of the cerebellum, which is known to be anatomically and functionally extremely complex (7), is affected by neurodegenerative diseases (8,9) and habits such as alcohol (1,10), smoking (11), and sportive activities (12,13). Moreover, studies have presented the effects of the aging process on the cerebellum that provide a clearer understanding of the pathophysiological mechanisms (14,15). Research focusing on the morphometry of structures related to the brain has been employing the MRI device, which allows us to visualize and evaluate soft tissues clearly (13-15). Despite the substantial number of studies reporting how the cerebellum is affected in different populations and in different diseases and conditions (7-15), it is noteworthy to point out that studies concentrating particularly on the age- related anatomical changes in healthy individuals are limited (16-18). In this regard, this study has been designed to observe and evaluate the age and gender related changes in the morphometry of the cerebellum in healthy adults.

CITATION
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MATERIAL AND METHOD

The retrospective cross-sectional study was designed to present the morphometric changes of angular and linear variables of the cerebellum and cerebrum in a healthy adult Turkish population in relation to age and gender. Approval number 2024/61 was obtained from Clinical Research Ethics Committee, Bolu Abant İzzet Baysal University. Brain MR images taken between March and July 2024 and stored in the Picture Archiving and Communication Systems (PACS) of Bolu Abant Izzet Baysal University Training and Research Hospital, were used. Those diagnosed with cardiovascular, neurodegenerative, psychiatric diseases and those with ischemic attacks were excluded from the study. The sample group consisted of 300 healthy adults (150 women and 150 men) aged 25-55 years, and were divided into three age groups (25-34, 35-44, 45-55) and each group consists of 50 women and 50 men. Brain MR images obtained from the PACS archive were imported into MicroDicom DICOM Viewer 2024.1 (64 bit) for measurement of the identified variables. MR images were taken with 1.5 T Signa Explorer MRI Scanner (GE Medical Systems, Milwaukee, Wisconsin, USA. The measurements were performed by one person only to avoid inter-observer errors. Variables measured were as follow; diameter of the posterior cranial fossa (PDFC), MCRae line (MCL), Klaus index (KI), supraocciput length (LSO), height of the posterior cranial fossa (PHFC), cerebellum width (WCL), cerebrum height (HC), cerebellum height (HCL), anterior dural angle of the cerebellum (ADAC), clivus length (LC), clivus angle of the cerebellum (ACC), lateral diameter of the cerebellum (LDC), anteroposterior diameter of the left cerebellar hemisphere (LCHD), anteroposterior diameter of the right cerebellar hemisphere (RCHD). Demonstration of the variables are given in Figure 1.

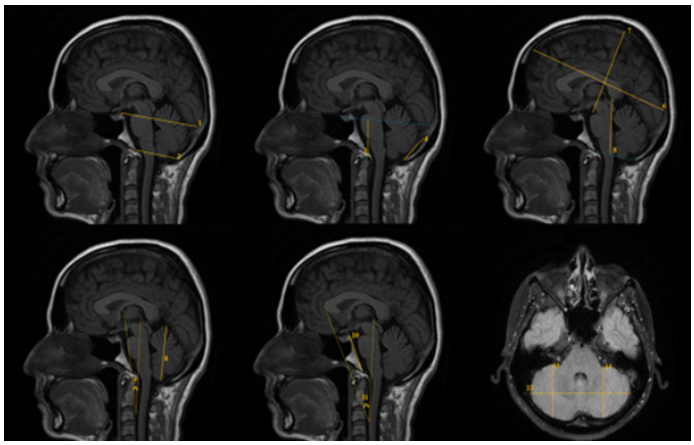

Figure 1. 1-PDFC, 2-MCL, 3-KI, 4-LSO, 5-PHFC, 6-WCL, 7-HC, 8-HCL, 9-ADAC, 10-LC, 11-ACC, 12-LDC, 13-LCHD, 14-RCHD; PDFC: diameter of the posterior cranial fossa, MCL: MCRae line, KI: Klaus index, LSO: supraocciput length, PHFC: height of the posterior cranial fossa, WCL: cerebellum width, HC: cerebrum height, HCL: cerebellum height, ADAC: anterior dural angle of the cerebellum, LC: clivus length, ACC: clivus angle of the cerebellum, LDC: lateral diameter of the cerebellum, LCHD: anteroposterior diameter of the left cerebellar hemisphere, RCHD: anteroposterior diameter of the right cerebellar hemisphere

Statistical Analysis

Analyses were conducted with RStudio (23.12.1) open-source software program. A two-factor analysis of variance was performed for all the variables in relation with age and gender. The normality distribution of the residual values was then tested with the Anderson Darling Test. Logarithmic and square root transformation was applied for the variables that do not fit the normal distribution. It yielded no significant result. Nonparametric variables analyzed the differences with the Kruskal-Wallis Test. For the variables that were significant upon the analysis with this test, Mann Whitney U Test was applied in pairs and the differences were again analyzed. For nonparametric variables, the differences of the individuals forming the groups were analyzed with Mann Whitney U Test in terms of gender, and parametric variables were checked with two-factor analysis of variance. Tukey Test was applied as a post-hoc test for parametric variables for the significant differences among the groups. Additionally, for the significant variables among the individuals of each group in terms of gender, Independent T Test was employed. As descriptive statistics, mean and standard deviation (sd) values for parametric variables, median, minimum (min) and maximum (max) values for nonparametric variables were calculated. $P<0.05$ was considered statistically significant.

RESULTS

The median values for the age variable in males and females respectively were 27.5 and 29 in the first group, 38.5 and 40 in the second group, and both 50 in the third group. The difference between the groups in age, MCL, LSO, PHFC, HCL variables was statistically significant. All groups were statistically different from each other in the age variable ($p<.001$). The difference between the first and third groups for the MCL variable was statistically significant ($p=0.018$). For the LSO variable, the difference between the second and third groups was statistically significant ($p=0.002$). In the HCL variable, the difference between the first and second group was not statistically significant, while the difference between the first and second group and the third group was statistically significant ($p=0.008$). The difference between the first and the third group in the PHFC variable was statistically significant ($p=0.012$).

In analyzing the individuals forming the groups in terms of gender, it was found that the difference in the variables of KI, LC, PHFC, LDC, WCL, HC, RCHD, LCHD was statistically significant for the first group. For the second group, the difference in MCL, KI, LDC, HC, LCHD variables is statistically significant. For the third group, the difference in LC, LDC, HCL, WCL, HC, ACC, LCHD variables was statistically significant.

Descriptive statistics of the variables and the results of the analysis among the groups in terms of gender were given in Table 1 and Table 2. The boxplot graph of the variables with significant differences was shown in Figure 2.

Table 1. Descriptive statistics and analysis results of Age, MCL, KI, LC, LSO, PDFC, and PHFC variables

Variable	Gender	G1 (N=100)	G2 (N=100)	G3 (N=100)	p-value
Age	M (n=50)	27.5 (25-34)	38.5 (35-45)	50 (45-55)	<.001⸗
	F (n=50)	29 (25-34)	40 (35-44)	50 (45-55)	
p-value≠		0.088	0.455	0.692	
MCL	M (n=50)	40.39 (28.14-51.35)	38.47 (27.5-49.42)	37.89 (28.7-55.99)	0.018⸗
	F (n=50)	38.72 (28.67-51.54)	37.3 (26.94-45.48)	36.86 (24.06-51.9)	
p-value≠		0.242	0.037	0.079	
KI	M (n=50)	45.75±6.13	45.96±6.68	43.88±7.45	<.001*
	F (n=50)	40.33±5.42	40.82±5.57	40.61±5.69	0.901**
p-value†		<.001	<.001	0.091	0.887***
LC	M (n=50)	36.47 (18.22-51.62)	34.52 (15.72-54.18)	37.92 (18.71-52.54)	0.254⸗
	F (n=50)	31.79 (16.92-47.81)	31.6 (15.86-47.97)	33.8 (16.45-46.47)	
p-value≠		0.009	0.203	0.008	
LSO	M (n=50)	37.91±5.43	38.14±5.36	37.17±6.16	0.807*
	F (n=50)	37.17±4.74	40.07±5.89	35.64±5.46	0.002**
p-value†		0.985	0.503	0.734	0.069***
PDFC	M (n=50)	96.59±6.39	96.06±8.13	94.07±7.33	0.001*
	F (n=50)	93.88±7.22	93.11±5.96	91.71±7.32	0.055**
p-value†		0.396	0.298	0.558	0.955***
PHFC	M (n=50)	62.34±6.1	58.71±7.16	58.52±6.41	<.001*
	F (n=50)	56.69±5.63	56.21±5.92	55.26±7.71	0.012**
p-value†		<.001	0.398	0.128	0.206***

≠: p values from Mann-Whitney U test; †: p-values in the result of the independent t-test; ⸗: the p-value from the Kruskal-Wallis test; *: the p value showing the difference between genders in the two-factor analysis of variance; **: the p value showing the differences among the groups in the two-factor analysis of variance; ***: the p-value indicating the interaction among the groups and between the gender in the two-factor analysis of variance

Table 2. Descriptive statistics and analysis results of LDC, HCL, WCL, HC, ADAC, ACC, RCHD, and LCHD variables

Variable	Gender	G1 (N=100)	G2 (N=100)	G3 (N=100)	p-value
LDC	M (n=50)	105.87±5.11	106.68±3.48	104.88±4.07	<.001*
	F (n=50)	101.98±3.5	101.8±4.43	101.96±5.05	0.404**
p-value†		<.001	<.001	0.01	0.282***
HCL	M (n=50)	52.78±4.54	51.42±5.19	51±4.64	<.001*
	F (n=50)	50.06±3.77	51.36±5.01	48.21±5.08	0.008**
p-value†		0.050	0.999	0.039	0.067***
WCL	M (n=50)	165.94 (142.46-190)	163.16 (147.65-183.71)	168.57 (141.66-181.91)	0.489⸗
	F (n=50)	162.6 (137.18-177.15)	161.17 (70.83-182.05)	159.64 (107.04-176.18)	
p-value≠		0.007	0.090	<.001	
HC	M (n=50)	100.5 (65.15-114.68)	98.72 (67.96-110.2)	96.4 (80.6-111.73)	0.198⸗
	F (n=50)	93.14 (65.03-106.52)	93.76 (10.54-109.65)	93.7 (63.85-104.2)	
p-value≠		<.001	<.001	0.006	
ADAC	M (n=50)	12.35±1.8	12.12±1.56	11.81±1.92	0.185*
	F (n=50)	12.65±2.11	12.4±2.68	12.17±2.15	0.220**
p-value†		0.976	0.985	0.948	0.988***
ACC	M (n=50)	26.22 (20.4-33.85)	26.73 (19.39-33.4)	25.16 (16.34-32.03)	0.319⸗
	F (n=50)	27.91 (20.31-36.8)	26.52 (19-50.13)	26.73 (19.44-33.46)	
p-value≠		0.180	0.917	0.034	
RCHD	M (n=50)	50.21±4.26	49.36±3.47	49.79±5.03	0.001*
	F (n=50)	47.58±4.08	48.18±3.79	49.09±4.01	0.478**
p-value†		0.020	0.710	0.958	0.203***
LCHD	M (n=50)	53 (39.16-59)	52.16 (39.94-61.38)	52.19 (26.44-62.64)	0.689⸗
	F (n=50)	49.64 (32.68-58.22)	50.03 (42.56-56.94)	49.45 (41.7-58.45)	
p-value≠		0.001	0.004	0.002	

≠: p values from Mann-Whitney U test; †: p-values in the result of the independent t-test; ⸗: the p-value from the Kruskal-Wallis test; *: the p value showing the differences between the genders in the two-factor analysis of variance; **: the p value showing the differences among the groups in the two-factor analysis of variance; ***: the p-value indicating the interaction among the groups and between the genders in the two-factor analysis of variance

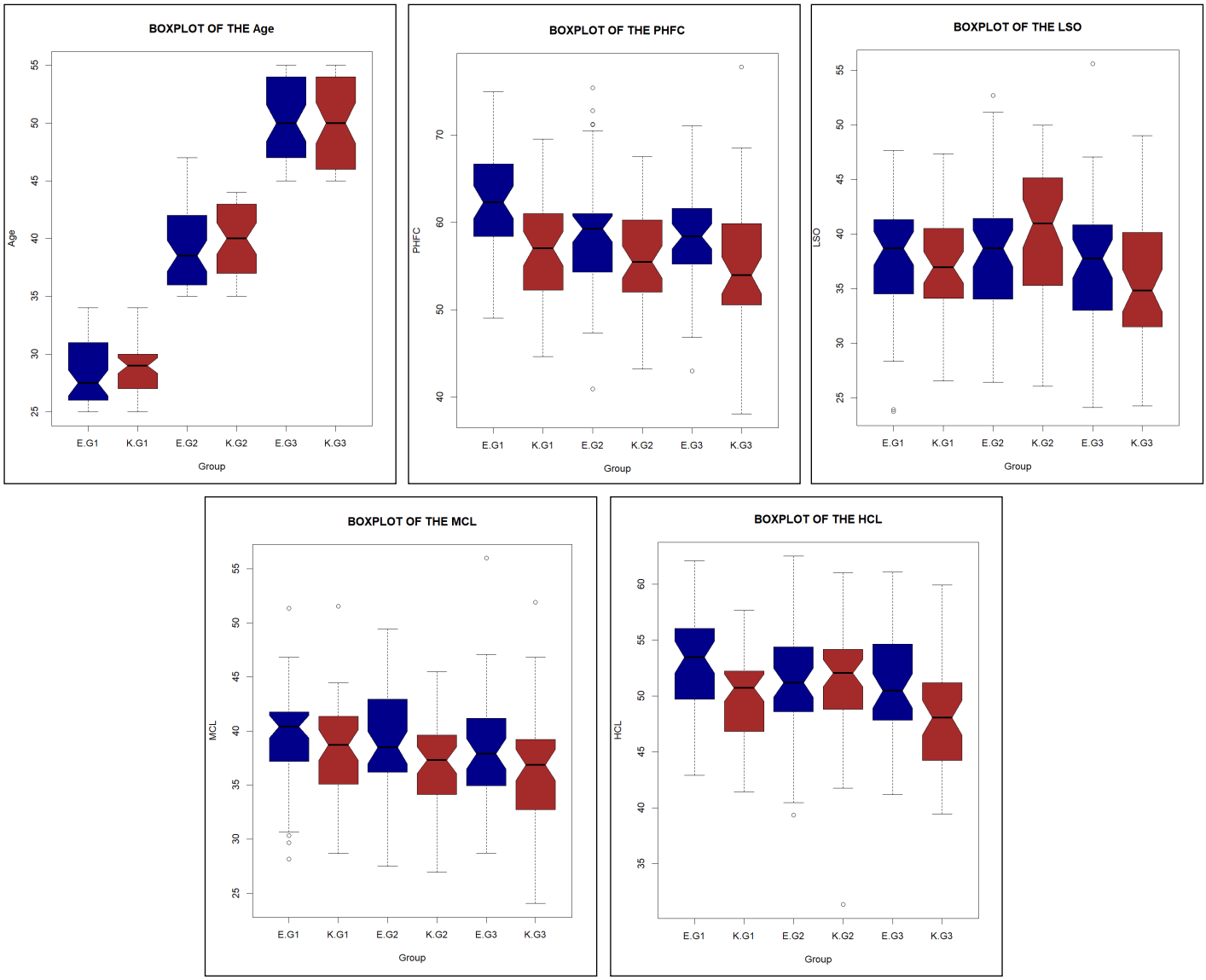

Figure 2. Boxplot for Age, PHFC, LSO, MCL and HCL variables

DISCUSSION

Anatomical and physiological changes in healthy individuals during the life span starting with the birth process and continuing into old age have been the subject of several research. In particular, the evaluation of age-related changes in healthy brain and its parts allows to help detection of pathological conditions and monitoring of changes in the brain caused by the natural aging process (18). The changes seen in the brain with aging are accompanied by deterioration in cognitive functions and this is also affected by gender (19). In this regard, the present study aims to fill the gap in literature by reporting the changes in cerebellum morphometry according to age and gender in healthy adults aged 25-55 years. While age-related changes have been found to be statistically significant for the MCL, LSO, PHFC and HCL variables evaluated in the study, it has also been determined that most variables show gender-related changes within the groups.

This age- and gender-related change observed in the present study is supported by several studies in literature. In a longitudinal study conducted in healthy children and adolescents to examine cerebellum development (3), the cerebellum volume has been found to be higher in males, even when compared to total brain volume. The fact that this difference is larger during adolescence indicates that this organ shows gender dimorphism. Another study (18), which aimed to assess the correlation of volumetric changes in the cerebellum with age and gender in healthy participants, has found a larger volume in males in all age groups, suggesting that this result may reflect gender differences in the body as well. Another research aiming to evaluate the correlation of white and gray matter and volumetric variables with cognitive functions with aging in the brain (19) has found an age-related decrease in the volumes of gray and white matter regions in both sexes. Moreover, differences have been observed between genders in the regions where the volume has decreased and in the slope of the decrease. Another study (20), which aimed to present the effect of aging on cerebellum volume, has grouped participants between the ages of 25 and 65 as early and late adults. As a result of the study, it has been reported that a decrease in cerebellum volume and atrophy

in gray matter have been observed in the late adult group. In a similar study (21), aging-related morphologic changes in the cerebellum in healthy participants between the ages of 20 and 80 have been presented with the convolutional neural network method. It has been found that aging causes a significant decrease in the absolute volumes of cerebellum subregions and atrophies in some cerebellar regions are more pronounced in men. In a study (22) designed with the method of convolutional neural network and aiming to reveal resent the gender differences of the cerebrum and cerebellum, it has been found that some subregions of the cerebellum show gender dimorphism. Another study evaluating brain volume changes in relation to aging has reported a decrease in brain volume and cerebellar atrophy (23). A study involving participants aged between 50 and 95 years (24) has examined the changes in the regions of the cerebellum during normal aging. The findings of the study have indicated that aging-related volumetric atrophy in several subregions of the cerebellum, and in addition, the findings have been affected by gender. In another study designed to reflect the morphometry of the lobules of the cerebellum and its relationship with cognitive status in healthy elderly people (25), segmentation method has been used, suggesting that there is a decrease in lobule volumes and cognition from middle age to old age.

Research involving in the measurements of linear variables of the cerebellum in a Sudanese population (26), contrary to the present study, has found no significant result between the age and the variables. Furthermore, the study findings have been found to be lower compared to the present study. This difference is thought to be due to the different populations, age distribution, and number of participants included in the case. Another study (27) on the evaluation of the variables of the posterior cranial fossa in a healthy population in relation to age and gender, has documented higher LSO variables than the present study while the other variables have been observed to be lower. The difference observed has not been found to be statistically significant, as in the present study, but the gender-related change was significant. Likewise, another report (28) which has analyzed the MCL variable using a bone collection from a South Indian population for the craniovertebral junction analysis, has reached a lower result than the present study. This is thought to be because different populations have been studied and the current study used MR images that also reflect soft tissues as a method. Furthermore, a study investigating the morphometry of the cranium, cerebrum and cerebellum in patients diagnosed with tonsillar herniation (29), has shown lower values of the linear variables in patients, as compared to healthy controls. The morphometric values of the control group have had very similar patterns, in comparison with the values of the present study. Yet, another study (30) performed on the morphometric analysis on brain MR images in patients between the ages of 20 and 65 diagnosed with Chiari malformation and healthy control subjects, has revealed volumetric decreases in the patient group. In the control group, on the other hand, the LC variable has been significantly higher and the MCL and KI variables lower than those in the present study. Finally, another report (31) focusing on the morphometric evaluation of the posterior cranial fossa in patients with Chiari malformation, has found higher values in the LC, LSO and HCL variables for the control group, in comparison with the present study. Although this difference between the studies has not been statistically significant, it may be attributed to the fact that the sample group in the present study consists of more participants.

Consequently, it is of essential to indicate that the study has certain limitations such as the retrospective design, the fact that radiological analyzes have been performed by a single specialist, the lack of participants from advanced age groups in the sample group, and the lack of variables evaluating hormonal processes such as childbirth and breastfeeding process in female participants.

CONCLUSION

The age-related change has been found to be statistically significant for MCL, LSO, PHFC, and HCL variables evaluated in the study. In the analysis of the individuals comprising the groups in terms of gender, it has been determined that the differences in KI, LC, PHFC, LDC, WCL, HC, RCHD, LCHD variables for the first group are statistically significant. For the second group, the differences in MCL, KI, LDC, HC, LCHD variables are statistically significant. For the third group, the differences in LC, LDC, HCL, WCL, HC, ACC, LCHD variables have been found to be statistically significant. It is thought that the present study provides a structural basis for the clinic by presenting atrophic changes in cerebellum morphometry during healthy aging with the effect of gender.

This study was presented orally at the 2nd International Congress of Multidisciplinary Medical and Health Sciences Studies on May 27-28, 2024.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Approval number 2024/61 was obtained from Clinical Research Ethics Committee, Bolu Abant İzzet Baysal University.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Can First Trimester Plasma Protein A Level Predict Gestational Diabetes Mellitus

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Abstract

Aim: Gestational diabetes mellitus (GDM), a condition with multifactorial etiology and adverse perinatal consequences, affects approximately 15% of pregnancies globally, with higher prevalence in certain populations, such as Türkiye. The role of pregnancy-associated plasma protein-A (PAPP-A) on GDM risk remains unclear. This prospective study aimed to assess whether first-trimester maternal PAPP-A levels are predictive of GDM.
Material and Method: This study involved 573 singleton pregnancies in women aged 18 to 45 years, conducted at a tertiary maternity hospital. PAPP-A and free β-hCG were assessed, and GDM screening was carried out using a 75 g oral glucose tolerance test. Comprehensive statistical analyses were applied to evaluate the findings.
Results: Of the participants, 28.09% were diagnosed with GDM. GDM group exhibited significantly lower PAPP-A MoM levels compared to controls (p=0.042). ROC analysis revealed limited predictive utility, with a PAPP-A threshold of 0.99 demonstrating 52.3% sensitivity and 51.7% specificity. Logistic regression identified low PAPP-A levels, advanced maternal age, and higher body mass index (BMI) as independent GDM risk factors.
Conclusion: While the findings underscore a potential association between PAPP-A levels and GDM, the predictive capacity of PAPP-A alone is modest. Future research should explore integrated predictive models incorporating PAPP-A and other biomarkers for improved early GDM screening.

Keywords: Gestational diabetes, pregnancy-associated plasma protein-A, pregnancy

INTRODUCTION

Gestational diabetes mellitus (GDM) is a condition characterized by impaired glucose metabolism first recognized during pregnancy and diagnosed within the gestational period (1,2) and complicates approximately 15% of all pregnancies (3). The prevalence of GDM varies significantly across different countries, with studies in Türkiye indicating a high prevalence rate of 27.9%, which surpasses the rates observed in many other nations (4-6). Given the direct relationship between maternal exposure to GDM and both long/short-term adverse outcomes in offspring, it is crucial to assess the accuracy of any diagnostics, using routine first or second trimester maternal biomarkers, to identify women at risk of GDM (7).

The etiology of GDM is considered to be multifactorial (1). In the pathogenesis of GDM, the role of Pregnancy Associated Plasma Protein-A (PAPP-A) has not been fully elucidated (1,8). PAPP-A is a biomarker utilized during first-trimester screening to assess the risk of fetal aneuploidies such as Down syndrome (trisomy 21), trisomy 13, and trisomy 18 (9). Its involvement in glucose regulation is notable, as reduced PAPP-A levels may contribute to glucose intolerance and the development of gestational diabetes. Assessing PAPP-A levels may offer important insights for predicting and addressing metabolic disorders in pregnancy (8,10).

Research examining the relationship between PAPP-A levels and the risk of diagnosing GDM has produced varying outcomes, emphasizing the absence of a clear consensus in the current scientific literature(10-14).

The aim of this study is to investigate whether PAPP-A levels are associated with the risk of developing GDM. Additionally, the study evaluates the potential value of PAPP-A as a stand alone biomarker in predicting the risk of GDM.

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MATERIAL AND METHOD

From July 2021 to December 2022, a tertiary care maternity hospital hosted this prospective observational study. The study enrolled singleton pregnant women aged 18 to 45 years, with PAPP-A and free β human chorionic gonadotrophin (free β-hCG) levels measured between 11 and 14 weeks of gestation for fetal aneuploidy screening. A 75 g oral glucose tolerance test (OGTT) was also conducted during the study period.

Using a 75 g OGTT, GDM screening was carried out between weeks 24 and 28 of pregnancy. Patients with pregestational diabetes, those using immunosuppressive medication, those having chronic illnesses or infections identified prior to pregnancy, those who had numerous pregnancies, and those on hormone therapy were not included. Fetal abnormalities identified prenatally were also excluded. Additionally excluded were those having obstetric problems such hemolysis, elevated liver enzymes and low platelets (HELLP) syndrome, pre-eclampsia, or prenatal hypertension. The research protocol received approval from the Local Ethics Committee (approval number E2-21-513). During patient interviews, the following information was noted: smoking, age, parity, gestational week. Two milliliters of venous blood were drawn and placed in yellow-capped BD Vacutainer® SSTTM (Serum Separator Tube) tubes for aneuploidy screening. The tubes were then left to clot for twenty minutes. Serum was subsequently extracted from the samples by centrifuging them for 15 minutes at 1000 × g in a NÜVE NF 800R Refrigerated Centrifuge. Serum free β-Hcg and PAPP-A levels were assessed using the Siemens Immulite 2000 XPi Immunoassay System (Siemens, Los Angeles, USA) and the Chemiluminescence Immunoassay (CLIA) method. The PRISCA 5 Prenatal Risk Assessment Software was used to analyze the findings. 161 (28.09%) of the 573 pregnant women developed GDM. GDM cases had significantly lower maternal PAPP-A MoM concentrations than the control group (p=0.042). Furthermore, the low PAPP-A group had significantly greater maternal age (p=0.036) and body mass index (BMI) (p<0.01), respectively. The PAPP-A multiple of the median (MoM) level threshold value for predicting GDM was established by ROC analysis. 161 (28.09%) of the 573 pregnant women developed GDM. In the group with low PAPP-A levels, both maternal age (p=0.036) and BMI (p<0.01) were significantly higher. A p-value of less than 0.05 is regarded as suggestive of statistical significance, and statistical analyses were conducted using SPSS software version 25.0 (SPSS Inc., Chicago, IL, USA). Frequency distributions were used to summarize categorical data, while mean±SD or median values were used to express continuous variables along with the interquartile range (IQR). Fisher's exact test or the chi-square test were used for categorical variable analysis, and the independent t-test or the Mann-Whitney U test, as appropriate, were used for group comparisons for continuous variables.

RESULTS

This study comprised 573 pregnant women with singleton pregnancies. 412 (71.91%) of the participants did not have a GDM diagnosis, while 161 (28.09%) did. Two groups of participants were formed based on their PAPP-A levels; PAPP-A levels were normal in 453 women and low in 121 women. Pregnant with GDM exhibited a median PAPP-A MoM of 0.68 (interquartile range [IQR]: 0.30–1.63), whereas pregnant without GDM had a median value of 0.85 (IQR: 0.32–2.49) (Table 1). GDM was linked to a low serum PAPP-A MoM level (p=0.042). However, women with and without GDM did not significantly differ in their levels of free β-hCG (p=0.801) (Table 2).

Table 1. Maternal and pregnancy characteristics of the study population characteristics PAPP-A MoM

	PAPP-A MoM<0.4 (n=120)	PAPP-A MoM≥0.4 (n=453)	p-value
Maternal age	32.61 (±4.8)	29.5±5.4	0.036
Gravida	2.4±1,6	1.9±1	0.000
Weight (kg)	70.4±10	68.1±11	0.023
BMI (kg/m²)	30.2±4.4	27.6±3.4	0.000
Smoker (n)	2 (1.66%)	6 (1.32%)	0.019
Gestational age	12	11.7±0.2	0.468

BMI: body mass index, PAPP-A : pregnancy-associated plasma protein-A, MoM: multiple of the median

Table 2. Median values of maternal serum biomarkers and nuchal translucency length in women with Gestational diabetes mellitus and normal pregnancies

	GDM group (n=161)	Non-GDM group (n=412)	P value
free-βhCG MoM, median (IQR)	0.76 (0.38-3.6)	0.68 (0.45-2.6)	0.801
free-βhCG (MU/L) median (IQR)	25.9 (14.7-146)	30.4 (14.3-97)	0.941
PAPP-A MoM, median (IQR)	0.68 (0.30-1.63)	0.85 (0.32-2.49)	0.042
PAPP-A (MU/L) median (IQR)	2.24 (0.60-10)	3.57 (0.47-10)	0.06

Data are presented as median (IQR); The mann-Whitney test was employed to compare the numerical variables between groups Gestational diabetes mellitus (GDM), free β-human chorionic gonadotropin (fβ-hCG), Interquartile range (IQR), Multiple of the median (MoM), pregnancy associated plasma protein A (PAP-A)

The independent risk factors linked to GDM were found using binary logistic regression analysis. The study discovered that lower PAPP-A MoM levels (OR=0.893, p=0.020), older maternal age (OR=1.030, p=0.001), and greater maternal weight (OR=1.028, p=0.001) were significant independent risk factors for GDM (Table 3). ROC analysis revealed that the PAPP-A MoM concentration threshold value for predicting GDM was 0.99. This threshold showed 52.3% sensitivity and 51.7% specificity. Its area under the curve (AUC) was 0.527, with a 95% CI of 0.46–0.59 (Figure 1).

Table 3. Investigation of the risk factors for GDM using binary logistic regression analysis OR 95%CI SE P value

	OR	95% C.I.for RR		P value
		Lower	Upper	
PAPP-A MoM	0.893	0.807	0.990	0.020
Maternal age	1.030	1.022	1.034	0.001
Weight	1.028	1.026	1.034	0.001

Binary logistic analysis was used to evaluate the relationship between GDM and maternal factors Odds ratio (OR), confidence interval (CI), multiple of the median (MoM), pregnancy-associated plasma protein A (PPAP-A)

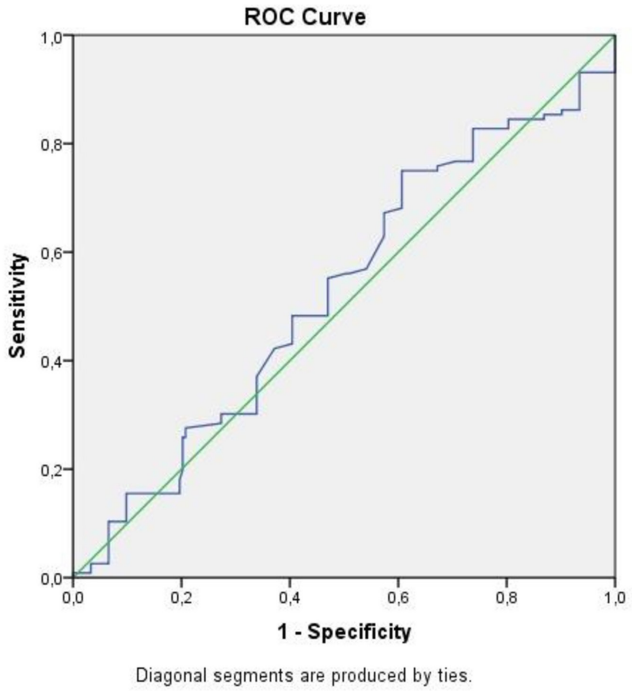

Figure 1. Roc curve statistics for PAP-a MoM level to predict

Analysis of Risk Factors

The following independent risk variables for GDM were found using binary logistic regression analysis:

1. Lower levels of PAPP-A MoM (OR=0.893, 95% CI: 0.807–0.990, p=0.020).
2. Maternal age at advanced age shows a significant association (OR=1.030, 95% CI: 1.022–1.034, p=0.001).
3. Greater maternal weight (p=0.001, OR=1.028, 95% CI: 1.026–1.034). The predictive value of PAPP-A for GDM and the usefulness of PAPP-A levels as a predictive marker for GDM were evaluated using ROC curve analysis. With a PAPP-A MoM threshold of 0.99, 52.3% sensitivity and 51.7% specificity were obtained. The area under the curve (AUC) was 0.473 with a 95% CI of: 0.523–0.561, suggesting that PAPP-A's prognostic power as a stand-alone marker for GDM is limited (Table 3).

DISCUSSION

This research explored the connection between PAPP-A and the likelihood of developing GDM. The results indicated that maternal PAPP-A levels were notably lower in individuals with GDM compared to those without, consistent with prior studies linking decreased PAPP-A levels to adverse pregnancy outcomes, including GDM (10-12,15-17). Despite this correlation, the standalone predictive value of PAPP-A for GDM was found to be modest, emphasizing the need for further exploration of integrated approaches to risk prediction.

Role of Insulin Resistance (IR) in GDM remains the cornerstone of GDM pathophysiology. Pregnancy naturally induces a state of IR, which is exacerbated due to decreased β-cell function and insulin receptor activity in adipose tissue (18,19). In this study, both age and BMI were significantly higher in GDM patients, consistent with earlier reports (1,19). Interventions aimed at improving maternal glucose metabolism in early pregnancy may reduce GDM risk; however, late diagnosis often limits the effectiveness of preventive measures (20).

PAPP-A is plays a key role in modulating the activity of insulin-like growth factors (IGFs) by breaking down IGF binding proteins, thereby affecting the bioavailability of IGFs. It has been extensively studied in various scenarios, including its significance during pregnancy and its association with conditions such as GDM and diabetic nephropathy. This mechanism is critical for placental development, functionality, and fetal growth (8-10). IGFs also play a pivotal role in modulating insulin sensitivity. Reduced PAPP-A levels in early pregnancy may impair IGF function, thereby contributing to glucose intolerance and IR. Supporting this hypothesis, recent meta-analyses and studies have linked low PAPP-A levels with GDM and other complications, including fetal growth restriction and preeclampsia (9,21-23). However, the predictive capacity of PAPP-A remains controversial, as sensitivity and specificity for GDM prediction are limited (24).

In some studies, no association has been found between PAPP-A and GDM (13,14,25). This inconsistency may

be attributed to differences in patient characteristics, diagnostic criteria, and varying severity of GDM. PAPP-A levels did not alter in women with GDM who needed insulin treatment between weeks 11 and 14 of pregnancy, according to Husslein et al. (26).

Therefore, combining PAPP-A measurements with other clinical tests may be necessary for better prediction of GDM risk. Since it was not within the scope of our study, we did not combine or compare other routinely checked markers with PAPP-A for GDM prediction (27).

Ethnic Variations in Biomarker Levels

Ethnic diversity is a critical factor. Variations in PAPP-A, free β-hCG, and placental growth factor (PlGF) levels across ethnic groups have been documented, with Asian women generally exhibiting higher PAPP-A levels and lower PLGF levels than in Caucasian populations (28). Despite these differences, studies investigating PAPP-A and its relationship with GDM in specific populations, such as Chinese women, remain limited (28). Future research should address these gaps to develop population-specific predictive models that account for ethnic variability.

Study Limitations

The primary limitations of this study include its single-center design and the relatively small sample size, which may restrict the generalizability of the findings to broader populations. Second, we did not classify GDM cases by severity or type, which may influence biomarker associations. Third, adverse neonatal and maternal outcomes associated with GDM were beyond the scope of this research. Future studies with larger, multicenter cohorts should explore the combined predictive value of PAPP-A with other clinical and biochemical markers. Additionally, longitudinal studies assessing the dynamic changes in biomarker levels throughout pregnancy could provide deeper insights into the temporal relationships between biomarkers and GDM development.

CONCLUSION

In conclusion, while first-trimester PAPP-A levels were inversely associated with GDM risk, their predictive accuracy as a standalone marker was limited. Integrating PAPP-A with other biomarkers and maternal risk factors holds potential for enhancing early GDM prediction. Given the rising prevalence of GDM and its implications for maternal and neonatal health, further research is essential to establish robust, clinically applicable predictive models for early intervention and improved outcomes.

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Research Article

Investigation of Normalized Volume Ratios of Motor and Sensory Cortices on Magnetic Resonance Images in Parkinson's Disease Patients: An Automatic Brain Segmentation Study

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Abstract

Aim: This study evaluates structural changes in the normalized volume ratios of the motor and sensory cortices in Parkinson's patients and compares these changes with healthy individuals to assess the disease's impact on brain structure.
Material and Method: The study included 55 Parkinson's patients (14 females, 41 males) and 28 control subjects (7 females, 21 males). The volumes of the precentral gyrus, paracentral lobulus, and postcentral gyrus were calculated using the BrainSuite automated segmentation software. Regional gray matter volumes were normalized by dividing them by the intracranial volume, and these normalized values were used for comparisons. Volumetric analyses were conducted on the precentral gyrus, postcentral gyrus, and paracentral lobulus to assess their morphological changes associated with Parkinson's disease.
Results: Results: In the left hemisphere, the normalized gray matter volume ratios of the postcentral gyrus were found to be lower in Parkinson's patients (0.82%±0.09) compared to the control group (0.88%±0.09) ($p<0.05$). According to MANOVA analysis, significant differences were observed in the normalized gray matter volumes of the precentral gyrus (KEK=0.069, $p=0.001$) and postcentral gyrus (KEK=0.300, $p<0.001$) concerning hemisphere and age variables. Significant differences were found in the precentral gyrus (KEK=0.034, $p=0.019$) and paracentral lobule (KEK=0.026, $p=0.041$) based on gender. In terms of group differences, a significant result was found in the postcentral gyrus (KEK=0.071, $p=0.001$) when comparing Parkinson's disease patients and healthy controls, while no significant differences were observed in the precentral gyrus (KEK=0.011, $p=0.193$) and paracentral lobule (KEK=0.000, $p=0.792$).
Conclusion: Significant structural differences were identified in the normalized gray matter volumes of Parkinson's patients, specifically in the left postcentral gyrus, where a reduction in volume was observed compared to the control group. This study highlights the importance of normalization in accurately assessing volumetric differences and provides valuable insights into the structural changes associated with Parkinson's disease, contributing to the existing literature.

Keywords: Precentral gyrus, paracentral lobulus, postcentral gyrus, intracranial volume, BrainSuite

INTRODUCTION

The primary motor cortex is located in the precentral gyrus region of the frontal lobe and plays a role in initiating voluntary movement. The motor cortex is connected to various structures, including the parietal lobe, premotor cortex, supplementary motor areas, basal ganglia, and cerebellum (1,2). It also receives afferent information from somatosensory, premotor and supplementary motor areas. On the other hand, the primary sensory cortex is located in the postcentral gyrus region of the parietal lobe and extends medially toward the paracentral lobule. This area processes sensory inputs such as touch and pressure and is responsible for interpreting information from muscle spindles and joint position (3-5).

Parkinson's disease (PD) is a neurodegenerative disorder primarily characterized by motor symptoms such as tremors, rigidity, and bradykinesia (6,7). However, non-motor symptoms may also appear in the early stages of the disease. These symptoms include cognitive impairment, autonomic dysfunction, fatigue, and pain (8,9). Given the complex nature of PD, it is hypothesized that it may cause structural and functional changes throughout the

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brain. Within this framework, it is thought that sensory dysfunctions may also be associated with motor function impairments (10). The gait and balance disturbances observed in PD are believed to be due to feedback from proprioceptive sensory systems.

Brain volume values are influenced by gender, head size, and other anatomical variations among individuals (11). Therefore, these values must be evaluated relative to a fixed reference value to enable accurate comparisons of volume values. This process is called normalization, a commonly used method in brain volume analyses (12,13). Specifically, the ratio of gray matter volumes to intracranial cavity volume (ICV) allows for an objective and comparable assessment of group volume differences (14).

The primary aim of this study is to examine the normalized gray matter volume ratios in the precentral gyrus, postcentral gyrus, and paracentral lobule of Parkinson's patients and to contribute to a more consistent and objective evaluation of volumetric data.

MATERIAL AND METHOD

Study Participants and Imaging Data

This study was initiated with the approval of the Non-Interventional Clinical Research Ethics Committee of Tokat Gaziosmanpaşa University Faculty of Medicine (approval number: 83116987-327). For the patient group, magnetic resonance (MR) images of patients diagnosed with Parkinson's disease based on neurological examination at the neurology department were used. Patients with a history of head trauma, brain surgery, trauma, or pathological conditions were excluded from the study. The healthy control group consisted of individuals who visited the hospital for various reasons, underwent MR imaging as part of routine examinations, and had no neurological diagnoses. The images were retrospectively reviewed through the faculty's patient follow-up system. Five MR images from the patient group and two MR images from the control group were excluded due to imaging artifacts. A total of 83 MR images, including 55 from the Parkinson's patient group and 28 from the control group, were included in the study.

Image Processing

MR images were acquired using a Philips Medical Systems 3.0 T Gyroscan NT MRI scanner. The images had the following specifications: voxel size of 1 mm x 1 mm x 1 mm, TR=8.1 ms, TE=3.7 ms, TFE=230 ms, flip angle=8°, matrix size of 224 x 224 pixels, and a field of view (FOV) of 224x224 cm. The acquired image series were selected as three-dimensional sagittal plane slices and transferred to the Horos program (V4.3.1) in Digital Imaging and Communications in Medicine (DICOM) format. Subsequently, the image voxel depth series, width, and height were adjusted to 1 mm using the ImageJ program. With a slice thickness of 1 mm, these image series were rotated 90 degrees to create a new axial image series. The obtained axial image series were saved in Analyze 7.5 format and reprocessed for use in the BrainSuite program. Finally, the automatic segmentation of MR images was performed using the BrainSuite software.

Automatic Segmentation Method: BrainSuite

In the BrainSuite program, the "cortical surface extraction sequence" was selected under the "cortex" menu for cortical surface area extraction. The "skull stripping" step, the initial and fundamental phase of the analysis, involved separating the cranium and meningeal tissues and defining the boundaries of the cerebrum (Figure 1). For image series where the boundaries of the cerebrum were not fully enclosed, adjustments were made in the diffusion constant, edge constant, and erosion size tabs. After the cerebrum boundaries were defined correctly, the analysis proceeded, and the remaining steps were performed automatically. The mask.nii.gz file, in which the cranium boundaries were determined by excluding other structures, was saved in a separate folder to calculate the ICV. Once the analysis was completed, the total volumes of the brain, hemispheres, cortical and subcortical regions, gray and white matter volumes, cortical surface area, and cortical thickness values were automatically saved as a "roiwise.stats" file in the BrainSuite program.

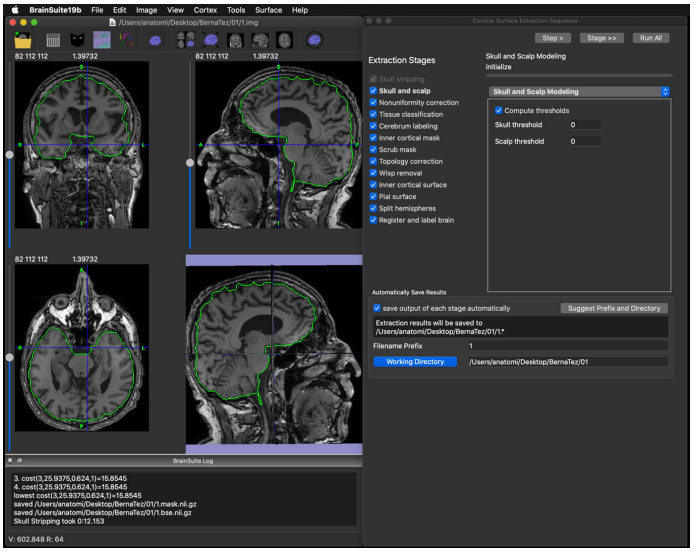

Figure 1. The initial phase of the BrainSuite program

Measurement of Intracranial Volume Using ImageJ Software and the Cavalieri Principle

ICV was measured using the ImageJ software (version 1.52a) and the "mask.nii.gz" file generated by the BrainSuite program. First, DICOM files were converted into a 16-bit image stack using the "Convert Images to Stack" function under the "Stacks" submenu. Then, a threshold value was applied to convert the images into a binary image that matched the original image.

Next, the ICV was manually defined as the region of interest (ROI) for each boundary using the "Polygon Selection Tool" under the "Analyze > Tools" menu. Each slice of the ROI was added to the ROI manager using the "Add" function, and the area of each ROI was calculated using the "Measure" function in the ROI manager menu.

The wand tool was used to measure the cross-sectional area of the ROI, and the software automatically measured the cross-sectional area. The ICV was calculated using the Cavalieri principle, which multiplies the total cross-sectional surface area by the slice thickness and cortical thickness.

To obtain the ICV, the sum of the areas of all ROIs (mm^2) was multiplied by the slice thickness (mm), yielding the ICV (mm^3).

Statistical Analysis

The statistical analysis of volumetric and demographic data obtained from the study was performed using SPSS (Statistical Package for the Social Sciences, version 25) software. Descriptive statistics of the data were presented with parameters such as numbers (n), means, and standard deviations (SD). For comparisons between groups, the normality distribution of the data was assessed using the Kolmogorov-Smirnov test. The independent samples t-test was used for data that met the normality assumption, while the Mann-Whitney U test was preferred for data that did not meet the normality assumption. Normalized volume data were analyzed using multivariate analysis of variance (MANOVA) to examine factors such as group, region (right/left), group and region interaction, gender, and age. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 83 participants were included in this study, consisting of 55 Parkinson's patients and 28 healthy controls. The age, number of subjects, cerebral and ICV volumes are listed in Table 1.

Table 1. Demographic characteristics, cerebral volume, and ICV of Parkinson patients and controls

	Parkinson patients	Controls
Subject number (n)	55	28
Age (years)	61.63±10.07	60.89±10.43
Sex (F/M) (n)	14/41	7/21
Cerebral volume (right/left)	229.18±20.6/227.6±19.1	231.55±21.9/229.00±20.5
ICV (cm^3)	1520.17±124.8	1485.44±121.1

F/M: female/male, ICV: intracranial volume

The gray matter volume of the precentral gyrus in the right hemisphere of Parkinson's patients was 11.41±1.49 cm^3, compared to 11.67±1.45 cm^3 in the control group. In the left hemisphere, it was 10.97±1.37 cm^3 for Parkinson's patients and 10.80±1.39 cm^3 for controls. The volumes of the precentral gyrus in both hemispheres showed no significant differences between the Parkinson's patients and the control group (p>0.05). The paracentral lobule volumes in Parkinson's patients were 3.97±0.61 cm^3 and 3.84±0.56 cm^3, compared to 3.81±0.55 cm^3 and 3.82±0.62 cm^3 in the control group; these differences were not significant (p>0.05). Similarly, the gray matter volumes of the postcentral gyrus were 10.74±1.73 cm^3 and 12.43±1.65 cm^3 in Parkinson's patients, versus 11.18±1.40 cm^3 and 13.09±1.51 cm^3 in the control group, also showing no significant differences (p>0.05). All results are presented in Table 2.

Table 2. Comparison of gray matter volumes in motor and sensory cortices between parkinson patients and controls

Side	Region	Gray matter volume (cm^3)		p
		Parkinson patients (mean±SD)	Controls (mean±SD)	
Right	**Precentral gyrus**	11.41±1.49	11.67±1.45	0.45
	Paracentral lobule	3.97±0.61	3.81±0.55	0.44
	Postcentral gyrus	10.74±1.73	11.18±1.40	0.24
Left	**Precentral gyrus**	10.97±1.37	10.80±1.39	0.60
	Paracentral lobule	3.84±0.56	3.82±0.62	0.87
	Postcentral gyrus	12.43±1.65	13.09±1.51	0.08

SD: standard deviation; the parts determined in bold are statistically significant (p<0.05)

In Parkinson's patients, the normalized gray matter ratios of the precentral gyrus were 0.75%±0.09 in the right hemisphere and 0.72%±0.09 in the left, compared to 0.79%±0.08 and 0.73%±0.08 in the control group, respectively. Statistical analysis showed no significant differences between the groups for these measurements (p>0.05). For the paracentral lobule, the gray matter ratios in both hemispheres of Parkinson's patients were consistently 0.26%±0.03, compared to 0.25%±0.03 in the right and 0.26%±0.04 in the left hemisphere of the control group, with no significant differences observed (p>0.05). However, in the postcentral gyrus, Parkinson's patients had gray matter ratios of 0.71%±0.11 in the right hemisphere and 0.82%±0.09 in the left, whereas the control group had ratios of 0.75%±0.08 and 0.88%±0.09, respectively. The significant difference was noted only in the left hemisphere, where the gray matter ratio was lower in Parkinson's patients compared to controls (p<0.05). These findings are detailed in Table 3.

Table 3. Comparison of normalized gray matter volumes in motor and sensory cortices between parkinson's patients and healthy controls

Side	Region	Gray matter volume/ICV (%)		p
		Parkinson patients (mean±SD)	Controls (mean±SD)	
Right	Precentral gyrus	0.75±0.09	0.79±0.08	0.07
	Paracentral lobule	0.26±0.03	0.25±0.03	0.90
	Postcentral gyrus	0.71±0.11	0.75±0.08	0.05
Left	Precentral gyrus	0.72±0.09	0.73±0.08	0.79
	Paracentral lobule	0.26±0.03	0.26±0.04	0.58
	Postcentral gyrus	0.82±0.09	0.88±0.09	**0.003**

SD: standard deviation; the parts determined in bold are statistically significant (p<0.05); ICV: intracranial volume

There were no statistically significant differences in the normalized gray matter volumes of the precentral gyrus (p=0.193) and paracentral lobule (p=0.792) between groups. However, significant differences were found in the postcentral gyrus (p=0.001). A significant difference was observed in the hemisphere effect for both the precentral gyrus (p=0.001) and the postcentral gyrus (p<0.001), but not for the paracentral lobule (p=0.663). The interaction between group and hemisphere did not show significant effects on the gray matter volumes across the tested regions (precentral gyrus, p=0.219; paracentral lobule, p=0.663; postcentral gyrus, p=0.513). Significant gender differences were observed in the gray matter volumes of the precentral gyrus (p=0.019) and the paracentral lobule (p=0.041), but not in the postcentral gyrus (p=0.971). This reveals that gender may influence gray matter volumes in specific brain regions. Age showed significant effects on the gray matter volumes in the precentral and postcentral gyrus (p<0.001 for both), but not in the paracentral lobule (p=0.529). The details of the MANOVA analysis presented in Table 4 explore the normalized gray matter volumes in motor and sensory brain regions, specifically examining factors such as group differences, hemisphere, group-hemisphere interactions, gender, and age.

Table 4. MANOVA analysis results of normalized gray matter volumes in motor and sensory brain regions

		Gray matter volume/ICV (%)		
		Precentral gyrus[1]	Paracentral lobule[2]	Postcentral gyrus[3]
Group	p	0.193	0.792	**0.001**
	KEK	0.011	0.000	0.071
Hemisphere (Right/left)	p	**0.001**	0.663	**<0.001**
	KEK	0.069	0.001	0.300
Group hemisphere (Interaction)	p	0.219	0.663	0.513
	KEK	0.009	0.001	0.003
Gender	p	**0.019**	**0.041**	0.971
	KEK	0.034	0.026	0.001
Age	p	**<0.001**	0.529	**<0.001**
	KEK	0.182	0.002	0.123

The parts determined in bold are statistically significant (p<0.05); ICV: intracranial volume; KEK: Wilks' Lambda; [1]R Squared: .241 (Adjusted R Squared: .217); [2]R Squared: .030 (Adjusted R Squared: .000); [3]R Squared: .411 (Adjusted R Squared: .392)

DISCUSSION

Our study revealed no significant difference in the gray matter volume of the motor cortex in Parkinson's patients compared to the control group. This finding is consistent with the study by Brenneis et al., which reported no difference in the motor cortex gray matter volume in Parkinson's patients and suggested that the gray matter damage in this region may be attributed to functional impairments rather than structural changes (15). This explanation supports the findings of our study. However, some studies report reduced precentral gyrus volume in Parkinson's patients (16-18). The precentral gyrus serves as the origin of the pyramidal tract. Shao et al. stated that damage in this region could partially contribute to motor impairments in Parkinson's patients (19). The complex and variable clinical manifestations of Parkinson's disease and differences in clinical data among studies may explain the diversity of such results.

On the other hand, the study by Zhi Yan et al. presents a contrasting finding. When comparing Parkinson's patients with and without dyskinetic syndrome to a healthy control group, they reported that the precentral gyrus gray matter volume was higher in Parkinson's patients. It was suggested that this increase might explain the neurological mechanisms underlying dyskinetic syndromes in Parkinson's patients treated with medication (20). In contrast, studies by Kang and Tian et al. reported reduced gray matter volume in the precentral gyrus of

Parkinson's patients compared to controls using voxel-based morphometric analyses (21,22). We believe these methodological differences could be a significant reason for the discrepancies between our study's findings and those of previous research.

Our findings regarding the sensory cortex, particularly in the postcentral gyrus, demonstrate that the ICV-normalized gray matter volume ratios were reduced compared to the control group. This result is consistent with the study by Xia et al., which reported decreased gray matter volume in the left postcentral gyrus of Parkinson's patients (23). It has been suggested that these reductions in the sensory cortex may impair the functions of the associated brain regions. Other studies indicate that such reductions may result from neuronal loss due to the shrinkage of large neurons or rarefaction of microvascular structures (24,25). However, Piguet et al. proposed that age-related changes in the brain are more pronounced in white matter than in gray matter (26). In light of this information, our study's observed reduction in gray matter volume in the sensory cortex is likely associated with the neurodegenerative effects of Parkinson's disease rather than the aging process.

ICV is a crucial variable influenced by factors such as gender and body size. It shows a rapid increase from birth, particularly during the first five years, and stabilizes between the ages of 16 and 20. It is assumed that ICV remains constant throughout life, even in the presence of brain atrophy (27-29). Due to the challenges posed by factors like age, gender, and body size in comparing brain atrophy among individuals, normalization is emphasized as a crucial step in such studies. Crowley et al. highlighted that volume data should be analyzed independently of age, gender, and ICV variables and argued that neglecting these factors in Parkinson's patients leads to complex results. In volumetric studies conducted on Parkinson's patients, results have shown significant variability when ICV is not controlled (30). Barnes et al. demonstrated that voxel-based morphometric analyses are influenced by age, gender, and head size (31). Studies that accounted for these variables reported reduced differences between groups (32-34), whereas studies that did not control these variables reported large discrepancies (35-37). Some studies have reported that ICV is larger in Parkinson's patients compared to control groups, potentially due to genetic variations (38). Additionally, normalization using ICV has been shown to correct differences arising from individual variations in head size. It allows for a more accurate assessment of clinical changes, such as brain atrophy. It has also been noted that raw volumes positively correlate with ICV, but when volumes are normalized to TIV, this relationship is reversed (30). Therefore, considering TIV is critical for obtaining more accurate and consistent results, especially in neurodegenerative diseases.

The findings of our study provide important insights into the understanding of the sensorimotor relationship between the motor and sensory cortices. The lack of a significant difference in the motor cortex suggests that structural changes in the sensory cortex may indirectly influence motor functions. Identifying a significant difference in the sensory cortex following the application of normalization methods highlights the critical importance of considering individual biological variability.

This study has certain limitations. The gender imbalance in the sample size may limit the generalizability of the findings. Additionally, the lack of clinical data made directly correlating structural changes in gray matter volume with motor and sensory symptoms difficult. Future studies should include larger sample groups and different stages of the disease to evaluate the clinical implications of gray matter changes. Furthermore, examining white matter changes and functional connectivity may contribute to a better understanding of the interactions between the motor and sensory systems during the disease process.

CONCLUSION

In conclusion, our study emphasizes the importance of methodological approaches, such as ICV normalization, in evaluating gray matter changes in the motor and sensory cortices in Parkinson's disease. We believe the findings provide valuable contributions to the literature by enhancing the understanding of the structural and functional relationships of the sensorimotor system in Parkinson's disease.

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MEDICAL RECORDS-International Medical Journal

Research Article

Evaluation of COVID-19 Findings on Thoracic CT: Is There any Correlation with Age and Comorbidity?

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Abstract

Aim: To share insights gained from low-dose thoracic computed tomography (CT) findings of patients diagnosed with COVID-19. Additionally, we aimed to evaluate the correlation between the observed CT findings, CT severity index, patient age, and the presence of comorbid conditions.

Material and Method: One hundred patients having a COVID-19 diagnosis were included in the study's sample. We meticulously reviewed the thoracic CT image characteristics, the lung severity index, and various clinical data related to the patients. The relationships between these factors were then analyzed to draw meaningful conclusions.

Results: The study included 100 patients, consisting of 67 men and 33 women. Among these patients, 30 had at least one underlying comorbid condition, with hypertension being the most prevalent. CT scans were positive in 65 patients. Within this group, 60 patients (93.3%) exhibited ground-glass opacities (GGO), 27 patients (41.5%) showed signs of consolidation, 22 patients (33.8%) had both GGO and consolidation, and 8 patients (12.3%) displayed the crazy paving pattern. The total lung severity score (TLSS) ranged from 0 to 19, with mean score of 3.11±3.71. Each lung lobe was systematically evaluated for the extent of involvement. We found a statistically significant relationship indicating that increasing age correlated with higher grades of lung involvement. Furthermore, significant association was noted between presence of comorbidities and the lung involvement grades. Our analysis revealed a moderate positive correlation between CT lung involvement grade and patient age, alongside a weaker positive correlation between the lung involvement grade and comorbid conditions.

Conclusion: CT imaging has proven to be important tool in managing patients suspected of or confirmed to have COVID-19. Notably, the CT lung severity grade was significantly elevated in patients over 65 years and those with comorbidities. These findings underscore the critical role that CT plays in evaluating and managing the severity of COVID-19 pneumonia.

Keywords: COVID-19, comorbidity, computed tomography, computed tomography lung severity grade

INTRODUCTION

Severe Acute Respiratory Syndrome SARS-CoV-2, also known as the coronavirus, is an RNA virus that is encapsulated and attacks the respiratory system. It causes viral pneumonia known as Coronavirus Disease 2019 (COVID-19) (1,2).

The outbreak of COVID-19 first emerged in December 2019 in Wuhan, China, and rapidly escalated into a global pandemic, affecting millions of individuals worldwide. Characterized by its high transmissibility, SARS-CoV-2 can lead to severe respiratory illnesses, particularly pneumonia. Patients with COVID-19 typically present with a range of clinical symptoms, the most prevalent of which include fever, persistent cough, shortness of breath, and overall weakness (3).

For diagnosing COVID-19 pneumonia, real-time polymerase chain reaction (RT-PCR) tests play a pivotal role as the primary diagnostic method. However, it is important to note that these tests can sometimes yield false-negative results or may not detect the virus in its early stages of

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infection. This limitation can lead to delays in diagnosis and subsequent treatment (4,5). Consequently, imaging studies, particularly chest Computed Tomography (CT) scans, have become essential in the clinical evaluation of patients suspected of having COVID-19 pneumonia (5). Typical findings observed on chest CT in COVID-19 patients often include bilateral peripheral multifocal ground-glass opacities, subsegmental patchy consolidations, and a distinctive crazy paving pattern. These radiological features are frequently located in the lower lobes and posterior segments of the lungs (6,7).

The presence of underlying health conditions, referred to as comorbidities, can significantly worsen the clinical course of COVID-19 pneumonia, especially among older adults (8). Moreover, individuals with pre-existing comorbidities are at an increased risk of developing severe complications from the virus, which can lead to poor health outcomes (9).

In light of these factors, the objective of our study is to share our clinical experiences regarding the findings from low-dose thoracic CT scans in patients during the COVID-19 pandemic. We also aim to investigate the correlation between the severity of CT imaging findings and variables such as the patients' age and the presence of comorbid conditions. By doing so, we hope to contribute valuable insights into the clinical management of COVID-19 pneumonia.

MATERIAL AND METHOD

Patients Selection

The Helsinki Declaration's ethical criteria were followed in the conduct of this retrospective investigation, which was approved by our Institutional Clinical Research Ethics Committee (Decision no: 2020/273). We undertook a comprehensive review of patients who were admitted to the emergency department with suspected cases of COVID-19 between March 2020 and June 2020. Each of these patients underwent chest CT upon admission and was diagnosed with COVID-19 through RT-PCR testing of naso-oropharyngeal swabs.

For inclusion in our study, patients were required to have a confirmed COVID-19 diagnosis based on RT-PCR results obtained at the time of their admission. Additionally, the chest CT images had to be captured within the first 24 hours following the PCR test. Major exclusion criteria were: patients under 18 years of age, patients with unconfirmed PCR diagnosis, and patients with artifactual CT images that would interfere with appropriate evaluation. Initially, 108 patients were identified as meeting the inclusion criteria. However, after applying the exclusion criteria, 8 patients were removed from the study: one was found to be under 18 years of age, and seven others exhibited motion artifacts in their CT images, which rendered those images unsuitable for analysis. Consequently, a total of 100 patients were ultimately included in our investigation. Clinical parameters—including age, gender, and the presence of comorbidities—were meticulously collected from the hospital information system.

Computed Tomography Imaging and Analysis of Images

All non-contrast chest CT images were acquired using a 16-section multidetector CT scanner (Toshiba Alexion, Tokyo, Japan). The imaging parameters were set as follows: kilovoltage peak (kVp) at 120, a rotation time of 0.75 seconds, a matrix size of 256x256, a slice thickness of 2 mm, and a low-dose algorithm to minimize radiation exposure. The existing low-dose CT protocol employed standard settings (AIDR3D, Canon Medical Systems, Otawara, Japan) to ensure consistent imaging quality while adhering to safety guidelines. The mean volume computed tomography dose index (CTDIvol) recorded was 3.3 mGy, with a range from 2.2 to 4.9 mGy, indicating a generally low radiation exposure for patients.

All CT images were carefully assessed using lung and mediastinum window settings to optimize the visibility of relevant structures. Two radiologists, each possessing 10 and 11 years of experience, respectively, independently evaluated the images without knowledge of the clinical data. They subsequently reached a consensus on their findings. The analysis of CT image features was organized into four primary categories: localization, infiltration pattern, additional features, and degree of lung involvement.

In the localization assessment, factors such as laterality, the specific lobes affected, and parenchymal distribution (whether central, peripheral, or diffuse) were thoroughly examined. The evaluation of infiltration patterns focused on identifying various characteristics, including ground-glass opacities (GGO), consolidations, GGO accompanied by consolidation, nodular lesions, crazy paving patterns, linear-reticular patterns, reverse halo sign, and vascular enlargement, as depicted in Figure 1. Additional CT features assessed included mediastinal lymphadenopathy (LAP), pleural effusion, thickening of the bronchial walls, bronchiectasis, halo sign, pericardial effusion, and the presence of an air bubble sign, illustrated in Figure 2.

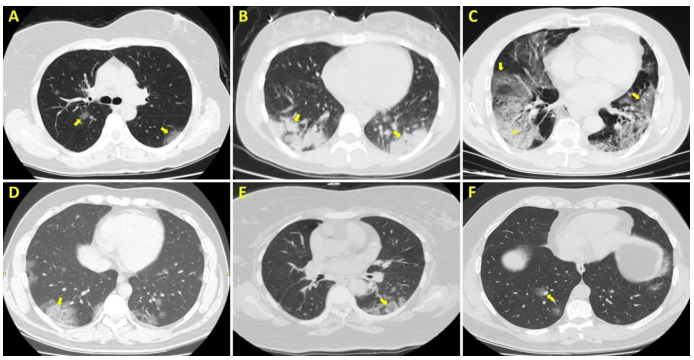

Figure 1. Parenchymal infiltration patterns of COVID-19 in lungs; **A.** ground glass opacity, **B.** consolidation, **C.** ground glass opacity (arrow) with consolidation (asterisk), **D.** crazy-paving pattern, **E.** reverse halo sign, **F.** vascular enlargement

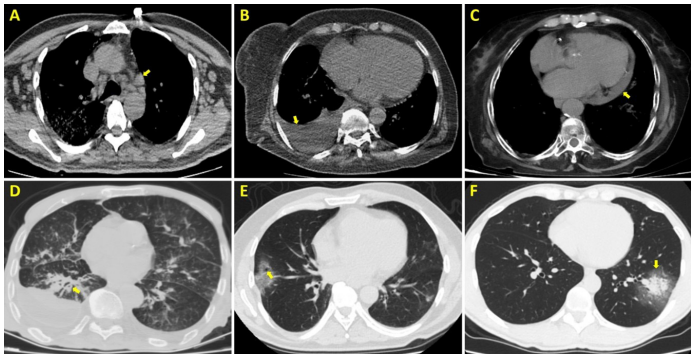

Figure 2. Other CT findings of COVID-19 on thoracic CT; **A.** mediastinal lymphadenopathy, **B.** pleural effusion, **C.** pericardial effusion, **D.** bronchial wall thickening, **E.** air bubble sign, **F.** halo sign

Lung severity scoring was performed according to established guidelines documented in the literature (5). Each lung lobe was evaluated for the extent of involvement and categorized into five categories. The overall lung involvement score, which ranges from 0 points to 20 points, was calculated by adding the degree of participation for each lobe. Patients were categorized based on their CT lung severity score as follows: a score of 0 classified as grade 0, scores between 1-5 as grade 1, scores of 6-10 as grade 2, scores of 11-15 as grade 3, and scores of 16-20 as grade 4. This systematic approach provided a comprehensive evaluation of lung involvement in patients diagnosed with COVID-19.

Statistical Analysis

The statistical software Statistical Package for the Social Sciences 18.0 (SPSS, IBM, Chicago, USA) was used to conduct the statistical analysis for this investigation. For the presentation of data, all quantitative variables were expressed as means accompanied by standard deviations, along with their respective ranges. Meanwhile, categorical variables were summarized as counts and percentages, offering a comprehensive overview of data distribution. This approach facilitated a clearer understanding of the characteristics and relationships within the dataset.

A test of normality was performed to assess whether the quantitative variables adhered to a normal distribution, which is essential for determining the appropriate statistical tests to apply. We used the Fisher Freeman Halton test, an appropriate technique for evaluating categorical data, to assess the association between the grade of CT lung involvement and variables including age and the existence of comorbidities. Furthermore, correlation analyses were conducted to explore the relationships between CT lung involvement grades and age, as well as CT lung involvement grades and comorbidities. The Spearman nonparametric correlation coefficient was utilized for this purpose, providing insights into the strength and direction of these associations without the assumption of normality. If p value is less than 0.05, it's accepted as statistically significant.

RESULTS

Patient Population and Clinical Data

Sixty-seven (67%) of the participants were male and 33 (33%) were female. The average age of participants was 44.21±17.09 (range 18-89). Among the patients, 70 (70%) had no accompanying comorbidities, while 30 (30%) had at least one, which included conditions such as hypertension (HT), diabetes Mellitus (DM), chronic obstructive pulmonary disease (COPD), cardiovascular disease, cerebrovascular disease, malignancy, asthma, and rheumatoid arthritis (RA). The most prevalent comorbidity was HT at 24%, followed by DM at 11% and cardiovascular disease at 8%. The frequencies of other comorbidities were as follows: COPD at 4%, cerebrovascular disease at 4%, malignancy at 2%, asthma at 4%, and RA at 2% (Table 1).

Table 1. The patient's clinical features

Parameter	Patients (n=100)
Sex	
Men	67
Women	33
Age	
Mean	44.21
Range	18-89
Standart deviation	17.09
Comorbidity	
Positive	70
Negative	30
Distribution of comorbidities	
Hypertension	24
Diabetes mellitus type 2	11
Chronic obstrucitve pulmonary disease	4
Cardiovascular disease	8
Cerebrovascular disease	4
Malignity	2
Asthma	4
Romatoid arthritis	2

Chest CT Findings

RT-PCR test results were positive for all patients (n=100). Upon evaluating the CT findings of these 100 patients based on the specified criteria, 35 patients were classified as grade 0, indicating that although their PCR tests were positive, their CT scans showed no findings (Table 2). Among the 65 patients with positive CT findings, 60 (93.3%) exhibited ground-glass opacities (GGO), 27 (41.5%) had consolidations, 22 (33.8%) presented both GGO and consolidation, and 8 (12.3%) displayed a crazy paving pattern. Examining the lateralization of lung involvement in these patients, 9 (13.8%) had involvement limited to the right lung, 8 (12.3%) to the left lung, and 48 (73.8%) had involvement in both lungs. When assessing the distribution of lung lobe involvement, the results were as follows: right upper lobe involvement in 43 patients (66.1%), right middle lobe in 34 patients (52.3%), right lower lobe in 54 patients (83%), left upper lobe in 42 patients (64.6%), and left lower lobe in 51 patients (78.4%). The total lung severity score was 3.11±3.71 (Table 3).

Table 2. Evaluating of relationship between age and lung severity grade in patients

Chest CT lung severity grade	Age (year)			Fisher Freeman Halton test	
	Lower than 65	65 and above	Total	p	r
Grade 0	34	1	35	0.001*	0.429
Grade 1	38	1	39		
Grade 2	10	6	16		
Grade 3	4	2	6		
Grade 4	1	3	4		
Total	87	13	100		

*p value <0.05

Table 3. Findings on chest CT scans

	Number of patients (n=65)
CT findings	
GGO	60 (93.3%)
Consolidation	27 (41.5%)
GGO and consolidation	22 (33.8%)
Crazy paving pattern	8 (12.3%)
Lateralisation of paranchymal findings	
Right	9 (13.8%)
Left	8 (12.3%)
Bilateral	48 (73.8%)
Frequency	
RUL	43 (66.1%)
RML	34 (52.3%)
RLL	54 (83.0%)
LUL	42 (64.6%)
LLL	51 (78.4%)
TLSS	
Mean	3.11
Range	0-19
Standart deviation	3.71

CT: computed tomography, GGO: ground glass opacity, RLL: right lower lobe, RML: right middle lobe, RUL: right upper lobe, LLL: left lower lobe, LUL: left upper lobe, TLSS: total lung severity score

When analyzing the characteristic features of the opacities seen in thoracic CT scans, nodular morphology was noted in 28 patients (43%), linear opacities in 38 patients (58.4%), a crazy paving pattern in 8 patients (12.3%), a reverse halo sign in 1 patient (1.5%), and a halo sign in 5 patients (7.6%). In terms of axial distribution of opacities within the lung parenchyma, 40 patients (61.5%) exhibited a peripheral distribution, while 25 patients (38.4%) showed a diffuse distribution. There were no patients with exclusively central distribution in our study. Regarding additional CT findings, we identified pericardial effusion in 1 patient (1.5%), pleural effusion in 8 patients (12.3%), mediastinal lymphadenopathy in 7 patients (10.7%), bronchiectasis in 9 patients (13.8%), bronchial wall thickening in 1 patient (1.5%), and air bubble findings in 2 patients (3%). Five patients had pre-existing lung parenchymal diseases; three had emphysema and two had fibrosis (Table 4).

When looking at the relationship between age and CT lung involvement grades in our study population, we found a significant relationship, showing that older age is associated with more severe grades of involvement ($p<0.001$) (Table 4). There was also a moderate positive correlation between age and the CT lung involvement grades ($p<0.001$, $r=0.429$).

Table 4. The imaging features on CT scan

Features	Number of patients (n=65)
Characteristics of opacities	
Rounded opacities	28 (43.0%)
Linear opacities	38 (58.4%)
Crazy paving pattern	8 (12.3%)
Reverse halo	1 (1.5%)
Halo sign	5 (7.6%)
Axial distribution of opacity	
Peripheral	40 (61.5%)
Central	0 (0%)
Diffuse (peripheral+central)	25 (38.4%)
Other findings	
Pericardial effusion	1 (1.5%)
Pleural effusion	8 (12.3%)
Mediastinal LAP	7 (10.7%)
Airways	
Bronchiectasia	9 (13.8%)
Bronchial wall thickening	1 (1.5%)
Air bubble sign	2 (3.0%)
Underlying paranchymal lung disease	
Emphysema	3 (4.6%)
Fibrosis	2 (3.0%)

CT: computed tomography

As the CT lung involvement grade increased, the rate of accompanying comorbidity also increased in the study population, showing a statistically significant relationship between comorbidity and lung involvement grades (p<0.001) (Table 5). There was a weak positive correlation between comorbidity and CT lung involvement grades (p<0.001, r=0.348).

Table 5. Evaluating of relationship between comorbidity and lung severity grade in patients

Chest CT lung severity grade	Comorbidity		Total
	Present	Absent	
Grade 0	7	28	35
Grade 1	7	32	39
Grade 2	7	9	16
Grade 3	5	1	6
Grade 4	4	0	4
Total	30	70	100

Fisher Freeman Halton test was used and p value was obtained as <0.001

DISCUSSION

This study demonstrated the relationship between the CT severity index and factors such as age, gender, and comorbidities in COVID-19 pneumonia.

This study showed that 67% of the patients were male. This was similar to the literature; the number of males was higher than females. In our study, the mean age was determined as 44.21 and the mean age of our study group was younger, according to the literature. Studies in literature have shown that male prevalence of COVID-19 in Chinese population is between 55% and 60%, with an average age of 47 to 59 years (10,11). In a study conducted in Europe, the male rate was reported as 52% and the average age was 57 (12). A meta-analysis examining 59 researches and total of 36,470 patients reported that male gender was at greater risk of infection and had higher rates of disease severity and mortality after infection (13).

Studies in the literature have reported that patients with comorbidities are at greater risk and more susceptible to COVID-19 infection (14). There are many studies reporting that HT, coronary artery disease, DM, COPD, malignancy, cerebrovascular disease and chronic kidney disease are more common in groups with higher COVID-19 infection severity (15-17). Guan et al. (2020) reported that 25% of COVID-19 patients had a comorbidity, and the most common comorbidities were HT (16.9%), DM (8.2%), and cardiovascular disease (3.7%) (18). Also in our research, consistent with literature, 30% of the patients had at least one comorbidity. Similarly, the three most common comorbidities were HT (24%), DM (11%), and cardiovascular disease (8%), respectively.

Our study found that the most common thoracic CT finding was GGO, accounting for 93.3%, consistent with the existing literature. The second and third most common findings were consolidation (41.5%) and GGO accompanied by consolidation (33.8%), respectively. When we look at distribution of findings in parenchyma in our study; similar to the literature, bilateral involvement (73.8%) was most frequent in lateralization, and peripheral distribution (61.5%) was the most frequent in axial distribution. The study by Pan et al (2020), development of findings in COVID-19 infection over time was summarized (4). While peripherally located ground glass opacities due to alveolar damage are observed initially, consolidation occurs later with an increase of damage in alveoli and coalescence of the GGO. Secondary to involvement of the pulmonary interstitium, thickening of the interlobular septa occurs and causing formation of a crazy paving pattern. After approximately the first week, consolidation becomes the predominant parenchymal finding. In the second week and later, GGO and crazy paving pattern can be seen again in these areas due to the regression in consolidations. As a result of many studies in literature, GGO with peripheral, lower lobe, and posterior involvement have been reported as typical imaging findings of COVID-19 pneumonia (5,19,20). In the consensus on reporting COVID-19-related thoracic CT findings published by RSNA, bilateraly, peripheraly, and multifocal GGO (with or without consolidation), crazy paving pattern, and reverse halo sign in later stages of the disease were stated as typical findings (21). In a meta-analysis comprising 109 studies and 2,908 patients, the most frequently observed parenchymal findings of COVID-19 on thoracic CT were reported as ground-glass opacities (68%), ground-glass opacities accompanied by consolidation (48%), and consolidation alone (18%) (22). When the findings were evaluated in terms of lobar distribution in our study, the right lung lower lobe was the most frequently affected lobe with 83%, left lung lower lobe was in second place with 78.4% and right lung upper lobe was in third place with 66.1%. Similar to our study, Caruso et al. (2020) reported the most frequently affected lobes in COVID-19 as right lung lower lobe, left lung lower lobe, and right lung upper lobe, respectively (12).

Numerous studies indicate that older age is a risk factor for COVID-19, increasing susceptibility to infection (23-25). A meta-analysis involving a large patient population found that individuals aged 70 and older had a higher risk of contracting COVID-19, experienced more severe disease,

and required intensive care more frequently compared to younger age groups (13). In our study, the proportion of patients aged 65 and older was significantly higher among those with high-grade CT lung involvement, consistent with existing literature (p<0.001). This trend is associated with the prevalence of comorbidities often found in older patients and changes in immune system responses due to aging (26,27). It is believed that elevated proinflammatory cytokines resulting from age-related immune response alterations may significantly influence the progression of the disease (28).

In our investigation, we found a strong positive correlation between the CT lung involvement grade and the existence of comorbidities. Literature contains studies indicating that the presence of accompanying comorbidities exacerbates the severity of COVID-19 infection and increases the need for intensive care (11,15). A meta-analysis involving 1558 patients found that COVID-19 was more severe in individuals with comorbidities such as COPD, DM, HT, cardiovascular disease, and cerebrovascular disease. Additionally, this meta-analysis reported that having COPD as a comorbidity raised the risk of severe COVID-19 infection by 5.9 times compared to those without it (29). Similarly, Bhandari (2020) reported in their study that the presence of comorbidities significantly increased the severity of lung involvement observed in CT scans (30).

This study has some limitations that should be acknowledged. Firstly, as it was conducted at a single center, the findings may not be fully generalizable to other populations or healthcare settings. Additionally, due to the retrospective design, data collection was dependent on pre-existing records, which may lead to information bias. Furthermore, our sample size was limited, and some comorbidities or demographic subgroups may not have been sufficiently represented, which could impact the robustness of the statistical analyses.

CONCLUSION

The severity of lung involvement on CT is notably greater in patients aged 65 and older, as well as in those with comorbidities. A moderate positive correlation is present between the CT lung involvement grade and age, whereas a weak positive correlation is noted between the CT lung involvement grade and comorbidity.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *The Helsinki Declaration's ethical criteria were followed in the conduct of this retrospective investigation, which was approved by our Institutional Clinical Research Ethics Committee (Decision no: 2020/273).*

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MEDICAL RECORDS-International Medical Journal

Research Article

Cancer Data, Case Increase Rates and Future Prospects in the Northeastern Anatolia Region of Türkiye, a Special Region for Gastric and Esophageal Cancers in 2018-2023

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Abstract

Aim: Cancer is a major cause of death. Globocan data shows 20 million new cancer cases and 9.7 million cancer deaths a year. Lung cancer is the most common cancer globally, followed by breast, colorectal, prostate and stomach cancers. Cancer types vary by age, gender, race, and region. Documenting regional cancer data is crucial for screening, early diagnosis, and treatment of common cancers, as well as understanding the underlying causes. Despite the high incidence of upper gastrointestinal (GI) cancers in eastern Türkiye, there is little documented evidence on specific cancer types in these regions.

Material and Method: In order to investigate the incidence of cancer in our region, the medical records of 6,603 patients diagnosed with cancer and subsequently treated in our clinic between 2018 and 2023 were analysed and specific cancer sites were recorded.

Results: It has been demonstrated that cancers of the upper GI tract, represent the most prevalent cancer site, accounting for 21.2% (n=1403) of all cases. This equates to one in every five patients diagnosed with cancer. Additionally, significant findings were yielded with respect to other forms of cancer.

Conclusion: It is imperative to document these data to highlight the necessity for investigating and preventing the underlying causes of upper GI cancer in our region. Furthermore, the establishment of screening programs for early diagnosis and intensified research on treatment modalities are crucial steps in combating this disease.

Keywords: Cancer data in Northeast Anatolia, stomach and oesophageal cancer in Northeast Anatolia, Asian belt

INTRODUCTION

The incidence of cancer has reached a level that represents a significant public health and economic concern, largely due to the growth of the elderly population and the multiplicity of potential etiologic factors. Cancer currently accounts for the second-highest mortality rate, trailing only that of cardiovascular diseases (1). According to Globocan data, there will be 20 million new cancer cases, including non-melanoma skin cancers, and 9.7 million cancer-related deaths in 2022 (2). Among all cancer cases worldwide, lung cancer is the most common cancer with 12.4%, followed by breast (11.6%), colorectal (9.6%), prostate (7.3%) and stomach (4.9%) cancers (2). The incidence of specific cancer types may vary according to age, gender, ethnicity, and geographical region (3). It is of great importance to have access to regional cancer statistics and to be able to calculate the estimated future incidence and prevalence in order to meet the needs for screening, early diagnosis, and treatment of regionally common cancers and to elucidate the etiologic factors. The East-Northeast Anatolia region of Türkiye is notable for its elevated incidence of cancers of the upper gastrointestinal (GI) tract (stomach, gastroesophageal junction, and esophagus). These cancers represent the most common malignancies in the region, yet the underlying etiologic factors remain unclear (4,5). The analysis of cancer statistics at the regional level can inform the development of an effective regional cancer policy and facilitate the investigation and elucidation of potential etiological causes.

Purpose

The objective of our study was to document cancer data, demonstrate the changes in the incidence of cancer types over the past five years, and calculate the estimated number of cases in the future in our region, where upper GI cancers are highly prevalent.

CITATION

Caglar AA, Tuhan A, Coban Esdur P, et al. Cancer Data, Case Increase Rates and Future Prospects in the Northeastern Anatolia Region of Türkiye, a Special Region for Gastric and Esophageal Cancers in 2018-2023. Med Records. 2025;7(1):258-62. DOI:1037990/medr.1572275

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MATERIAL AND METHOD

For this purpose, it was planned to retrospectively record the cancer sites of a total of 6,603 patients who applied to our center between 2018 and 2023, according to years and gender. It was not possible to obtain informed consent from the patients, as the data were obtained retrospectively by means of a file review. Ethics committee approval dated 27.09.2024 and numbered B.30.2.ATA.0.01.00/538 was obtained for our study. The medical records of patients between the ages of 18 and 80 years were reviewed, and the locations of the cancers were documented. Hematologic malignancies were excluded from the analysis. The data were statistically analyzed using the IBM SPSS Statistics 20 program.

RESULTS

A review of the data from the previous five years revealed that lung cancers constituted the most prevalent cancer type, accounting for 17.02% (n=1124) of the total 6603 cancer cases. This was followed by breast cancers (16.7%, n=1108), stomach cancers (13.07%), and colorectal cancers (9.7%, n=643), esophageal (5.8%, n=384), prostate (5.0%, n=331) and ovarian (3.83%, n=253) cancers. Upper GI cancers (stomach and esophagus) were the most prevalent, accounting for 21.2% (n=1403) of the total cases (Figure 1).

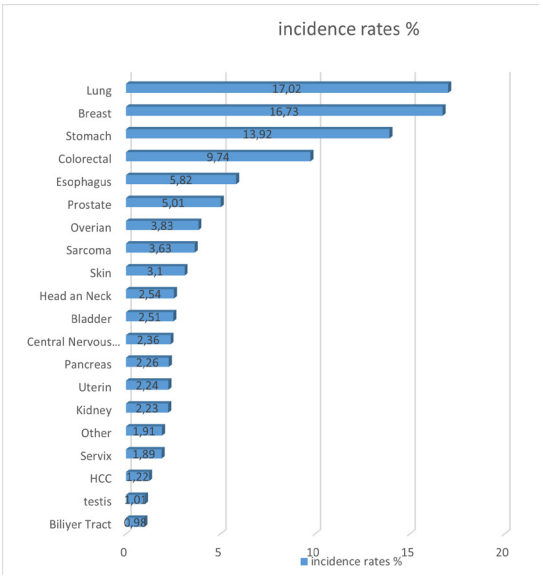


Figure 1. The most common types of cancer in 2018-2023

Over the past five years, 52.8% of all cases were diagnosed in males, while 47.2% were diagnosed in females. Amongst the male population, lung cancer was the most prevalent form of cancer, accounting for 28.27% of cases (n=966). Subsequently, stomach (17.4%, n=595), colorectal (10.39%, n=355), prostate (9.69%, n=331), and esophageal cancers (4.86%, n=166) were the next most prevalent. Upper GI cancers constituted 22.27% (n=761) of all cases (Table 1).

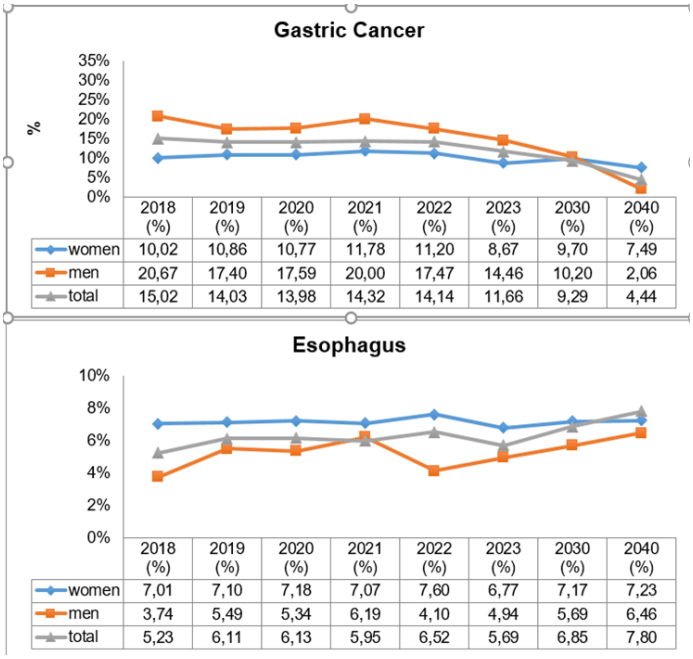
Table 1. Ranking of the most common cancers in women and men in the last 5 years

Women (n=3060)			Men (n=3417)		
	n	%		n	%
Breast	1093	35.72	**Lung**	966	28.27
Stomach	324	10.59	**Stomach**	595	17.41
Colorectal	288	9.41	**Colorectal**	355	10.39
Overian	253	8.27	**Prostate**	331	9.69
Ezophagus	218	7.12	**Ezophagus**	166	4.86
Lung	158	5.16	**Bladder**	148	4.33
Uterin	148	4.84	**Head&Neck**	146	4.27
Servix	125	4.08	**Sarcoma**	137	4.01
Sarcoma	103	3.37	**Skin**	128	3.75
Skin	77	2.52	**Kidney**	104	3.04
Central Nervous	73	2.39	**Pancreas**	84	2.46
Pancreas	65	2.12	**Central Nervous**	83	2.43
Kidney	43	1.41	**Testis**	67	1.96
Biliyer Tract	32	1.05	**HCC**	59	1.73
Head&Neck	22	0.72	**Biliyer Tract**	33	0.97
HCC	20	0.65	**Breast**	15	0.44
Bladder	18	0.59			

Among women, breast cancers constituted more than one-third of all cases, with a rate of 35.72% (n=1093). The next most common cancers were gastric (10.59%, n:324), colorectal (9.41%, n:288), ovarian (8.27%, n=253), esophageal (7.12%, n=218), and lung cancers (5.16%, n=158) (Table 1). Upper GI cancers constituted 17.71% (n=542) of all cases.

The male-to-female ratios within cancer types, changes in the number of cases over time, and projected future case rates were assessed. The evaluation of upper GI cancers over the past five years revealed that approximately two-

thirds (64.7%) of gastric cancer cases were males and one-third (35.3%) were females. In contrast, the majority of oesophageal cancers were female (56.8%). The total number of cases, the proportion of cases between the male and female sexes, and the distribution in the coming years are illustrated in the graph below (Figure 2).

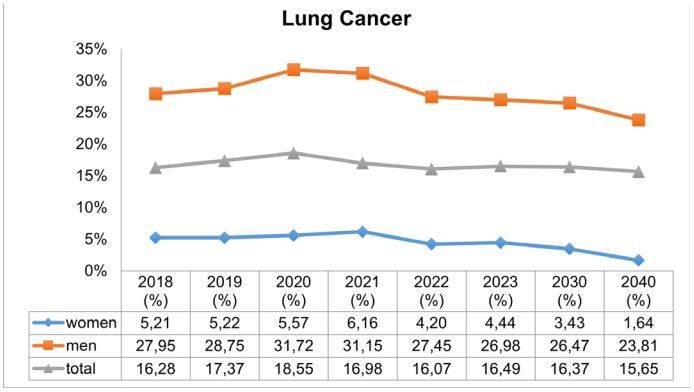


	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)	2030 (%)	2040 (%)
women	10,02	10,86	10,77	11,78	11,20	8,67	9,70	7,49
men	20,67	17,40	17,59	20,00	17,47	14,46	10,20	2,06
total	15,02	14,03	13,98	14,32	14,14	11,66	9,29	4,44

	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)	2030 (%)	2040 (%)
women	7,01	7,10	7,18	7,07	7,60	6,77	7,17	7,23
men	3,74	5,49	5,34	6,19	4,10	4,94	5,69	6,46
total	5,23	6,11	6,13	5,95	6,52	5,69	6,85	7,80

Figure 2. Changes in the ratios of male to female rates of upper GI cancers by years and estimated case rates in the future

Over the past five years, 14.1% of lung cancer cases were diagnosed in women, while 85.9% were diagnosed in men. When analysed by year, the rates remained consistent. There was no significant change in the number of cases or rates between 2018 and 2023, and it was predicted that similar rates would be observed in the coming years (Figure 3).



	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)	2030 (%)	2040 (%)
women	5,21	5,22	5,57	6,16	4,20	4,44	3,43	1,64
men	27,95	28,75	31,72	31,15	27,45	26,98	26,47	23,81
total	16,28	17,37	18,55	16,98	16,07	16,49	16,37	15,65

Figure 3 Changes in the ratios of male to female rates of lung cancers by years and estimated case rates in the future

A review of data on other cancers revealed a twofold increase in the number of prostate cancer cases in men between 2018 and 2023. Similarly, there was an approximately two-fold increase in cervical cancer cases in women. The table below (Table 2) provides a detailed overview of the number of cases in all cancers according to years and future predictions.

Table 2. Estimated expected case rates in 2030-2040 based on total female to male ratios, annual number of cases, five-year incidence change and rate of increase in all cancers

	2018		2019		2020		2021		2022		2023		2030 (%)*	2040 (%)*
	n	%	n	%	n	%	n	%	n	%	n	%		
Lung														
Women	26	5.2	25	5.2	31	5.6	34	6.2	21	4.2	21	4.4	**3.43**	**1.64**
Men	142	28.0	157	28.8	184	31.7	176	31.2	154	27.5	153	27.0	**26.47**	**23.81**
Total	168	16.3	182	17.4	215	18.6	211	17.0	175	16.1	174	16.5	**16.37**	**15.65**
Stomach														
Women	50	10.02	52	10.86	60	10.77	65	11.78	56	11.20	41	8.67	9.70	7.49
Men	105	20.67	95	17.40	102	17.59	113	20.00	98	17.47	82	14.46	10.20	2.06
Total	155	15.02	147	14.03	162	13.98	178	14.32	154	14.14	123	11.66	9.29	4.44
Ezophagus														
Women	35	7.01	34	7.10	40	7.18	39	7.07	38	7.60	32	6.77	**7.17**	**7.23**
Men	19	3.74	30	5.49	31	5.34	35	6.19	23	4.10	28	4.94	**5.69**	**6.46**
Total	54	5.23	64	6.11	71	6.13	74	5.95	71	6.52	60	5.69	**6.85**	**7.80**
Colorectal														
Women	38	7.62	38	7.93	54	9.69	56	10.14	55	11.00	47	9.94	15.16	21.23
Men	53	10.43	74	13.55	57	9.83	63	11.15	57	10.16	51	8.99	6.33	1.74
Total	91	8.82	114	10.88	111	9.58	119	9.57	112	10.28	98	9.29	9.88	10.04
Breast														
Women	207	41.48	169	35.28	190	34.11	181	32.79	170	34.00	176	37.21	28.62	21.04
Men	2	0.39	0	0.00	3	0.52	7	1.24	1	0.18	2	0.35	0.73	1.04
Total	209	20.25	169	16.13	193	16.65	188	15.12	171	15.70	178	16.87	11.43	5.80

* These predictions were made using the Linear Regression Model

Table 2. Estimated expected case rates in 2030-2040 based on total female to male ratios, annual number of cases, five-year incidence change and rate of increase in all cancers

	2018		2019		2020		2021		2022		2023		2030 (%)*	2040 (%)*
	n	%	n	%	n	%	n	%	n	%	n	%		
Prostate														
Men	39	7.7	60	11.0	44	7.6	73	12.9	58	10.3	57	10.1	14.06	18.41
Total	39	3.8	60	5.7	44	3.8	73	5.9	58	5.3	57	5.4	7.42	9.98
Overian														
Women	45	9.02	43	8.98	49	8.80	38	6.88	39	7.80	39	8.25	5.76	3.10
Total	45	4.36	43	4.10	49	4.23	38	3.06	39	3.58	39	3.70	2.20	0.48
Uterin														
Women	21	4.21	26	5.43	28	5.03	24	4.35	23	4.60	26	5.50	**5.71**	**6.57**
Total	21	2.03	26	2.48	28	2.42	24	1.93	23	2.11	26	2.46	**2.39**	**2.54**
Servix														
Women	14	2.81	16	3.34	21	3.77	25	4.53	28	5.60	21	4.44	**8.34**	**12.82**
Total	14	1.36	16	1.53	21	1.81	25	2.01	28	2.57	21	1.99	**3.63**	**5.48**

* These predictions were made using the Linear Regression Model

DISCUSSION

According to Globocan 2022 data, lung cancers are the most common all over the world. Together with lung cancers, breast, colorectal, prostate and stomach cancers constitute the five most common cancer types (2). Similarly, in our study, lung and breast cancers were in the first two ranks, gastric cancer was in the third, colorectal cancers were in the fourth and oesophageal cancers were in the fifth. It has been shown that gastric cancer and especially oesophageal cancer are more common in our region compared to the average of Türkiye and the world. While oesophageal cancers ranked 11th with a rate of 2.6% among the most common cancers in the world, it ranked 5th with a rate of 5.82% in our region. It is established that the prevalence of specific cancers exhibits geographic and racial disparities (2). Gastric cancer is a neoplasm with a complex aetiology, involving both environmental and genetic factors (6). It is more prevalent in developing countries globally, with the highest incidence rates observed in Central-South America, Eastern Europe, and Eastern Asia (7). Additionally, it is two to three times more common in males than in females (2). The aetiology of gastric cancer is multifactorial, with a complex interplay between genetic predisposition, dietary habits, tobacco consumption, alcohol intake, infection with the bacterium Helicobacter pylori (HP) and the Epstein-Barr virus (EBV). Approximately 10% of gastric cancer cases have a family history, with the majority of cases being sporadic (8). With regard to dietary characteristics, it is established that the Mediterranean diet, characterised by a high consumption of vegetables, fruits and fish, is protective against gastric cancer. Conversely, the consumption of meat, smoked and pickled foods has been identified as a risk factor (9). HP infection is one of the most important causes of non-cardia gastric cancers in developing societies (10). Our findings align with existing literature, indicating that gastric cancer occurs approximately two times more frequently in males. When considering the aforementioned etiological factors, the high consumption of red meat and low consumption of vegetables, fruits, and fish in our region may contribute to the elevated incidences of gastric cancer. In addition, in a study conducted in our region, the prevalence of HP infection was found to be 58%, similar to developing countries (11). It is thought that the frequency of HP infection is among the reasons increasing the incidence of gastric cancer.

The incidence of oesophageal cancer is particularly high in East Asia, East Africa and Northern Europe (12). While the oesophageal squamous cell carcinoma (SCC) subtype is prevalent in developing countries, the adenocarcinoma (AC) subtype has been on the rise in developed countries in recent years. The etiological causes of SCC include smoking, alcohol consumption, hot drinks and the ingestion of foods containing nitrosamines. In contrast, the main risk factors for AC are obesity and Barrett oesophagus (13-15). The gender distribution of oesophageal cancers indicates that these malignancies are more prevalent in males globally, although they are more common in females in certain regions (16). In our region, 56.8% of cases involved female patients. It is postulated that the high prevalence of oesophageal cancer in our region is attributable to heavy smoking, the consumption of hot tea, and dietary factors.

CONCLUSION

The eastern Turkish is situated at the western end of the Asian belt, a region where upper GI cancers are prevalent. Gastric cancer represents the seventh most prevalent form of cancer in our country. Oesophageal cancers are the 20th most common form of cancer. The findings of our study indicate that gastric cancers represent the third most prevalent cancer type, while oesophageal cancers constitute the fifth most common cancer type. The most

common cancer region was identified as the upper GI tract, with one in every five patients admitted to the clinic having been diagnosed with an upper GI cancer. It was imperative to document these data in order to demonstrate the necessity for investigating and preventing the underlying causes of upper GI cancer in the region, establishing screening programmes for early diagnosis and intensifying studies on treatment. The utilisation of data extracted from the medical records of 6,603 cancer patients, rather than relying solely on ICD-10 codes, was a crucial factor in ensuring the accuracy and reliability of the data. In addition to the aforementioned strengths of our study, the limitations include the exclusion of haematological malignancies, inability to differentiate disease subtypes, inability to access demographic characteristics of the patients and inability to document risk factors.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Ethics committee approval dated 27.09.2024 and numbered B.30.2.ATA.0.01.00/538 was obtained for our study.*

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MEDICAL RECORDS-International Medical Journal

Research Article

Investigation of the Effects of Pendimethalin on Liver and Kidney Tissue in Mice by Histological Methods

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Abstract

Aim: Pesticides, which provide many benefits in terms of production and yield, can also be toxic substances that can harm human health. In this study, the effects of pendimethalin (PND), a type of pesticide, on the liver and kidney tissue of mice were examined by histopathological methods.

Material and Method: A total of 30 mice were used in our study. They were divided into 5 groups, 6 mice in the control group and 6 mice in the other groups. One of the groups was reserved as the control group. No application was made to the control group. Group I received 0.1 mg/l PND, group II received 0.2 mg/l PND intraperitoneally on the 1st and 3rd days of the study. Group III received 0.1 mg/l PND intraperitoneally and 0.1 mg/l vitamin A and C orally, group IV received 0.2 mg/l PND intraperitoneally and 0.1 mg/l vitamin A and C orally on the 1st and 3rd days of our study. On the 4th day of our study, the experimental animals were sacrificed by cervical dislocation method under general anaesthesia. Liver and kidney tissues of the mice were histopathologically examined under light microscope.

Results: In our study, sinusoidal enlargement and vascular congestion were observed in the liver tissue of the I. experimental group, while tubular dilatation and intertubular vascular congestion were observed in the kidney tissue. In the second experimental group, in addition to the similar findings in the first experimental group, an increase in the number of pyknotic nuclei and Kuppfer cells in the liver tissue and loss of cells and disrupted areas in the tubules in the kidney tissue were observed. In addition, the findings in this group were more pronounced. In the third experimental group, histopathological findings were similar to those in the first group. Similarly, the findings in experimental group IV and experimental group II, which were given vitamin A and C, were similar.

Conclusion: In conclusion, our findings showed that PND negatively affected the histology of liver and kidney of mice. Vitamins A and C did not contribute positively to these histopathological findings.

Keywords: Liver tissue, kidney tissue, pendimethalin, histopathology

INTRODUCTION

As a result of the rapid increase in the world population, the increase in urbanisation activities in agricultural areas requires maximum yield from the products. This has made the use of pesticides almost mandatory. Therefore, pesticides are recognised as essential substances all over the world (1). Chronic toxicity occurs when pesticides are exposed to pesticides for a certain period of time at long-term or low dosages. Carcinogenicity, mutagenicity, teratogenicity, oncogenicity, liver damage, reproductive disorders, neural damage and allergic symptoms can be listed as defects resulting from chronic effects (2).

Pendimethalin (PND), which is included in the herbicide class among the pesticide types classified according to the field of use, is a dinitroaniline group member. In the studies conducted, PND has been identified as a substance that pollutes water resources (3-6). It also adversely affects water resources as well as air and soil (7). The United States Environmental Protection Organisation (EPA) has classified PND as a probable human carcinogen (8). Another study concluded that PND exposure may induce tumour development (9). Increased incidence of cancer has been found to be associated with PND exposure by some agricultural health study committees (10-12). PND compound has the potential to cause problems in the functioning of the endocrine system (13). Due to the toxic effects of pesticides on non-target organisms and the negative effects on natural resources, there is a need for a more comprehensive evaluation of pesticides (14,15).

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Studies on PND exposure on the liver and kidneys of freshwater fish were carried out and histopathological changes were found (16).

When the necessary literature is reviewed, it is seen that the protective effect of vitamin A and C on the liver and kidney tissue of mice against PND toxicity has not been investigated and there is a need for further studies in this field. In this study, it was aimed to make examinations for the need and to provide an original work to the literature. Mouse liver and kidney tissues were histopathologically examined to determine the damage caused by PND and to see the effect of vitamin A and C in treating the damage. Thus, it was aimed to determine whether vitamins A and C would be effective in preventing the damage that PND exposure may develop in living organisms.

MATERIAL AND METHOD

Experimental Animals

In the study, 30 Balb-c female mice were used. The mice used were 84 days old at the beginning of the study and weighed 32-35 g on average. The experimental animals were housed in polycarbonate standard type 3 cages for 12 hours day and 12 hours night, 08.00 in the morning and 08.00 in the evening. Mice were fed ad libitum with tap water and standard feed. The ambient temperature was kept between 22-24°C, humidity was kept between 45-50% and ventilation was provided automatically.

Work Plan and Groups

A preliminary study was conducted before the study. Firstly, it was observed that mice given 0.5 mg/l PND could not survive at this dose for a long time. Likewise, mice were lost at 0.4 mg/l PND dose. At the last dose of 0.2 mg/l, although the mice were restless, they survived. Thus, 0.2 mg/l high dose was determined as 0.1 mg/l low dose in the study.

In the study, the experimental animals were divided into 5 groups consisting of 6 mice, one of which was the control group. One group was divided as the control group. In group I, 0.1 mg/l PND was administered intraperitoneally (ip) on the 1st and 3rd days of the experiment. In group II, 0.2 mg/l PND was administered ip on days 1 and 3 of the experiment. The animals in group III were firstly given 0.1 mg/l PND by ip route and then vitamin A and C were given orally on the 1st and 3rd days of the experiment. In group IV, 0.2 mg/l PND was administered ip, then vitamin A and C were administered orally on the 1st and 3rd days of the experiment.

Tissue Collection and Histological Examination

At the end of the 3rd day, the experimental animals were sacrificed by cervical dislocation method under anaesthesia. Then, the liver and both kidneys were dissected by making a vertical incision in the periumblical region. The tissues were placed in 10% formaldehyde solution and fixed in formaldehyde for 14 days. After fixation was completed, the tissues were kept in tap water overnight to remove the fixative. Complete removal of the water permeating the tissue was achieved by passing through alcohol series. The tissues, which were rendered transparent in xylol to make them transparent to light, were embedded in paraffin blocks. From the obtained blocks, 5 µm thick sections were taken using a microtome (DIAPATH-Galileo Auto). The sections were floated in 38°C water to open the folds and placed on slides. After the sections were opened, they were left to dry in an oven at 37°C on the slides.

After the sections were taken, the tissue samples placed on the slides were stained with haematoxylin-eosin (H&E) double stain. After staining, the slides were covered with coverslips using entellan. Photographs were taken from the obtained preparations in a Light Microscope (LEICA DM 2500) with a digital camera (LEICA DMC 4500) attachment and transferred to digital media for evaluation.

Differences in the H&E method used in dyeing are due to the waiting time in the alcohol used after dyeing. Such phenomena are natural in new and old solutions. You mentioned that bars should be used, the magnification criteria are specifically stated for each image. In addition,the use of bars is not deemed appropriate since the objective lens gives the magnification result more clearly. Here the phrase “increasing the number of image and better explaining the lesions at large and small magnification” is normally true. The cursors here are thought to be more meaningful since they were selected for each texture. I would like to thank you especially for your useful criticism. This work only possible within our means.

RESULTS

In this study, when the data obtained from the control group were examined under light microscope, it was observed that the liver lobule had a normal structure. Hepatocytes were observed to be arranged in a radial pattern. The vena centralis, portal area, sinusoids and sinusoidal Kupffer cells and endothelial cells in the liver tissue were observed in normal structures. Sinusoids were normal in terms of their width and arrangement (Figure 1A, 1B). In the kidney tissue of the control group, normal renal tubule and glomerular structure in the cortex and medulla and regular interstitial space were present (Figure 1C, 1D).

In our study, irregularities in hepatocyte arrangement and necrotic areas were present in group I in which low dose PND was administered. Sinusoidal areas were enlarged and mononuclear cell infiltration was observed in the vena centralis. Vascular congestion in the portal area was also among the findings we observed (Figure 1E, 1F). Tubular dilatation and intertubular vascular congestion were observed in group I kidney tissue. There were also necrotic areas in places (Figure 1G, 1H).

In group II in which high dose PND was administered, histopathological changes were quite remarkable. There was vascular congestion covering almost the entire vena centralis. Necrotic areas and pyknotic nuclei were observed. Sinusoidal areas were more dilated compared to group I. Kuppfer cells were observed more prominently. The presence of erythrocytes in the sinusoids was also observed (Figure 1I, 1J). Haemorrhage foci in the cortex and Bowman's capsule, loss of cells in the proximal tubules and distal tubules were observed. These findings were more prominent compared to the findings in group I.

Degeneration was observed in hepatocytes in group III in which we applied low dose PND, which was one of the groups in which we administered vitamin A and vitamin C. There was also some enlargement in the sinusoids. A slight change was observed in mononuclear cell infiltration in the vena centralis compared to group I in which we administered low dose PND. Tubular dilatation and vascular congestion were observed in group III kidney tissue. Necrotic areas were found to be almost similar to group I. According to these results, the healing effect of vitamins A and C was not significantly observed in our study.

Histopathological findings were found in all groups. These findings included mononuclear cell infiltration, sinusoidal dilatation, vascular congestion, pyknotic nucleus, hepatocyte degeneration and necrotic area in the liver. In the kidney tissue, tubular dilatation and degeneration, intertubular vascular congestion, degeneration in Bowman's capsule were observed as haemorrhage foci and necrotic areas. Group II was found to be the most affected group. It was concluded that this was related to the dose increase. In the groups receiving vitamin A and C, histopathological findings were almost similar to those in the groups receiving the same dose of PND.

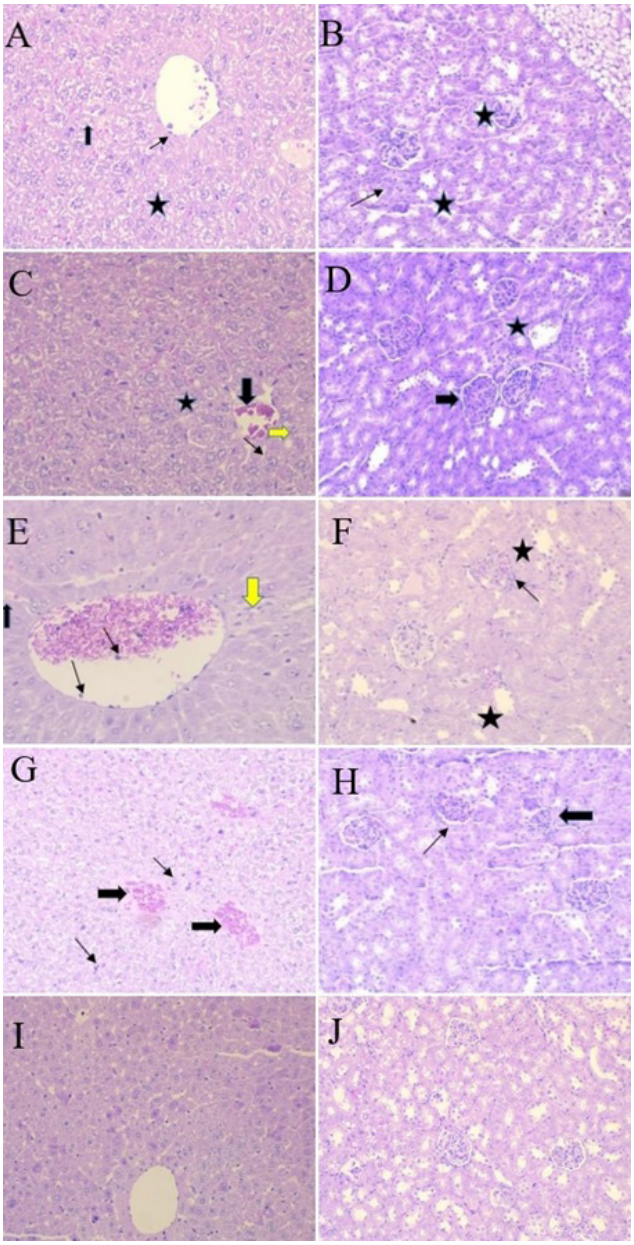

Figure 1. Histopathologic findings liver tissue of group I (**A**). Hepatic mononuclear cell infiltration (thin arrow), necrotic areas (asterisk) and dilatation of sinusoidal areas (thick arrow) seen in the vena centralis H&E X20. Kidney tissue of group I (**B**). Tubular dilatation (asterisk) and intertubular vascular congestion (thin arrow). H&E X20. Mouse liver tissue from group II (**C**). Vascular congestion in the vena centralis; (thick arrow) sinusoidal dilatation, (thin arrow) necrotic area (asterisk) and pyknotic nucleus (yellow arrow). H&E X20. Kidney tissue from group II (**D**). Foci of hemorrhage (thick arrow) and tubular dilatation (asterisk) are seen in Bowman's capsule and cortex. H&E X20. Liver tissue from group III (**E**). Vena centralis shows mononuclear cell infiltration (thin arrow) sinusoidal dilatation (thick arrow) and hepatocyte degeneration (yellow arrow). H&E X40. Kidney tissue from group III (**F**). Tubular dilatation (asterisk) and vascular congestion (thin arrow) are seen H&E X20. Mouse liver tissue from group IV (**G**). Vascular congestion (thick arrow) and Kuppfer cells (thin arrow) in the vena centralis H&E X20. Kidney tissue from group IV (**H**). Vascular congestion in Bowman's capsule (thin arrow) and Bowman's capsule with narrowed borders (thick arrow) are seen. H&E X20. Images of liver (**I**) and kidney (**J**) tissue in the control group.

DISCUSSION

Chemical pesticides have been an agent that has helped nations in their endeavours to eradicate insect-based problems, ensure adequate food supplies, and protect agricultural lands and forests. However, overuse of more toxic and cheaper pesticides, especially in developing countries, leads to acute health problems and causes environmental and global pollution (17). The damages of pesticides that cause changes in antioxidants and cause ROS formation have been clearly demonstrated (18,19). Vitamins A, C and E are vitamins with antioxidant properties (20). In our study, it was wondered how vitamin A and vitamin C, which are antioxidants, would affect the damage caused by pesticides, and vitamin A and C were included in the study.

In measurements made in various soil types, it was observed that heterotrophic activity was adversely affected where PND was intensively present (21). The consumption of agricultural products grown in soils contaminated with PND causes people to be exposed to this pesticide in some way. Therefore, PND was considered to be a pesticide type that should be investigated and used in our study.

El-Sharkawv et al. evaluated the toxic effect of PND on commercially important fish by measuring growth performance, biochemical parameters, histopathological findings and genotoxic effect. The results showed that there were significant decreases in body weight and weight gain in fish exposed to PND depending on the doses given, while serum glucose, aspartate amino transaferase (AST), alkaline phosphatase, total protein and cholesterol were significantly increased. When liver and kidney tissues were examined histologically, necrotic areas and degenerative changes were observed similar to our study (22).

In a study using low dose PND, oxidative stress, DNA damage and mitochondrial dysfunction triggering apaptosis were evaluated in human lymphocytes and rat bone marrow cells. It was found that PND stimulated micronucleus formation showing clastogenic potential. The results showed that DNA damage was 35.6 times higher in PND-treated human lymphocytes. In addition, imbalance in antioxidant enzymes was observed. In this study, histopathological findings were found to be consistent with our results. In conclusion, PND has been shown to have genotoxic and apoptotic potentials in human and animal test models (23).

In the study conducted by Ahmad et al. male rats were given PND at various doses of 62.5, 125 and 250 mg/kg. Toxic effects were evaluated in terms of oxidative stress, DNA damage, histopathological changes, stimulation of anti-inflammatory and apoptotic responses. Significant changes were recorded in oxidative stress indicators and antioxidant defence mechanisms in liver and kidney tissues. Significant DNA damage was also detected in this study. PND-induced cellular stress induced anti-inflammatory and apoptotic changes. When histopathological changes were examined, leukocyte infiltration, pyknotic nuclei, necrosis, large Bowman's capsule and narrowed renal cortex were observed in liver and kidney tissues. The results of this study showed that PND causes cellular toxicity and genetic disorders affecting normal physiological functions in rats (24). Similar histopathological findings were found in our study. Unlike this study, Bowman's capsule was narrowed in our study.

In a study conducted on Nile tilapia fish, four groups were formed, one of the groups was separated as a control group, the other two were given two different doses of PND, and the fourth group was given Moringa plant, which may show antioxidant effect in addition to PND, similar to our study. At the end of this period, haematological and biochemical changes and oxidative stress biomarkers were analysed. PND treatment caused significant decreases in haemoglobin concentration in white and red blood cells, while PND treatment caused significant decreases in hemoglobin concentration in white and red blood cells, significant increases were detected in serum total protein, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), creatinine, uric acid, glucose, cortisol, cholesterol and lactate dehydrogenase (LDH) levels. On the other hand, serum total protein, albumin, globulin and acetylcholinesterase (AChE) decreased. Hepatic superoxide dismutase (SOD), catalase (CAT), total antioxidant capacity (TAC) and glutathione peroxidase (GSH-Px) levels were significantly increased compared to the control group. Addition of Moringa oleifera leaf extract to water overcame the negative effects of pendimethalin and the parameters examined were almost normalised compared to the control group (25). In our study, similar to this study, we investigated the protective effects of antioxidant vitamins A and C on the toxic effects of PND given together with PND. Unlike this study, no significant normalisation was observed in our study. This was attributed to the fact that only two doses of vitamin A and C were given.

In this study, histopathological findings were detected in all groups. These findings were observed as mononuclear cell infiltration, sinusoidal dilatation, vasculer congestion, pyknotic nükleus, hepatocyte degenerasyon and necrotic area in the liver. Tubuler dilatation and, degeneration, intetubuler vasculer congestion, degeneration in Bowman's capsule were observed as bleeding foci and necrosis areas in the kidney tissue. The most affected group is II. İdentified as a group. It was concluded that situation was due to dose increase. This histopathological findings in the groups receiving the same dose of PND.

CONCLUSION

According to the results of the study, it was observed that PND adversely affected liver and kidney tissue. Longer-term studies with different doses of PND will be useful to evaluate the damages of this pesticide in more detail. In addition, we think that the antioxidant effects can be seen more clearly when the doses of vitamin A and C and the number of days on which the mice are given are increased.

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Ethical approval: *For this study, Saki Yenilli Experimental Animal Production and Application Laboratory Permission for the study was obtained with the decision of the Local Ethics Committee for Animal Experiments (Decision No: 07-24.04.2019).*

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MEDICAL RECORDS-International Medical Journal

Case Report

A Rare Cause of Inguinal Herniation: Bladder Herniation

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Abstract

Herniation of the bladder into the inguinal canal is a rare condition. It is mostly asymptomatic but symptoms such as dysuria, sudden and severe urge to urinate, nocturia and haematuria may also be observed. Early diagnosis of inguinal bladder hernia is important to minimize potential complications and those that may arise during treatment. In male patients over the age of fifty with unilateral inguinal swelling, possible bladder herniation should be considered, and when necessary, computed tomography and other radiological imaging methods should be used in addition to ultrasonography. We aimed to present our case of bladder herniation accompanying inguinal hernia, supported by the literature.

Keywords: Inguinal hernia, bladder hernia, ultrasonography, computed tomography

INTRODUCTION

The incidence of inguinal hernia ranges between 3% and 8%, but it is more common among men. Herniation of the bladder into the inguinal canal is rare and this rate is reported to be between 1% and 4% in the literature (1). It has also been reported that the bladder herniates into the femoral canal, abdominal wall, perineum, and obturator canal (2). It is mostly seen in men over 50 years of age and on the right side. It is seen that various factors play a role in its pathophysiology. Possible reasons for facilitating herniation include weakness of the bladder detrusor muscle and abdominal wall muscles, hernia sac that causes the bladder to shrink, obesity, and previous inguinal surgery. Most patients are asymptomatic. They may rarely show nonspecific urinary symptoms (3). It is mostly detected incidentally during inguinal hernia surgeries (4). Early diagnosis is important due to the possibility of complications. In this study, we aimed to present a case who presented to the emergency department with complaints of abdominal pain and swelling in the groin and was diagnosed with bladder hernia based on imaging findings in light of the literature.

CASE REPORT

A 51-year-old male patient was admitted to the emergency department with complaints of abdominal pain, right groin pain, and swelling in the groin for the last 1 week. Laboratory findings of the patient were normal. Physical examination showed no signs other than swelling in the right groin. It was observed that the patient was obese. He also had a history of Chronic Obstructive Pulmonary Disease (COPD). Abdominal ultrasonography and superficial groin ultrasonography were performed in the emergency radiology department. While no pathology was detected in the abdominal ultrasonography, superficial ultrasonography revealed a right inguinal hernia and loculated fluid in the inguinal region, and therefore, upper abdominal and pelvic computed tomography was performed. Computed tomography revealed a right inguinal hernia and accompanying bladder hernia (Figures 1-3). Surgical intervention was recommended to the patient whose hernia was reduced and pain decreased, but the patient did not accept it.

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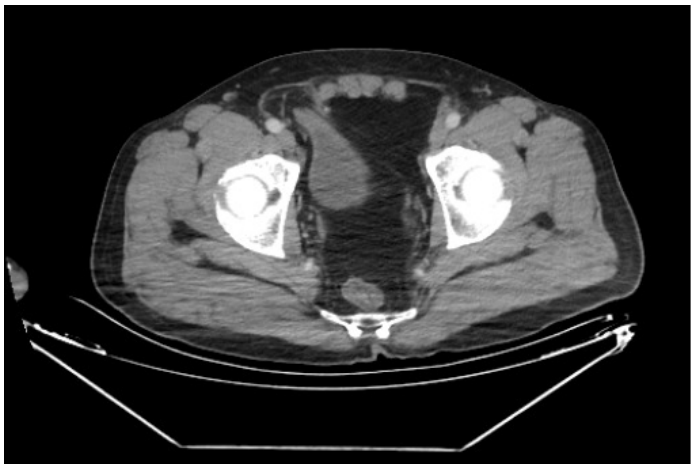

Figure 1. Right inguinal bladder herniation on axial computed tomography images

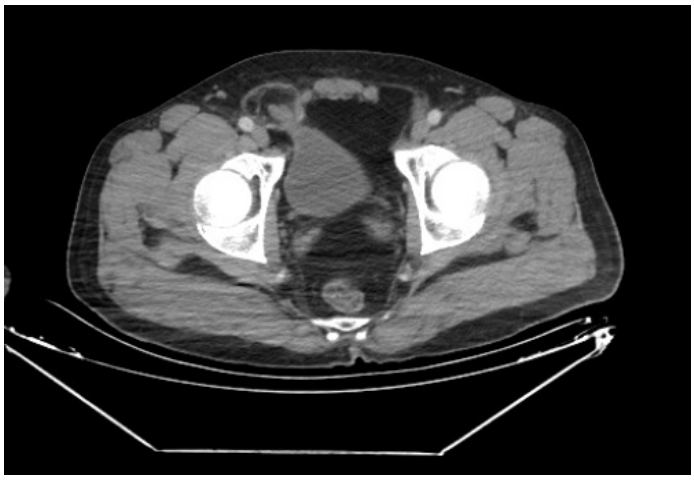

Figure 2. Right inguinal bladder herniation on axial computed tomography images

Figure 3: Right inguinal bladder herniation on sagittal computed tomography images

DISCUSSION

Bladder hernias are rarely seen. It was first described and accepted as an acquired pathology by Levine in 1951 (5). It is generally more common in men over the age of fifty and on the right side (6). Our case was a fifty-one-year-old male patient and his hernia was on the right side.

Bladder hernias are evaluated in 3 groups: paraperitoneal, intraperitoneal, and extraperitoneal hernias according to their relationship with the peritoneum. Paraperitoneal hernias are the most common. The herniated part of the bladder is located outside the inguinal hernia sac and extends along its medial edge. While the intraperitoneal hernia is totally surrounded by the peritoneum, extraperitoneal bladder hernias do not have any relationship with the peritoneum (1). Our case had an extraperitoneal hernia.

Various systemic and local factors play a role in the etiology as factors that facilitate the development of hernia. Advanced age, obesity, history of inguinal surgery, impaired bladder tonus, and weakness of bladder detrusor muscles are some of the predisposing factors. Apart from these factors, situations where intra-abdominal pressure increases such as COPD, atrophy of the abdominal wall muscles, increased perivesical adipose tissue density, and increased pressure associated with prostate hypertrophy while urinating may cause herniation in advanced-age patients. It has been suggested that all these factors may lead to bladder diverticulum formation and bladder herniation (7,8). Our case was a patient with a high body mass index (BMI) and a diagnosis of COPD.

While minimal bladder herniation usually does not show symptoms, symptoms such as decreased swelling in the groin after micturition, impaired urination, and increased urination by pressing on the swelling area may be seen in patients with significant hernia (9). In our case, there were no urinary complaints other than swelling since the hernia was minimal.

Early diagnosis is important to prevent complications and possible bladder injuries during inguinal surgery. When radiological imaging is performed, possible complications such as perforation, renal failure, and strangulation can be avoided (10,11). No complications were detected in our case.

Radiological imaging techniques have various advantages and deficiencies over each other. Although ultrasonography is the primary radiological diagnosis method used in inguinal hernias, the gold standard in diagnosis is cystography. This imaging method creates disadvantages such as the inability to show additional pathologies and false negativity in narrow-necked hernias (12). Computed tomography imaging can be performed for additional pathologies accompanying herniation, but this technique is disadvantageous due to its high cost and radiation exposure. The advantages of magnetic resonance imaging include its ability to display the relationship of hernia with peritoneal structures, accompanying additional

pathologies, inflammatory changes, and absence of radiation exposure (11,13). In our patient, ultrasonography was performed first, and then computed tomography was performed to make the diagnosis.

The main treatment of inguinal bladder hernias is surgical repair after the reduction or resection of the herniated bladder (9).

CONCLUSION

In conclusion, possible bladder hernia should be kept in mind, especially in patients with inguinal hernia with lower urinary tract symptoms. We believe that the familiarity of radiologists with the images will enable them to make the possible diagnosis and contribute to preventing possible complications.

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