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EDITORIAL / EDİTÖRYAL

RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

SYSTEMATIC REVIEW/ SİSTEMATİK DERLEME

Is bilingualism really an advantage? What about individuals with autism?

İki dilli olmak gerçekten bir avantaj mı? Peki ya otizmli bireyler?

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ABSTRACT

The prevalence of autism spectrum disorder (ASD) is rising globally, making the identification of at-risk groups increasingly important. The proportion of bilingual families has also increased in recent years. There are very few studies examining the relationship between ASD and bilingualism. Although bilingualism is considered an advantage in terms of child development, its consequences in the presence of ASD are unclear. Therefore, there is no consensus among professionals in this field on the subject of bilingualism. Being bilingual is a factor that should not be overlooked during interventions for children with ASD. More research is needed to examine the relationship between being bilingual and ASD longitudinally.

Keywords: Autism Spectrum Disorder; Bilingualism; Children; Language

ÖZ

Otizm spektrum bozukluğu (OSB) tanısının yaygınlığı küresel olarak artmakta olup, riskli grupları belirlemek daha önemli hale gelmektedir. İki dile sahip ailelerin oraları da son yıllarda artmaktadır. OSB ile iki dillilik arasındaki ilişkiyi inceleyen çok az çalışma vardır. İki dillilik çocuk gelişimi açısından bir avantaj olarak görülse de, OSB varlığındaki sonuçları net değildir. Bu nedenle, bu alandaki profesyoneller arasında iki dillilik konusunda bir fikir birliği yoktur. İki dilli olmak, OSB'li çocuklarda müdahale sırasında göz ardı edilmemesi gereken bir faktördür. İki dilli olmak ve OSB arasındaki ilişkiyi uzunlamasına inceleyecek daha fazla araştırmaya ihtiyaç vardır.

Anahytar kelimeler: Otizm spektrum bozukluğu; iki dillilik; Çocuklar; lisan

Is bilingualism really an advantage? What about individuals with autism?

Regular use of more than one language has become increasingly common in today's societies. It is estimated that more than half of the world's population today is bilingual or multilingual. However, bilingualism is difficult to define. There are many different definitions of bilingualism in the literature. Researchers have proposed different definitions of bilingualism, such as simultaneous bilingualism and consecutive bilingualism, based on factors such as length of exposure to two languages or parents' language preferences [1]. Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by deficits in social interaction, communication difficulties, and repetitive behaviors [2]. Studies focusing on the relationship between ASD and bilingualism are few and have important definitional limitations. It is not clear from many studies to what extent these current definitions were taken into account in previous studies examining the relationship between bilingualism and ASD.

Although bilingualism was previously shown as an advantage for cognitive processes, this view has been questioned over the years. A study has shown that the literature challenging the bilingualism advantage (BA) hypothesis has increased after 2014 [3]. However, it is thought that publication bias may be an obstacle to discourses opposing the BA hypothesis in the literature [4]. Studies with results that fully support the BA hypothesis are most likely to be published. However, it has been observed that studies questioning the BA hypothesis have a lower chance of being published [4]. Studies were found to be published relatively frequently (68%) if the data showed a bilingual advantage. In contrast, only 29% of studies showing no effect of bilingualism or even disadvantages of being bilingual have been published [4]. Based on this, it is useful to question the relationship between Autism spectrum disorders (ASD) and bilingualism. Although some clinicians thought there was no disadvantage, families had ongoing concerns. Unlike parents of monolingual children, parents of children with ASD have been found to express concerns that a bilingual environment will cause confusion and increase language delays in their children [5]. Perhaps these concerns of families may actually show us that there is something that researchers have overlooked. In summary, although the literature often indicates that bilingualism is an advantage, including ASD, it seems that concerns about this issue have not been resolved. In addition, many variables, such as definitions of bilingualism, environments of exposure to two languages, and times of exposure to two languages, seem to be ignored in these studies. It will also be important to change the focus of studies in groups with defined clinical characteristics (especially ASD). Existing research generally agrees on the assertion that bilingualism does not create additional difficulties in language development in ASD [6]. In future studies, it may be more appropriate to focus on core symptoms in neurodevelopmental disorders such as ASD. If we look at ASD symptoms rather than language acquisition in bilingual children diagnosed with ASD, results that we have not encountered before will await us. It is clear that larger-scale longitudinal studies on bilingualism and ASD are needed.

ORCID and Author contribution: T.K. (0000-0002-2156-3457): Concept, literature search, writing, critical review. **A.A (0000- 0001-5797-1287):** Critical review, editing.

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Comparative Analysis of Radiologic Outcomes and Mechanical Complications Associated with Four Different Proximal Femoral Nail Designs

4 Farklı PFN Tasarımı ile Tedavi Edilen Kalça Kırıklarının Radyolojik Sonuçlarının ve Mekanik Komplikasyonlarının Karşılaştırmalı Analizi

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ABSTRACT

Aim: This study aimed to retrospectively assess the efficacy of four commonly used Proximal Femoral Nail (PFN) designs in the surgical treatment of hip fractures, focusing on factors that influence patient outcomes.

Patients and Methods: We evaluated 220 patients treated for extracapsular hip fractures with different PFN designs from January 1, 2017, to January 1, 2023. We reviewed patient demographics, comorbidities, anesthesia type, operative details, and postoperative radiographs.

Results: A cohort of 220 patients was analyzed. Of these, 138 were female, and 82 were male. Patients were divided into four groups based on the type of PFN used. Group 1 (double lag screw PFN) had the best radiological outcomes with superior reduction quality and fewer complications. The groups showed no significant differences in terms of age, gender, type of anesthesia, or comorbidities. However, Group 3 (Intertan PFN) had a lower tip-apex distance, and Group 1 showed the fewest complications overall.

Conclusion: This study demonstrates that the use of PFN with double lag screws in extracapsular hip fractures is associated with superior fracture reduction, fewer complications, and a lower incidence of nonunion.

Keywords: Double lag screws, Extracapsular hip fracture, Mechanical complications, PFN-A, Proximal Femoral Nail, Radiologic outcomes, Talon.

ÖZ

Amaç: Bu retrospektif gözlemsel kohort çalışması, ekstrakapsüler kalça kırığı ameliyatı geçiren hastalarda dört farklı Proksimal Femoral Çivi (PFN) tasarımının etkinliğini değerlendirmek ve hasta sonuçlarını etkileyen faktörleri araştırmayı amaçlamaktadır.

Hastalar ve Yöntemler: 1 Ocak 2017'den 1 Ocak 2023'e kadar farklı PFN tasarımları ile ekstrakapsüler kalça kırığı nedeniyle tedavi edilen 220 hasta değerlendirildi. Hasta demografisi, komorbiditeler, anestezi tipi, ameliyat detayları ve ameliyat sonrası radyografiler incelendi.

Bulgular: 220 hastadan retrospektif analiz edildi. Bu hastaların 138'i kadın, 82'si erkekti. Hastalar kullanılan PFN tipine göre dört gruba ayrıldı. Grup 1(çift lag vadalı PFN), en iyi radyolojik sonuçlara sahip olup, daha iyi redüksiyon kalitesi ve en az komplikasyon ile öne çıktı. Gruplar arasında yaş, cinsiyet, anestezi türü veya komorbiditeler açısından anlamlı bir fark gözlenmedi. Ancak Grup 3 (İnterTan PFN), daha düşük tip-apeks mesafesine sahipti ve Grup 1 genel olarak en az komplikasyona sahiptir.

Sonuç: Bu çalışma, ekstrakapsüler kalça kırıklarının tedavisinde çift lag vidalı PFN kullanımının daha iyi kırık redüksiyonu, daha az komplikasyon ve daha düşük kaynamama oranı ile ilişkili olduğunu göstermektedir.

Anahtar kelimeler: Çift yivli vidalar, Ekstrakapsüler kalça kırığı, Mekanik komplikasyonlar, PFN-A, Proksimal Femoral Çivi, Radyolojik sonuçlar, Talon.

Introduction

Proximal Femoral Nail (PFN) is one of the most commonly used osteosynthesis methods in the surgical treatment of extracapsular hip fractures. PFN has biomechanical advantages, fewer postoperative complications, and good clinical outcomes [1]. Although PFN has superior results in treating hip fractures, some mechanical complications can be troublesome. Mechanical complications such as cut out, femoral shaft fracture at the nail dissection, and Z effect can be seen after PFN [2]. Although improvements in implant design have reduced these complications, they have not been eliminated. Surgical technique is as crucial as implant design in developing these complications. The quality of reduction, Tip apex distance, and placement of the lag screw in the femoral neck are directly related to the complication [3, 4]. While previous studies have explored the outcomes of hip fractures treated with various PFN designs, there remains a notable gap in the literature regarding a comprehensive comparative analysis of the most commonly employed systems. Although some research has compared the results of two or three different PFN designs, to the best of our knowledge, no study has yet evaluated patients treated with the four widely utilized designs: the double delayed screw PFN (DLS-PFN), PFN Antiglide (PFN-A), Talon PFN, and PFN Intertrochanteric Antegrade Nail (PFN-Intertan). This retrospective study aimed to assess the efficacy of surgical treatment using these four distinct PFN designs, focusing on identifying the factors that influence patient outcomes.

Patients and Methods

This retrospective observational cohort study was conducted according to the principles of the Declaration of Helsinki. This study was approved by the authors' IRB (decision date and number: 01/10/2024, 01/025). The study center was the Department of Orthopaedic Surgery of our regional trauma center in a city with a population of more than 1,500,000. A retrospective analysis was performed on data from patients who underwent surgery for an extracapsular hip fracture using a proximal femoral nail between January 1, 2017, and January 1, 2023. We followed the principles of the Strengthening the Reporting of Observational

Studies in Epidemiology (STROBE) guidelines in preparing this report.

The inclusion criteria for this study were as follows: patients over 18 years of age who underwent PFN for extracapsular hip fracture and had sufficient file data for at least one year. Patients with pathologic fractures, insufficient follow-up data, and multiple fractures were excluded from the study. In addition, extracapsular hip fractures treated with implants other than PFN and intracapsular fractures treated with PFN were excluded. A flow chart of the study is shown in Figure 1.

The same surgical team performed all procedures. All patients received four weeks of thromboprophylaxis with low-molecular-weight heparin. Preoperatively, patients could ambulate and perform daily activities without assistive devices. Postoperatively, patients were mobilized within 48 hours with partial weight bearing and the assistance of medical care staff.

The clinical evaluation included age, sex, side of the fracture, comorbidities, ASA score, type of anesthesia, operative position, complications, and postoperative blood transfusion. The radiologic evaluation included assessing the patients' pre- and postoperative anteroposterior and lateral hip radiographs by a senior orthopedic specialist blinded to the other patient data. The radiologic assessment assessed fracture type, reduction quality, Cleveland index, Sign index, shaft neck angle, union, type-apex distance, and mechanical complications.

Statistical Analyses

Statistical analyses were performed using SPSS for Windows 25.0 software. The conformity of the variables to normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/ Shapiro-Wilk tests). A p-value above 0.05 in the Kolmogorov-Simirnov test was accepted as a normal distribution. When normal distribution was not determined, the Kruskal-Wallis test was used for quantitative variables, and the chi-square test was used to compare qualitative variables between the four groups. Qualitative variables were presented as frequency and percentage values.
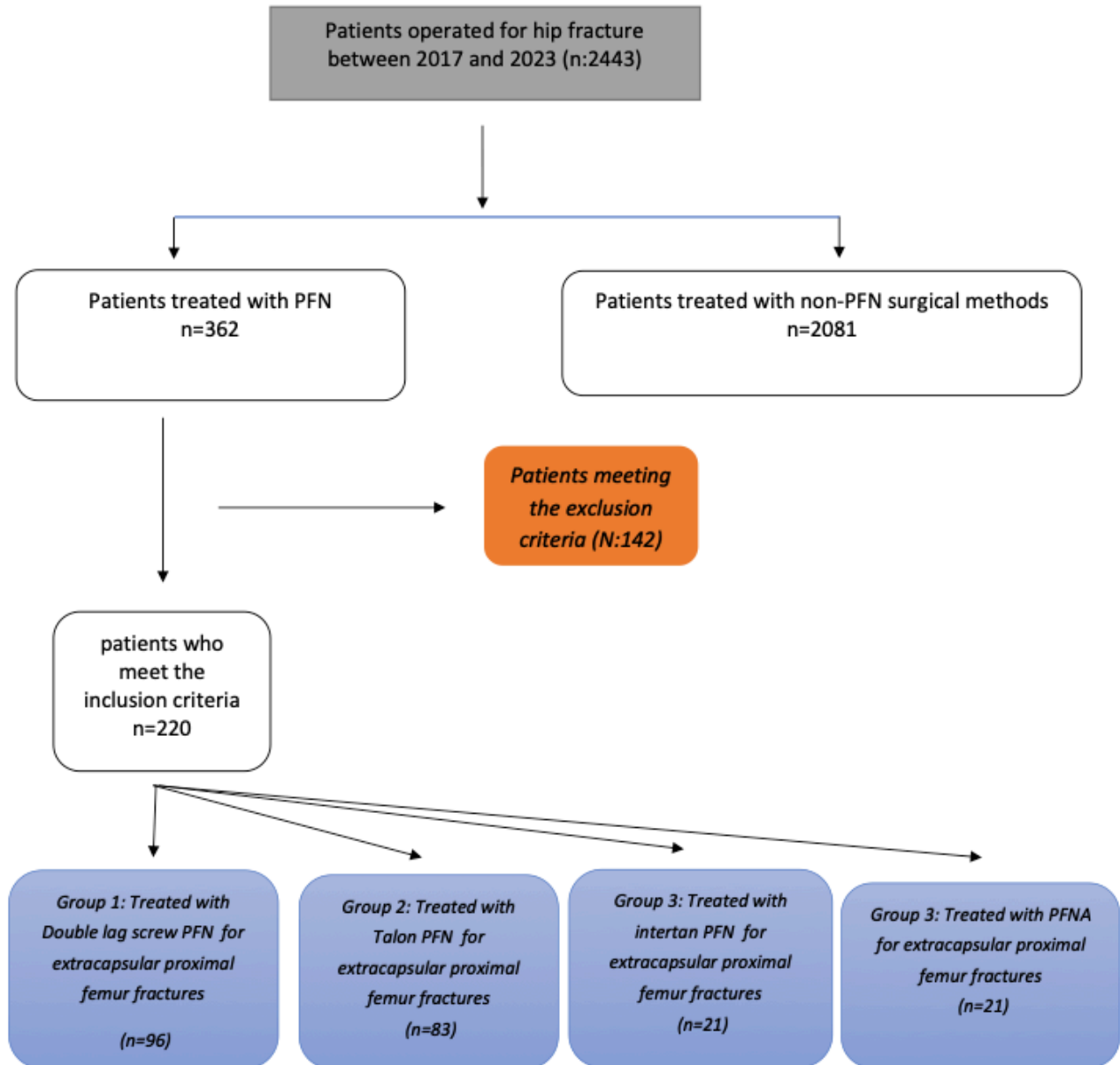
Figure 1. Flowchart of the study

Results

A cohort of 220 patients meeting the inclusion criteria was evaluated. Of these, 138 were female, and 82 were male. Most patients had left-sided fractures (125) compared to those with right-sided fractures (95). The ASA classification system was used to assess the physical status of the patients, with 8.2% classified as ASA 1, 15.5% as ASA 2, 63.2% as ASA 3, and 13.2% as ASA 4.

Patients were categorized according to the type of PFN used: Group 1 consisted of 96 patients, Group 2 had 83 patients, Group 3 had 21 patients,

and Group 4 had 20 patients. The general characteristics of the groups are summarized in Table 1.

The groups were similar in terms of age, gender, type of anesthesia, postoperative blood transfusion, and surgical positions.

A comparison of the groups in terms of comorbidities revealed no significant differences.

When the patients were evaluated using the Singh Index, they were found to be similar. Evaluation

of the reduction quality from postoperative radiographs showed no statistically significant difference between the groups, but it was observed that Group 1 had a better reduction. The postoperative diaphysis/neck ratios of patients with similar Cleveland indices were observed to be identical. Additionally, patients in group 3 had a lower type-apex distance. The radiologic union evaluation shows the superiority of group 1. The results of the radiological assessment of the patient are summarized in Table 2.

Table 1. The general characteristics of the groups

	Group 1	Group 2	Group 3	Group 4	p
Age, Median (min-max)	77 (26-98)	74 (31-89)	75 (37-83)	73,5 (57-82)	0.051
Gender Median (%)					
Female	60 (62.5)	49 (59)	13 (61.9)	16 (80)	0.385**
Male	36 (37.5)	34 (41)	8 (38.1)	4 (20)	
Anesthesia n(%)					
General anesthesia	11(11.5)	10(12)	-	-	0.215*
Spinal anesthesia	85(88.5)	73(88)	21(100)	20(100)	
Blood Transfusion unit n(%)					
0	76 (79.29)	68 (81.9)	10 (47.69)	12 (60)	0.149*
1	13 (13.5)	13 (15.79)	8 (38.1)	6 (30)	
2	7 (7.3)	2 (2.4)	3 (14.3)	2 (10)	
Surgical Position n(%)					
Supine	41 (42.7)	35 (42.2)	9 (42.9)	10 (50)	
Lateral Decubitus	55 (57.3)	48 (57.8)	12 (51.1)	10 (50)	0.935*
Orthopedic Traction Table	-	-	-	-	

n= number of individuals. * Chi-square test, ** Kruskal–Wallis test.

The distribution of fracture types was evaluated according to the AO classification. The most common fracture type was 31a1.2 (simple intertrochanteric femoral fracture- ITFF), followed by 31a1.3 (two-part ITFF) and 31a2 (multi-part ITFF). Fracture type 31a3 (reverse oblique fracture) was less frequent, with 31b2.3 (basicervical fracture) being the least common.

A significant difference was observed in the distribution of fracture types across the groups, particularly with 31a1.2 fractures, which were more frequent in Group 1 compared to other groups (p = 0.038). The distribution of groups according to AO classification is shown in Table 3.

Table 2. Comorbidities of the groups

Comorbities	Group 1	Group 2	Group 3	Group 4	p value
pulmonary n(%)	21(21.9)	18(21.7)	4(21)	6(20)	0.840*
nephrological n(%)	10(10.4)	10(12	-	-	0.159*
neurological n(%)	9(9.4)	15(18.1)	-	-	0.022*
cardiac n(%)	53(55.2)	46(55.4)	13(61.9)	4(20)	0.02*
DM n(%)	14(14.6)	18(21.7)	4(19)	4(20)	0.665*

n= number of individuals. * Chi-square test, ** Kruskal–Wallis test.

Table 3: AO classification of the patients

Fracture Type	Group	Counts (n)	% of Total
31a1.2	1	11	11.2%
	2	16	16.3%
	3	2	2.0%
	4	4	4.1%
31a1.3	1	11	11.2%
	2	9	9.2%
	3	0	0.0%
	4	3	3.1%
31a2.	1	7	7.1%
	2	6	6.1%
	3	3	3.1%
	4	1	1.0%
31 a3.	1	5	5.1%
	2	3	3.1%
	3	2	2.0%
	4	1	1.0%
31b 2.3	1	7	7.1%
	2	3	3.1%
	3	3	3.1%
	4	1	1.0%

When evaluating the patients' complications, group 1 had the fewest occurrences. Five patients in group 1 had heterotrophic ossification, nine patients in group 2, and two patients in group 3 had fractures. A summary of the complications is given in Table 4.

Table 4. Complications

Complications n(%)	Group 1	Group 2	Group 3	Group 4	p value
None	78(81.2)	57(68.7)	15(71.5)	18(90)	p<0.001*
Cut-out					0.515*
No	83 (85.5)	66(79.5)	17(81)	18(90)	
Yes	13 (13.5)	17(20.5)	4(19)	2(10)	
Heterotrophic Ossification	1(1.1)	1(1.2)	-		p<0.001*
Fracture	-	-	2(9.5)	-	p<0.001*

n= number of individuals. * Chi-square test

Discussion

This study evaluated the radiologic outcomes and complications of patients undergoing extracapsular hip fracture surgery with four different PFN implant designs. The results of the study indicate that patients treated with double lag screws have better fracture reduction, fewer complications, and less nonunion.

A study comparing PFN and PFNA radiologically and clinically reported that PFN had less operative time, less blood loss, fewer complications, and better clinical outcomes than PFNA [5]. The study results indicate that the PFN with the double lag screw design had fewer complications, fewer cases of nonunions, and less need for post-operative blood transfusion. Our work was conducted in parallel with this study. A comparative study between PFN and PFNA with double lag screws found conflicting results: PFNA was associated with fewer complications and less blood loss. Additionally, PFNA was superior regarding radiation exposure during the application, application time, and learning curve [6]. However, the results should be considered inconclusive due to the small sample size. A comparable study of 30 patients likewise demonstrated reduced surgical time, diminished blood loss, and a relatively lower incidence of complications with PFNA in comparison to PFN with double lag screw [7].

 A study comparing the efficacy of Talon and Intertan PFN revealed that while both methods resulted in successful fixation, Talon PFN exhibited more excellent stability. However, it was noted that Talon PFN also demonstrated the advantage of reduced surgical time and fluoroscopy exposure [8].

In a study comparing Talon-PFN, Intertan, and double lag screw PFN designs, all three were found to be successful in surgeries [9]. The most notable finding of this study was that better reduction was achieved in surgeries performed with the double lag screw PFN. Similarly, in our research, it was observed that double lag screw PFN provides better reduction. This is attributed to the necessity of sound reduction to be able to place two lag screws in the femoral neck. We also have the same opinion on this matter. We have the same view on this matter. More effort put into reduction results in longer surgical time increased bleeding, and radiation exposure. In their study, Yalın et al. compared three PFN designs: A-PFN, Intertan, and double lag screw PFN. The results showed that A-PFN had the worst outcomes. The results showed that A-PFN had the worst outcomes, while Intertan and double lag screw PFN had similar results [10]. In a meta-analysis comparing different PFN implant systems, it was found that the helical blade (PFNA) was not superior to screw systems, and long nails were not superior to short nails in terms of fixation stability and reoperation rates. However, the use of double lag screw systems resulted in lower rates of fixation failure and reoperation [11].

In our study, the most common complication was cut out. Cut-out rates ranging from 10-20% were observed depending on the implant design. These rates are consistent with the 3-18% cut-out rates reported in the literature [12, 13]. The lower cut-out rate in group 1 may be associated with a better reduction in those patients. However, the reliability of the low cut-out data in group 4 could be better due to the small sample size of only 20 patients.

The Z effect is a complication that can arise in PFN designs with double lag screws. It is characterized by the medial migration of the inferior and proximal lag screws and is closely related to the implant design [14]. In our study, we did not observe a Z-effect in any patient, possibly because all four nails used the locking mechanism of the locking screw to the blade.

One limitation of our study is its retrospective nature. Additionally, an unbalanced number of patients in groups 3 and 4 may affect the results.

Furthermore, we did not analyze the patients' clinical conditions before and after the fracture and surgery, which is another study limitation.

Conclusion

In conclusion, the results of this study indicate that the use of double lag screws in PFN implants is associated with superior fracture reduction, fewer complications, and a lower incidence of nonunion. Biomechanical studies and prospective randomized clinical trials are needed to understand this issue better.

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Retrospective Comparison of Age-Related Efficacy and Cost of Sugammadex and Neostigmine in Obese Female Patients Undergoing Elective Surgery

Elektif Cerrahi Uygulanan Obez Kadın Hastalarda Sugammadeks ve Neostigminin Yaşa Bağlı Etkinlik ve Maliyetinin Retrospektif Olarak Karşılaştırılması

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ABSTRACT

Aim: The purpose of the study is to compare the clinical impact and cost of sugammadex and neostigmine in obese, young-elderly patients

Materials and Methods: In this study, the medical and anesthesia records of patients whose operation did not exceed 150 minutes and who used rocuronium as a muscle relaxant were evaluated retrospectively. Patients whose files were examined were divided into 4 groups according to age and drug given; Group YS: 2 mg/kg sugammadex between 20–60 years, Group ES: 2 mg/kg sugammadex between 60-80years, Group YN: 0.04 mg/kg neostigmin + 0.01 mg/kg atropine between 20–60 years, Group EN: 0.04 mg/kg neostigmin + 0.01 mg/kg atropine between 60–80 years. Time of TOF 25, 75, 90 recovery scores were recorded from the anesthesia records of the patients.

Results: Regarding the time to reach TOF 25,75,90, it was seen that the patients in Group YS and Group ES reached faster TOF values than Group YN and Group EN (p<0,05). Compared with neostigmine, patients who were given sugammadex in the same age group were found to have faster recovery time and statistically significant differences (p<0,05).

Conclusion: Sugammadex provides rapid and effective reversal of moderate neuromuscular block compared to neostigmine, with a very low incidence of side effects and faster recovery times.

Keywords: Neostigmine, Obesity, Sugammadex, TOF, Age

ÖZ

Amaç: Çalışmanın amacı, obez, genç-yaşlı hastalarda sugammadeks ve neostigminin klinik etkisi ve maliyetini karşılaştırmaktır.

Gereç ve Yöntemler: Bu çalışmada, ameliyat süresi 150 dakikayı geçmeyen ve kas gevşetici olarak rokuronyum kullanılan hastaların tıbbi ve anestezi kayıtları retrospektif olarak değerlendirildi. Dosyaları incelenen hastalar yaş ve verilen ilaca göre 4 gruba ayrıldı; Grup YS: 20-60 yaş arası 2mg/kg sugammadeks, Grup ES: 60-80 yaş arası 2mg/kg sugammadeks, Grup YN: 20-60 yaş arası 0,04 mg/kg neostigmin + 0,01 mg/kg atropin, Grup EN: 60-80 yaş arası 0,04 mg/kg neostigmin + 0,01 mg/kg atropin. TOF 25,75,90 zamanı, derlenme skorları hastaların anestezi kayıtlarından kaydedildi

Bulgular: TOF 25,75,90'a ulaşma süreleri açısından Grup YS ve Grup ES'deki hastaların Grup YN ve Grup EN'ye göre daha hızlı TOF değerlerine ulaştığı görüldü. (p<0,05). Neostigmin ile karşılaştırıldığında, aynı yaş grubunda sugammadeks verilen hastaların daha hızlı iyileşme süresine sahip olduğu ve istatistiksel olarak anlamlı farklılıklar olduğu bulundu (p<0,05).

Sonuç: Sugammadeks, neostigmine göre orta dereceli nöromüsküler bloğun hızlı ve etkili geri dönüşümünü sağlamakla birlikte, çok düşük yan etki insidansına ve daha hızlı iyileşme sürelerine sahiptir.

Anahtar kelimeler: Neostigmin, Obezite, Sugammadeks, TOF, Yaş

Introduction

Neuromuscular blockers are agents frequently used during anesthesia to facilitate tracheal intubation, maintain mechanical ventilation, and make surgical operation conditions favorable. Reversal agents are used to reverse neuromuscular block and prevent postoperative residual curarization [1]

Postoperative residual decurarization due to neuromuscular blocker use is a problem of modern anesthesia. Neostigmine does not allow safe decurarization, especially when neuromuscular block monitoring cannot be performed [2]. Since these agents do not have full nicotinic selectivity, they also stimulate the muscarinic system and many serious undesirable effects may be encountered. To avoid these effects, decurarization is usually performed with the concomitant use of an anticholinergic agent (atropine, glycopyrrolate, etc.) [3].

Sugammadex is a fast-acting drug designed to surround rocuronium bromide [4]. Administration of sugammadex during rocuronium-induced neuromuscular block leads to4 rapid separation of free rocuronium molecules from plasma. A concentration gradient is formed as the remaining rocuronium molecules move from the neuromuscular junction to the plasma. Neuromuscular block ends rapidly with the diffusion of rocuronium molecules from the neuromuscular junction to the plasma [5].

As the obese and elderly population is increasing, the number of obese and elderly receiving general anesthesia is also growing. Anesthetic management is more difficult in obese and elderly patients. Geriatric patients are more sensitive to the depressant effect of the anesthetic drugs used and redistribution and elimination of the drugs used are slower [3]. Prolonged neuromuscular blockade is more frequently observed in obese patients because the distribution, metabolic half-life, and excretion of neuromuscular blockers change [6]. Most muscle relaxants are hydrophilic and their effects start early and last longer in obese patients [7]. The growth in the number of general anesthesia in elderly and obese patients leads to an increase in the number of perioperative complications, which in turn leads to an increase in patient costs [8-9].

We aimed to compare the clinical efficacy and cost of sugammadex and neostigmine in obese-elderly and obese-young patients scheduled for elective surgery due to the increase in the obese and elderly population and the increase in healthcare costs.

Materials and Methods

In this study, after the approval of Suleyman Demirel University Clinical Research Ethics Committee (decision dated 27.07.2016 and numbered 134), the files of a total of 130 patients who underwent an elective operation in Suleyman Demirel University Faculty of Medicine, Obstetrics and General Surgery between January 1, 2016, and June 31, 2016, were retrospectively analyzed.

The data of American Society of Anesthesiologists (ASA) I-II, 20-80 years old, obese (BMI: 30-40) patients who underwent general anesthesia under elective conditions, whose operation time did not exceed 150 minutes, who used propofol, fentanyl, lidocaine, rocuronium as muscle relaxant in induction, desflurane, oxygen and nitrogen protoxide in maintenance and whose muscle relaxant effect was reversed with neostigmine or sugammadex were included in the study.

Exclusion criteria were determined; pregnant women, patients with liver failure, renal failure, morbid obesity, muscle disease, magnesium, calcium channel-blocking drugs, and those allergic to the drugs used were excluded from the study.

Information about the patients was collected by examining anesthesia forms, our hospital's data processing program, epicrises, and archive files. However, 20 patients were not included in the study because of missing data, 5 patients were pregnant and 5 patients had preoperative calcium channel blocker use in the evaluated files. The remaining 100 patients were divided into 4 groups according to their data and evaluated:

GROUPS:

GROUP Young-Sugammadex (YS): 2mg/kg sugammadex between 20-60 years of age

GROUP Young-Neostigmine (YN): 0.04 mg/kg

neostigmine + 0.01 mg/kg atropine between 20-60 years of age

GROUP Elderly-Sugammadex (ES): 2 mg/kg sugammadex between 60-80 years of age

GROUP Elderly-Neostigmine (EN): Patients aged 60-80 years who received 0.04 mg/kg neostigmine + 0.01 mg/kg atropine were divided into groups.

According to the data we obtained from the files, patients were evaluated in terms of demographic data (age, height (cm), weight (kg), Body Mass Index (BMI) (kg/m2), Corrected Body Weight (CBW) (kg), rocuronium dose (mg), surgical time (min), Train of four (TOF) values (TOF 25-75-90), recovery time (time from extubation to MAS 9), complications - side effects, cost (drug vial price per patient) and comparisons were made.

The doses of the drugs used were calculated and administered according to the patient's corrected body weight (CBW).

CBW: ideal body weight (IBW)+0.4*(real body weight(RBW) - IBW), IBW: height (cm) - 105, BMI: weight/height (m²) was calculated according to the formulas.

Statistical Analysis

All data were analyzed with the statistical program SPSS 20.0 (Statistical Package for Social Sciences Inc; Chicago, IL, USA). Qualitative data were presented as numbers and percentages, and quantitative data were presented as mean and standard deviation. Kolmogorov-Smirnov test was used to analyze the distribution of the data. In this context, parametric tests were applied to normally distributed data, while nonparametric tests were applied to non-normally distributed data. The chi-square test was used to analyze qualitative data and the Mann-Whitney U test was used to analyze quantitative data. A two-way ANOVA test was used for intragroup comparisons. $p < 0.05$ was considered statistically significant.

Results

Demographic characteristics, CBW (kg), BMI (kg/m2), surgical time (min), and total rocuronium dose (mg) are shown in Table 1. There was no difference between the groups in terms of demographic

characteristics, CBW, total rocuronium dose, and duration of surgery, but there was a statistical difference in terms of age.

Table 1. Demographic characteristics, rocuronium dose, and duration of surgery according to groups

	Group YN (n:25)	Group YS (n:25)	Group EN (n:25)	Group ES (n:25)	ᵃp
Age (years)	49.9 ±5.3	45.2 ±5.6	66.6 ±6.0	65.7±5.2	<0.001*
Height (cm)	157.4 ±3.8	157.6 ±4.1	158.0 ±5.1	157.6 ±3.9	0.965
Weight (kg)	83.6 ±7.7	82.4 ±6.6	81.3 ±9.8	79.9±5.4	0.359
BMI (kg/m2)	33.3 ±2.0	33.2 ±2.4	32.7 ±2.8	32.4±2,1	0.464
CBW (kg)	65.0 ±5.0	65.4 ±4.0	64.4 ±6.0	64.0±3,6	0.740
Rocuronium Dose (mg)	54.88 ±10.2	55.2 ±8.9	52.6 ±7.7	57±7.2	0.652
Surgical time (min)	104.8 ±28.3	99.6 ±23.1	105.2 ±25.0	113.2 ±20.9	0.275

BMI: Body Mass Index, CBW: Corrected Body Weight, min:minutes
Data are shown as mean ±SD, Chi-square test used in the analysis of the variables, (p<0.05): Statistically significant

When TOF 25, 75, and 90 values were analyzed in patient groups aged 20-60 years, it was observed that sugammadex was more effective than neostigmine and there was a statistically significant difference (p<0.05) (Table 2). When TOF 25, 75, and 90 values were analyzed in the patient groups aged 60-80 years, it was observed that sugammadex was more effective than neostigmine and there was a statistically significant difference (Table 2).

Table 2. TOF 25, 75, and 90 values of sugammadex and neostigmine in patient groups aged 20-60 years and 60-80 years

	Group YN (n:25)	Group YS (n:25)	Group EN (n:25)	Group ES (n:25)	ᵃp
TOF 25 (min)	6.64±1.8	1.52±0.7	7.08±1.1	1.72±0.7	<0.001*
TOF 75 (min)	9.68±2.0	2.72±0.8	10.48±1.4	2.96±0.7	<0.001*
TOF 90 (min)	11.24±2.4	3.04±0.7	12.16±1.6	3.80±0.7	<0.001*

TOF: Train of Four. Data are shown as mean ±SD, Chi-square test used in the analysis of the variables, (p<0.05): Statistically significant

When the recovery times were analyzed, it was observed that those who received sugammadex recovered faster than neostigmine in the patient groups aged 20-60 years (Group GN-Group GS) and it was found to be statistically significant (p<0.05) (Table 3). In patients aged 60-80 years (Group YN-Group YS), those who received sugammadex recovered faster than those who

received neostigmine, which was statistically significant (p<0.05) (Table 3).

Tablo 3. Recovery times of patients aged 20-60 years and 60-80 years who received sugammadex and neostigmine

	Group YN (n:25)	Group YS (n:25)	Group EN (n:25)	Group ES (n:25)	ᵃp
Recovery time (min)	13.16±7.6	7.92±4.4	14.4±6.7	9.08±3	<0.001*

Data are shown as mean ±SD, p<0.05: Statistically significant, Chi-square test used in the analysis of the variables

When the complications and side effects between the groups were analyzed, no side effects and complications were observed in Group YS, nausea-vomiting was observed in one patient, and surgical incision site pain was observed in one patient in Group ES. In Group YN, salivation was observed in 6 patients, surgical incision site pain in 1 patient, and spasm in 1 patient. In group EN, increased salivation was observed in 5 patients, surgical incision site pain in 1 patient, nausea-vomiting in 2 patients, and bradycardia in 1 patient. When compared between groups, there was a significant difference in complications and side effects in neostigmine groups compared to sugammadex (p= 0.032).

When sugammadex and neostigmine were compared in terms of cost, it was observed that the price per patient of sugammadex (price per patient; 85 TRY) was higher than the other group (price per patient; 3.37 TRY) and there was a statistical significant difference (p<0.05).

Discussion

Neuromuscular blocking agents (NMBA) are an important part of modern anesthesia. Muscle relaxants provide more favorable intubation conditions by suppressing voluntary and reflex muscle movements. In addition, adequate muscle relaxation is achieved for surgical intervention under less anesthetic agent requirement [10].

Sugammadex is a new-generation cyclodextrin derivative agent used in the reversal of the effect of steroidal NMBAs. It encapsulates lipophilic NMBAs with high affinity and forms encapsulation. Thus, the binding of steroidal NMBAs to the receptor is prevented [11]. Sugammadex can be administered at doses between 2 mg/kg and 16

mg/kg depending on the depth of neuromuscular blockade [12]. Sorgenfrei et al. examined the dose-response relationship of sugammadex in reversing neuromuscular block provided by rocuronium in their study, administered sugammadex at doses of 0.5, 1.0, 2.0, 3.0, and 4.0 mg/kg and found that sugammadex dose of 2 mg/kg and above was safe [13]. In our study, 2 mg/kg sugammadex was applied in moderate neuromuscular blocks (when TOF was 2) in parallel with the literature.

Neostigmine inhibits acetylcholinesterase at the nerve-muscle junction and increases acetylcholine levels and enables non-depolarizing muscle relaxant drugs to discharge acetylcholine receptors through competitive inhibition [3]. Choi et al. administered neostigmine at doses of 10 mcg/kg, 20 mcg/kg, and 40 mcg/kg in the superficial neuromuscular blockade and TOF values were examined. It was found that neostigmine administered at 40 mcg/kg reversed neuromuscular block effectively [14]. In our study, neostigmine was administered at a dose of 40 mcg/kg.

Obesity leads to changes in the pharmacodynamics of anesthetic drugs [7]. Van Lancker P. et al. compared the dose of sugammadex according to four different weights in morbidly obese patients (BMI>40) in the reversal of neuromuscular block provided by rocuronium. The time from TOF 2 to TOF 0.9 was IBW: 188 sec, IBW+IBW(20%): 154 sec, IBW+IBW(40%): 112 sec and RBW: 128 sec. In this study, sugammadex 2 mg/kg IBW+IBW (40%) was recommended as the optimal dose [15]. In our study, similar to this study, drugs were administered at the same dose according to CBW to reverse the neuromuscular block induced by rocuronium.

When we look at the studies comparing the efficacy of sugammadex and neostigmine, Woo et al. showed that sugammadex at a dose of 2 mg/kg administered when TOF ratio reached 2 provided TOF 0.9 after an average of 1.8 minutes, whereas the average time to reach TOF 0.9 with neostigmine administered when TOF was 2 was found to be 14.8 minutes in their study on a total of 128 patients [16]. In a review by Chambers et al., the clinical effect of sugammadex was evaluated and a total of 2132 abstracts and 265 publications

were reviewed. In shallow blocks, mean TOF values of 1.3-1.7 min for sugammadex, 21-86 min for placebo, 17.6 min for neostigmine, and 0.9 TOF values were found. In deep blocks, TOF 0.9 values of 2.7 min for sugammadex, >90 min for placebo, and 49 min for neostigmine were found [17]. Unal et al. compared the efficacy, cost, and respiratory complications of sugammadex and neostigmine in patients with obstructive apnea syndrome. In the times to reach TOF 0.9, sugammadex was found to be 2 minutes and neostigmine 8 minutes [18]. In our study, the time to reach TOF 0.9 was found to be 3.04 min for sugammadex in young patients and 3.8 min in elderly patients, while neostigmine was found to be 11.24 min in young patients and 12.16 min in elderly patients and a statistically significant difference was found ($p<0.001$).

Ach esterase inhibitors affect muscarinic receptors as well as nicotinic receptors and related side effects occur (bradycardia, hypotension, bronchoconstriction, hypersalivation, nausea, and vomiting) [19]. Sugammadex, on the other hand, affects NMBA via encapsulation, and muscarinic side effects are not observed since there is no interaction at the receptor level [20]. Diego et al. investigated postoperative visual analog score and nausea and vomiting in 88 morbidly obese patients who underwent bariatric surgery. The patients were divided into two groups neostigmine and sugammadex. In the post-anesthetic care unit (PACU), the visual analog score and nausea and vomiting values of the group given sugammadex were found to be lower at 30 and 60 minutes [21]. Similar to the results of the previous studies, side effects were observed less in the patient groups receiving sugammadex in our study.

Residual curarization is the presence of still blocked nicotinic receptors in the postoperative patient [22]. Although the effect of NMBAs is carefully monitored and reversed in the operating room, residual effects may occur in the early period. Esteves et al. found that 26% of patients admitted to PACU had a TOF value below 0.9 [23]. It has been reported that residual curarization is higher in elderly patients and therefore, it is recommended that neuromuscular junction conduction monitoring should be performed in the recovery room until the postoperative TOF ratio is 0.9 and above to prevent residual curarization,

especially in elderly patients [24]. Considering these studies, the gold standard TOF response that provides neuromuscular recovery has been accepted as 0.9.

Looking at the studies in which postoperative recovery scores were evaluated, Pişkin et al. compared the postoperative recovery times of sugammadex and neostigmine in their study and found that the MAS ≥ 9 score of sugammadex and neostigmine was 8.26 min and 16.93 min, respectively, and a statistically significant difference was found [25]. When MAS in our study was analyzed, a statistically significant difference was found between the sugammadex and neostigmine groups ($p<0.001$).

In terms of cost, in the study conducted by Unal et al., the efficacy and cost of sugammadex and neostigmine were compared in patients with obstructive apnea syndrome, and although the vial price of sugammadex was higher in terms of cost, sugammadex was found to be more advantageous than neostigmine in terms of complications and total cost [17]. In terms of cost, sugammadex was found to be more expensive than neostigmine in terms of drug price in our study and a statistically significant difference was found ($p<0.001$). However, a complete cost analysis could not be performed because the effect of the time spent in the operating room and PACU on the price, the prices of operating room doctors, technicians, and personnel were not taken into account, and the prices of the patient's side effects and complication-related conditions could not be calculated.

Our study has some limitations. The first of these is that our study was retrospective. In addition, difficulties in accessing archival documents, insufficient epicrises, and deficiencies in anamnesis forms caused difficulties. Another limitation is that TOF values were not analyzed in PACU, and the lack of detailed cost analysis constitutes another limitation of the study.

Conclusion

Despite its higher cost compared to neostigmine in young and elderly obese patients, sugammadex was found to be effective in terms of rapid and effective reversal from moderate neuromuscular

block, very low incidence of side effects, and reduced recovery time.

Ethics Committee Approval: Suleyman Demirel University ethics committee approved this study (decision number: 134, approval date: 27.07.2016)

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Functional and radiological comparison of volar locking plate and K-wire augmented volar locking plate fixation in intra-articular and comminuted distal radius fractures

Eklem içi ve parçalı distal radius kırıklarında volar kilitli plak ile K-teli destekli volar kilitli plak tespitinin fonksiyonel ve radyolojik karşılaştırması

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ABSTRACT

Aim: This study aims to determine whether additional K-wires to volar plating impact the radiologic and functional outcomes of comminuted distal radius fractures (DRFs).
Methods: Forty-two patients treated with either a volar locking plate or a K-wire augmented volar locking plate for intra-articular comminuted distal radius fractures (AO type C) between February 2008 and December 2014 at Haseki Hospital were retrospectively analyzed. Wrist range of motion and hand grip strength were recorded. Patients were evaluated using the Gartland-Werley scale, QuickDASH scale, and Mayo wrist score. Radiological assessments were based on wrist radiographs taken during the last follow-up.
Results: No statistically significant difference was observed between the two groups in terms of the range of motion of the affected wrist joint (all p values >0.05). Similarly, there were no statistically significant differences in the Mayo wrist score, Gartland-Werley score, QuickDASH scale, or Stewart score between the two groups (p=0.17, p=0.36, p=0.38, and p=0.35, respectively). At final follow-ups, radial length loss and radial tilt loss did not significantly differ in either group compared to the healthy side (p=0.98 and p=0.96, respectively).
Conclusion: Given the potential complications associated with bridge external fixators and K-wires in treating comminuted distal radius fractures, volar locking plates can be safely used alone for managing these fractures.

Keywords: Intra-articular distal radius fracture; K-wire augmented locking plate; functional outcomes; wrist injuries

ÖZ

Amaç: Bu çalışmanın amacı, volar plaklamaya eklenen K-tellerinin parçalı distal radius kırıklarının radyolojik ve fonksiyonel sonuçlarını etkileyip etkilemediğini belirlemektir.
Gereç ve Yöntem: Şubat 2008 ile Aralık 2014 tarihleri arasında Haseki Hastanesi'nde eklem içi parçalı distal radius kırıkları (AO tip C) nedeniyle volar kilitli plak veya K-teli destekli volar kilitli plak ile tedavi edilen 42 hasta retrospektif olarak incelenmiştir. Bilek hareket açıklığı ve el kavrama kuvvetleri kaydedilmiştir. Hastalar, Gartland-Werley skalası, QuickDASH ölçeği ve Mayo bilek skoru kullanılarak değerlendirilmiştir. Radyolojik değerlendirmeler, son kontrolde çekilen bilek grafileri ile yapılmıştır.
Bulgular: Etkilenen bilek ekleminin hareket açıklığında iki grup arasında istatistiksel olarak anlamlı bir fark saptanmamıştır (tüm p değerleri >0,05). Aynı şekilde, Mayo bilek skoru, Gartland-Werley skoru, QuickDASH ölçeği ve Stewart skoru açısından da istatistiksel olarak anlamlı bir fark gözlenmemiştir (sırasıyla p=0,17, p=0,36, p=0,38 ve p=0,35). Son kontrollerde radial uzunluk kaybı ve radial tilt kaybı her iki grupta sağlıklı tarafa göre anlamlı farklılık göstermemiştir (sırasıyla p=0,98 ve p=0,96).
Sonuç: Eklem içi parçalı distal radius kırıkları tedavisinde köprü eksternal fiksatörler ve K-tellerinin olası komplikasyonları göz önünde bulundurulduğunda, bu kırıkların tedavisinde volar kilitli plakların tek başına güvenle kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Eklem içi distal radius kırığı; K-teli destekli kilitli plaklama; fonksiyonel sonuçlar; el bilek yaralanmaları

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Introduction

Distal radius fractures (DRFs) are among the most common fracture types, accounting for 8% to 15% of all fractures [1]. In young patients, intra-articular fractures typically result from high-energy trauma, whereas extra-articular distal radius fractures more commonly arise from low-energy trauma in the osteoporotic geriatric population [2]. The pathophysiology of intra-articular distal radius fractures involves shear forces generated as axial loads transfer from the hand to the radius articular surface. These forces can cause both displaced articular fractures and central impaction [3].

According to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, the "C" subgroup includes comminuted fractures that involve the joint [4]. Distal radius type C fractures are considered unstable. Given the risks of malunion, joint incongruity, and osteoarthritis, unstable DRFs are typically managed surgically rather than conservatively [5]. Various surgical methods have been described for unstable DRFs, including open reduction internal fixation, bridge plating, percutaneous pinning with casting, external fixation, and adjunctive Kirschner (K) wire fixation. However, no consensus exists on an optimal approach [6, 7].

Despite advancements in fixation methods, K-wires remain essential in the treatment of unstable DRFs. In comminuted DRFs managed with open reduction and internal fixation, articular subsidence is common because fracture fragments lack soft tissue attachments and may not be fully supported by peri-articular plates. Additionally, discrepancies between plate design and patient anatomy may result in screw placement below the joint line, limiting direct support for osteochondral fragments. Adding K-wires aims to address these limitations by providing additional stabilization. While a few studies have compared radiologic and functional outcomes of K-wire fixation with internal or external fixation for comminuted DRFs [8, 9], findings suggest no definitive superiority in functional outcomes between methods [8, 9]. However, Micic et al. reported significantly reduced articular step-off when K-wires were added to external fixation [9].

To our knowledge, few studies have examined the role of additional K-wires in volar plating specifically. Thus, our study aims to evaluate whether adding K-wires to volar plating affects the radiologic and functional outcomes of comminuted DRFs. The hypothesis of our study was that fractures fixed with volar plate and fractures fixed with k-wire augmented volar plate would have similar results in terms of joint range of motion, functional scoring, and grip strength, while k-wire augmented volar plating would be superior in terms of radiological evaluations.

Methods

In this retrospective study, we analyzed 42 patients who were treated with either a volar locking plate or a K-wire-augmented volar locking plate for intra-articular, comminuted distal radius fractures (AO type C) between February 2008 and December 2014 at Haseki Training and Research Hospital. The study was approved by the hospital's Institutional Review Board, and informed consent was obtained from all patients. Inclusion criteria were patients aged ≥16 years who had no follow-up loss and responded to the final follow-up call. Patients were excluded if they were aged <16 years, had additional injuries in the same extremity, a history of previous surgery, medical contraindications, open or pathological fractures, bilateral wrist fractures, refused study participation, or presented with AO type A or B fractures. Patients under 16 were excluded to control for the potential impact of bone remodeling on fracture healing. Of the initial 42 patients, six did not meet the inclusion criteria, resulting in a final sample of 36 patients who underwent surgery. (Figure 1.) These patients were classified into two groups based on fixation technique: Group I received volar locking plate fixation (Figures 2a–2d), and Group II received K-wire-augmented volar locking plate fixation (Figures 3a–3d).

Preoperative evaluation of DRFs was conducted using wrist X-rays and computed tomography, and fractures were classified according to the AO classification system [4]. The distribution of fracture types was as follows: Group I - C1 (n=6), C2 (n=9), C3 (n=3); Group II - C1 (n=6), C2 (n=8), C3 (n=4) (Table 1).

42 patients
Treated with volar locking plate or K-wire augmented volar locking plate

1 patient have ipsilateral supracondylar humerus fracture

41 patients

2 patients has bilateral fracture

39 patients

3 patients loss follow up

36 patients
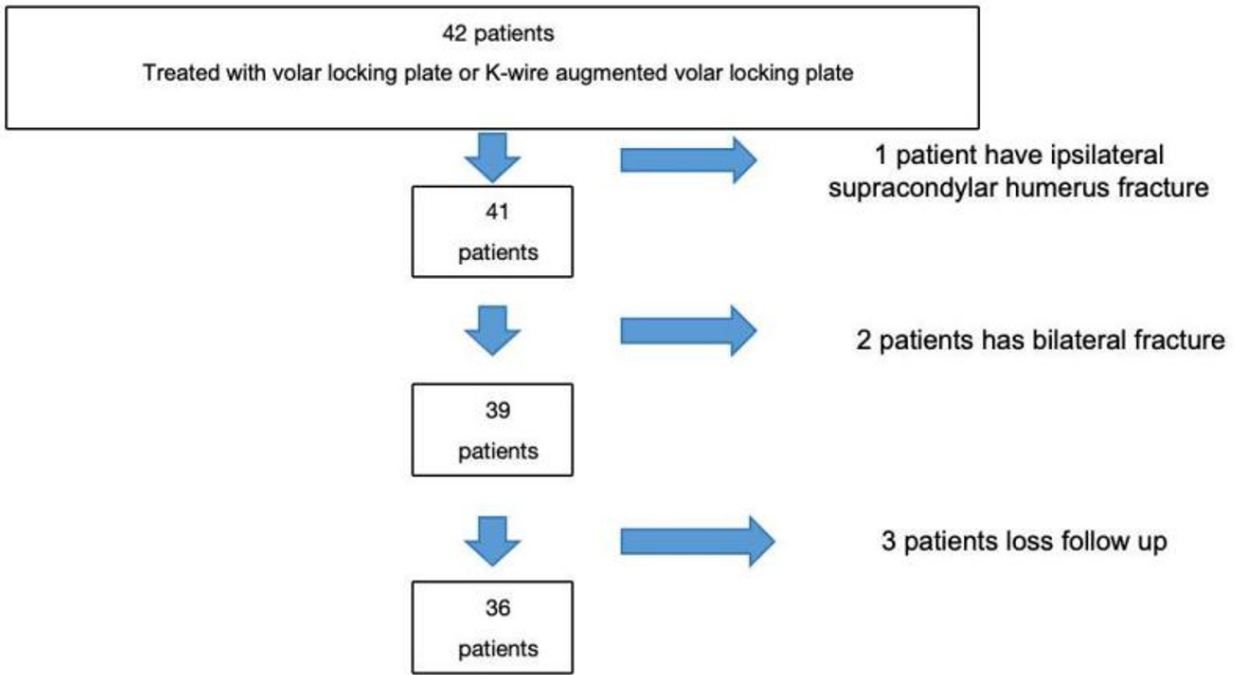
Figure 1. Inclusion and exclusion criterias

Figure 2. A 45-year-old female patient with an intra-articular fracture of the left radius (AO C2). AP/lateral radiographs in the pre-operative period (a, b). Early radiographs following open reduction with a volar plate (Group I) (c, d). AP/lateral radiographs of the patient at the postoperative 24th month (last follow-up) (e, f).
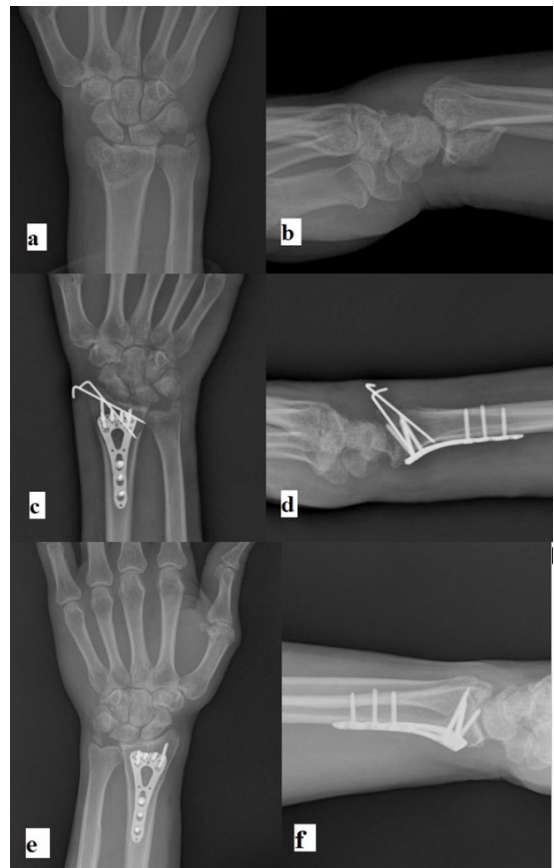
Figure 3. A 54-year-old male patient with an intra-articular fracture of the right radius (AO C2). AP/lateral radiographs in the pre-operative period (a, b). Early radiographs of the patient who underwent K-wire augmented volar locking plate (Group II) (c, d). AP/lateral radiographs of the patient at the postoperative 48th month (last follow-up) (e, f).

Table 1. Patient characteristics of 36 patients treated for type C distal radius fracture in both groups. SD: Standard deviation

Variable	Group I (Volar locking plate) (n=18)	Group II (K-wire augmented volar locking plate) (n=18)	P value
Age (years) (Mean ± SD)	50,05±15,39 (range: 41-87)	53,16±14,19 (range: 41-87)	0.65
Sex			
Female	7	7	1
Male	11	11	
AO type of fracture			
23-C1	6	6	0.9
23-C2	9	8	
23-C3	3	4	
Affected hand (n)			
Right	8	10	0.74
Left	10	8	
Dominant hand (n)			
Right	16	17	0.5
Left	2	1	
Follow-up mean (month)	44,00±22,35 (range: 18-104)	51,44±23,54 (range: 10-100)	0.39
Time interval between trauma and operation (Mean ± SD, range, day)	11,11±5,07 (range: 1-21)	11,66±7,95 (range: 3-30)	0.62
Time of bone healing (Mean ± SD, range, week)	7,27±3,17 (range :4-14)	7,22±2,66 (range: 4-12)	0.91
Complications (n)			
Tenosynovitis	2	2	0.54
Carpal tunnel syndrome (CTS)	1	1	
Pin site infection	0	2	

Surgical Technique

All surgeries were performed by a senior orthopedic surgeon. Patients received a single preoperative dose of 2 g cefazolin administered intravenously, and a proximal tourniquet was applied at 250 mmHg. A skin incision was marked along the volar Henry approach [8]. In Group I, following skin incision, the flexor carpi radialis (FCR) tendon was retracted radially, and the pronator quadratus muscle was detached from its origin and shifted to the ulnar side, exposing the fracture site. After achieving reduction with temporary K-wires under fluoroscopy, a 2.4-mm variable angle, locking compression 2-column distal radius plate (Synthes, Paoli, PA) was secured with locking screws, and K-wires were removed post-fixation. The pronator quadratus muscle was then repaired, the tourniquet was released, hemostasis was achieved, and the skin was closed in layers. In Group II, the same procedure was followed, with the addition of 1.5-mm diameter K-wires to stabilize intra-articular fragments after reduction. An average of two K-wires was used per patient, with the wire ends bent outside the skin.

Postoperative Management

Postoperatively, a soft resting wrist cast was applied to both groups. On the first postoperative day, active and passive exercises for finger and elbow joints were initiated under physiotherapy guidance. The cast was removed after two weeks, following clinical and radiographic evaluation. During follow-ups, patients were encouraged to perform muscle-strengthening and wrist range of motion exercises according to the degree of union. In Group II, wire ends were checked for infection every three days, and the supportive K-wires were removed at six weeks.

Evaluation

Radiographic evaluations were performed using standard posterior-anterior and lateral wrist radiographs during the final postoperative follow-up (Figures 2e, 2f, 3e, and 3f). Comparisons were made between the affected and unaffected sides, measuring radial length, radial inclination, and dorsal angulation for each patient through a calibrated hospital digital imaging system (PACS). Anatomical findings were assessed according to **Stewart's radiological criteria [10].**

Joint range of motion was objectively measured with a standard goniometer at the final follow-up, referencing the healthy side. Grip strength was evaluated using the Jamar Hand Dynamometer (Jamar, Preston, USA), with comparisons made to the unaffected wrist (scored 0 = completely impaired to 100 = normal function). Demographic data, including age, gender, hand dominance, fracture type, and complications, were recorded.

An independent observer conducted a subjective functional evaluation using the Turkish version of the QuickDASH scale [11], visual analog scale (VAS), Gartland-Werley scale [12], and Mayo wrist score at the final follow-up. The mean follow-up duration was 44.00 ± 22.35 months (range: 18–104 months) for the volar locking plate group (Group I) and 51.44 ± 23.54 months (range: 20–100 months) for the K-wire-augmented volar locking plate group (Group II), with no statistically significant difference observed between the groups (Table 1).

Statistical Analysis

The statistical analyses were conducted using SPSS version 22.0 (IBM Corp, 2011, Armonk, New York). Group differences were analyzed using the Mann-Whitney U test, chi-square test, and, when applicable, Student's t-test. A p-value of ≤ 0.05 was considered statistically significant.

Results

All fractures healed without the need for additional intervention. No patients experienced distal radioulnar instability. Group I experienced complications in three patients, with one case of carpal tunnel syndrome (CTS) and two cases of tenosynovitis. In Group II, complications arose in five patients, with carpal tunnel syndrome in one patient, tenosynovitis in two, and superficial pin infection in two (Table 1). Patients with superficial pin infections were treated with oral antibiotics and daily dressing. No deep bone infections were observed at the final follow-up. All cases of tenosynovitis and carpal tunnel syndrome resolved with medical treatment and physical therapy. No patients experienced joint stiffness or reflex sympathetic dystrophy during follow-up.

There were no statistically significant differences in demographic characteristics between groups (p>0.05) (Table 1). The two groups showed similarity in terms of age, gender, fracture type distribution, interval between trauma and surgery, and bone healing time (p=0.65, p=1, p=0.9, p=0.62, and p=0.91, respectively).

The final postoperative mean active range of motion for both groups is displayed in Table 2. Although Group I demonstrated slight superiority in flexion, extension, supination, and pronation, no statistically significant difference was found between groups regarding wrist joint range of motion (all p values >0.05) (Table 2). Grip strength was marginally higher in Group I at the final follow-up but without statistical significance (p=0.38). Group I's mean grip strength was 29.50±8.25 kg (range: 8–42), equating to 80% of the healthy side, while Group II's mean grip strength was 26.88±15.61 kg (range: 4–45), representing 73% of the healthy side (Table 2). The mean VAS score in Group I was 0.77±1.00 (range: 0–0.3) compared to 2.44±2.77 (range: 0–1) in Group II. Although Group I showed an advantage, the difference was not statistically significant (Table 2).

Table 2. Comparison of wrist range of motion and functional assessments of the two treatment groups at final follow-up. SD: Standard deviation. QuickDASH: Quick Disability of the Arm, Shoulder, and Hand

Variable	Group I	Group II	
Range of motion at final follow-up (°)			
Flexion (º) (Mean ± SD)	64,61±24,90 (range: 5-95)	57,83±21,62 (range: 15-90)	0.28
Extension (º) (Mean ± SD)	66,11±21,52 (range: 25-90)	59,16±19,19 (range: 15-90)	0.24
Supination (º) (Mean ± SD)	79,44±12,35 (range: 45-90)	73,61±16,16 (range: 45-90)	0.28
Pronation (º) (Mean ± SD)	80,00±12,60 (range: 45-90)	71,94±8,32 (range: 30-90)	0.15
Radial deviation (º) (Mean ± SD)	16,94±7,88 (range: 5-30)	16,83±9,10 (range: 3-35)	0.91
Ulnar deviation (º) (Mean ± SD)	25,50±10,45 (range: 5-40)	24,16±10,18 (range: 5-50)	0.59
Grip strength (kg)	29,50±8,25 (range: 8-42)	26,88±15,61 (range: 4-45)	0.38
Visual Analogue Scale	0,77±1,00 (range: 0-0.3)	2,44±2,77 (range: 0-1)	0.08
Mayo Wrist Score (Total points)	80,00±16,35 (range: 30-100)	75,00±12,24 (range: 50-90)	0.17
Poor (n)	1	4	0.14
Fair (n)	5	4	
Good (n)	5	8	
Excellent (n)	7	2	
Gartland & Werley Score (Total points)	4,22±4,68 (range: 0-14)	6,44±6,06 (range: 0-22)	0.36
Poor (n)	0	1	0.21
Fair (n)	5	5	
Good (n)	2	6	
Excellent (n)	11	6	
QuickDASH scale	8,96±11,28 (range: 0-40,90)	14,17±16,59 (range: 0-47,72)	0.38

In Group I, the mean Mayo wrist score was 80.00±16.35 (range: 30–100), with results being excellent in seven patients, good in five, fair in five, and poor in one. Group II's mean Mayo wrist score was 75.00±12.24 (range: 50–90), with excellent results in two patients, good in eight, fair in four, and poor in four. No significant difference was observed between groups regarding Mayo wrist score distribution (p=0.14) or means (p=0.17) (Table 2). The mean Gartland-Werley score in Group I was 4.22±4.68 (range: 0–14), yielding excellent results in eleven patients, good in two, and fair in five. In Group II, the mean Gartland-Werley score was 6.44±6.06 (range: 0–22), with excellent results in six patients, good in six, fair in five, and poor in one. No significant difference was noted between groups for Gartland-Werley score distribution (p=0.21) or means (p=0.36) (Table 2). The mean QuickDASH score was 8.96±11.28 (range: 0–40.90) in Group I and 14.17±16.59 (range: 0–47.72) in Group II, with no statistically significant difference (p=0.38) (Table 2).

The final follow-up radiological measurements for both groups are presented in Table 3. Both groups were comparable regarding radial height (p=0.61), radial inclination (p=0.87), and volar tilt (p=0.78). Radial length and tilt losses did not differ significantly from the healthy side in either group (p=0.98 and p=0.96, respectively) (Table 3). In Group I, the mean Stewart score was 1.83±2.70 (range: 0–10), with results classified as excellent in ten patients, good in six, and fair in two. Group II's mean Stewart score was 1.94±1.39 (range: 0–5), with excellent results in five patients, good in twelve, and fair in one. No statistically significant differences were found between groups in terms of Stewart score distribution (p=0.15) or means (p=0.35) (Table 3).

Discussion

This study aimed to evaluate the impact of additional Kirschner wires alongside volar plating on the final follow-up outcomes in terms of range of motion, grip strength, functional scores, and radiological measurements in DRFs with intra-articular collapsed osteochondral fragments. The findings support our initial hypothesis that, although Group I had minor advantages, both techniques would yield comparable outcomes

in range of motion, functional scores, and grip strength. However, the lack of significant differences in radiological measurements and scoring between the two techniques does not support our secondary hypothesis.

Table 3. Comparison of radiographic measurements at last follow-up between the two groups. SD: Standard deviation.

Variable	Group I (Volar locking plate) (n=18) (Mean ± SD)	Group II (K-wire augmented volar locking plate) (n=18) (Mean ± SD)	P value
Radial height (mm)	10,61±4,03 (range: 0-15)	10,58±3,64 (range: 4-17)	0,61
Loss of radial length (mm)	3,22±4,26 (range: 0-14)	2,64±2,87 (range: 0-9)	0,98
Radial inclination (°)	18,77±6,59 (range: 2-30)	19,47±4,90 (range: 10-30)	0,87
Loss of radial inclination (°)	3,94±5,12 (range: 0-19)	3,52±4,15 (range: 0-12)	0,96
Volar tilt (°)	7,94±5,41 (range: 0-16)	7,47±3,76 (range: 1-13)	0,78
Stewart score (Total points)	1,83±2,70 (range: 0-10)	1,94±1,39 (range: 0-5)	0,35
Fair (n)	2	1	0.15
Good (n)	6	12	
Excellent (n)	10	5	

Restoring the joint surface and preserving radial height are crucial in the surgical management of comminuted distal radius fractures to protect cartilage and restore normal wrist kinematics [13]. Postoperative joint surface incongruity has been associated with arthritic changes in the wrist [14]. Various approaches to treating comminuted distal radius fractures have been studied extensively [15-17]. Treatment choice is influenced by surgeon preferences, potential complications, and patient factors such as lifestyle, age, comorbidities, mental attitude, and compliance [18,19]. Open reduction and volar plating have become widely accepted approaches for comminuted DRFs, yet these fractures remain challenging for orthopedic surgeons.

Anatomical plates for distal radius fractures generally align well with the average distal radius contour, but variations in patient anatomy and plate design can cause distal screws to be positioned below the joint line, potentially compromising contact with osteochondral fragments [20]. Consequently, osteochondral fragment stability

relies on the surrounding bone, which is less rigid and more susceptible to collapse. Our secondary hypothesis—that radiological outcomes might favor the K-wire-augmented volar locking plate group—was based on these anatomical and design limitations. However, our findings showed no significant difference between groups in terms of radial height, radial length loss, radial inclination, radial inclination loss, volar tilt, or Stewart score.

There remains no consensus in the literature on the optimal surgical approach for comminuted distal radius fractures [21,22]. K-wire-augmented external fixation has been reported to yield favorable results, particularly in very distal fractures where screws alone cannot secure osteochondral fragments [8, 17, 23, 24]. Egol et al. found that volar locking plates, as opposed to K-wire-supported external fixation, provided better range of motion and radiological outcomes at three and six months, with better long-term pronation preservation in the volar plating group [17]. Additionally, patients treated with external fixation required twice as much postoperative physiotherapy [17]. Gereli et al. reported improved wrist flexion and supination with volar plate fixation in intra-articular distal radius fractures, with no significant differences in grip strength loss, return-to-work time, Gartland-Werley score, and QuickDASH score between groups [8]. Another study found a significant advantage in wrist pronation and supination in the volar plate group compared to the K-wire-supported external fixation group at early follow-up, with the volar plate group demonstrating better grip strength after one year [24]. Kumbaracı et al. observed no significant difference in grip strength between groups after 12 months, despite the early initiation of wrist ROM exercises in the volar plating group [25]. In our study, no significant difference was found between groups regarding wrist ROM, grip strength, or functional scores (VAS, Mayo Wrist Score, Gartland-Werley Score, QuickDASH) at the final follow-up, aligning with previous literature comparing volar locking plates and K-wire-supported external fixation for intra-articular distal radius fractures.

Minimizing the articular step-off and restoring radial length are key radiological criteria associated with improved postoperative outcomes [26]. Gereli

et al. reported that volar plating was superior to K-wire-supported external fixation in preserving ulnar variance and correcting palmar angulation [8]. Similarly, Duramaz et al. demonstrated that all radiological parameters except ulnar variance and palmar tilt favored volar plating over K-wire-supported external fixation [23]. In our study, radiological parameters (radial height, radial length loss, radial inclination, radial inclination loss, volar tilt) were similar between the K-wire-augmented and volar locking plate groups in treating intra-articular distal radius fractures, with no significant difference observed in the Stewart score.

It is essential to consider that excessive distraction and prolonged fixation with K-wire-supported bridge external fixators, commonly used for comminuted distal radius fractures, can lead to complications [27]. Common complications include superficial radial nerve injury, reflex sympathetic dystrophy, grip strength loss, fixation loss, pin tract infections, and joint stiffness [27]. Moreover, loss of palmar angulation may persist long-term, even after fixator removal [27]. Managing these complications is challenging and negatively impacts treatment success. Additionally, studies have shown higher patient satisfaction with volar plating compared to K-wire-supported bridge external fixation for comminuted distal radius fractures [8, 23]. Our study similarly found no significant difference in functional and radiological outcomes when percutaneous pinning was combined with volar plating.

The limitations of this study include its retrospective design, small sample size, lack of randomization, and absence of follow-up data beyond the final assessment. However, the study's strengths include homogeneous demographic data in terms of age, gender, hand dominance, affected hand, time between trauma and surgery, and fracture type. Furthermore, our study provided an average follow-up of at least 44 months for both groups.

Conclusion

In conclusion, our study data did not demonstrate any clinical or radiological superiority of K-wire support when added to volar locking plating in the treatment of comminuted distal radius fractures. In distally located intra-articular distal radius

fractures, subchondrally placed distal screws in volar locking plates appear to provide sufficient stability to free osteochondral fragments via a buttress effect. We suggest that the potential impact of K-wire support on radiological outcomes may become evident with a larger sample of AO type C3 distal radius fractures, particularly those involving multiple osteochondral fragments.

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Association of Troponin, C-Reactive protein, Albumin and C-Reactive protein/Albumin Ratios with Mortality in Intensive Care Unit Patients with Community-acquired Pneumonia

Toplum Kökenli Pnömonisi olan Yoğun Bakım Hastalarında Troponin, C-Reaktif protein, Albumin ve C-Reaktif protein/Albümin Oranlarının Mortalite ile İlişkisi

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ABSTRACT

Aim: Parameters used to determine prognosis in community-acquired pneumonia (CAP) patients often have limited clinical value. This study aims to examine the efficacy of CRP, albumin, CRP/albumin ratio and troponin elevation in predicting 30-day mortality in patients hospitalized in the intensive care unit with CAP.

Material and Methods: In this study, 200 patients (85 females and 115 males) older than 18 years of age with a diagnosis of CAP who were followed up in the intensive care unit after emergency department admission between January 1, 2023 and January 1, 2024 were included. Patients who underwent chest radiography and biochemical analyses, including complete blood count, CRP and albumin, within the first 24 hours, were divided into two groups: those who died and those who survived. Troponin, CRP, albumin, and CRP/albumin ratios were compared between the groups about mortality.

Results: The findings obtained in our study were as follows: Troponin, CRP, albumin and CRP/albumin ratio values differed significantly in patients with mortality. When ROC analysis was performed to determine the power of troponin, CRP, albumin and CRP/albumin ratio to predict mortality in the emergency department, it was found that troponin value was the strongest marker in terms of sensitivity with 82.25%. In terms of specificity, low albumin was the most specific parameter, with 82.50% and CRP/albumin ratio followed albumin with 72.50%.

Conclusion: We believe that CRP, albumin, CRP/albumin and troponin are significant predictors of 30 day mortality in patients with CAP hospitalized in the intensive care unit.

Keywords: Pneumonia, Troponin, CRP/albumin, C-reactive protein, Albumin

ÖZ

Amaç: Toplum kökenli pnömoni (TKP) hastalarında prognozu belirlemek için kullanılan parametreler sıklıkla sınırlı klinik değere sahiptir. Bu çalışmanın amacı TKP tanısıyla yoğun bakıma yatırılan hastalarda 30 günlük mortaliteyi öngörmede CRP, albümin, CRP/albümin oranı ve troponin yüksekliğinin etkinliğini incelemektir.

Gereç ve Yöntemler: Bu çalışmaya 1 Ocak 2023- 1 Ocak 2024 yılları arasında acil servis başvurusu sonrası yoğun bakımda takip edilen TKP tanısı alan 18 yaşından büyük 85'i kadın, 115'i erkek olmak üzere toplam 200 hasta dahil edilmiştir. Çalışmada ilk 24 saat içinde akciğer grafisi çekilen, tam kan sayımı, CRP ve albumin dahil biyokimyasal analizleri yapılan hastalar, ölenler ve hayatta kalanlar olmak üzere iki gruba ayrıldı. Gruplar arasında troponin, CRP, Albumin, ve CRP/Albümin oranlarının mortalite ile olan ilişkisi karşılaştırıldı.

Bulgular: Çalışmamızda elde edilen bulgular şu şekildedir: Mortalite gerçekleşen hastalarda troponin, CRP, Albumin ve CRP/albumin oranı değerleri anlamlı şekilde farklılaşmıştır. Troponin, CRP, albumin ve CRP/albümin oranının acil serviste mortaliteyi öngörme gücünü belirlemek için ROC analizi gerçekleştirildiğinde %82,25 ile troponin değerinin sensitivite açısından en güçlü belirteç olduğu bulunmuştur. Spesifite açısından bakıldığında albümin düşüklüğü %82,50 ile en spesifik parametre olarak tespit edilmiştir ve CRP/albümin oranı %72,50 ile albümini takip etmektedir.

Sonuç: Yoğun bakıma yatan TKP hastalarında CRP, albümin, CRP/albümin ve troponin değerinin 30 günlük mortalite açısından anlamlı birer öngörücü olduğunu düşünüyoruz.

Anahtar Sözcükler: Pnömoni, Troponin, CRP/albümin, C-reaktif protein, Albümin

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Introduction

Community-acquired pneumonia (CAP) is one of the leading causes of morbidity and mortality worldwide. The clinical presentation of CAP ranges from mild pneumonia characterized by fever and cough with sputum to severe pneumonia characterized by respiratory distress and sepsis [1]. In patients with community-acquired pneumonia, traditional infection criteria based on clinical signs and symptoms, clinical scoring systems and general inflammatory markers (e.g., leukocytosis, fever, C-reactive protein (CRP) and blood cultures) are often of limited clinical value. They also have limited reliability regarding etiology, optimal treatment and prognosis [2]. Ideally, the management strategy for CAP and the nature of the intervention (including hospitalization and ICU (Intensive Care Unit) admission) should be tailored to the individual patient's severity of illness and risk of death. In our era of personalized medicine, it is important to minimize potential harm and maximize the effectiveness of each intervention through rapid diagnostic and treatment strategies based on unique patient characteristics [3]. Various biomarkers are used in the treatment, hospitalization, intensive care unit admission decision-making and prognosis of pneumonia patients [4].

Currently, the mechanism of severe pneumonia is unclear and not fully understood. Researchers' efforts aim to address the gaps in identifying the causes of CAP severity in patients with similar histories. For example, mixed viral-bacterial infections may be associated with an increased mortality risk [5]. In this context, supportive studies are needed to predict the severity and mortality risk of CAP. Currently, many studies aim to predict morbidity using parameters, such as CRP, albumin and troponin [6,7].

As in other infections, albumin synthesis in the liver is reduced in CAP infections. The severity of hypoalbuminemia reflects the severity of inflammatory stress in both acute and chronic conditions. Chronic conditions associated with hypoalbuminemia also complicate hospital management due to mechanisms described as the 'second strike' phenomenon. On the other hand, albumin levels have been found to be associated with mortality in diseases including CAP [8].

CRP, which is frequently used as a marker in patients with community-acquired pneumonia, is an acute-phase protein produced predominantly in the liver. In response to infection or tissue inflammation, CRP production is rapidly stimulated by cytokines, especially interleukin (IL)-6 [9]. As a new parameter, the CRP/albumin ratio has been shown to be more accurate than albumin and CRP alone in predicting the overall prognosis of certain clinical conditions [6,7]. Cardiac troponin may be elevated in patients with community-acquired pneumonia. Studies, especially in rodents and non-human primates, have shown that Streptococcus pneumoniae causes direct cardiac damage by invading the myocardium and forming microscopic lesions, ultimately leading to cardiac scar formation. A large proportion of patients hospitalized with CAP have elevated cardiac troponin levels. Hypoxemia, increased sympathetic activity, increased inflammatory activity within coronary atherosclerotic plaques and endothelial dysfunction are thought to cause elevated troponin levels in patients with CAP, suggesting that CAP is often complicated by myocardial injury, a phenomenon that can predict poor outcomes, and therefore troponin elevation may be a parameter that can be used to predict prognosis. [10]. However, we still do not have sufficient information about the subsequent cardiovascular effects of pneumonia.

For all these reasons, in our study, we aimed to investigate the role of CRP, albumin, CRP/albumin ratio, and the role of high levels of troponin in predicting 30-day mortality in patients admitted to the emergency department and hospitalized in the intensive care unit with a diagnosis of CAP.

Methods

Research Design

Between January 1, 2023 and January 1, 2024, a total of 200 patients diagnosed with CAP who were admitted to the emergency department and followed up in the intensive care unit were included in our retrospective study. This study was approved by the Non-interventional Clinical Research Ethics Committee of Erzurum City Hospital (Date 13.03.2024, Decision No: 2024/03-

56). It was conducted in accordance with the ethical standards specified in the 1964 Declaration of Helsinki and its subsequent amendments. The diagnosis of pneumonia in the patients included in this study was based on the "Thoracic Society Guideline for the Diagnosis and Treatment of Community-acquired Pneumonia." The need for intensive care was also determined according to the same guideline.

Patients admitted to the emergency department and admitted to the intensive care unit with a diagnosis of pneumonia, who underwent chest radiography and/or thoracic computed tomography within the first 24 hours and biochemical analysis, including complete blood count, CRP and albumin were included in this study. In addition, the patients included in this study underwent cardiology consultation to determine whether the primary cause of troponin elevation was cardiac in origin. In conclusion, this study included 200 patients over the age of 18 years, in whom ACS and CHF were excluded and whose ECHO data were registered in the database of our hospital. Pregnant women, patients with active infections other than CAP, patients with ventilator-associated pneumonia, patients with hospital-acquired pneumonia, and patients with a history of chronic kidney disease, malignancy and connective tissue disease were excluded. Patients with severe congestive heart failure, myocardial infarction, direct cardiac injury, toxin exposure (adriamycin, 5-fluorouracil, trastuzumab, snake venom), viral myocarditis, pericarditis, cerebro vascular events, sepsis, tachyarrhythmias, lobarpneumonia and patients who refused to participate in this study were also excluded. Patients who were discharged were not included in this study if they were readmitted during the study. A data collection form was created for this study. Patient data were accessed using the hospital information management system. Patients were divided into two groups: patients who survived and patients who died within 30 days. Troponin, CRP, albumin, and CRP/albumin ratios were compared between the groups in relation to mortality.

Data Collection Form

A form was created to record the information obtained from the electronic environment for this study. Age, gender, comorbid diseases, vital signs (blood pressure, pulse rate, saturation, respiratory rate), duration of intensive care unit stay, total length of stay, whether they were intubated or not, and mortality status of the patients were recorded on this form. Blood parameters (White blood cell (WBC), RDW (red blood cell distribution volume), platelet, neutrophil, lymphocyte, lactate, troponin, BUN (blood urea nitrogen), creatinine, glomerular filtration rate, albumin, C-reactive protein, d-dimer) were added to the form. CRP/albumin ratio was calculated and recorded on the form.

Statistical analysis

Data were analyzed using the SPSS 23.0 program. Before the analysis of the data, a general screening was performed for missing and outlier data, and while no missing data were observed in categorical variables, 260 missing data were detected in five variables: systolic blood pressure, diastolic blood pressure, pulse, saturation and respiratory rate. These are were follows: systolic blood pressure 52, diastolic blood pressure 52, pulse 52, saturation 45 and respiratory rate 59. Little's MCAR test was used to determine whether these missing data were random to not distort the analyses. Based on a chi-square value of 19.39 and a significance value of 0.08, it was determined that the missing data did not distort the analyses ($p>0.05$), and they were replaced with the means of the relevant variables. Following this step, the data were analyzed descriptively and interpretatively. Descriptive statistics were reported as frequency and percentage for categorical variables and as the mean and standard deviation for continuous variables depending on the normality of the data, if the data were normally distributed, and median and IQR (interquartile range) otherwise. Interpretative statistics were reported by checking the necessary assumptions before conducting the analyses. When the necessary assumptions for the tests were not met, the alternative non-parametric tests were applied. Accordingly, comparisons of independent groups were performed with the independent sample t-test or Mann-Whitney U test, depending on whether the assumptions were met. In addition, ROC analysis was performed to determine the predictive level of Troponin, CRP, albumin, and CRP/albumin variables for mortality, to calculate the AUC, sensitivity and specificity

predictive values, and to find the optimal cut-off point if a significant predictive value was detected. Youden'sindex (sensitivity + 1-specificity) was used for the optimum threshold levels of the parameters. In all statistical analyses, 0.05 was taken as the significance level.

Results

A total of 200 patients, 85 women and 115 men, were included in this study. When the entire patient group was analyzed in terms of comorbidities, chronic obstructive pulmonary disease (COPD) stood out as the most common chronic disease. The average duration of total hospitalization was 12 days. Among the patients included in this study, 110 were intubated, and 80 patients died in the whole patient group. Demographic data of the patients are given in detail in Table I.

In this study, it was examined whether Troponin, CRP, albumin and CRP/albumin ratio values differed significantly according to mortality status in the hospital. Troponin rank scores (MeanRank) were 115.14 in the mortality group and 90.74 in the survivor group and were significantly different (U=3629 p<0.00). The findings showed that CRP was higher in the deceased group (t(198)=-2.49; p=0.013), albumin was higher in the survivor group (t(198)=4.72; p=0.000) and CRP/albumin ratio was higher in the deceased group (t(198)=-3.32; p=0.001) and these variables were significantly differentiated according to mortality.

ROC analysis was performed to determine the predictive power of troponin, CRP, albumin and CRP/albumin ratio for mortality in the emergency department. Details of the analysis findings and ROC Curve are given in Table 3 and Figure 1. Youden's method was used to determine the cutoff values for the variables. The findings revealed that the variables were statistically significantly predictive of mortality at the 0.05 level for CRP (p=0.014) and at the 0.01 level for troponin (p=0.002), albumin (p=0.000) and CRP/albumin (p=0.001). The cut-off values for troponin, CRP, albumin and CRP/albumin were >19.27, >124.93, <=31, and >4.16, respectively. This showed that all of these variables were significant parameters in predicting mortality.

As a result of the ROC analysis of the predictive power of tropin, CRP, albumin, and CRP/albumin ratio for mortality, troponin value was the most powerful marker in terms of sensitivity with 82.25%. In terms of specificity, low albumin was the most specific parameter with 82.50% and CRP/albumin ratio followed albumin with 72.50% (Table 3).

Table 1. Demographic and clinical characteristics of the patients

Variables *	Total Patients (n = 200)
Gender	
Female, n (%)	85 (42,5)
Male, n (%)	115 (57,5)
Age, years old x̄ (sd)	74,22 (14,93)
Comorbidities n (%)	
HT	79 (39,5)
DM	37 (18,5)
CAD	24 (12)
COPD	86 (43)
CHF	26 (13)
Malignancy	26 (13)
CVD	18 (9)
CRF	17 (8,5)
Vital signs	
SBP, mmHg x̄ (sd)	116,52 (21,17)
DBP, mmHg x̄ (sd)	70,47 (62 - 76)
Pulse /min median, (IQR)	101,89 (92 -110)
SpO2 % median x̄ (sd)	81,25 (8,78)
Respiration Rate /min, x̄ (ss)	25,26 (4,77)
Troponin, ng/ml median, (IQR)	35,11 (15,29 – 149,34)
CRP, mg/dl x̄ (sd)	121,49 (99,58)
Albumi n, g/dl x̄ (sd)	33,63 (6,16)
CRP/Albumin, x̄ (sd)	3,89 (3,37)
Total Duration of Hospitalization, median, (IQR)	12 (7 – 29,50)
Duration of ICU stay, median, (IQR)	9 (4,25 - 22)
Intubation, n (%)	
Yes	110 (55)
No	90 (45)
Mortality, n (%)	
Yes	80 (40)
No	120 (60)

Note: DM, Diabetes mellitus; HT, Hypertension; CRF, Chronic renal failure; CAD, Coronary artery disease; CHF, Congestive heart failure; CVD, Cerebrovascular disease; COPD, Chronic obstructive pulmonary disease; CRP, C-reactive protein; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; SpO2, Oxygen saturation ICU, Intensive care unit; IQR, interquartilerange; x̄, mean; sd, standard deviation

Table 2. Comparison of Troponin, CRP, Albumin and CRP/Albumin ratio according to mortality

| | Mortality | | p |
	Yes (n=80, %40)	None (n=120, %60)	
Troponin, median (IQR)	69,33 (22,88 – 209,09)	26,73 (12,31 – 107,81)	b0,00**
CRP, x̄ (sd)	142,67 (102,84)	107,28 (95,17)	a0,01*
Albumin, x̄ (sd)	31,23 (6,27)	35,33 (5,57)	a0,00**
CRP/Albumin, x̄ (sd)	4,83 (3,60)	3,25 (3,07)	a0,00**

Note: b, mann-whitney U-test; a, independent sample t-test; **, p<0,01; *, p<0,05; CRP, C-reactive protein

Table 3. ROC analysis findings regarding the predictive power of tropin troponin, CRP, albumin and CRP/Albumin ratio for mortality

	Troponin	CRP	Albumin	CRP/Albumin
AUC	0,62	0,60	0,69	0,63
95% CI	0,55-0,69	0,53 – 0,67	0,62 - 0,75	0,55 – 0,70
P Value	<0,00**	0,014*	<0,00**	<0,00**
Youden index J	0,24	0,24	0,325	0,27
Cut-off Pointa	>19,27	>124,93	<=31	>4,16
Sensitivity [CI]	82,25	55,00	50,00	55,00
Specificity [CI]	43,33	69,17	82,50	72,50
Positive Predictive Value [CI]	48,9 [44,2 – 53,6]	54,3 [46,0 – 62,4]	65,6 [54,9-74,8]	57,1 [48,4 – 65,5]
Negative Predictive Value [CI]	77,6 [67,8 – 85,1]	69,7 [63,8 – 75,1]	71,2 [66,2 – 75,8]	70,7 [64,9 – 75,9]

Note: CRP, C-reactive protein; a, Youden index method; **, p<0,01; *, p<0,05; AUC, Area under curve
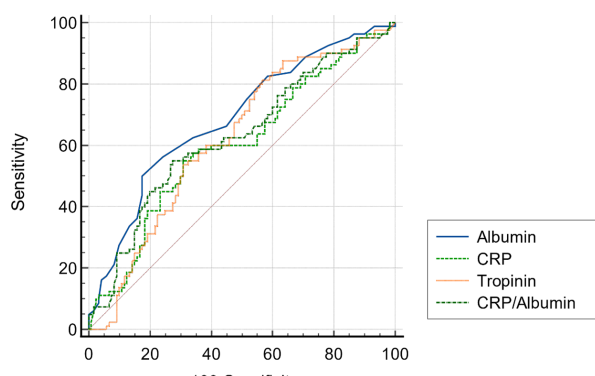
Figure 1. ROC analysis curves to measure the predictive value of laboratory tests for mortality

Discussion

Considering patients' demographic data and clinical characteristics of the, the in-hospital mortality rate was higher in our study, which is different from the literature. In a meta-analysis of 127 studies evaluating the mortality rate associated with CAP in adults, in which medical outcomes of more than 33,000 patients were reported, the mortality rate was reported as 5.1% for outpatients and hospitalized patients, 13.6% for inpatients and 36.5% for patients admitted to the intensive care unit [11]. Our study shows that mortality occurred in 40% of patients with pneumonia hospitalized in the intensive care unit. We attribute the higher mortality rate compared to the literature to our clinicians' more accurate use of intensive care hospitalization criteria when admitting patients to the ICU.

A study in the literature showed that clinicians used different criteria in making hospitalization decisions for adults with CAP, which led to serious differences in the appropriate care of their patients, and that clinicians often overestimated the short-term mortality risk of patients, even in low-risk patients [12].

Accurate prognosis is particularly crucial in critically ill patients and many biochemical markers can reflect the severity of their illness. CRP, albumin and troponin are some of these biochemical markers. Many scoring systems, such as PSI and CURB-65, and many parameters, such as CRP, Procalcitonin and albumin are used to determine the severity of CAP [13,14].

CRP is an acute phase reactant and non-specific marker used in the diagnosis of various conditions, such as infectious diseases, autoimmune and rheumatologic disorders. Elevated CRP levels are associated with the prognosis of various diseases, such as coronary artery disease, ischemic stroke, sepsis and cancer [15,16]. Albumin is a negative acute phase reactant associated with mortality in critically ill patients. When we look at the literature, Reinhardt et al. reported that 25% mortality occurred in patients with serum albumin concentrations below 34 g/L for 30 days, and the same study reported that mortality increased to 62% when serum albumin concentrations fell to 20 g/L or less during hospitalization [17]. Min Hyung

Kim et al. found the CRP/albumin ratio as an independent predictor of mortality in patients with severe sepsis or septic shock in a study on severe sepsis patients in which mortality was investigated within 180 days [18]. In another study in which patients over 65 years of age were retrospectively analyzed, and 811 patients were included in this study, it was found that low albumin and CRP/albumin ratio during admission to the emergency department were associated with all-cause in-hospital mortality in patients over 65 years of age [19]. In our study, CRP, albumin, and CRP/albumin ratio values were compared between the group with in-hospital mortality and the group that survived, and these parameters were found to differ significantly between the two groups. Also, albumin levels were low and CRP and CRP/albumin ratios were high in the deceased patient group consistent with the literature.

Troponin is an enzyme found mainly in the heart muscle and is released into the bloodstream in cardiac damage. However, blood troponin levels are also increased in many other diseases and this is thought to have an effect on prognosis. For example, Orly Efros et al. showed that high troponin levels have a significant effect on prognosis in patients hospitalized for pneumonia. In addition, a meta-analysis by Francis Bessière et al. showed that high troponin was significantly associated with all-cause mortality [20,21]. In our study, in addition to the literature, troponin rank scores were significantly higher in the deceased patient group than in the survivors. Our study showed that high troponin levels have a significant effect on prognosis in patients hospitalized in the intensive care unit for pneumonia, which supports very few literature studies. Previous studies have shown that myocardial injury is associated with prolonged hospitalization, multiple organ failure and increased short-term mortality. However, it is not yet clear whether the poor prognosis is due to the myocardial injury itself or whether it is a sign of a severe disease.

In our study, ROC analysis was also performed to determine the predictive power of Troponin, CRP, albumin, and CRP/albumin ratio for mortality. As a result of the analysis, the troponin value was the strongest marker in terms of sensitivity with 82.25%. In terms of specificity, low albumin is the most specific parameter with 82.50%. In the literature, there are studies showing that the predictive power of CRP/albumin ratio for mortality has higher AUC values than CRP [22-24].

There are very few studies on the ability of troponin to predict mortality in patients with pneumonia. However, Vestjens et al. showed that cTnT combined with PSI had higher AUC values than cTnT alone in predicting 30-day mortality in a study of patients with pneumonia. [25].

Limitations

Our study indicated that prospective, multicenter studies are needed to further evaluate the prognostic significance of troponin levels in patients hospitalized for pneumonia.

Conclusion

To our knowledge, our study is the first to report that troponin value is a significant predictor of one-month mortality in intensive care unit patients with CAP. In this study, CRP, albumin, CRP/albumin and troponin values were significant predictors of one-month mortality in patients with CAP.

ORCID and Author contribution: N.O.C. (0000-0003-4883-3776): Concept and Design, Data Collection, Interpretation of Results, Literature Search, Writing, Critical Review. Final Approval, **Ş.A. (0000-0002-6636-5307):** Data Collection, Literature Search, Writing. Editing **F.A. (0009-0007-2089-5437):** Concept and Design, Data Collection, Critical Review. Final Approval **H.İ.D. (0000-0001-9467-621X):** Data Collection, Interpretation Literature Search, Critical Review. Final Approval.

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The Effectiveness of Matrix Rhythm Therapy in Patients with Ankylosing Spondylitis

Ankilozan Spondilit'li Hastalarda Matrix Ritm Terapinin Etkinliği

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ABSTRACT

Aim: The aim of this study was to investigate the effects of matrix rhythm therapy in addition to exercise treatment on mobility, functionality, disease activity, presence of enthesitis, quality of life, biopsychosocial level, fatigue, sleep quality and exercise beliefs in patients with Ankylosing Spondylitis (AS).
Method: Total of 7 AS patients, 3 women and 4 men, were included in the study. In addition to exercise treatment, matrix rhythm therapy was applied to patients with AS, 2 days a week for 6 weeks. Exercise treatment consisted of a total of 20 exercises aimed at increasing flexibility and muscle strength. Matrix rhythm therapy started from the thoracic region and progressed to the lumbar region and lower extremities. Mobility was evaluated with Bath Ankylosing Spondylitis Metrology Index (BASMI), functional limitations with Bath Ankylosing Spondylitis Functional Index (BASFI), disease activity with Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), the presence of enthesitis with Maastrich Ankylosing Spondylitis Enthesitis Score (MASES), quality of life with Ankylosing Spondylitis Quality of Life Questionnaire (ASQoL), disease-related biopsychosocial level with Biopsychosocial Questionnaire (BETY-BQ), fatigue with Multidimensional Assessment of Fatigue Scale (MAF), sleep quality with Pittsburgh Sleep Quality Index (PSQI), exercise beliefs with Exercise Beliefs Questionnaire. All evaluations were performed in approximately 60 minutes pre and post intervention.
Results: When the data were analyzed, there was a significant difference in BASMI-intermalleolar distance (p:0.041), MAF (p:0.028) PSQI (p:0.046) Exercise Beliefs Questionnaire/ Benefit (p: 0.027) and Disadvantage (p:0.042) scores after the intervention compared to before the intervention.
Conclusions: Matrix rhythm therapy applied in addition to exercise treatment increased hip abduction and sleep quality, reduced fatigue, and positively affected exercise-related beliefs in patients with AS.

Keywords: Ankylosing spondylitis, therapy, exercise

ÖZ

Amaç: Bu çalışmanın amacı, Ankilozan Spondilit (AS)'li hastalarda egzersiz tedavisine ek olarak uygulanan matriks ritm terapinin mobilite, fonksiyonellik, hastalık aktivitesi, entezit varlığı, yaşam kalitesi, biyopsikososyal düzey, yorgunluk, uyku kalitesi ve egzersiz inanışları üzerine etkisini incelemekti.
Yöntem: Çalışmaya 3 kadın ve 4 erkek olmak üzere toplam 7 AS hastası dahil edildi. AS'li hastalara haftada 2 gün 6 hafta boyunca egzersiz tedavisine ek olarak matriks ritm terapi uygulaması yapıldı. Egzersiz tedavisi, esneklik ve kas kuvvetini arttırmaya yönelik toplam 20 egzersizden oluşmakta idi. Matriks ritm terapiye, torakal bölgeden başlanıldı ve lumbal bölge ve alt ekstremitelere doğru ilerlendi. Mobilite Bath Ankilozan Spondilit Mobilite İndeksi (BASMİ) ile, fonksiyonel limitasyonlar Bath Ankilozan Spondilit Fonksiyonel İndeks (BASFİ) ile, hastalık aktivitesi Bath Ankilozan Spondilit Hastalık Aktivitesi İndeksi (BASHAİ) ile, entezit varlığı Maastricht Ankilozan Spondilit Entezit Skoru (MASES) ile, yaşam kalitesi Ankilozan Spondilit Yaşam Kalitesi Anketi (ASYKA) ile, hastalıkla ilişkili biyopsikososyal düzey Bilişsel Egzersiz Terapi Yaklaşımı Ölçeği (BETY-BQ) ile, yorgunluk Yorgunluğu Çok Boyutlu Değerlendirme Ölçeği (YÇBDÖ) ile, uyku kalitesi Pittsburgh Uyku Kalitesi İndeksi (PUKİ) ile, egzersiz inançları Egzersiz İnançları Anketi ile değerlendirildi. Tüm değerlendirmeler, müdahale öncesi ve sonrasında yaklaşık 60 dakika da gerçekleştirildi.
Bulgular: Veriler analiz edildiğinde, müdahale sonrasında müdahale öncesine göre BASMİ- intermalleolar mesafe (p:0.041); YÇBDÖ (p:0.028); PUKİ (p:0.046), Egzersiz İnançları Anketi/ Avantaj (p: 0.027) ve Dezavantaj (p:0.042) puanlarında anlamlı düzeyde fark vardı.
Sonuç: Egzersiz tedavisine ek olarak uygulanan matriks ritm terapi uygulaması, AS'li hastalarda kalça abduksiyonunu ve uyku kalitesini arttırmış, yorgunluğu azaltmış ve egzersizle ilgili inanışları olumlu yönde etkilemiştir.

Anahtar Kelimeler: Ankilozan spondilit, terapi, egzersiz

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Introduction

Ankylosing Spondylitis (AS) is a chronic, progressive, systemic inflammatory disease that mainly affects the sacroiliac joints and axial skeleton. Less commonly, it may involve peripheral joints and can also cause extra-articular manifestations such as enthesitis and uveitis [1].

Inflammation in the axial skeleton in the early stages of the disease causes new bone formation and restriction of spinal mobility and function in later stages. Restriction of movement in the spinal region generally occurs due to ossification of the facet joints and syndesmophytes developing from the edges of the vertebral bodies. Inflammation of the axial skeleton is often accompanied by tenderness and stiffness of the paraspinal muscles. As the disease progresses, lumbar lordosis and spinal mobility gradually decreases [2]. Inflammatory low back pain is the leading and most typical symptom of AS and usually begins insidiously with sacroiliitis and is felt in the lower thoracic, lumbar and sacroiliac joint areas. Initially, the pain may be intermittent, but over time it become more constant, with morning stiffness lasting longer than 30 minutes. Pain that decreases with movement is typical.

According to the evidence-based recommendations of Assessment of SpondyloArthritis International Society (ASAS) and the European Alliance of Associations for Rheumatology (EULAR), the integration of pharmacological and non-pharmacological treatment approaches in the management of AS enhances treatment effectiveness by creating a synergistic effect [3]. Exercise should be initiated as soon as the patient is diagnosed and continued throughout their lifetime as a treatment method. The main purpose of exercise, which is the primary non-pharmacological treatment approach for spondyloarthropathy patients, is to maintain mobility and strength, reduce symptoms, prevent or limit spinal deformities, reduce disease activity, contribute to cardiopulmonary health in the long term, and generally improve physical function and quality of life. Personalized, pain-controlled exercises can be safely prescribed at all stages of the disease [4].

Matrix rhythm therapy aims to restore the mobility of tissues with external oscillators given to the cells. With this therapy, various chemical, physiological and mechanical effects are created in the tissue. As a result of these effects, various benefits are provided, such as shortening the renewal time of cells and cell matrix in muscles, nerves and bones, reducing muscle spasm and muscle pain, increasing cell regeneration, accelerating lymphatic passage, accelerating the metabolism and removing toxic substances, and strengthening the immune system [5]. Various studies on matrix rhythm therapy have proven its effect on pain and increased functionality in different musculoskeletal conditions [6,7]. To our knowledge, there were no studies investigating the effectiveness of matrix rhythm therapy in AS or other rheumatic diseases.

The symptoms and findings in patients with AS lead to a decline in physical function, which impacts their quality of life. The effectiveness of treatment methods is very important in terms of reducing symptoms and improving quality of life. Considering the effects of exercise and the chemical, physiological and mechanical mechanisms of matrix rhythm therapy in the treatment of patients with AS, these treatments can provide positive effects on various parameters of the disease, and the results obtained from this study may contribute to the literature on the treatment of patients with AS.

The aim of this study was to examine the effectiveness of matrix rhythm therapy in addition to exercise treatment in patients with AS.

Method

Total of 7 AS patients, 3 women and 4 men, were included in this study, which was planned as a cross-sectional study. Patients were diagnosed with AS by the same rheumatologist according to the modified New York criteria. Inclusion criteria were - diagnosed with AS by a rheumatologist, -18 years or older, -stable pharmacological treatments for the last month. Exclusion criteria were:- done regular physical activity in the last 3 months, -any orthopedic or neurological disorder that will affect exercise, -uncontrolled cardiopulmonary disease, - pregnancy, -malignancy and a history of surgery in the last 6 months, - situations in which physical therapy modalities are contraindicated (sensory

impairment, pacemaker users),

The results of patients who did not participate in 75% of the intervention and had changes in pharmacological treatments during the study were not included in the analyses.

Ethical approval of the study was obtained from the local ethics committee (E-60116787-020-601289). This study was ethically carried out with Helsinki Declaration Principles. Verbal information was given to all patients and an informed consent form was signed.

Intervention

In addition to exercise treatment, matrix rhythm therapy was applied to patients with AS by the same physiotherapist, 2 days a week for 6 weeks.

Exercise Treatment: Twenty exercises were performed in approximately 30-minute sessions, 2 days a week for 6 weeks. This treatment consisted of spinal mobility exercise, flexibility exercises for the cervical, thoracic and lumbar spine, stretching for the shoulder complex, hamstring, quadriceps and erector spinal muscles, and strengthening exercises for the abdominal region, back extensors and proximal muscle groups.

Matrix Rhythm Therapy: Matrix rhythm therapy was applied for approximately 40 minutes to the thoracic, lumbar, and gluteal regions of the patients twice a week for 6 weeks. Therapy was performed in supine and prone positions. In prone position, abdominal parts of the patients were supported with a thin pillow to ensure relaxation. To ensure effective use of the device head, powder was applied to the application surface. To increase parasympathetic activity, therapy started from thoracic region and progressed to lumbar region and lower extremities. The application was performed parallel to the muscle fibers, starting from the midpoint and moving towards the origin and insertion. It began on the less painful side, with the compression technique applied by keeping the device head fixed on the paravertebral muscles, targeting areas with intense muscle spasm, pain, and sensitivity. The head rhythm of the device was increased according to the patient's tolerance.

Outcome Measures

Mobility was evaluated with Bath Ankylosing Spondylitis Metrology Index (BASMI), functional limitations with Bath Ankylosing Spondylitis Functional Index (BASFI), disease activity with Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), the presence of enthesitis with Maastrich Ankylosing Spondylitis Enthesitis Score (MASES), fatigue with Multidimensional Assessment of Fatigue Scale (MAF), sleep quality with Pittsburgh Sleep Quality Index (PSQI), quality of life with Ankylosing Spondylitis Quality of Life Questionnaire (ASQol), disease-related biopsychosocial level with Biopsychosocial Questionnaire (BETY-BQ), exercise beliefs with Exercise Beliefs Questionnaire,. All evaluations were performed in approximately 60 minutes pre and post intervention. The physiotherapist who conducted the evaluation was different from the one who administered the intervention.

Bath Ankylosing Spondylitis Metrology Index (BASMI): BASMI consists of clinical measurement of cervical rotation, tragus to wall distance, modified Schober's, lumbar lateral flexion and intermalleolar distance. It is scored between 0 and 10. As the score increases, mobility decreases [8].

Bath Ankylosing Spondylitis Functional Index (BASFI): This index consists of 10 questions. The total score is between 0-10. A high score indicates that the patient's functional limitations in daily life increase [9].

Bath Ankylosing Spondylitis Disease Activity Index (BASDAI): BASDAI consists of 6 questions that examine the patient's level of weakness/fatigue, spinal pain, joint pain/swelling and sensitivity to touch, and the level and duration of morning stiffness in the last week. The total score is from 0 to 10. As the score increases, disease activity increases [10].

Maastricht Ankylosing Spondylitis Enthesitis Score (MASES) : With this scale, evaluate whether the 1st and 7th costochondral joints, anterior superior and posterior superior iliac spines, iliac crest, Achilles attachment site at the heel are bilaterally and whether the 5th lumbar spinous process is sensitive to pressure. The total score is calculated by giving 0 points for non-sensitive areas and 1 point for sensitive areas. A higher score means there are more enthesitis areas [11].

Multidimensional Assessment of Fatigue scale (MAF): This scale consists of 16 items and measures four dimensions of fatigue: a higher score indicates greater fatigue [12].

Pittsburgh Sleep Quality Index (PSQI): PSQI consists of seven-component scores that sleep latency, sleep duration, subjective sleep quality, sleep disturbances, use of sleeping medication, habitual sleep efficiency, and daytime dysfunction. Total score has a range of. 0-21. Higher score indicates worse sleep quality [13].

Ankylosing Spondylitis Quality of Life Questionnaire (ASQol): ASQoL consists of 18 questions regarding symptoms, function, and illness-related anxiety. Each question is answered yes or no and the number of "yes" is taken into account. High score is interpreted as decreased quality of life [14].

Biopsychosocial Questionnaire (BETY-BQ): BETY-BQ is a measurement tool developed in accordance with the biopsychosocial model and evaluates the biopsychosocial status of patients with rheumatic disease. It consists of 30 items. Each item is scored between 0 and 4 and high score is associated with poor biopsychosocial status [15].

Exercise Beliefs Questionnaire: Each question is answered on a 6-point Likert scale. Two scores are obtained: Benefit and Disadvantage. While the total score for "Benefit" is between 13-78; Total score for "Disadvantage" is between 12-72 [16].

Statistical analysis

The data were analyzed with the SPSS package program. Continuous variables were given as mean ± standard deviation and categorical variables as numbers and percentages.

For dependent group comparisons, Wilcoxon Signed Ranks Test was used. In the statistical analysis, the significance level was accepted as $p < 0.05$.

Results

Total of seven AS patients, three women and four men, participated in the study. The mean age of the seven AS patients was 55.57±12.23 years and

disease activity was 9.50±8.06 years. There were 2 (28.6%) patients who smoked and had chronic respiratory disease. Demographic and disease-related data of AS patients were shown in Table 1. There were no side effects or adverse events associated with matrix rhythm therapy.

Table 1. Demographic and disease-related data of patients with Ankylosing Spondylitis

Variables	Ankylosing Spondylitis Patients (n:7)	
	Mean±SD	Median (min/max)
Age (years)	55.57±12.23	56(38/72)
Height (m)	1.66±0.07	1.70(1.49/1.72)
Weight (kg)	76.71±8.57	74(66/90)
BMI (kg/m2)	27.82±3.31	27.18(22.84/32.43)
Disease duration (years)	9.50±8.06	6(0.5/20)
Education year	7±3.41	5(5/12)
	n (%)	
Gender		
-woman	3 (42.9)	
-man	4 (57.1)	
Employed		
-Yes	2 (28.6)	
-No	5 (71.4)	
Smoking		
-Yes	2 (28.6)	
-No	5 (71.4)	
History of chronic respiratory disease		
-Yes	2 (28.6)	
-No	5 (71.4)	

After intervention, there was a significant difference in BASMI- intermalleolar distance (p:0.041), MAF (p:0.028) PSQI (p:0.046) and Exercise Beliefs Questionnaire/ Benefit (p: 0.027) and Disadvantage (p:0.042) scores, but no significant difference in BASMI-cervical rotation (p:0.317), BASMI-tragus to wall distance (p:0.705), BASMI-lumbar side flexion (p:0.279), BASMI-modified Schober's (p:0.595), BASMI-Total (p:0.141), BASDAI (p:0.753), BASFI (p:0.176), MASES (p:0.581), ASQoL (p:0.225), BETY-BQ (p:0.173) (Table 2).

Discussion

In this study, matrix rhythm therapy applied in addition to exercise treatment increased hip abduction and sleep quality, reduced fatigue, and positively affected exercise-related beliefs in

patients with AS.

Table 2. Analysis of pre and post intervention results

Variables	Ankylosing Spondylitis Patients (n:7)		
	Pre Median (min/max)	Post Median (min/max)	p*
BASMI-cervical rotation	4(3/9)	4(3/9)	0.317
BASMI-tragus to wall distance	2(0/6)	3(1/7)	0.705
BASMI-lumbar side flexion	7(2/10)	5(2/8)	0.279
BASMI-modified Schober's	6(1/10)	3(0/9)	0.595
BASMI-intermalleolar distance	4(3/8)	3(0/6)	0.041
BASMI-Total	3.6 (2.6/8.4)	3.6 (1.2/7.8)	0.141
BASDAI	5.41 (1.83/7.58)	5.46 (1.33/7.83)	0.753
BASFI	6.5 (2.11/9.4)	2.7 (0/8.81)	0.176
MASES	5 (1/13)	7.5 (5/11)	0.581
MAF	41.6 (25.63/45.40)	26.9 (15.04/33.13)	0.028
PSQI	9 (5/16)	5 (4/9)	0.046
ASQoL	15 (7/18)	8 (3/18)	0.225
BETY-BQ	80 (51/120)	60 (18/112)	0.173
Exercise Beliefs Questionnaire/Benefit	62 (48/78)	67 (64/78)	0.027
Exercise Beliefs Questionnaire/ Disadvantage	43 (28/62)	36 (28/41)	0.042

*Wilcoxon Signed Ranks Test, Bold values mean p<0.05, BASMI: Bath Ankylosing Spondylitis Metrology Index, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, MASES: Maastrich Ankylosing Spondylitis Enthesitis Score, MAF: Multidimensional Assessment of Fatigue Scale, PSQI: Pittsburgh Sleep Quality Index, ASQoL: Ankylosing Spondylitis Quality of Life Questionnaire, BETY-BQ: Biopsychosocial Questionnaire.

Matrix rhythm therapy is a technique that targets abnormalities at the cellular level while maintaining various physiological functions of the body [17]. Matrix rhythm therapy provides oscillations between 8-11 Hz physiological frequencies. These frequencies synchronize with the body to re-establish the disrupted rhythm at the cellular level. Matrix rhythm therapy improves microcirculation, provides oxygen supply and thus increases energy production. The immediate effect of matrix rhythm therapy can be seen as relaxation of tissue, muscle and fascia. As the metabolic process is regulated at the cellular level and the flow of oxygen to the cells increases, this

relaxation continues and is maintained for a longer time. Once the pain subsides and the soft tissues relax, the condition is brought under control and this can be maintained with routine exercises. Matrix rhythm therapy can be applied for many conditions related to non-healing wounds, arthritis, osteoporosis, vascular insufficiencies, spasticity, migraine, bone degeneration, neuropathy, pain and swelling [18]. The compression effect created by matrix rhythm therapy may cause greater soft tissue mobilization and more afferent stimulation. However, the vibration frequency created by matrix rhythm therapy is thought to be compatible with the natural vibration frequency of the muscle, and this is thought to contribute to the therapeutic effectiveness in the body [19].

The studies on matrix rhythm therapy have proven its effect on pain and increased functionality in different musculoskeletal conditions [6,7]. Jager et al evaluated the effect of matrix rhythm therapy on pain level, sleep patterns and flexibility of the spine in 80 patients with low back pain. As a result of this study, matrix rhythm therapy application was shown to be effective in reducing pain and increasing flexibility compared to conservative treatment [20]. Gohil et al compared the effects of matrix rhythm therapy and pilates exercises on lumbar flexibility, functional disorders and pelvic tilt in 50 patients with chronic low back pain (pilates group (n = 25) and matrix rhythm therapy group (n = 25)). After two weeks, a more significant improvement was reported in the matrix rhythm therapy group compared to the pilates group [21].

Taspınar et al. examined the effects of massage and matrix rhythm therapy on peripheral blood circulation in 15 healthy young female individuals. They reported that matrix rhythm therapy application showed a more significant increase in circulation compared to massage application [22]. Rawtani et al compared the acute effects of passive stretching therapy and matrix rhythm therapy on hamstring flexibility in 30 healthy women. Significant improvement in hamstring flexibility was found after the intervention compared to before the intervention in both groups. Greater improvement in flexibility was achieved in the matrix rhythm therapy group compared to the passive stretching group. According to the results of the study, matrix rhythm therapy was found

to be superior to passive stretching in improving hamstring flexibility [23]. Palekar et al divided 30 patients diagnosed with supraspinatus tendinitis into two groups. While therapeutic exercise and ice application were applied to the control group; matrix rhythm therapy, therapeutic exercise and ice application were applied to the study group. As a result, the study group showed greater improvement in pain, disability, and shoulder range of motion compared to the control group [24].

In the present study, matrix rhythm therapy applied in addition to exercise treatment increased hip abduction and sleep quality, reduced fatigue, and positively affected exercise-related beliefs in patients with AS. We believe that the muscle, fascia and tissue relaxation achieved in hip abductors with matrix rhythm therapy may be strengthened with exercises, allowing patients with AS to have a better quality of sleep. Thanks to this positive change in the hip abductors, which have important roles in mobility, and a more rested body at night, patients' perceptions of fatigue may have decreased and their perspectives may have changed in a positive direction.

Matrix rhythm therapy is a relatively new technique. When the literature was examined, no study was found regarding the effectiveness of matrix rhythm therapy on AS or other rheumatological diseases. To our knowledge, the present study was unique as it was the first study to apply this approach to patients with AS.

The limitation of our study was the small number of patients and the lack of a control group. If there was a control group, clearer comments could be made about the effectiveness of matric rhythm therapy based on the results of the comparative analyses.

Since the sample size of this study is small, generalization may be insufficient, therefore, results from larger sample groups may contribute to future studies. Also, we recommend that in future studies, more detailed physiological or laboratory evaluations should be made regarding the effects of matrix rhythm therapy at the cellular level in patients with AS. It may also be interesting to know whether matrix rhythm therapy has different effects on gender.

Conclusion

We recommend the application of matrix rhythm therapy in addition to exercise treatment, especially in patients with AS who have problems with hip abduction, high fatigue levels and affected sleep quality.

Ethic: Ethical approval of the study was obtained from the local ethics committee (E-60116787-020-601289). This study was ethically carried out with Helsinki Declaration Principles. Verbal information was given to all patients and an informed consent form was signed.

Conflict of Interest: No conflict of interest was declared by the authors.

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Prevalence and Predictors of Prilocaine Induced Abnormal Methemoglobinemia During Cardiac Device Implantation Procedure

Kardiyak Cihaz İmplantasyon Prosedürü Esnasında Prilokain Kaynaklı Anormal Methemoglobineminin Prevalansı ve Prediktörleri

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ABSTRACT

Aim: The aim was to determine the prevalence and predictors of prilocaine-induced methemoglobinemia during the cardiac implantable electronic device (CIED) implantation procedure.
Methods: One hundred patients who underwent CIED implantation procedures under local anesthesia with prilocaine were included in the study. Patients were divided into two groups according to the percentage of methemoglobin (MetHb) in arterial blood gas analysis. Data regarding patients, laboratory, and procedure-related factors were compared between the two groups.
Results: The mean age of the patients was 70.97 ± 11.54 years, and 42% were female. Based on the criterion of MetHb level above 3%, the prevalence of pathologic methemoglobinemia was 47%. Multivariate logistic regression analyses were performed to identify independent predictors for the development of prilocaine-induced abnormal methemoglobinemia. In multivariate analysis, the presence of low body mass index (BMI) and chronic obstructive pulmonary disease (COPD) (OR: 0.876; 95% CI 0.781-0.981; p=0.022 and OR: 5.170; 95% CI 1.535-17.411; p=0.008) independently predicted the development of abnormal methemoglobinemia.
Conclusion: Abnormal MetHb levels were found in almost half of patients who underwent the CIED implantation procedure after subcutaneous prilocaine injection. Methemoglobinemia may occur even at doses lower than the recommended maximum dose, especially in patients with low BMI and COPD.

Key Words: Methemoglobinemia, Prilocaine, Cardiac device, Anesthesia

ÖZ

Amaç: Kardiyak implante edilebilir elektronik cihaz (CIED) implantasyonu işlemi sırasında prilokainin neden olduğu methemoglobineminin prevalansını ve öngörücülerini belirlemeyi amaçladık.
Yöntem: Prilokain ile lokal anestezi altında CIED implantasyonu yapılan 100 hasta çalışmaya dahil edildi. Hastalar arteriyel kan gazı analizinde methemoglobin (MetHb) yüzdesine göre iki gruba ayrıldı. Hastalara ilişkin, laboratuvar ve prosedür ilişkili faktörlerle ilgili veriler iki grup arasında karşılaştırıldı.
Bulgular: Hastaların ortalama yaşı 70,97 ± 11,54 yıl olup, %42'si kadındı. MetHb düzeyinin %3'ün üzerinde olması kriterine göre patolojik methemoglobinemi prevalansı %47 idi. Prilokainin neden olduğu anormal methemoglobinemi gelişiminin bağımsız prediktörlerini belirlemek için çok değişkenli lojistik regresyon analizleri yapıldı. Çok değişkenli analizde düşük vücut kitle indeksi (VKİ) ve kronik obstrüktif akciğer hastalığı (KOAH) varlığı (OR: 0,876; 95% GA 0,781-0,981; p=0,022 ve OR: 5,170; 95% GA 1,535-) 17,411; p=0,008) bağımsız olarak anormal methemoglobinemi gelişimini öngördü.
Sonuç: Subkutan prilokain enjeksiyonu sonrası CIED implantasyon işlemi uygulanan hastaların neredeyse yarısında anormal methemoglobin düzeyleri bulundu. Özellikle düşük VKİ ve KOAH'lı hastalarda önerilen maksimum dozun altındaki dozlarda bile methemoglobinemi meydana gelebilir.

Anahtar Sözcükler: Methemoglobinemi, Prilokain, Kardiyak cihaz, Anestezi

Introduction

Methemoglobinemia is a rare condition that is often neglected and potentially life-threatening if not treated promptly [1]. Hemoglobin (Hb) is an erythrocyte molecule that carries oxygen to tissues and contains iron in the ferrous (Fe+2) form. When Hb is oxidized to the ferric state (Fe+3), it is converted into methemoglobin (MetHb), which is unable to bind oxygen and thus the oxygen-carrying capacity of blood is reduced [2]. Due to the decrease in the oxygen transport capacity of the blood, the hemoglobin-oxygen dissociation curve shifts to the left. Functional anemia and tissue hypoxia result from excessive replacement of hemoglobin with methemoglobin. In response to oxidative stress, the body regularly produces MetHb at a rate of 3% daily [3]. This can be acquired due to certain anesthetics or inherited via mutations in the cytochrome-b5 reductase enzyme or the presence of hemoglobin defects [4]. The clinical presentation varies from cases with mild symptoms to severe cases [5]. The symptoms of methemoglobinemia are related to the MetHb level in the blood, and cyanosis may be observed when the MetHb value exceeds 10%; fatigue, dizziness, and dyspnea when it exceeds 30%; dysrhythmia, lethargy, syncope, seizures, and coma when it exceeds 50%; and values above 70% are fatal [4]. The severity of clinical presentation may vary depending on the MetHb percentage, the rate of increase in MetHb level, and the patient's underlying comorbidities.

In the last decade, the use of permanent pacemakers and implantable cardioverter defibrillators (ICD) has increased (20% vs. 44%) [6]. Unfortunately, serious complications such as pneumothorax, local or systemic infections, and venous thrombosis can occur with these procedures. In addition, another overlooked complication associated with local anesthetics, methemoglobinemia, can occur [7].

The most commonly used local anesthetic is prilocaine, a medium-long acting local anesthetic with a rapid onset of action compared to lidocaine but significantly reduced systemic toxicity [8-9]. Although prilocaine is considered to be a safer anesthetic agent than other local anesthetic agents, the extent of prilocaine-associated methemoglobinemia occurring during cardiac device implantation procedures is still unknown. Therefore, we aimed to determine the prevalence and predictors of abnormal methemoglobinemia due to prilocaine used for local anesthesia of the pectoral region prior to the cardiac implantable electronic device (CIED) implantation procedure.

Material and Methods

Study Population

This single-center, prospective, observational cross-sectional study was conducted at Antalya Education and Research Hospital, a 1270-bed tertiary health center in Turkey. All patients undergoing cardiac device implantation and using prilocaine between March and June in 2022 consecutively were enrolled.

Patients with any of the following conditions were excluded: age<18 years, hypersensitivity to local anesthesia, history of previous methemoglobinemia episode, exposure to local anesthetic in the last seven days, pneumothorax, hemothorax, fever in the past 24 hours, and development of tamponade during the procedure. After applying the exclusion criteria, 100 participants were included in the study.

Cardiac Device Implantation Protocol

The protocol used in our institution for anesthesia of the pectoral region prior to pacemaker implantation is based on the local application of prilocaine hydrochloride subcutaneously to the left or right pectoral region (8 mg/kg and a maximum total dose of 600 mg) (Priloc® 2%, Vem Pharmaceutical Company Tekirdag, Turkey). None of the patients were administered deep sedation or general anesthesia. All patients had blood pressure, cardiac rhythm monitoring, and O2 saturation with pulse oximetry monitored during the procedure. All patients had a PA chest radiography immediately and 24 hours after the procedure. Patient O2 saturations were recorded post-procedure using pulse oximetry. Patients were discharged 24 hours after the procedure with the necessary treatment and referrals if no adverse events occurred.

Arterial Blood Gas Analysis

Arterial blood samples for measurement of MetHb concentration were taken 60 min after injection of the local anesthetic. The collected sample was immediately analyzed with an ABL800 FLEX (Radiometer Medical, Denmark). The analyzer also has a co-oximetry module based on a multiwavelength spectrophotometric optical system that measures total hemoglobin concentration, O2 saturation, and Hb fractions such as oxyhemoglobin (O2Hb), deoxyhemoglobin (HHb), MetHb, and carboxyhemoglobin (COHb).

Previous studies showed that MetHb routinely forms in the body at a rate of 3% per day in response to oxidative stress [3]. Therefore, the patients in our study were divided into two groups according to MetHb content in arterial blood gas analysis: a group with MetHb content below 3% and a group with MetHb content above 3%.

Ethical Considerations

The study was approved with Protocol No:2022/23 Decision No:2/8 by the Ethics Committee of Antalya Education and Research Hospital. The study was conducted under the guidelines of the Declaration of Helsinki.

Statistical Analysis

Statistical analyses were conducted using SPSS version 24.0 (Statistical Package for the Social Sciences, v24.0). The distribution of the variables was assessed using both visual methods and the Kolmogorov-Smirnov test to determine normality. Descriptive statistics are presented as frequencies and percentages for categorical variables and as means with standard deviations (SD) or medians with interquartile ranges (IQR) for continuous variables, depending on the distribution of the data.

Comparisons between groups were performed using the Student's t-test for normally distributed continuous variables, and the Mann-Whitney U test for non-normally distributed continuous variables. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. In univariate analyses, categorical variables were assessed using Chi-square or Fisher's exact tests, while independent-sample t-tests were used for continuous variables.

Multivariate analysis was performed using logistic regression to control for potential confounders. Variables found to be significant in univariate analyses, including Body Mass Index (BMI) and Chronic Obstructive Pulmonary Disease (COPD), were included in the logistic regression model. The results are presented as odds ratios (OR) with corresponding 95% confidence intervals (CI). Statistical significance was set at $p < 0.05$.

Results

A total of 100 patients who received subcutaneous prilocaine for pectoral local anesthesia prior to CIED implantation were included in the study. The mean age was 70.9±11.5 years (range: 35-94 years) and 42 (42%) were female. Based on the definition of methemoglobinemia above 3%, the prevalence was 47% (n=47). The mean Met-hb percentage in the methemoglobinemia group was 7.55±2.46%, while the mean Met-hb percentage in the group without methemoglobinemia was 2.60±0.79%.

Table 1 presents an overview of the baseline demographic data and laboratory findings of the study group. There were no significant differences in most variables between the two groups. However, an interesting aspect of the table is that the presence of COPD and low BMI (p = 0.001 and p = 0.003, respectively) were higher in the methemoglobinemia group. In addition, laboratory parameters were also similar between the groups (Table 1).

Basal parameters for transthoracic echocardiography (TTE), electrocardiography (ECG) and CIED procedure-related findings of the study group are presented in Table 2. The ECG and TTE parameters did not differ between the groups. In addition, the arterial blood gas parameters there was no significant difference was evident between the two groups, except for saturation gap (5.80 ± 2.68 vs. 3.50 ± 2.71, p<0.001) and MetHb % (7.55 ± 2 .46 vs. 2.60±0.39 <0.001). Also, the percentage of the patients with a methemoglobinemia level above 10% were 12%.

Figure 1 provides a summary of treatment strategies for patients with abnormal MetHb levels. While most patients received no treatment (n=24), supplemental oxygen therapy was

Table 1. Baseline demographics and laboratory findings of the study groups

	Presence of methemoglobinemia	Absence of methemoglobinemia	P value
Mean age, years	70,66±12,46	68,98±12,78	0,509*
Gender (male) ,n, (%)	28 (59.6%)	30 (56.6%)	0,764**
BMI	26,18±3,20	28,66±4,76	0,003*
Diabetes mellitus, n, (%)	14 (29.8%)	16 (30.2%)	0,965**
Hypertension, n, (%)	30 (63.8%)	29 (54.7%)	0,355**
Smoking, n, (%)	12 (25.5%)	12 (22.6%)	0,736**
CAD, n, (%)	21 (44.7%)	21 (39.6%)	0,609**
PAD, n, (%)	4 (8.5%)	2 (3.8%)	0,416**
Cerebrovascular disease, n, (%)	3 (6.4%)	2 (3.8%)	0,664**
COPD, n, (%)	16 (34.0%)	4 (7.5%)	0,001**
CRF, n, (%)	6 (12.8%)	2 (3,8%)	0,143**
Antiaggregant therapy, n, (%)	16 (34.0%)	23 (43.4%)	0,339**
Anticoagulant therapy, n, (%)	12 (25.5%)	16 (30.2%)	0,605**
Hemoglobin, g/dL	12,87±1,92	13,28±2,05	0,310*
Platelet count, (× 10³ per µL)	225,11±79,50	248,69±72,04	0,123*
WBC, (× 10³ per µL)	8,29±2,41	8,43±2,34	0,755*
Neutrophil to lymphocyte ratio	3,19±2,09	3,73±3,02	0,307*
MPV, (fl)	10,76±1,76	10,94±1,07	0,531*
Fasting blood glucose, mg/dL	122,98±48,77	116,17±42,23	0,456*
Creatinine, mg/dL	1,29±0,90	1,19±0,26	0,430*
HDL, mg/dl	49,60±12,92	47,89±13,97	0,529*
LDL, mg/dl	110,96±38,38	115,04±45,52	0,631*

*Independent Samples T Test, ** Chi-Square T

(BMİ: Body mass index; CAD: Coronary artery disease; PAD: Peripheral artery disease; COPD: chronic obstructive pulmonary disease CRF: Chronic renal failure; WBC: White blood cell; MPV: Mean platelet volume, HDL: High-density lipoprotein cholesterol, LDL: Low density lipoprotein cholesterol)

Table 2. Basal transthoracic echocardiography, electrocardiography parameters and findings related to the patients' implantation procedure

	Presence of methemoglobinemia	Absence of methemoglobinemia	P value
Pre-implantation rhythm	19 (40.4%)	26 (49.1%)	0,147*
- Atrial fibrillation, n (%)	7 (14.9%)	6 (11.3%)	
- Atrioventricular block, n (%)	12 (25.5%)	5 (9.4%)	
- Pacemaker rhythm, n (%)	9 (19,1%)	14 (26.4%)	
- Nodal rhythm, n (%)	0 (0.0%)	2 (3.8%)	
QRS duration, msn	114,47±31,61	123,85±44,09	0,221**
Ejection fraction,%	49,89±15,34	48,02±16,56	0,560**
Severe valve disease			0,654*
- No, n (%)	30 (63.8%)	34 (64.2%)	
- Mitral valve, n (%)	9 (19.1%)	13 (24.5%)	
- Aortic valve, n (%)	3 (6.4%)	1 (1.9%)	
- Tricuspid valve, n (%)	5 (10.6%)	5 (9.4%)	
- Pulmonary valve, n (%)	-	-	
Pacemaker type			0,863*
-DDDR	24 (51.1%)	24 (45.3%)	
-VVIR	4 (8.5%)	6 (11.3%)	
-ICD	10 (21.3%)	11 (20.8%)	
-Biventricular pacing	9 (19.1%)	11 (20.8%)	
-VDD	0 (0.0%)	1 (1.9%)	
Nitrate usage, n (%)	1 (2.1%)	2 (3.8%)	1,000*

* Chi-Square Test, **Independent Samples T Test

(DDDR: Dual Chamber, Rate-Modulated Pacemaker; VVIR: Ventricular Inhibited, Rate-Modulated Pacemaker; ICD: Implantable Cardioverter Defibrillator; VDD: Single Pass Ventricular Pacemaker with Atrial Sensing.)

sufficient in 22 patients. Only 1 patient required methylene blue therapy (1-2 mg/kg intravenously for 5 minutes). The mean methemoglobin levels of patients given oxygen therapy was 9%, while the mean methemoglobin level of the single patient that given methylene blue was 22%.
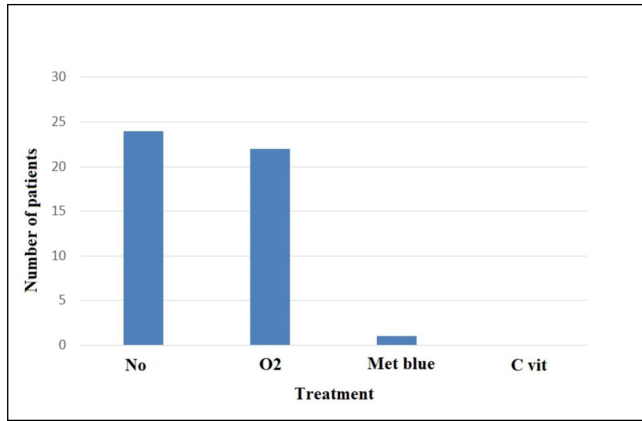
Figure 1: The treatment strategies applied to patients with abnormal methemoglobin levels

Univariate and multivariate logistic regression analyses were performed to identify independent "predictors for the development of prilocaine-induced abnormal methemoglobinemia prior to the CIED procedure (Table 3). Further statistical tests revealed low BMI [Odds ratio (OR): 0.876; 95% Confidence interval (CI) 0.781-0.981); p=0.022] and COPD (OR: 5.170; 95% CI 1.535-17.411; p=0.008) independently predicted the development of abnormal MetHb. In addition, according to logistic regression analysis, BMI and abnormal methemoglobinemia were negatively associated, and a unit numerical increase in BMI reduced the development of abnormal methemoglobinemia by 12.7%.

Table 3. Independent predictors associated with prilocaine-induced methemoglobinemia

Variables	Odds Ratio	95% C.I.for EXP(B)		p-value
		Lower bound	Upper bound	
BMI	0,876	0,781	0,981	0,022
COPD	5,170	1,535	17,411	0,008

(CI: Confidence Interval, BMI: Body mass index; COPD: chronic obstructive pulmonary disease)

Discussion

This study found that almost half of the patients (47%) who received subcutaneous prilocaine had high levels of MetHb. To the best of our knowledge, this is the first study to prospectively analyze the effect of subcutaneous administration of prilocaine prior to the CIED procedure on blood methemoglobin levels and the occurrence of abnormal methemoglobinemia. Another key finding of our study was that low BMI and COPD were independent predictors for prilocaine-induced MetHb .

Four types of local anesthetic agents are major suspects for the development of acquired methemoglobinemia: prilocaine, benzocaine, lidocaine, and tetracaine. As local anesthetics are absorbed from the injection site, their concentration in the bloodstream increases, and dose-dependent suppression is observed in the peripheral and central nervous systems. Prilocaine, which is a medium-long-acting local anesthetic, has fewer side effects on the cardiovascular and central nervous systems than other local anesthetics [8]. Due to its large volume of distribution, the probability of systemic toxic reactions is very low [10]. Therefore, we prefer to use prilocaine as a local anesthetic during the CIED implantation procedure. However, a major disadvantage of prilocaine is the risk of MetHb development induced by its metabolites o-toluidine and nitrosotoluidine [11,12]. If prilocaine is metabolized by the liver (and possibly the kidneys), in contrast to other local anesthetics, o-toluidine is the primary product. A metabolite of prilocaine, o-toluidine, can oxidize the iron in hemoglobin from ferrous (Fe+2) to ferric (Fe+3). The resulting met-Hb prevents the release of oxygen from hemoglobin into tissues. Previous studies linked this condition to many clinical factors, including age, drug dosage, enzyme deficiencies, malnutrition, hospitalization, sepsis, and anemia [13].

The mechanism of MetHb formation after prilocaine administration was investigated in the literature. For example, Sadove et al. first reported a sudden change in blood color at the surgical site after using prilocaine on a patient. Spectroscopic analysis after the development of cyanosis in this healthy individual without any cardiovascular

disease revealed a significant increase in MetHb levels [14]. Later, Nolte et al. found a dose-response relationship for the development of methemoglobinemia and stated that a dosage of >600 mg was associated with a high risk of developing methemoglobinemia [15]. In addition, studies found that there were large variations in the development of methemoglobinemia among individuals and suggested that methemoglobinemia can develop in individuals with sensitivity, even at low doses. Kaiser et al. reported asymptomatic and acyanotic MetHb elevations in different individuals with the same dosage of prilocaine [16]. The maximum recommended dose of prilocaine for healthy adults is 8 mg/kg (600 mg) [17] or 6 mg/kg (400 mg) [18]. Some reports suggest that lower doses should be administered to children and patients with renal impairment [17,19]. In our study, we limited the dose of prilocaine to 8 mg/kg (total maximum dose of 600 mg). However, in multivariate logistic regression analysis performed in our study, abnormal methemoglobinemia levels were observed at a higher rate in people with low BMI. Low dose administration of prilocaine appears to be safer in individuals with multiple comorbidities.

Guay et al. reported that benzocaine caused the most cases of methemoglobinemia induced by local anesthetics, followed by prilocaine [19]. The incidence of symptomatic methemoglobinemia due to prilocaine requiring treatment in pediatric patients was reported to be 0.008% [20]. However, its incidence in teenagers or adults is uncertain. In our study, the abnormal MetHb level was 47%, which is too high. This finding was higher than previous studies conducted in different patient patterns. This discrepancy might be caused by the older, more frail, and comorbid individuals in our study cohort compared to those in prior studies. Another reason could be that prilocaine-induced methemoglobinemia can often present without symptoms. Indeed, although abnormal methemoglobinemia was observed in approximately 47% of patients in our study, only one patient was symptomatic and required treatment (1%).

Another result of our analysis showed that COPD diagnosis was an important predictor of abnormal methemoglobinemia. This finding is consistent with the literature, in case reports of anesthetic-associated methemoglobinemia COPD was the most common comorbid problem [21-23]. In patients with severe cardiopulmonary disease or multiple comorbidities such as anemia, even MetHb values below toxic levels can cause the development of symptoms [24]. In patients with a tendency to develop methemoglobinemia, much higher MetHb levels with severe symptoms can be observed with the same dose of prilocaine [24].

Contrary to theoretical knowledge, the risk of developing methemoglobinemia in patients with chronic renal failure is not as high as previously assumed. Wald-Oboussier et al. reported that prilocaine was safely administered to ten patients with chronic renal failure and anemia requiring hemodialysis. They reported that the patients' MetHb levels were similar to values measured in healthy individuals [25]. In addition, Tryba et al. reported that no side effects occurred when 600 mg prilocaine was administered to patients with renal failure or chronic anemia. Therefore, our results are consistent with the literature, in which univariate analysis revealed that chronic renal failure and anemia were not predictors for the development of abnormal methemoglobinemia in patients receiving local prilocaine injections.

In our study, 24 patients who developed abnormal methemoglobinemia were not given any treatment, while 22 were given supportive oxygen therapy. Intravenous methylene blue (1-2 mg/kg for 5 minutes) was given to one patient who developed symptoms. Initial treatment for methemoglobinemia starts with discontinuation of the relevant oxidant agent and symptomatic support. Supplemental oxygen should be initiated immediately and titrated as needed. According to guidelines, methylene blue (a starting dose of 1–2 mg/kg of 1% methylene blue to be repeated up to a dose of 5.5 mg/kg if there is no response after 30 min) is given to symptomatic patients with a MetHb level above 20% or asymptomatic patients with MetHb levels above 30% [4]. If the patient has underlying anemia and cardiac or pulmonary comorbidities, administration of methylene blue at lower MetHb levels should be considered. Ascorbic acid can be added as adjunctive therapy. Exchange transfusion or hyperbaric oxygen therapy should be administered to patients who

do not respond to first-line therapy.

Limitations

The present study includes a number of limitations; therefore, these findings should be regarded with caution. Firstly, while this is the first study examining prilocaine-associated MetHb in CIED patients, our study population was relatively small. Secondly, the study was conducted in a single heart center. The final limitation of this study is that MetHb was only tested with blood gas measurement, not evaluated with the Evelyn-Malloy assay, which is considered the most accurate test.

Our findings should be validated with multicenter studies involving greater patient populations. Nonetheless, this research has raised many questions that require further investigation.

Conclusion

In conclusion, given that approximately half of patients administered local anesthetic prior to the CIED procedure suffer from abnormal MetHb levels, cardiologists should be more sensitive to the use of prilocaine and the signs of methemoglobinemia in order to quickly and timely diagnose and prevent this condition. However, due to the large inter-individual variability between prilocaine dose and the rate of MetHb occurrence, an accurate and reliable assessment about the development of methemoglobinemia is not possible. Therefore, when using prilocaine as a local anesthetic, physicians should be aware that methemoglobinemia can occur at doses lower than the maximum recommended dose, particularly in patients with low BMI and COPD.

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Bibliometric Analysis of Articles Published in Acta Orthopaedica et Traumatologica Turcica Between 2013 and 2023

2013-2023 Yılları Arasında Acta Orthopaedica et Traumatologica Turcica'da Yayımlanan Makalelerin Bibliyometrik Analizi

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ABSTRACT

Aim: This study aims to perform a bibliometric analysis of articles published in Acta Orthopaedica et Traumatologica Turcica (AOTT) from 2013 to 2023.
Methods: Articles published in AOTT from January 2013 to December 2023 were analyzed using bibliometric methods. The analysis included article type, number of authors, number of institutions authors worked for, country of the first author, international collaboration for Turkish authors, citation counts, and numbers of reads and downloads.
Results: 1035 articles were reviewed, with a significant portion being retrospective studies (44.4%). Basic science studies constituted 16.5% of the total, closely followed by case reports (15.7%). The structure of the institution where the first author worked was a university hospital, in 603 articles (58.26%). In 932 articles (90.05%), the gender of the first author was male, and in 103 articles (9.95%), the gender of the first author was female. The total number of authors ranged from 1 to 15 (average: 4.75±1.53, median: 5), and the number of institutions authors worked for averaged 2.24±1.32 (range: 1-14, median: 2). Citation numbers ranged from 1 to 186 (average: 12.78±15.68, median: 8). The total number of citations to all articles was 15127.
Conclusion: This study reveals the status and trends of articles published in AOTT over 11 years.

Key Words: Orthopedics, citation count, bibliometric analysis, article

ÖZ

Amaç: Bu çalışma, 2013-2023 yılları arasında Acta Orthopaedica et Traumatologica Turcica'da (AOTT) yayımlanan makalelerin bibliyometrik analizini gerçekleştirmeyi amaçlamaktadır.
Yöntem: 2013 Ocak ile 2023 Aralık arasında AOTT'da yayımlanan makaleler bibliyometrik yöntemler kullanılarak analiz edilmiştir. Analiz; makalelerin türü, yazar sayısı, yazarların çalıştığı kurum sayısı, ilk yazarın ülkesi, Türk yazarlar için uluslararası iş birliği, atıf sayıları, okunma ve indirilme sayılarını kapsamıştır.
Bulgular: Toplam 1035 makale gözden geçirildi, çalışmaların önemli bir kısmı retrospektif çalışma (%44.4) idi. Temel bilim çalışmaları yayımlanan makalelerin %16,5'ini, vaka raporları ise %15,7'sini oluşturdu. Birinci yazarın çalıştığı kurumun yapısı 603 (%58.26) makalede üniversite hastanesiydi. Toplam 932 makalede (90.05%) ilk yazarının cinsiyeti erkek, 103 makalede (9.95%) ise kadın idi. Toplam yazar sayısı 1 ile 15 (ortalama: 4.75±1.53, medyan: 5) arasında değişirken, yazarların çalıştıkları kurum sayısı ise ortalama 2.24±1.32 (dağılım: 1-14, medyan: 2) olarak bulundu. Atıf sayısının 1 ile 186 (ortalama:12.78±15.68, medyan:8) arasında değiştiği saptandı. Tüm makalelere yapılan toplam atıf sayısı 15127 idi.
Sonuç: Bu çalışma AOTT'de 11 yıllık süre içinde yayımlanmış makalelerin durumunu ve eğilimlerini ortaya koymuştur.

Anahtar Sözcükler: Ortopedi, atıf sayısı, bibliyometrik analiz, makale

Introduction

In recent years, as the number and diversity of scientific studies have increased, the bibliometric analysis of articles published in journals has become an important research area for researchers and academics. Bibliometrics analyzes the numerical data of scientific publications to assess their dissemination trends, impact levels, and citations. These analyses provide valuable information for identifying trends in scientific research, guiding publication strategies, and understanding the development of research fields [1-2].

The 21st century has seen rapid scientific development in medicine, some of which have occurred in specific areas such as orthopedics and traumatology. During this time, respected journals like Acta Orthopaedica et Traumatologica Turcica (AOTT) have been essential platforms for publishing research in these fields. The articles published in this journal reflect scientific advancements ranging from clinical practices to laboratory research. AOTT is the official publication of the Turkish Society of Orthopaedics and Traumatology (TOTDER) and the Union of Turkish Societies of Orthopaedics and Traumatology (TOTBID). This journal is independent, impartial, and publishes bimonthly in English as a scientific, open-access journal adhering to double-blind peer review principles. It is published every two months, in January, March, May, July, September, and November. The journal's Impact Factor was 0.226 in 2008, 0.614 in 2014, 1.0 in 2024, and the 5-year Impact Factor is 1.6 [3-4].

This study, conducted with the utmost thoroughness, aims to co-examine the articles published in AOTT between 2013 and 2023 using bibliometric methods, determining their publication trends and structural features. The particular value of this study stems from the fact that AOTT has been a leading catalyst for orthopedic and traumatology research in Turkey. During this period, the articles published in the journal have reached a wide readership, both nationally and internationally. The results of this study will contribute to the review process of AOTT's publication strategies and will guide future research. Additionally, it will be an essential resource for researchers in orthopedics and traumatology and will serve as a guide for future research in this area.

Material and Methods

The articles published between January 2013 and December 2023 in the archive section of the AOTT website (https://www.aott.org.tr) were evaluated. The evaluation criteria previously used by Yalçınkaya et al. for the bibliometric analysis of articles published between January 2003 and December 2012 were employed [5]. In addition to these criteria, the gender of the first author, the presence of international collaboration (for Turkish authors), citation counts, reading counts, and download numbers of the published articles were also assessed. Editorials, letters to the editor, and conference proceedings were excluded from the evaluation. Additionally, two articles published twice in May and September 2016 were excluded from the study.

The published articles were classified as retrospective observational studies, prospective observational studies, reviews, basic science studies, surveys, technical notes, and case presentations. Their subtypes divided observational studies into surgical, conservative, laboratory, radiological, and epidemiological studies. Basic science studies were further categorized into animal experiments, human cadaver studies, biomechanical studies, and laboratory studies. Case presentations were also divided into surgical and conservative treatments [5].

Orthopedic sub-disciplines subdivided the published articles into general orthopedics, pediatric orthopedics, orthopedic trauma, foot and ankle, shoulder and elbow, sports injuries/arthroscopy, adult reconstruction/arthroplasty, spine, hand and microsurgery, external fixation, and orthopedic oncology. Spine fractures and pediatric spine pathologies were evaluated under the spine category. Isolated traumas of the hand and wrist were assessed under the orthopedic trauma category [5].

Each article was evaluated individually, assessing the gender of the first author, number of authors, number of institutions the authors worked for, the structure of the institution where the first author worked, the first author's country, the first author's

specialty, presence of international collaboration, time between submission and acceptance (in months), sample size, outcome of the study (positive/neutral/negative), presence of statistical methods, and whether financial support was received. The study's outcome was considered positive if it showed a favorable result, negative if it showed an undesirable or harmful outcome, and neutral if no significant difference was found [5].

All published articles were searched in the Google Scholar database to record the total number of citations. The number of reads and downloads for each article on the AOTT website was also recorded.

Statistical analysis

Data were analyzed using a Python software package. $p < 0.05$ and correlation coefficient $r > +/-0.3$ were considered statistically significant. ANOVA test was used to evaluate the differences between the number of authors and the institutions they worked in-between years. The chi-square test was used to analyze the distribution of articles according to years. In addition, t-test and correlation analysis were used to examine the relationships between the number of citations and article types.

Results

Between 2013 and 2023, a total of 1035 articles were evaluated. It was observed that 460 articles (44.4%) were retrospective, 171 articles (16.5%) were basic science studies, 163 articles (15.7%) were case presentations, 128 articles (12.3%) were prospective, 51 articles (4.9%) were reviews, 42 articles (4%) were survey studies, and 20 articles (1.9%) were technical notes. The detailed analysis of article types by year is shown in Table 1.

The distribution of published articles by subspecialties of orthopedics by year is summarized in Table 2 and Graph 1. According to the chi-squared test results, statistically significant differences were found in the number of articles across orthopedic subspecialties over the years ($p < 0.05$, $p = 0.000687$). When the expected and observed frequencies of articles by orthopedic subspecialties were compared statistically (post-

hoc analysis), it was found that in 2016, the number of articles in pediatric orthopedics was below expectations, while in 2022, it was above expectations (standardized residual value: -2.08 to 2.38). In 2023, the number of articles in orthopedic oncology was below expectations; in 2019, it exceeded expectations (standardized residual value: -2.17 to 2.84). Similarly, in 2018, the number of articles on spine, shoulder, and elbow was above expectations, while in general orthopedics, it was below expectations (standardized residual value: 2.94 and 3.1 to -2.45).

The total number of authors in the published articles ranged from 1 to 15 (average: 4.75±1.53, median: 5). According to the results, no statistically significant difference was found in the number of authors over the years ($p > 0.05$, $p = 0.661$). The number of institutions the authors were affiliated with averaged 2.24±1.32 (range: 1-14, median: 2).

When the published articles were examined based on the gender of the first author, it was found that in 932 articles (90.05%), the first author was male, and in 103 articles (9.95%), the first author was female. Statistical analysis over the years showed that the number of male first authors was significantly higher than that of female first authors ($p < 0.05$, $p = 5.15 \times 10^{-9}$).

The affiliation of the first author was identified as university hospital in 603 articles (58.26%), training and research hospital in 194 articles (18.74%), state hospital in 124 articles (11.98%), private hospital in 99 articles (9.57%), military hospital in 10 articles (0.97%), and other institutions in 5 articles (0.48%). According to the results, statistically significant differences were found in the affiliation structure of the first authors over the years ($p < 0.05$, $p = 0.0071$). In 2018 and 2021, the number of first authors working in military hospitals was higher than expected (standardized residuals: 2.28 and 2.24). In 2017, the number of first authors working in private hospitals was lower than expected, and in 2019, it was the opposite, higher than anticipated (standardized residuals: -2.1 to 2.63). Additionally, in 2022, the number of first authors working in state hospitals was higher than expected (standardized residuals: 2.11).

The country of the first author is Turkey in 712 (68.79%) articles, China in 94 (9.08%) articles,

Table 1: Number of article types by year

Year	Retrospective Basic	Science Study	Case Report	Prospective Review	Review	Survey	Technical Not	Total
2013	30	21	18	7	-	-	1	77
2014	59	21	24	10	4	1	3	122
2015	53	19	22	13	4	3	1	115
2016	56	20	19	11	2	9	2	119
2017	48	14	19	8	3	4	3	99
2018	28	12	15	23	6	5	1	90
2019	39	9	13	21	9	4	-	95
2020	47	15	12	10	5	6	2	97
2021	45	11	8	11	9	4	4	92
2022	37	11	9	5	5	5	1	73
2023	18	18	4	9	4	1	2	56
Total	460	171	163	128	51	42	20	1035

Table 2: Distribution of prospective/retrospective articles by subtypes according to years

Year	Article Type	Surgical Treatment	Conservative Treatment	Laboratory Study	Radiological Study	Epidemiological Study
2013	Prospective	4	1	-	-	2
	Retrospective	21	2	-	2	5
2014	Prospective	1	6	1	1	1
	Retrospective	39	9	2	5	4
2015	Prospective	6	4	2	1	-
	Retrospective	36	4	2	7	4
2016	Prospective	4	4	2	1	-
	Retrospective	38	4	6	4	4
2017	Prospective	3	5	-	-	-
	Retrospective	35	3	2	6	2
2018	Prospective	17	5	-	1	-
	Retrospective	17	6	-	2	3
2019	Prospective	13	3	-	4	1
	Retrospective	26	5	-	6	2
2020	Prospective	3	5	1	1	-
	Retrospective	29	4	2	8	4
2021	Prospective	7	1	2	-	1
	Retrospective	25	2	1	5	12
2022	Prospective	3	-	1	-	1
	Retrospective	26	1	-	4	6
2023	Prospective	4	1	2	-	2
	Retrospective	8	3	-	2	5

South Korea in 54 (5.22%) articles, Japan in 16 (1.55%) articles, Italy in 13 (1.26%) articles, India, Taiwan and Germany in 12 (1.06%) articles, United Kingdom in 10 (0.96%) articles, Greece and Thailand in 7 (0.68%) articles, India, Taiwan, and Germany in 11 (1.06%) articles, Greece and Thailand in 6 (1.06%) articles (Graph 2). A significant difference was found in the first author's country distribution according to years.

In all years, the first author's country, Turkey, was statistically higher than all other countries (p<0.05).

The sample size was found to be between 1 and 95,484 (mean: 280±3,190.76, median: 35). In 24 articles (technical note or biomechanical study), the sample size was 0, so these articles were not included in the evaluation. No significant difference

was found in the sample size distribution according to years (p>0.05, p=0.707).
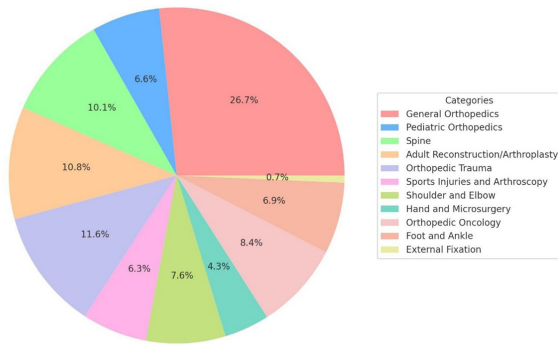
Graph 1: Percentage distribution of published articles according to orthopedics sub-branch
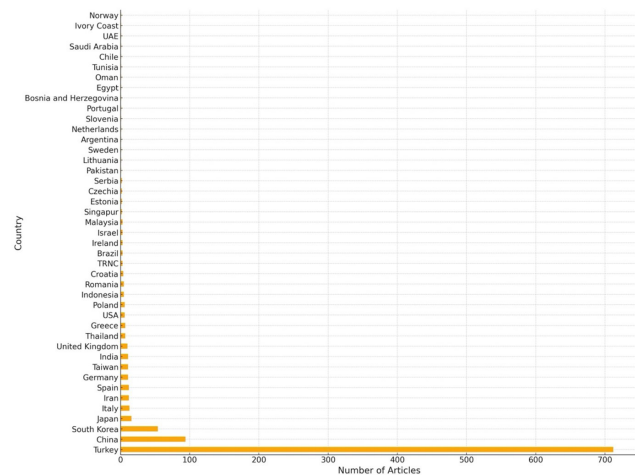
Graph 2: Distribution of first author by country

The results of the study were positive in 618 (59.71%) articles, negative in 73 (7.06%) articles, and neutral in 344 (33.27%) articles.

Statistical methods were used in 826 (79.81%) articles, while they were not used in 209 (20.19%) articles. There was no statistically significant difference in using statistical analysis according to years (p=0.418, Chi-Square value: 10.26).

It was reported that 953 (92.08%) published articles received no financial support, and 82 (7.92%) articles received financial support. This shows that the financial support status should have been reported or indicated. In addition, no conflict of interest was reported in any published articles.

When the published articles were evaluated according to the branch of the first author, the branch of the first author was orthopedics in 855 (82.65%) articles, physical therapy and rehabilitation in 67 (6.47%) articles, neurosurgery in 20 (1.93%) articles, anesthesia and neurosurgery in 18 (1.74%) in anesthesia and reanimation, 14 (1.35%) in plastic, reconstructive and aesthetic surgery, 7 (0.68%) in anatomy, 5 (0.48%) in pathology, 4 (0.39%) in sports medicine, 3 (0.29%) in medical oncology. Emergency medicine, infectious diseases and clinical microbiology, pharmacology, public health, biomedical engineering, and electrical and electronics engineering were the first author's branches in 2 (0.19%) articles each. In the remaining articles, the branch of the first author belonged to other departments.

In 25 (2.42%) published articles, at least one Turkish author was accompanied by foreign authors from other countries.

The mean time between admission and acceptance was 8.26±4.91 (range: 1-34; median: 7) months. In 3 articles, the time of application and admission could not be accessed and were not included in the evaluation. The time between application and acceptance (months) and article type (correlation coefficient: 0.038, p=0.223), number of authors (correlation coefficient: -0.024, p=0.449), country of the first author (correlation coefficient: 0.038, p=0.221), institutional structure of the first author (correlation coefficient: 0.032, p=0.309), orthopedic subspecialty (correlation coefficient: 0.019, p=0.540) and sample size (correlation coefficient: -0.020, p=0.551).

The published articles were also evaluated according to the number of citations, readings, and downloads. The total number of citations to all articles was 15127. The number of citations ranged from 1 to 186 (mean: 12.78±15.68, median: 8). The number of articles with no citations was 69. The average citation number of the 100 most cited articles was 50.1. Although the number of citations fluctuated according to year, it was observed that the number of citations decreased after 2021. In the statistical analysis, it was seen that there was a positive correlation between the number of citations and the number of articles by year (correlation value: 0.79). In other words, as the number of articles increased, the total number of citations also increased. The analysis found

statistically significant differences between the number of citations according to years (F statistic 7.83 and p<0.05, p= 3.39.x10^{-12}). Approaching 2023, it was observed that there was a decrease in the number of citations.

All articles published have been read 1,374,721 times and downloaded 564,405 times. Detailed information about citation, download, and reading counts is summarized in Table 3. The analysis found statistically significant differences in reading and downloading counts over the years (p<0.05, p=1.64x10^-12). To determine between which years the differences in reading counts occurred, the Tukey HSD posthoc test results showed that the reading counted in 2020 and 2022 was significantly higher compared to 2013, and the reading counted in 2020 was considerably higher compared to 2015 to 2017. Additionally, it was found that the reading counts in 2023 were substantially lower compared to 2016 to 2018-2022. The highest total reading count by year was in 2020 (n=153,509, 11.16%) and by month in July 2021 (n=15,737, 1.14%). The main reason the total number of readings by year was the highest in 2020 is that academics spent more time on articles due to the curfew due to the COVID-19 pandemic. The highest total download count by year was in 2014 (n=100,427, 17.80%) and by month in January 2016 (n=3,951, 0.7%).

When examining the differences between reading and downloading counts over the years, the most significant difference was found in July 2021 (n=23,206), indicating that reading activities were significantly more frequent than downloading activities that year. On the other hand, the slightest difference was observed in January 2013 (n=1,994), showing that the difference between reading and downloading counts was relatively less at that time.

The multiple linear regression model analysis showed that articles with higher reading and downloading counts received more citations (p=0.007, p=0.005). This means that although citation counts have decreased over time, citations are increasing as reading and downloading counts increase. Graph 3 shows reading and downloading counts over the years.

The article with the highest number of citations was the study by Simsek et al., published in March 2013 with 186 citations [6]. The highest number of reads was the article by Lee et al., published in July 2021, with 15747 reads. However, the number of citations of this article was surprisingly 3 [7]. The highest number of downloads was the article by Huang et al., published in January 2016, with 3963 downloads. The number of citations of this article was 106 [8]. The longest distance between application and acceptance was the meta-analysis study conducted by Shengyuan et al. in August 2023, which lasted 34 months [9]. The largest sample size was the study by Hsun Lee et al., published in July 2016, with 95,484 patients. The number of citations for this study was 50 [10]. These data are based on the date the article was written.
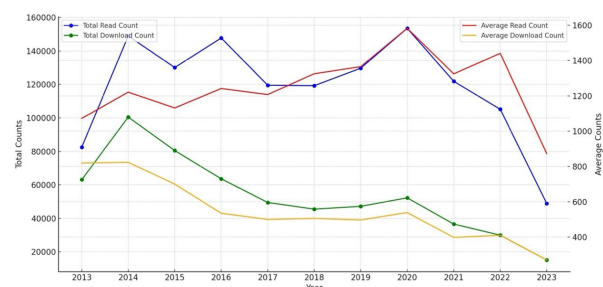
Graph 3: Total and average number of readings/downloads by year

Discussion

The number of articles published in orthopedics and traumatology worldwide is continually increasing. This number changes as research activities globally increase. The number of studies conducted in orthopedics and traumatology is expressed in thousands each year. These studies cover various topics such as diagnosis and treatment of diseases, surgical techniques, rehabilitation methods, implants, and technological innovations. Therefore, it is difficult to state the exact number of articles published each year in this field, but it is possible to say it involves a large volume. According to a study by Lee et al., 46,322 orthopedic articles were published worldwide between 2000 and 2009 [11]. Jiang et al. reported in another study that between 2003 and 2014, 123,317 articles were published in 63 orthopedic journals in China, Hong Kong, and Taiwan [12].

In Turkey, the number of articles on the

Table 3: Number of citations, readings, and downloads of articles by year

Year	Average Number of Citations	Total Number of Citations (%)	Average Number of Reads	Total Number of Reads (%)	Average Number of Downloads	Total Number of Downloads (%)
2013	19.57	1507 (%10.65)	1071.58	82512 (%6.01)	819.17	63076 (%11.17)
2014	17.30	2110 (%14.93)	1220.65	148919 (%10.83)	823.17	100427 (%17.8)
2015	13.04	1500 (%10.6)	1131.10	130077 (%9.46)	699.83	80481 (%14.26)
2016	23.61	2810 (%19.89)	1241.18	147701 (%10.75)	534.41	63595 (%11.27)
2017	18.81	1862 (%13.18)	1207.01	119494 (%8.69)	499.63	49463 (%8.76)
2018	16.56	1490 (%10.53)	1324.78	119230 (%8.67)	505.49	45494 (%8.06)
2019	14.39	1367 (%9.68)	1369.96	129671 (%9.43)	496.53	47170 (%8.36)
2020	10.53	1021 (%7.22)	1882.57	153509 (%11.16)	538.62	52246 (%9.26)
2021	3.87	356 (%2.52)	1324.30	121836 (%8.86)	397.26	36548 (%6.48)
2022	2.33	170 (%1.2)	1440.36	105146 (%7.65)	409.53	29896 (%5.3)
2023	0.61	34 (%0.24)	872.43	48856 (%3.55)	269.88	15113 (%2.68)
Average /Total	12.78	15127	1252	1374721	544.86	564405

bibliometric analysis of orthopedic publications needs to be improved [1,13-14]. Gürbüz et al. have reported in a study examining the first 40 journals in the Science Citation Index Expanded (SCI-E) list between 1980 and 2013 that the total number of publications worldwide was 130,494, and the number from Turkey was 1,594, ranking Turkey 14th with 1.22% of total publications [13]. A study reviewing all articles of the Joint Diseases and Related Surgery (JDRS) journal, the official publication of the Turkish Joint Diseases Foundation, over 30 years (1989/1 - 2019/1) examined a total of 18 volumes comprising 44 issues and 688 articles and evaluated the pre-SCI-E period data (1989-2006). This study found that 22% of the articles were in general orthopedics, 14.4% in orthopedic trauma, and 9.7% in pediatric orthopedics. The type of articles was reported as 72.2% research articles, 16% reviews, and 10.8% case reports. The average number of authors per article was 3.8, and the average number of citations per article was 0.7. It was also reported that most articles were submitted from universities [14].

In a study in which all articles of Acta Orthopaedica et Traumatologica Turcica (AOTT), the official publication of the Turkish Association of Orthopaedics and Traumatology (TOTBID), were reviewed for a period of 10 years (2003-2012), a total of 699 articles were analyzed. As a result of this study, 18.3% of the articles were published in orthopedic trauma, 14.3% in hand and microsurgery, and 13% in general orthopedics. The most common study design was a retrospective observational study with 48.5%

and a case report with 21.9%. The institution where the first author worked was reported as a university hospital in 56.4% of the articles and as a training and research hospital in 30.8%. The number of authors was reported to be between 1 and 22 (mean: 4.63±1.62, median: 5) [5]. Our study published the most shared articles in general orthopedics, orthopedic trauma, spine, and adult reconstruction/arthroplasty. Retrospective studies, basic science studies, and case reports are among the most common studies. The institution where the first author worked was a university hospital at a similar rate. In light of these data, it is concluded that more than half of the articles published in AOTT were conducted in universities.

The number of citations a paper receives generally indicates how much interest it has generated within the academic community and how much it has been used. However, high citation numbers only sometimes signify high quality. Citations may not always be made in a positive context. Some citations could point out criticisms or errors in previous studies. Moreover, citation rates can vary significantly between different scientific fields. For example, in some fields, studies quickly become outdated; in others, old studies can remain valid for a long time. Sometimes, researchers may consciously or unconsciously tend to cite each other's work. This situation can exaggerate the actual impact or quality of the work. Review articles generally receive more citations because they summarize a wide range of literature and provide comprehensive information. This does not mean that the quality of original research articles

is lower. Therefore, a paper's citation count can indicate its impact, but more is needed to judge its quality definitively. To assess the quality of an article, it is necessary to examine the content in detail, critique the methodology, and compare the findings with similar studies.

A certain amount of time is needed for a paper to be cited. This period averages between 7-10 years from the time of publication [15]. Banerjee et al. conducted a study on the bibliometric analysis of the top 100 systematic reviews and meta-analyses in the orthopedic literature, reporting that the citation count ranged from 1073 to 198, totaling 30,589 citations [16]. Kelly et al. analyzed 100 classic papers in orthopedic surgery and reported an average citation count of 446.5 [17]. Another study related to pediatric orthopedics evaluated 100 classic articles, finding the average citation count to be 168 [18]. Erivan et al. used the Scopus database to determine the citation rates for 2158 articles published in Orthopaedics & Traumatology: Surgery & Research (OTSR) and assessed the 100 most cited articles, finding an average citation count per article of 49.59±24.16 (range: 30-169) [19]. Another analysis assessed 107 articles published in the European Journal of Orthopaedic Surgery and Traumatology (EJOST), reporting an average citation count per article of 15.3 [20]. In our study, the average citation count per article was 12.78, and the average number of authors per article was 4.75. The average citation count for the top 100 most cited articles was 50.1. These results indicate that the citation count and average citation count for the first 100 articles published in AOTT are comparable to those in OTSR and EJOST.

From 2013 to 2023, a bibliometric analysis of the articles published in AOTT shows a notable trend regarding the gender distribution of the first authors. Notably, the proportion of female first authors has been relatively low over these eleven years. This situation indicates that gender equality has not yet been fully achieved in fields such as orthopedics and traumatology. The underrepresentation of female researchers in academic publications points to structural issues that could hinder the career development of women in these fields. Although various studies on gender differences in surgical fields

have been conducted recently, no consistency has been found [21-23]. One study reported that the orthopedics department lags behind general surgery and other surgical branches regarding female representation [23]. Hiller et al. conducted a survey covering the bimonthly issues of Clinical Orthopaedics and Related Research® (CORR®), Journal of Bone and Joint Surgery, American Volume (JBJS), and American Journal of Sports Medicine (AJSM) from 2006 to 2017, examining the original research publications. It was found that a woman wrote 13% of the 6292 articles (800) as the first author. During the examined period, the percentage of female first authors at JBJS was 14%, while at CORR and AJSM, it was 12%. The overall rate of female first authors in the journals studied increased (from 11% in 2006 to 17% in 2017) [24]. In our study, the percentage of female first authors varied over the years but averaged around 10%. The low rate of female first authors can be explained in several ways. One reason is the relatively lower number of female orthopedists globally and in our country than males. Another reason is the imbalance between family and work, which is skewed against women in the field of orthopedic surgery.

In recent years, the increasing number of authors in academic publications has emerged as a notable trend. Although this increase reflects positive developments such as expanded research scope and increased interdisciplinary collaboration, it also brings undeserved or inappropriate authorship problems [24]. Factors like career advancement and funding pressures in academic circles can compel some researchers to add their names to papers without significant contributions, a practice considered unethical in scientific research and endangering the integrity of the study. Thus, academic journals and related institutions must clearly define authorship criteria and strictly adhere to them. This would ensure that researchers who genuinely contribute to the scientific literature receive deserved recognition and that the quality of research is maintained. Rahman et al. conducted a study on the number of authors and their geographical origins in articles published in the Journal of Bone and Joint Surgery British Volume (JBJS) and Clinical Orthopaedics and Related Research (CORR) over the last 50 years, analyzing 2776 articles published in ten-

year intervals between 1958 and 2008 (CORR, n=1809; JBJS, n=967). They found a significant increase in the average number of authors per article from 1.638 to 4.08 in CORR (P<.0001) and from 1.633 to 4.540 in JBJS (P<.0001). They also emphasized the need for efforts by the International Committee of Medical Journal Editors or individual journals to prevent the proliferation of inappropriate authorship [25]. Camp et al. examined all original research articles and case reports published in The Journal of Bone and Joint Surgery (American and British Volumes) (JBJS-A and JBJS-B) over ten-year intervals from 1949 to 2009. They reported that the average number of authors in original research articles increased from 1.6 in 1949 to 5.1 in 2009, suggesting a trend of growing authorship in biomedical research is also evident in orthopedic literature [24]. Yalçınkaya et al. conducted a study on 699 articles published in AOTT between 2002 and 2013, analyzing the number of authors and the institutions they are affiliated with. They found that the number of authors ranged from 1 to 22 (average: 4.63±1.62, median: 5), and the number of institutions ranged from 1 to 21 (average: 1.72±1.23, median: 1). They also noted that the 'publish or perish' phrase still holds [5]. In our study, the total number of authors ranged from 1 to 15 (average: 4.75±1.53, median: 5), and the number of institutions they are affiliated with averaged 2.24±1.32 (range:1-14, median:2). These two studies show that while the average number of authors is similar, the number of institutions they are affiliated with has increased.

This article has some limiting factors. Analyzing articles within a specific time frame can lead to missing a broader perspective. Moreover, the citation counts of the articles, especially for newly published ones, may be low, which may not reflect the true impact of the studies.

Conclusions

This study includes a bibliometric analysis of the articles published in AOTT in the last 11 years. Although the citation numbers of recently published articles are low, it is evident that these numbers will increase over time. In addition, an increase in the number of female first authors in the future will be an essential parameter for gender equality.

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Is ChatGPT a Useful Tool for Ophthalmology Practice?

ChatGPT Oftalmoloji Pratiğinde Faydalı Bir Araç Mıdır?

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ABSTRACT

Aim: This study aimed to assess ChatGPT-3.5's performance in ophthalmology, comparing its responses to clinical case-based and multiple-choice (MCQ) questions.
Methods: ChatGPT-3.5, an AI model developed by OpenAI, was employed. It responded to 98 case-based questions from "Ophthalmology Review: A Case-Study Approach" and 643 MCQs from "Review Questions in Ophthalmology" book. ChatGPT's answers were compared to the books, and statistical analysis was conducted.
Results: ChatGPT achieved an overall accuracy of 56.1% in case-based questions. Accuracy varied across categories, with the highest in the retina section (69.5%) and the lowest in the trauma section (38.2%). In MCQ, ChatGPT's accuracy was 53.5%, with the weakest in the optics section (32.6%) and the highest in pathology and uveitis (66.7% and 63.0%, respectively). ChatGPT performed better in case-based questions in the retina and pediatric ophthalmology sections than MCQ.
Conclusion: ChatGPT-3.5 exhibits potential as a tool in ophthalmology, particularly in retina and pediatric ophthalmology. Further research is needed to evaluate ChatGPT's clarity and acceptability for open-ended questions.

Key Words: Artificial intelligence, ChatGPT, Large language model, Ophthalmology

ÖZ

Amaç: ChatGPT-3.5'in performansını göz hastalıkları alanında değerlendirmek, klinik vaka bazlı sorular ve çoktan seçmeli sorulara (ÇSS) verdiği yanıtların doğruluk oranını karşılaştırmaktır.
Yöntem: Çalışmada OpenAI tarafından geliştirilen bir yapay zeka modeli olan ChatGPT-3.5 kullanıldı. Modelden, "Ophthalmology Review: A Case-Study Approach" kitabından 98 vaka bazlı soruya ve "Review Questions in Ophthalmology" kitabından 643 ÇSS'ye yanıt vermesi istendi. ChatGPT'nin cevapları kitaplarla karşılaştırıldı ve istatistiksel analizi yapıldı.
Bulgular: ChatGPT, vaka bazlı sorularda genel olarak %56,1 doğruluk oranı gösterdi.. Doğruluk oranı kategoriler arasında en yüksek retina bölümünde (%69,5) ve en düşük travma bölümünde (%38,2) idi. ÇSS'de ChatGPT'nin genel doğruluk oranı %53,5 olarak gözlendi, bunların en düşüğü optik bölümünde (%32,6) ve en yükseği patoloji ve üveit bölümlerinde (%66,7 ve %63) idi. ChatGPT özellikle retina ve pediatrik oftalmoloji bölümlerindeki vaka bazlı sorularda ÇSS'ye kıyasla daha iyi performans gösterdi.
Sonuç: ChatGPT-3.5, özellikle retina ve pediatrik oftalmoloji alanlarında göz hastalıkları için potansiyel bir yardımcı araç olarak görülmektedir. ChatGPT'nin açık uçlu sorular için netlik ve kabul edilebilirliğini değerlendirmek için daha fazla araştırma yapılması gerekmektedir.

Anahtar Sözcükler: Yapay zeka, ChatGPT, Büyük dil modeli, Oftalmoloji

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Introduction

Artificial intelligence (AI) based tools have recently been gaining popularity in medicine, including medical education, public health, and disease treatment and management. Deep learning algorithms (DLAs), a branch of AI, have been widely integrated into clinical practice. These algorithms obtain results via neural networks in a somewhat similar manner to the human brain. [1]

Chat Generative Pre-trained Transformer (ChatGPT), an AI-based chatbot developed by OpenAI (San Francisco, CA, USA), combines DLA and neural networks. This large language model (LLM) enables users to obtain text responses based on extensive textual datasets in various languages as human-like conversations.[2]

ChatGPT-3 has garnered significant attention worldwide since its release in November 2022. Like previous versions, it has also found its place in medicine.[3] While it was initially preferred for scientific writing, such as article abstracts or book chapters. [4] It has since found diverse uses in analyzing data generated from medical exams.

ChatGPT noted a significant improvement in answering the medical questions in the United States Medical Licensing Exam (USMLE).[5,6] Additionally, Cai et al.[7] demonstrated that the latest version of ChatGPT had a similar ability to human respondents in finding solutions in the Basic Science and Clinical Science Self-Assessment Program. These studies focused on multiple-choice questions (MCQs). However, clinical case-based learning, another popular educational method, is essential to achieve sufficient competency for clinical practice.

In ophthalmology, DLAs have proven a promising tool for diagnosing and screening common retinal diseases such as diabetic retinopathy and age-related macular degeneration.[8,9]

However, since chatbots have not yet reached impressive accuracy, their performance with ophthalmological questions requires improvement. Therefore, this study compared the performance of ChatGPT-3,5 with MCQ and clinical case-based questions in ophthalmology.

Material and Methods

AI

This study used the ChatGPT GPT-3.5 models. ChatGPT uses multiple mechanisms, including self-attention, training data, and fine-tuning, to produce natural language responses to text input on a user interface accessed at https://chat.openai.com/. This iterative deployment could not browse other databases or Internet searches at the time of this study. All responses are generated in situ, based on the abstract relationship between user-inputted words in the neural network. The ChatGPT version used in this study contained only information indexed from its last update until January 1, 2022.

Obtaining Data

The Ophthalmology Review: A Case-Study Approach book was chosen for the case-based questions.[10] It comprises 98 case-based questions divided into 11 categories: cornea and external disease, lens, glaucoma, retina, uveitis, tumors, posterior segment complications, trauma, neuro-ophthalmology, pediatric ophthalmology, and orbit/oculoplastics. Each question has seven sections:

• Section 1: The history and findings on examination of a typical patient;

• Section 2: Relevant diagnostic testing and interpretations;

• Section 3: The diagnosis and differential diagnosis;

• Section 4: Medical management;

• Section 5: Surgical management;

• Section 6: Recommendations for rehabilitation and follow-up care;

• Section 7: Suggested Reading.

The Review Questions in Ophthalmology book was chosen for the MCQs, which contains 1062 MCQs spanning 12 chapters: fundamentals, embryology and anatomy, optics, neuro-ophthalmology, pediatric ophthalmology and strabismus, plastics, pathology, uveitis, glaucoma, cornea, lens/cataract, and retina and vitreous.[11]

Model testing was conducted for two months, from February to April 2023, using version 3.5 of ChatGPT. Both books provide questions with their corresponding answers and explanations. Since the questions are not publicly accessible, they have not been indexed in any search engine or included in the ChatGPT database.

Each question was entered into the ChatGPT interface. A new ChatGPT session was launched for every question to prevent crossover learning and memory retention. The recorded responses were compared to the answers in the book. Due to inadequate interpretation by ChatGPT, 419 MCQs comprising clinical, radiological, or graphical images were excluded from the analysis. All 98 case-based questions were processed from the Ophthalmology Review: A Case-Study Approach book. These questions comprise five parts:

1. What is the most likely diagnosis of this case?

2. What is the most likely differential diagnosis of this case?

3. How should this case be medically managed?

4. How should this case be surgically managed?

5. How should this case be rehabilitated and followed up?

Parts 1 (diagnosis) and 5 (rehabilitation and follow-up) were evaluated as "Correct" (1) or "Incorrect" (0). All other parts were converted to percentiles (i.e., the ability of ChatGPT to generate two correct answers in five differential diagnoses corresponded to 40%; Figure 1).

The 643 remaining MCQs that contained only the question stem without answer choices were processed from the Review Questions in Ophthalmology book. The responses were encoded as "Correct" and "Incorrect" (Figure 2).

Statistical Analysis

The data were statistically analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows software (version 26.0). Categorical variables are presented as numbers (n) and percentages (%) that indicate the accuracy of ChatGPT responses. Categorical variables were compared using the Chi-Square test. The data were examined at a 95% confidence level. A P-value of <0.05 was considered statistically significant.
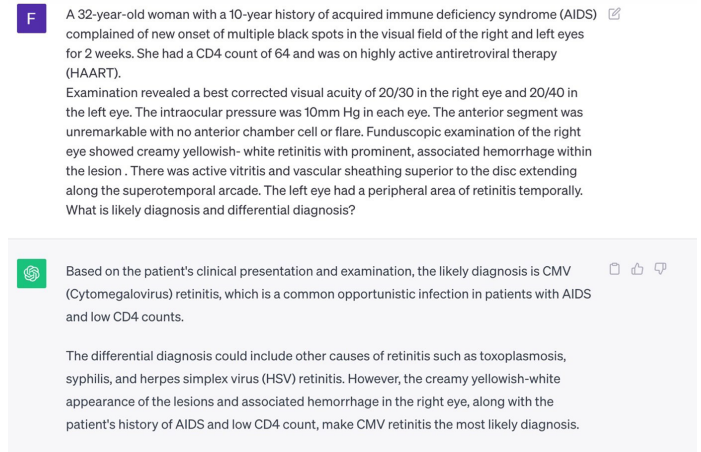
Figure 1. A question inspired from the book "Ophthalmology Review: A Case-Study Approach" and ChatGPT's response.
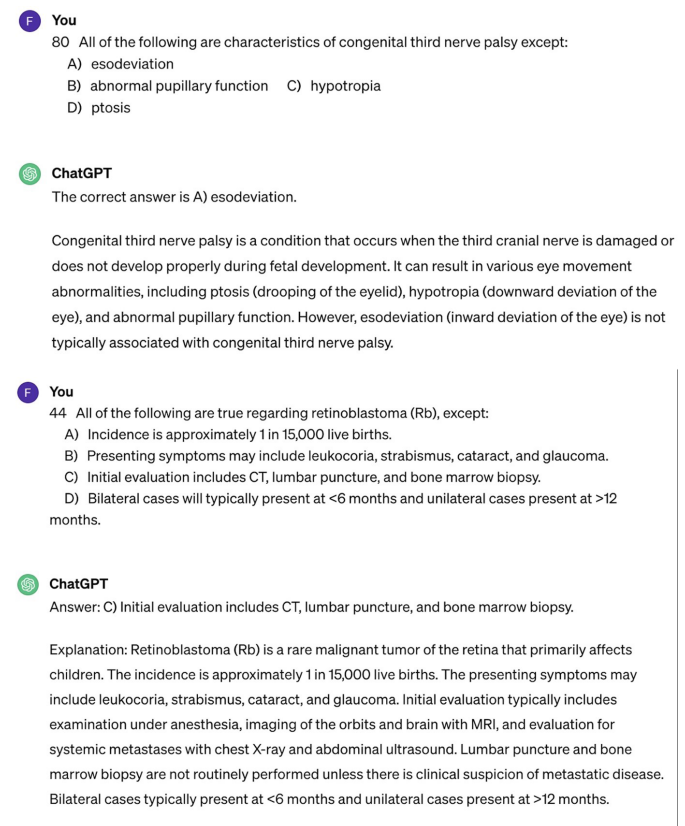
Figure 2. Examples of MCQ's inspired from the book "Review Questions in Ophthalmology" and ChatGPT's response. MCQ: Multiple choice question

Results

ChatGPT generated 56.1% correct responses to each part of the 98 case-based questions. The distribution of correct answer rates in the 11 categories is presented in Table 1. The correct answer rate was highest in the retina section (14 questions; 69.5%) and lowest in the trauma section (two questions; 38.2%). The correct answer rate was <50% for the tumors, posterior segment complication, trauma, neuro-ophthalmology, and orbit/oculoplastics sections. ChatGPT correct answer rates were highest in diagnosis and lowest in differential diagnosis.

ChatGPT correctly answered 344/643 MCQs (53.5%; Table 2). The correct answer rate was lowest in the optics section (32.6%) and highest in the pathology (66.7%) and the uveitis (63.0%) sections. ChatGPT achieved more than 50% correct answer rate in all sections, except the embryology and anatomy (40.9%) and the optics (32.6%).

Figure 3 represented as the comparison of each book according to sectors. The correct answer rates for case-book questions and MCQs did not differ significantly in each section except the retina and pediatric ophthalmology (p = 0.020 and p = 0.025, respectively).

Discussion

Since the release of ChatGPT 3.5, the conversational abilities of LLMs have come to the forefront, particularly in more human-like conversational features. This feature makes ChatGPT a prominent tool for assisting medical applications. However, clinical approaches require many abilities, such as situational assessment, interpretation, and theoretical knowledge. Additionally, clinical reasoning requires years of training and experience, making this complex cognitive process difficult for LLMs to master.

ChatGPT showed significant improvement in answering medical questions. Our study is the first to compare the quality of answers to ophthalmology open-ended questions and MCQs using ChatGPT. Case book questions are noteworthy in ophthalmology as a guide for clinical approach. While the correct answer rate was similar for each book, it was <60% in our study.

ChatGPT 3 achieved a passing score (>60%) for a third-year medical student on the National Board of Medical Examiners.[5] Additionally, ChatGPT 3 performed at or near the passing threshold for all three exams (Steps 1, 2, and 3) in the USMLE. [6] The performance of ChatGPT 3.5 on questions from each book seemed similar to its theoretical performance in different studies that compared its performance against human respondents. [7,12,13]

Antaki et al.[12] reported that ophthalmology residents who graduated in 2022 had an average score of 74% on the Basic and Clinical Science Course question bank and 63% on the OphthoQuestions. Additionally, ChatGPT Legacy and ChatGPT Plus performed worse than the human scores. Another MCQ study showed that ChatGPT could not correctly answer a sufficient number of questions from the OphthoQuestions practice question bank.[13] ChatGPT 3.5 achieved similar performance on the MCQs from the Review Questions in Ophthalmology book in our study to previous MCQ studies in ophthalmology or general medicine.[12,14]

Furthermore, ChatGPT has shown remarkable improvement in performance as its version was updated from ChatGPT Legacy to ChatGPT Plus. [12] The factors predicting answer accuracy were question difficulty, cognitive level, and examination section. The updated ChatGPT 3 Plus version was less affected by the examination section, but it performed poorly in neuro-ophthalmology, oculoplastics, and clinical optics.[12]

In our study, ChatGPT 3.5 performed worst in the MCQs on optics (32.6%) and embryology and anatomy (40.9%), consistent with ophthalmologists being more familiar than ChatGPT with these topics since they constitute the fundamentals of clinical practice. However, ChatGPT 3.5 performed worst in the case book questions on trauma (38.2%), followed by tumors (40.8%) and posterior segment complications (46.1%). However, it should be considered that these sections contained fewer than five questions. In addition, ChatGPT 3.5 performed poorly on the case book questions on neuro-ophthalmology (46.5%) and orbit/oculoplastics (46.7%), consistent with previous

Table 1. The distribution of answers among subfields for case-based questions book

	n		Diagnosis (%)	Differential diagnosis (%)	Medical management (%)	Surgical management (%)	Rehabilitation and follow-up (%)	Total (%)
Cornea and external disease	13	True	69.2	56	67	53	61.5	60.2
		False	30.8	44	33	47	38.5	
Lens	5	True	80.0	67	35	90	100	65.7
		False	20.0	33	65	10	0	
Glaucoma	12	True	58.3	24	61	50	58.3	54.0
		False	41.7	76	39	50	41.7	
Retina	14	True	78.6	53	68	87	64.3	69.5
		False	21.4	47	32	13	35.7	
Uveitis	3	True	66.7	49	58	50	66.7	52.3
		False	33.3	51	42	50	33.3	
Tumors	2	True	100.0	32	NA	50	0	40.8
		False	0	68	NA	50	100	
Posterior segment complications	4	True	100.0	13	62	68	75	46.1
		False	0	87	38	32	25	
Trauma	2	True	50.0	50	50	20	0	38.2
		False	50.0	50	50	80	100	
Neuro-Ophthalmology	20	True	50.0	37	60	64	55	46.5
		False	50.0	63	40	36	45	
Pediatric Ophthalmology	10	True	80.0	26	69	83	40	65.6
		False	20.0	74	31	17	60	
Orbit/Oculoplastics	13	True	61.5	37	42	53	76.9	46.7
		False	38.5	63	58	47	23.1	
Total	98	True	67.3	40	59	64	60.2	56.1
		False	32.7	60	41	36	39.8	

Table 2. The distribution of answers among subfields for multiple choice book

	Total n	True n (%)	False n (%)
Fundamentals	50	28 (56.0)	22 (44.0)
Embryology and Anatomy	44	18 (40.9)	26 (59.1)
Optics	46	15 (32.6)	31 (67.4)
Neuroophthalmology	63	34 (53.9)	29 (46.0)
Pediatric ophthalmolgy and Strabismus	67	34 (50.7)	33 (49.3)
Plastics	63	35 (55.6)	28 (44.4)
Pathology	6	4 (66.7)	2 (33.3)
Uveitis	54	34 (62.9)	20 (37.0)
Glaucoma	85	46 (54.1)	39 (45.9)
Cornea	63	38 (60.3)	25 (39.7)
Lens and Cataract	28	17 (60.7)	11 (39.3)
Retina and Vitreous	74	41 (55.4)	33 (44.6)
Total	643	344 (53.5)	299 (46.5)
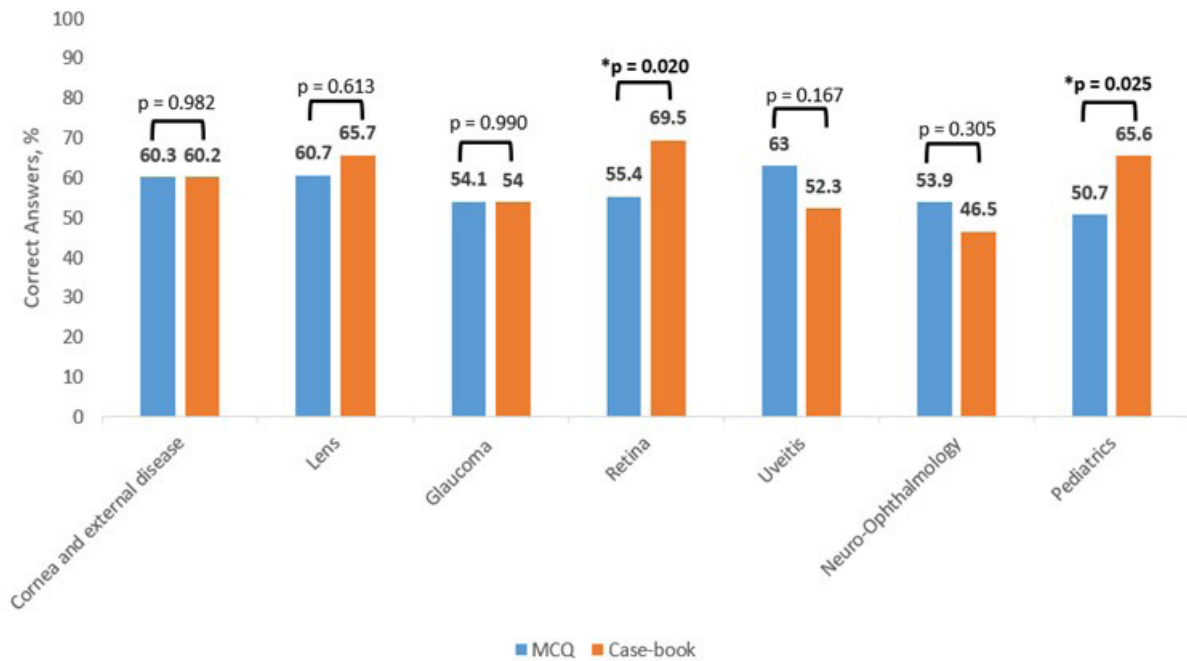
Figure 3. Pairwise comparison of correct answer rates for common subfields between two books.

* p values were obtained by Chi-Square test

MCQ studies.[12]

ChatGPT uses a vast amount of available data and resources on the internet. Like human respondents, ChatGPT is known to perform better on easier questions. Moshirfar et al.[15] demonstrated that ChatGPT 3.5 and ophthalmology professionals performed similarly on 467 ophthalmology StatPearls questions, although the performance gap increased with question difficulty. However, specialized domains, including optics, neuro-ophthalmology, and oculoplastics, are highly challenging and less familiar topics even within the ophthalmology community.[16] In addition, there is a knowledge cutoff of September 2023 for all versions of ChatGPT.

Notably, our study examined many more MCQs than previous studies. Our study found that ChatGPT 3.5 excelled in MCQs on pathology (66.7%), uveitis (63.0%), lens and cataracts (60.7%), and cornea (60.3%). Each section contained more than 25 questions except for pathology, which contained six. The correct answer rates for MCQs differ between our study and previous MCQ studies, possibly reflecting differences in the distribution and difficulty of questions in each section.[12,15] In addition, the latest version of ChatGPT outperforms previous versions. Moreover, Moshirfar et al. found that ChatGPT 4.0 was superior to humans on ophthalmology StatPearls questions.[15]

Furthermore, ChatGPT achieved the highest performance (69.5%) on the case book questions in the retina section. Indeed, its performance was significantly higher than our theoretical knowledge benchmark, the MCQs. Given its significantly higher performance on the case book questions on pediatric ophthalmology than the MCQs, this result indicates that ChatGPT 3.5 could be a tool for retinal diseases, as previously demonstrated with earlier versions, and for pediatric ophthalmology. It also achieved high performance on questions about lens (65.7%), pediatric ophthalmology (65.6%), and cornea and external disease (60.2%). In addition, it performed best in diagnosis and worst in differential diagnosis. Therefore, ChatGPT receives appropriate updates that are considered to be the results of user inputs. This outcome might be encouraging and notable in ophthalmology despite being an example of a specialized case book examination. However, ChatGPT provided longer and more vague explanations for open-ended questions than the case book answers.

Limitations

Our study was limited by its relatively small sample size of 98 case-book questions, even when considering their divisions. While our study included 643 MCQs, many more than previous studies, these comparisons may not represent the entire knowledge of ophthalmology, especially for clinical practice. Furthermore, our study only used ChatGPT 3.5, which might not reflect all available models at the time of publication. The last version (ChatGPT 4.0) was released in March 2023. However, it is less accessible and had a limited capacity of 25 messages during our study period. Our study did not assess the difficulty levels of the included questions. Additionally, unlike previous studies, our study did not compare answers between ChatGPT and human respondents.

In conclusion, our study suggests that ChatGPT may be suitable for future integration into clinical decision-making in ophthalmology, especially in the retina and pediatric ophthalmology sub-fields. Despite its promising performance, the existing limitations of ChatGPT may be overcome by enabling it to process images and incorporating other transformer models or domain-specific sources. Further studies are needed to assess the clarity and acceptability of LLM answers to open-ended questions.

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Four-Year Study on Subcutaneous Port Catheters in Oncology Patients: Patency, Complications, and Outcomes

Onkoloji Hastalarında Subkutan Port Kateterler Üzerine Dört Yıllık Çalışma: Açıklık, Komplikasyonlar ve Sonuçlar

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ABSTRACT

Aim: Our primary focus was port patency, postoperative complications, mortality rates, and demographic factors.
Methods: In this extensive four-year study, we examined subcutaneous port catheter placement in 172 oncology patients (111 men, 61 women) between March 2018 and December 2021. We excluded one 10-month-old infant who received a pediatric port catheter.
Results: Patients predominantly underwent jugular intervention via the right internal jugular vein (97%) and occasionally via the left internal jugular vein (3%). On average, the port patency lasted for 375 days, with an overall duration of 432 days. Males had a mean patency of 13.58 months, while females averaged 11.97 months. Notably, bladder cancer patients had the longest port patency (44 months), followed by uterine cancer (35 months) and breast cancer (22.5 months). Among the 171 patients, nine had mild to moderate infections, six had mild ecchymosis-hematoma, and two required early catheter removal due to severe infections. Only one patient had mild pneumothorax that did not necessitate surgery. No major complications, such as hemothorax, nerve injury, neck compression, massive hematoma, blood transfusion, substantial bleeding, port detachment, rupture, or fragment embolism were recorded.
Conclusion: Subcutaneous port catheter placement proved to be safe and effective for patients undergoing chemotherapy, particularly with skilled surgical teams. Procedures via the right internal jugular vein consistently yielded favorable outcomes, with low infection rates, minimal occlusion, stenosis, thrombosis, and complication rates, while maintaining extended port patency. This study underscores the substantial improvement in oncology patients' quality of life by eliminating the challenges associated with frequent peripheral vessel access.

Keywords: Port catheter, Complications, Intravenous Chemotherapy, Malignancy, Internal Jugular Vein

ÖZ

Amaç: Öncelikli odak noktamız port açıklığı, postoperatif komplikasyonlar, mortalite oranları ve demografik faktörlerdi.
Yöntem: Bu dört yıllık kapsamlı çalışmada, Mart 2018 ve Aralık 2021 tarihleri arasında 172 onkoloji hastasında (111 erkek, 61 kadın) subkutan port kateter yerleştirilmesini inceledik. Pediatrik port kateteri takılan 10 aylık bir bebek hariç tutulmuştur.
Bulgular: Hastalara ağırlıklı olarak sağ internal juguler venden (%97) ve nadiren soldan (%3) juguler girişim uygulandı. Ortalama olarak, port açıklığı 375 gün sürmüş ve toplam süre 432 gün olmuştur. Erkeklerde ortalama açık kalma süresi 13,58 ay iken, kadınlarda ortalama 11,97 aydır. Özellikle, mesane kanseri hastaları en uzun port açıklığına (44 ay) sahipken, bunu rahim kanseri (35 ay) ve meme kanseri (22,5 ay) takip etmiştir. 171 hastanın dokuzunda hafif ila orta derecede enfeksiyon, altısında hafif ekimoz-hematom ve ikisinde ciddi enfeksiyon nedeniyle kateterin erken çıkarılması gerekmiştir. Sadece bir hastada ameliyat gerektirmeyen hafif bir pnömotoraks görülmüştür. Hemotoraks, sinir yaralanması, boyun sıkışması, masif hematom, kan transfüzyonu, ciddi kanama, port ayrılması, rüptür veya fragman embolisi gibi majör komplikasyonlar kaydedilmedi.
Sonuç: Subkütan port kateter yerleştirme işleminin kemoterapi hastaları için, özellikle de deneyimli cerrahi ekiplerle, güvenli ve etkili olduğu kanıtlanmıştır. Sağ internal juguler ven yoluyla yapılan prosedürler, düşük enfeksiyon oranları, minimal oklüzyon, stenoz, tromboz ve komplikasyon oranları ile sürekli olarak olumlu sonuçlar verirken, uzun süreli port açıklığını da korumuştur. Bu araştırma, sık periferik damar erişimiyle ilişkili zorlukları ortadan kaldırarak onkoloji hastalarının yaşam kalitesindeki önemli iyileşmenin altını çizmektedir.

Anahtar Kelimeler: Port Katater, Komplikasyonlar, İntravenöz Kemoterapi, Malignite, Internal Juguler Ven

Introduction

A port catheter is a highly favored vascular access method in oncology. This preference stems from the challenges associated with establishing new vascular access points for repeated intravenous chemotherapy, blood transfusions, fluid replacement, parenteral nutrition, and routine follow-up examinations [1]. Relying solely on the peripheral vascular access during routine clinical use can lead to severe complications. These complications may include chronic intravascular damage, extravasation, thrombophlebitis, phlebitis, cellulitis, and in advanced cases, the risk of skin and subcutaneous tissue necrosis.

Until 1982, Broviac and Hickman-type multilumen central venous access catheters, featuring a traditional felt component protruding into the subcutaneous tissue (Picture 1), were the standard choice. However, in 1982, Niederhuber introduced a series of conical chamber port catheters connected to a silicone catheter that could be entirely implanted under the skin. This innovation was applied to 30 patients with cancer who required both arterial and venous vascular access [2].
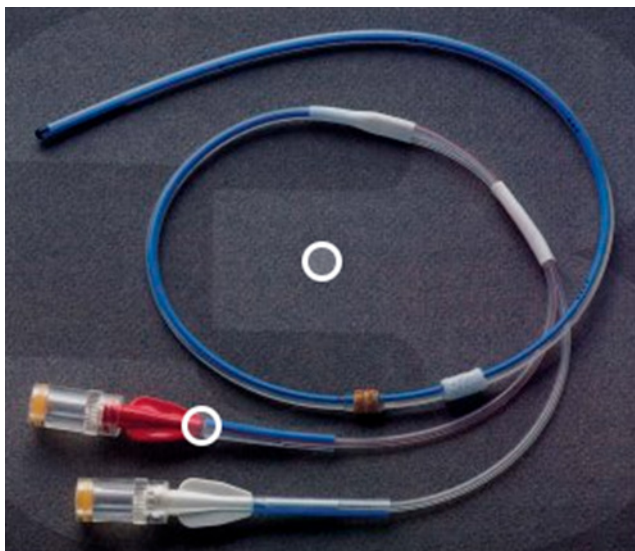
Picture 1. Broviac and Hickman type 2-lumen venous catheter

Subsequently, with the publication of the findings of Schwarz et al., who documented an average patency of 1,191 days in a series of 680 patients between 1987 and 1989, the use of port catheters

gained widespread acceptance in the global medical community [3].

Furthermore, a cost-effectiveness analysis conducted on 1,050 patients in 2021 revealed that venous catheters were more cost-effective during the initial 3-9 months of use. However, during the 9-12 month follow-up period, port catheters demonstrated superior cost-effectiveness compared to venous catheters [4]. In the context of long-term use, port catheters have emerged as a cost-effective and comfortable option.

Port catheters have evolved in design, incorporating materials such as plastic, titanium, polyurethane, and silicone, accompanied by structural modifications. However, their fundamental composition typically includes a 1-1.5 cm elliptical or round reservoir chamber and a silicone-polyurethane catheter system connected to an apparatus, all implanted under the skin (Picture 2).

Picture 2. Subcutaneous venous port catheter

This study presents our clinical experience and outcomes in patients who underwent subcutaneous venous port implantation within the operating room of the cardiovascular surgery clinic.

Patients and Method

This study enrolled 171 patients (110 male and 61 female) who were referred from our hospital's Oncology Clinic for port catheter insertion between March 2018 and December 2021. A comprehensive assessment, including general systemic and local neck examinations, was conducted prior to the procedure. Detailed

inquiries were made regarding anticoagulant and antiplatelet medications, and any drugs potentially causing bleeding diathesis were discontinued 4-7 days prior. Additionally, recent hemograms and routine blood tests, along with coagulation tests within the last 10 days, were carefully reviewed.

During the pandemic, patients admitted to the Cardiovascular Surgery Clinic underwent routine operating room procedures and were required to present negative PCR test results from the previous 2 days. Before surgery, patients and their families received detailed information about the operation, associated risks, potential complications, the specific anatomical region where the port catheter would be inserted, and the essential aspects of the surgical procedure. Informed consent for surgical intervention was obtained.

Upon admission to the hospital, the patients were brought to the Cardiovascular Surgery operating room after establishing peripheral vascular access. The animals were closely monitored and maintained under sterile conditions. For patients who underwent mastectomy and tracheostomy, a surgical chamber sac was created in the skin area away from the wound site between the pectoral muscles to house the catheter reservoir. In cases in which patients had neck fullness or a palpable mass prior to jugular puncture, we investigated the possibility of thrombosed vascular beds using a B-mode Doppler ultrasonography device, although routine punctures did not routinely employ Doppler. The reservoir chamber, situated in a subcutaneous pouch, was connected to the silicone catheter line and securely anchored to the pectoral muscles using bilateral fixation sutures (Picture 3).

Retrograde flow was monitored using a set needle, and the reservoir and line were filled with heparinized washing liquid and 10 mL saline. The subcutaneous bleeding was controlled, and surgical sutures were applied. Following skin closure, the patients were transferred to their rooms with pressure bandages to monitor for potential hematoma and ecchymosis. Patients in good general condition, without bleeding, hematoma, ecchymosis, neck, or surgical field swelling, underwent an allergy history evaluation and were prescribed Cephalosporin or Ciprofloxacin group antibiotics. The patients were discharged on the same day after receiving their prescriptions. Ten days later, all patients returned for routine follow-up, and the stitches were removed between days 12th and 18th day.

Picture 3. Port catheter reservoir placed in the pouch opened between the pectoral muscle

A comprehensive review of all catheter patients treated at our clinic over a four-year period was conducted using the hospital database. This retrospective analysis was performed with written approval from both the hospital and the university Ethics Committee, covering data such as demographic information, age, sex, cancer type, intervention date, active use of the port catheter, patency duration, and comorbidities, including hypertension, diabetes, and vascular diseases.

Statistical Analysis

Statistical analyses were performed using SPSS version 20 (IBM SPSS Statistics, ed. 20, 2014) for data analysis. Continuous variables are presented as mean ± standard deviation (SD). For a more complex and multivariate data analysis, we utilized the high-level professional statistical program GRETL: Gnu Regression, Econometrics, and Time-series Library GRETL 2020 B MS WINDOWS (X86).

Results

Among 171 patients, 110 were men (64%) and 61 were women (36%). The patients' ages ranged from 21 to 84 years, with an average age of 61.32 (SD+/- 4) for females and 61.98 (SD+/- 3.5) for males. A detailed examination revealed that 28% of the 48 patients had additional conditions such as hypertension, diabetes mellitus, or at least one vascular disease (Table 1).

Table 1. Patients' Characteristics

Patient Characteristics	Total (n=171)	Men (n=110)	Women (n=61)
Age (years)			
- Range	21-84	21-84	21-84
- Mean (SD)	-	61.98 (±3.5)	61.32 (±4)
Gender, n (%)		110 (64%)	61 (36%)
Comorbidities (Hypertension, DM, or Vascular Disease)			
- Patients with comorbidities, n (%)	48 (28%)		

The most prevalent cancer types were colon (48 patients), stomach (47 patients), rectum (21 patients), and pancreas (16 patients), with gastrointestinal malignancies accounting for 77% of the entire group.

Studies involving 115 and 99 patient series have highlighted a higher risk of thrombosis and occlusion in the subclavian veins compared to the jugular vein [5, 6]. Moreover, it has been reported that the right jugular vein carries a lower risk of thrombus formation than the left jugular vein [7]. Additionally, in an extensive study encompassing 831 catheter patients, infection rates in the jugular vein were found to be significantly lower than those in the femoral and subclavian areas [8].

In our clinic, we exclusively used jugular catheters, with right jugular punctures and procedures performed in 166 of 171 patients (97%) and left jugular punctures in the remaining 5 patients (3%). Performing the procedure on the left side involves two angulations when advancing the catheter, potentially affecting the endothelial integrity of the guidewire and the silicone catheter that slides over it. Moreover, the risk of thrombosis escalates when local chemotrauma induced by chemotherapeutic drugs is added to the endothelial damage [7]. These risks are minimized when using the right internal jugular vein route, which is characterized by a straight anatomical extension and provides angle-free access to the superior vena cava and atrio-caval junction.

Our cumulative port monitoring time spanned 64,410 days, equivalent to 2,147 months, with an average duration of 375 days or 12.5 months of active port use. The mean active port usage time for male and female patients was 13.58 and 11.97 months, respectively (Figure 1), and this difference was not statistically significant (p: 0.45).

No statistically significant correlation was observed between the duration of active port use and patient age (Figure 2).

According to the GRETL Statistics program, the variables most closely related to active port catheter time in the initial modeling were age and cancer type. In the process of progressively refining the model by automatically excluding less relevant variables, additional diseases were excluded owing to low correlation in the second model, followed by the presence of diabetes in the third model. Gender was the least significant variable in the fourth statistical model. The strongest statistically significant correlations were found between port patency time and cancer type (p = 0.0016) in the fifth model (Figure 3), with weaker correlations observed between the presence of hypertension and age (p: 0.08 and p = 0.05).
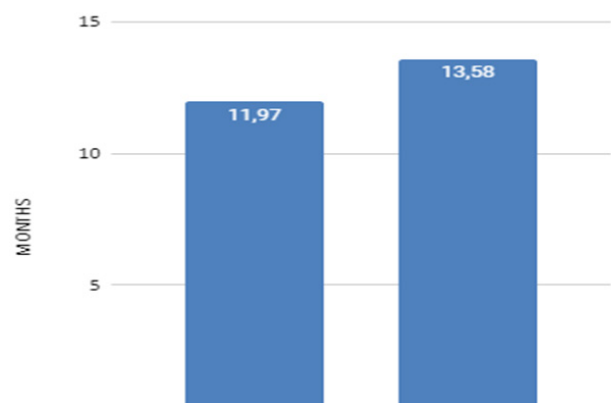
Figure 1 : Active port usage time by gender (in months)
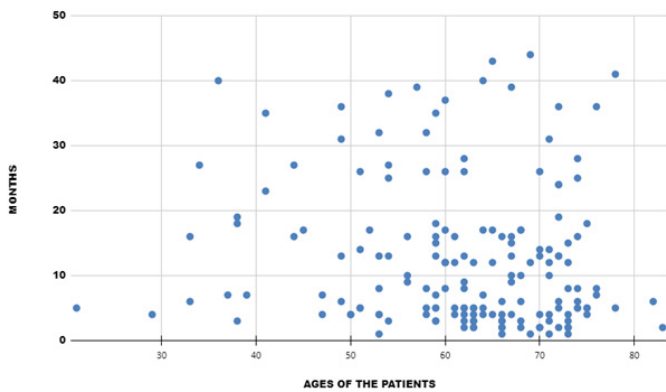
Figure 2: Active port usage time distribution graph by age groups (in months)

Analysis of the relationship between cancer type and port patency revealed that the highest patency time was 44 months in the bladder cancer group, followed by 35 months in the uterine cancer group. However, it is important to note that these groups represent a relatively small proportion of cancer types compared to the overall patient population, which limits their statistical significance owing to the low number of patients. Breast cancer exhibited the third-highest average active port usage time at 22.5 months, whereas rectal cancer, with an average of 17.04 months, provided more quantitatively significant data in terms of patient numbers.

Conversely, the group with ovarian and brain spinal cord malignancies displayed the lowest active port opening time. While some hematological cancers are associated with an increased risk of deep venous thrombosis and catheter embolism, there are no definitive data on port open time for specific cancer types, and clear information on this topic remains absent in the literature.

Over the 4-year follow-up period, 25% of the total patient cohort (43 patients) sadly passed away. Among these, 29 (26%) of 109 male patients and 14 (22%) of 62 female patients died during the study period. The mean duration of port use for these patients was 6.88 months, which was notably lower than the 14.4-month average observed in the patient group followed throughout the study. When transitioning from modeling port patency time to mortality risk analysis, we found significant correlations between mortality and the presence of vascular disease (p = 0.03), with

hypertension displaying weaker significance (p = 0.08). Our study did not reveal any statistically significant associations between mortality and other factors such as cancer type, age, and sex. Among patients who died during the 4-year period, laryngeal malignancies exhibited the highest mortality rate (60%), followed by lung cancer (50%). Esophageal and pharyngeal cancers had the third highest mortality rate, averaging 33%. Notably, no mortality occurred in seven cancer types, including brain, bladder, and ovarian cancer.

Complications observed in port patients during the early period included pneumothorax due to lung tissue injury, hemothorax, ecchymosis, hematoma in the port pocket, catheter malposition, dysfunction due to vascular access issues, arrhythmias, cardiac injury, arteriovenous fistula formation, and phrenic nerve injury. Late complications include cutaneous subcutaneous tissue necrosis, catheter rupture, detachment, leakage and embolism, infection, sepsis, catheter occlusion, and inadequate retrograde flow during blood aspiration.

Discussion

In our study, we observed that mild-to-moderate infectious conditions improved with antibiotic therapy in 9 out of 171 patients (5%). Additionally, mild ecchymosis and hematoma in the port pocket were present in 6 patients (3%), but they did not affect port functionality. In two patients (1%), the port catheter had to be removed within one month due to severe infection. In one patient with a history of coronary bypass surgery, mild pneumothorax and subcutaneous emphysema developed, which was likely attributable to prior vascular interventions. Fortunately, the pneumothorax resolved during follow-up, without requiring a thoracic tube.

Two patients had their catheters removed 2-5 months later because of thrombosis, while one patient experienced leakage at the catheter site. Another patient developed a foreign body reaction in the late 5th month, leading to catheter removal. Importantly, we did not report any cases of hemothorax, nerve injury, significant hematoma compressing the neck, massive bleeding at the surgical site, port detachment, rupture, fragment

embolism, or sepsis. Notably, a study involving 550 patients over an 11-year period reported a thrombosis rate of 7.5%, with left-sided ports demonstrating the highest complication rate [9].

In a 2017 study involving 100 ports, the early infection rate was 4%, the late infection rate was 4%, and septic infections were recorded at 2% [10]. A comprehensive study conducted in 2022 comprising 4,480 patients reported symptomatic catheter thrombosis at a rate of 2.1%, with early and late temporary complications occurring at a rate of 20% [11].

In our study, we observed a serious infection rate of 1% in the early period. Port removal was necessary for 2 of 171 patients due to severe reactions and infections. In the late period, our thrombosis rate was 1%, affecting 2 patients. Among these, six patients (3%) required port catheter removal for various reasons, including infection, thrombosis, leakage, and foreign body reaction. Notably, one thrombosed patient and one infected patient underwent port catheter reinsertion 6-8 weeks later. The rate of catheter revision in our study was 1% among the three patients.

The psychological well-being of port patients is a crucial consideration, especially in surgical procedures performed under local anesthesia, where patients are fully conscious. Unlike surgeries in major surgical branches, where patients are often under general anesthesia with continuous vital sign monitoring, minor surgical procedures conducted under local anesthesia require careful attention to the patient's psychological comfort.

Recent research from 2021 demonstrated that patients who listened to their preferred relaxing music in the operating room experienced lower and more stable vital parameters, including reduced anxiety and stress levels, salivary cortisol measurements, blood pressure, and heart rate [12]. A similar study conducted in our country involving 100 port catheter patients confirmed the pain- and anxiety-reducing effects of music [13].

In our practice, we prioritize creating a calming atmosphere in the operating room. We informed patients about each step of the procedure, such as administering a narcotic injection or initiating the port chamber placement process. This approach has proven to be highly effective in preventing panic attacks and ensuring that patients remain calm and cooperative throughout the procedure, ultimately contributing to its successful completion.

While there have been reports of cases lasting up to four weeks and sometimes even up to four months with symptoms of flushing, redness, and heat sensations on the face and neck following port catheter placement, which can be uncomfortable for patients [14], we encountered a patient who experienced facial flushing for approximately two weeks. In this case, clinical signs, such as jugular fullness, redness, and edema, were not evident. Two weeks after the sutures were removed, the patient reported that the sensation had subsided, and upon reexamination, there were no signs of jugular fullness, edema, infection, or hematoma.

A recent publication from 2022 detailed an exceptionally rare case involving a 3-year-old pediatric patient in which the catheter had completely separated and fell into the right ventricle, with the other end extending into the pulmonary artery. Fortunately, the catheter was successfully removed via open-heart surgery [15]. Similar studies have discussed the complications related to catheter separation. It is noteworthy that in our patient cohort, we did not encounter any catastrophic complications such as embolism or catheter separation.

Percutaneous venous port catheters offer a significant advantage in addressing challenges associated with frequent and repetitive peripheral vascular access. They enhance the convenience of long-term drug infusion, parenteral nutrition, and blood test administration in patients undergoing extended chemotherapy and infusion therapy. Furthermore, they contribute to increased patient comfort and are preferred over external catheters because of their exceptionally low infection rates [16].

A recent cost-effectiveness analysis involving a substantial patient cohort revealed that venous catheters are more cost-effective during the initial 3-9 months of use. However, it is worth noting that port catheters have emerged as more cost-effective options during the 9-12 month period [4]. This underscores the importance of considering

the duration of treatment when selecting between the two options.

Our low rate of port thrombosis revisions can be attributed to our specific approach of exclusively using the internal jugular vein for surgical vascular interventions, with the right internal jugular vein being the preferred choice in 97% of the cases. Existing studies have consistently shown that subclavian veins carry a higher risk of thrombosis and occlusion compared to jugular veins [5, 6]. Therefore, in our patient cohort, we opted for port implantation solely through the internal jugular vein.

While femoral IPs have been found to be a safe option for breast cancer patients, their use in gastrointestinal cancers requires careful consideration [17]. Moreover, research has shown that the jugular vein has significantly lower infection rates compared to the femoral and subclavian sites [8]. Larger, prospective studies are necessary to validate the findings of the current study.

We believe that the low rates of infection and sepsis in our patients are consistent with these findings. This can be attributed to rigorous sterilization practices, standardization of sterilization protocols, meticulous surgical sepsis measures such as surgical antiseptic application, sterile covering, complete sterile surgical scrubbing by both nurses and surgeons, and thorough cleaning intervals of 30-45 minutes between each patient. Furthermore, we recommend that patients shower the night before the procedure, ensure the cleanliness of the chest and neck area, provide professional surgical nursing care following wound dressing, conduct daily wound care, and encourage early polyclinic follow-up. Prophylactic antibiotics were prescribed to every patient as an additional preventive measure.

Conclusions : The implantation of chemotherapy port catheters is a procedure that can be safely performed in cardiovascular surgery clinics with the requisite surgical expertise to minimize complications and effectively address potential major issues. Although there are inherent risks associated with the implantation process, it remains a highly secure surgical method that can be favored for patients scheduled for chemotherapy because of its long-term treatment benefits and enhanced patient convenience.

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Bibliometric Analysis of the Joint Diseases and Related Surgery: Part-2: The period after the SCI-E

Eklem Hastalıkları ve Cerrahisi Dergisinin Bibliometrik Analizi: Bölüm-2: SCI-E sonrası dönem

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ABSTRACT

Aim: The first part of this article, the pre-SCI-E period, was previously published in Acta Medica Alanya as 'Bibliometric analysis of the Journal of Joint Diseases and Related Surgery (JDRS). In this article, in the second part of the study, the factors affecting citation and the definition of bibliometric data in the post-SCI-E period were investigated by scanning Google Scholar, Scopus and WOS.

Methods: This second study was designed as retrospective bibliometric. Articles were reviewed beginning from 2007 when the Journal covered by SCI-E, up to 2020 when it covered by PMC. Both authors scanned one by one the articles published in the JDRS Journal within the above stated time period, according to the Turkish-English or English titles and by using the information available on the journal's website for each article. At the end of year 2021 and in a 3 month period all articles were chronologically searched in Google Scholar, Scopus, and Web of Science databases. All accessed articles were analyzed according to the characteristics and institutions of the authors, also language, type, topic, and discipline of the article.

Results: Scanning for Scopus, Google Scholar,, and WOS showed that the mean number of citations were 7.69 ± 11.72 for Google Scholar, 5.11 ± 6.88 for Scopus, and 4.36 ± 6.18 for WOS. In the last step of the logistic regression model analysis performed with the backward stepwise method; the article year-volume, male author, foreign author, article subtopic (6), article type (2), article type (1), and article language (1) were found to be variables effective on having a citation. In the linear regression analysis, the male sex variable was found to be significant for citations in all databases. English as the article language was a significant variable in citations, in all databases and subvariables.

Conclusion: The results of this study showed that research articles and/or review articles contribute significantly to citations, and having English as the article language is important. Also, acceptance of articles that may call the attention of more than one specialty may increase the number of citations.

Keywords: Bibliometric Analysis, Joint Diseases and Related Surgery Google Scholar, Scopus, Web of Science, Citation

ÖZ

Amaç: Bu makalenin ilk bölümü, SCI-E öncesi dönem olup daha önce Acta Medica Alanya dergisinde "Joint Diseases and Related Surgery (JDRS) Dergisi'nin Bibliyometrik Analizi" başlığıyla yayınlanmıştı. Bu makalede, çalışmanın ikinci kısmı olan SCI_E sonrası dönemde, bibliyometrik verilerin tanımlanması ve atıf almayı etkileyen faktörler Google akademik, Scopus ve WOS taranarak araştırılmıştır.

Yöntem: Bu ikinci çalışma retrospektif bibliyometrik olarak tasarlandı. Makaleler, Derginin SCI-E tarafından kapsandığı 2007'den başlayarak, PMC tarafından kapsandığı 2020'ye kadar incelendi. Her iki yazar da yukarıda belirtilen süre içerisinde JDRS Dergisi'nde yayınlanan makaleleri, Türkçe-İngilizce veya İngilizce başlıklara göre ve her makale için derginin web sayfasında yer alan bilgilerden yararlanarak taradılar. 2021 yılı sonunda ve 3 aylık bir süreçte tüm makaleler Google Akademik, Scopus ve Web of Science veri tabanlarında kronolojik olarak tarandı. Erişilen tüm makaleler yazarların özellikleri ve kurumları, ayrıca makalenin dili, türü, konusu ve disiplini açısından analiz edildi.

Bulgular: Scopus, Google Akademik ve WOS taramalarında ortalama atıf sayısının; Google Akademik için 7,69 ± 11,72, Scopus için 5,11 ± 6,88 ve WOS için 4,36 ± 6,18 olduğu görüldü. Geriye doğru adımsal eleme yöntemi ile gerçekleştirilen lojistik regresyon modeli analizinin son aşamasında; makale yılı-cilt, erkek yazar, yabancı yazar, makale alt başlığı (6), makale türü (2), makale tipi (1) ve makale dili (1) atıf almada etkili değişkenler olarak bulunmuştur. Lineer regresyon analizinde, erkek cinsiyet değişkeninin tüm veri tabanlarında atıflar için anlamlı olduğu bulundu. Makale dili olarak İngilizce, tüm veri tabanlarında ve alt değişkenlerde atıflarda anlamlı bir değişkendi.

Sonuç: Bu çalışmanın sonuçları, araştırma makalelerinin ve/veya derleme makalelerinin atıflara önemli katkı sağladığını ve makale dilinin İngilizce olmasının önemli olduğunu göstermektedir. Ayrıca birden fazla uzmanlık alanının ilgisini çekebilecek makalelerin kabul edilmesi atıf sayısını artırabilir.

Anahtar Sözcükler: Bibliyometric Analiz, Eklem Hastalıkları ve Cerrahisi Dergisi, Google Akademik, Scopus, Web of Science, Atıf

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Introduction

Bibliometric research uses mathematical and statistical methods to analyze and measure the quantity of publications [1]. Bibliometric analyses are important in the acceptance and archiving of scientific publications, and in receiving guidance from past studies for prospective ones. From the publishers' point of view, the bibliometric analysis data can be utilized to determine the editorial policies for increasing the impact factor of the journal [2,3]. Bibliometric methods may be used for mapping the scientific productivity of journals, authors, institutions, countries, authorship models, research collaborations, and general scientific productivity in any discipline [4]. It also helps to determine the most commonly cited journals, sort productive authors, find out the authors' productivity model, find the impact factor of the journal and other significant details of any publication that has been analyzed [5]. Assessment of scientific production through bibliometric analysis is useful to provide evidence for the spread of registry based knowledge within the orthopedic community [6]. On the other hand, citation metrics that will be obtained from bibliometric analyses may contribute to the strategies directed toward increasing the impact factor of the journal. The most commonly used databases are Google Academic, Scopus, and Clarivate Analytics Web of Science (WOS) [7]. However, each uses different algorithms, each has its own strengths and weaknesses [8]. For these reasons, it is noted that if one wants to find all possible citations of an article and thus of a journal, this can only be achieved by combining all three databases [9]. On the other hand, several factors affect the number of citations. These can generally be categorized as factors related to the article, the authors, and the journal [10].

In the field of medical sciences, a large number of scientific journals originating from Turkiye are published, and some of these journals are covered in national indexes such as TR-Dizin and some are covered in important international indexes such as Scopus, Web of Science (SCI-Expanded, SSCI, ESCI) and PubMed Medline [11-13]. The Journal of "Joint Diseases and Related Surgery" (JDRS), which has long been included in important journal indexes in the field of Orthopedics and Traumatology and is within the covered in SCI-Expanded, is the scientific publication of the Joint Diseases Treatment Foundation of Türkiye. JDRS is an open access scientific journal that publishes, after double blind peer review and editorial evaluation processes, original experimental and clinical research articles or other scientific articles including reviews and case reports in all areas of orthopedics and traumatology. The historical periods of JDRS are listed in Table 1. JDRS is already an international journal because of it is covered by Clarivate Analytiscs Web of Science SCI-Expanded Database and therefore bibliometric analyses of this journal, such as citation analyses between 2007 and 2019, are of interest to researchers not only at the national level but also at the international level. These bibliometric analyses also provide valuable information for the evaluation and measurement of scientific production i.e. scientometrics.

The first section of the study was previously published, as "Bibliometric analysis of the Journal of Joint Diseases and Related Surgery; Part 1: The period before the SCI-E" (JDRS Part-1) [14]. The purpose of this study is to reveal the bibliometric data of JDRS between the years of 2007-2019 and to investigate the factors affecting citations in this period. Also differently, in order to access all citations and bibliometric data, more than one database was scanned in this study.

Material and Methods

The study was designed as retrospective bibliometric analysis of the JDRS. Because of the periods before and after SCI-E had significant differences especially in the number of citations received by the articles, presenting the study data in two sections was decided to have homogenous data and objective results. In this article, in the second part of the study, the factors affecting citation and the definition of bibliometric data in the post-SCI-E period were investigated by scanning Google scholar, Scopus and WOS. Articles were reviewed beginning from 2007 when the Journal covered by SCI-E, up to 2020 when it covered by the Pubmed Central (PMC). The study was conducted in accordance with ethical rules.

Data collection: In this study, a bibliometric analysis of all articles during the JDRS in SCI-E

Table 1: The historical periods of Journal of Joint Diseases and Related Surgery.

Years	Title	Short Title	ISSN (and Format)	Language	İndexes	Other
1989-2001	Artroplasti Artroskopik Cerrahi / Journal of Arthroplasty & Arthroscopıc Surgery	-	1300-0594 (Printed)	Turkish, English	-	Full text available online from issue 1999-2
2002-2004	Artroplasti Artroskopik Cerrahi / Journal Of Arthroplasty & Arthroscopıc Surgery	-	1300-0594 (Printed)	Turkish, English	TR Index	Manuscript submission by e-mail
2005-2007	Eklem Hastalıkları ve Cerrahisi/ Joint Diseases and Related Surgery	Joint Dis Rel Surg	1305-8282 (Printided) (e-ISSN:1309-0313) (Online)	Turkish, English	SCI-E (2007) SCOPUS (2008) Pubmed (2008)	Science Citation Index Expanded. Starting from issue of 2007-1
2007-2015	Eklem Hastalıkları ve Cerrahisi/ Joint Diseases and Related Surgery	Eklem Hastalik Cerrahisi	1305-8282 (Print) 1309-0313 (Online)	Turkish,English	SCI-E, SCOPUS, Pubmed, TR Index	Online article submission and evaluation system (2010- Currently)
2015-2018	Eklem Hastalıkları ve Cerrahisi/ Joint Diseases and Related Surgery	Eklem Hastalik Cerrahisi	1305-8282 (Print) 1309-0313 (Online)	Turkish, English (mostly english)	SCI-E, SCOPUS, Pubmed, TR Index	Crossref (Starting from issue of 2013-1). Doi prefix: 10.5606/ehc
2020-Current	Joint Diseases and Related Surgery	Jt Dis Relat Surg (Starting from issue of 2020-1)	2687-4792 (Online) 2687-4784 (Print) 2687-4792 (Linking)	English	SCI-E, SCOPUS, Pubmed, TR Index, PMC	Pubmed Central Starting from issue of 2020-1

period beginning from Volume 18 Issue 1 in 2007 when the journal covered by SCI-E and up to Volume 30 Issue 3 (included) in 2019 when the Journal was renamed and covered by PMC was performed. Both authors scanned one by one the articles published in the JDRS Journal within the above stated time period, according to the Turkish-English or English titles and by using the article information on the journal's website (https://www.jointdrs.org/). At the end of year 2021 and in a 3 month period all articles were in chronological order searched in Google Scholar, Scopus, and Web of Science databases. Therefore, care was taken to ensure that minimum 2 years had elapsed from the publication of each article. JDRS articles already have open access. Subscription articles in some of the databases were accessed from the libraries of the authors' universities.

Categoric classifications of the article: Article type: Original research article, case report, review, letter to the editor, and technical note. Article subtopic: Arthroplasty, arthroscopy, arthroscopy-sports medicine, spine, shoulder-elbow, hand-wrist, oncology, trauma, pediatric orthopedics, general orthopedics, and others. An article with an overlap of topics was assessed in only one topic (Table1). Article topics were classified as reported in JDRS Part-1 [14]. Authors' characteristics: Gender, number of foreign authors, and total number of authors. Institutions: University, state, or private hospital according to the affiliation of the first and/or corresponding author Article language: Turkish and English Discipline of the study: Orthopedics, non-orthopedics, and multidisciplinary .

Evaluation Methods: All accessed articles were

analyzed according to the characteristics and institutions of the authors, also language, type, topic, and discipline of the article. Subsequently, articles that could be evaluated under the context of citation were scanned separately (articles in English scanned only in English, articles in Turkish scanned both in Turkish and English) using search engines of the Google Scholar, Scopus, and Web of Science databases. The number and type (self-citation, citation in other journals) of citations were determined.

Statistical Analysis: First, the data on all articles were recorded on Excel software and converted into numeric values for analysis. Descriptive statistics was performed, and the data were presented as %(n) or mean ± standart deviation. Significance tests were made with the SPSS (version 19, IBM, USA) package software. Categoric values were analyzed with the chi-square test, numeric values with the ANOVA test, and post hoc comparison with the t test. Regression analysis was made for factors affecting citation. The effect of dependent variables on a citation were evaluated using the linear regression method. The effect of independent categoric variables on citations was assessed in the logistic regression model constructed with the backward elimination method. P<0.05 was accepted as statistically significant.

Results

During the stated period (from issue 1 in 2007 to issue 3 in 2019), 13 volumes, 39 issues, and 484 articles were published. The number of articles per volume was between 28 and 55. In recent years, the number of articles per volume increased. Universities submitted the majority of articles (69.6%), there were more research articles (64.7%), and English was more common (75.8%). The ratio of non-orthopedic articles was 4.8%, and multidisciplinary studies involving orthopedic surgeons were 33.2%. Characteristics of the studies published during the stated period are summarized in Table 2.

The mean number of male authors per article was 3.38 ± 1.74, whereas this was 0.4 ± 0.8 for females. There were few foreign authors (0.45 ± 1.41). Mean time between article submission and acceptance was 99.43 ± 83.12 days (Table 3). Scanning for Scopus, Google, and WOS showed

that the mean number of citations were 7.69 ± 11.72 for Google scholar, 5.11 ± 6.88 for Scopus, and 4.36 ± 6.18 for WOS.

Table 2: Factors affecting citation

Parameter	Subparameter / explanation	n	%
Volume-Years	2007	28	5,8
	2008	31	6,4
	2009	33	6,8
	2010	33	6,8
	2011	40	8,3
	2012	41	8,5
	2013	39	8,1
	2014	39	8,1
	2015	36	7,4
	2016	35	7,2
	2017	40	8,3
	2018	34	7,0
	2019	55	11,4
Corresponding Author Affiliation	1. Universities (including the Foundation)	336	69,6
	2. State (including education and research)	121	25,1
	3. Overseas (including Private)	26	5,4
Non-orthopedics	1.Non	460	95,2
	2.Yes	23	4,8
Multidisciplinary	1.Non	322	66,8
	2.Yes	160	33,2
Article subtopic	1. Shoulder-Elbow	28	5,8
	2. Hand-Wrist	32	6,6
	3.Hip disease and surgery	26	5,4
	4.Knee disease and surgery	38	7,9
	5.Foot-Ankle	19	3,9
	6.Orthopedic Trauma	54	11,2
	7. Orthopedic Oncology	44	9,1
	8.Vertebra disease and surgery	9	1,9
	9.Pediatric Orthopedics	33	6,8
	10.General orthopedics	72	14,9
	11.Arthroplasty	52	10,8
	12. Arthroscopy-sports medicine	16	3,3
	13.Experimental study	60	12,4
Article type	1. Original Research	313	64,7
	2.Review	51	10,5
	3.Case report	110	22,7
	4.Technical note	4	0,8
	5.Letter to Editor	6	1,2
Article language	1.English	367	75,8
	2.Turkish	117	24,2
	Total	484	

Table 3: Comparison of databases in terms of factors affecting citation

	n	Mean ± S.D.	Med (IQR)	min -max
Author_Male	484	3.83 ± 1.74	4 (3 - 5)	0 - 9
Author_Female	484	0.4 ± 0.8	0 (0 - 1)	0 - 5
Author_Overseas	483	0.45 ± 1.41	0 (0 - 0)	0 - 8
Submission-Accept time	483	99.43 ± 83.12	80 (38 - 143)	0 - 560
Cited.total_gscholar	484	7.69 ± 11.72	5 (2 - 9)	0 - 177
Cited.outer_gscholar	482	6.27 ± 10.72	3 (1 - 8)	0 - 173
Cited.self_gscholar	482	1.49 ± 4.34	1 (0 - 2)	0 - 74
Cited.1.and 2. years_gscholar	473	1.76 ± 2.71	1 (0 - 2)	0 - 35
Cited.3. and 5. years_gscholar	481	3.07 ± 4.93	2 (1 - 4)	0 - 75
Cited. after 5.year_gscholar	469	3.06 ± 6.45	1 (0 - 3)	0 - 90
Cited.total_scopus	456	5.11 ± 6.88	4 (1 - 6)	0 - 84
Cited.outer_scopus	456	3.37 ± 5.4	2 (1 - 4)	0 - 78
Cited.self_scopus	456	1.76 ± 4.08	1 (0 - 2)	0 - 62
Cited.1.and 2. years_scopus	456	1.11 ± 2.44	1 (0 - 1)	0 - 36
Cited.3. and 5. years_scopus	456	2.38 ± 3.13	2 (1 - 3)	0 - 32
Cited. after 5.year_scopus	456	1.64 ± 3.52	0 (0 - 2)	0 - 47
Cited.total _wos	484	4.36 ± 6.18	3 (1 - 6)	0 - 70
Cited.outer_wos	484	2.66 ± 4.52	1 (0 - 3)	0 - 65
Cited.self_wos	484	1.71 ± 3.96	1 (0 - 2)	0 - 61
Cited.1.and 2. years_wos	484	0.92 ± 2.25	0 (0 - 1)	0 - 35
Cited.3. and 5. years_wos	484	2.09 ± 2.95	1 (0 - 3)	0 - 26
Cited. after 5.year_wos	480	1.4 ± 3.08	0 (0 - 2)	0 - 41

In the last step of the logistic regression model analysis performed with the backward stepwise method; the article year-volume, male author, foreign author, article subtopic (6), article type 1 (origial research), article type 2 (review) and article language (1) were found to be variables effective on having a citation.

In the linear regression analysis, the male sex variable was found to be significant for citations in all databases. English as the article language was a significant variable in citations, in all databases and subvariables. Articles whose authors were not orthopaedic surgeons affected total citations, and especially contributed to citations after 5 years in Google scholar. Multidisciplinary studies had a significant effect on external citations. In articles

with a short manuscript submission-acceptance time, self citation was significant.

Discussion

The major outcome of our study, as covered in this article, was that the most important factors in receiving a citation were article language, author characteristics, multidisciplinary studies, article characteristics, and research topic. The secondary outcomes showed that most publications had been submitted by orthopedic surgeons and universities. Among all searched databases, Google Scholar reached more citations.

JDRS Part-1 study by Aslan showed that the most important factors in receiving a citation were full text availability over the internet, English as the article language, and foreign author contribution [14]. On the other hand, Kocak et al. [15] reported that being covered in PubMed Central, which allows free access to full texts, was significant. Ercan et al. [3] made a bibliometric study on a Turkish journal which publishes articles on general medicine, and they suggested that in order to increase the number of citations and impact factor, English should be used more frequently as the publication language and high quality multidisciplinary studies should be accepted for publication [3]. Another bibliometric study investigating the authorship characteristics in an orthopedics journal reported that although the number of female authors increased slightly in recent years, most of the first or corresponding authors were males [16]. In a comprehansive systematic review; It has been stated that the publication language of the article is English, the presence of authors from different disciplines and international collaboration are important factors in obtaining citations. In addition, it has been reported that male authors and faculty members affiliated with the University receive more citations [10]. In this Part-2 study we found that male author, English as the article language, and multidisciplinary study were significant in citations. Also, the articles were mostly from universities. Hence, our results were similar to other studies. On the other hand, during the study period being indexed in important databases and online access to the full text of the article did not create a difference. Although foreign authors significantly

contributed to the number of citations, their ratio was low.

In JDRS Part-1 study, Aslan reported that the mean number of citations per article was 0.7 [14]. A 10 year bibliometric study, performed by scanning the Google Scholar database, of a general medicine journal from our country found that the mean number of citations per article was 1 [3]. Gurbuz et al. [17] studied the first 40 orthopedic journals in the journal impact factor list, and reported that the mean number of citations per article in Turkiye based articles was 7.47. In our current study, mean number of citations was 7.69 per article.

Two different bibliometric studies on a Pakistan based scientific general medicine journal which used data from the journal's website and Scopus, found that the most common type of publication was research article, most submissions were national and from the universities, and that the impact factor of the journal clearly increased over the years [4, 5]. In a bibliometric study that used the WoS database and investigated the scientific productivities of countries, Turkiye based publications were mostly from the universities, and the total number of citations increased every year [17]. Dokur et al. [18]. studied the articles with the highest number of citations in the field of traumatology, and found that clinical research papers were placed at the top. Aslan reported that more than half of the published articles, 72.2%, were original research articles [14]. Also, the journal received more citations over the years. Our study showed that research articles contributed to citations significantly. Also the articles were mostly national and from the universities.

A bibliometric analysis of 100 articles that received the highest number of citations in an important international orthopedics and traumatology journal found that most common topics associated with citations were bone reconstruction, trauma, and bone fracture [19]. Baysan et al. [20]. used the data of National Thesis Center of the Higher Education Council and performed a bibliometric analysis of theses in orthopedics and traumatology. They reported that the most commonly studied topic was orthopedic trauma (28.1%), followed by adult reconstruction (15.8%) and arthroplasty. Aslan stated that the highest number of submissions

were in general orthopedic and trauma topics [14]. In our study, orthopedic trauma was found to be a significant factor in citations.

In this study we found that Google Scholar reached a higher mean number of citations than Scopus and WoS. Also, there were more citations in Scopus than WOS. This may have few reasons: Similar to ours, studies comparing the three databases found that Google Academic had the highest number of citations [10]. While Scopus and WoS use mostly the English publications, Google Academic uses non-English publications as well [10, 21, 22]. Besides, approximately half of the additional citations detected by Google Academic may come from sources other than journals, including preprint servers, conference articles, books, theses, and unpublished materials [10, 21, 22]. Also, it was shown that WoS and Scopus did not count duplicates of articles, whereas Google Academic sometimes counted an article more than once [10, 23]. Google Academic scans citations in all types of publications, whereas Scopus and WoS scans articles on journals listed only in their own databases. Scopus has a larger database than WoS, and therefore may have a greater access to citations [22]. Scopus includes more than 28,300 journals (https://www.scopus.com/), WOS (SCI-Exp.+SSCI+AH&CI+ESCI) includes approximately 22,588 (https://mjl.clarivate.com/home). All these reasons explain why Google Academic has a higher number of citations.

Scientific journals are important in distribution of research reports to the whole world. Acceptance of scientific journals to important indexes increase the quality of a journal, contributes to the high quality article flow, and has a positive effect on increasing citation rates [11, 12]. Of course, it should be noted that international publishers such as Elsevier, Springer, Sage, Wiley, etc. are known worldwide and they make meticulous selections of the journals they publish. The scientific journals published by such publishers are more likely to be accepted into important databases such as Web of Science, Scopus, PubMed, etc. Moreover, some journal publishers may receive higher citations than others. For example, articles published by Springer are found to be more cited than articles published by Taylor and Francis [24].

The use of bibliometric studies have recently increased to present publication outputs, assess the development of the journal, and increase its impact factor [4]. Turkiye ranks 14th in the number of publications, and 26th in number of publications per million [20]. The article quality in the journals from Turkiye is reported to be low [25]. Therefore the number and quality of articles published in Turkiye based journals must be increased. Results from bibliometric studies may contribute to the internal audit and development of a journal and planning of the scientific studies of a country [11-14]. We believe that the results of this study may guide the journals in Turkiye which aim important indexes. JDRS has been accepted into many important indexes over the years (Table 1), and its articles are freely accessible through open access. Furthermore, the journal's title was changed to English at the beginning of 2020, and its inclusion in the PMC database further increased JDRS's accessibility. All of these factors have made the journal more visible, accessible, and reachable, thus contributing to an increase in its impact factor. Indeed, in the literature, accessibility and the visibility of articles are often cited to citation counts in numerous studies [10,14].

Limitations: This bibliometric research study has some limitations. First, care was taken to ensure that at least two years had elapsed at the time of database scanning. However during the period when the study was performed, the times that elapsed after the publications of the first and last articles were different, and this may have affected the citations beyond the second year. Besides, scanning of the all databases were performed in a three month period. This also may have affected the results, because it is reported that Google Academic is updated monthly, WoS is updated weekly, and Scopus is updated Daily [9]. Due to the update frequency of these databases, there may be inconsistencies in the number of citations provided. Finally, care was taken to make sure that the same citation to a single article was evaluated only once, however some articles may have been missed, especially in Google Academic search. Because Google Academic scans the duplicates of the same article, it is stated to count an article more than once [23].

Conclusion: The results of this study indicated that research and/or review articles contribute significantly to citations and that the language of the article, English, also contributes to take of more citation. Acceptance of articles that may call the attention of more than one specialty may increase the number of citations. By taking these issues into consideration in editorial policies, the international visibility of the journal can be increased and international, multidisciplinary studies with a high probability of being cited can be ensured. It is crucial to increase the number and quality of publications from Turkiye. Outcomes of bibliometric analyses may contribute to both developing the impact factor of a journal and increasing the number and quality of scientific publications from our country. It is likely that the results of this study will serve as a guide to journals from Turkiye which purpose to be listed in important indexes.

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Bibliometric Analysis of The 40 Years Literature On Vertebral Fractures With Science Mapping Method

Bilimsel Haritalama Yöntemiyle Vertebral Kırıklara İlişkin 40 yıllık Literatürün Bibliyometrik Analizi

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ABSTRACT

Each year, over 1.5 million individuals in the United States are diagnosed with vertebral compression fractures. The concept of bibliometrics pertains to the analysis of bibliographic data. The examination and visualization of the literature within a scientific discipline or its subcategories is referred to as science mapping. This study represents a comprehensive analysis of the literature on vertebral fractures. In our research, the Web of Science database was utilized for analyses, encompassing the period from 1980 to 2022. The analyses were divided into four categories: performance analysis, keyword analysis, thematic analysis, and co-citation network analysis. Word Cloud, Frequency Table, Trend Topics, and Co-occurrence Networks were examined. Thematic Maps and Thematic Evolution Maps were also constructed. Furthermore, a co-citation network analysis of articles was conducted. The analyzed articles were authored by 9,020 researchers. The annual increase in the number of publications was recorded as 9.54%. The average number of citations per document was 44.05. Approximately 18.7% of the articles were published through international collaborations, with Europe standing out prominently in this regard. Genant HK was identified as the author with the highest h- and g-indices. The most active institution was the University of California, San Francisco. The most frequently used keywords included Vertebral Fracture, Osteoporosis, and Bone Mineral Density. Over the past 40 years, the scientific literature on spinal fractures has been analyzed through science mapping. The developmental dynamics of this field have been identified.

Key Words: Bibliometrics, Science Mapping, Vertebral Fractures, Web of Science.

ÖZ

Amerika Birleşik Devletleri'nde her yıl 1,5 milyondan fazla kişiye vertebral kompresyon kırığı tanısı konmaktadır. Bibliyometri kavramı bibliyografik verilerin incelenmesidir. Bir bilimsel disiplinin veya onun alt kategorisine ait literatürün analizi ve görselleştirilmesi bilim haritalaması olarak tanımlanmaktadır. Bu çalışma vertebra kırıkları ile ilgili literatürün kapsamlı bir analizidir. Araştırmamızda analizler için Web of Science kullanılmıştır. Çalışmamız 1980'den 2022'ye kadar olan zaman dilimini kapsamaktadır. Analizler; performans, anahtar kelime, tematik ve ortak atıf ağı analizleri olmak üzere dört bölümden oluşmaktadır. Kelime Bulutu ve Frekans Tablosu, Trend Konuları ve Birlikte Oluşum Ağı analiz edilmiştir. Tematik Harita ve Tematik Gelişim Haritası oluşturulmuştur. Makale Ortak Alıntı Ağı analizi gerçekleştirilmiştir. Analiz edilen makaleler 9.020 yazar tarafından yazılmıştır. Makale sayısındaki yıllık artış ise %9,54 oldu. Belge başına ortalama alıntı sayısı 44,05'tir. Makalelerin yaklaşık %18,7'si uluslararası işbirliği yoluyla yayınlanmıştır. Uluslararası işbirliği açısından Avrupa özellikle öne çıkıyor. Genant HK en yüksek h ve g-indeksine sahip yazardır. En aktif kurum San Francisco'daki Kaliforniya Üniversitesi'dir. En çok tekrarlanan anahtar kelimeler Vertebral Kırık, Osteoporoz, Kemik Mineral Yoğunluğu'dur. Omurga kırıklarına ilişkin son 40 yıllık literatür bilimsel haritalamayla analiz edilmiştir. Konunun gelişim dinamikleri belirlenmiştir.

Anahtar Kelimeler: Bibliyometri, Bilim Haritalaması, Vertebral Kırıklar, Web of Science.

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Introduction

The vertebrae, which consist of 33 vertebrae, protect the spinal cord and provide axial support to the limbs. While vertebral fractures can arise from trauma, infection, and metastatic disease, the most common cause is osteoporosis [1].

The most common precipitating factor for vertebral fractures is osteoporosis. However, trauma, chemotherapy, and steroid use can also lead to compression fractures. Smoking, alcohol, and low estrogen levels are associated with the etiology of low bone density. Trauma is the second most frequent cause of vertebral fractures [2].

It is estimated that there are over 200 million osteoporosis patients worldwide [3], with 30% of women being affected by osteoporosis [2]. In the United States, more than 1.5 million people are diagnosed with vertebral compression fractures each year [2,3]. The frequency of these fractures is 10.7 per thousand in women and 5.7 per thousand in men. Traumatic vertebral fractures are more commonly seen in men around the age of 30, with an incidence of 160,000 cases each year. These fractures can cause pain, decrease quality of life, and lead to social isolation [4].

The concept of bibliometrics is the examination of bibliographic data. Bibliometrics has two pillars: performance analysis, which is measurable through article and citation counts, various indices, and scientific mapping. The analysis and visualization of the literature of a scientific discipline or its subcategory is defined as science mapping [5]. Bibliometrics is an interdisciplinary field involving the quantitative analysis of academic literature, facilitating the evaluation of research output and impact through statistical methods. In medicine, bibliometrics plays a pivotal role in tracking the dissemination of knowledge, evaluating the performance of researchers, and guiding decision-making in academic and clinical practice [5].

Science mapping is generally used to determine the evolution of academic knowledge, multidisciplinary connections, and research trends [6]. Science mapping is utilized to fund scientific research and strategic planning. This method guides policies related to the academic field. It benefits interaction between researchers and across scientific areas. In today's world, the volume of scientific literature has reached a vast extent and continues to grow. This makes it increasingly difficult for researchers to keep track of developments. At this stage, bibliometric analysis intervenes, rendering the extensive literature manageable and providing a qualified projection [7].

Bibliometric studies on vertebral fractures are limited in number [8,9]. Therefore, it has been determined that such a study is needed. This study is a comprehensive reviewing analysis of the literature on vertebral fractures. It aims to analyze research on vertebral fractures, obtaining information that will guide future research on vertebral fractures.

Methods of Research and Analysis:

Research Strategy: Our study's flowchart of data collection, data analysis, and data visualization is in Figure 1 A.Our research utilized the Web of Science (WoS), with analyses and scans conducted on this platform on November 20, 2023. Our study encompasses the time frame from 1980 to 2022. The search incorporated the keywords "Vertebral Fractures" and "Vertebral Fracture." Article types, excluding Research and Review Articles, were omitted. The language preference was set to "English." The scope of WoS was confined to the SCI, SCI-E, and SSCI indices. Clarivate Analytics' Web of Science Core Collection comprises eight databases. Only SCI, SCI-E, and SSCI are utilized due to their indexing of the most significant sources related to the subject under investigation. The year 2023 was excluded from the scope owing to the year needing to be completed at the time of the study. Ultimately, the analyses were performed with 2187 articles.

The analyses comprised four sections: performance, keyword, thematic, and co-citation network analyses. These analyses consolidated terms, combining "Vertebral Fractures" with "Vertebral Fracture."

Performance Analysis: An extensive evaluation has been conducted encompassing Main Information on Publications, delineating the volume and impact of scholarly works and their citations over time. This includes meticulously

analyzing the Corresponding Author's Nationality, the influence exerted by authors and sources, and identifying prominently cited local articles. Additionally, intricate relationships among authors, keywords, sources, and the dynamics within Institutional Collaboration Networks have been scrutinized.

Analyzing the main information on publications has established a detailed elucidation of Author Collaboration. This segment offers statistical insights into the Annual Growth rate, the mean lifespan of documents (Document Average Age), and the average number of citations per document.

In dissecting the Corresponding Author's Country, total, single, and multiple country publications (TCP, SCP, and MCP) have been computed alongside the MCP Ratio (MCP/TCP).

The analyses concerning Author Impact and Source Local Impact encompass sophisticated metrics like the h-index, g-index, m-index, number of publications (NP), total citations (TC), citations per publication (TC/NP), and the inception year of publication (PY-start).

The Most Local Cited Articles analysis has computed variables such as Year of Publication (YP), 2023-Year of Publication (YYP), Global Citations (GC), and Local Citations (LC), along with ratios adjusted for temporal influence, including LC/YYP, GC/YYP, and the LC/GC Ratio%. Here, LC denotes the count of citations made by articles within the dataset, while GC represents citations from articles indexed in the Web of Science database.

The interconnections between authors, keywords, and sources have been analytically explored using Sankey diagrams, illustrating the flows and transitions among these entities.

Lastly, in the Institutions Collaboration Network analysis, clusters of institutions have emerged, with each circle within the clusters representing a distinct institution. The size of these circles is proportional to the level of collaboration of the institution, and the thickness of the lines between circles correlates with the degree of collaboration between institutions.

Keyword Analysis: In our study, two types of keywords were utilized in the databases: those added by the author and those generated by the system. Only the keywords provided by the author were employed in the analyses. Word Cloud and Frequency Table, Trend Topics, and Co-Occurrence Network have been analyzed. In the Word Cloud and Frequency Table analyses, the top 50 keywords used in the articles were employed. The Trend Topic analysis reveals the years in which these keywords became popular. For each year, the first two keywords used at least five times have been visualized in the analysis. In the Co-Occurrence Network analysis, the keywords formed clusters represented by different colors. Each circle within these clusters represents a keyword, and the most frequently used keyword within a cluster denotes its representative keyword.

Thematic Analysis: A Thematic Map and a Thematic Evolution Map have been created. The Thematic Map (Strategic Diagram) was constructed using the first 250 keywords repeated at least five times. The research period (1980-2022) has been divided into distinct eras, considering the number of documents for thematic examination. The first period spans 28 years (1980-2007), the second period covers seven years (2008-2014), the third period is five years (2015-2019), and the fourth period is three years (2020-2022).

The most frequently repeated keywords are grouped into thematic clusters. The three most recurring keywords represent each cluster. The size of the circles is proportional to the frequency of use of the keyword represented by the circle. Two parameters, centrality on the X-axis and density on the Y-axis, have been determined to form the Thematic Map. Centrality indicates the importance of the theme, while density represents its development. The X-axis and the Y-axis have been divided into four quadrants to represent themes. In the top right corner of the thematic map are Motor Themes, in the top left corner are Niche Themes, in the bottom left corner are Emerging or Declining Themes, and in the bottom right corner are Basic Themes.

A thematic evolution map has been additionally created to examine the changes and developments in themes over the years. In the evolution map, the size of the nodes indicates the abundance of

keywords, while the flow lines between the nodes represent the direction of evolution of the thematic clusters.

Co-Citation Network: A paper co-citation network analysis was conducted to examine common citations. The top 30 publications were analyzed. The common citations formed clusters represented by different colors. Each circle within these clusters represents an individual article. The circle size correlates with the number of citations received, while the thickness of the lines between the circles is proportional to the citation relationship among the articles. Data from the Web of Science (WoS) database has been utilized for the Co-Citation Network analysis. All the articles are available within the WoS database.

Results of Comprehensive Review

Performance Analysis: Table 1 presents the performance analysis results. The annual increase in the number of articles is 9.54%.

Figure 1 B presents the annual number of articles and citations. According to the table, the number of articles has been increasing steadily. The number of citations also increased regularly until the early 2000s. Subsequently, it entered a decreasing trend and has fluctuated at a certain level.

Figure 1 C presents the countries of the authors of the analyzed articles. The authors are ranked according to the total number of articles published. The United States (USA) leads with 357 articles, boasting the highest number of publications and MCP-Ratio with 70 articles. Japan has published 305 articles, yet its MCP ratio is relatively low. In terms of international collaboration, Europe is notably prominent. Countries like the United Kingdom, Germany, and the Netherlands exhibit high MCP ratios.

Table 2 lists the first 20 authors according to their h-index values. Genant HK has the highest h and g-index. Cummings SR and Kanis JA are second and third regarding the h-index, respectively. Mazziotti G has the highest m-index value.

Table 3 displays the top 20 sources ranked according to their h-index values. 51.12% of the articles included in the analysis were published in these sources. Osteoporosis International's

h-index value is 71. Despite its high h-index value, its TC/NP (Total Citations per Number of Publications) value is average. Regarding the TC/NP value, the Archives of Internal Medicine stands out among others. The journal Archives of Osteoporosis, which started its publication life in 2015, has quickly become influential.

Table 4 lists the top 20 publications with the most citations according to their LC values. The 1993 article by Genant HK has the highest LC value. Following this are the articles by Lindsay R. from 2001 and Cooper C. from 1992. The publication with the highest GC value is the 1996 article by Black DM. The 2006 article by Schousboe JT is more recent than the others. Nevertheless, it has become influential in a short time.

Figure 1 D illustrates the relationships among authors, keywords, and sources. The results of the analysis of inter-institutional collaboration are presented in Figure 2 A. A network of 30 nodes was established employing the Walktrap Algorithm. Each node represents an institution, which has formed eight clusters.

The University of California, San Francisco, is the most active institution regarding collaborative activity, located in the blue cluster. McMaster University, the University of British Columbia, and the University of Toronto follow this. The most intensive collaboration and interaction are observed in the red cluster.

Keyword Analysis: Figure 2 B presents the most frequently used keywords as a word cloud and a frequency table, with the top 50 shown. The most recurrent keywords include Vertebral Fracture, Osteoporosis, Bone Mineral Density, Vertebroplasty, Kyphoplasty, and Epidemiology. According to trend topic analysis, researchers today focus on artificial intelligence and deep learning (Figure 2 C).

In Figure 2 D, the co-occurrence network of keywords is presented. The keywords have been clustered into four groups. The red cluster represents the keywords for osteoporosis, the blue cluster for Vertebroplasty, the green cluster for Fracture, and the purple cluster for Vertebral Fracture Assessment.
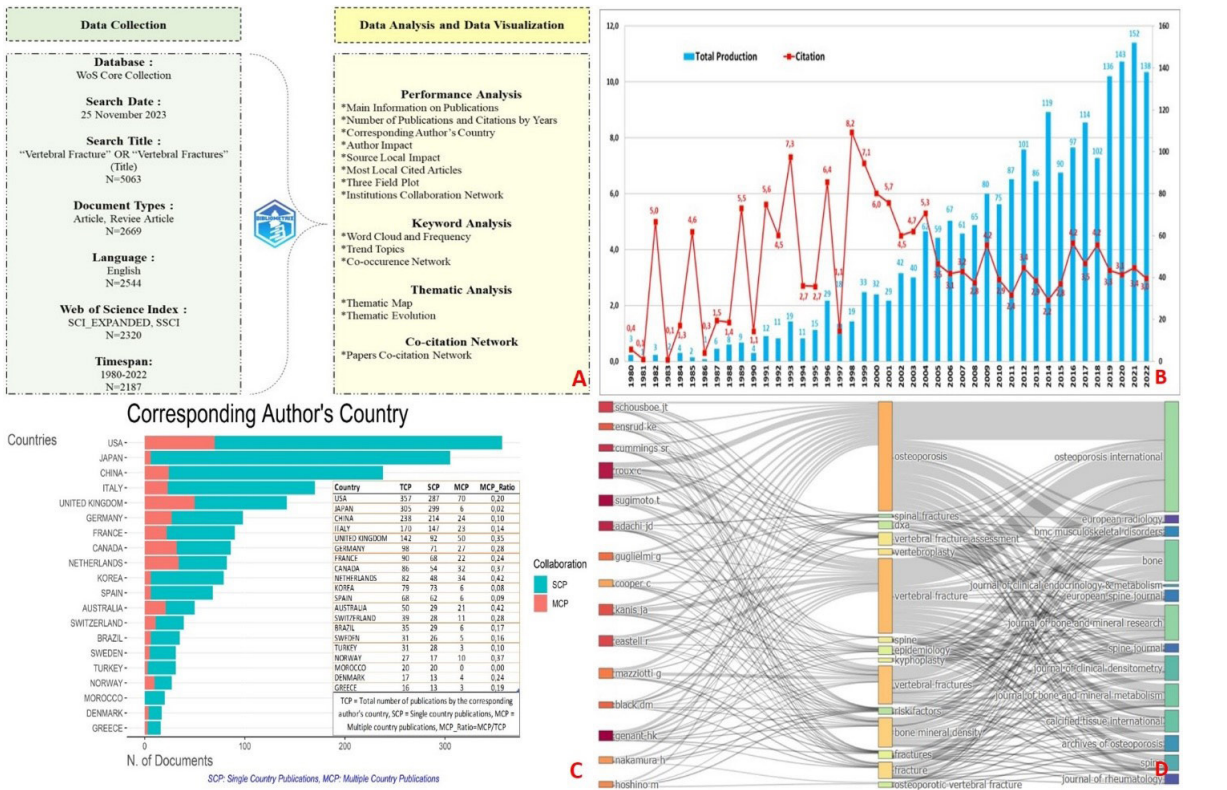
Figure 1. A. Flowchart of Data Collection, Data Analysis and Data Visualization, B. Number of Publications and Citations by Years, C. Corresponding Author's Country, D. Relationship between Authors (left), Keywords (middle) and Sources (right).
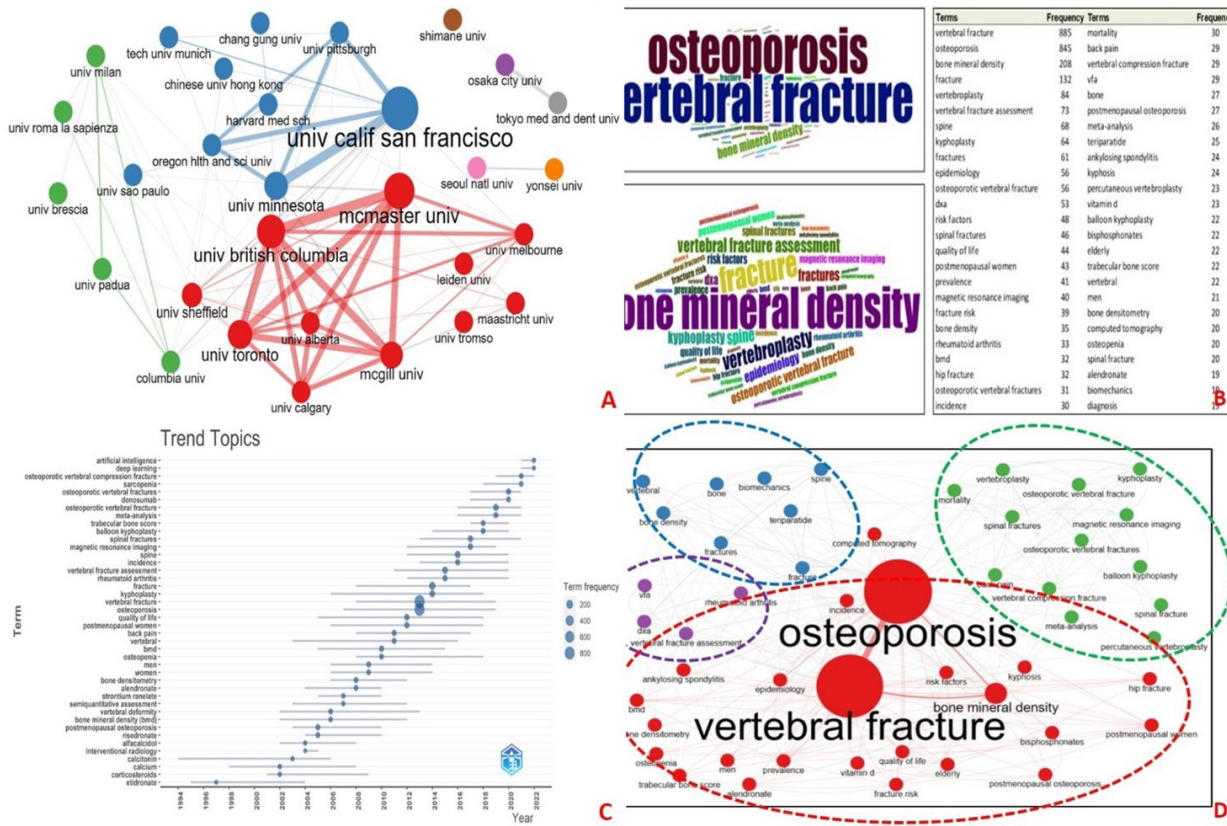
Figure 2. A. Institutions Collaboration Network. The size of these circles is proportional to the level of collaboration of the institution, and the thickness of the lines between circles correlates with the degree of collaboration between institutions. B. Word Cloud and Frequency Table, C. Trend Topics, D. Co-Occurrence Network. The size of these circles is proportional to the level of Co-Occurrence, and the thickness of the lines between circles correlates with the degree of Co-Occurrence.

Table 1. Performance Analysis Results and Main Information

Description	Results	Description	Results
MAIN INFORMATION ABOUT DATA		AUTHORS	
Timespan	1980:2022	Authors	9020
Sources	484	Authors of Single-Authored Docs	43
Documents	2187	AUTHORS COLLABORATION	
Annual Growth Rate %	9,54	Single-Authored Docs	46
Document Average Age	11,3	Co-Authors per Doc	7,35
Average Citations per doc	44,05	International Co-Authorships %	18,7
References	32743	DOCUMENT TYPES	
DOCUMENT CONTENTS		Article	2003
Keywords Plus (ID)	2755	Article; Early Access	2
Author's Keywords (DE)	2819	Article; Proceedings Paper	56
		Review	126

Table 2. Author Impact

Author	h_index	g_index	m_index	TC	NP	PY_start
Genant HK	36	47	0,923	16673	47	1985
Cummings SR	29	36	0,829	13507	36	1989
Kanis JA	29	32	0,935	3809	32	1993
Eastell R	28	32	0,8	5821	32	1989
Black DM	26	29	0,743	11323	29	1989
Roux C	25	40	1,042	4702	40	2000
Ensrud KE	24	31	0,857	7935	31	1996
Sugimoto T	24	45	1,043	2059	45	2001
Adachi JD	23	36	0,742	2983	36	1993
Cooper C	22	26	0,688	5914	26	1992
Yamauchi M	21	25	0,913	1553	25	2001
Delmas PD	20	22	0,8	5886	22	1999
Felsenberg D	20	21	0,69	3674	21	1995
Giustina A	20	26	1,111	1280	26	2006
Schousboe JT	20	33	1,053	1359	33	2005
Yamaguchi T	19	22	0,826	1486	22	2001
Mazziotti G	18	29	1,125	995	29	2008
Guglielmi G	17	29	0,773	1233	29	2002
Johnell O	17	18	0,472	2619	18	1988
Siminoski K	17	23	0,81	1094	23	2003

NP = Number of publications, TC = Total citations, PY_start = Publication year starting.

Thematic Analysis: The Thematic Map for 2020-2022 is presented in Figure 3 A. Our research focal point from 2020 to 2022 encompasses basic themes such as Osteoporosis-Vertebral Fracture, Osteoporotic Vertebral Fracture-Kyphoplasty, and Fracture-Vertebral Fracture Assessment. Figure 3B displays the Thematic Evolution Map. According to this map, osteoporosis is the predominant theme during the 2020-2022 period. In addition, themes such as Hip Fracture, Osteoporotic Vertebral Fracture, and Spine have emerged.

Co-Citation Network Analysis: Figure 3 C depicts the results of the paper co-citation network analysis. Three clusters have formed, each distinguished by different colors. The red cluster comprises articles such as "Genant HK 1993, O'Neill TW 1996, and Melton LJ 1989." The blue cluster includes papers like "Lindsay R. 2001, Cooper C 1992, and Black DM 1999." The green cluster contains articles like "Black DM 1996, Ettinger B 1999, and Harris ST 1999."

Table 3. Source Local Impact

Source	H Index	G Index	M Index	TC	NP	TC/NP	PY start
Osteoporosis International	71	112	2,219	16258	308	52,79	1992
Journal of Bone and Mineral research	65	127	1,757	16272	135	120,5	1987
Bone	42	77	1,077	6216	111	56,00	1985
Calcified Tissue International	30	52	0,833	2837	62	45,76	1988
J of Clinical Endocrinology & Metabolism	29	47	0,806	3213	47	68,36	1988
SPINE	26	49	0,765	2460	55	44,73	1990
Journal of Clinical Densitometry	21	38	0,875	1593	61	26,11	2000
European Spine Journal	20	34	0,909	1222	38	32,16	2002
Journal of Bone and Mineral Metabolism	19	31	0,731	1153	67	17,21	1998
Journal of Rheumatology	17	22	0,63	731	22	33,23	1997
Bmc Musculoskeletal Disorders	15	26	0,682	728	41	17,76	2002
European Journal of Endocrinology	13	15	0,684	636	15	42,40	2005
European Radiology	13	20	0,684	477	20	23,85	2005
Spine Journal	13	18	1	391	28	13,96	2011
Archives of Osteoporosis	12	16	1,333	386	46	8,39	2015
Endocrine	11	16	0,733	385	16	24,06	2009
Rheumatology	11	14	0,458	535	14	38,21	2000
American Journal of Medicine	10	10	0,417	1265	10	126,5	2000
American Journal of Neuroradiology	10	12	0,417	504	12	42,00	2000
Archives of Internal Medicine	10	10	0,27	2418	10	241,8	1987

Table 4. Most Local Cited Articles

Document	YP	LC	LC/YYP	GC	GC/YYP	LC/GC Ratio%
Genant hk, 1993, J Bone Miner Res	1993	712	23,733	2618	87,267	27,20
Lindsay r, 2001, Jama-J Am Med Assoc	2001	284	12,909	1228	55,818	23,13
Cooper c, 1992, J Bone Miner Res	1992	245	7,903	1077	34,742	22,75
Genant hk, 1996, J Bone Miner Res	1996	212	7,852	502	18,593	42,23
Kado dm, 1999, Arch Intern Med	1999	176	7,333	757	31,542	23,25
Nevitt mc, 1998, Ann Intern Med	1998	173	6,920	617	24,680	28,04
Ross pd, 1991, Ann Intern Med	1991	168	5,250	890	27,813	18,88
Melton lj, 1989, Am J Epidemiol	1989	141	4,147	742	21,824	19,00
Delmas pd, 2003, Bone	2003	138	6,900	394	19,700	35,03
Delmas pd, 2005, J Bone Miner Res	2005	138	7,667	385	21,389	35,84
Black dm, 1996, Lancet	1996	125	4,630	2931	108,556	4,26
Eastell r, 1991, J Bone Miner Res	1991	119	3,719	502	15,688	23,71
Melton lj, 1999, Osteoporosis Int	1999	106	4,417	374	15,583	28,34
Jiang g, 2004, Osteoporosis Int	2004	103	5,421	207	10,895	49,76
Ettinger b, 1999, Jama-J Am Med Assoc	1999	99	4,125	2428	101,167	4,08
Gehlbach sh, 2000, Osteoporosis Int	2000	99	4,304	280	12,174	35,36
Felsenberg d, 2002, J Bone Miner Res	2002	95	4,524	477	22,714	19,92
Oleksik a, 2000, J Bone Miner Res-a	2000	90	3,913	385	16,739	23,38
Schousboe jt, 2006, Osteoporosis I.	2006	78	4,588	139	8,176	56,12
V. Der klift m, 2002, J Bone Miner Res	2002	76	3,619	222	10,571	34,23

Year of Publication (YP), YYP= Year 2023-Year of Publication, Global Citations (GC), Local Citations (LC)

Figure 3. A. Thematic Map. The size of the circles is proportional to the usage level of the keyword. B. Thematic Evolution (1980–2022). The thickness of the lines correlates with the frequency of the keyword usage. C. Papers Co-Citation Network. The size of these circles is proportional to the level of Co-Citation, and the thickness of the lines between circles correlates with the degree of Co-Citation between papers

Discussion:

Science mapping is a multifaceted domain within the broader scope of scientometrics, primarily concerned with the systematic and quantitative analysis of scientific literature. Its primary objective is to uncover scientific research's intricate structural and dynamic patterns. This endeavor involves meticulously examining various elements such as citations, authorship, co-authorship networks, and keyword frequencies [10]. At its core, science mapping leverages sophisticated methodologies and algorithms to visualize the landscape of scientific fields. This analytical approach is not only instrumental in understanding the evolution of scientific disciplines but also aids in identifying interdisciplinary connections and potential areas for future research [8].

Furthermore, science mapping is crucial in policy-making and strategic planning for research institutions and funding bodies. A comprehensive overview of the scientific terrain enables stakeholders to make informed decisions about resource allocation, collaboration opportunities, and research directions [7].

Eugene Garfield, a notable figure in scientometrics, has made significant contributions to this area. He developed the widely used academic resource, the WoS, an expansive dataset and a continually growing international database. Its characteristics make it the most effective data source for bibliometric analyses. The utilization of WoS in our study is of utmost importance for the reliability of our data [11,12].

The Bibliometrix program we employed is based on R, an open-source software. The R language is used in a wide range of studies, including medicine, and its primary feature is the production of visual data, especially graphics. This enhances comprehensibility. Our study has been enriched with these detailed graphics [10].

In the published article, the United States and Canada stand prominently. Both nations exhibit high MCP values, with Canada particularly noteworthy for its collaborative efforts. European countries have made significant contributions to

Vertebral Fracture, with nations like the United Kingdom, Germany, the Netherlands, and Switzerland demonstrating high MCP values, indicative of their leadership in global collaboration. In Asia, the contributions of Japan, China, and Korea are notable. These countries tend to favor internal collaboration, though China's MCP value surpasses the others. Overall, Europe and North America are leading in international collaboration.

The h-index, conceived by physicist Jorge E. Hirsch in 2005, represents a unique metric designed to quantify the cumulative impact and relevance of an individual scientist's research output [13]. An h-index of 'n' implies that a researcher has authored 'n' papers, each of which has been cited in other scholarly works at least 'n' times. This index mitigates the disproportionate weight given to a few highly cited papers or the mere quantity of publications, thus offering a more balanced and comprehensive evaluation of a researcher's contributions [14]. The h-index also provides a robust framework for comparing scholarly influence across disciplines. It may undervalue the contributions of early-career scientists. Furthermore, it must account for the context or nature of citations, potentially overlooking the nuance in the citation landscape [13,14].

The g-index was conceived to address certain limitations inherent in the h-index and developed by Leo Egghe in 2006. The g-index aims to provide a more nuanced reflection of a researcher's scholarly influence. At its core, the g-index asserts that a researcher's top g articles have, collectively, garnered at least g^2 citations [14]. This metric furnishes a more comprehensive appraisal of a researcher's contribution to their field. Developed as a derivative of the h-index, the m-index provides a more time-sensitive analysis by accounting for the duration of an individual's active research career. The m-index is calculated by dividing the h-index of a researcher by the number of years since their first published paper. This approach offers a more equitable comparison between early-stage researchers and those with more extended careers. The m-index should be employed with other measures to assess a researcher's impact holistically [15].

Professor Harry K. Genant, a renowned figure in radiology, passed away in 2021. He is the editor or author of over 40 books and over 600 scholarly articles [16].

The journal Osteoporosis International boasts the highest scores in terms of h, g, and m-index, as well as NP Number of Publications and TC Total Citations. This publication enjoys a broad impact and citation reach. Osteoporosis International is a multidisciplinary journal published by the International Osteoporosis Foundation and the USA National Osteoporosis Foundation [17].

Following "Osteoporosis International" in terms of h-index is the "Journal of Bone and Mineral Research," published by the American Society for Bone and Mineral Research. However, when considering TC/NP, which represents the average number of citations per article, the "Journal of Bone and Mineral Research" takes a leading position. This indicates that the articles in this journal receive more citations, underlining their significant presence in the literature [18].

The Genant HK 1993 article pertains to the criteria for assessing vertebral fractures using conventional radiography [19]. Lindsay R's 2001 publication focuses on the frequency of recurrent vertebral fractures within the same year. It is a multicenter study involving approximately 5000 participants [20]. The 1996 article by Black DM investigated the effect of alendronate on fracture risk in postmenopausal women with low bone mass [21]. The 2006 paper by Schousboe JT calculated the cost per Quality-Adjusted Life Year QALY for oral bisphosphonate therapy in menopausal osteopenia [22].

The relationship among authors, keywords, and sources was examined. For this purpose, a Sankey diagram or data visualization technique was utilized. Sankey diagrams emphasize the flow, movement, or change from one state or time to another, illustrating the significance and generalizability of the study. Sankey diagrams can visualize processes and interactions [23]. The nodes in the diagram are rectangular, and the size of each node and the width of the lines between nodes are proportional to the number of members. Roux C, Kanis JA, Sugimoto T, and Mazziotti G frequently use keywords like osteoporosis, vertebrae fracture, and bone mineral density.

These authors have published their works in Osteoporosis International, Bone, and the Journal of Bone and Mineral Research [24–27].

In the Institutions Collaboration Network analysis, 30 nodes were based, and the Walktrap Algorithm was applied. Each node represents an institution. The institution with the most publications in terms of collaboration is the University of California San Francisco, followed by McMaster Univ, the University of British Columbia, and the University of Toronto. The thick lines between them indicate that the most frequent collaborations are between the California San Francisco -, Minnesota, Mcmaster Univ - of Univ British Columbia, and Mcmaster Univ - of Univ Toronto.

Keywords define and represent articles, identifying current topics and themes in the field of study through analyses utilizing these terms. Word cloud analysis facilitates the identification of intermingled fields and eases the analysis of keywords prevalent in these fields over the years [20].

The ten most frequent keywords encompass crucial terms related to vertebral fractures. These terms represent focal points of the subject and are associated with aspects such as the definition, assessment, treatment, and epidemiology of vertebral fractures.

Between 1994 and 2004, keywords like Etidronate, Corticosteroids, Calcitonin, and Alfacalcidol were prominent, reflecting significant treatment methods or assessment parameters relevant to the research of that era.

In contrast, contemporary research reveals a shift in focus. Terms like Artificial Intelligence, Deep Learning, and Denosumab have become trendy, indicating increased scrutiny of these technologies and novel treatment approaches. Keywords co-occurrence networks are utilized in scientific mapping studies. In these networks, each keyword is a node, and the co-occurrence of a pair of terms in a single article represents a link. The frequency of co-occurrence across multiple articles determines the strength of the link. Such networks represent cumulative knowledge in the field, and insights can be derived based on the strength of connections between key terms. Co-occurrence network-based analyses provide a rapid avenue for uncovering vast amounts of literature-related data [28]. According to the results of the keyword co-occurrence analysis conducted in our research:

The cluster represented by the keyword 'Osteoporosis' focuses on bone health, osteoporosis, and related subjects. It addresses research and review-oriented topics like bone mineral density, epidemiology, and risk factors and includes various treatment and assessment methods. It targets different populations, such as postmenopausal women and older individuals.

The cluster represented by 'Fracture' encompasses imaging techniques focusing on osteoporotic vertebral fractures and includes aspects related to mortality and pain. It also covers review approaches like meta-analysis.The cluster represented by 'Vertebroplasty' includes topics like Vertebral Fractures and Biomechanics, terms such as Spine and Bone Density, and mentions Teriparatide, a treatment for osteoporosis. It emphasizes treatment methods, with the term 'Biomechanics' addressing the formation of fractures and bone health from a biomechanical perspective.

The 'Vertebral Fracture Assessment' cluster concentrates on vertebral health and fracture assessment, indicating measurement and evaluation techniques. It highlights advanced imaging techniques used in these assessments. Vertebral fractures are clinically silent in approximately 65-75% of cases. Only 30-40% of these cases seek medical assistance [29]. Additionally, radiologists often encounter challenges in diagnosing these fractures accurately. Some studies have revealed that while the prevalence of vertebral fractures is around 29%, only a third of these cases are reported by radiologists [30]. This discrepancy highlights the need for improved diagnostic approaches in identifying vertebral fractures. In the diagnosis of vertebral fractures, diagnostic approaches such as Artificial Intelligence and Deep Learning are increasingly being investigated [31,32]. Consequently, their usage as key terms has escalated in recent years.

Denosumab, an inhibitor of osteoclast-mediated

bone resorption, reduces the risk of vertebral fractures [33,34]. Its usage has proliferated in the past decade, elevating Denosumab to prominence among keywords in this field.

Creating a Thematic Map has been accomplished using the first 250 keywords repeated at least five times, with the most frequently recurring keywords grouped into thematic clusters. In Thematic Map analyses, research themes are visualized across multiple periods, enabling the identification of research dynamics [35]. The Thematic Map reflects the interactions of the elements within the examined field of science over time, serving as a static description of the field's network structure [35].

The Thematic Map is divided into four quadrants, each representing different themes. Each quadrant is interpreted in its context. For this purpose, two parameters have been determined, encompassing centrality and density. The density parameter is represented along the y-axis, while the centrality parameter is represented along the x-axis, depicting the thematic map. The more central a chosen theme is, the more significant it is deemed, and the denser it is, the more it is considered to have completed its development [36].

Thematic Maps identify four different themes based on the x and y axes. Motor themes are considered developed themes and are essential in structuring research topics. Niche themes are those with limited interest. Emerging or declining themes are at a low level of development, while Basic themes are significant in interdisciplinary research topics.

Our study has certain limitations. One notable constraint is that the data were exclusively obtained from the WoS database. Incorporating data from additional databases could enrich the study.

In conclusion; using the bibliometric method, our study is a rare analysis of vertebral fractures. Thus, it is highly unique. This is likely an essential resource for policy formulation and strategic planning for research institutions and funding organizations. The findings of this study will serve as a fundamental tool in the academic analysis of research on vertebral fractures. By quantifying citations and collaboration networks, the study outputs offer a systematic evaluation of scientific productivity and the dissemination of knowledge. However, while metrics such as the h-index and impact factor provide valuable insights, they may only sometimes fully reflect the quality or significance of individual contributions. Therefore, they should be interpreted with caution. Moreover, the increasing reliance on quantitative metrics in academic assessment necessitates the development of more detailed and comprehensive approaches that integrate qualitative evaluations. As scientometrics continues to evolve, its role in shaping research policies, funding decisions, and advancing scientific knowledge will undoubtedly become increasingly significant.

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List of abbreviations:

- WoS : Web of Science

- YP: Year of Publication

- LC: Local Citations

- GC: Global Citations

- YYP: Year 2022-Year of Publication

- LC/YYP: Annual Local Citations

- • GC/YYP: Annual Global Citations

- • TC: Total Citations

- • NP: Total Number of Publications

- • TC/NP: Citations per paper

- • PY_start: Publication year starting

- • TPC: Total number of publications by the corresponding author's country,

- • SCP: Single country publications,

- • MCP: Multiple country publications,

- • MCP_Ratio: MCP/TCP

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