e-ISSN 1308-8459

Official Publication of the Turkish Society of Anatomy and Clinical Anatomy

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An International Journal of Experimental and Clinical Anatomy

Volume 15 / Issue 2 / August 2021

Published three times a year

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Publication Information

Anatomy (e-ISSN 1308-8459) as an open access electronic journal is published by Deomed Publishing, Istanbul, for the Turkish Society of Anatomy and Clinical Anatomy, TSACA. Due the Press Law of Turkish Republic dated as June 26, 2004 and numbered as 5187, this publication is classified as a periodical in English language.

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http://dergipark.org.tr/en/pub/anatomy
Received: December 29, 2020; Accepted: August 15, 2021
doi:10.2399/ana.21.849525

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An International Journal of Experimental and Clinical Anatomy

An anatomical study of the bicipital aponeurosis in embalmed and fresh frozen cadavers

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Abstract

Objectives: The bicipital aponeurosis is a fascial expansion which arises from the distal tendon of biceps brachii muscle. It is an important structure for protecting the median nerve and brachial artery. The aim of this study was to analyze the morphometry and shape of the bicipital aponeurosis and its implications for the protection of the median nerve and brachial artery.

Methods: Upper extremities of two fresh frozen and seven embalmed cadavers (five right, four left sides) were dissected. The ages of the cadavers varied between 60–86 years. The central length, superior width, central width, inferior width and the shape of bicipital aponeurosis were evaluated. All measurements were performed by using digital caliper.

Results: The central length of the bicipital aponeurosis was measured 3.6±1.2 cm. The superior, central and inferior width of the bicipital aponeurosis were found 1.5±0.7 cm, 1.5±0.6 cm and 1.8±0.8 cm, respectively. Through the examination of upper extremities; two different shapes of bicipital aponeurosis were observed. In type I; the bicipital aponeurosis was fusiform in shape and observed in four upper extremities. In five extremities, it was found as quadrangular in shape and classified as type II.

Conclusion: The morphometry and shape of bicipital aponeurosis have a clinical importance to protect the median nerve and brachial artery or to reduce compression of these neurovascular structures. A better understanding of bicipital aponeurosis morphometry is important in assessment of biomechanical properties of biceps brachii.

Keywords: bicipital aponeurosis; brachial artery; median nerve; morphometry

Anatomy 2021;15(2):99–103

Introduction

The bicipital aponeurosis is a fascial expansion which arises from the distal tendon of biceps brachii muscle.[1] It is an important structure for the protection of the median nerve and brachial artery.[2] There are several functions attributed to the bicipital aponeurosis in the literature. These functions are as follows: (1) Increasing the tension of biceps brachii tendon;[3] (2) reinforcement of the ante-brachial fascia;[4] (3) pulling the posterior border of the ulna medially to do supination of the forearm;[5] (4) stabilization of the distal biceps brachii tendon;[6] (5) feedback role between the fascia and biceps brachii muscle.[7]

The aim of this study was to analyze the morphometry and shape of the bicipital aponeurosis and its implications for the protection of the median nerve and brachial artery.

Materials and Methods

In this study, upper extremities of two fresh frozen and seven embalmed cadavers (4 female, 5 male; five right, four left sides) were dissected. The ages of the cadavers varied between 60–86 years. All of the upper extremities were free from pathology, trauma, surgical incision or deformity. All procedures were approved by the Ethical Committee of Lokman Hekim University and the study was conducted in the gross anatomy dissection laborato-

This study was presented as a poster at the Winter Meeting of the British Association of Clinical Anatomists, Univeristy of Leeds, 15 December 2016, Leeds, UK.

ry of Hacettepe University. The measurements were performed by using digital caliper.

The parameters evaluated in this study were as follows: (1) The central length of the bicipital aponeurosis; (2) The superior width of the bicipital aponeurosis; (3) The central width of the bicipital aponeurosis; (4) The inferior width of the bicipital aponeurosis; (5) The shape of the bicipital aponeurosis (**Figure 1**).

Results

Two fresh frozen and seven embalmed upper extremities (4 female, 5 male; five right, four left sides) were dissected in this study. Through the examination of upper extremities; two different shapes of bicipital aponeurosis were observed. In type I; the bicipital aponeurosis was fusiform in shape and observed in four upper extremities (**Figure 2**). In these cadavers, bicipital aponeurosis run obliquely and covered the median nerve and brachial artery. In only one extremity, the bicipital aponeurosis was fusiform in shape, but membranous in structure and it was difficult to separate it from the antebrachial fascia (**Figure 3**).

In five of the upper extremities, it was quadrangular in shape and classified as type II (**Figure 4**). Quadrangular bicipital aponeurosis was wider and thicker than the fusiform shaped ones.

The mean central length of the bicipital aponeurosis (A-B) was 3.3±0.6 cm (min-max: 2.8–3.9 cm) on the left side, 3.8±1.5 cm (min-max: 1.8–5.9 cm) on the right side and 3.6±1.2 cm in general. The mean superior width (C-D) was 1.5±0.4 cm (min-max: 1.3–2.2 cm) on the left side, 1.5±0.7 cm (min-max: 0.7–2.8 cm) on the right side and 1.5±0.6 cm in general. The central width (E-F) was found to be 1.4±0.3 cm (min-max: 1.1–1.7 cm) on the left side, 1.6±0.9 cm (min-max: 0.7–3.1 cm) on the right side and 1.5±0.6 cm in general. The inferior width of the bicipital aponeurosis (G-H) was 1.7±0.4 cm (min-max: 1.3–2.1 cm) on the left side, 1.9±1.0 cm (min-max: 0.8–3.5 cm) on the right side and 1.8±0.8 cm in general. There was no statisti-

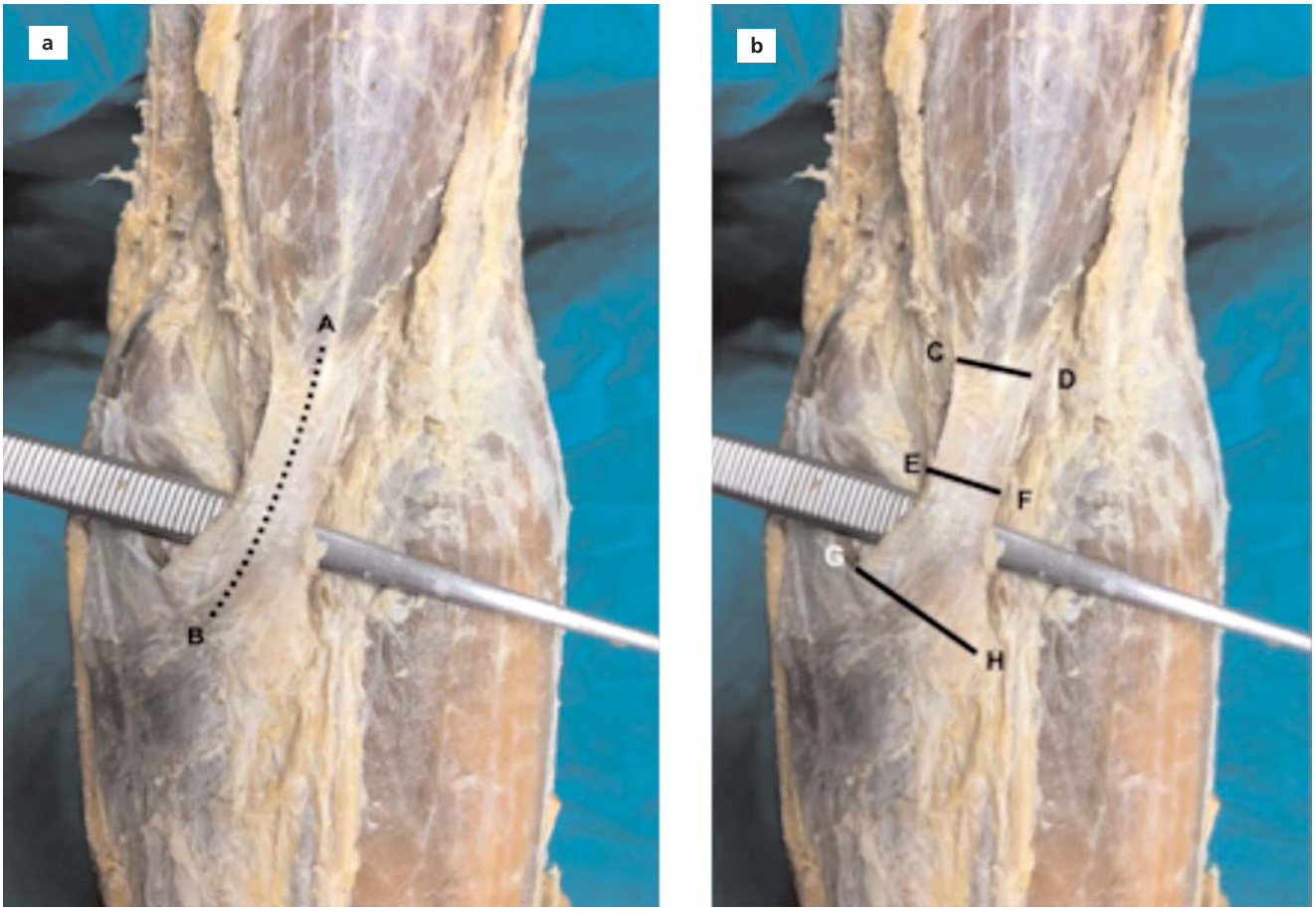

Figure 1. Figures (**a**) and (**b**) show the parameters measured in this study. **A-B:** the central length of the bicipital aponeurosis; **C-D:** the superior width of the bicipital aponeurosis; **E-F:** the central width of the bicipital aponeurosis; **G-H:** the inferior width of the bicipital aponeurosis.

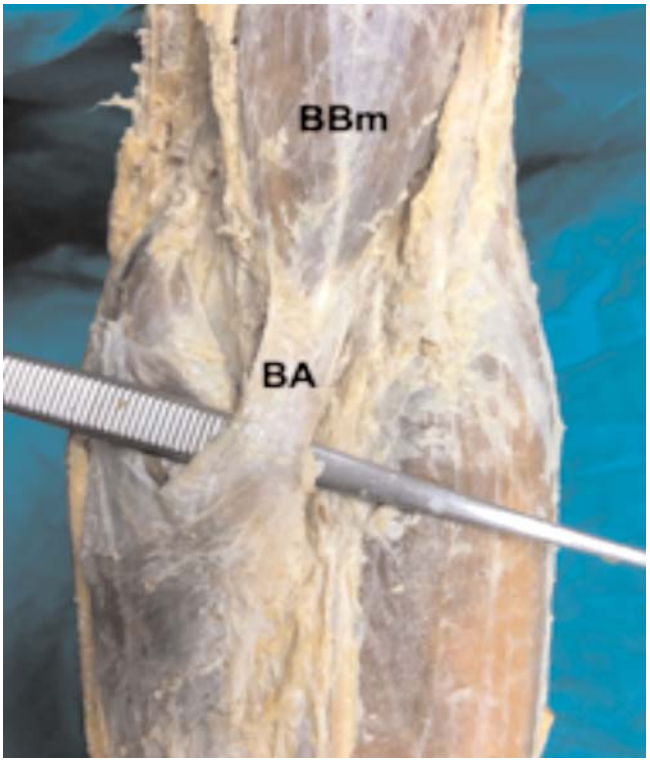

Figure 2. Fusiform bicipital aponeurosis (Type I). **BA:** bicipital aponeurosis; **BBm:** biceps brachii muscle.

Figure 3. Fusiform bicipital aponeurosis in membranous structure. **BA:** bicipital aponeurosis; **BBm:** biceps brachii muscle.

cally significant relationship between the variables and among right and left sides (p>0.05).

Discussion

The bicipital aponeurosis was described as a fibrous lamina arising from the medial margin of the distal biceps brachii tendon. It runs distally and medially, broadens, and joins with the antebrachial fascia. It surrounds the flexor muscles of forearm as well as the brachial artery and median nerve.[7,8] The flexor-pronator muscles can be compressed by the bicipital aponeurosis during pronation against resistance.[8] It can cause compression of the median nerve and brachial artery, by narrowing the space under it.[8,9]

Snoeck et al.[7] dissected 50 upper extremities of 36 embalmed cadavers (23 females, 13 males) and measured the central length of the bicipital aponeurosis as 8.6±1.0 cm. Caetano et al.[9] dissected 60 upper limbs of 30 cadavers (26 males, 4 females) and found that the length of aponeurosis ranged from 4.5 to 6.2 cm. In this study, the central length was found to be 3.6±1.2 cm, which was lower than the previous studies in the literature.

Caetano et al.[9] reported that the width of the bicipital aponeurosis ranged from 0.5 to 2.6 cm. Snoeck et al.[7] measured the mean width as 0.9±0.4 cm superiorly,

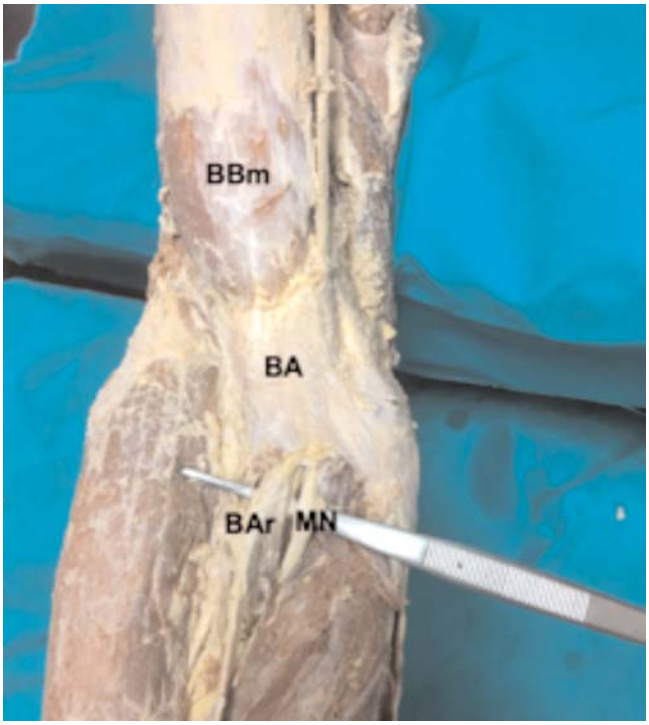

Figure 4. Quadrangular bicipital aponeurosis (Type II). **BA:** bicipital aponeurosis; **BAr:** brachial artery; **BBm:** biceps brachii muscle; **MN:** median nerve.

1.2±0.4 cm centrally and 1.0±0.4 cm inferiorly. Joshi et al.[10] dissected 30 cadaveric upper limbs (16 right, 14 left side) and measured the mean width of bicipital aponeurosis 15.74 mm on the right and 17.57 mm on the left side. In this study, the mean superior, central and inferior width of the bicipital aponeurosis were found to be 1.5±0.7 cm, 1.5±0.6 cm and 1.8±0.8 cm, respectively. Our results were compatible with the other studies in the literature. The width of the bicipital aponeurosis is important clinically because hypertrophy or enlargement of the aponeurosis may cause compression of the median nerve.[9,11] Caetano et al.[9] observed that the bicipital aponeurosis which was very narrow and thin, was unlikely to compress the median nerve. Martinelli et al.[11] reported one case with median nerve compression caused by a thick and well-developed bicipital aponeurosis. The knowledge of normal dimensions of the aponeurosis will help the physicians to diagnose nerve compression syndromes accurately.

Caetano et al.[9] showed that it had a rectangular formation in most cases, while it was trapezoidal in few cases. We observed two different morphological shapes of bicipital aponeurosis as follows: quadrangular shape in five cases and fusiform shape in four cases. Similar to Caetano et al.,[9] quadrangular shape was frequently detected in present study. We suggest that quadrangular and fusiform shapes were effective for the protection of the brachial artery and median nerve, except the bicipital aponeurosis in membranous structure. However, since quadrangular shaped aponeurosis surrounds the neurovascular structures tightly, it may be a risk factor for the compression of the neurovascular structures.

Caetano et al.[9] demonstrated that the short and long heads of the biceps brachii muscle contributed to the formation of the bicipital aponeurosis in 55 limbs, and the most significant contribution was always from the short head. In three limbs, only the short head contributed to the formation of the bicipital aponeurosis. Joshi et al.[10] reported that the fibers from the short head formed the proximal part of aponeurosis, while the long head contributed to the distal part of bicipital aponeurosis. Athwal et al.[12] dissected 15 fresh-frozen upper extremities and showed that the aponeurosis originated from the short head of biceps in all specimens. Dirim et al.[5] made a dissection of 17 upper limbs (7 left, 10 right side; 9 male, 8 female) and they found that the bicipital aponeurosis was formed by superficial tendinous fibers arising from both muscle bellies in most cases (94.1%). In 5.9% (1/17) of the specimens, only fibers of the short head contributed to the bicipital aponeurosis. The structures that contribute to the formation of bicipital aponeurosis are still controversial in the literature. Further investigation with a larger samples is required to better understand bicipital aponeurosis formation.

Repairing the bicipital aponeurosis in cases with distal biceps tendon rupure is controversial in clinical practice. Some researchers reported that the presence of an intact bicipital aponeurosis limited retraction of the distal biceps tendon and increased the chance of direct repair regardless the time of the injury.[13,14] Landa et al.[3] performed a cadaveric study and showed that termino-terminal sutures of the bicipital aponeurosis increased the mechanical strength in distal biceps tendon repair. Conlin et al.[15] treated 24 male patients with a distal biceps tendon rupture. They reported that repair of the bicipital aponeurosis in conjunction with distal biceps tendon repair led to a faster return to activities compared with isolated tendon repair. Fontana et al.[16] described a new surgical technique as treating distal biceps tendon tear with bicipital aponeurosis augmentation. They used autologous vascularized bicipital aponeurosis graft and found that recovery time was quicker and integration was faster than the techniques described in the literature. The topographic anatomy of the bicipital aponeurosis is essential for the successful repair of the aponeurosis and distal biceps tendon.

Conclusion

In conclusion; the morphometry and shape of bicipital aponeurosis have a clinical importance to protect the median nerve and brachial artery or to reduce compression of these neurovascular structures. A better understanding of bicipital aponeurosis morphometry is a great value in assessment of biceps brachii movement biomechanics.

Acknowledgments

We would like to thank the cadaver donors without whom such research would not be possible.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

HAA: project development, data collection, manuscript writing; SA: project development, data analysis, manuscript editing; MF: project development, data analysis, manuscript writing and editing; MFS: data analysis, statistical evaluation, manuscript editing.

Ethics Approval

All procedures were approved by the Ethical Committee of Lokman Hekim University (approval date: 09.08.2021, approval number: 2021/088).

Funding

None.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Akdemir Aktaş H, Akkaşoğlu S, Farımaz M, Sargon MF. An anatomical study of the bicipital aponeurosis in embalmed and fresh frozen cadavers. Anatomy 2021;15(2):99–103.

anatomy
http://dergipark.org.tr/en/pub/anatomy
An International Journal of Experimental and Clinical Anatomy

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: November 13, 2020; Accepted: May 19, 2021
doi:10.2399/ana.21.825667

Variations of the branches arising from the third part of the axillary artery: a cadaveric study

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Abstract

Objectives: This study aims to describe variations of the third part of the axillary artery branches with respect to their diameter, origin, subsequent branches, and gender.

Methods: One-hundred and forty cadaveric shoulders were examined bilaterally in the Centre for Anatomy and Human Identification, University of Dundee, which is regulated by Human Tissue Act (Scotland) 2006. Branches arising from the third part of the axillary artery were dissected and the diameter, origin, subsequent branching patterns of each branch were documented, as well as gender. T-tests and chi-square tests were used to determine the association between the variables.

Results: The most common variations were associated with the posterior circumflex humeral artery (48.3%), followed by the anterior circumflex humeral (25%) and subscapular arteries (16.7%). Variations of the anterior circumflex humeral artery were more common in females than males ($p<0.05$). A significant association between the origin of posterior circumflex humeral artery and its subsequent branching pattern was observed. In females, the anterior circumflex humeral artery was more likely to give rise to the profunda brachii when it originated from the posterior circumflex humeral artery.

Conclusion: Branches of the third part of the axillary artery vary in diameter, origin and subsequent branching patterns and the gender. An understanding of these variations is essential for accurate radiological diagnostic interpretation and therapeutic intervention. The difference in the variations observed and those reported in the literature suggest the need for further large scale studies.

Keywords: axilla; axillary artery; shoulder; variations

Anatomy 2021;15(2):104–115

Introduction

The axillary artery is a continuation of the subclavian artery at the outer border of the first rib. It continues as the brachial artery at the lower border of teres major. Pectoralis minor lies anterior to the artery dividing it into three parts: the first part (suprapectoral) is proximal between the lateral border of the first rib and medial border of pectoralis minor; the second part (retropectoral) lies posterior to it; and the third part (infrapectoral) extends from the lateral border of pectoralis minor to the lower border of teres major. During its course the axillary artery gives six branches: the superior thoracic artery from the first part; the thoracoacromial and lateral thoracic arteries from the second part; and the anterior and posterior circumflex humeral and subscapular arteries from the third part. Its continuation, the brachial artery, gives the profunda brachii artery.[1–3]

The vasculature of the upper limbs originates from the primitive axial and superficial brachial arteries, with the axillary, brachial and interosseous arteries arising from the primitive axial artery. In the proximal arm, both the brachial and axillary arteries merge with the superficial

The abstract has been presented at the Summer Meeting of the British Association of Clinical Anatomists UCLan School of Medicine, Greenbank Lecture Theater, Greenbank Building, University of Central Lancashire, 2 July 2019, Preston, UK.

brachial artery, while in its distal part, the superficial brachial artery anastomoses with the brachial artery. In the forearm, the primitive axial artery (ulnar system) gives a terminal trunk which anastomoses with the median artery (derivative of forearm arteries), the deep branch of the radial artery (branch of the primitive axial artery) and the ulnar artery.[4,5] Differentiation of the vessels occurs proximal to distal by regression of some capillaries and maintenance and enlargement of others. It is the variations in differentiation, regression and persistence of these capillaries which result in the variations seen in the vessels of the upper limb.[5] An in-depth knowledge of the normal arterial anatomy of the axillary artery and its variants is essential for clinical diagnosis and treatment, for example in coronary bypass and shoulder dislocation.[6]

Nevertheless, a series of case studies report variations in the branching pattern of the 3rd part of the axillary artery: variations in origin,[7,8] course,[9,10] the presence of common trunks,[11–13] and of additional branches, such as the radial artery.[14] According to Rao et al.[11] and Olinger[15] the classical description of the axillary artery is only present in 10% of cases. The most common variation is a common trunk rather than individual branches, followed by branches arising distally or from proximal branches, such as the deep brachial artery arising from the posterior circumflex humeral artery, which according to Olinger[15] occurs in 5% of cases.

Variations of the third part of the axillary artery have been reported either as scattered in the literature,[6,11,15–17] or reviews on a small number of cadavers.[18–20] The subscapular artery, largest branch of the 3rd part of the axillary artery, arises from a common trunk with the posterior circumflex humeral artery in up to 30% of cases. Furthermore, either the subscapular, anterior or posterior circumflex humeral arteries, as well as the profunda brachii having been reported arising from a common trunk.[21] One cadaveric study using 423 upper limbs reported truncus subscapulocircumflexus in 22.9%, truncus profundocircumflexus in 13.75%, and truncus bicircumflexus in 13.95% of the cases.[21]

Consequently, an inconsistency exists in the literature in which variations of the 3rd part of the axillary artery may be presented as an exception or may occur in high frequencies. For example, Miguel-Perez[22] and Siri et al.[23] found only one variation among 36 and 50 upper limbs respectively.[21–23] Others, however, report variations with greater frequency, with Gaur et al.[24] observing variations in 16% of 50 specimens and Maheswary Thampi et al.[20] reporting variations in 40% of 40 shoulders examined. It is difficult, therefore to determine the incidence of variations. Furthermore, many studies tend to focus on the frequencies of the variations and do not provide sufficient information on their relationship to gender, for example.[9,19,22]

A knowledge of variations in the branching pattern of the axillary artery is important for both diagnostic purposes and therapeutic interventions.[25–31] Vascular radiologists acknowledge the significance of variations when conducting angiographic imaging,[6] while surgeons may be faced with interpreting arterial variations in procedures for trauma or neoplasm.[26] The current study, therefore, aims to determine the incidence of variations in the branching pattern of the 3rd part of the axillary artery, and describe these variations with respect to their association with vessel diameter, side, and gender.

Materials and Methods

A total of 140 cadaveric shoulders from 70 cadavers of British origin (30 males and 40 females), with an average age of 81.5 (range 53–101) years were dissected and examined. The cadavers had been donated to the Centre for Anatomy and the Human Identification University of Dundee: all donations are in line with the Human Tissue Act (Scotland) 2006. Each shoulder was dissected following classical incisions and dissection procedures described in Grant's Dissector 16th edition.[32] Careful dissection was carried out to expose the axillary region, following which the 3rd part of the axillary artery and its branches were inspected: the presence of additional was also documented. The origin of each branch or common trunk was noted, as was its relation to the axillary artery, i.e. from which aspect it arose. The diameter (in mm) of each artery/common trunk at its origin was taken.

Classical descriptions of the 3rd part of the axillary artery state that it has three single branches, the anterior and posterior circumflex humeral, and subscapular arteries. Deviations from this pattern were considered as being a variation.

The data were entered into with Statistical Package for Social Sciences (SPSS Version 20, Armonk; NY, USA) for subsequent analysis. In the results the incidence of variations is presented. This is followed by a consideration of the variations in origin on the right and left sides, the branches observed, and the diameter or common origin of the anterior and posterior circumflex humeral, and subscapular arteries are described. Categorical variables are presented as frequencies and percentages of occurrence. Vessel diameter, as a continuous variable, was tested for its distribution using the Kolmogorov-Smirnov test: diameter is described by its mean and associated standard deviation. Inferential statistics were carried out to determine the presence of statistical differences when comparing characteristics of the arteries inspected with demographic vari-

ables. Independent t-tests, chi-square tests and one-way ANOVA were conducted. Chi-square post-hoc analysis with Bonferroni adjustment was carried out if statistically significant differences were observed. Correlation analysis, using the Pearson coefficient, was conducted between vessel diameter and age. All results were considered significant if p-value was less than 0.05.

Results

Variations in the 3rd part of the axillary artery were observed in 80% of specimens, with only 20% showing the classical anatomical pattern bilaterally. Notably, 95 specimens (67.9%) showed variations of which 52 (54.7%) were on the right and 43 (45.3%) the left side (**Table 1**). No significant differences was observed between right and left limbs (χ^2=2.653, p>0.05). Comparison of the incidence of variations in males and females revealed 36.8% (n=35) of variations were observed in males, and 63.2% (n=60) in females (**Table 1**). There was a significant difference between males and females (χ^2=4.366, p<0.05). No difference was observed between the mean age of specimens with and without variation (p>0.05).

Table 1

The number of 'classical' origin of branches from the third part of the axillary artery, together with the percentages of the variations observed in the right and left limbs, as well as between genders.

	Limb		Gender	
	Left	Right	Male	Female
Classical origin	27	18	25	20
Variation	43 (45.3%)	52 (54.7%)	35 (36.8%)	60 (36.8%)
Total	70	70	60	80

Variation in the origin of the anterior circumflex humeral artery was observed in 58 specimens (41.4%) (**Figures 1–3**). It most frequently arose from the 3rd part of the axillary artery (85.7%, n=106), the posterior circum-

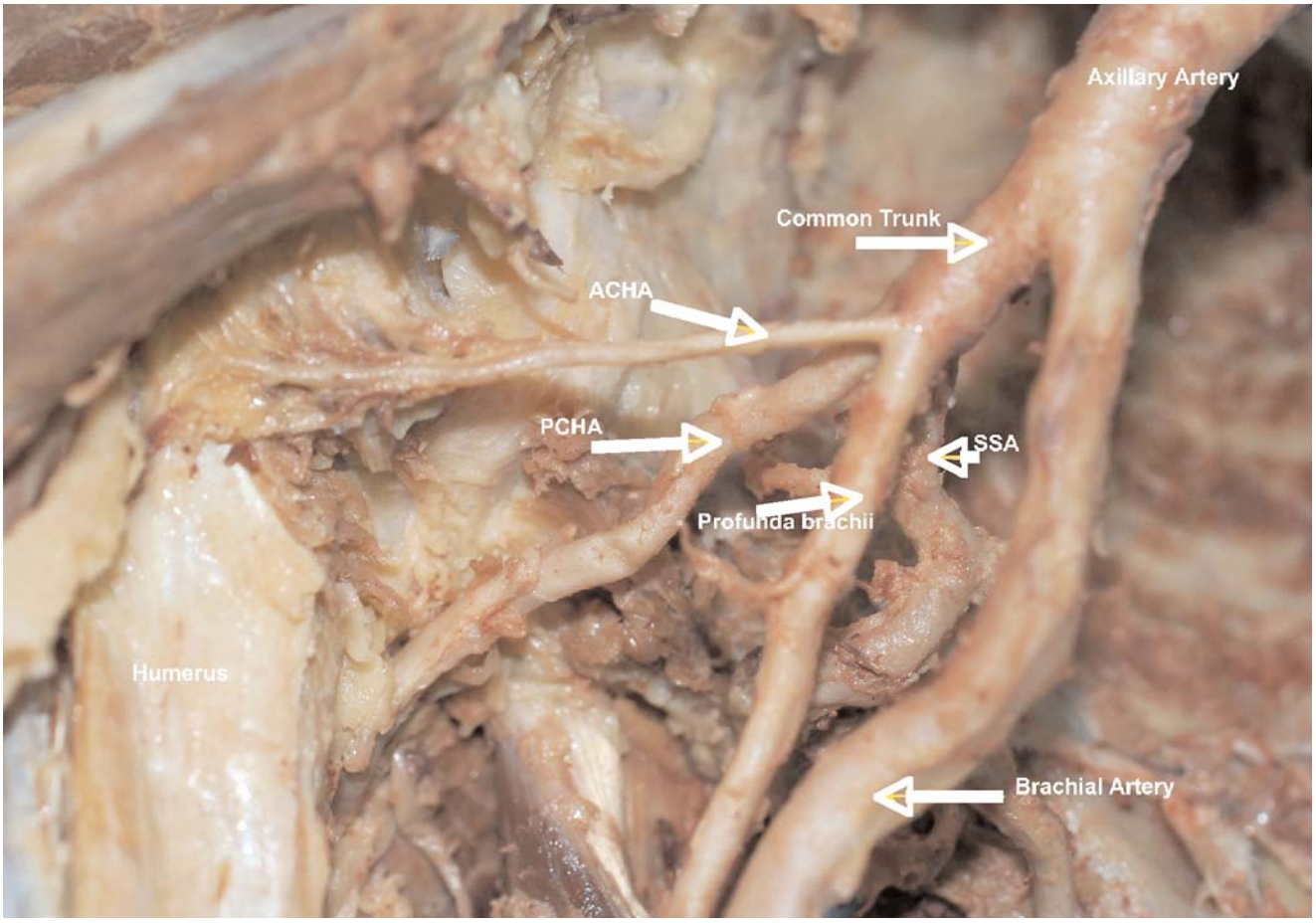

Figure 1. Anterolateral view of the right shoulder showing the axillary artery giving a common trunk, which divides into the subscapular artery (**SSA**), the posterior circumflex humeral artery (**PCHA**), the anterior circumflex humeral artery (**ACHA**) and profunda brachii.

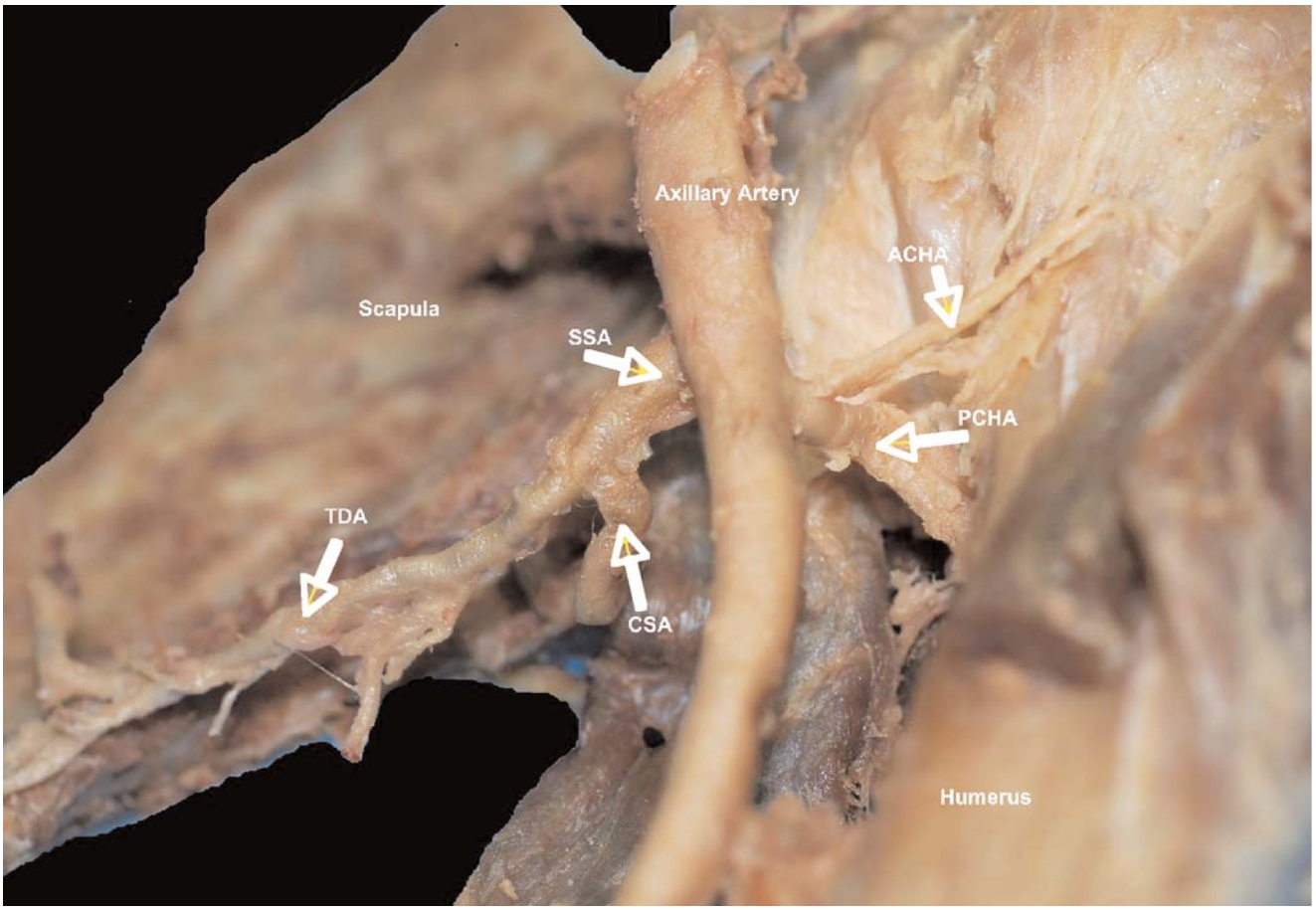

Figure 2. Anterior aspect of the left shoulder showing the third part of the axillary artery (**AA**) and its branches, the subscapular artery (**SSA**) and the anterior (**ACHA**) and posterior circumflex humeral arteries (**PCHA**). Note the **ACHA** and **PCHA** arise from a common trunk. **CSA:** circumflex scapular artery; **TD:** thoracodorsal artery.

flex humeral artery in 15 specimens (11.4%), profunda brachii in 3 specimens (2.1%) and the 1st part of the axillary artery in 1 specimen (0.7%) (**Table 2**). In 129 specimens (92.1%) the artery arose as a single branch, while in 11 specimens (7.9%) it had a common origin with the posterior circumflex humeral artery (**Table 3**; **Figure 2**).

Table 2

Origin of the anterior circumflex humeral artery, posterior circumflex humeral artery and the subscapular artery.

Origin	ACHA	PCHA	SSA
3rd part AA	120 (85.7%)	106 (75.7%)	127 (90.7%)
PCHA	15 (10.7%)	-	-
PB	4 (2.9%)	4 (2.9%)	1 (0.7%)
1st part AA	1 (0.7%)	-	-
BA	-	20 (14.2%)	-
SSA	-	9 (6.4%)	-
CSA	-	1 (0.7%)	-
2nd part AA	-	-	12 (8.5%)
Total	140 (100%)	140 (100%)	140 (100%)

AA: axillary artery; **ACHA:** anterior circumflex humeral artery; **BA:** brachial artery; **CSA:** circumflex scapular artery; **PCHA:** posterior circumflex humeral artery; **SSA:** subscapular artery.

In 99 specimens the anterior circumflex humeral artery originated from the lateral side (70.7%) of the axillary artery. The anterior circumflex humeral artery originated posterolaterally in 25 specimens (17.9%), superiorly in 8 (5.7%), anterolaterally in 4 (2.9%), and from the posterior, anterior, anterosuperior and posterosuperior aspects in 1 specimen each (0.7%) (**Table 4**). In 11 specimens both anterior and posterior circumflex humeral arteries arose from a common trunk, while in 21 specimens (15%) the anterior circumflex artery gave the profunda brachii as a branch.

Variations were observed in 21 male and 37 female specimens, with a significant difference between origin and gender being observed ($p<0.05$). Further analysis, using post-hoc tests, showed significant differences in the aspect of origin from the 3rd part of the axillary artery ($p<0.05$)

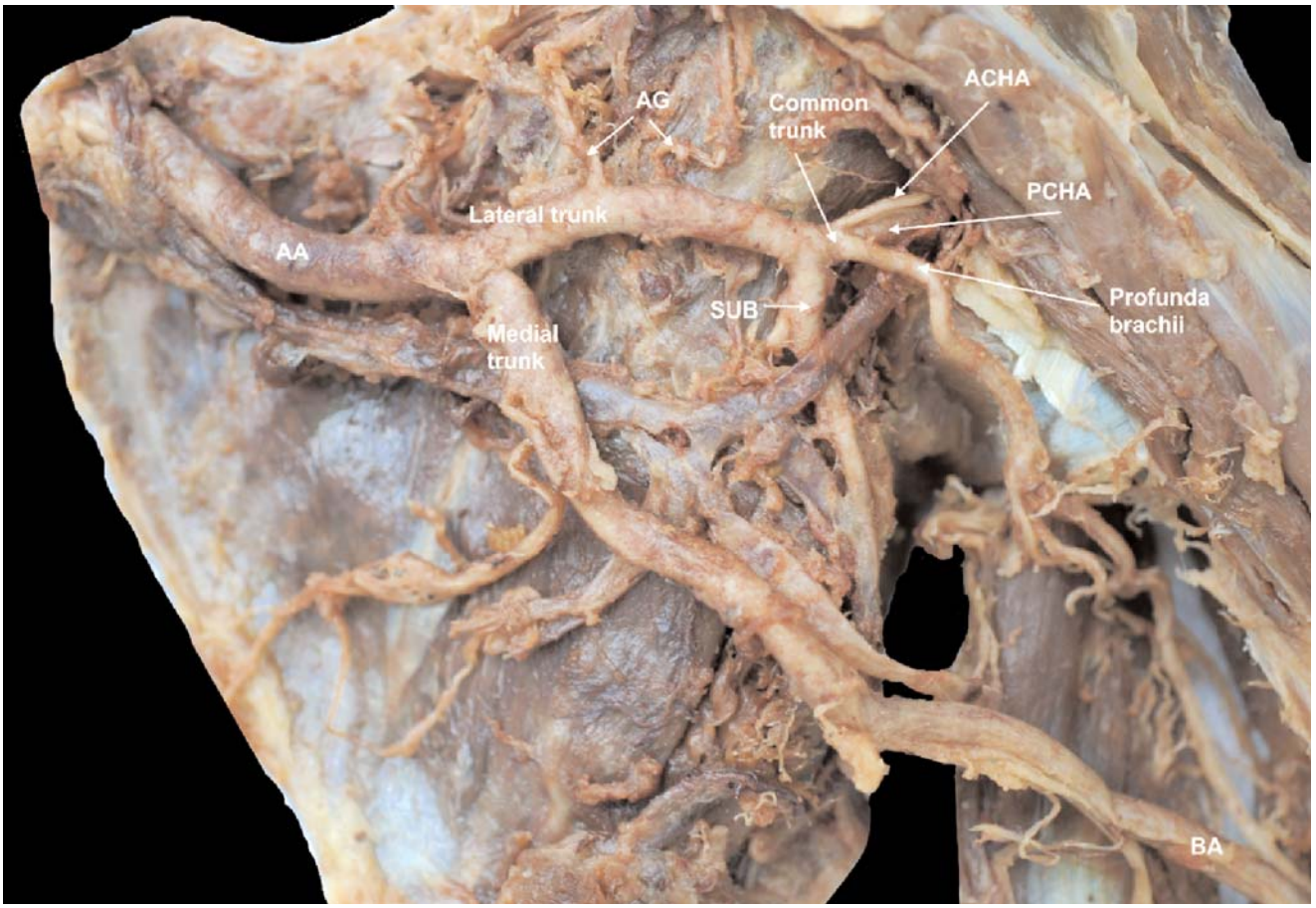

Figure 3. Anterior view of the left shoulder showing the axillary artery dividing into lateral and medial trunks. The lateral trunk gives a common trunk, which divides into anterior circumflex humeral (**ACHA**), posterior circumflex humeral (**PCHA**) and profunda brachii (**PB**) arteries. The medial trunk becomes the brachial artery (**BA**).

(**Table 3**). The mean diameter of the anterior circumflex humeral artery was 2.15±0.06 mm, with no difference being observed between males and females ($p>0.05$). However, a significant difference was observed in diameter depending on its aspect of origin ($p<0.05$). Significant differences were also revealed when comparing the diameter

Table 3

The frequency with which the anterior circumflex humeral artery, posterior circumflex humeral artery and the subscapular artery arose from a common trunk with other branches.

Origin	ACHA	PCHA	SSA	Total
as a single branch	129 (92.1%)	91 (65%)	109 (77.9%)	329 (78%)
with PCHA	11 (7.9%)	-	27 (19.3%)	38 (9%)
with ACHA	-	11 (7.9%)	1 (0.7%)	12 (2.9%)
with ACHA and PCHA	-	-	1 (0.7%)	1 (0.2%)
with PCHA and CSA	-	-	1 (0.7%)	1 (0.2%)
with ACHA and PB	-	-	1 (0.7%)	1 (0.2%)
with SSA	-	30 (21.4%)	-	30 (7.1%)
with PB	-	7 (5%)	-	7 (1.7%)
with CSA	-	1 (0.7%)	-	1 (0.7%)

ACHA: anterior circumflex humeral artery; **CSA:** circumflex scapular artery; **PB:** profunda brachii; **PCHA:** posterior circumflex humeral artery; **SSA:** subscapular artery.

Table 4

The aspect of the third part of the axillary artery from which the anterior circumflex humeral artery, posterior circumflex humeral artery and the subscapular artery originated.

Site of origin	ACHA	PCHA	SSA	Total
Lateral	99 (70.7%)	27 (19.3%)	-	126 (30%)
Postero-lateral	25 (17.9%)	46 (32.9%)	-	71 (16.9%)
Antero-lateral	4 (2.9%)	-	-	4 (1%)
Superior	8 (5.7%)	3 (2.1%)	-	11 (2.6%)
Posterior	1 (0.7%)	63 (45 %)	7 (5%)	71 (16.9%)
Anterior	1 (0.7%)	-	-	1 (0.2%)
Antero-superior	1 (0.7%)	-	-	1 (0.2%)
Postero-superior	1(0.7%)	-	-	1 (0.2%)
Medial	-	-	97 (69.3%)	97 (23.1%)
Posteromedial	-	1 (0.7%)	24 (17.1%)	25 (6%)
Inferior	-	-	12 (8.6%)	12 (2.9%)

ACHA: anterior circumflex humeral artery; **PCHA:** posterior circumflex humeral artery; **SSA:** subscapular artery.

between age groups, but there was no correlation between vessel diameter and age. No differences were found in diameter irrespective of whether the artery arose from a common origin or the aspect from which it arose, or relation to side, age or gender.

Variation in the origin of the posterior circumflex humeral artery was reported in 112 specimens (80%). The most common origin for the posterior circumflex humeral artery (**Figures 1–6**) was from the 3rd part of the axillary artery (106, 75.7%), the brachial artery in 20 speci-

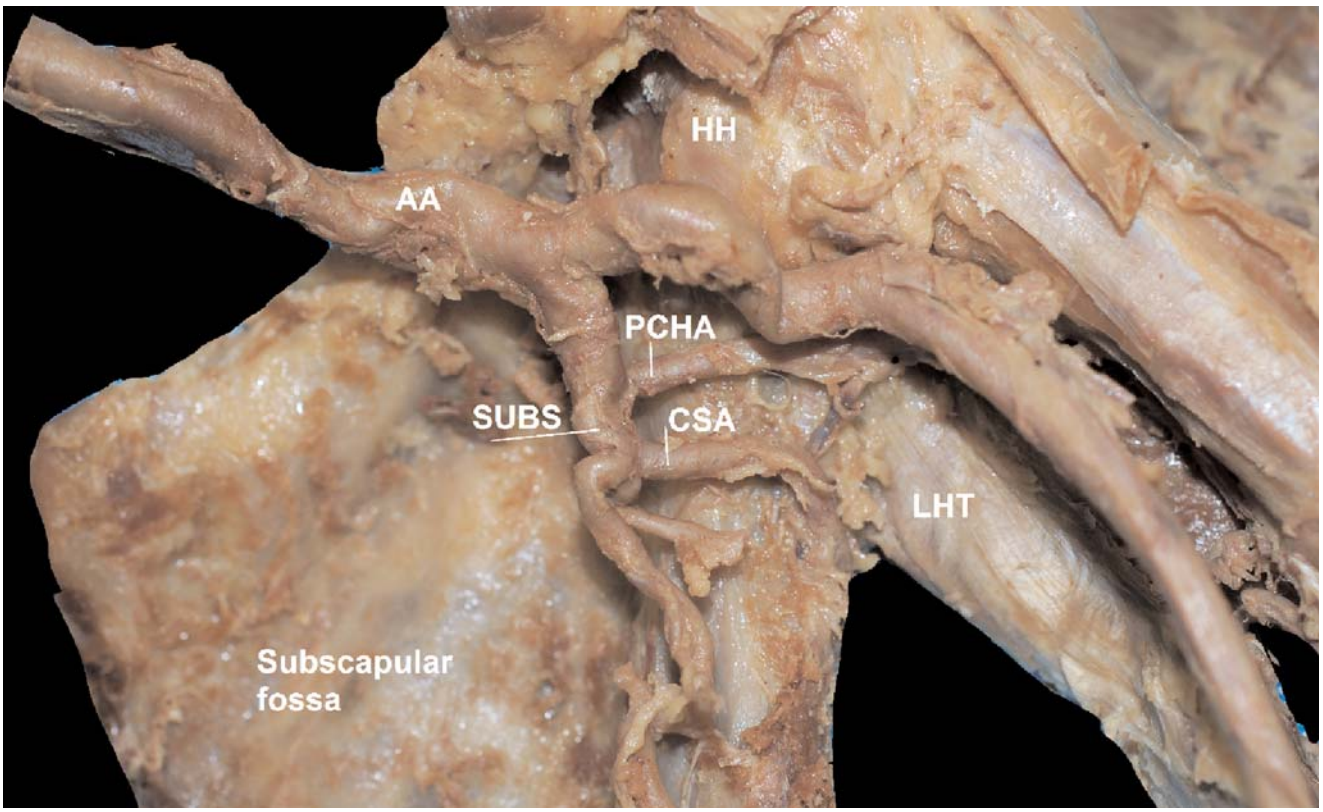

Figure 4. Anterior view of the left shoulder showing dissection of the inferior aspect of the glenohumeral joint. **AA:** axillary artery; **CSA:** circumflex scapular artery; **HH:** humeral head; **LHT:** long head of triceps; **PCHA:** posterior circumflex humeral artery; **SUBS:** subscapular artery.

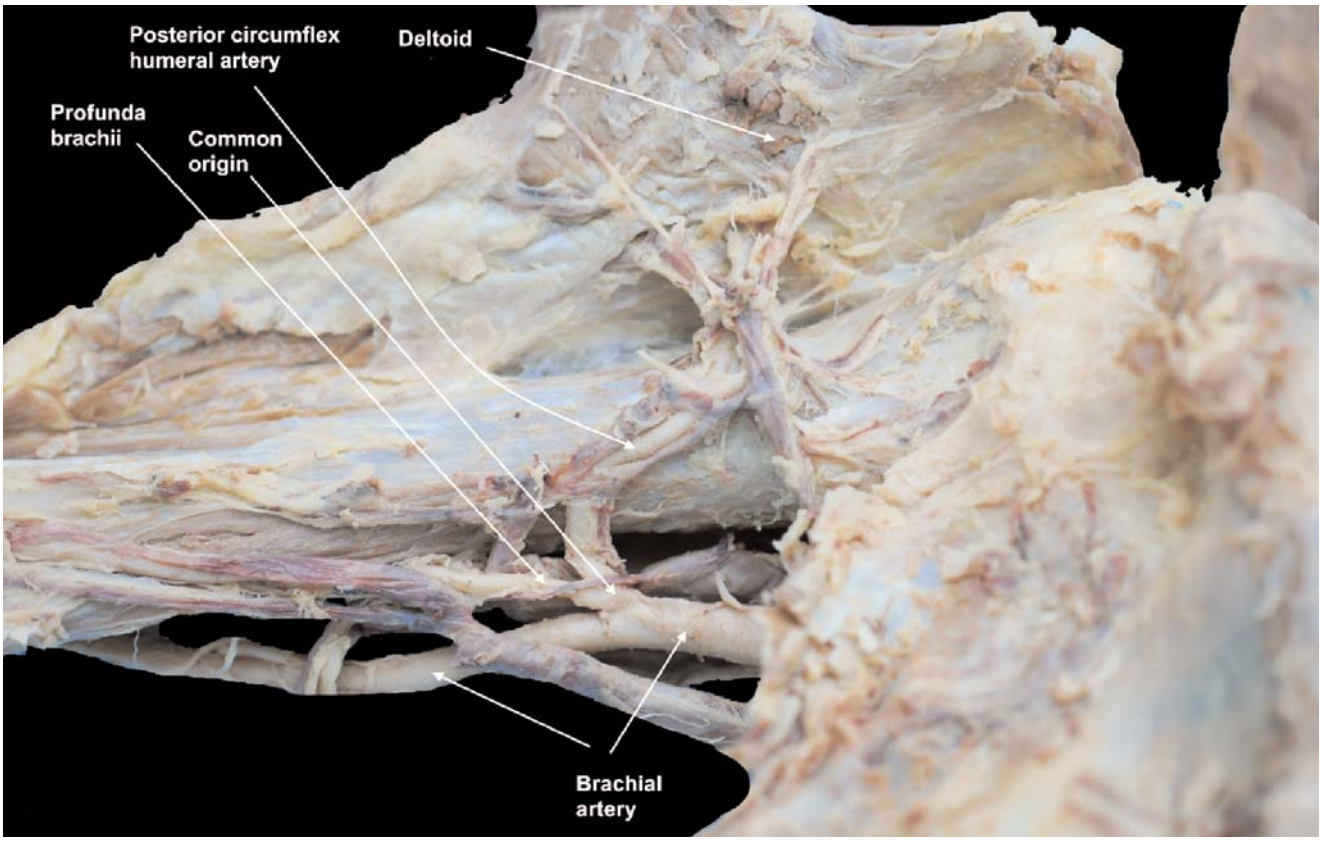

Figure 5. Posterior view of the left shoulder showing the common origin of the posterior circumflex humeral artery with the profunda brachii arising from the brachial artery.

mens (12.1%), the subscapular artery in 9 (9.3%), the profunda brachii in 4 (2.1%), and the circumflex scapular in 1 (0.7%) (**Table 2**). The posterior circumflex humeral artery arose as a single branch in 91 specimens (65%), from a common trunk with the anterior circumflex humeral artery in 11 specimens (7.9%), with subscapular artery in 30 specimens (21.4%), with profunda brachii in 7 specimens (5%) and with circumflex scapular artery in 1 specimen (0.7%) (**Table 3**).

The posterior circumflex humeral artery arose from the posterior aspect of the axillary artery in 62 specimens (44.3%), posterolateral in 44 specimens (31.4%), lateral in 27 specimens (19.3%), superior in 4 specimens (2.9%), inferolateral in 2 specimens (1.4%) and posteromedial in 1 specimen (0.7%) (**Table 4**). During its course the posterior circumflex humeral artery gave rise to the anterior circumflex humeral artery in 17 specimens and the profunda brachii in 4. A significant difference was observed between genders of the profunda brachii or anterior circumflex humeral artery arising as branches of posterior circumflex humeral artery (p=0.02). No other differences were observed in relation to gender, side, age and posterior circumflex humeral artery variations. The mean diameter of the posterior circumflex humeral artery was 3.98±1.00 mm, there being no difference between females and males (p>0.05). Furthermore, there was no correlation between age and diameter of the posterior circumflex humeral artery.

Variation of the subscapular artery was found in 62 specimens (44.3%) (**Figures 1**, **3**, **4** and **6**). It arose from the 3rd part of axillary artery in 127 shoulders (88.6%), from the 2nd part in 12 specimens (8.6%), and the profunda brachii in 1 specimen (0.7%). In 2 specimens (1.4%) the subscapular artery gave rise to the posterior circumflex humeral artery. The subscapular artery arises from a common trunk with either the posterior circumflex humeral artery or the anterior circumflex humeral artery in 0.7% each. The subscapular artery arose as a single branch in 109 specimens (77.9%), it had a common origin with the posterior circumflex humeral artery in 27 specimens (19.3%), with the anterior circumflex humeral artery, the anterior and posterior circumflex humeral arteries, the posterior circumflex humeral and circumflex scapular arteries, and the posterior circumflex humeral and profunda brachii arteries in 1 specimen (0.7%) each (**Table 3**).

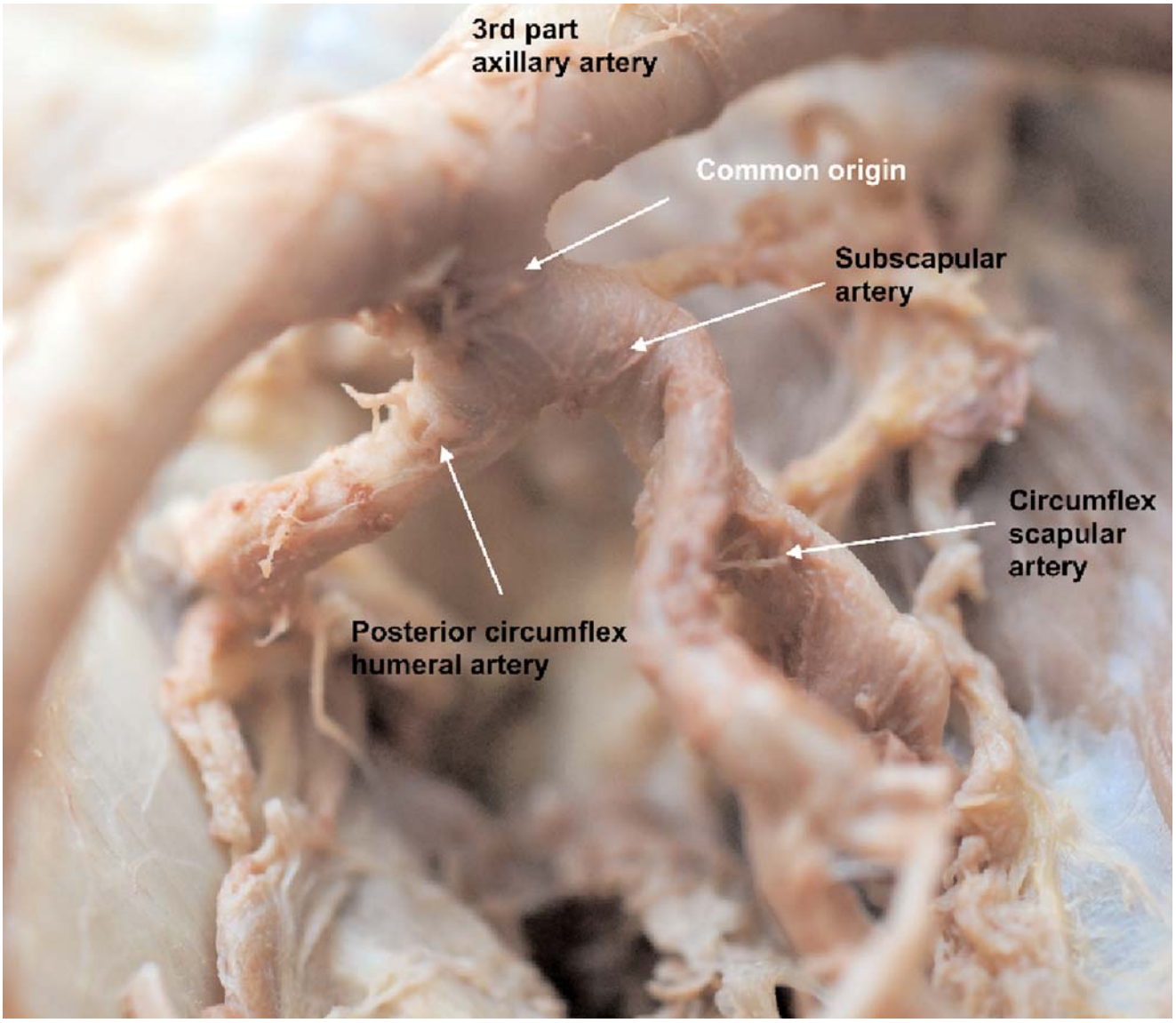

Figure 6. Posteromedial aspect of the right third part of the axillary artery showing the common origin between the subscapular and posterior circumflex humeral arteries.

The subscapular artery arose from the medial aspect of the axillary artery in 97 specimens (69.3%), posteromedially in 24 specimens (17.1%), inferiorly in 12 specimens (8.6%) and posteriorly in 7 specimens (5%) (**Table 4**). In 92.8% of specimens, the subscapular artery gave the circumflex scapular artery, and in 7.2% it gave both the circumflex scapular and posterior circumflex humeral arteries. A variation in the origin of the subscapular artery was observed in 22 males and 40 females. The mean vessel diameter was 5.2±1.2 mm, with a significant difference being observed between males and females in diameter and origin ($p<0.05$). Significant differences were found between vessel diameter and age ($p<0.05$).

Considering the above observations together, the most common variants were associated with posterior circumflex humeral artery (48.3%), followed by the anterior circumflex humeral artery (25%) and then the subscapular artery (16.7%). The anterior circumflex humeral artery arose as a single artery more commonly in females than males ($p<0.05$), whereas the posterior circumflex humeral and subscapular arteries arose equally frequently in males and females. There was a statistically significant difference ($p<0.05$) branching pattern according to the origin of the artery between females and males. In females, the anterior circumflex humeral artery was more likely to give the profunda brachii when it originated from the posterior cir-

cumflex humeral artery. There was a significant association ($p<0.05$) between the origin of posterior circumflex humeral artery and the branches it subsequently gave. When it originated from the 3rd part of axillary artery, the posterior circumflex humeral artery gave the anterior circumflex humeral artery in 15.1% of specimens, when it arose from the profunda brachii it gave no branches, when it arose from the circumflex scapular artery it always gave rise to the anterior circumflex humeral artery, and when it originated from the brachial artery it gave the profunda brachii in 11.8% of specimens.

The posterior circumflex humeral artery gave rise to no branches in 85% of specimens, but gave rise to the anterior circumflex humeral artery in 12.1% of specimens and the profunda brachii in 2.9% of specimens. A significant association ($p<0.05$) was observed between the branches given off and gender: in males it was the profunda brachii, while in females it was the anterior circumflex humeral artery.

The site of origin from the 3rd part of the axillary artery in relation to presence or absence of variations are summarized in **Table 4**. The anterior circumflex humeral artery arose from the lateral aspect of the axillary artery, including posterolateral and anterolateral, aspect of the artery in 91.5% of specimens. The posterior circumflex humeral artery commonly arose from the 3rd part from the posterior aspect, including the posterolateral, posteromedial and posterosuperior, in 95% of specimens. The subscapular artery arose from the medial aspect, including the posteromedial, in 86.4% of specimens.

Discussion

The branching pattern of the 3rd part of the axillary artery was studied with respect to its three classical branches, the anterior and posterior circumflex humeral and subscapular arteries, with respect to their origin, variations (if present), diameter and gender. The current study shows a high frequency of variations in the branching pattern, with only 20% of specimens having the classical branching pattern bilaterally. Of the 140 dissections undertaken and examined variations were noted in 67.9% of specimens, which were significantly more frequent in females. These observations show that only 32.1% of specimens followed the description given of textbooks, that the 3rd part of the axillary artery gives rise to three single branches. Consequently, the 'typical' pattern can be considered to less common. Although previous research has reported the frequencies of variation in any one of the three branches, little is known about the incidence of variations. Gaur et al.[24] reported an incidence of variation of 16% in 25 cadavers, while Maheswary Thampi et al.[20] reported an incidence of 40% in 20 dissected cadavers. The observations of the current study are closer to the findings of Astik and Dave,[18] who reported a total incidence of the variant branching pattern of the axillary artery in 62.5% of their 40 samples; however their findings did not show any gender differences.

Although a high frequency of variations was found, the 3rd part of the axillary artery remained the most frequent site of origin of the anterior circumflex humeral artery (85.7%), posterior circumflex humeral artery (75.7%) and subscapular artery (90.7%). Similarly, in the majority of specimens the anterior circumflex humeral artery (92.1%), posterior circumflex humeral artery (65%) and subscapular artery (77.9%) arose as single branches (**Table 3**). However, it must be noted that this high incidence did not occur in all specimens. The current high incidence of variation highlights the importance of reporting the incidence of variations in the branching pattern and not merely describe the variation of branches, in order to determine the true incidence of variation in the population.

The anterior circumflex humeral artery arose from the 3rd part of the axillary artery (85.7%), posterior circumflex humeral artery (10.7%), profunda brachii (2.9%) and the 1st part of the axillary artery (0.7%) (**Table 2**). In the majority of specimens (92.1%) it arose as a single branch and only in 7.9% as a common trunk with the posterior circumflex humeral artery (**Table 3**). Fontes et al.[27] reported that the anterior circumflex humeral artery originated as a single branch in 62.5% of their sample, from the profunda brachii in 4.2%,[27] which is a similar to the current study. Both Fontes et al.[27] and Maheswary Thampi et al.[20] reported that it arose from the subscapular artery in 8.3% of specimens, a variation not observed in the present study. Interestingly, double anterior circumflex humeral arteries have been reported[24,27] and even its absence.[27] The anterior circumflex humeral artery arose from a common trunk in 7.9% of specimens, agreeing with the 8.3% reported by Fontes et al.[27] and the 10% reported by Maheswary Thampi et al.[20]

The posterior circumflex humeral artery arose from the third part of the axillary artery in 75.7% (**Table 3**), which is in agreement with the 77.1% reported by Olinger and Benninger.[28] The second most frequent origin was from the brachial artery (14.2%), followed by the profunda brachii (2.9%), which is lower than the 8.4% reported by Olinger and Benninger.[28] The origin of the posterior circumflex humeral artery (as a single branch) from the circumflex scapular artery that was observed in the present

study in 0.7% has not been reported in previous studies. The 6.4% arising from the subscapular artery is lower than previous reports: 12% in Olinger and Benninger,[28] 30% Kanaka et al.[19] and 54.2% in Fontes et al.[27] Furthermore, its origin from profunda brachii in 2.9% of specimens is lower than the 4.2% of Fontes et al.[27] and the 8.4% of Olinger and Benninger.[28] Moreover, one study[28] report an origin from the lateral thoracic artery in 1.2% of their sample: this was not observed in the current study. Although the literature reports the posterior circumflex humeral artery arising as a common trunk with other arteries,[9,18,29] these are case reports, therefore it is not possible to make comparisons with the current study.

Subscapular artery originated form the 3rd part of the axillary artery in 90.7% of specimens in the current study (**Table 2**), Olinger and Benninger[28] reported 78.3%. Its origin from profunda brachii has not been previously in the literature. The subscapular artery arising from the 2nd part of the axillary artery has been reported by Maheswary Thampi et al.[20] in 10% of specimens and by Gaur et al.[24] in 4%. The current study observed it originated from the 1st first part of the axillary artery in 8.5% of specimens. Moreover, one study[28] describe the origin of subscapular artery from the lateral thoracic artery in 5.4%.

The current study is the first to examine variations in males and females separately. We found that significantly more variations were present in females, implying that this should be taken into consideration during medical procedures. Significant differences between genders were found in relation to the origin of the anterior circumflex humeral artery, branches of posterior circumflex humeral artery and the diameter of subscapular artery. Significant differences were also observed when comparing anterior circumflex humeral artery diameter between different age groups, anterior circumflex humeral artery origin and diameter, subscapular artery origin and diameter and age groups. Despite differences in anterior circumflex humeral artery diameter between age groups, no correlation was found between age and the diameter of the artery.

Variations in the origin of vessels from the 3rd part of the axillary artery might be explained by one of three previously suggested developmental theories.[5,30–34] Aharinejad et al.[30] have suggested that variation may be due to remodeling of the complex primitive vascular networks. A second theory, the sprouting theory, suggests that arteries of the upper limb sprout from the axial artery.[30,31,33,34] While the third theory postulates that a proximodistal differentiation of the initial capillary plexus, together with a posterior-to-anterior polarity, is responsible for development of the arterial pattern of the upper limb. The maintenance, enlargement and differentiation of particular capillary networks and the regression of others leads to the development of the vascular pattern, including its variation.[5]

The major strength of the present study is its sample size. All previously published literature had smaller sample sizes, and as such mainly provided information about specific branches of the axillary artery or specific aspects of these branches. Therefore, the literature provides a scattered approach to variations and is not a true representative of the population. In contrast the current study focused on all three branches of the axillary artery describing a range of variables: it therefore provides a more holistic picture of the characteristics of the branches of the 3rd part of the axillary artery. Another further advantage of the current study is that it used gross dissection to examine each artery and its branching pattern. Combined with the large sample size this limits the risk of selection bias.

Despite the advantages of this study, there were some limitations. Even though a variety of aspects of the branching patterns are presented, there is no consideration of the relationship of the arteries to adjacent structures, such as nerves. Such variations have been described elsewhere and are of clinical importance, as they may result in compression of the arteries.[13] Furthermore, the variations described do not include the origin of additional branches from the 3rd part of the axillary artery. Consequently, some variations might not have been identified, so that the frequency of variations may be higher.

The variations in the origin and course of third part of axillary artery are clinically important in diagnostic vascular procedures and surgical treatment. Treatment of chronic shoulder dislocation using axillary approach may injure axillary and brachial arteries.[35] Such variation should be considered during pectoralis major myocutaneous graft, mastectomy or in cardiac bypass surgery for grafting: These variations can be diagnosed and rolled out using doppler study or angiography. It has been also reported that arterial variations can be used to confirm and explain the causes of the upper limb pathologies including peripheral vascular diseases and treatments of axillary artery thrombosis.[36]

Conclusion

This study found a high frequency of variations in the branching pattern whereas when each branch was considered separately a high frequency of "normal" anatomy was found. These results indicate that it is common for one individual to have a variation, but it is uncommon for variations to exist in multiple arteries. Furthermore, this study

was the first to provide information concerning the relation of variables such as sex, age and side with the presence of variations. Among them, sex was found to be a significant variable influencing the presence of variations in the branching pattern of the third part of the axillary artery. As the topographic anatomy of vascular variations is of major clinical importance, further research should focus on documenting the course of the arteries in relation to adjacent structures.

Acknowledgments

The authors would like to express their sincere gratitude to the donors and their families. Special thanks to Anatomy at University of Zawia and Centre for Anatomy and Human Identification, University of Dundee.

Conflict of Interest

None.

Author Contributions

AMA: collection, processing of material data analysis and interpretation, writing manuscript; TA: data analysis and interpretation, writing manuscript; RS: Proofreading the manuscript.

Ethics Approval

The specimens were obtained from Centre for Anatomy and Human Identification, which is regulated by the Anatomy Scotland Act (2006).

Funding

None.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Alashkham A, Almabrouk T, Soames R. Variations of the branches arising from the third part of the axillary artery: a cadaveric study. Anatomy 2021;15(2):104–115.

anatomy
http://dergipark.org.tr/en/pub/anatomy
An International Journal of Experimental and Clinical Anatomy

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: March 29, 2020; Accepted: July 28, 2021
doi:10.2399/ana.21.898254

Anatomic correlation of common fibular nerve palsy encountered after short leg casts

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Abstract

Objectives: Short leg casts are routine applications in orthopaedic practice. The aim of the study was to investigate the course of the common fibular nerve and its branches (deep and superficial fibular nerves) around the fibular neck in order to describe a convenient method for applying the lower extremity casts with low risk of fibular nerve entrapment.

Methods: Fifty lower extremities of 26 cadavers were examined. The point where common fibular nerve itself or its branches (deep and superficial fibular nerves) crossed over the fibular neck were dissected. The points where the nerve or its branches have risk of compression between the fibula and the cast were investigated in relation to fibular length.

Results: The average fibular length was 356.9±26.4 mm. The common fibular nerve did not pass over the fibular neck in any specimen, instead, its branches crossed over it. The average distance from the tip of the fibular head to deep fibular nerve and superficial fibular nerve were 42.9±6.5 mm and 52±6.3 mm, respectively. The mean ratio of fibular length to these distances were 8.5±1.2 and 7.0±0.8, respectively.

Conclusion: As short knee casts is a frequent application in clinical practice, it is important to determine a safe upper border for the casts to protect common fibular nerve or its branches. We recommend that the upper border of short leg casts should not exceed the upper 1/7th of the fibular length of the patient in order to avoid fibular nerve palsy.

Keywords: compression; fibular nerve palsy; short leg cast

Anatomy 2021;15(2):116–120

Introduction

Lower extremity plasters (casts) are frequently used in orthopaedic practices, as immobilization of the lower extremity helps the healing process. Although this practice seems harmless, it has specific complications. These are; deep venous thrombosis (the most frequent one), the compartment syndrome of the extremity, degradation of the repositioning gained in the fracture area, rigidity of the motionless joints due to the plaster, skin problems as a result of the pressure of the plaster and compression wounds.[1]

Common fibular nerve palsy is the most common entrapment neuropathy of the lower extremity.[2–4] The common fibular nerve may either be compressed internally or externally. Internal factors include tumors, bony or synovial spurs, ganglions, hematoma, vascular abnormalities and entrapment. The external ones are improper leg cast, trauma, fracture, traction injuries, surgical procedures related with proximal fibula; i.e. anterior cruciate ligament reconstruction and treatment of tibial plateau fractures, leg orthoses and pneumatic compression, compression stockings after surgery, postural cases such as pressure caused by prolonged positioning in bedridden patients, poor patient positioning during surgery, prolonged squatting and leg crossing. Moreover fibular nerve palsy may occur due to vascular conditions, diabetes mellitus and some other idiopathic reasons.[1,4–11]

This study was an oral presentation at 18th Congress of the International Federation of Associations of Anatomists, 8–10th August 2014, Beijing, China.

The common fibular nerve is relatively unprotected as it traverses the lateral aspect of the neck of the fibula. This is the place where the subcutaneous tissue is thin and the common fibular nerve is superficial. Consequently, it is more vulnerable to be compressed or injured in here.[4,5,8,9,12] Particularly, thin and slender people have thin subcutaneous tissue at the fibular neck that makes them more vulnerable to such injuries.[8,9] Aigner et al.[13] confirmed that the neck of the fibula had not been a safe area, concerning osteotomies or bone biopsies. When the nerve is compressed, decrease in microvascular blood flow and axonal transport degradation can destroy the nerve structure and function within hours.[11] Acute compression causes focal demyelination. If compression is prolonged, there becomes perineural edeuma and permanent fibrosis.[11,14] Probably, long duration of the compression plays a critical role in the severe nerve entrapment findings.[5] The timing of the treatment plays an important role in the neurological recovery.[15]

The plasters applied under the level of the knee are finalysed approximately at the region where the common fibular nerve or its branches wind around the fibular neck. The fibular nerve anatomy and the fibular length is variable among individuals. A standardization concerning the length of the fibula may help determination of the places where the nerve is minimally at risk when a cast is applied. While applying a lower extremity plaster, this dreary but reversible complication may be prevented if small tips are taken into account. Thus, we decided to investigate the course of the common fibular nerve and its branches (deep and superficial fibular nerves) around the fibular neck in order to describe a convenient method for applying the lower extremity casts with low risk of fibular nerve entrapment.

Materials and Methods

Fifty lower extremities from 26 formalin fixed cadavers in (21 males and 5 females) were dissected with a mean age of 60.4 years (range: 36 to 74). The cadavers were belonging to the collection of İstanbul University Faculty of Medicine, Department of Anatomy and none of them had any pathological findings in the related region.

The part of the common fibular nerve, where it crossed over the neck of the fibula, was examined in each cadaver, as this part had the maximum risk of compression in a leg cast. The vertical distance between the point where the common fibular nerve or its branches passed over the anterior part of the neck of the fibula and the most proximal palpable point of head of the fibula was measured (a distance) (**Figure 1**). In order to standardize this vertical distance for people of any fibular length, the distance between the most proximal palpable point of

Figure 1. Measurement of the fibular length and the vertical distances between the point where the deep and superficial fibular nerves passed over the anterior part of the fibula and the most proximal palpable point of head of the fibula. **a1** and **a2**: vertical distances of the points where the deep (**a1**) and superficial fibular nerves (**a2**) passed over the anterior part of the fibula to the most proximal palpable point of head of the fibula, respectively; **b**: measurement of the fibular length; **v**: the most prominent palpable point of the lateral malleolus of the fibula; **x**: the most proximal palpable point of head of the fibula; **y**: the point where the deep fibular nerve passed over the anterior part of the fibula; **z**: the point where the superficial fibular nerve passed over the anterior part of the fibula.

head of the fibula and the most prominent palpable point of the lateral malleolus of the fibula was determined as the fibular length (b distance) (**Figure 1**). Then, the "b" distance was divided to "a" distance to figure out the relation of the fibular neck with the fibular nerve (or its branches) in respect to fibular length.

Results

In none of the cases, the common fibular nerve crossed over the neck of the fibula but its main branches (deep and superficial fibular nerves). The mean vertical distance between the point where the deep fibular nerve passed over the anterior part of the neck of the fibula and the most proximal palpable point of head of the fibula (a1) was 42.9±6.5 mm. The mean vertical distance between the point where the superficial fibular nerve passed over the anterior part of the neck of the fibula and the most proximal palpable point of head of the fibula (a2) was 52±6.3 mm. The average fibular length was 356.9±26.4 mm. The mean ratio of the length of the fibula (b) to the vertical distances of deep (a1) and superficial (a2) fibular nerves was 8.5±1.2 and 7±0.8, respectively.

Discussion

The common fibular nerve is formed by the posterior divisions of the fourth and fifth lumbar and the first and second sacral ventral rami. It descends obliquely along the lateral side of the popliteal fossa to the head of the fibula, close to the medial margin of the biceps femoris muscle. It courses between the tendon of the biceps femoris and the lateral head of the gastrocnemius muscle. It curves lateral to the neck of the fibula, deep to the peroneus longus muscle, and here it divides into its superficial and deep branches; the superficial fibular nerve and the deep fibular nerve.[12] Deutsch et al.[16] investigated the division pattern of the common fibular nerve in 70 legs of 35 embalmed cadavers and reported that in 81.4 % of their cases, the common fibular nerve divided into its deep and superficial branches at or distal to the fibular neck. In 10 % of their cases, the common fibular nerve divided to its branches at an average 7.5 mm proximal to the knee joint. In 8.6 % of them, the division occurred at an average of 33mm distal to the knee joint but proximal to the fibular neck. Likewise, in the present study, none of the cases had an undivided common fibular nerve passing over the anterior part of the neck of the fibula. In all of our cases, the deep and superficial branches of it passed over the anterior part of the fibula.

The common fibular nerve supplies the skin on lateral part of posterior aspect of the leg, via its branch, the lateral sural cutaneous nerve. Moreover, by its articular branches, it supplies the knee joint. The superficial fibular nerve provides the motor innervation of the fibularis longus and brevis muscles and it provides sensory innervation of the skin on distal third of the anterior surface of leg and dorsum of the foot. The deep fibular nerve mainly has motor function. It innervates the anterior muscles of leg and dorsum of foot, besides it supplies the skin of first interdigital cleft. In the common fibular nerve palsy, motor deficits are more frequently involved than the sensory ones.[2,12,17] In such a case, all muscles in the anterior and lateral compartments of the leg (dorsiflexors of the ankle and evertors of foot) are paralysed. Because of the loss of eversion of the foot and dorsiflexion of the ankle, foot drop is developed. Moreover, paresthesis is seen at the sensory area and there becomes a loss of sensation on the anterolateral aspect of the leg and dorsum of the foot.[18]

In order not to give harm to the common fibular nerve in proximal fibular surgical procedures, several studies have been made to explain the anatomical relationships of the common fibular nerve in this region. Dissecting 31 unembalmed cadaver legs, Rubel et al.[19] had preferred to define the relationship of the fibular nerve according to the Gerdy's tubercle. They reported that the course of the common fibular nerve defined an arc with a circumference having an average of 45 mm and this circumferential trajectory had been seen at the most prominent aspect of Gerdy's tubercle. They added that using Gerdy's tubercle as a landmark, the trajectory of the common fibular nerve could be easily defined at the level of the proximal aspect of tibia.

Aydogdu et al.[20] investigated the close anatomical relationship of the common fibular nerve and the surgical area of the high tibial osteotomy techniques in 13 human cadavers. They reported that the common fibular nerve passed within 3–6 mm of the posterior aspect of the fibular head and neck and then divided to its branches 22–28 mm distal to the fibular apex.

With the aims of minimizing injury to the common fibular nerve and its branches and establishing a clinical protocol for preoperative and postoperative evaluation of patients who would have surgery on the proximal third of the leg, Reebye[21] performed a study on 20 lower limbs of cadavers. It was reported that 76.7% of all motor nerve branches from the common fibular nerve and its terminal branches had been distributed in the proximal third of the leg; 19.5% in the middle third and 3.8% in the distal third. The same researcher added that 51.1% of the motor nerves were 60 mm distal to the fibular

head. Deutsch et al.[16] also confirmed that the risk of nerve injury is high 60 mm distal to the fibular head. In our study, the point where the common fibular nerve, deep fibular nerve or superficial fibular nerve crossed over the fibular neck, where the nerves were at risk between fibula and cast, were investigated in respect to fibular length. The common fibular nerve did not cross fibular neck in any specimen, but its branches. The average fibular length was 356.9±26.4 mm.The average distance from the tip of the fibular head to deep and superficial nerves were 42.9±6.5 mm and 52±6.3 mm, respectively. The ratio of fibular length to these distances were found to be 8.5±1.2 and 7±0.8, respectively. Our results were similar with Reebye.[21] Additionally we have determined a beneficial ratio and we suggest that the upper border of the plasters for leg should end at the upper 1/7 of the fibular length.

Common fibular nerve palsy cases due to casts are reversible. Nevertheless as the timing of the treatment is important for recovery, it is important to eliminate the other possible reasons for the common fibular nerve palsy on time. Clinical examination, electrophysiological testing and magnetic resonance imaging (MRI) is helpful for diagnosis of fibular nerve damage. MRI of the lumbar spine and sometimes knee and proximal leg, can provide eliminating the proximal lesions.[8]

Conclusion

Based on the data obtained in the present study, we recommend that the upper border of the plasters/casts for leg should end at the upper 1/7 of the fibular length. We believe that the common fibular nerve palsy due to lower extremity casts may be prevented considering this suggestion.

Acknowledgments

We would like to express our sincere gratitude to the donors and their families.

Conflict of Interest

None.

Author Contributions

FD: designing the project, writing the manuscript; ÖG: designing the project, collecting data, performing analysis, writing the manuscript; İAG: collecting data; AK: writing the manuscript; MEE: designing the project, AÖ: collecting data; AU: collecting data; OC: collecting data, performing analysis.

Ethics Approval

All studies carried out in the Department of Anatomy, İstanbul University School of Medicine using bone or cadaver specimens are regulated and approved by the İstanbul University Faculty of Medicine Clinical Research Ethics Committee.

Funding

The research was not supported by any foundation.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Dikici F, Gayretli Ö, Gürses İA, Kale A, Erdil ME, Öztürk A, Usta A, Coşkun O. Anatomic correlation of common fibular nerve palsy encountered after short leg casts. Anatomy 2021;15(2):116–120.

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: February 23, 2021; Accepted: August 7, 2021
doi:10.2399/ana.21.885318

anatomy
An International Journal of Experimental and Clinical Anatomy

Can Whitnall's tubercle be localized using palpable landmarks around the orbit?

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Abstract

Objectives: Whitnall's tubercle (WT) is located deep in the lateral canthus and on the lateral orbital wall and has crucial structures attach to it. We aimed to define the location of WT using the palpable bone landmarks which can be used as reliable landmarks in eyelid and orbital surgery to prevent the damage of stuctures associated with WT.

Methods: Forty-four adult skulls (22 right, 22 left) were included to the study. The skulls were divided into two groups according to the apparancy of the WT. The distances from WT to the frontozygomatic suture, the marginal tubercle, the anterior point of the zygomatic arch, and the lateral margin of the orbit were measured. The clock positions of WT according to the marginal tubercle and the anterior point of the zygomatic arc were determined.

Results: The distances of the WT to the marginal tubercle, the anterior point of the zygomatic arch, the lateral margin of the orbit, and the frontozygomatic suture were 9.92±1.65 mm, 16.48±1.86 mm, 2.32±0.53 mm and 9.66±1.44 mm, respectively. WT was at 8 and 9 o'clock positions on the left, and at 4, 3, and 2 o'clock positions on the right according to the marginal tubercle. WT was at 10 o'clock position on the left, and 2 and 1 o'clock positions on the right according to the anterior point of the zygomatic arch.

Conclusion: The marginal tubercle, the lateral margin of the orbit, and the anterior point of the zygomatic arch can be used as standart bony landmarks in eyelid and orbital surgery to prevent the soft tissue damage relevant to WT. The high kappa values of the interclass and intraclass correlations suggest that these parameters are reliable and repeatable for clinical use. Out of these parameters, the anterior point of the zygomatic arch is more beneficial to locate the WT because of the standard clock positions. The WT is typically located at 10 o'clock position on the left and 2 o'clock position on the right according to the anterior point of the zygomatic arch.

Keywords: lateral canthus; marginal tubercle; orbita; Whitnall's tubercle; zygomatic arch

Anatomy 2021;15(2):121–126

Introduction

Whitnall's tubercle (WT) was first described as a bony prominence located on the lateral orbital wall by Samuel Ernest Whitnall in 1911. He indicated that this tubercle was about 11 mm below the frontozygomatic suture and a few millimeters deep to the lateral margin of orbit.[1] Other terms used for WT are; lateral orbital tubercle,[2–7] lateral palpebral tubercle,[8] orbital eminence,[8,9] and orbital tubercle.[3,5,7,8,10–13]

The clinical importance of the WT comes from the anatomical structures attached to it. These structures are the check ligament of lateral rectus, aponeurosis of levator palpebrae superioris, suspensory ligament of the eyeball (Lockwood's ligament), and lateral palpebral or tarsal ligament (raphe palpebralis lateralis) which also participate in the lateral retinaculum.[1] Other anatomical structures participating in the lateral retinaculum are the Whitnall's ligament, intermuscular transverse ligament, and orbital septum.[8,14,15] The anatomy of this tubercle is essential to protect the soft tissue structures attached to or adjacent to the WT in orbital and eyelid surgeries such as lateral canthopexy,[15] lateral canthotomy,[16] lateral orbitotomy,[17] and blepharoplasty.[6,18]

The lateral palpebral ligament consists of two parts, superficial and deep. The superficial part contributes to

the orbital septum.[1] However, the deep part participates in the lateral retinaculum and attaches to the WT.[1] The signs of aging are due to the weakening of the lateral retinaculum elements' elastic fibers. These are noticed in the lower and upper eyelids. In healthy individuals, elastic fibers weaken with aging, but the lower eyelid length has not increased.[19] Due to this pathophysiology mechanism, the lateral retinaculum and WT are crucial in eyelid surgeries.[6,15,16,18]

Another critical aspect of WT is exotropic Duane syndrome. In this situation, the lateral rectus is released from the WT, where the check ligament of this muscle is attached and then sutured to the lateral canthal tendon.[20]

In this study, we aimed to locate the WT using palpable bony structures close to the WT. We determined these bony structures as the marginal tubercle, the lateral margin of the orbit, the anterior point of the zygomatic arch, and the frontozygomatic suture. Since the WT location could not be determined by inspection, we think our study will be valuable for the preparation phase of surgical access.

Materials and Methods

A total of 30 skulls (60 orbits) taken from the bone collection of Department of Anatomy, Ankara University School of Medicine were included to the study. However, 8 of the skulls had orbits with impaired bone integrity or had pathological deformation, so they were excluded from the study. Thus, the measurements were carried out on 44 orbits bilaterally (22 left and 22 right). The age and gender of these orbits were not certain. WT was determined on the lateral wall of the orbit. After that, we divided orbits into two groups according to the appearance of WT (**Figure 1**). If WT was visible, it was considered as "apparent". If it was only determined by palpation, it was regarded as "non-apparent". Skulls were positioned and fixed on the Frankfort horizontal plane to determine the anatomical position of the WT deep within the lateral orbital wall. The shortest distances of WT to the marginal tubercle, the lateral margin of the orbit, the anterior point of the zygomatic arch, and the frontozygomatic suture were measured directly on the skulls using vernier caliper (0.01 mm resolution). The position of the WT was noted taking the marginal tubercle and the anterior point of the zygomatic arch as landmarks for to use a clock method (**Figures 2** and **3**).

Two observers (ACK and NS) measured all parameters three times. The first measurement was performed by only one observer (ACK). The second and third measurements were performed by another observer (NS). Descriptive statistics (mean and standard deviation) of the measurements were calculated with all three measurements. Interclass (ACK-NS) and intraclass (NS-NS) correlations were examined with the distances meas-

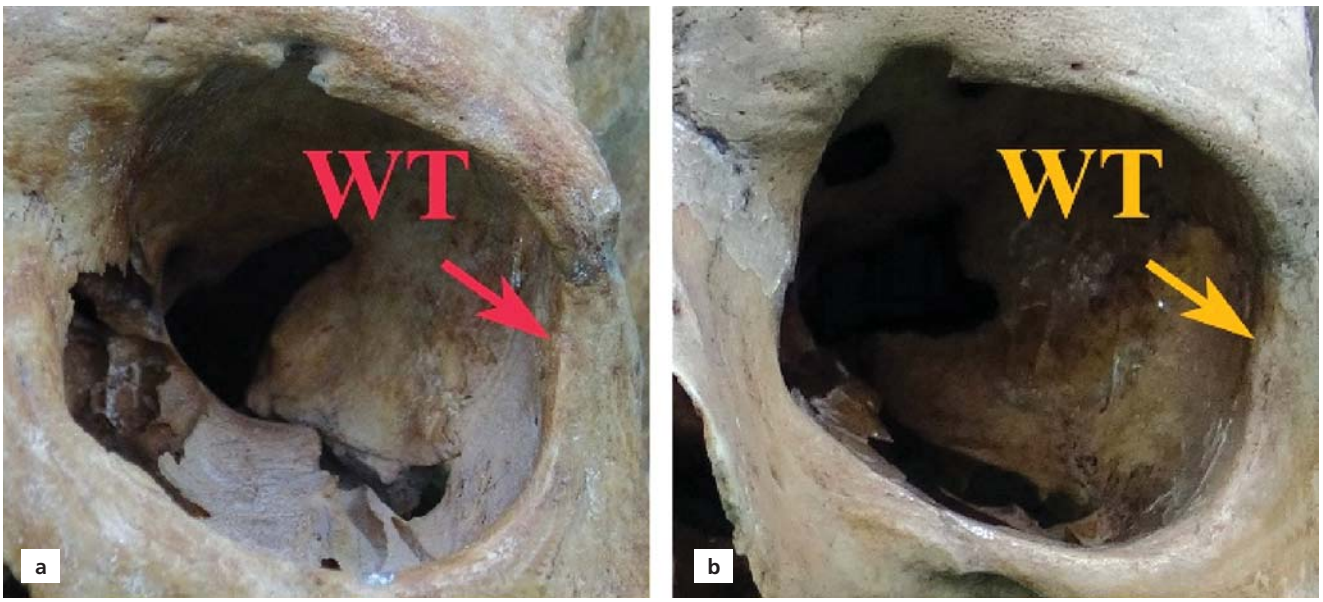

Figure 1. Whitnall's tubercle on the lateral orbital wall (**anterior view**). (**a**) Non-apparent Whitnall's tubercle; (**b**) apparent Whitnall's tubercle. **WT:** Whitnall's tubercle.

Figure 2. Clock position of the Whitnall's tubercle (**yellow point**) according to the marginal tubercle (**blue point**).

ured three times. An independent sample t-test was used to determine whether there was a significant difference between right and left sides, and between apparent and non-apparent WTs. The statistical analyses were performed with Statistical Package for Social Sciences (SPSS Version 20, Armonk; NY, USA).

Figure 3. Clock position of the Whitnall's tubercle (**yellow point**) according to the marginal tubercle (**blue point**).

Table 1
The topographical measurements of Whitnall's tubercle.

Parameters	Right (mm)	Left (mm)	Apparent WT (mm)	Non-apparent WT (mm)	Total (mm)
WT–marginal tubercle	9.91±1.38	9.94±1.89	10.02±1.42	9.64±2.2	9.92±1.65
WT–anterior point of the zygomatic arch	16.92±1.94	16.04±1.69	16.55±1.94	16.27±1.62	16.48±1.86
WT–lateral margin of orbit	2.36±0.52	2.27±0.54	2.35±0.54	2.22±0.5	2.32±0.53
WT–frontozygomatic suture	9.41±1.46	9.91±1.39	9.53±1.25	10.04±1.88	9.66±1.44

WT: Whitnall's tubercle.

Results

Out of 44 orbits (22 right, 22 left), WT was apparent in 33 orbits (75%) and non-apparent in 11 orbits (25%). Sixteen of apparent WTs were on the right side; 17 apparent WT were on the left side (**Table 1**). There was no significant difference between the parameters whether the WT was apparent or not, and whether it was on the right or left side.

Our measurements defining the WT clock position concerning the anterior point of the zygomatic arch and marginal tubercle were demonstrated in **Table 2** and **3**. According to the marginal tubercle, WT was at 8 o'clock (13 orbits) and 9 o'clock (9 orbits) positions on the left side and it was at 4 o'clock (15 orbits), 3 o'clock (6 orbits), and 2 o'clock (1 orbit) positions on the right side. According to the anterior point of the zygomatic arch, WT was located at 10 o'clock position on the left side and at 2 o'clock (20 orbits) and 1 o'clock (2 orbits) positions on the right side.

The kappa values of the interclass and intraclass correlations were demonstrated in **Table 4**. The values between 0.61 and 0.8 in **Table 4** indicated a strong correlation. The values between 0.81 and 1 in **Table 4** showed an almost perfect correlation.

Table 2
The clock position and distance of Whitnall's tubercle as with respect to the marginal tubercle.

	Clock	Number	Percentage (%)	Distance (mm)
Left	8	13 orbits	59	9.84±1.51
	9	9 orbits	41	10.1±2.37
Right	9	9 orbits	41	10.1±2.37
	4	15 orbits	68	9.78±1.46
	3	6 orbits	27	10.2±1.27
	2	1 orbit	5	10.18±0.08

Table 3
The clock position and distance of Whitnall's tubercle with respect to the anterior point of the zygomatic arch.

	Clock position	Number	Percentage (%)	Distance (mm)
Left	10	22 orbits	100	16.04±1.69
Right	2	20 orbits	91	16.62±1.76
	1	2 orbits	9	19.93±0.56

Table 4
The kappa values of intraclass and interclass correlation.

	Kappa values		
	Interclass		Intraclass
Parameters	ACK-NS1	ACK-NS2	NS1-NS2
WT–marginal tubercle	0.946	0.6	0.632
WT–frontozygomatic suture	0.958	0.958	1
WT–lateral margin of orbit	0.789	0.788	0.998
WT–anterior point of zygomatic arch	0.954	0.979	0.969

WT: Whitnall's tubercle.

Discussion

Recent studies showed that WT is not always present. This tubercle was noticed at a rate of 95% by Whitnall,[1] 63% by Buschkowitsch,[13] 80.1% by Kangas,[12] 80% by Ono,[11] 49.15% by Tomita,[21] 96.3% by Didio,[9] and 70% by Fries at al.[8] The most crucial reason why it is seen at different rates is the differences between populations. Another important reason is how the existence of tubercle is decided in these studies. Buschkowitsch considered the tubercles that were only palpated as absent in the study[13] In Gray's Anatomy,[22] this tubercle suggested to be noticed only by palpation.[22] Therefore, we evaluated the visible WTs as apparent and only palpable WTs as non-apparent. This tubercle was observed in all orbits and was not apparent in 11 orbits (25%) in our study.

Previous studies showed that the distances from WT to the frontozygomatic suture and the lateral-inferior margin of the orbit are the most reliable measurements to find out its location.[4,14,23] Moreover, Whitnall[1] first described this

tubercle to be approximately 11 mm below the frontozygomatic suture. This distance was 7.4±2 mm on the right and 8.3±1.9 mm on the left in the study by Fries et al.[8] In our study, the distance between the WT and the frontozygomatic suture was 9.41±1.46 mm on the right and 9.91±1.39 mm on the left. In the present study and the study by Fries et al.,[8] the distance on the left was longer than the right ones. Due to the difference in this distance between studies, we suggested that new parameters were needed to determine the position of this tubercle. So that, we used three new parameters in addition to frontozygomatic suture to define WT in this study: the marginal tubercle, the lateral margin of the orbit and the anterior point of the zygomatic arch. The interclass and intraclass correlations of the WT distances were determined as strong or almost perfect correlations in the present study. By this means, we contributed three new bony landmarks to the literature in addition to the frontozygomatic suture to locate the WT.

The clock position of the WT according to the marginal tubercle had high kappa values of the interclass and intraclass correlations. However, WT was located at 8 and 9 o'clock positions in almost similar percentages to the marginal tubercle on left side. Additionally, it is located at 2, 3 and 4 o'clock positions on right side. These results support orbital asymmetry that is crucial in oculofacial surgery patients.[24,25] For this reason, we suggest that this parameter is not appropriate for clinical use since it may show variations according to sides.

Our study and some recent studies[8,23] have shown that WT is difficult to detect by palpation as it is not always a prominent protrusion. Therefore, the clock position of WT was revealed according to the marginal tubercle and the anterior point of the zygomatic arch in this study. On the Frankfort horizontal plane, the WT was observed on the same plane with the marginal tubercle or slightly below it. In only one case, it was observed above the marginal tubercle on the right side. The WT was found above the anterior point of the zygomatic arch.

The most suitable parameters for determining the position of WT according to the kappa values of intraclass and interclass correlation were the distance of WT to the anterior point of zygomatic arch and the lateral margin of orbit as well as the clock position in between. After determining the location of the WT according to the anterior point of zygomatic arch, the depth of the WT to the lateral margin can easily be determined with the distance between the WT and lateral margin of orbit. These two bony landmarks allow even invisible or non-palpable WTs to be easily detected. In the skulls with apparent WT; both distances and o'clock directions were not different from non-apparent WTs. Thus, it can be predicted as a standard distance and direction before the operation. The WT was about 16 mm to the anterior point of the zygomatic arch and 10 mm to the marginal tubercle (**Tables 2** and **3**). Additionally, there was no significant difference between the directions and the distances. The mean distance did not change in any direction.

Conclusion

The results of the present study suggests that the marginal tubercle, the lateral margin of the orbit, and the anterior point of the zygomatic arch can be used as reliable bony landmarks in eyelid and orbital surgery to prevent the soft tissue damage associated with WT.

Acknowledgments

The authors wish to express their gratitude to all those who donated their bodies to medical science.

Conflict of Interest

The authors certify that they have no conflict of interest and no affiliations or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

Author Contributions

ACK: project development, data acquisition, photography for figures, writing text, critical revision of the manuscript; NS: project development, data acquisition, critical revision of the manuscript; AU: project development, writing text, critical revision of the manuscript.

Ethics Approval

All studies carried out in the Department of Anatomy, Ankara University School of Medicine using bone or cadaver specimens are regulated and approved by the Ankara University Faculty of Medicine Clinical Research Ethics Committee Unit.

Funding

This study did not receive any funding.

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Conflict of interest statement: No conflicts declared.

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: March 29, 2021; Accepted: August 10, 2021
doi:10.2399/ana.21.905078

anatomy
An International Journal of Experimental and Clinical Anatomy

Examination of presence and location of the accessory mental foramen, and its implications on the mental nerve block

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Abstract

Objectives: It is clinically essential to know the location of accessory mental foramen in the mental nerve anesthesia. The aim of this study was to determine the frequency of accessory mental foramen and examining its morphometric properties.

Methods: A total of 35 adult mandibles of unknown age, gender, and ethnicity were examined. The presence of accessory mental foramen of the mandible was investigated bilaterally. In cases with the accessory mental foramen, its localization, number, and distance relative to the mental foramen were evaluated.

Results: Eleven (15.71%) accessory mental foramens were detected in the 35 mandibles (70 sides) examined. Six (54.55%) of the accessory mental foramens were on the left side, and 5 (45.45%) were on the right side.

Conclusion: Knowing the frequency and localization of the accessory mental foramen will make the mental nerve block more effective and facilitate surgical procedures. It should be kept in mind that the presence of accessory mental foramen should be considered in cases where mental nerve block applications are insufficient.

Keywords: accessory mental foramen; mental foramen; mental nerve block

Anatomy 2021;15(2):127–131

Introduction

The primary goal of nerve blocks and any surgical interventions should be not damaging the critical anatomical structures in the area where the procedure is performed.[1] Particularly, in the last decades, increase demand for dental implantations, cosmetic and orthognathic surgeries had also led to an increase in interest regarding the variations of the maxilla and mandible.[2–4] The mandibular canal, which is one of the critical anatomical structures in the mandible, starts from the mandibular foramen and ends at the mental foramen.[2,5] The inferior alveolar nerve and the corresponding vessels runs in the mandibular canal. Then, this nerve emerges as the mental nerve through the mental foramen.[3,6] After passing through the mental foramen, the mental nerve innervates part of the lower lip, the buccal vestibule, and the gingival mesial side of the first mandibular molar tooth. To prevent damage to the neurovascular bundle in this area, the location of the mental foramen must be definitively identified before surgical procedures such as periodontal, periapical, and implant surgeries.[7,8] Besides, the position of the roots of premolar and molar teeth in respect to mental foramen should also be determined before dental treatment.[3,8] The mental foramen is also very important in implant placement in the foraminal region of the mandibular arch.[9] Although the mental foramen is a bilateral opening localized on the anterior surface of the mandible,[3] the presence of accessory mental foramen,[6,10] unilateral absence,[11] bilateral absence[12] and hypoplasia of mental foramen[13] have also been reported in the literature. In these variations, the mental nerve or some of its branches exit the mandible through alternative openings.[7]

Other foramens located outside the mental foramen on the anterior outer surface of the mandible is called accessory mental foramen.[14] In this case, while the men-

tal nerve passes through the mental foramen, the accessory mental nerve pass through the accessory mental foramen.[6] In the presence of accessory mental foramen, the areas to be innervated by mental and accessory mental nerves will be different, as some of the fibers of the mental nerve will come out of this foramen. In this instance, invasive procedures around the mental foramen may fail, or the mental nerve block may be insufficient. Therefore, it is clinically essential to know the accessory mental foramen.

The aim of this study was to contribute to the literature by determining the frequency of accessory mental foramen and examining its morphometric properties.

Materials and Methods

A total of 35 adult mandibles of unknown age, gender, and ethnicity were examined in the laboratory of the Department of Anatomy, Faculty of Medicine, Gaziantep University. The presence of accessory mental foramen of the mandible was investigated bilaterally. In cases with the accessory mental foramen, its localization, number, and distance relative to the mental foramen were evaluated. In the mandibles with accessory mental foramen, photographs were taken with a Nikon D500 camera (Nikon Corp., Tokyo, Japan) and 55 mm lens, in which the mental foramen and accessory mental foramen were clearly seen, in a standard position that can be repeated during examinations and with an equal distribution of light. All measurements were made on the photographs with the ImageJ software. Descriptive analyzes were performed Statistical Package for Social Sciences (SPSS Version 22, Armonk; NY, USA).

Results

Eleven (15.71%) accessory mental foramens were detected in 35 mandibles (70 sides) (**Figure 1**). Six (54.55%) of the accessory mental foramens were on the left side, and 5 of

Figure 1. The mental foramen (**MF**) and accessory mental foramen (**AMF**) in a mandible.

them (45.45%) were on the right. All accessory mental foramens (100%) were unilateral. The distance between the accessory mental foramen and mental foramen varied between 4–12 mm. For the right and left sides, the localization and distance of the accessory mental foramen relative to the mental foramen are shown in **Figure 2**.

Discussion

The mental foramen is of great importance for diagnosis, anesthesia, and surgical procedures.[15] Although the mental foramen is usually found as a single foramen on each side of the mandible, there may be more than one foramen in this area.[14] The presence of accessory mental foramen is significant, especially in dentistry.[16] Although the accessory mental foramen is a rare structure, it should be well known not to damage the neurovascular bundle during several surgical procedures and prevent inadequate nerve block.[7,17]

There are studies examining this variation with panoramic radiography,[18] CBCT[8,16] and on dry mandibles in the literature.[19] Rahpeyma and Khajehahmadi[4] suggested that the difference in the frequency of its presence is related with the assessment method. Imada et al.[10] reported that this formation was more hardly visible on panoramic graphs. On the other hand, Katakami et al.[20] reported that cone-beam computed tomography scanning is better to detect an accessory mental foramen. Although it is known that the cone-beam computed tomography images clearly show bony structures,[21,22] we think that small structures such as accessory mental foramen is readily seen on bony specimens. However, the most crucial disadvantage of dry bone studies is the lack of information such as gender, age, and ethnicity.[23]

There are differences in the literature regarding the localization of the accessory mental foramen in respect to the mental foramen.[17,20,24] Katakami et al.[20] and Oliveira-Santos et al.[24] reported that the accessory mental foramen is mostly located lateral to the mental foramen. On the other hand, Neves et al.[17] reported that it was most commonly located inferolateral of the mental foramen. In this study, it was observed that there was a difference between both sides, and it was usually located medially on the right side and laterally on the left side. However, we think that it is difficult to provide statistically significant information because the frequency of this variation is low. Oliveira-Santos et al.[24] reported that the longest distances between the mental and accessory mental foramens were 7.4 mm horizontally, and 3.58 mm vertically. However, in this

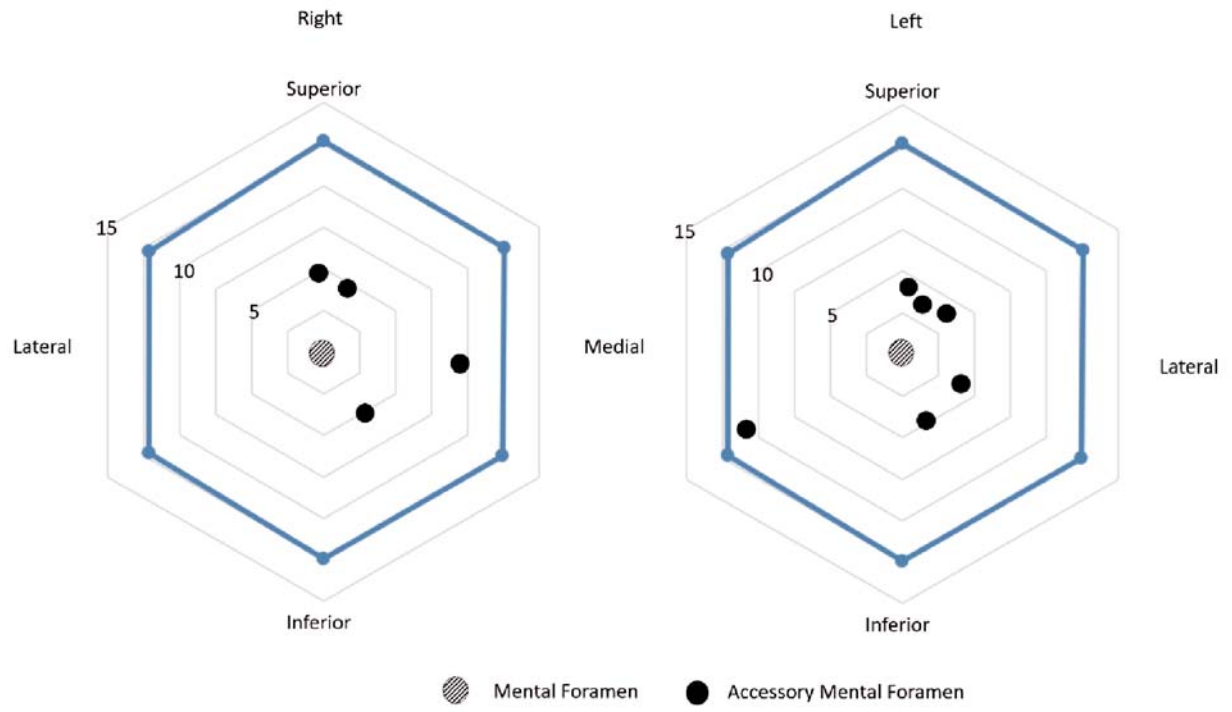

Figure 2. Localization of the accessory mental foramens according to the mental foramen (the unit for values 5, 10 and 15 is mm).

study, the longest distance was found to be 12 mm. We suggest that as this distance increases, the failure rate in the mental nerve block may also increase. Therefore, we think that this distance worth consideration in addition to the presence of the accessory mental foramen.

Conclusion

Although the mental foramen is usually found as a single foramen on each side of the mandible, an accessory mental foramen can also be found with a low but significant incidence. For this reason, knowing the frequency and localization of the accessory mental foramen will increase the effectivity of the nerve blocks, facilitate surgical procedures involving the lower jaw and minimize the damage to the vascular-nerve structures in this area. In addition, the presence of accessory mental foramen should be considered in cases where mental nerve block applications are insufficient.

Acknowledgments

The authors would like to express their sincere gratitude to the donors and their families.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

Author Contributions

FS: protocol/project development, data collection or management, data analysis and manuscript writing/editing; İB: protocol/project development, data collection or management, data analysis and manuscript writing/editing; MO: protocol/project development, data collection or management, data analysis and manuscript writing/editing.

Ethics Approval

The study was conducted in accordance with the ethical rules of the Declaration of Helsinki and its later amendments. Scientific studies on dry bones in our institution do not require ethical approval.

Funding

None.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Sevmez F, Bahşi İ, Orhan M. Examination of presence and location of the accessory mental foramen, and its implications on the mental nerve block. Anatomy 2021;15(2):127–131.

anatomy
http://dergipark.org.tr/en/pub/anatomy
An International Journal of Experimental and Clinical Anatomy

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: April 20, 2021; Accepted: July 19, 2021
doi:10.2399/ana.21.922706

The normal width of the linea alba in cadavers – a parameter to define rectus diastasis

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Abstract

Objectives: The aim of the present study was to evaluate the width of the linea alba in cadavers with no abdominal wall defects.

Methods: Fifty-three fresh adult male cadavers were dissected. The cadavers were placed supine and a xiphopubic incision was made, exposing the myoaponeurotic layer. Two horizontal lines were marked, at 3 cm superiorly and 2 cm inferiorly to the umbilicus, to measure the distance between the recti muscles. Measurements were performed with a digital pachymeter. Statistical analysis was performed using the t-test for 2 independent means where the considered p value was less than 5%.

Results: The normality test of the sample revealed no significant variations. The average length of the linea alba and recti muscles were similar (33.02 cm). The mean values for the width of the rectus muscles were 7.37 cm on the right side and 6.84 cm on the left side with no statistical significance between these values (p=0.479). The mean values of the width of the linea alba of the 53 cadavers were 2.17 cm at the supraumbilical level and 1.51 cm at the infraumbilical level; comparing these, a statistically significant difference was observed, with higher values for the supraumbilical level (p=0.034).

Conclusion: The width of the alba line was greater at the supraumbilical level and the right abdominal rectus muscle was wider than the left.

Keywords: abdomen, anatomy, anthropometry, cadaver, rectus abdominis

Anatomy 2021;15(2):132–136

Introduction

Abdominal wall deformities are very frequent and can be due to congenital or acquired etiology.[1] Rectus abdominis diastasis occurs due to many factors that weaken the abdominal wall. The causes described in the etiopathogenesis of the phenomenon can be divided into congenital and/or acquired.[2,3] Major risk factors for the development of acquired rectus diastasis include conditions that increase intra-abdominal wall pressure such as obesity, pregnancy, abdominal surgeries and connective tissue disorders.[4]

Large abdominal wall deformities and defects may be associated with problems such as low back pain, breathing disorders and also misperception of body image.[5,6] Congenital defects are also associated with abdominal wall muscles hypoplasia as described in Cantrell's pentalogy (thoracoabdominal syndrome), Beckwith-Wiedemann syndrome, Opitz syndrome, midline defect syndrome and plum belly syndrome; however, those require a complex abdominal wall reconstruction.[1]

Excessive separation of the abdominal muscles may compromise the function of the abdominal wall[7] and is noticed when the patient sits up during clinical examination.[8] When a patient with rectus diastasis lifts his head and starts to sit, a fusiform bulging appears in the midline from the xiphoid to the umbilicus or pubis.[9,10] This can also be confirmed with the Valsalva's maneuver.

One of the most frequent deformities is the rectus abdominis diastasis after pregnancy, and treatment is performed by abdominoplasty, and the correction of the rectus diastasis is an important step of the procedure.[4]

Although there is no specific definition, some authors define rectus muscle diastasis, when the distance between the medial aspect of the rectus muscle (the width of the linea alba) is greater than 2 cm.[4,9] However, it is not a consensus because there is no objective data to define this value. Therefore, the aim of the present study is to evaluate the width of the linea alba in cadavers with no abdominal wall defects, in order to determine which measurements could be considered as normal.

Materials and Methods

After obtaining the informed consent from the relatives, fifty-three fresh adult cadavers were dissected at room temperature (22–25°C) at the Legal Medical Institute. Male cadavers were selected, regardless of race. Anthropometric data were recorded. Cadaver was placed supine and a xipho-pubic incision was made, including skin and subcutaneous, surrounding the umbilicus, down to fascia. A suprafascial undermining was performed, exposing the anterior lateral abdominal muscles (**Figure 1**).

The separation between the recti abdominis muscles was marked. Two reference levels were marked 3 cm superior (supraumbilical level) and 2 cm inferior (infraumbilical level) to umbilicus for to measure the distance between the medial aspect of the muscles.[5] Measurements were performed with a digital pachymeter, by two examiners, and the mean value between them was considered. General data of the sample was displayed in the **Table 1**.

The width of the left rectus muscle was compared with the right side. The width of the linea alba obtained at the supraumbilical level was also compared to the infraumbilical pre- marked levels.

The t-test for two independent means was applied for statistical test, considering as significant where the considered p-value was less than 5%.

Results

The normality analysis of the sample revealed no significant variations. The length of the linea alba and rectus abdominis muscles were similar, with an average of 33.02 cm.

The mean value of the width of the right rectus muscle was 7.37 cm whereas the left was 6.84 cm. Although the right muscle was wider than the left when the values were compared, there was no statistically significant difference (p=0.479) (**Figure 2**).

The mean width of the linea alba was 2.17 cm at the supraumbilical level and 1.51 cm at the infraumbilical level. A statistically significant difference was found when these values were compared, demonstrating that the linea alba is wider at the supraumbilical level (p=0.034) (**Figure 3**).

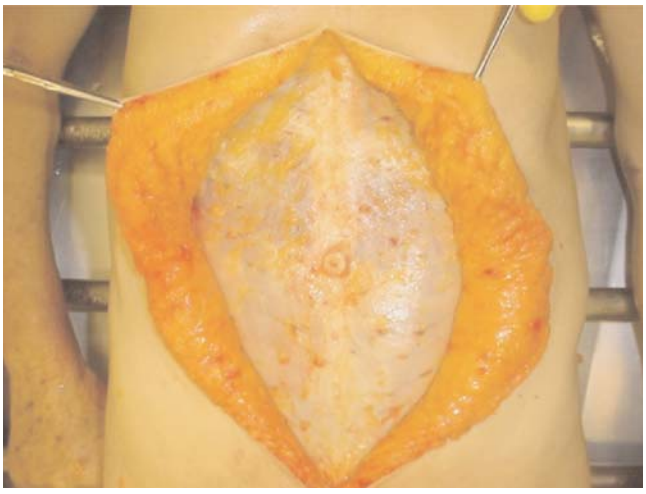

Figure 1. Exposure of the anterior lateral abdominal muscles.

Discussion

Rectus diastasis is a common deformity that may lead to an increase in the overall anterior projection of the abdominal wall, mainly observed at the profile position.[9] This anatomic deformity can contribute to postural changes and low back pain, secondary to the alteration of the corporal gravity axis. It usually occurs due to weight variation, age, congenital condition and pregnancy.[11,12]

Correction of this deformity is considered as an important step during abdominoplasty and lipoabominoplasty.[13] A special attention should be taken in the preoperative evaluation of the abdominal wall integrity when performing lipoabdominoplasty because of the risk of intestinal perforation during liposuction. Small hernias of 1 or 2 mm diameter may be found in the area of diastasis, especially in the supraumbilical area, what may facilitate the risk of cannula insertion in the abdominal cavity during liposuction.[2]

The definition of rectus diastasis is quite heterogeneous and varies from any distance between the recti mus-

Table 1

Average of the anthropometric data of the 53 cadavers.

Anthropometric data	Cadavers (n=53)
Age (years)	42.07
Weight (kg)	73.06
Height (m)	1.68
BMI (kg/m^2)	25.55
XP (cm)	33.02
CC (cm)	26.80

BMI: Body mass index; **CC:** distance between the iliac crests; **XP:** xyphopubic distance.

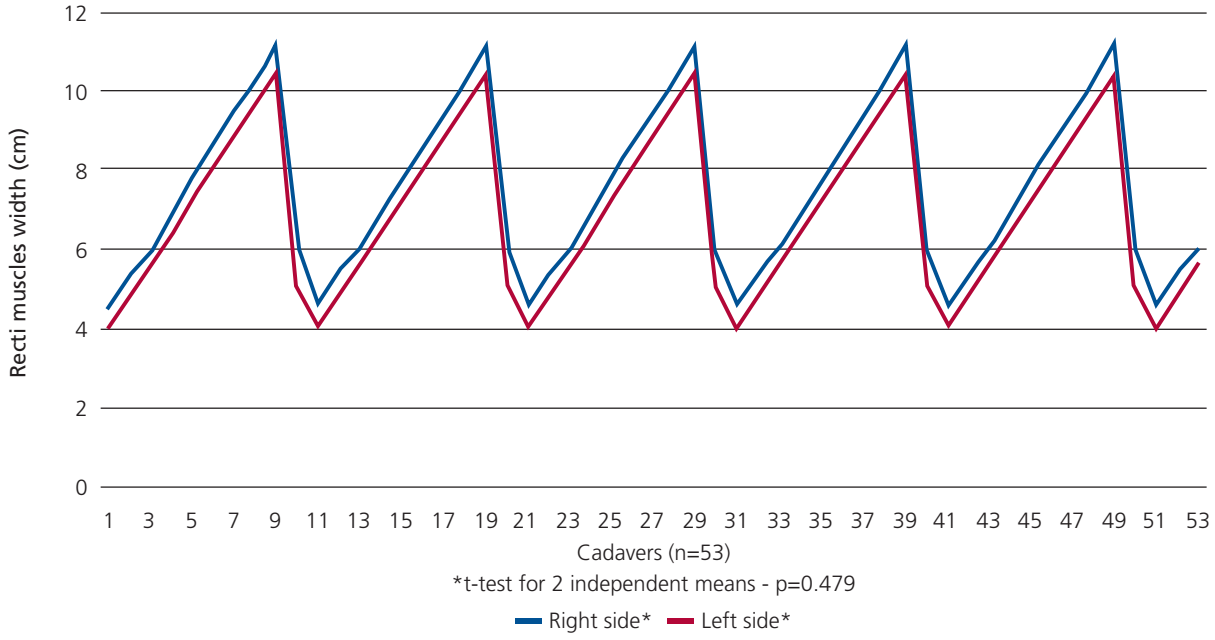

Figure 2. Rectus abdominis muscle width on both sides (cm).

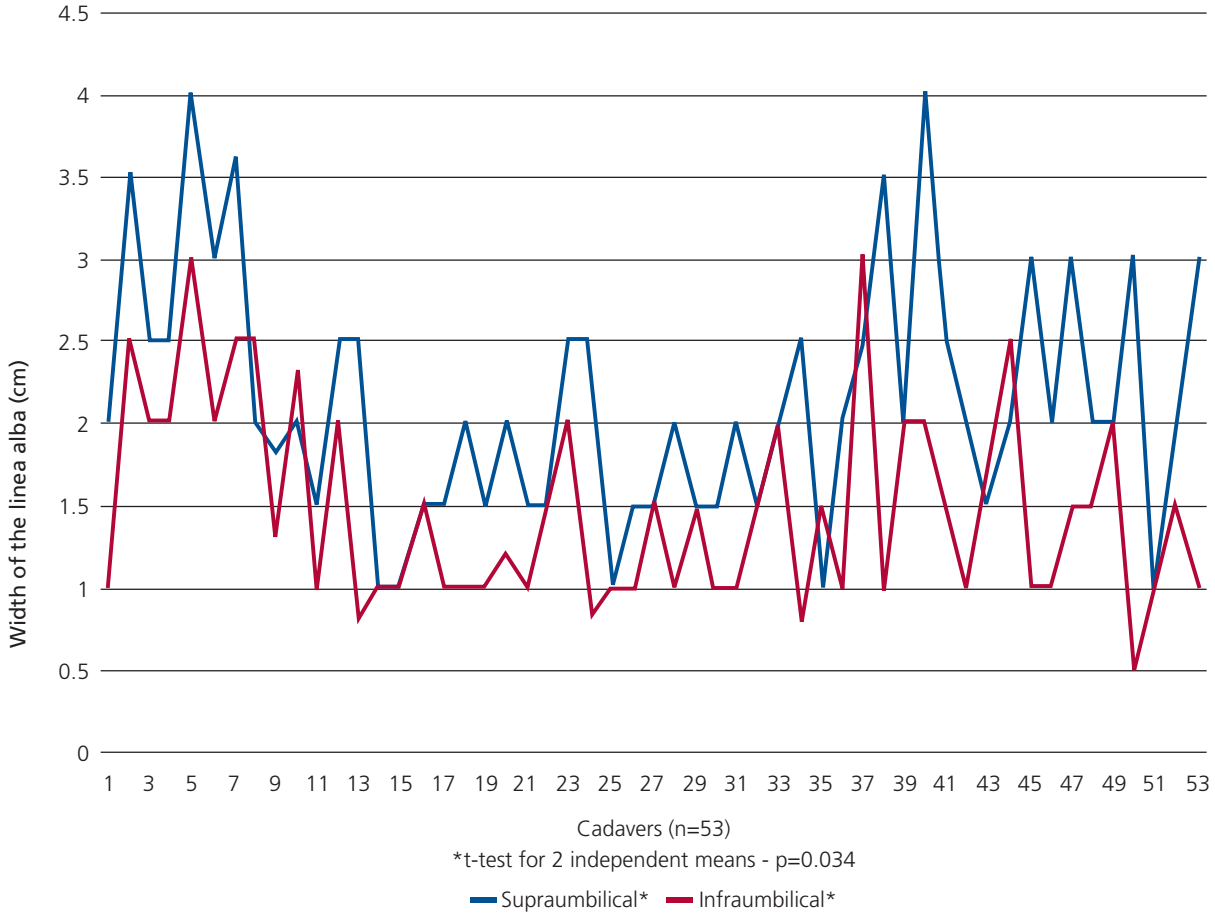

Figure 3. Comparison between the width of the linea alba at the supra and infraumbilical levels.

cles[2] to values greater than 1–3 cm above the umbilicus, and 1–1.5 cm below the umbilicus.[3,4,6,10] Therefore, there is no well-defined pattern to determine what is a normal or abnormal width between recti muscles. There is not a reference that defines rectus diastasis. In this way the diagnosis of diastasis is usually made by the experience of the professional who examines. Therefore, despite the use of ultrasound[2] or computerized tomography,[4] which requires a relative learning curve.

The use of cadavers to evaluate the abdominal wall is well established in the literature.[5] In most studies that described and evaluated rectus diastasis, patients were not homogeneous, adding some bias to the study, such as previous pregnancy, especially because of the almost totality of the evaluated sample was female gender.[1,3,5,6,9] Pregnancy may expand the abdominal wall as a whole or more specifically in the area of the linea alba, thus promoting diastasis. Diastasis secondary to pregnancy will depend on the individual's genetic condition and weight gain. Rodrigues et al.[14] has shown that an increase in intraabdominal pressure after plication of the anterior rectus sheath is not directly related to the width of diastasis. This study demonstrated that the genetic structure of the aponeurosis is more important than the rectus diastasis itself when competency of the abdominal wall is considered. The width of the diastasis of the rectus is probably due to the loosening of the aponeurosis and, in this case, the patient will have a less intense impact on intra-abdominal pressure after the plication of the anterior rectus sheath. In the present study, the authors have chosen to evaluate only male cadavers, with normal BMI and without abdominal scars or other alteration/abnormality in the abdominal wall. This aspect was considered precisely to avoid bias in relation to the female gender due to the possibility of previous pregnancies.

The use of a paquimeter/caliper for this kind of study is well described in the literature,[2,3] with measurements taken by two observers. The average values of the width of the rectus abdominis muscles were 7.37 cm on the right and 6.64 cm on the left side did not show statistically significant difference when compared. Despite this little difference was found, no information about this tendency was found in the literature review. However, it is possible that it has a direct correlation with congenital or acquired asymmetries that can occur due to postural vices observed in the clinical practice. It may also be related to the fact that the majority of the specimens are right-handed, who use most of the time the right side of the body when doing movements, with a consequent hypertrophy of the right rectus muscle.

Corvino et al.[15] evaluated rectus diastasis in 92 women by ultrasound and found rectus diastasis in 82 patients; from these, 5 were nulliparous. The authors proposed a classification of rectus diastasis in five patterns when the most frequent (59%) was Type 1 (rectus diastasis above the umbilicus). In the present study, comparisons of the mean distances between the medial margins of the rectus muscles at the supra and infraumbilical levels, showed statistically significant difference, with greater values at the supraumbilical area, similarly to the Type 1 pattern. These data did not corroborate to the findings presented by Mendes et al.[2] who compared rectus diastasis by measuring preoperative and intraoperative values by ultrasound and found no statistical difference between the supra and infraumbilical levels. Similarly, Rett et al.[3] evaluated rectus diastasis in primiparous and multiparous women, by clinical exam (palpation) and the use of a paquimeter. They did not find significant differences between supra and infraumbilical levels. It is well known that the increase of the intra-abdominal pressure during pregnancy may promote a distension of the linea alba and even affect the integrity of the abdominal wall. However, despite these changes on the structure of the abdominal muscles during pregnancy, they still maintain their function.[15] This fact could explain the findings of the present study (using male cadavers) and others that evaluated women with previous history of pregnancy.

This research evaluated male cadavers, without age and biotypes restriction, making the results relevant and useful in clinical practice on different areas such as plastic surgery, general surgery and physical therapy. It was also demonstrated the importance of the normal anatomy of the rectus abdominis muscle and linea alba, making the diagnosis of diastasis and myoaponeurotic distension in male patients easier. This study has some limitations, as cadaver is not a dynamic model. Although the number of studied specimens (n=53) was large, a greater sample might be necessary in order to determine the normal separation between the recti muscles. In the same way, a more representative group with different genders, ages, and ethnicity would be interesting to determine the range of values of the width of the linea alba to be considered as normal.

Conclusion

The width of the linea alba in male cadavers is significantly wider at the supraumbilical level as compared to the infraumbilical level. The right rectus abdominis muscle has shown to be wider than the left one.

Acknowledgments

The authors would like to express their sincere gratitude to the donors and their families.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

MVJB: conceptualization, methodology, formal analysis and investigation, writing manuscript, review and editing, supervision; AdLD: writing manuscript, review and editing; IB: writing manuscript, review and editing; IPBJ: writing manuscript, review and editing; FXN: conceptualization, methodology; LMF: conceptualization, formal analysis and investigation. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics Approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (number 084-13).

Funding

There were no external funding bodies involved in this investigation.

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Conflict of interest statement: No conflicts declared.

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: April 5, 2021; Accepted: July 29, 2021
doi:10.2399/ana.21.909951

anatomy
An International Journal of Experimental and Clinical Anatomy

Forniceal and hippocampal atrophy in temporal lobe epilepsy patients with a history of complex febrile convulsion

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Abstract

Objectives: Temporal lobe epilepsy (TLE) is the most common seizure type in adults. Recent studies showed that 28–58% of TLE patients had a previous history of complex febrile convulsions (CFC). We compared the hippocampal volumes and volumes of amygdaloid body and widths of fornix and mammillary bodies on magnetic resonance imaging (MRI) of TLE patients with and without history of CFC.

Methods: MRI scans of 42 subjects retrospectively examined. The amount of atrophy in hippocampus, amygdaloid body, fornix and mammillary bodies were determined by two formulas depending on the mean values of the controls.

Results: We found no difference between TLE patients with a history of CFC and TLE patients without such a history in terms of all the quantitative measurements results ($p>0.05$) except the absolute right-left hippocampus volume and fornix % difference rate ($p<0.01$, $p<0.05$ respectively).

Conclusion: Forniceal atrophy was more prominent in the TLE group of patients with previous CFC history when compared to those patients without a CFC history. The CFCs should not be underestimated in the childhood, as they are associated with more atrophy in the particular brain structures in patients with TLE.

Keywords: complex febrile convulsion; limbic system; magnetic resonance imaging; morphometry; temporal lobe epilepsy

Anatomy 2021;15(2):137–144

Introduction

Epilepsy is an umbrella term characterized by epileptic seizures. An epileptic seizure results from the transient occurrence of several clinical symptoms due to abnormal discharge of the neurons in the brain.[1] The lifetime prevalence of epilepsy has been reported as 7.60 per 1000 persons.[2] Temporal lobe epilepsy (TLE) is the most common type of epilepsy in both adolescents and adults being 2/3 of all the epileptic patients undergoing surgery.[2,3] Previous studies revealed that 40% of TLE patients suffer from Ammon's horn sclerosis, hippocampal sclerosis or by its more appropriate name mesial temporal sclerosis (MTS).[4,5] Volumetric changes are typical in TLE patients; moreover, reduction in hippocampal volume is one of the diagnostic criteria for MTS.[6] Enlargement in amygdaloid body[7,8] and decreases in the volumes of extratemporal structures such as thalamus[9] are of most commonly reported findings in TLE patients.

The size of the fornix, which constitutes the major output pathway of the hippocampus has also been reported to decrease in TLE patients compared to the controls.[10,11] In addition, the width of mammillary body on MRI was investigated to uncover its role in seizure lateralization by Ng et al.[11]

MRI serves as a useful tool that can be used in diagnosis of TLE and for evaluating the morphometric changes and understanding the etiopathogenesis of TLE. However, morphological changes in limbic system structures other than hippocampus and amygdaloid body were not evaluated sufficiently.[12]

In TLE one of the most important concepts the MRI morphometric studies focused at is its relation with complex febrile convulsion (CFC) of the childhood.[13] Febrile convulsions are convulsions induced with fever caused by infections other than central nervous system infection. To differentiate febrile convusions from epilepsy, the patients should not have a history of any afebrile convulsion except neonatal convulsions which is seen between 1 month-5 years old in early childhood.[14,15] They are seen in 2–4% of all the children.[16] 2–10 % of the children who suffer from febrile seizures later have one or more unprovoked seizures.[16] 75% of these febrile seizures are actually complex febrile convulsions in nature.[5] A CFC is characterized by one or more of the following aspects : (a) the onset should be a partial onset, (b) it must have a duration of more than 10–15 minutes,[16] (c) multiple seizures should occur in 24 hours.[5] Sometimes 30 minutes is used as a criterion for longer duration.[17] 28–58% of TLE patients were reported to have history of CFC (TLE-CFC[+] patients).[17–19] Especially long duration of CFC is an important predictor for determining risk for developing TLE.[20] In an animal study it was shown that the number of febrile convulsion attacks were related to development of TLE.[21] In the studies with the post-operative specimens the number of neurons in TLE-CFC[+] patients tended to decrease more than the patients without a history of CFC (TLE-CFC[-] patients).[22,23] Several theories had been proposed by different authors to explain the relation between CFCs of the childhood and TLE including TLE patients having a predisposition for CFCs[24] and inflammatory mechanisms.[25]

Reduction in size of hippocampus in TLE-CFC[+] patients was reported to be more than the patients without such a history.[13,26–28] However, some authors contradicts this result and reported no relation with hippocampal volume reduction and existence of history of CFC in TLE patients.[29]

It is evident that not every TLE patient with a hippocampal atrophy has a history of CFC.[30] Hippocampal volume reduction after CFC detected by MRI was observed as a marker of acute damage.[31] The size of amygdaloid body seems to reduce more in TLE-CFC[+] patients than the TLE-CFC[-] patients. But this change revealed to be relatively less when compared with reduction in hippocampal volume.[28]

Fornix is the primary efferent pathway of the hippocampal formation and the forniceal fibers mostly end in the mammillary bodies. Although TLE-CFC[+] patients and TLE-CFC[-] patients were compared according to reduction in size of hippocampus and amygdaloid body, no comparison was made between the sizes of fornix and mammillary bodies. In this study, we aimed to asses the relation between hippocampus and amygdaloid body volumes, the width of fornix and mammillary bodies and the presence of history of CFC in TLE patients.

Materials and Methods

The study was conducted in 84 adults with equal number of patients and controls; the patient group included 42 cases (23 males, 19 females) having complex partial seizures originating from the temporal lobe. The patients had a mean age of 30.69±13.34 and they were outpatients of the Neurology Clinic of Medical Faculty of Uludağ University. The patients with space-occupying lesions (tumor, scar etc.) were not included to the study. The patients were taking their anti-epileptics in the prescribed doses and free of any seizure during the study period. The control group included 42 healthy volunteers with a mean age of 31.09±12.06. The controls were not taking any medication or hormones etc. One case in each group was left-handed and all the other cases in both groups were right handed. The history of CFC in childhood was questioned and recorded. CFC was defined as febrile seizures occurred before 5 years of age, lasting 20 minutes or longer without any underlying pathology of the central nervous system. The "age of epilepsy onset" was defined as the age when the first unprovoked afebrile seizure was seen. The "epilepsy duration" referred to the time interval between the first afebrile seizure and the time when MRI was performed.

MRI investigations were performed with 1.5 Tesla MRI scanner (Magnetom, Siemens, Erlangen, Germany). The measurement of intracranial area was performed at the midsagittal plane using sagittal T1 weighted Spin Echo (SE) sequences. The images of hippocampus and amygdaloid body were acquired at oblique coronal plane using a section thickness of 3 mm without any gap and using T1 turbo Inversion Recovery (IR) sequence.

The volume of hippocampus and amygdaloid body and the width of fornix and mammillary bodies were measured on 1.5 T MRI unit in both TLE and the control group. Assessing the images by the raw data without being normalized according to brain size one can get wrong results especially when bilateral atrophy exists.[32–35] Since the brain size can affect the volumes of hippocampus and amygdaloid body; we normalized the volume of hippocampus and amygdaloid body according to the following formula:

[Mean mid-intrasagittal area of the control group × volume of hippocampus or amygdaloid body] / mid-sagittal area of the patient (**Figure 1**).[10]

We used Cavalieri's principle while performing volumetric measurements.[35,36] Normalized hippocampus volume, the width of fornix and mammillary bodies were acquired after performing measurements using the images acquired from T1-weighted oblique coronal sections in 42 cases with TLE. One of the patients had artefacts in the scans; therefore, it is excluded. The hippocampus and amygdaloid body were drawn manually by a cursor in each section where they were seen, and the area measurement was calculated automatically. The sum of the areas were then multiplied by the section thickness (0.3 cm).[11] We then normalized the volumes accordingly.

Hippocampus was delineated on the coronal slices by the following borders;[12] posterior border: crus of fornix; superior border: choroid plexus; inferior border: subiculum and parahippocampal gyrus; lateral border: temporal horn of the lateral ventricle; median border: cisterna ambiens (**Figure 2**). For the amygdaloid body, following borders on the coronal plane were used to asses its volume;[12] posterior border: optic tract; superior border: a horizontal line drawn from the entorhinal sulcus; inferior and lateral borders: temporal horn and white matter of temporal lobe; medial border: ambient gyrus. The gyrus ambiens was seperated from gyrus parahippocampalis by the free margin of tentorium; uncal recess (**Figure 3**).

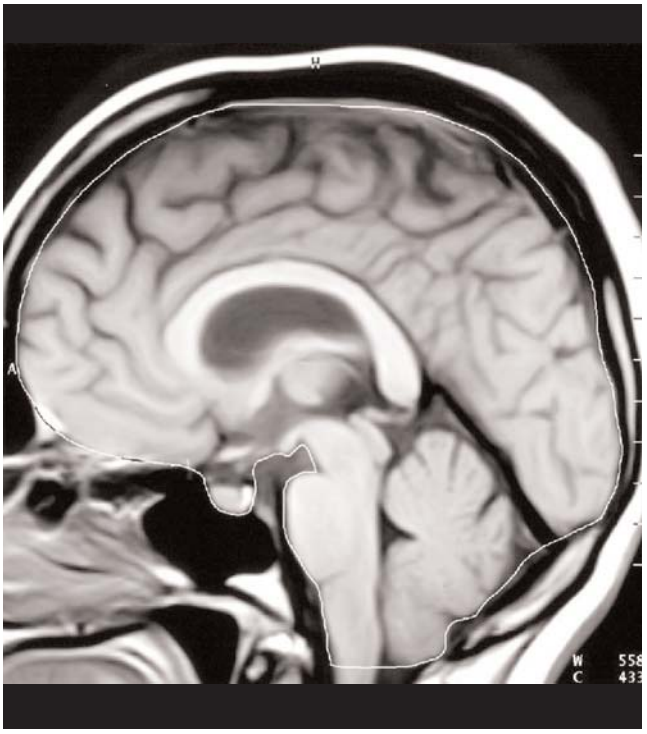

Figure 1. Intracranial measurement of mid-sagittal area of a subject. From "Morphometry of some elements of limbic system in normal population: a quantitative MRI study" by Yücel K, Hakyemez B, Parlak M, Oygucu IH. Neuroanatomy 2002;1:15–21.[33] ©neuroanatomy.org. Reprinted with permission.

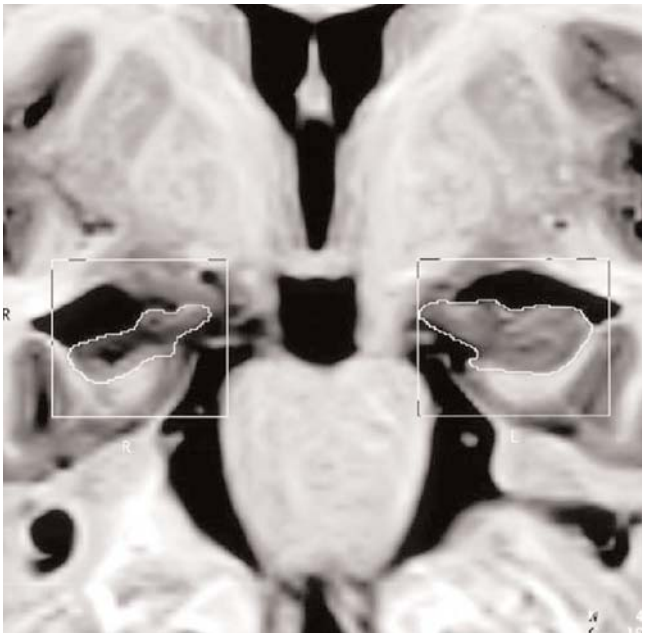

Figure 2. Hippocampal area measurement. From "Morphometry of some elements of limbic system in normal population: a quantitative MRI study" by Yücel K, Hakyemez B, Parlak M, Oygucu IH. Neuroanatomy 2002;1:15–21.[33] © neuroanatomy.org. Reprinted with permission.

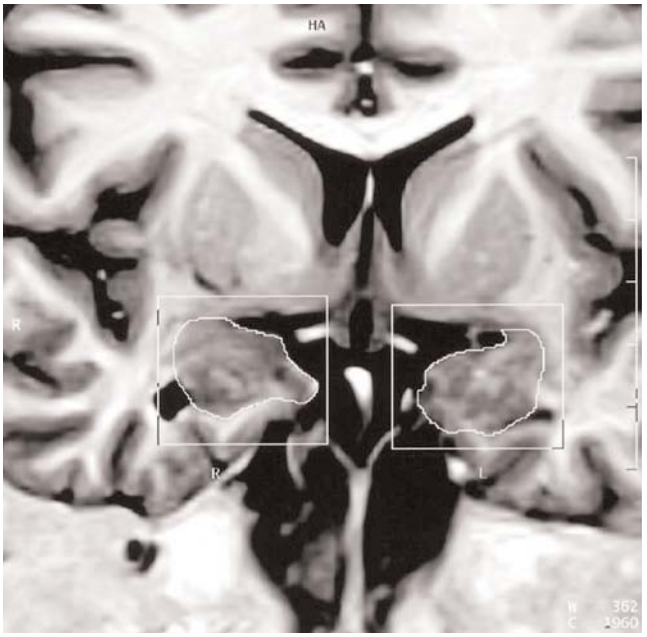

Figure 3. Amygdaloid body area measurement. From "Morphometry of some elements of limbic system in normal population: a quantitative MRI study" by Yücel K, Hakyemez B, Parlak M, Oygucu IH. Neuroanatomy 2002;1:15–21.[33] © neuroanatomy.org. Reprinted with permission.

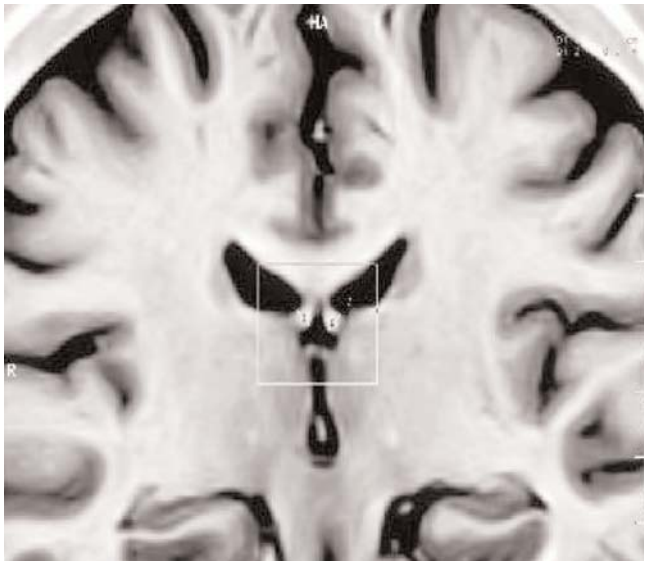

Figure 4. Fornix width measurement on a coronal section. From "Morphometry of some elements of limbic system in normal population: a quantitative MRI study" by Yücel K, Hakyemez B, Parlak M, Oygucu IH. Neuroanatomy 2002;1:15–21.[33] © neuroanatomy.org. Reprinted with permission.

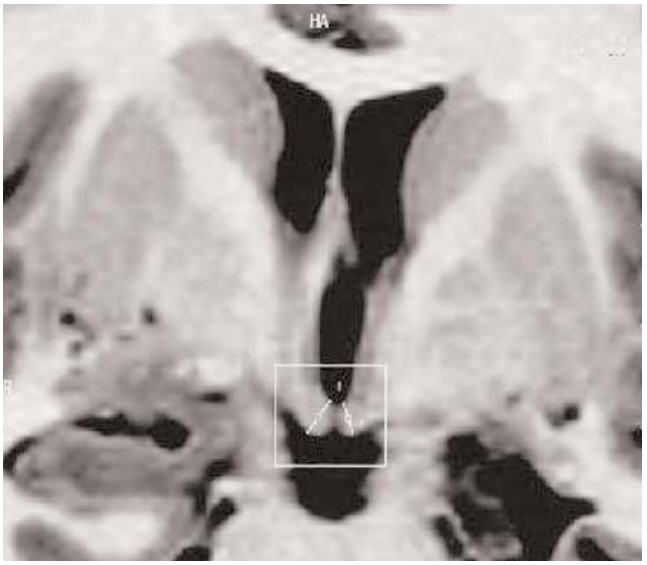

Figure 5. Mamillary body width measurement on a coronal section. From "Morphometry of some elements of limbic system in normal population: a quantitative MRI study" by Yücel K, Hakyemez B, Parlak M, Oygucu IH. Neuroanatomy 2002;1:15–21.[33] © neuroanatomy.org. Reprinted with permission.

Fornix width was measured at the coronal section where crus of fornix from the right and left side gather to form the corpus fornicis (**Figure 4**).[10] The width of mamillary body was measured at the section where hippocampal digitations were seen at the hippocampal head (**Figure 5**).[11] In the epilepsy neuroimaging literature particularly, in order to define atrophy in the hippocampus and amygdaloid body, normative data from a properly matched control group has been used.[37,38] Accordingly, the values 2 standart deviations below the mean volumes of the control group for hippocampus and amygdaloid body and the width of fornix and mammillary bodies were considered as "atrophic". In order to compare the sizes of the anatomical structures measured between TLE-CFC[+] patients and TLE-CFC[-] patients we took the amount of atrophy into consideration. We used two different formulas to detect the amount of atrophy quantitatively in hippocampus/amygdaloid body and fornix/mammillary bodies. The first formula was for assessing hippocampal and amygdaloid atrophy calculating the absolute difference between right and left hippocampal and amygdaloid volume (R-L) in the TLE group. The second formula was the "% difference rate" for measuring the width of fornix and mamilary body as demonstrated below:

$$\%\ \text{difference rate} = \frac{(\text{larger side} - \text{smaller side})}{\text{larger side}} \times 100$$

% difference rate was also helpful detecting the number of patients with and without atrophy of these two structures when compared with the 2 standard deviations above the mean of the control group as an overlapping exists in fornix and mamillary body sizes between the normal cases and pathological cases.[11] Regarding fornix or mamillary body % difference rates of standart deviations above the mean of control group for these was considered as "atrophic."

The results of our study were assessed using Statistical Package for Social Sciences (SPSS Version 7, Armonk; NY, USA). In comparing the results of patient and control group t-test and Mann–Whitney U test were used. For the correlations Pearlson's correlation rate was used. For all the comparisons, p-values less than 0.05 were considered as significant.

Results

We found no difference between TLE and control group in terms of age ($p>0.05$). The years of education were different between the two groups ($p>0.05$). The demographic data of the TLE and control group are shown in **Table 1**. The mean of seizure frequency in the patient group was 5.66 seizures/per month (0.08–25). After performing partial correlations it was found that this variable had an effect on normalized amygdaloid body volume and fornix % difference rate. After control-

Table 1

Demographic data in TLE and control group including age, education, age at onset of epilepsy, epilepsy duration.

Group	Age Mean±SD (min-max)	Education (years) Mean±SD (min-max)	Age at onset of epilepsy Mean±SD (min-max)	Epilepsy duration (years) Mean±SD (min-max)
TLE	30.69±13.34 (10–67)	7.76±3.97 (0–15)	14.59 (9 month–42 years)	16.24 (2–54)
Control	31.09±12.06 (13–62)	11.97±4.21 (0–17)	-	-
Statistical significance	0.775	<0.05	-	-

Max: maximum value; **min:** minimum value; **SD:** standart deviation.

Table 2

The dispertion of cases with history of CFC in the TLE and control group.

Group	Number of cases with a history of CFC	Number of cases without a history of CFC
TLE (n=42)	19 (8 females, 11 males)	23 (11 females,12 males)
Control (n=42)	2 (1 male, 1 female)	40 (18 females, 22 males)
Statistical significance	p<0.01	p<0.01

ling for numbers of years of education variable, the results of the study with statistical significance remained the same.

We found no difference between TLE-CFC[+] patients and TLE-CFC[-] patients in terms of age of epilepsy onset, epilepsy duration and seizure frequency (p>0.05). There was no difference between the TLE-CFC[+] patients and TLE-CFC[-] patients according to age and gender (p>0.05). In TLE group the number of cases with a history of CFC was more than the cases with such a history in the control group (p<0.01). The distribution of number of cases with and without history of CFC in both groups are demonstrated in **Table 2**.

There was no difference between TLE-CFC[+] patients and TLE-CFC[-] patients in terms of all the quantitative measurements results (p>0.05) except the atrophy rate of hippocampus and fornix % difference rate (p<0.01, p<0.05 respectively) (**Table 3**).

Table 3

Comparison of quantitative measurements of hippocampus, amygdala, fornix and mamillary body between TLE patients with and without a history of CFC.

	TLE patients with a history of CFC (n= 19) Mean±SD (min-max)	TLE patients without a history of CFC (n=23) Mean±SD (min-max)	Statistical significance
Right hippocampus volume	2968.78±769. 29 (1886.56–4099.55)	3189.77±843.49 (1110.56–4456.81)	p>0.05
Left hippocampus volume	2849.38±583.56 (1889.51–4550.41)	3115.05±583.56 (1889.51–4550.41)	p>0.05
Amount of atrophy in the hippocampus (22 m,16 f)	1471.06±575.17 (47.5–2334.35)	819.90±611.08 (9.19–1919.93)	p<0.01*
Right amygdala volume	1987.73±361.96 (1224.83–2618.22)	2149.12±365.2 (1406.29–2699.11)	p>0.05
Left amygdala volume	1918.57±388.09 (977.27–2552.24)	2085.44±341.09 (1380.9–2561.55)	p>0.05
Amount of atrophy in the amygdala (22 m, 15 f)	358.59±331.82 (6.07–965.31)	292.33±331.82 (6.07–965.31)	p>0.05
Right fornix width	2.3±0.05 (1–3.4)	2.48±0.06 (1.4–3.9)	p>0.05
Left fornix width	2.46±0.05 (1.3–4.8)	2.59±0.05 (1.4–43.9)	p>0.05
% fornix difference rate	23.43±17.99 (0–56.52)	13.74±16.54 (0–47.37)	p<0.05*
Right mamillary body width	4.26±0.06 (3.3–5.3)	4.09±0.06 (2.3–5.6)	p>0.05
Left mamillary body width	4.24±0.06 (3–5.4)	4.17±0.06 (2.7–5.5)	p>0.05
% mammillary body difference rate	7.78±8.66 (0–25)	7.17±8.14 (0–36.36)	p>0.05

F: females; **M:** males; hippocampus and amygdala quantitative values are expressed as mm^3; fornix and mamillary body widths are expressed as mm; *statistically significant.

Ten of the patients with hippocampal atrophy did not have a history of CFC while 14 had. Twelve of 14 patients with normal hippocampal size did not have a history of CFC and only 2 patients with normal hippocampus size had. The difference between the two groups was statistically significant ($p<0.01$). Fourteen of 20 patients without forniceal atrophy, did not have a history of CFC and 6 had. Nine of 22 patients with forniceal atrophy did not have a history of CFC while 13 had. The dispersion of patients with and without a history of CFC between the two groups had tendency to be statistically significant ($p=0.059$). Fourteen of 24 patients without atrophy of mammillary bodies, and amygdaloid body atrophy did not have a history of CFC and 10 had. Nine of 18 patients with atrophy of mammillary bodies and amygdaloid body did not have a history of CFC while 9 had. The dispersion of patients TLE-CFC[+] patients and TLE-CFC[-] patients between the two groups was not significant ($p>0.05$).

Discussion

We found no differences in bilateral hippocampus and amygdaloid body volumes and fornix and mamillary body widths between TLE-CFC[+] patients and TLE-CFC[-] patients. On the other hand, the amount of atrophy in the hippocampus and fornix were more in TLE-CFC[+] patients. We found that TLE-CFC[+] patients had more reduction in hippocampal volume with a mean of 8.36% than TLE-CFC[-] patients.

Some studies reported atrophy in the hippocampus of TLE-CFC[+] patients compared to TLE-CFC[-] patients,[13,18,26,28] although some reported no relation between hippocampal atrophy and history of CFC.[29,39] Several different mechanisms have been proposed to explain the role of CFCs in the atrophy of medial temporal structures in MTS. One of the theories suggest a further susceptibility of the hippocampus to seizures in the adulthood following cellular and molecular changes occurred following CFC experienced in childhood.[40] An other mechanism is that an initially pre-existing insult can make hippocampal damage to cause CFC initially and then to TLE.[25] Common genetic mechanisms for the development of CFC and TLE have been suggested as a third theory.[41] However, not each case with hippocampal atrophy has a history of CFC. In fact, there is only a certain small group of TLE-CFC[+] patients. Factors such as head trauma, afebrile status epilepticus and meningitis can also cause MTS.[42] As a result we can say that CFC is not the solely etiologic factor of TLE, but only can be one the factors.

We found that history of CFC was not related to any volumetric changes in the amygdaloid body in TLE patients consistent with the findings of the previous studies.[27,34] Actually, amygdaloid body has been related to the psychogenic auras seen in TLE patients, rather than an insult related to the CFC experienced in the childhood[27,43] and hippocampus has a more dominant role than amygdaloid body has for the origin of epileptic seizures.[44]

In spite of their inconsistencies, there are many studies where correlations were reported between hippocampus and amygdaloid body volumes and epilepsy duration, age of onset and seizure frequency.[13,18,45] Parallel to the findings of Bower et al.[39] and Fuerst et al.,[46] we found no difference between TLE-CFC[+] patients and TLE-CFC[-] patients regarding these three variables. Therefore we do not think that they can affect our findings.

Finally, as far as we know more forniceal atrophy in TLE-CFC[+] patients is a new finding. Thinner fornix has been reported previously in TLE patients compared to the controls.[47] It was proposed that forniceal atrophy was associated with relatively larger hippocampal volume loss in TLE.[48] There is only one study with adults with a history of childhood febrile seziures and the authors did not find any difference in forniceal integrity between this sample and controls.[29] Fornix is one of the pathways for seizure spreading along with other pathways including stria terminalis, amygdalofugal fibers, and uncinate fasciculus.[44] An increase in white matter integrity was observed in a group of subjects whose diffussion tensor imaging (DTI) scans were performed eight years after the prolonged febrile seizures compared to controls.[49] We can speculate that fornix atrophy associated with the history of CFC can be secondary to the hippocampal atrophy seen in TLE patients. Considering the proposed mechanisms for the relationship between hippocampus atrophy and CFC, what has been said about the hippocampus may also apply to the fornix; i.e. fornix atrophy may have occurred due to a trauma before CFC or the direct effect of CFC. In this neuroimaging study of ours, however, we can not explain the mechanism of the relation between forniceal atrophy and history of CFC in TLE patients. TLE patients with relatively more hippocampal atrophy and history of CFC can be a separate clinical group, and more forniceal atrophy might be a feature of this particular group of TLE patients.

The point of view from a perspective on genetics is very important when planning future MRI morphometric measurements to uncover the relation between history of CFC and TLE. For example, why not every child with a history of CFC develops TLE and related hippocamapal damage may be answered partly by planning collaborative prospective studies of genetics and MRI morphometery.

Our study has several limitations. First, it is a cross-sectional study with relatively a small sample size. We do not

have any treatment history, as the antiepileptics also can be a confounding factor. Rather than measuring the width of the fornix, DTI as a relatively new and more advanced technique might have been used to see whether there is any deficit in the white matter integrity in this pathway in this subgroup of TLE patients.[50]

In our study, we replicated the consistent finding of more hippocampal atrophy in TLE-CFC[+] patients with an additional finding of more forniceal atrophy in that group of patients compared to those patients TLE-CFC[-] patients. The CFCs should be taken care of carefully in the childhood, as they are associated with more atrophy in the particular brain structures in patients with TLE.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

KY: project development, manuscript writing/editing; BH: data collection and data analysis; İB: supervision of the study and collecting patients.

Ethics Approval

The study was approved by the Local Ethics Committee of the Medical School of Uludag University (date of approval: 09.05.2000, approval number: 2000-51).

Funding

The study was not conducted by any available funding resources.

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Conflict of interest statement: No conflicts declared.

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: February 23, 2021; Accepted: August 7, 2021
doi:10.2399/ana.21.990828

anatomy
An International Journal of Experimental and Clinical Anatomy

The frequency of the bony parameters of femoroacetabular impingement syndrome in young asymptomatic individuals: a computed tomography study

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Abstract

Objectives: Femoroacetabular impingement syndrome is a painful disorder of the hip formed by movements in the hip joint between the femoral head-neck junction and the acetabular edge. The aim of this study was to determine the prevalence of radiological femoroacetabular impingement syndrome findings in a young, asymptomatic Turkish population.

Methods: A total of 1000 abdominal pelvic CT images were collected from patients aged between 18–40 years. Measurements were taken on the CT images of the alpha angle and femoral head offset as signs of cam-type deformity, and of the acetabular version angle and center-edge angle as signs of pincer-type deformity.

Results: Femoroacetabular impingement syndrome was determined in 2.3% of the individuals. Pincer type deformity was determined in 56.5%, being 83.3% in females and 47.1% in males. The cam-type deformity was present in 43.5% of all cases, being in 16.7% of the females and in 52.9% of the males. No difference was determined between the genders in respect of alpha angle which is >55°. A head-neck offset which is <8 mm was at a higher rate in females (13.3%) than males. An acetabular anteversion angle which is <15° and centre-edge angle which is >40° was more in males than females at a rate of 11% and 25.2% respectively.

Conclusion: The results of this study showed that the incidence of cam-type deformity in the adult males and the incidence of pincer-type deformity in the adult females were lower in the asymptomatic Turkish population than previously reported in literature.

Keywords: cam deformity; computed tomography; femoroacetabular impingement syndrome; mixed deformity; pincer deformity

Anatomy 2021;15(2):145–151

Introduction

Femoral acetabular impingement syndrome (FAIS) has been defined as a painful hip disorder which results from abnormal contact between the femoral head-neck junction and the acetabular edge in hip joint movements, especially in flexion.[1] In young adults, FAIS is the most common cause of hip pain and early degenerative changes.[2,3] It has been previously described in as acetabular rim syndrome or cervico-acetabular impingement.[3,4] Since this syndrome was defined by Ganz et al.[2] in 2003, it has been the subject of continuous debate in the field of orthopedics. There are 3 different types of FAIS; cam type deformity (CD), pincer type deformity (PD), and mixed type deformity (MD) which is a combination of the CD and PD. Asymmetrical femoral head and neck junctionmay lead to CD impingement (femoral

type: pistol grip).[2–4] In this deformity, the spherical property of the femoral head is lost, and the protrusion at the head-neck junction leads to a decrease in femoral head-neck offset.[5,6] In PD (acetabular type), the femoral head is covered by the acetabulum focally or in a wide diameter. PD impingement occurs as a result of greater coverage than normal of the femoral head by an abnormally deep or retroverted acetabulum.[7] The MD is characterized by morphological abnormalities in both the acetabulum and the femur head-neck junction.[2]

The prevalence of FAIS may change according to ethnicity and level of physical activities.[8] Therefore, knowledge of the prevalence in an asymptomatic population will be useful both for patients and physicians for the implementation of the appropriate approach to the disease and the prevention of unnecessary arthroplasties. Only a limited number of studies have investigated the prevalence of FAIS in the asymptomatic Turkish population.[9] Therefore, the aim of this study was to determine the incidence of FAIS on Computed Tomography (CT) images in a young adult asymptomatic Turkish population. The main hypothesis of the study was that FAIS incidence would be affected by demographic and ethnic factors and level of physical activities in different populations.

Materials and Methods

A retrospective evaluation was performed of pelvic CT images of patients, all aged 18–40 years, taken in the Radiology Department of Akdeniz University Medical Faculty Hospital between 2015 and 2020. CT images of the patients who had pelvic trauma, an orthopedic disorder, or an oncology history were not included in this study.

CT images taken at the upper level of the iliac crest to the proximal diaphragm of the femur were evaluated. The pelvic bone structure was examined in respect of cam, pincer, and mixed type deformities. Oblique, axial, and coronal images were obtained from multiplanar reformatted (MPR) images. Femoral head-neck junction distance, acetabular version angle, and center-edge angle were measured on these images.

The MDCT images were acquired by a 128-detector CT device (Somatom Definition Edge, Siemens Healthcare, Erlangen, Germany) in the Radiology Department of Akdeniz University Medical Faculty Hospital. The image acquisition parameters were set as 16×1.5 mm detector collimation, 120 kV tube voltage, 0.5 sec gantry rotation, and 180–220 mA tube flow. The images were reconstructed with a 1.5 mm reconstruction interval at a slice thickness of 1.5 mm. The MDCT images sent from the picture archiving and communication system (Sectra Workstation IDS7; Sectra AB, Linköping, Sweden) through the network were evaluated on the workstation.

The alpha angle and femoral head offset were measured for determination of the CD, and acetabular version angle and center-edge angle were measured for the determination of PD. The alpha angle was formed in the oblique axial plane by centralization of the femoral neck center in the coronal plane on MPR images. For measurement of the alpha angle, a line was drawn along the long axis of the femoral neck to the center of the femoral head. A circle covering the subchondral bone was drawn. A second line was drawn to the center of the femoral head from the point where the femoral head emerges outside the circle. The angle between these two lines was defined as a alpha angle (**Figure 1**). An alpha angle value of >55° was evaluated as an indicator of FAIS.[10]

The femoral head-neck junction distance was measured in the oblique axial plane, where the alpha angle was obtained. The distance between the line drawn along the anterior of the femoral neck and the parallel line drawn from the widest anterior point of the femoral head, was measured as the femoral head-neck junction distance (**Figure 2**). A value <8 mm was accepted as significant for FAIS.[11]

The acetabular version angle was evaluated on axial slices. On sections where the acetabulum was deepest a line was drawn at the level of the posterior boundaries of the acetabular labrum. The angle between the defined line and the line that was drawn between the anterior and posterior edges of the acetabulum is the acetabular version angle (**Figure 3**). An acetabular version angle <15° was accepted as abnormal.[12]

The centre-edge angle was measured on CT scanogram images. Firstly, a horizontal line was drawn passing through inferior borders of both ischial tuberosities. Then a vertical line was drawn perpendicular to this line from the centre of the femoral head. The angle between the perpendicular line passing through the center of the femoral head and the line drawn from the center of the femoral head to the lateral border of the acetabulum was considered as the central-edge angle (**Figure 4**). A centre-edge angle of >40° was accepted as abnormal.[13,14]

Data obtained in the study were analyzed statistically with Statistical Package for Social Sciences (SPSS Version 23, Armonk; NY, USA). Descriptive statistics were given as mean±standard deviation (SD), median (minimum-maximum) and percentage (%). Conformity of the data to normal distribution was assessed with the Shapiro Wilks

Figure 1. Measurement of the alpha angle. (**a**) Axial plane, (**b**) coronal plane.

test. In the analyses of relationships between categorical variables, Pearson Chi-square test and Fisher's Exact test were used. In the analysis of the difference between two groups, Student's t-test was applied when the data showed normal distribution and Mann-Whitney U test was applied when distribution was abnormal. Spearman's correlation analysis was applied to evaluate relationships between ordinal variables or data not conforming to the

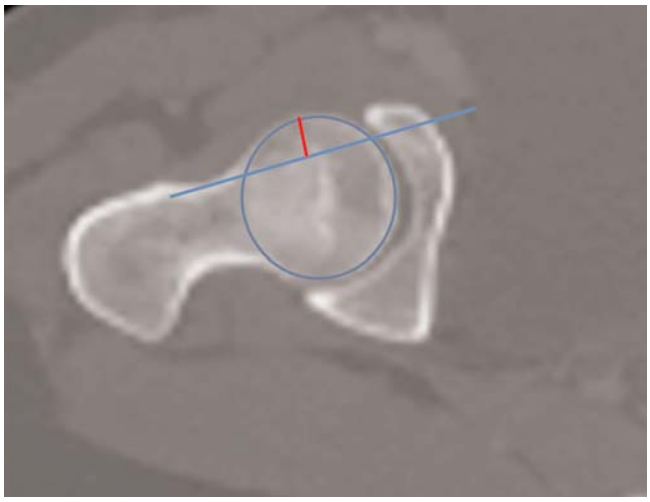

Figure 2. Measurement of the femur head-neck distance.

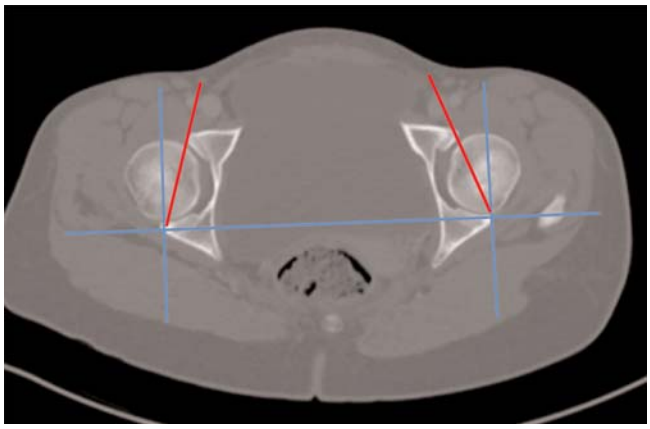

Figure 3. Measurement of the acetabular version angle.

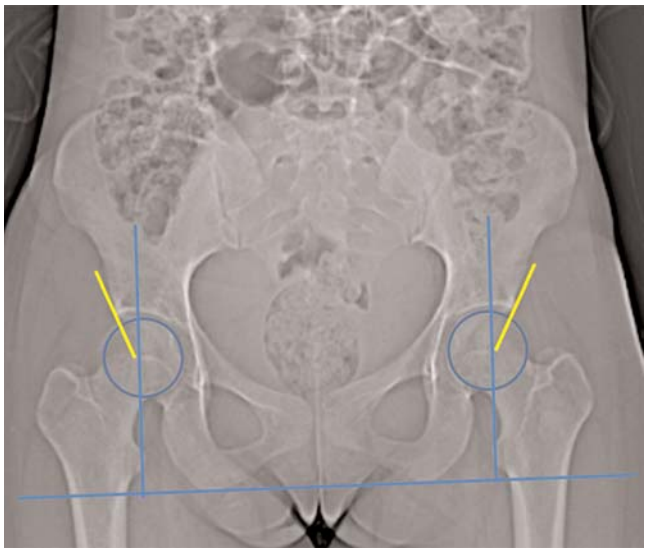

Figure 4. Measurement of the centre-edge angle.

Figure 5. (**a**) Bilateral cam-type deformity (**black arrows**); (**b**) bilateral pincer-type deformity (**black arrows**)

normal distribution, and Pearson correlation analysis was applied to continuous variables with normal distribution. A p-value <0.05 was accepted as statistically significant. The incidence of male and female subjects was calculated by dividing the total number of hips for each gender by the total number of abnormal hips.

Results

Out of 1000 hips, 480 hips (48%) were female and 520 hips (52%) were male. FAIS was present in 2.3% of the hips examined. Thirteen (56.5%) hips with FAS had PD and 10 (43.5%) had CD (**Figure 5**). FAIS was identified in 1.3% of the females and in 3.3% of the males and the difference was statistically significant (p=0.033). FAIS was effecting the right hip joint in 2.4% and the left hip joint in 2.2%. The difference between sides was not statistically significant (p=0.833). No significant difference was found when evaluated bilaterally (p>0.5). The PD was found in 83.3% of the females with FAIS and in 47.1% of males. CD was found in 16.7% of females and in 52.9% of males. The PD was present on the right side in 58.3% of the patients and on the left side in 54.5%. The CD was present on the right side in 41.7% of the patients and on the left side in 45.5% (**Table 1**).

The summary of descriptive statistics of the radiological measurements of the patients were presented in the tables (**Tables 2** and **3**). No statistically significant difference was observed between the genders in respect of the alpha angle (p=0.712). In males, the head-neck offset measurement and center-edge angle were determined to be higher than those of females. The acetabular anteversion angles were statistically significantly higher in females than males (p<0.001). No significant difference was determined between the genders in respect of an alpha angle which is >55° (p=0.110). Head-neck offset measurement which is <8mm was present at a higher rate in females (13.3%) than males (p<0.001). Acetabular version angle which is <15° and center-edge angle which is >40° was present at a higher rate in males (11% and 25.2%, respectively) than in females (p=0.001, p<0.001). A significant positive weak correlation was found in all the hips between age and head-neck offset measurements (r=0.094, p=0.003), acetabular anteversion angle (r=0.199, p<0.001), and the center-edge angle (r=0.153, p<0.001) (**Tables 2** and **3**).

Discussion

As a result of the impaired anatomic relationship in FAIS, there is unusual contact between the two sides of the cartilage and the labrum, and there may be degeneration in the hip joint in this process. This unusual form of contact can be determined with radiological tools such as conventional radiography, CT, and magnetic resonance imaging (MRI), taking measurements of some angles and distances using significant points in the bones.[2] According to the 2016 Warwick Agreement, it was regarded that the morphology could be better characterized on cross-sectional images such as CT or MRI.[15] CT imaging has been reported to provide detailed visualization of the hip joint

Table 1
Patient characteristics.

		n: 1000
Age (years)		27.8±6.6 (18–40)
Gender	Female	480 (48%)
	Male	520 (52%)
FAIS	Absent	977 (97.7%)
	Present	23 (2.3%)
FAIS Type	PINCER	13 (56.5%)
	CAM	10 (43.5%)

Results are presented as n (%) and mean±SD values.

Table 2
Comparison of the parameters according to gender.[1]

Measurements		Total		Female		Male		p-value
		Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	
Right (n=500)	Alpha angle	38.69±5.45	38.1 (15.2–63.2)	38.22±5.19	37.7 (15.2–52.3)	39.14±5.66	38.45 (24–63.2)	p= 0.106 z=-1.618
	Head-neck offset	10.47±1.84	10.55 (4.5–15.3)	9.81±1.73	10 (4.5–13.7)	11.08±1.73	11.2 (5–15.3)	p<0.001* t=-8.228
	Acetabular anteversion	21.11±3.55	21 (8.5–34.1)	22.05±3.3	22.1 (13.1–34.1)	20.24±3.55	20.2 (8.5–31.2)	p<0.001* t=5.886
	Centre-edge angle	36.32±4.87	36.3 (19.1–51.9)	35.17±4.63	35 (23.2–51.1)	37.39±4.84	37.3 (19.1–51.9)	p<0.001* t=-5.231
Left (n= 500)	Alpha angle	38.37±5.68	37.7 (20.9–62.1)	38.65±5.69	38 (27.2–61.1)	38.12±5.66	37.2 (20.9–62.1)	p=0.285 z=-1.068
	Head-neck offset	10.67±2.17	10.75 (6–37.4)	10.11±1.56	10.3 (6–13.9)	11.2±2.49	11.3 (6.4–37.4)	p<0.001* z=-6.458
	Acetabular anteversion	20.03±3.89	20.4 (8.5–32.1)	20.7±3.69	21.1 (9.9–30.3)	19.42±3.97	19.8 (8.5–32.1)	p<0.001* z=-4.112
	Centre-edge angle	35.88±4.87	35.7 (18.6–57.1)	34.97±4.67	34.8 (21.8–49.2)	36.71±4.91	36.5 (18.6–57.1)	p<0.001* t=-4.054
Total (n=1000)	Alpha angle	38.53±5.57	37.9 (15.2–63.2)	38.43±5.45	37.8 (15.2–61.1)	38.63±5.68	38.1 (20.9–63.2)	p=0.712 z=-0.369
	Head-neck offset	10.57±2.01	10.65 (4.5–37.4)	9.96±1.65	10.2 (4.5–13.9)	11.14±2.14	11.2 (5–37.4)	p<0.001* z=-9.946
	Acetabular anteversion	20.57±3.76	20.7 (8.5–34.1)	21.37±3.57	21.45 (9.9–34.1)	19.83±3.79	20 (8.5–32.1)	p<0.001* t=6.618
	Centre-edge angle	36.1±4.87	36 (18.6–57.1)	35.07±4.65	34.9 (21.8–51.1)	37.05±4.88	37 (18.6–57.1)	p<0.001* t=-6.558

Mann-Whitney U test, Student's t-test. *p<0.001.

segments such as the inferoposterior and posterolateral hip joint which may be difficult to define on radiographs.[16] In addition, CT scanning can provide information about the proximal femoral version for the characterization of extra-articular deformity and impingement.[17] In several studies, researchers have examined the parameters and prevalence

Table 3
Comparison of the parameters according to gender.[2].

Measurements		Total n (%)	Female n (%)	Male n (%)	p-value
Right (n: 500)	Alpha angle >55°	3 (0.6)	0 (0)	3 (1.2)	0.250
	Head-neck offset <8 mm	54 (10.8)	42 (17.5)	12 (4.6)	<0.001*
	Acetabular anteversion <15°	24 (4.8)	4 (1.7)	20 (7.7)	0.002*
	Centre-edge >40°	105 (21)	36 (15)	69 (26.5)	0.002*
Left (n: 500)	Alpha angle >55°	7 (1.4)	2 (0.8)	5 (1.9)	0.452
	Head-neck offset <8 mm	35 (7)	22 (9.2)	13 (5)	0.068
	Acetabular anteversion <15°	57 (11.4)	20 (8.3)	37 (14.2)	0.038
	Centre-edge >40°	96 (19.2)	34 (14.2)	62 (23.8)	0.006
Total (n: 1000)	Alpha angle >55°	10 (1)	2 (0.4)	8 (1.5)	0.110
	Head-neck offset <8 mm	89 (8.9)	64 (13.3)	25 (4.8)	<0.001*
	Acetabular anteversion <15°	81 (8.1)	24 (5)	57 (11)	0.001*
	Centre-edge >40°	201 (20.1)	70 (14.6)	131 (25.2)	<0.001*

Pearson chi-square test, Fisher's exact test. *p<0.001.

of FAIS on conventional radiography-based, CT, and MR images in large populations.[9,18–20]

The prevalence of FAIS in asymptomatic individuals in the Turkish population was found to be 29.6%. Polat et al.[9] reported FAIS at the rate of 30% in Turkish males. Fukushima et al.[20] concluded that FAIS cases were very rare in the Japanese population. Frank et al.[21] reported the prevalence of cam deformity was 37% and the prevalence of pincer deformity was 67%. Interestingly, there was an almost 3:1 ratio of cam deformity in the athletic population compared with the nonathletic people.

Laborie et al.[18] reported the prevalence of CD and PD in males to be 21.5% and 23.4%, respectively. In females, PD impingement was reported at the rate of 11% by Laborie et al.[18] and 11.6% by Polat et al.[9] In the current study, the CD was determined at 16.7% and PD at 83.3% in females. Gosvig et al.[19] found CD prevalence in males to be 17%. Polat et al.[9] reported CD prevalence as 30.8% and PD as 9.3%. In the current study, PD in the male population was determined to be 47.1%, and CD, 52.9%.

Reichenbach et al.[22] examined CD prevalence in young males and reported that 24% of the males had CD. CD impingement is generally seen in young males and PD impingement in middle-aged females.[8] In studies of asymptomatic individuals, the CD has been reported at rates varying between 9% and 25% in males and between 3% and 10% in females.[23] In a by Gosvig et al.[19] CD impingement morphology was determined in 17% of males and 4% of females. In a study of the CT images of a young population, Chakraverty et al.[24] examined FAIS prevalence and reported MD at the rate of 22%. No cases of MD were observed in our study.

Tannenbaum et al.[25] found a higher rate of acetabular retroversion in women compared to men, similar to our findings. In another study, alpha angle was found to be 45.6° in females and 48° in males, the acetabular version angle was 16.8° in females and 16.2° in males, and the center-edge angle was 37° in females and 37.4° in males.[14] In the CT-based study of Jung et al.,[26] the mean alpha angle was reported as 59.1° in 215 male hip joints and 45.4° in 540 female hip joint. These results demonstrated that CD was not uncommon in an asymptomatic population group. Jung et al.[26] revealed the mean alpha angle as 38.6° in men and 38.4° in women. These findings are similar to our findings.

Our study showed that the incidence of FAIS was 2.3%. The mean alpha angle was 37.8° in women and 38.1° in men, and there was no significant difference between the genders. Head-neck deviation and center-edge angle values were higher in men, and acetabular anteversion angles were higher in women. In our study, the center-edge angle was measured as 35° in women and 37° in men. As a result, the alpha angle was found to be extremely low in this study compared to other studies. Since the pelvis is horizontal during CT measurements, we think that this will affect the acetabulum version angle. We believe that in Turkish society, the acetabulum is associated with more lordosis, especially in women. According to the results obtained in this study, a slight anteverted position was observed in the Turkish population. The incidence of CD in the adult male asymptomatic population and the incidence of PD in the adult female asymptomatic population were higher than the rates reported in the literature. The incidence of pathological acetabular version angle was higher in women. There was no significant difference between men and women in terms of alpha angle measurements.

Conclusion

In conclusion, our study is one of the most comprehensive studies conducted in the Turkish population. We think that the alpha angle is a controversial parameter in the diagnosis of cam-type deformity. On the other hand, head-neck offset measurement and median margin angle were higher in males and higher in females in acetabular version angles. The fact that our study results differ from previous CT studies may be due to genetic factors and the difference at the level of physical activity done during childhood and adolescence.

Conflict of Interest

The authors declare that they have no related conflicts of interest.

Author Contributions

MC: investigation, data collection, data analysis; AK: data collection, data analysis; SO: data analysis, manuscript writing, manuscript editing; HS: data analysis, manuscript editing; MG: manuscript writing, manuscript editing; KG: project development, data collection; MS: project development, manuscript editing, supervision.

Ethics Approval

All protocols were approved by Akdeniz University Clinical Research Ethics Committee and carried out under the supervision of them (Date-Number of the ethical approval: 24.07.2019-732). Approval from the Institutional Review Board was obtained and in keeping with the policies for a retrospective review, informed consent was not required.

Funding

This research did not receive any grants from any funding agency in the public, commercial or not-for-profit sectors.

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Conflict of interest statement: No conflicts declared.

anatomy
http://dergipark.org.tr/en/pub/anatomy
An International Journal of Experimental and Clinical Anatomy

Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: May 18, 2021; Accepted: July 22, 2021
doi:10.2399/ana.21.938977

Evaluation of knowledge and attitudes of physicians in Turkey about body donation processes

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Abstract

Objectives: Individuals who want to get information about body donation sometimes apply to physicians instead of Anatomy Departments in Turkey. The aim of the study was to evaluate the knowledge and attitudes of physicians who are frequently consulted by body donors.

Methods: In this descriptive study, questionnaire form which consisted of three parts and 20 questions was prepared. In the first part, demographic informations; in the second part; the physicians' answers to frequently asked body donation questions and physician responsibilities in the process; in the third part, the physicians' request for information was questioned. The survey was conducted online.

Results: Of the 238 physicians from 33 different provinces (aged between 25–68 years, 58.8% female, 41.2% male), 62.6% were specialist, 37.4% were non-specialized. 12.6% of them stated that at least one person applied to them for body donation. While only 52.5% of the physicians chose the Anatomy Departments to direct the donor, 35.3% chose the Organ Donation Units. 80.3% did not know that the body of an individual who did not fill out the donation form could be donated by their relatives and 29.4% did not know that body donation does not prevent organ donation. 90.8% of the physicians stated that they needed to be informed about the laws and procedures related to cadaver donation.

Conclusion: The study reveals that physicians do not have enough information about body donation and they demand to be informed about it. The findings should be carefully evaluated as a factor that may adversely affect the decision of the body donor who cannot be properly guided by the physicians.

Keywords: attitude; body donation; cadaver supply; physician; survey

Anatomy 2021;15(2):152–162

Introduction

Along with many technological developments that contribute to the understanding of the human body, working with cadavers in medical education and specialist training in surgical fields maintains its importance and priority all over the world. For this reason, although there are priority sub-topics that vary in different geographies, problems related to the supply of cadavers occupy an important place on the agenda of anatomists and medical educators.[1–24] As general social and ethical values evolve in all societies over time, the historical process regarding the way of cadaver supply is also evolving from the stages of grave robbing, the use of the dead bodies of criminals or unclaimed bodies to the use of donated bodies. This evolution, which progresses at different speeds in different geographies, can be shaped by solutions accepted by the society that questions ethical values on one hand and the needs on the other, and laws and regulations develop in a way that adapts to this.[2,7,9,14,16,18,20,25–32] Unclaimed bodies are the most common source of cadaver supply worldwide. However, the ethical problems arising from the use of

This study was as an oral presentation at the online 21st National Anatomy Congress, 27th–29th November 2020, Turkey.

unclaimed bodies as cadavers are a disturbing factor primarily for anatomists, researchers and students, needs to be discussed and resolved. Of course, it is much more comforting for the researchers and students to know that someone has allow his body dissection while living, rather than it was approved by a medical institution.[28] From this viewpoint, the adoption of cadaver supply through body donation is an important and efforts toward this are spreading to all continents. In the UK, one of the countries where body donation is relatively common, "The Human Tissue Act" (2004) which makes the use of unclaimed bodies illegal has been put into use. Although this practice has resulted in a decrease in cadaver supply, it is still valid. Similarly, prohibition of the use of unclaimed bodies in North American medical schools, where donor cadavers made up 80% of total cadavers, is strongly debated.[7,28] Body donation based on the donor's informed consent, an approach that respects the donor's personal autonomy and dignity of the human body is considered as the backbone of anatomy ethics. This approach is well regulated by International Federation of Associations of Anatomists (IFAA) recommendations in 2012.[19]

In countries where the use of unclaimed bodies as cadavers is limited and body donation is insufficient, the supply of cadavers from other countries is common. In the USA, there are legal entreprises that provide human cadaver and body parts to the medical schools, medical training centers, and medical device companies.[33,34] However, the monetary costs related to the protection, preservation and transfer of donated bodies add a commercial dimension to the issue with the profit price. Another query is whether the bequest covers the transfer of all or part of the body to other countries. Thus, transfer of these bodies between countries raises many other ethical questions for body donors, public, anatomists and students.[19,27]

Significant progress has been made in Turkey, in the legal aspect of body donation with the articles related to cadaver supply and body donation added to the Law on the Retrieval and Protection of Organs and Tissues in 1982, and the regulations made by the Ministry of Health.[35,36] National athlete Cavit Cav, who donated his body in the same year and still continues to contribute to medical education, is one of the first examples of body donation in Turkey.[37] Following the actions initiated by Turkish Society of Anatomy and Clinical Anatomy (TSACA) in 2012, it is observed that awareness of body donation in the society has increased slowly, and this awareness has improved the use of donated cadavers in medical faculties.[20,38,39] The fact that the efforts to create awareness about body donation in the Turkish society turn into positive results very slowly, is similar to the processes in the other countries of the world.[11,12,15,17,20,32,40–42] And, body donation is still far from fully meeting the need for cadavers in the faculties.

Although it is uncertain which factors are most responsible for the low rates of body donation in many societies, lack of awareness, religious uncertainties, distrust of medicine, hostility to new ideas and misinformation are held responsible.[26] Turkey is considered to be one of the countries where religious and cultural characteristics negatively affect donation and the concept of voluntary donation has not yet been established.[38,39] On the other hand, there is a strong belief that the religion factor may not be as determinant as it seems in the multi-factor body donation decision and that these difficulties can be overcome by organizing well-informed and culturally sensitive body donation programs.[21] Israel, India, China, New Zealand and South Africa are cited as promising examples for other societies for their success in overcoming the challenges of religious, cultural and traditional beliefs through their efforts to raise awareness of the public and members of Anatomy about body donation.[7,12,15,17,43] In Turkey, TSACA is gradually enhancing the attitudes about body donation by introducing the ways of communication for donor applications and bringing the supportive statements of competent clergy to the public, especially in the events held during "Body Donation Awareness Week".[20,44]

On all continents, the accepted and encouraged option for anatomy training with cadaver is local donated bodies instead of unclaimed bodies or bodies obtained from abroad with certain monetary costs. The information obtained from body donors has an important place in determining the steps that can be taken to reach the sufficient level of body donation. There are many suggestions in the literature based on the results of the survey studies that focus on determining the sociodemographic characteristics, preferences and opinions of the donors.[2,8,11,12,16,40,42,43,45–47] One of the most emphasized issues is the correct and effective use of society's information resources. Resources for the body donation are generally listed as TV, social media, word of mouth from relatives, friends or other donors, and health professionals.[8,14,18,25,26,43,48–50] In a survey conducted in New Zealand in 2010, it was reported that the primary source of information for 13% of the population was family physicians.[8] Anatomists in Turkey carry out studies to raise the awareness, such as radio and television programs about body donation, sharing the ceremonies of "thanks to cadaver" news on the internet, publishing on institutional websites the informative documents, etc.[20,39]

Reliability of the sources from which donors get information about the donation process can be a factor that will facilitate the fulfillment of the bequest. In our face-to-face interviews with body donors who applied to Mersin University Department of Anatomy, it was noted that some of the donors who applied to the family physician or any physician in the hospital claimed that the physicians were inadequate in directing them to the right address for donations and answering their questions. Some of them even stated that they "considered giving up donation" due to their problems in finding a respondent. While the number of cadavers in medical faculties is so insufficient, the fact that a person who decide to donate their bodies has difficulty in reaching the relevant units despite applying to physicians reveals that it is necessary to question how reliable the physicians are as a source of information in the body donation process. Although there are studies in the literature that evaluate whether anatomists, medical students and physicians want to donate their bodies,[6,8,10,13,21,23,32,38,46,51–54] studies that question the attitudes of physicians who may face the body donor's questions are very limited in number and scope.

In this study, in order to reach the data that will contribute to the strategies that will improve the "Donor-Physician-Anatomist" communication bridges in Turkey, it was aimed to reveal whether the knowledge of physicians about body donation procedures and their attitude towards directing the donor to the relevant units contain any weaknesses.

Materials and Methods

This descriptive survey study consisted of 3 parts and 20 questions. The population of the study consisted of all physicians working in Turkey (as reported by the Ministry of Health, the total number of physicians is 164,594 in 2020).[55] The first part of the questionnaire was about demographic information such as age, gender, professional working time, field of work. In the second part, there were items that question the frequency of encountering the body donors, the responses given by the physicians to some frequently asked questions by the donors, the donation form and the awareness of the physicians about their role in the donation process. Third part of the form included whether the physicians have a request to be informed about the body donation process and their preferences regarding the method of being informed. An English translation of the whole questionnaire form can be found in **Appendix 1**.

The online questionnaire was sent via the electronic communication addresses of the members of medical professional associations and graduates of some medical faculties in their social media groups. Those who did not work as a physician in Turkey and those work in the anatomy department were excluded. The number of physicians who voluntarily answered the questionnaire was 238. For this study, error margin was calculated as 5.5% at the 90% significance level of the sample size. Descriptive statistics were shown in tables as numbers (n) and percentages. Pearson's chi-square test was used to compare the groups. Statistical significance level was determined as $p<0.05$.

Results

Of the 238 physicians who participated in the survey from 33 different provinces of Turkey, 41.2% were male and 58.8% were female. The distribution of participants according to the geographical regions of Turkey was as follows: 86 physicians from the Mediterranean, 68 physicians from the Central Anatolia, 31 physicians from the Marmara, 25 physicians from the Eastern/Southeast Anatolia, 15 physicians from the Black Sea, and 13 physicians from the Aegean regions.

The age range of physicians was 25–68 years (mean±SD=37.89±10.44). The distribution according to the working period in the profession was as follows: 4.2%: 0–1 year; 28.2%: 1–5 years; 21.4%: 6–10 years; 16.8%: 11–20 years; 29.4%: more than 20 years. To simplify; 53.8% of the surveyed physicians have worked for 10 years or less, and 46.2% for more than 10 years.

Distribution rates by career groups were determined as; non-specialized physicians (non-specialist family physicians/general practitioners/occupational physicians) 37%, physicians who have completed their specialization in a particular specialty (specialist physicians/sub-branch specialist/lecturers) 37%, physicians currently receiving specialty training (resident physicians/research assistants) 26%. Distribution of specialists and residents (n=150) by branches were; internal medicine: 64.2%; surgical sciences 24.5%, basic medical sciences 11.3%.

To the question "Did you work with cadavers during your medical education or after graduation?", 86.6% of the physicians answered "yes", while 13.4% answered "no".

To the question "Have you examined any body donation (or cadaver donation) form before?", 91.2% of the respondents answered "no", and only 8.8% answered "yes" (**Table 1**).

To the question "Did you know that a week of October is 'body donation awareness week in Turkey?'", 86.1% of the participants answered "no" and 13.9% answered "yes".

While 12.6% (n=30) of the physicians stated that there were people who applied to them for body donation,

Table 1

Summary of findings on physicians' responses to questions about attitudes and awareness towards body donation processes.

Questions about the attitudes and awareness of body donation*	Options	Careers of physicians n (%)				Gender n (%)		Total n (%)
		Basic science	Internal medicine	Surgical science	Non-specialized	Female	Male	
The number of people who applied to you for information about body donation?	None	15 (88.2%)	80 (84.2%)	33 (89.2%)	80 (89.9%)	127 (90.7%)	81 (82.7%)	208 (87.4%)
	1–5	1 (5.9%)	14 (14.7%)	4 (10.8%)	6 (6.7%)	10 (7.1%)	15 (15.3%)	25 (10.5%)
	6–10	1 (5.9%)	0 (0.0%)	0 (0.0%)	2 (2.2%)	2 (1.4%)	1 (1.0%)	3 (1.3%)
	More than 10	0 (0.0%)	1 (1.1%)	0 (0.0%)	1 (1.1%)	1 (0.7%)	1 (1.0%)	2 (0.8%)
How to direct the person who applied to you to get information about body donation?	Ask to any doctor in a Medical Faculty	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (2.2%)	1 (0.7%)	1 (1.0%)	2 (0.8%)
	Ask to the Organ Donation Units	4 (23.5%)	34 (35.8%)	14 (37.8%)	32 (36.0%)	56 (40.0%)	28 (28.6%)	84 (35.3%)
	Ask to the Anatomy Dept.	12 (70.6%)	50 (52.6%)	18 (48.6%)	45 (50.6%)	68 (48.6%)	57 (58.2%)	125 (52.5%)
	I say, "I have no knowledge, I can't help".	1 (5.9%)	8 (8.4%)	4 (10.8%)	7 (7.9%)	13 (9.3%)	7 (7.1%)	20 (8.4%)
	Other	0 (0.0%)	3 (3.2%)	1 (2.7%)	3 (3.4%)	2 (1.4%)	5 (5.1%)	7 (2.9%)
Have you reviewed any body donation?	Yes	1 (5.9%)	9 (9.5%)	2 (5.4%)	9 (10.1%)	12 (8.6%)	9 (9.2%)	21 (8.8)
	No	16 (94.1%)	86 (42.9%)	35 (94.6%)	80 (89:9%)	128 (91.4%)	89 (90.8%)	217 (91.2%)
According to current laws, whose approval is required for body donation to be a "testament?"	Consent of a prosecutor	0 (0.0%)	15 (15.8%)	4 (10.8%)	14 (15.7%)	19 (13.6%)	14 (14.3%)	33 (13.9%)
	Consent of any lecturer in Anatomy Dept.	4 (23.5%)	8 (8.4%)	3 (8.1%)	10 (11.2%)	12 (8.6%)	13 (13.3%)	25 (10.5%)
	Consent of any physician	3 (17.6%)	17 (17.9%)	6 (16.2%)	10 (11.2%)	22 (15.7%)	14 (14.3%)	36 (15.1%)
	Consent of any healthcare professional	0 (0.0%)	2 (2.1%)	2 (5.4%)	4 (4.5%)	4 (2.9%)	4 (4.1%)	8 (3.4%)
	I don't know	10 (58.8%)	53 (55.8%)	22 (59.5%)	51 (57.3%)	83 (59.3%)	53 (54.1%)	136 (57.1%)
Reply for "Does the cadaver have a grave later?"	Yes	9 (52.9%)	61 (64.2%)	21 (56.8%)	67 (75.3%)	93 (66.4%)	65 (66.3%)	158 (66.4%)
	No	1 (5.9%)	2 (2.1%)	1 (2.7%)	2 (2.2%)	3 (2.1%)	3 (3.1%)	6 (2.5%)
	I don't know	7 (41.2%)	32 (33.7%)	15 (40.5%)	20 (22.5%)	44 (31.4%)	30 (30.6%)	74 (31.1%)
Reply for "Does body donation prevent organ donation?"	Yes	4 (23.5%)	4 (4.2%)	0 (0.0%)	2 (2.2%)	9 (6.4%)	1 (1.0%)	10 (4.2%)
	No	8 (47.1%)	64 (67.4%)	28 (75.7%)	68 (76.4%)	93 (66.4%)	75 (76.5%)	168 (70.6%)
	I don't know	5 (29.4%)	27 (28.4%)	9 (24.3%)	19 (21.3%)	38 (27.1%)	22 (22.4%)	60 (25.2%)
Reply for "Can I donate the body of my relative?"	Yes	2 (11.8%)	22 (23.2%)	4 (10.8%)	19 (21.3%)	27 (19.3%)	20 (20.4%)	47 (19.7%)
	No	4 (23.5%)	23 (24.2%)	8 (21.6%)	22 (24.7%)	33 (23.6%)	24 (24.5%)	57 (23.9%)
	I don't know	11 (64.7%)	50 (52.6%)	25 (67.6%)	48 (53.9%)	80 (57.1%)	54 (55.1%)	134 (56.3%)
Should physicians be informed about the subject after graduation?	Yes	16 (94.1%)	84 (88.4%)	35 (94.6%)	81 (91.0%)	126 (90.0%)	90 (91.8%)	216 (90.8%)
	No	1 (5.9%)	11 (11.6%)	2 (5.4%)	8 (9.0%)	14 (10.0%)	8 (8.2%)	22 (9.2%)
Your choice (s) for the way to be informed about the body donation process	To be informed face-to-face	2 (12.5%)	4 (4.7%)	1 (2.9%)	11 (12.9%)	11 (8.5%)	7 (7.6%)	18 (8.1%)
	To be informed via printed/electronic texts	10 (62.5%)	51 (59.3%)	21 (60.0%)	54 (63.5%)	86 (66.2%)	50 (54.3%)	136 (61.3%)
	Both	4 (25.0%)	31 (36.0%)	13 (37.1%)	20 (23.5%)	33 (25.4%)	35 (38.0%)	68 (30.6%)

*The full version of the questionnaire items can be found in the "Appendix" of the article.

87.4% of them stated that they did not encounter an application for body donation. 15.8% of physicians were in internal medicine, 10.8% were in surgical sciences, 11.8% were in basic medical sciences and 10.1% of non-specialist physicians stated that they encountered body donation applications (**Table 1**). There was no statistically significant difference between career groups in terms of encountering body donation application ($p>0.05$).

A calculation was planned to roughly compare the estimated number of donors reaching the doctors with the number of donors reaching the anatomy department. For this, Mersin was chosen as an example due to the high participation of the questionnaire (n=62) and the availability of body donation application records to the Anatomy Department in this province. Total number of physicians in Mersin was found to be 1764 on the official website of the governorship.[56]

Thirteen of the 62 people reported that they had received information requests about body donation (8 physicians had experience between between 1 and 5 years; 3 physicians between 6 and 10 years; and 2 physicians more than 11 years). With the formula below, these numbers were proportioned to the total number of physicians, taking into account the smallest number of each group:

Estimated number of body donors reaching physicians in Mersin =

$$[(TM \times RR1 / RM) \times LR1] + [(TM \times RR2 / RM) \times LR2] + [(TM \times RR3 / RM) \times LR3]$$

$$[(1764 \times 8 / 62) \times 1] + [1764 \times 3 / 62) \times 6] + [1764 \times 2 / 62) \times 11] = 1366$$

TM: Total number of physicians in Mersin; **RM:** Total number of respondents from Mersin to the survey; **RR:** Number of respondents who received applications as much as in the range of the group; **LR:** Lower limit of the group range.

When the body donation applications were evaluated according to the working time of the physicians, it was found that 12.5% (16/128) of physicians working for less than 10 years and 12.7% (14/110) of those who worked for 10 years or more met at least one body donors.

The rate of female physicians whose information was consulted for body donation (9.3%, 13/140 female physicians) was found to be significantly lower than the rate of male physicians (18.4%, 18/98 physicians) ($p=0.04$).

For the question "How would you approach the person who applied to you to get information about body donation?", 52.5% of the physicians chose to direct the donor to the anatomy department of medical faculty, 35.3% chose to direct him/her to organ donation units (of the medical faculties, or of the community health center, or of the district health directorate). The rate of those who stated that they did not have knowledge about the subject and that they would not be able to help is 8.4% (**Table 1**).

To the question "Who do you think is the person who can approve the donation form by signing it it in the presence of two witnesses, according to the current laws and regulations?", 57.1% of the physicians answered "I don't know". The rate of physicians who stated that any physician could approve this form was only 15.1% (**Table 1**).

For the question, "Does a donated cadaver have a grave after his contributions to medical education?" 66.4% of the physicians answered "yes", while 31.1% answered "no" and 2.5% answered "I don't know".

For the question, "Does body donation prevent organ donation?" 70.6% of the physicians answered "no", 25.2% answered "I don't know" and 4.2% answered "yes".

For the question, "My relative passed away. He did not fill out a body donation form while he was alive, but he said he wanted to be a cadaver. Can we donate his body as a cadaver?", only 19.7% answered "yes", while 23.9% answered "no" and 56.3% answered "I don't know" (**Table 1**).

To the question "Did you take any courses or training on the laws and procedures related to body donation during your medical education?", only 11.8% (28 physicians) answered "yes", while 88.2% (210 physicians) answered "no".

To the question "Do you think that physicians should be informed about the laws and procedures regarding cadaver donation after graduation?", it was remarkable that the "yes" answer was 90.8% (216 physicians) (**Table 1**). There was no statistically significant difference between the physicians who had worked with cadavers before and those who had never worked with cadavers in terms of the answers given to this question ($p>0.05$). More than one option was allowed to be selected in the preferences regarding the method of informing, and 222 physicians responded. The responses were summarized in three groups: Those who selected at least one of the two options, which included only face-to-face information requests were determined as the first group, and the rate was 8.1%. Those who marked at least one of the three options, which included only the requests to be informed by printed/electronic document, were determined as the second group, and the preference rate is 61.3%. In the third group, there were those who ticked at least one of the options in both the first and second groups, and the rate was 30.6%. Pearson's chi-square test was used to evaluate whether there were differences between career groups (internal,

surgical, basic sciences, non-specialized groups) and genders in terms of these three knowledge preferences. There was no significant difference in terms of career groups and gender ($p>0.05$).

Discussion

Anatomy departments of Turkey are independent from each other in keeping records related to body donation, and there is no record system in which annual total donor applications to all anatomy departments can be tracked. For this reason, the records of our own institution, which is the only Anatomy department in Mersin, were used in the estimated donor calculation of the study. The estimated number of body donors reaching physicians in Mersin (1366) is considerably higher than the number of people who applied to the Anatomy Department of Mersin University (92 donors) (even if it is possible that the same person may have gone to more than one physician). The findings suggest that the donor potential in Turkey may also be higher than those registered in anatomy departments, and there is a need to facilitate donors' access to anatomists.

According to a study conducted in 2004, 78.3% of anatomists recommend increasing body donation as a solution for supplying cadavers, while only 51.8% believe that donation can be a long-term solution.[38] However, it is a fact that efforts to inform the people about body donation and to improve body donation procedures and legislation began to yield positive results in the following years.[20] TSACA declared the last week of October as the "National Anatomy Week" (Body donation awareness week) in 2012, and then this week is evaluated with various activities every year, trying to reach the public directly or through the press.[39,44] In general, it is expected that the probability of a physician encountering any case increases with the duration of the profession. However, the results of our study show that the rate of encountering a body donor is similar between physicians who have worked for less than 10 years (12.5%) and those who have worked for more than 10 years (12.7%). This may be related to the fact that body donation has been questioned more and more in the last decade. In addition, it is necessary to believe in the power of informing the society instead of despairing in the face of difficult to overcome features such as psychological, cultural and religious factors that are thought to have negative effects on body donation. Our results suggest that in addition to awareness raising and procedural improvement actions, solutions to facilitate access to anatomists by individuals who have decided on body donation should be addressed. In this case, it may be of critical importance that the physicians, whom donors choose to contact first, can answer questions about the subject correctly or at least direct the donor to the right units, facilitating the completion of the donation process. It seems that anatomists are responsible for improving the knowledge resources and awareness of physicians on this subject.

Research questioning whether a physician is properly guiding body donors and answering donation-related questions is very limited. One of the most curious questions is whether the donated bodies will have a grave. Although the issue of what will happen to the corpse after the completion of the will varies according to the cultural characteristics of the countries, it is important to consider the sensitivities of the relatives. In some countries when the donated body is no longer used by anatomy institutes, it is not returned to family and friends, but is incinerated.[46] In the Netherlands, in recent years, considering that mourners need a symbolic resting place for their loved ones, it is stated that this practice has been accompanied by the "Body Donor Monument" built for the donor, and this practice has attracted great interest from the public.[57] Relevant acts and regulations in Turkey indicate that the cadaver is buried when the education and research activities are completed.[20,35,36,39] In practice, taking into account the demands of the donor and their relatives, the expectation that the donor will eventually have a grave is met, provided that he/she is buried at the end of 3–5 years. This practice, which is observed to contribute to the positive approach of donor's relatives to the bequest, is emphasized especially in public information activities.[39] However, in this survey, a considerable amount of physicians stated that the donor body would not have a grave, or that they did not know the answer (33.6%).

The literature emphasizes the importance of encouraging donors to discuss donation requests with relatives before death.[2,8,14,19,43,49] There are two different aspects of the reflection of the "body donation-informed relative" relationship on the donation process. On one hand, families may negatively affect the donor's decisions on body donation, on the other hand, the presence of a family member who has donated body before increases the probability of a person to decide on body donation.[8,46,49] The "Uniform Anatomical Gift Act (UAGA)", updated in 1987 in the USA, designated the human body as a property and allowed the fulfillment of the bequest in court even if close relatives of a donor object to the donation after death.[9] The acts and regulations in Turkey are in favor of donation bequest and anatomist. However, in practice, even if the donor has fulfilled the bequest in accordance with the acts, if the first-degree relatives state that they are adverse-

ly affected, the body is delivered back to the family.[39] While filling out the body donation form in the anatomy departments, the donor is encouraged to inform the first-degree relatives about the bequest, although it may adversely affect the donor's decision. Expanding the information authority to physicians, which can be easily reached by a wider segment of the society, including donors' relatives, may contribute to the elimination of possible negative emotional reactions.

Another question frequently asked by donors is "Does organ donation prevent body donation, and body donation prevent organ donation?" In Netherlands, where 0.1% of the population donates bodies, the bodies of people who donate their organs are not accepted by most anatomy institutes.[46] There is no restriction in both respects in Turkey and the physician who informs the donors is expected to explain that body donation does not prevent organ donation and organ donation does not prevent body donation. However, in our survey, 29.4% of the physicians did not mark the answer that supports the common practice.

The third one is the following question that can be directed to physicians from the relatives of any funeral: "Can I donate the body of my relative who did not have a bequest?" According to Act No. 2238, even if he/she did not make a bequest while he was alive, the relatives of the deceased can donate his/her body as a cadaver unless there is a will to the contrary.[20,35] 80.2% of the physicians could not give the expected answer to this question. The fact that a considerable number of physicians could not give appropriate answers to these three questions, which may affect the decision of the body donors and their relatives, is an issue that needs to be handled carefully.

It is remarkable that only half of the physicians (52.5%) chose to refer the body donor to the Anatomy departments and 35.3% preferred to Organ Donation Units instead of Anatomy. However, in Turkey, as in some other countries, the body donation process is still managed only by the anatomy departments of medical faculties, and is completed with a form signed here.[20,44,46,58] Body donation procedures (informing about body donation, filling out a body donation form) are not officially within the scope of the organ donation units. These results indicate that the organ donation units of all health institutions (medical faculties, community health centers, district health directorate organ donation units, etc.) should be targeted primarily in the actions to be planned for body donation awareness for healthcare professionals.

In the Act no 2238 on organ tissue harvesting, preservation and transplantation (including also body donation), Article of 6 stated that the written report signed by the donor clearly and consciously must be approved in the presence of at least two witnesses and by a "physician".[35,39] The regulation numbered 17727 of the Health Ministry on scientific research on human body is also attributed to this act.[36] Body donation forms created by TSACA were also prepared and used in accordance with this law and regulation.[58] In practice, these forms are filled only under the supervision of by faculty members in anatomy departments, but this law also indicates that physicians have the authority to approve the body donation report.[39] In this study, when physicians were asked who is the authorized person to approve the body donation form; while 57.1% of the physicians gave the answer "I don't know", the rate of those who stated that the physician would approve was only 15.1%. Moreover, the rate of physicians who prefer the anatomy department option was only 10.5%. Only 8.8% of the participants stated that they examined a body donation form. It is clear that physicians in Turkey, most of whom have worked on cadavers before, do not know the legal legislation on body donation. Similarly, in India in 2011, it is reported that 8% of medical professionals are unaware of the concept body donation, and most of them do not know the authority controlling body donation or the criteria for accepting donated bodies.[51]

There are some studies in the literature that draw attention to the facts that educating physicians and medical students about body donation can play an important role in maintaining communication with potential donors.[7,13,21,18,23,25,51] Thus physicians who are in contact with the people can be expected to participate in body donation programs, explain the importance of the bequest to those concerned, and facilitate the donation process by giving advice or answering questions. In a survey study conducted with body donors in New Zealand, 37% of donors cited family or friends as their source of information, while only 13% cited family physicians as their primary source of information.[8] Similarly, in the survey conducted by Conesa et al.,[48] among the information sources that affect the donation decision, health workers were in the last place after TV, press and radio, conversations with family and friends, magazines, advertisements, posters and donation campaigns. In a survey study conducted in New Zealand, South Africa and Ireland, it was reported that donors discuss donation decisions with physicians in varying degrees by country, but always less than relatives and friends. The authors suggested that donors primarily care about the comfort of the family in the decision-making process.[43] In Turkey, where the body donors frequently reach physicians instead of anatomy, it is an important

advantage that a physician can legally approve the body donation form. On the other hand, the fact that most of the physicians are unaware of these procedures, this advantage becomes unusable.

The results of our study showed that whether physicians worked with cadavers previously or not did not affect their demand to be informed about body donation ($p>0.05$). On the other hand, the fact that 88.2% of the physicians who graduated from various universities did not receive any course or training on the laws and procedures related to cadaver donation during their medical education. This condition clearly explains the source of the lack of awareness reflected in the survey. Considering that there is no significant difference in the number of donors encountered between specialist subgroups and non-specialist physicians ($p>0.05$), it would be appropriate for the awareness studies to include specialist physicians and academics as well as family physicians.

Although the participation of female physicians to the survey is 1.5 times higher than that of male and there was no difference between groups in terms of information demand, the rate of donors applying to male physicians was slightly higher than those applying to female physicians. The reasons for this may be the subject of a separate sociological discussion.

The limitations of the study was that, we could not reach the total number of people who filled out the body donation form in Turkey. For this reason, it was not possible to compare the donors reaching the physicians and the donors reaching the anatomists for the whole country. Instead, we tried to interpret the records of the only anatomy department in Mersin according to the answers of the physicians participating in the study from Mersin. However, possibility of the same donor to consult more than one physician was ignored. A much more comprehensive study is needed to reveal the effect of this factor. In this survey, due to the very low number of participants in some provinces and the fact that it is common for a physician to be relocated several times during his/her professional life, an estimate of body donors by province could not be made.

Conclusion

While the lack of cadavers is accepted as an important problem affecting the quality of medical education, the supply of cadavers and body donation is quite insufficient in our country. On the other hand, the study indicates that the number of donors reaching any physicians may be higher than the number of donors filling out forms in Anatomy Departments. The results reveal that physicians in Turkey do not have sufficient knowledge about body donation and do not know how to direct the donor candidates who apply to them. This situation should be considered as a factor that may adversely affect the decision of the donor, who cannot be properly guided by a physician, and the relatives of the donor, who play an important role in the donation process. “Donor-Physician-Anatomist” communication bridges do not seem strong enough.

It was revealed in the study that 90.8% of physicians demanded to be informed about body donation. It is a very promising outcome and encourages the creation of a broad physician-focused action plan. This high rate of information requests is likely to be related to the fact that the order of this question in the questionnaire comes after items that confront the physician with critical questions from a potential donor. For this reason, in awareness-raising studies for physicians, it may be beneficial to confront physicians with possible donor questions, as well as to talk about the possibility of individuals who have decided to donate to give up donation due to misinformation. Additionaly, Organ Donation Units of all health institutions should be considered as a priority for awareness activities.

The physicians seem to almost agree that they can benefit from any printed or electronic document that includes body donation procedures, answers to the most frequently asked donor questions, and Anatomists’ contact information. Considering that physicians can also contribute to body donation processes, a widespread action can be taken in line with this demand under the guidance of anatomists. Additionally, a brief course on body donation processes just before graduation in all medical faculties can also contribute to the long-term solution.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

ZKO: project development, data analysis, manuscript writing, manuscript editing; ÇYK: data collection, data analysis

Ethics Approval

This study was approved by the Mersin University Clinical Research Ethics Committee (Approval number: 2020-677).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Kurtoğlu Olgunus Z, Yeşil Kayabaşı Ç. Evaluation of knowledge and attitudes of physicians in Turkey about body donation processes. Anatomy 2021;15(2):152–162.

Appendix 1

"Physicians and body donation" questionnaire.

A. The section related to general demographic information

1. Your name and surname (Optional): …….
2. Your age: ……..
3. Indicate your gender: ☐ Female ☐ Male
4. Write the province where you are currently working: …….
5. How many years have you been in the medical profession?
   ☐ 0–1 years ☐ 1–5 years ☐ 6–10 years ☐ 11–20 ☐ More than 20
6. Mark the appropriate option for your career (Mark only one option)
   ☐ Family doctor/ General practitioner ☐ Occupational physician ☐ Residency student ☐ Specialist physician ☐ Lecturer ☐ Other: ……
7. Mark the institutions you have served so far (If you have worked in more than one institution before, mark all of them)
   ☐ Family health center/Health clinic ☐ Community Health Center ☐ Occupational Medicine
   ☐ Private health center or Private hospital ☐ State hospital/City hospital ☐ University Hospital ☐ Other: ……
8. Mark your main field of specialization (For only specialist or residency student)
   ☐ Basic sciences ☐ Internal sciences ☐ Surgical sciences
9. Have you ever worked with cadavers during your medical education or after graduation?
   ☐ Yes ☐ No
10. During your medical education, did you receive any lectures or training on the laws and procedures regarding cadaver donation?
    ☐ Yes ☐ No
11. Do you know that a week of October in Turkey is "Body Donation Awareness Week"?
    ☐ Yes ☐ No

B. The section related to body donation applications answers to the donor's questions

12. Select the option that corresponds to the number of people who have applied to you to get information about body donation so far.
    ☐ None ☐ 1–5 ☐ 6–10 ☐ More than 10
13. Which of the following would be your approach to the person who applied to you to get information about body donation?
    ☐ I would tell him/her ask to any doctor in the Hospital of Medical Faculty.
    ☐ I would tell him to apply to the Organ Donation Units.
    ☐ I would tell him to apply to the Anatomy Dept. of the Medical Faculty.
    ☐ I would say that I have no knowledge of the subject, and I cannot help.
    ☐ Other: …….
14. Have you reviewed any body donation form before?
    ☐ Yes ☐ No
15. Who do you think is the person who could approve the donation form by signing it, in addition to two witnesses, according to the laws and regulations?
    ☐ Signed consent of a prosecutor
    ☐ Signed consent of any lecturer of the Anatomy Department
    ☐ Signed consent of a physician
    ☐ Signed consent of any healthcare professional
    ☐ I don't know
16. What would be your answer to the question of a body donor who apply to you as: "Does a cadaver have a grave after their contribution to medical education is completed?"
    ☐ Yes ☐ No ☐ I don't know
17. If a body donor applies to you, "Does body donation prevent organ donation?" What would be your answer to the question?
    ☐ Yes ☐ No ☐ I don't know
18. What would be your answer to a person who ask you "My relative passed away. He had not filled out a body donation form, but he wanted to be a cadaver. Can we donate his body as a cadaver?"
    ☐ Yes ☐ No ☐ I don't know

C. The section related to need for information about body donation

19. Do you think that physicians should be informed about the laws and procedures regarding cadaver donation after graduation?
    ☐ Yes ☐ No
20. *(Please answer this question, if your reply to the previous question is "Yes",)* Select the options you prefer for information activities about cadaver-related processes, laws and procedures related to body donation *(You can tick more than one item).*
    ☐ If a conference is held on the subject, I will attend.
    ☐ If interactive small group sessions or seminars are organized to inform about the subject, I will attend.
    ☐ If a detailed information text on the subject is delivered to me as a printed material, I will examine it.
    ☐ If the addresses of the web pages where I can get detailed information about the subject are sent to me, I will use it.
    ☐ If the contact addresses of the people I can get information from are sent to me, I will take it into account.
    ☐ Other: …….

Teaching Anatomy

http://dergipark.org.tr/en/pub/anatomy
Received: April 17, 2021; Accepted: July 30, 2021
doi:10.2399/ana.21.928791

anatomy
An International Journal of Experimental and Clinical Anatomy

Distance education during social isolation: an evaluation of student attitudes and perceptions using the web-based learning environment instrument (WEBLEI)

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Abstract

Objectives: Until recently, distance education at universities has supplemented face-to-face education in blended programs that combine the two. But during the COVID-19 pandemic in the spring of the 2019–2020 academic year, many universities were forced to conduct distance education exclusively. The aim of this study is to determine the perceptions, thoughts, and experiences of university students regarding the completely online process of distance education during this period.

Methods: In this process, all theoretical lessons and exams were conducted on the advance learning management system (ALMS) for distance education at İstinye University. The present study used the original form of WEBLEI to survey 324 students from medicine, pharmacy and health science departments at İstinye University.

Results: WEBLEI measures students' perceptions using four scales: access, interaction, response and results. Though students did not experience problems accessing online lessons or interacting with their teachers and other students, they did not find online distance education alone more effective and satisfying than combined with face-to-face education.

Conclusion: This study contributes to a better understanding of the pros and cons of distance education by evaluating the attitudes and perceptions of university students.

Keywords: distance education; online lessons; social isolation; WEBLEI; web-based learning

Anatomy 2021;15(2):163–170

Introduction

Distance education is an educational method that does not require students to attend school lessons physically.[1] It may be seen in hybrid (blended) programs that combine online education courses with face-to-face education courses or it may appear alone as online education courses.[2] Web-based learning is defined as a form of distance education which uses computer and internet technology.[3]

Universities prefer distance education more commonly than in the past, but there are still conflicts about distance education at universities, and educators have some doubts about its effectiveness.[4] Many studies have shown the benefits of distance education for both schools and students. Singh[5] remarked that hybrid lessons offer students better learning experiences and are more effective than classroom-based lessons alone. Young[6] supported the idea that offering various materials to students maximizes student engagement since not all students learn in the same way. A study at the University of Wisconsin (Milwaukee, WI, USA) showed that students learn better in hybrid education programs compared to face-to-face education alone. Teachers responsible for the hybrid education program at the university reported that students wrote better papers, got higher marks, produced more quality projects, and discussed lessons more meaningfully.[7] Dantas and Kemm[8] showed a high positive correlation between distance education lessons and students' final exam results. Joynes and Fuller[9] remarked that distance education, with the advancement of technology, allows

students to attend classes from anywhere with an internet connection. Kirtman[10] maintained that distance education offers students opportunities that face-to-face education cannot offer, stating that distance education enables students to listen again to what they could not understand well during the lesson. Distance education also benefits universities. The hybrid education may enable universities to reduce the number of overcrowded classes, which allows universities to make more classes available even at peak demand times of the day.[11]

Despite its advantages, distance education has its critics. Students may lack adequate technologic infrastructure and proper training to use a distance education system correctly, which may cause them bad experiences in the distance education process.[12] One study has argued that social isolation during the distance education process and lack of social interaction reduces the educational success of students and prevents them from developing socially.[5] Green and Whitburn[13] stated that face-to-face education is of a higher quality than distance education, particularly in terms of experimental learning, and indicated that students do not value distance education as much as face-to-face education. Courses offered only online were not perceived by students to be as successful as face-to-face courses.[14,15]

SARS-Cov-2 is a coronavirus that causes a severe acute respiratory syndrome in humans. It was first identified in December 2019 in China and thereafter spread rapidly to other countries.[16,17] The World Health Organization (WHO) declared COVID-19 infections worldwide a pandemic in March 2020, forcing governments across the world to take precautions against the further spread of the disease; one such precaution was to close university campuses, and many universities elected to continue to their courses online.

Though many studies have shown the benefits of distance education, deficiencies are also clearly visible and these increase the pandemic anxiety of university students.[18,19] This study aims to determine students' attitudes and perceptions regarding lessons delivered via distance education in the pandemic period. We surveyed medicine, physiotherapy/rehabilitation, nutrition/dietetics, and pharmacy students because of the prevalence of practical lessons in their syllabi and the many practical lessons these students missed. Our study included a total of 324 students enrolled at İstinye University who participated in distance education during the pandemic. All participants completed the web-based learning environment instrument (WEBLEI).

Materials and Methods

The literature contains studies that evaluate and compare the advantages and disadvantages of distance education to those of face-to-face education using various surveys. After reviewing the literature, the researchers decided to use the WEBLEI for this study. Developed by Chang and Fisher,[20] the WEBLEI is a multidimensional construct that assesses student perceptions of four core aspects of the Web-based learning environment: access, interaction, response and results. After obtaining permission from the survey owner, our study used the survey to evaluate student attitudes and perceptions of distance education during the pandemic.

A total of 324 students (231 female, 93 male) at İstinye University from the departments of medicine, pharmacy and health science participated in the study. The departments of the students participating in the study are shown in **Table 1**.

The survey was sent to first- and second-year students in health-related departments; departments providing instruction in English were preferred. Participation in the study was voluntary. Participation rates in the courses was not considered because students could take courses online or offline using the ALMS platform. The demographic characteristics of the students are presented in **Table 2**.

At İstinye University, all theoretical lessons and exams that could not be conducted face-to-face in the spring of 2020 due to the COVID-19 pandemic were given online via the advanced learning management system (ALMS) for distance education. In this process, the distance education system implemented the content of the face-to-face education lessons. Study participants received online lessons through the "ALMS" and "Perculus plus" software systems. For online lessons, students and lecturers needed a computer, tablet, or mobile devices with camera features. The duration of each lesson was limited to a maximum of 50 minutes. A message ('chat') box on the lesson screen permits students to share their questions or problems with lecturers and other students. Online lessons are

Table 1
Distribution of students according to their departments.

Faculty/Department	Frequency
Faculty of Medicine	55
Faculty of Pharmacy	154
Faculty of Health Sciences / Department of Physiotherapy and Rehabilitation	92
Faculty of Health Sciences / Department of Nutrition and Dietetics	23
Total	324

Table 2
Frequencies and relative percentages of demographic characteristics.

Demographic Characteristics		Frequency			
		Faculty of Medicine	Faculty of Pharmacy	Department of Physiotherapy and Rehabilitation	Department of Nutrition and Dietetics
Gender	Female	38	104	66	23
	Male	17	50	26	-
Age (in years)	18-22	52	137	84	22
	23-26	3	17	8	1
Grade	1st	46	146	56	15
	2nd	9	8	36	8

automatically recorded and later published, so students can watch them after the lesson concludes.

For the purposes of the study, survey questions were uploaded to the Internet via Google Forms. The candidates consented in writing to participate in the study before beginning the survey. After giving their approval, they were allowed to access the survey questions via a link to the web page containing the questionnaire. After the distance education program was implemented for the COVID-19 period, the survey was conducted from 22.07.2020 to 29.07.2020.

This study used the WEBLEI[20] to collect data on student perceptions of their web-based learning experience. The WEBLEI measures student perceptions along four scales: access, interaction, response, and results. All four scales include necessary components for student success in a teaching and learning environment. In this study, WEBLEI scales were unchanged and used in their original forms.

The WEBLEI survey contains a total of 32 items, with eight items along each scale. The answers to the items in the scales include: almost always (5), often (4), sometimes (3), seldom (2), and almost never (1). The 'access' scale measures the accessibility of the learning environment to students; this scale aims to learn how well students adapt to their learning environment. The 'interaction' scale investigates how beneficial students judge distance education to be; through this scale, students evaluate the quality of the interactions amidst their classmates, lecturers, and themselves. The 'response' scale indicates how students feel and think about the web-based learning system. The 'results' scale expresses the extent to which students believe they accomplished any of the learning objectives within the online learning environment.[19–21]

The data was analyzed using Statistical Package for Social Sciences (SPSS Version 24, Armonk; NY, USA). A parametric Student's t-test compared two independent groups of students, and parametric ANOVA test compared more than 2 groups. Bonferroni was used as the post-hoc test. Quantitative data was expressed in the tables as mean ± standard deviation and median (minimum-maximum) values, and categorical data was expressed in n (number) and percentages (%). The data was analyzed in the 95% confidence interval, p-value was considered as significant if less than 0.05.

Results

Results of the study have been presented using the scales and items of WEBLEI. The WEBLEI contains four main scales, each including eight questions. Students' emotions, experiences, and thoughts about the accessibility of distance education lessons, the interaction between students and teachers during the distance education period and the process of the distance education method were obtained through the questionnaire items. The participants were students in the health sciences departments at İstinye University and all completed the questionnaire in its entirety. Participants' answers were evaluated without regard to their different faculties. Means of 3.32, 3.37, 2.75 and 3.00 were obtained for access, interaction, response, and results scales (**Table 3**). Questionnaire items and results of the scales are shown in **Table 4**.

Table 3
Weighted means, median and standard deviation for the four scales of the WEBLEI

WEBLEI scales	Mean	Median	Standard deviation
Scale I- Access	3.32	3.50	1.02
Scale II- Interaction	3.31	3.37	0.93
Scale III- Response	2.75	2.62	1.04
Scale IV- Results	3.00	3.00	1.07

Table 4

Questionnaire items and scale results.

	Almost never		Seldom		Sometimes		Often		Almost always				
	n	%	n	%	n	%	n	%	n	%	M	Mdn	SD
I. Questionnaire items of access scale													
I can access lessons on the Internet at time convenient to me	19	5.86	46	14.19	68	20.98	111	34.25	80	24.69	3.57	4	1.17
Lessons on the Internet are available at locations suitable for me	25	7.71	27	8.33	52	16.04	132	40.74	88	27.16	3.71	4	1.17
I can access lessons on the Internet on days when I am not class or absent from school	33	10.18	25	7.71	32	9.87	123	37.96	111	34.25	3.78	4	1.27
Lessons on the Internet allow me to work at my own pace to achieve learning objectives	54	16.66	63	19.44	75	23.14	68	20.98	64	19.75	3.07	3	1.36
Lessons on the Internet enable me to decide how much I want to learn in a given period	44	13.50	59	18.20	91	28.08	70	21.60	60	18.51	3.13	3	1.29
Lessons on the Internet enable me to decide I want to learn	55	16.97	54	16.66	75	23.14	92	28.39	48	14.81	3.07	3	1.31
The flexibility of lessons on the Internet allows me to meet my learning goals	54	16.66	49	15.12	86	26.54	73	22.53	62	19.13	3.12	3	1.34
The flexibility of the lessons on the Internet allows me to explore my own areas of interest	50	15.43	63	19.44	80	24.69	72	22.22	59	18.20	3.08	3	1.32
II. Questionnaire items of interaction scale													
I communicate with my teacher in this subject electronically via email	36	11.11	61	18.82	76	23.45	103	31.79	48	14.8	3.20	3	1.22
In this learning environment, I have to be self-disciplined in order to learn	27	8.33	19	5.86	51	15.74	109	33.64	118	36.41	3.83	4	1.21
I have the option to ask my teacher what I do not understand by sending an email	27	8.33	49	15.12	91	28.08	90	27.77	67	20.67	3.37	3	1.20
I feel comfortable asking my teacher questions via an email	37	11.41	55	16.97	84	25.92	81	25	67	20.67	3.26	3	1.27
The teacher responds to my email	29	8.95	56	17.28	96	29.62	90	27.77	53	16.35	3.25	3	1.18
I can ask other student what I do not understand during computer lessons	39	12.03	47	14.50	77	23.76	104	32.09	57	17.59	3.28	3	1.25
Other students respond positively to questions in relation to Internet lessons	32	9.87	43	13.27	101	31.17	86	26.54	62	19.13	3.31	3	1.20
I was encouraged by the positive attitude of my friends towards the Internet lessons	53	16.35	59	18.20	105	32.40	58	17.9	49	15.12	2.97	3	1.27
III: Questionnaire items of response scale													
This mode of learning enables me to interact with other students and my teacher	88	27.16	94	29.01	64	19.75	48	14.81	30	9.2	2.50	2	1.28
I felt a sense of satisfaction and achievement about this learning environment	76	23.45	87	26.85	61	18.82	52	16.04	48	14.81	2.71	2	1.37
I enjoy learning in this environment	94	29.01	58	17.90	60	18.51	46	14.19	66	20.37	2.79	3	1.50
I could learn more in this environment	98	30.24	74	22.83	50	15.43	45	13.88	57	17.59	2.65	2	1.47
I can easily get students to work with me on the Internet	80	24.69	82	25.30	70	21.60	53	16.3	39	12.03	2.65	2.5	1.33
It is easy to work with other students and discuss the content of the lessons	82	25.30	77	23.76	65	20.06	64	19.75	36	11.11	2.67	3	1.33
The web-based learning environment held my interest in this subject throughout this term	84	25.92	60	18.51	75	23.14	61	18.82	44	13.58	2.75	3	1.37
I felt a sense of boredom in this subject towards end of this term	40	12.34	48	14.81	85	26.23	72	22.22	79	24.38	3.31	3	1.32
IV: Questionnaire items of result scale													
I can work out exactly what each lesson on the Internet is about	47	14.50	66	20.37	87	26.85	74	22.83	50	14.43	3.04	3	1.27
The organization of each lesson on the Internet is easy to follow	40	12.34	54	16.66	59	18.20	96	29.62	75	23.14	3.34	4	1.32
The structure of the lessons on the Internet keeps me focused on what is to be learnt	52	16.04	74	22.83	74	22.83	73	22.53	51	15.74	2.99	3	1.31
Internet lessons helped me better understand the work that was taught in class	82	25.30	77	23.76	57	17.59	54	16.66	54	16.66	2.75	3	1.42
Lessons on the Internet are well-sequenced	42	12.96	46	14.19	83	25.61	91	28.08	62	19.13	3.26	3	1.28
The subject content is appropriate for delivery on the Internet	76	23.45	67	20.67	62	19.13	64	19.75	55	16.97	2.86	3	1.41
The presentation of the subject content is clear	68	20.98	60	18.51	68	20.98	81	25	47	14.50	2.93	3	1.36
The multiple-choice test at the end of each lesson on the Internet improves my learning in this subject	63	19.44	67	20.67	85	26.23	63	19.44	46	14.19	2.88	3	1.31

*All questionnaire items were responded by all participants (324 students). **M:** Mean; **Mdn:** median; **SD:** standard deviation.

The first scale of this questionnaire concerns accessibility of distance education lessons via internet connection. This scale evaluated the convenience of online lesson times and locations for students and the effects of online lesson flexibility on students' learning processes. Many participants remarked that online lessons permitted access at any time (M=3.57) and any location (M=3.71). The access scale suggested that the online learning environment allows access to lessons even when students are not in class or absent from school (M=3.78). However, percentage about students deciding how much they learn and what they learn on the online lessons is close to each other. Moreover, the answers regarding the flexibility of the lessons on the internet for the realization of learning goals and the exploration of their own interests were close to each other. The median response to questions related to contribution of online courses to student learning goals and achievements was 3. While some students agreed that these lessons met their learning goals and allowed them to explore their areas of interest, some of them have strongly disagreed. As a result, not all the students shared the same idea about their educational attainment. In a comparison of departments, statistically significant differences were seen between Physiotherapy/Rehabilitation (M=2.91) and Medicine (M=3.75) / Pharmacy (M=3.37) / Nutrition (M= 3.44) ($p<0.001$).

The interaction scale is associated with the student experience of communication within distance education. Participants indicated that they often contacted their teachers electronically via email (M=3.20). There are other platforms where students communicate with their teachers besides e-mail, but the interaction scale specifically asks about communication established via e-mail. Students stated that they were able to communicate with their teachers easily and conveniently via e-mail. Further, they remarked that their teachers sometimes responded to their emails (M=3.25). Participants liked email as a means of communicating about lesson content they did not understand, and they generally felt comfortable asking their teachers questions via email (M=3.26). A high percentage of the students chose 'often' and 'sometimes' options regarding their communication with other students. The majority of students thought they could ask other students questions during online lessons (M=3.28); some students responded positively to questions in relating to online lessons (M= 3.31). Further, the majority of students indicated that self-discipline was necessary in the online learning environment (M=3.28).

The response scale posed questions relating to student satisfaction in the online learning environment. A high percentage of the participants did not think that the online learning model allows them to interact, work and discuss the content of the lessons with other students. Furthermore, the majority of participants had negative impressions of learning in this environment. The majority of them replied they 'almost never' enjoyed learning in this environment (M=2.79). Likewise, students thought they could not learn more in this environment (M=2.65) and many did not feel a sense of satisfaction or achievement in this learning environment (M=2.71). They indicated that they found this education model boring (M=3.31) and the online learning environment did not hold their interest in throughout this term (M=2.75). Statistical analysis showed that the mean answer for the second-grade students (M=2.44) is significantly lower than the first-grade students (M=2.83) in this scale ($p=0.009$).

The result scale, the last part of the questionnaire, included questions about the organization and content of the lessons on the internet. Study results indicated the participants believed they could sometimes figure out completely what each lesson online was about (M= 3.04). While the organization of each lesson online was easily followed by many participants (M=3.34), the majority did not think that lessons online helped them understand the subject better than lessons in the classroom (M=2.75). In addition, the students did not all share the opinion that online lessons kept them focused. When asked about content presentation, a high percentage of the students thought that content was not appropriate to online delivery (M=2.86). Many participants stated that course content and presentation of information were not effectively delivered online (M=2.93). In the distance education program, multiple-choice tests and other types of exams were given to students at the end of each lesson or at the end of the term. The lowest percentage of the participants believed that multiple-choice tests at the end of each lesson online always facilitated learning, but the highest percentage of the participants believed that multiple-choice tests at the end of each lesson online 'sometimes' facilitated learning (M=2.88). In this scale, there were statistically significant differences among departments, gender, and grades. Statistically significant differences were seen in comparing the Physiotherapy/Rehabilitation departments (M=2.58) and both Medicine (M=3.46) / Pharmacy (M=3.07) / Nutrition (M=3.17) departments ($p<0.001$). The average mean for the female students (M=3.11) is significantly higher than the male students (M=2.76) along this scale ($p=0.008$); and the mean for the second-grade students (M=2.56) is significantly lower than the first-grade students (M=3.12) ($p<0.001$). The results of all the scales are shown in **Figure 1**.

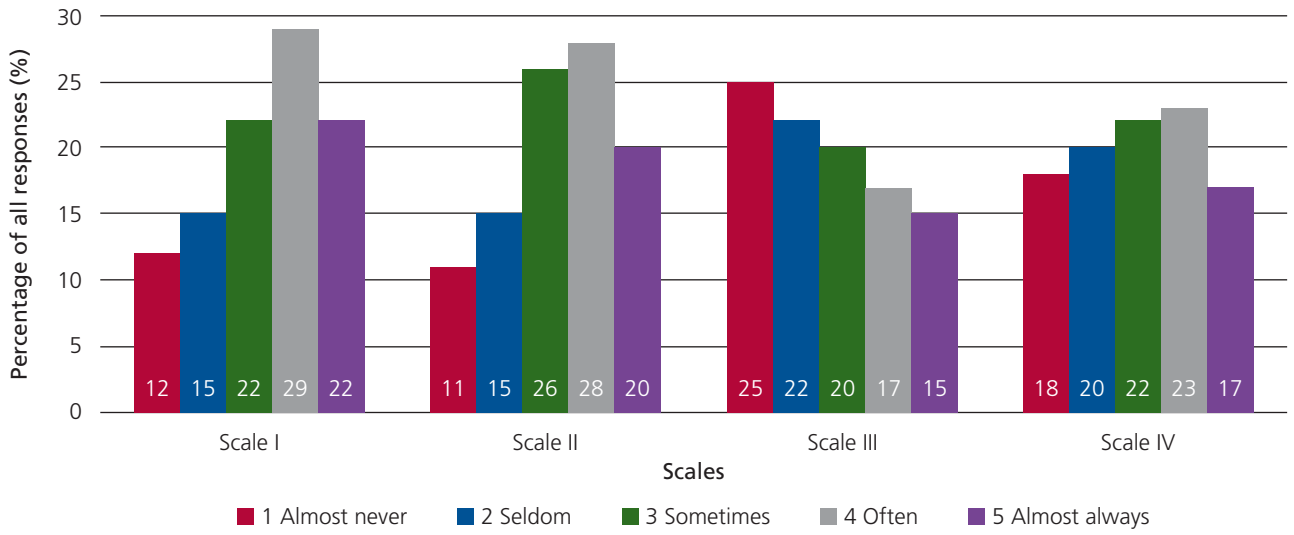

Figure 1. The four scales of the WEBLEI: student responses.

Discussion

The popularity of distance education has increased, especially in the undergraduate and postgraduate context. The COVID-19 pandemic has shown implementation of distance education to be accelerating and in need of focus.[21] This questionnaire study examines student perceptions about distance education during the COVID-19 pandemic.

Distance education has numerous undisputed advantages, including student access to lessons and course materials at any time with an internet connection.[4] Joynes and Fuller[9] remarked that distance education, with the advancement of technology, allows students to attend classes from anywhere with an internet connection. Sheryl et al.[22] maintained that the learning environment was easily accessible in time and space for students. This study's access scale results support the findings of Sheryl et al.[22] and Joynes and Fuller.[9] Yet participants in this study had mixed views about the success of online lessons in helping them realize their learning goals and develop their interest areas. Although accessing lessons at any time and location offers clear advantages, distance education alone is not sufficient to meet the learning goals and interests of students. According to the significant differences seen in comparing the Physiotherapy/Rehabilitation and Medicine / Pharmacy fields along the access scale, it is possible to conclude that physiotherapy students have difficulty accessing their courses. It may be that these students had adaptation and motivation problems during the distance education period.

Students were able to contact with their teacher via communication options such as online chat, videoconferencing during class. When they needed to get in contact with their teacher for extracurricular questions during face-to-face education, they could ask them face-to-face; but students had only e-mail in the ALMS platform or personal e-mail accounts to access their teachers during distance education. WEBLEI's interaction scale (and the interaction scale of this study) specifically examines this method of communication between students and teachers. Dyrbye et al.[23] has stated that lack of face-to-face communication between students and lecturers negatively affects the clarity of instructions and the quality of the feedback. Although they generally agreed that web-based learning gave them an opportunity to contact their teachers and other students, students stated that they did not completely feel comfortable communicating in this way. The interaction scale of other studies using WEBLEI showed similar results.[22] Horzum[24] suggested that students who cannot adapt technologically to distance education have learning problems. Instructing both students and lecturers on how to interact on distance education platforms could positively affect student responses along the interaction scale.

The response scale included questionnaire items relating to student satisfaction surrounding the learning environment. In this study, the response scale was rated the lowest (M=2.75). The results show the participants generally gave negative responses. Undergraduate students did not generally find web-based teaching in the COVID-19 pandemic period to be satisfactory and enjoyable; they did not feel successful during this learning period and did not find it easy to work with other students online. On the contrary, Ilahi et al.[25] stated that postgraduate students were

satisfied and enjoyed the learning process and working with other students in a blended learning environment. Chandra and Fisher[26] revealed that students generally agreed that web-based learning was satisfactory. While Chandra and Fisher[26] reported that the highest rating item for the response scale is "I enjoy learning in this environment" (*M*=4.15), the rate is 2.79 for our study. The results showed that although students were generally satisfied in a blended learning environment, they were not satisfied when the education process was completely online and distanced. It can be concluded that although students like the fact that online learning is included along with face-to-face education, they are not satisfied taking all their lessons online. First and second-grade health-related faculties have course intensities and they have also theoretical and practical course differences. In our study, the scale mentioned above was used to question whether these factors affect the education model. Moreover, the weighted mean of first grade was significantly higher than the second grade in the response and result scale. Second-grade lessons were more intense than first-grade lessons in the health sciences departments. Thus, the weighted mean of first grade was significantly higher than the second grade in the response and result scales. All practical courses had to be conducted only on the ALMS platform, rather than in a laboratory or internship environment, so this situation may be due to student perception. Horzum[24] stated that problems during the learning process can arise when practical lessons are conducted online. In our study, it is possible to report that second-grade students were not as satisfied as first-grade students with web-based learning due to the increasing intensity of their lessons, especially practical ones.

The results scale contains questions related to student perceptions about the structure, design, and content of the learning objectives. In this study, students stated generally that although they followed lessons easily and found the lessons well sequenced, they did not totally agree that the course content and presentation of information were best delivered online. This is dissimilar to other studies' findings that content and presentation of information were appropriate for distance education.[22] The result scale's mean score for Physiotherapy/Rehabilitation is significantly lower than Medicine and Pharmacy, reflecting that physiotherapy students had difficulty adjusting to the distance education platform compared to the students in the other health faculties. In this study overall, the means of the four scales for the medicine students are the highest of all the departments. The reason for this significant difference is likely the motivation and adaptation of medical students and the academic staff during the pandemic period. Furthermore, future comprehensive studies are needed to address the comparisons between face-to-face and distance education with different methods in various departments due to differences in course intensity and contents among the departments.

Conclusion

The COVID-19 pandemic has forced universities to conduct the education through online platforms. Distance education has advantages and disadvantages and there are conflicts among educators and students regarding distance education.[4] During the pandemic period, some pros and cons of distance education have been clearly realized. The COVID-19 pandemic period has shown that distance education platforms are needed and must continue to develop and evolve. This study identified student perceptions about distance education during the COVID-19 pandemic period and suggested that some aspects of distance education platforms need to improve. When online lessons are the only option, students should not be left thinking that online lessons are less effective and satisfying than face-to-face lessons. The COVID-19 pandemic period proved that educational institutions should always be prepared to conduct education using complete distancing.

Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

İD: manuscript writing/editing; SA: manuscript writing/editing; BA: data collection and data analysis; İD: protocol/project development; KÇK: manuscript writing/editing; İD: data analysis.

Ethics Approval

Approved by İstinye University's Social and Human Sciences Research Ethics Committee, meeting number 2020/9 (decision number 05; date:20.07.2020).

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Demirtaş İ, Ayyıldız S, Ayyıldız B, Kuş KÇ. Distance education during social isolation: an evaluation of student attitudes and perceptions using the web-based learning environment instrument (WEBLEI). Anatomy 2021;15(2):163–170.

Case Report

http://dergipark.org.tr/en/pub/anatomy
Received: March 3, 2021; Accepted: July 17, 2021
doi:10.2399/ana.21.890222

anatomy
An International Journal of Experimental and Clinical Anatomy

The anatomical relationship between recurrent laryngeal nerve and high inferior thyroid artery: a case report

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Abstract

In this case report, we present a case with an unusually high course of inferior thyroid artery and its relationship with the recurrent laryngeal nerve on the right side of the neck of a 91 years-old formalin fixed male cadaver. Dissection showed that the inferior thyroid artery gave off branches between the branches of the recurrent laryngeal nerve following a sharp curvature descending downward to the thyroid gland. Knowledge of such a variation of the location and course of the inferior thyroid artery and the recurrent laryngeal nerve is important for surgical and radiological procedures.

Keywords: inferior thyroid artery; recurrent laryngeal nerve; thyrocervical trunk; thyroid gland; variation

Anatomy 2021;15(2):171–174

Introduction

Previous studies discussed the importance of differences in origin, course and distribution of the arteries supplying the thyroid gland and their relationship with the recurrent laryngeal nerve (RLN).[1–4] The variations regarding the course and branching pattern of the arteries of the thyroid gland may also be associated with ethnicity and gender.[3] During the surgical approaches directed to the neck region, it is important to consider the variational relationship between the course of inferior thyroid artery (ITA) and the neighbouring neurovascular structures; particularly, the RLN to prevent iatrogenic injuries.[4,5] In this case report, we report an ITA variant, which has an unusually high course on the right side and its anatomical relations with the RLN.

Case Report

During routine educational dissection of a 91 years old formalin fixed male cadaver, ITA was observed to have an unexpected long course on the right side of the neck of the cadaver. The artery, after its origin, made a sharp curve inferiorly to reach the thyroid gland (**Figures 1a** and **b**). After removing the superficial muscles on the anterior side of the neck region throughout the dissection procedure, the carotid sheath and surrounding structures of the neck were exposed. In order to better visualize the anatomic structures, the anterior thoracic wall was removed and the structures around the subclavian artery were dissected and the branches originating from the subclavian artery were followed. Behind the carotid sheath, ITA, originating from the right thyrocervical trunk, ascended to the level of the fifth cervical vertebra, which can be considered as a very high level. Then it sharply angled down and divided into two branches at the level of the lower half of the thyroid gland. One of these two branches was directed to the lower lobe of the thyroid gland and the other to the upper lobe. One of the two branches of the RLN was ascending anterior to the branches of ITA and the other from the back (**Figures 1a** and **b**).

In our case, this course of ITA was present only on the right side. On the left side, ITA divided into branches under the thyroid gland at the level of the sixth cervical vertebra after originating from the thyrocervical trunk. In addition, the course of superior thyroid artery on both sides and their relationship with the external branch of superior laryngeal nerve were regular. The origin, course and branching pattern of superior thyroid arteries on both sides, ITA on the left side and RLN on the left side showed a regular pattern.

Discussion

It is known that inferior laryngeal nerve damage is seen at a relatively higher rate after total thyroid resections.[4] In total thyroidectomy, it is important to know the relationships of some structures such as ITA, Berry ligament, Zuckerkandl tubercle and pyramidal lobe formed by the extension of thyroid lobe. Dissection, ligation and excision of these structures according to the technique have remarkable details.[4,5]

Inferior laryngeal nerve is composed of mostly motor fibers that enter the larynx. It innervates the laryngeal muscles with different courses on the right and left sides after arising from the vagus nerve. However, its most vulnerable part to the iatrogenic injury is the last part before entering the larynx where it is adjacent to the thyroid gland. This part is just the distal to the intersection of the RLN with ITA.[5,6] In safe thyroidectomy technique, the association of RLN with ITA, Berry ligament, and posterior extension of the growing thyroid lobe is therefore important.[6] In safe thyroidectomy technique, ITA serves as an important landmark for dissection of RLN. Therefore, for preserving the RLN in the surgical dissection of ITA, anatomical variations of ITA should be taken into account.[5]

Although several studies about variations of anatomical origin of ITA have been published,[3,7] there are few studies on the course of ITA and its relationship with RLN. RLN is usually located posterior to the ITA on the right side. The relationship between ITA and inferior laryngeal nerve is also very important.[5] Detailed knowledge of neck anatomy contributes effective surgical procedures, as well as help reducing the risk of intraoperative iatrogenic injuries.[8–11] Other causes such as stellate ganglion blocks, central venous catheter placement,[11] and direct trauma may lead to serious injury to ITA.[12] It is reported that using imaging techniques such as ultrasound to identify any variations in anatomical structures prior to surgical and interventional procedures also prevents damage to ITA.[11]

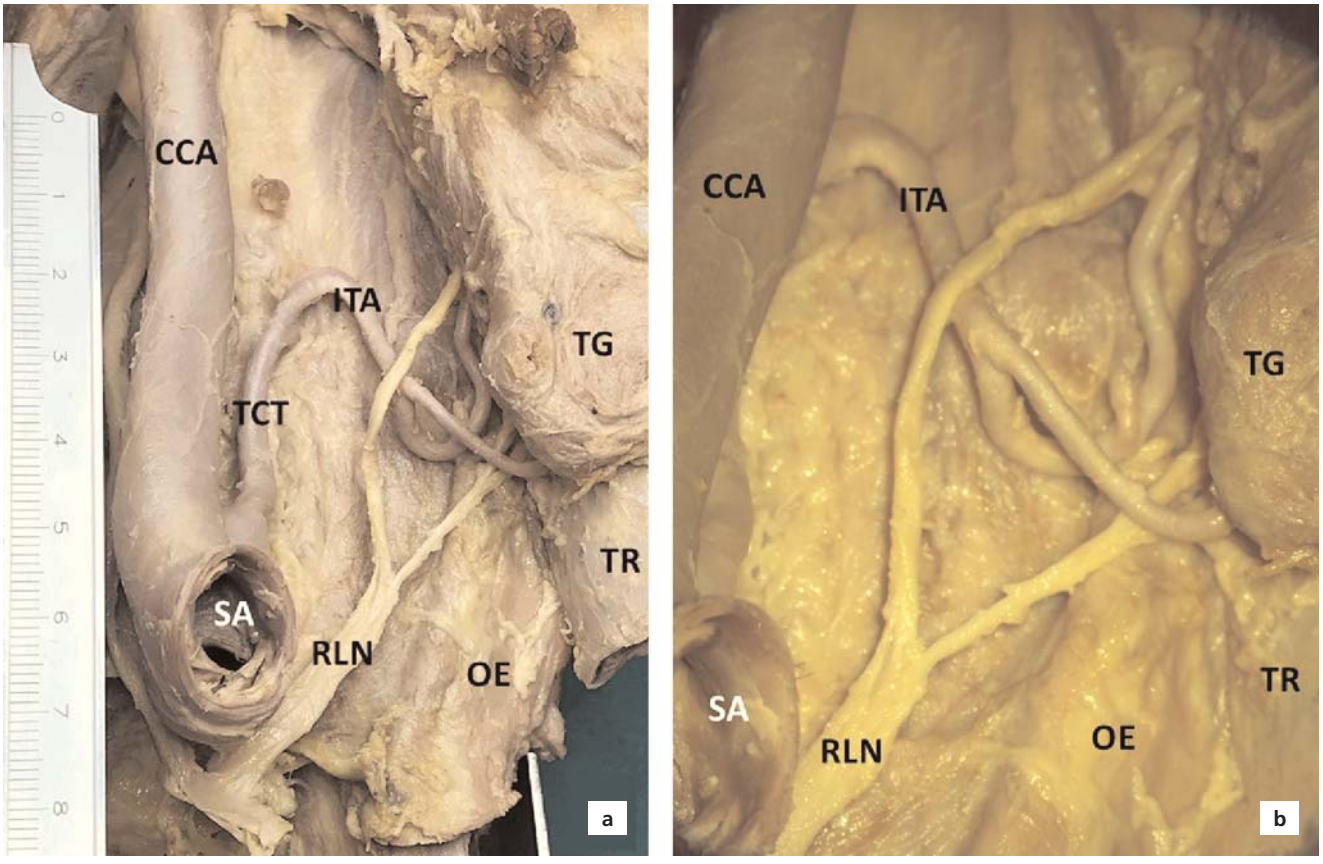

Figure 1. (**a**) Anterior view of right inferior thyroid artery, right recurrent laryngeal nerve and related structures; (**b**) magnified view. **CCA:** common carotid artery; **ITA:** inferior thyroid artery; **OE:** oesophagus; **RLN:** recurrent laryngeal nerve; **SA:** subclavian artery; **TCT:** thyrocervical trunk; **TG:** thyroid gland; **TR:** trachea.

Variations of superior thyroid artery and ITA have been previously published by many authors.[1] Sarkar et al.[2] reported an unusually high division level of ITA on the left side. In their report, it is stated that after arising from the thyrocervical trunk, ITA divides into the branches near the upper pole of the thyroid gland while curving inward at the level of the fifth cervical vertebra on the left side. It is reported that the branching of ITA on the left occurs at a higher level than the right side. In our case, it was determined that the ascending ITA suddenly turned downwards with a sharp angle after a long course rising up to the fifth cervical vertebra and ITA was divided into two branches at a level close to the inferior pole of the thyroid gland on the right side.

Makay et al.[6] investigated the relationship between RLN and ITA, and demonstrated sixteen variants of RLN in 253 adult patients. They reported that in most of the cases, RLN is located deep to the ITA. They also reported that RLN divided into 2 branches in 22.5% and 3 branches in 1.6% of the cases. They observed nerve bifurcation mostly on the left side. Campos and Henriques[13] dissected 76 formalin fixed cadavers and reported that RLN is mostly located among the branches of ITA in both sexes. In their study, RLN on the right side were found between the branches of ITA in 49.30%, anterior aspect of ITA in 38.04% and posterior aspect of the ITA in 11.26% of the cases. However, in our case, the RLN was divided into two branches at the level of subclavian artery on the right side. The inferior branch was ascending underneath the branches of ITA, while the superior branch was ascending superficial to the branches of ITA (**Figures 1a** and **b**). Sarkar et al.[2] reported that the left RLN coursed between the branches of ITA at a high level. In our study, on the contrary, on the right side the branches of the ITA passed between the branches of the RLN and gave off the minor branches to the thyroid gland.

Variations of superior thyroid artery, RLN, and ITA should be taken into consideration before and during the surgical procedures directed to the neck and thyroid gland, and are of great importance for the surgeons in order to prevent iatrogenic injuries. Preoperative consideration of arterial variations and their neurovascular relationships may result in better planning of the operation with less iatrogenic neurovascular injury and more favorable results.

Acknowledgments

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.[14]

Conflict of Interest

The authors have no conflicts of interest to declare.

Author Contributions

KEÖ: dissection of the case, manuscript writing; KE: manuscript writing; GAK: dissection of the case; MAM: supervision, manuscript editing.

Ethics Approval

The study was performed following the aid of the ethical standards down in the 1964 Declaration of Helsinki and its later amendments.

Funding

None.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Özen KE, Erdoğan K, Ay Keselik G, Malas MA. The anatomical relationship between recurrent laryngeal nerve and high inferior thyroid artery: a case report. Anatomy 2021;15(2):171–174.

Case Report

http://dergipark.org.tr/en/pub/anatomy
Received: June 1, 2021; Accepted: August 10, 2021
doi:10.2399/ana.21.946049

anatomy
An International Journal of Experimental and Clinical Anatomy

Renal artery piercing the diaphragmatic crus

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Abstract

The anatomical variations of renal artery related with number, branching pattern and origin level have been well described. The variations regarding the course of the artery are limited and mainly related with its relation of vena cava inferior. However, diaphragmatic crus is also on the pathway of renal artery and this relationship might also have variations. Different from its usual precrural position, there are a few cadaveric dissections reported as retrocrural or transcrural renal artery. This is the report of a rare variant of renal artery course, where it was crossing between the fibers of diaphragmatic crus detected on CT angiography.

Keywords: CT angiography; diaphragmatic crus; renal artery; variation

Anatomy 2021;15(2):175–177

Introduction

Vertebral attachments of diaphragm are called as crura.[1,2] At the caudal portion, the tendinous part of the right and left crus attaches to the first three and two lumbar vertebrae respectively.[2,3] Above the celiac trunk, the two crura conjoin to form an arch called as median arcuate ligament.[3] Anomalies and variations of diaphragmatic crus are usually asymptomatic.[3] Duplication is the most commonly reported variation of diaphragmatic crus and reported to be usually on the right side. However, the discontinuity between the crura of the diaphragm and lateral arcuate ligament has been defined as a normal variant. Herein, we report a rare anatomical variation related with diaphragmatic crus and the course of renal artery.

Case Report

A 55-year-old man presented to the emergency department with complaints of sudden and severe chest pain. On initial examination, myocardial ischemia and aortic dissection were thought previously in the differential diagnosis. The blood pressure of the patient was 150/80 mmHg. Following the electrocardiogram and the blood tests, patient underwent a CT angiography with a 64-slice scanner (Toshiba Aquilion 64, Toshiba Medical Systems, Tokyo, Japan). One hundred cc nonionic contrast material was administered through an antecubital venous catheter. Scanning was performed from the top of the aortic arch to the bifurcation level of femoral arteries. Multiplanar reformatted and three-dimensional images were created. A dissection extending from the root of aorta to the iliac arteries were detected. There was an accessory right renal artery originating from the true lumen that was feeding the lower pole of right kidney. However, the right main renal artery, originating from the false lumen, was crossing between the muscle fibers of the right diaphragmatic crus along its course (**Figures 1** and **2**). The origin level of right renal artery was at the level of L1. Additionally, renal artery was compressed with the fibers of diaphragmatic crus (**Figure 3**). The left renal artery was normal. Patient underwent an emergency operation but unfortunately had died.

Discussion

Variations that may affect the relationship of renal artery and diaphragmatic crus is limited and generally have been reported in renal artery entrapment cases.[4,5] For example, in a cadaveric dissection, Shruthi[6] reported a renal artery which was passing posterior to the crus of the diaphragm. In 1924, Guinane[7] reported a case in which enlarged right crus was pierced by the right renal artery. Renal artery, in that case, was entirely covered by the muscular fibers of the crus. Martin[8] defined a right renal artery passing through a cleft in the right crus of

diaphragm in 1971. Renal artery was at its normal level and there was a separation persisted into the muscular portion of the crus for a distance of 4 to 5 cm, so that two separate bundle of muscle fibers could be distinguished. Our case showed similarity to the one described by Martin,[8] however was detected with CT angiography.

The renal artery in our case was piercing the crus at its normal level and compressed by the crus of the diaphragm where it was passing. At the caudal portion of renal artery there were two separate crura. Herein, one can say that this might also be entitled as an accessory or duplicated crus. Different forms of duplication in cadavers have been described. Sirasanagandla et al.[2] reported a duplicated crus which were widely and completely separated. In another case reported by Vadgaonkar et al.,[1] the accessory right crura arosing from the right psoas major were separated from the normal crus by an interval of 0.7 cm throughout its length except distal attachment. The terms of partial or complete separation have been used by different authors. In the light of previous definitions, a cleft in the right crus may be used rather than a duplicated crus for the present case because of the position of renal artery.[8] Although there was a separation of the crus, this was not complete and both of the distal ends were attached to L2 and L3 vertebrae consecutively.

The diaphragm start developing during 4th to 12th weeks of embryonic life and classified as costal and crural. The crural diaphragm develop from myoblasts growing into the dorsal mesentery of the esophagus.[1,3,9] However, the kidney reaches its location between the 6th and 9th weeks and renal arteries arise from lateral splanchnic arteries during the development of mesonephric kidney.[10] As the kidneys migrate, they are vascularized by a succession of transient aortic sprouts that arise at progressively higher levels.[10] Various mechanisms have been defined to explain the anomalies of diaphragm, kidney and its vasculature. Partial duplication of the diaphragm that may involve the crura is thought to result from improper timing in the interaction of the lung buds and septum transversum.[3] Considering the time of formation of the crus and renal arteries, the arrangement of this variation might also be related with the timing of renal arteries' occurrence at their normal localization. Therefore, the position of renal artery and the cleft of the diaphragmatic crus suggest that renal artery forms before diaphragmatic crus.

Conclusion

The clinical importance of this variation is the potential of causing renal artery entrapment which is an infrequent

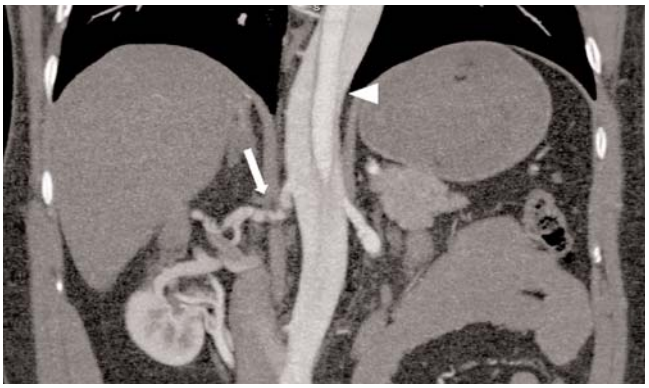

Figure 1. Coronal maximum intensity projection (MIP) CT image shows the stenosis of right renal artery (**arrow**). Note the dissection of aorta (**arrowhead**).

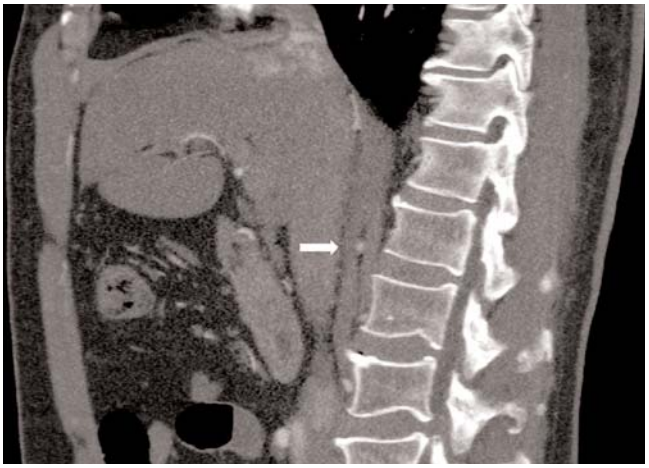

Figure 2. Renal artery piercing the diaphragmatic crus on sagital MIP image (**arrow**).

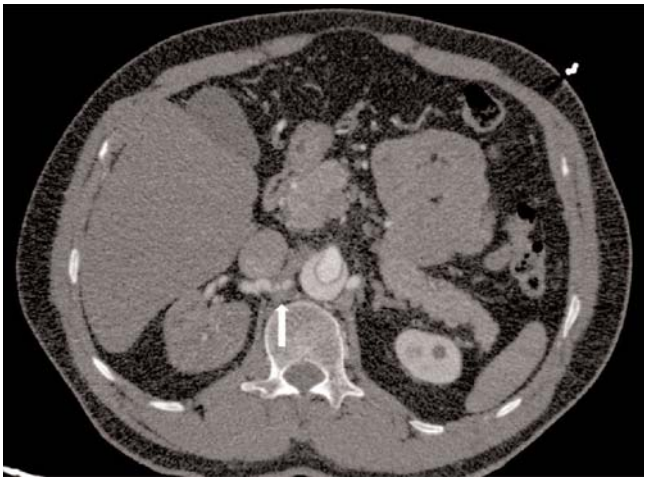

Figure 3. Axial MIP CT image shows the entrapment and critical stenosis of right renal artery (**arrow**). Note the ostial compression of left renal artery with left diaphragmatic crus and the nonenhancing upper pole of right kidney.

cause of renovascular hypertension.[6] Thony et al.[5] classified the entrapments as ostial and truncular with respect to the length of compression at which renal artery is in normal precrural localization. While the retrocrural and transcrural course of renal artery is very rare, a classification of entrapments with respect to renal artery course may also be defined. Although we did not have a chance to explore a relationship between the hypertension and renal artery stenosis in our case, this entity has a clinical interest. We suggest using cross-sectional CT angiography imaging to evaluate the variations that are under risk of compression.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

KE: Project development, data collection, manuscript writing; YB: Literature review.

Ethics Approval

Not applicable.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Esen K, Balcı Y. Renal artery piercing the diaphragmatic crus. Anatomy 2021;15(2):175–177.

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Anterior view of the left shoulder showing the axillary artery dividing into lateral and medial trunks. The lateral trunk gives a common trunk, which divides into anterior circumflex humeral (**ACHA**), posterior circumflex humeral (**PCHA**) and profunda brachii (**PB**) arteries. The medial trunk becomes the brachial artery (**BA**). From Alashkham A, Almabrouk T, Soames R. Variations of the branches arising from the third part of the axillary artery: a cadaveric study. *Anatomy* 2021;15(2):104–115.

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