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Research

# The Relationships Between Wrist Joint Position Sense, Anthropometric Characteristics and Grip Strength of the Hand in Healthy Individuals

## Sağlıklı Bireylerde El Bileği Eklem Pozisyon Hissi, Kavrama Gücü ve Elin Antropometrik Özellikleri Arasındaki İlişki

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## ABSTRACT

**Objective:** The hand is an extremely unique structure with its own characteristics that should be better understood. To determine the relationship between joint position sense (JPS), hand anthropometrics, and grip strength (GS) in healthy individuals.

**Methods:** Both hands of 50 healthy adults were evaluated. The anthropometric characteristics (AC) were determined using small paper insertion tape. Hand and finger strength were measured using hand dynamometry and a pinchometer, respectively. The wrist JPS was evaluated for wrist flexion, extension, and deviations via a position error test using a goniometer.

**Results:** AC and GS were positively correlated with both the dominant and non-dominant sides in all parameters ($p<0.05$). There was a significant positive relationship between palmar GS and wrist flexion JPS error on the dominant side ($p=0.039$, $r=0.292$) and on the non-dominant side ($p=0.033$, $r=-0.303$). There was no significant relationship between JPS and the AC of any other GS parameters ($p>0.05$).

**Conclusion:** The use of anthropometric data in calculating GS, as well as other complimentary data, can be utilized to determine the type and diversity of exercise for physiotherapy and rehabilitation program organization. The results showed a weak correlation between wrist JPS, AC, and GS. In conclusion, our study showed that AC can be used as an indicator of GS, but GS alone is insufficient to indicate joint position.

**Keywords:** Wrist joint position sense, anthropometric variables, grip strength, pinch strength

## ÖZ

**Amaç:** El, daha fazla anlaşılması gereken kendine has özellikleri ile son derece benzersiz bir yapıdır. Sağlıklı insanlarda eklem pozisyon duyusu (EPD), el antropometrisi ve kavrama kuvveti (KK) arasındaki ilişkiyi belirlemek amacıyla yapılmıştır.

**Gereç ve Yöntem:** Elli sağlıklı yetişkinin her iki eli değerlendirildi. Antropometrik özellikler (AÖ) ölçülürken referans noktaları küçük kağıtlarla işaretlendi. El ve parmak kuvveti sırasıyla el dinamometrisi ve pinç metre ile ölçüldü. Bilek eklemi pozisyon hissi, bilek fleksiyonu, ekstansiyonu ve deviasyonları için gonyometre ile pozisyon hata testi ile değerlendirildi.

**Bulgular:** AÖ ve KK, tüm parametrelerde hem baskın hem de baskın olmayan taraf için pozitif korelasyon gösterdi ($p<0,05$). Antropometrik ölçümler ile eklem pozisyon hisleri arasında istatistiksel olarak anlamlı ilişki saptanmadı ($p>0,05$). Fleksiyon yönünde eklem pozisyon hissi ile palmar KK arasında pozitif yönde anlamlı ilişki bulundu ($p<0,05$). Lateral KK ile hem fleksiyon hem de ekstansiyon yönünde el bileği eklem pozisyon hissi ile negatif yönde anlamlı ilişki bulundu ($p<0,05$).

**Sonuç:** KK'nin hesaplanmasında antropometrik verilerin yanı sıra diğer tamamlayıcı verilerin kullanılması, fizyoterapi ve rehabilitasyon programının belirlenmesinde, egzersiz türüne ve çeşitliliğine karar vermek için kullanılabilir. Bu çalışmanın bulguları; el bileği eklem pozisyon hissi, antropometrik özellikler ve KK arasında zayıf bir korelasyon olduğunu göstermiştir. Sonuç olarak, çalışmamız antropometrik özelliklerin KK'nin bir göstergesi olarak kullanılabileceğini, ancak KK'nin eklem pozisyon hissini göstermede yetersiz olduğunu göstermektedir.

**Anahtar Kelimeler:** El bileği eklem pozisyon hissi, antropometrik ölçümler, el kavrama kuvveti, parmak kavrama kuvveti

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## INTRODUCTION

The upper extremity is an extremely dynamic and mechanically complex part of the body. It connects with the trunk through the hand and wrist, elbow, and shoulder, thereby maximizing the functionality of the upper extremity (1). The hand's complexity is obvious, with its structure well-organized for performing a range of complicated jobs. These jobs need a mix of complex motions and precise force output. The hand's complicated kinesiology is due to the close interaction between diverse soft tissue components. Minor injuries to any of these structures can change the general function of the hand, thereby complicating therapeutic management (2,3).

Measurements of hand grip and pinch strength were tested using extremely simple methods that did not require advanced patient compliance (4). Unique proprioception, grip strength, and anthropometric characteristics contribute to versatile hand functions. Proprioception is described as muscle, tendon, and joint-based sense of movement and posture that is regulated by somatosensory and sensorimotor systems (5). Altered proprioception causes functional limitations, and muscle weakness has a serious effect on functional limitations in the presence of weak proprioception (6). In existing studies of hand and wrist proprioception, position, kinesthesia, and vibration sense were measured, and the activation of some muscles in the wrist was evaluated using electromyography (7-9). Anthropometric measurements are non-invasive quantitative measurements of the body that can be used to assess overall health, nutritional status, and potential for future disease (10). In many different populations, grip strength reflects general muscle strength, and low grip strength is an indicator of negative health status (11-13).

Although the relationship between anthropometric characteristics and grip strength has been investigated in different populations to the best of our knowledge, no study has examined the relationship between joint position sense and grip strength (14,15). Therefore, the aim of this study was to define the relationship between joint position sense, grip strength, and anthropometric characteristics of the hand in healthy individuals.

## METHODS

One hundred hands of 50 university student participants were evaluated in this observational study. Our study was approved by the Ethics Committee of Haliç University, Non-Interventional Clinical Research Ethics Committee (no: 41, date: 01.04.2015) and was conducted in accordance with the principles outlined in the Declaration of Helsinki. Sample size was calculated using the data of a similar research, and it was found that 100 hands were needed to conduct the study with 80% power with 0.05 $\alpha$ error. In addition, after competition of the study, power analysis performed by G-Power indicated a power of 87% with 0.05 $\alpha$ error (effect size was 0.304). The process of the study was explained in detail to all participants. Written informed consent was obtained from all participants. Physical and demographic characteristics (age, gender, height, weight occupation) were recorded using a structured self-administered questionnaire. Information on hand dominance was obtained by asking the respondent which hand they preferred for writing and throwing a ball.

### Inclusion Criteria

The inclusion criteria of the study were as follows: age between 18 and 30 years, normal vision and sensation, and willingness to participate in the study.

### Exclusion Criteria

Individuals with pain, callus, open wounds, limited range of motion, neurological, or infectious diseases, and those with missing assessment parameters were excluded.

### Anthropometric Measurements

Anthropometric measurements were performed using a small paper insertion tape with a precision of 0.1 cm. A straight back chair with adjustable leg height was used for sitting positions (16). Hand length was measured as the straight distance from the midpoint of the line formed by the styloid process of the radius and ulna bones to the most forward point of middle finger. Forearm length was measured as the length between the olecranon and styloid process of the radius when the elbow was flexed 90 degrees. The wrist circumference was measured by locating the styloid process of the ulna and radius and encircling the margin at the widest part of the wrist. The forearm circumference was measured at the largest part of the forearm or 10-15 cm above the styloid process of the ulna. Hand width was determined by measuring the circumference at the level of the 2$^{nd}$ and 5$^{th}$ metacarpophalangeal joints. Palm length was determined by measuring the distance between the 3$^{rd}$ metacarpophalangeal joint and the wrist line.

### Grip Strength Measurements

Hand grip strengths were measured using hand dynamometry (Saehan Corporation, Masan, Korea) according to the standard procedures recommended by the American Society of Hand Therapists (17). Participants were asked to sit down and hold the dynamometer with the elbow flexed at 90 degrees and the forearm and wrist in a

neutral position. First, the manner in which the test would be conducted was explained to the participants. Before the test, a trial was conducted for the participant to understand the measurement. After establishing the proper starting position, the participant was instructed to squeeze the dynamometer with maximal isometric effort without any other body movement for 3 s and then release it. The tests were repeated 3 times. Prior to testing, participants rested for 1 min between repetitions. Verbal encouragement was given during the trials to ensure maximal participant performance. The non-dominant side was also tested after a 1-min rest period. The average value of 3 measurements was recorded (Figure 1).

Fingergrip strengths were evaluated using a pinchometer (Saehan Corporation, Masan, Korea). First, the test procedures were explained to the participants. Before the test, a trial was conducted for the participant to understand the measurement. After establishing the proper starting position, the participant was asked to squeeze the dynamometer with maximal isometric effort without any other body movement for 3 s and then release it. Participants rested for 1 min between repetitions. Verbal encouragement was given during the trials to ensure maximal participant performance. The non-dominant side was also tested after a 1-min rest period. The average values of the three measurements were recorded. Figure 2a. shows the positions of the fingertip, Figure 2b. lateral and Figure 2c. palmar grip measurements.

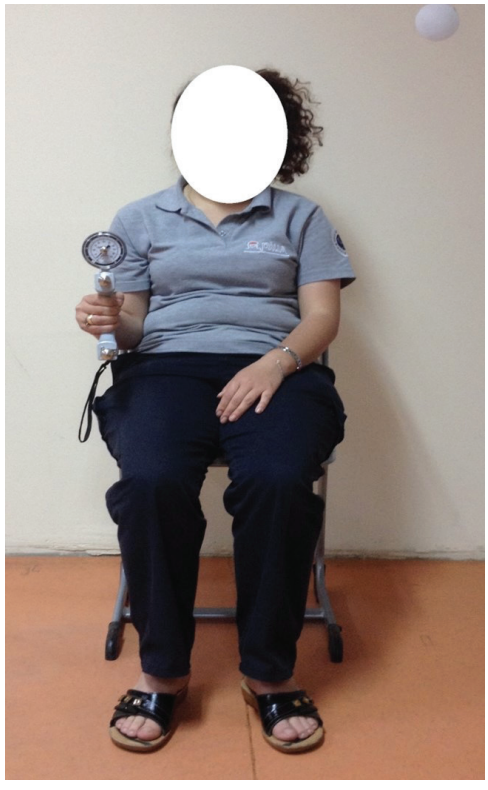

**Figure 1.** Measurement of grip strength

### Joint Position Sense

The wrist position sense assessment was performed using a standardized goniometric active wrist joint position sense test performed by the method of repeating the previously taught angle with active movement (Figure 3a,b). A universal goniometer with a central 360° scale marked in two increments and 2-18 cm long arms was used. The goniometer was placed over the volar wrist, with its moving arm aligned palmarly with the third metacarpal, the stationary arm placed at the distal forearm, and the axis adjacent to the wrist. Each participant was seated with their elbow resting on a medical plinth in a flexed position, while their forearms and wrists were in a neutral position with fingers resting in a flexed posture. After the placement of the goniometer, the participants were asked to perform 30° palmar flexion and hold this position for 5 s in the eyes closed position. After returning to the neutral position, the participants were asked to duplicate their previously attained position and hold the position for 3 s in a row. The same protocol was used for dorsal flexion. The difference between the original position and the other three attempts was recorded. The mean of the three remaining scores was used to assess joint position sense. The same procedures were repeated for

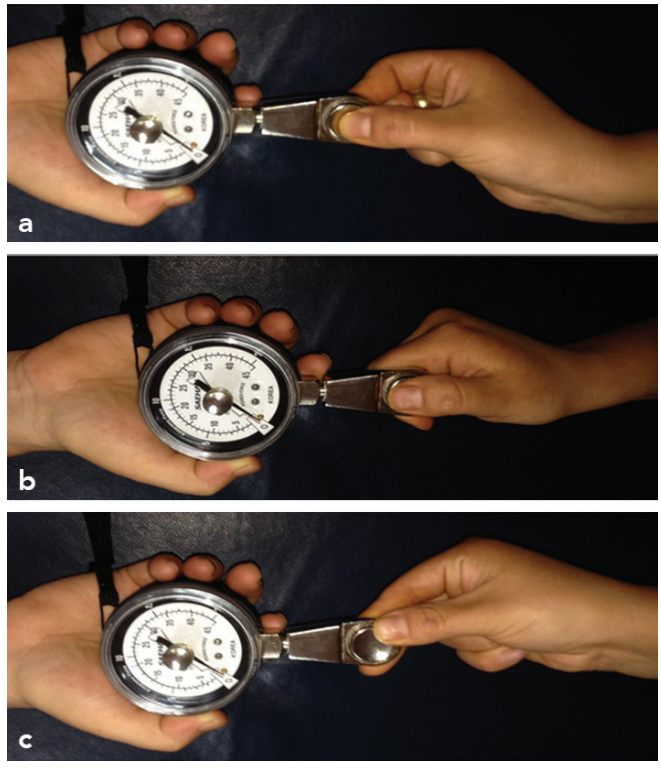


**Figure 2.** a. Fingertip grip strength measurement. b. Measurement of lateral grip strength. c. Palmar grip strength measurements

wrist extension and ulnar and radial deviations. Both wrists were tested. Since the test determines the margin of error, a higher value indicates a worse joint position sense. Since meaningful results were obtained by using these angles in a similar study, we also used these angles in our study (18).

### Statistical Analysis

Statistical analysis was performed with the SPSS 15.0 (Statistical Package for Social Science) (IBM SPSS Inc., Chicago, IL) program. Mean ± standard deviation was used for variables (age, height, weight, body mass index) in descriptive statistics. The normal distribution of variables was examined graphically and using the Shapiro-Wilk test. The relationships between variables were evaluated using the Pearson correlation test. Statistical significance was set as $p<0.05$.

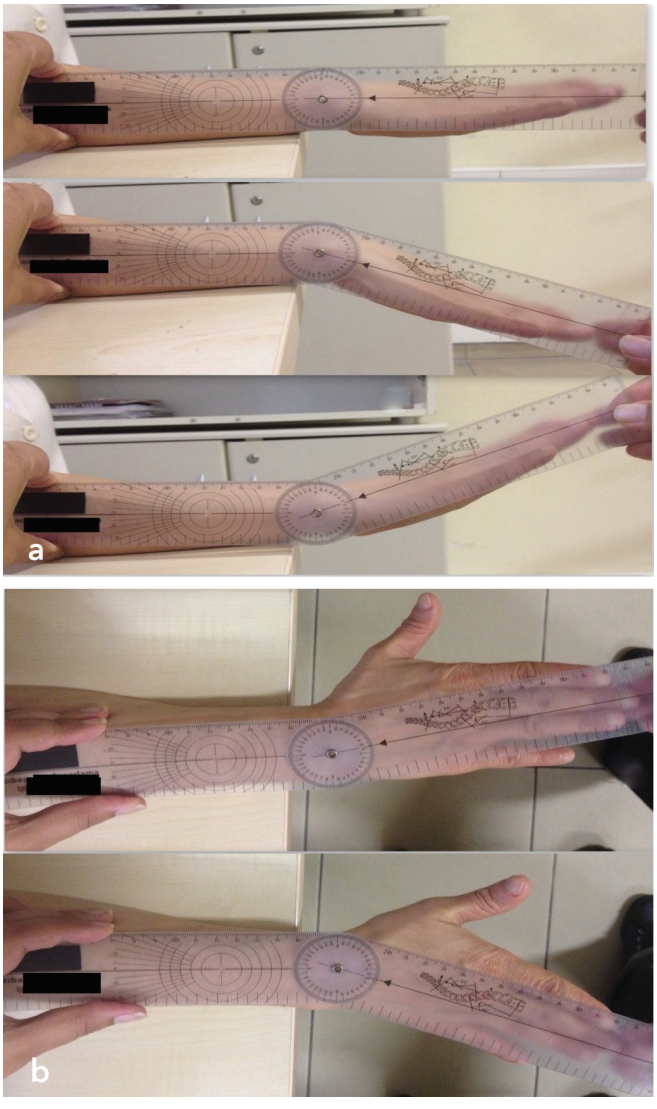


**Figure 3.** a. Joint position sense evaluation of flexion and extension. b. Joint position sense evaluation of radial and ulnar deviation

## RESULTS

The study was completed with 100 hands out of 50 participants. The characteristics of the participants are presented in Table 1. The mean values of grip strength, anthropometric characteristics, and joint position sense are presented in Table 2. Correlations between grip strength, anthropometric characteristics, and joint position sense are presented in Table 3. A statistically significant positive correlation was found between the anthropometric measurements and grip strength of both the dominant and non-dominant sides for all parameters. ($p<0.05$). There was no significant relationship between anthropometric measurements and joint position sense ($p>0.05$). There was a statistically significant positive relationship between palmar grip strength and wrist flexion joint position sense error on the dominant side ($p=0.039$, $r=0.292$) and a significant negative relationship between lateral grip strength and wrist flexion joint position sense error on the non-dominant side ($p=0.033$, $r=-0.303$). No statistically significant relationship was found between grip strength and joint position sense error.

## DISCUSSION

In this study, we aimed to investigate the relationship between wrist joint position sense, grip strength, and anthropometric characteristics of the hand in healthy individuals and found a relationship between anthropometric characteristics, grip strength, and some joint position sense parameters.

Studies investigating the anthropometric characteristics and grip strength of athletes with different sport branches, including volleyball (19), cricket (20), basketball, and handball (21). According to Koley and Pal Kaur (18), anthropometric characteristics were greater in athletes than in controls, and all anthropometric characteristics were correlated to dominant-side grip strength. Barut et al. (20) also found a similar correlation for various sports branches (21). Grip strength and anthropometric parameters were found to be related in comparable studies undertaken for the 10-14 age group (22), the 17-19 age group (23) and the 55-85

**Table 1.** Demographic characteristics of the participants

| | Median ± SD | Min | Max |
|---|---|---|---|
| Age (year) | 21.30±2.09 | 18 | 30 |
| Height (m) | 1.69±0.07 | 1.57 | 1.88 |
| Weight (kg) | 63.87±13.17 | 47 | 109 |
| BMI (kg/m$^2$) | 22.17±3.93 | 17.63 | 38.62 |

BMI: Body mass index, SD: Standard deviation, Min: Minimum, Max: Maximum

age group (24). The relationship between grip strength and anthropometric characteristics was revealed in the study of Saha (15) and Koley and Singh (19) conducted in the university population which is our study's population as well. However, differently from these studies, our study focused on some anthropometric measurements of the hand and its surroundings. Consistent with the other studies, similar results were obtained in the relationship between all of

**Table 2.** Mean values of grip strength, joint position sense and anthropometric measurement

| Variables | | Mean ± SD (min-max) Dominant side | Mean ± SD (min-max) Non-dominant side |
|---|---|---|---|
| Anthropometric measurements | Hand length | 18.03±1.05 (16.20-21.00) | 18.01±1.06 (16.00-21.00) |
| | Forearm length | 27.02±1.80 (23.50-31.00) | 26.92±1.87 (23.50-31.00) |
| | Wrist circumference | 15.81±1.17 (13.50-18.00) | 15.63±1.19 (13.00-18.50) |
| | Forearm circumference | 24.83±2.42 (20.30-30.90) | 24.13±2.29 (20.50-29.60) |
| | Hand width | 10.50±0.71 (9.00-12.00) | 10.52±0.71 (9.00-12.00) |
| | Palm length | 19.14±1.53 (16.90-23.00) | 18.90±1.49 (16.40-23.00) |
| Grip strength | Hand grip | 29.06±8.24 (18.00-51.33) | 26.63±7.78 (15.00-49.00) |
| | Lateral grip | 7.62±2.05 (4.67-12.67) | 7.12±1.79 (4.17-11.6) |
| | Fingertip grip | 6.08±1.70 (3.33-11.33) | 5.51±1.60 (3.33-11.17) |
| | Palmar grip | 7.59±2.36 (4.50-16.00) | 7.10±2.22 (4.50-14.83) |
| Joint position sense error | Flexion | 5.40±3.11 (0.67-13.33) | 8.55±2.75 (3.33-16.67) |
| | Extension | 4.05±2.93 (0.33-15.00) | 6.07±3.17 (0.67-12.67) |
| | Radial deviation | 1.91±0.95 (0.67-4.67) | 3.84±1.72 (0.00-9.33) |
| | Ulnar deviation | 3.20±2.29 (0.67-10.33) | 5.61±3.11 (1.33-16.67) |

*Pearson correlation test. SD: Standard deviation, min-max: Minimum-maximum

**Table 3.** Correlation between grip strength and anthropometric measurements and joint position sense error

| Variables | | | Hand grip | | Lateral grip | | Fingertip grip | | Palmar grip | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DM | NDM | DM | NDM | DM | NDM | DM | NDM |
| Anthropometric measurements | Hand length | p | 0.000* | 0.000* | 0.001* | 0.001* | 0.004* | 0.000* | 0.024* | 0.006* |
| | | r | 0.672 | 0.661 | 0.465 | 0.474 | 0.396 | 0.477 | 0.320 | 0.384 |
| | Forearm length | p | 0.000* | 0.000* | 0.000* | 0.000* | 0.002* | 0.000* | 0.001* | 0.000* |
| | | r | 0.667 | 0.620 | 0.475 | 0.506 | 0.437 | 0.497 | 0.441 | 0.496 |
| | Wrist circumference | p | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.003* | 0.000* |
| | | r | 0.718 | 0.740 | 0.561 | 0.620 | 0.497 | 0.587 | 0.411 | 0.525 |
| | Forearm circumference | p | 0.000* | 0.000* | 0.001* | 0.001* | 0.011* | 0.003* | 0.033* | 0.006 |
| | | r | 0.653 | 0.659 | 0.442 | 0.470 | 0.357 | 0.417 | 0.302 | 0.385 |
| | Hand width | p | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* | 0.000* |
| | | r | 0.831 | 0.858 | 0.639 | 0.618 | 0.589 | 0.636 | 0.550 | 0.616 |
| | Palm length | p | 0.000* | 0.000* | 0.001* | 0.001* | 0.002* | 0.003* | 0.013* | 0.004* |
| | | r | 0.596 | 0.620 | 0.450 | 0.438 | 0.437 | 0.416 | 0.349 | 0.402 |
| Joint position sense error | Flexion | p | 0.404 | 0.062 | 0.620 | 0.033* | 0.206 | 0.260 | 0.039* | 0.059 |
| | | r | 0.121 | -0.266 | 0.072 | -0.303 | 0.182 | -0.162 | 0.292 | -0.269 |
| | Extension | p | 0.524 | 0.390 | 0.756 | 0.044 | 0.715 | 0.419 | 0.260 | 0.290 |
| | | r | 0.092 | -0.124 | 0.045 | -0.287 | 0.053 | -0.117 | 0.162 | -0.153 |
| | Radial deviation | p | 0.370 | 0.227 | 0.058 | 0.308 | 0.090 | 0.951 | 0.115 | 0.427 |
| | | r | -0.130 | -0.174 | -0.269 | -0.417 | -0.242 | 0.009 | -0 226 | -0.115 |
| | Ulnar deviation | p | 0.407 | 0.811 | 0.670 | 0.607 | 0.235 | 0.898 | 0.137 | 0.923 |
| | | r | 0.120 | -0.035 | 0.062 | -0.075 | 0.171 | 0.019 | 0.213 | 0.014 |

DM: Dominant, NDM: Non-dominant, *Pearson correlation test

the evaluated anthropometric values and grip strength. Grip strength is clinically important in evaluating the functions of the hand. The use of anthropometric data in estimating the grip strength together with other complementary data can be used to determine the type and variety of exercise in the organization of the physiotherapy and rehabilitation program.

Joint position sense is typically referred to as proprioception in clinical terms. There is no standard method for evaluating joint position sense. Goniometers, which were used in this study, motion analysis systems; instruments and devices designed by the researchers were used to evaluate the joint position sense (9,25,26). In different studies, the position sense of the upper extremity (27), wrist flexion-extension (28), and all wrist movements (18) were reported differently. The reasons for these differences may be the selected evaluation method, the process of evaluation, and other factors that affect the sense of joint position. Although healthy individuals were included in this study, problems in the visual and vestibular system, injuries in the extremity or trunk, age, gender, pain, and fatigue, factors such as immobility, previous surgery, not using the extremity, hypermobility, and arthritis can affect the sense of joint position (29). It has been reported that mechanoreceptors show a different distribution in triangular fibrocartilage (30), ligaments in the wrist joint (31). For this reason, all wrist movements were evaluated in this study. We found that lateral grip on the non-dominant side, and joint position error of wrist flexion was found to be negatively correlated. However, this relationship is weak, and no relationship was found between other grips and joint position errors expect the positive correlation of palmar grip and joint position sense of wrist flexion. To the best of our knowledge, there is no study investigating the relationship between wrist joint position sense and grip strength although there are studies investigating joint position sense and muscle strength in different joints and structures. This gap makes it difficult to interpret our current results. On the other hand, it is the innovative part of our study We think that understanding the relationship between proprioception and grip strength will facilitate the diagnosis and treatment of other diseases, especially rheumatological and orthopaedic problems. We also think that it will help the physiotherapist in creating and updating the rehabilitation program, as it will provide a prediction to the physiotherapist in terms of prognosis. We acknowledge some limitations of our study. No further cautions were taken to control for factors that may affect joint position sense, only one method (goniometer) was used to joint position sense. Further studies may compare the wrist position sense and grip strength with different evaluation methods or focus on the relationship between the muscle strength of the wrist and surrounding muscles rather than the grip strength and the joint position sense.

## CONCLUSION

In conclusion, it is determined that anthropometric measurements are related to grip strength. Anthropometric measurements can provide information about muscle strength, along with other assessment methods, to regulate physiotherapy and rehabilitation programs. In clinics without dynamometers, anthropometric measurements can provide information about grip strength, thereby leading to relatively objective information about grip strength during evaluation. It is thought that the reason why a significant association between grip strength and joint position sense could not be found was the method chosen or factors that may affect joint position sense.

### ETHICS

**Ethics Committee Approval:** Our study was approved by the Ethics Committee of Haliç University, Non-Interventional Clinical Research Ethics Committee (no: 41, date: 01.04.2015) and was conducted in accordance with the principles outlined in the Declaration of Helsinki.

**Informed Consent:** Written informed consent was obtained from all participants.

### Authorship Contributions

Surgical and Medical Practices: A.A., M.G.Y., Concept: A.A., Y.C., M.G.Y., Design: A.A., Y.C., M.G.Y., Data Collection or Processing: A.A., B.V., M.G.Y., Analysis or Interpretation: A.A., B.V., M.G.Y., Literature Search: A.A., Y.C., M.G.Y., Writing: A.A., Y.C., B.V., M.G.Y.

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

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# Analysis of Dental Caries Experience and Parents Perception on the Oral Health Status of Children with Autism Spectrum Disorders From South India

## Güney Hindistan'da Otizm Spektrum Bozukluğu Olan Çocuklarda Diş Çürüğü Deneyiminin ve Ebeveynlerin Ağız Sağlığı Durumuna İlişkin Algılarının Analizi

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## ABSTRACT

**Objective:** Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder that can significantly affect various aspects of an individual's life, primarily communication and behavior. Poor oral health in children with ASD can further exacerbate these challenges and negatively affect their overall health and quality of life. This study aimed to investigate and analyze the experiences of dental caries and parental perceptions of the oral health status of children with ASD.

**Methods:** The study involved 20 children with autism who were residing in a special school in Mangaluru. Clinical recordings, including the calculus index-simplified (CI-S), oral hygiene index-simplified (OHI-S), caries status [decayed missing and filled teeth (DMFT) and debris index-simplified (DI-S), treatment needs, and periodontal status community periodontal index (CPI). Additionally, parents' perceptions of their children's OHI-S were collected through a pre-designed questionnaire. Special diet recommendations and oral hygiene counseling were provided to the parents, followed by a 3-month follow-up. The chi-square test was applied to the discrete data, whereas One-Way ANOVA was used for the continuous data analysis.

**Results:** Initial dental counseling showed mean scores for CI-S, DI-S, DMFT, and OHI-S was 0.13±0.23, 0.35±0.27, 2.40±3.18, and 0.46±0.37, indicating important components for tooth decay. Half of the parents did not have proper knowledge of their teeth and gums. However, after the 3-month follow-up, the parents' perceptions regarding oral health were positive, with a decrease in DI-S and OHI-S scores, suggesting improvement in oral health.

**Conclusion:** Children with autism exhibited poor oral hygiene and a high prevalence of dental caries, indicating substantial unmet dental treatment needs. Routine parental counseling and training on proper oral care can play a crucial role in promoting the oral health of children.

**Keywords:** Autism spectrum disorders, dental caries, oral health, children, parental perceptions

## ÖZ

**Amaç:** Otizm spektrum bozukluğu (ASD), bir bireyin hayatının çeşitli yönlerini, özellikle iletişimi ve davranışı önemli ölçüde etkileyebilen karmaşık bir nörogelişimsel bozukluktur. ASD'li çocuklarda kötü ağız sağlığı, bu sorunları daha da derinleştirebilir ve ASD'li çocukların genel sağlıklarını ve yaşam kalitelerini olumsuz etkileyebilir. Bu çalışma, diş çürüğü deneyimlerini ve ASD'li çocukların ağız sağlığı durumuna ilişkin ebeveyn algılarını araştırmayı ve analiz etmeyi amaçlamaktadır.

**Gereç ve Yöntem:** Çalışmaya Mangalore'daki özel bir okulda ikamet eden 20 otizmli çocuk dahil edildi. Calculus indeksi (CI-S), ağız hijyeni durumu (OHI-S), çürük durumu [çürük, eksik ve dolgulu dişler (DMFT) ve DI-S], tedavi ihtiyaçları ve toplum periodontal endeksi (CPI) dahil olmak üzere klinik kayıtlar incelendi. Ek olarak, ebeveynlerin çocuklarının OHI-S'sine ilişkin algıları önceden tasarlanmış bir anket aracılığıyla toplandı. Ebeveynlere özel diyet önerileri ve ağız hijyeni danışmanlığı verildi ve ardından 3 aylık bir takip yapıldı. Aralıklı verilere ki-kare testi uygulanırken, sürekli veri analizi için Tek-Yönlü ANOVA kullanıldı.

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## ÖZ

**Bulgular:** İlk diş danışmanlığı, diş çürüğü için önemli bileşenler olan CI-S, DI-S, DMFT ve OHI-S için ortalama puanların 0,13±0,23, 0,35±0,27, 2,40±3,18 ve 0,46±0,37 olduğunu gösterdi. Ebeveynlerin yarısı dişleri ve diş etleri hakkında yeterli bilgiye sahip değildi. Ancak, 3 aylık takipten sonra, ebeveynlerin ağız sağlığına ilişkin algıları olumluydu ve DI-S ve OHI-S puanlarında bir düşüş vardı ve bu da ağız sağlığında iyileşme olduğunu gösteriyordu.

**Sonuç:** Otizmli çocuklar kötü ağız hijyeni ve yüksek oranda diş çürüğü sergilemiştir, bu da karşılanmamış önemli diş tedavisi ihtiyaçlarını göstermektedir. Rutin ebeveyn danışmanlığı ve uygun ağız bakımı konusunda eğitim, çocukların ağız sağlığını geliştirmede önemli bir rol oynayabilir.


**Anahtar Kelimeler:** Otizm spektrum bozuklukları, diş çürükleri, ağız sağlığı, çocuklar, ebeveyn algıları

## INTRODUCTION

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by impaired social interaction, communication challenges, and restricted and repetitive behaviors. Individuals with ASD often face various health-related difficulties, and oral health is no exception. Maintaining optimal oral health is crucial for overall well-being, as disruptions in oral health can directly impact physical and mental activities, leading to adverse effects on social life and quality of life (QoL). The estimated prevalence of ASD is 1% in the United Kingdom and 1.5% in the United States (1), whereas in India, most of the reported studies on ASD are based on hospital-based data; therefore, data on the prevalence of ASD are lacking (2). However, several studies have consistently highlighted poor oral hygiene and a high prevalence of periodontal disease among children with ASD.

Practicing healthy oral habits, such as regular brushing, flossing, and routine dental checkups, is essential for preventing or reducing oral cavities in children. However, children with developmental disorders, including those with ASD, require special care to ensure proper oral hygiene. Unfortunately, oral healthcare remains one of the most neglected aspects of healthcare for children with ASDs. Altered behaviors, unusual oral habits, medications, and dietary preferences may lead to the development of oral diseases in ASD. Autism generally challenges dentists and dental care, but behavioral modification techniques have value in changing self-injurious behaviors. Studies have shown that children with ASD often struggle with oral hygiene because of difficulties in cognition, understanding instructions, and remembering tasks. Additionally, factors such as limited access to oral healthcare services and competing demands contribute to the challenges faced by individuals with ASD in maintaining good oral health (3). Consequently, this population is at a higher risk of developing periodontal diseases and dental caries, which can have a significant impact on overall health and well-being.

However, the studies examining the prevalence of dental caries in children with ASD have yielded conflicting results, leading to a lack of consensus in the literature (4). Some studies have reported a lower prevalence of caries among individuals with ASD, suggesting that they may experience a reduced risk of dental cavities compared with their typically developing peers. These findings could be attributed to various factors, such as differences in dietary habits, salivary composition, and oral microbial profiles among children with ASD (5,6). The complex nature of oral health and specific challenges faced by individuals with ASD, such as low physical ability, difficulties in understanding and managing oral health needs, anxiety about dental procedures, and dependence on caregivers, underscore the need for a comprehensive multidisciplinary approach to their healthcare. While children with autism typically receive treatment from a range of professionals, including psychologists, neurologists, psychiatrists, speech therapists, and physiotherapists, the involvement of dentists in the multidisciplinary approach can further enhance the oral health outcomes of these individuals (7-9).

It is worth noting that further research is necessary to clarify the conflicting findings and gain a comprehensive understanding of the oral health profile of individuals with ASD, considering the various factors that can influence the prevalence of dental caries and periodontal health in this unique population. Most children with ASD require assistance in performing daily routine tasks such as shopping, cooking, washing clothes, paying bills, and managing money (9). Poor oral hygiene and periodontal condition could be caused by inadequate knowledge of teeth brushing or improper brushing techniques.

In this study, we aimed to investigate and analyze the experience of dental caries and parental perception of the oral health status of children with ASDs in South India. By assessing baseline oral health data and parental perceptions, we aimed to identify areas of concern and evaluate the effectiveness of dental interventions and counseling in improving oral health outcomes for children with ASD. Understanding the specific oral health needs

of children with autism and implementing appropriate interventions can contribute toward better oral hygiene and overall QoL for children with autism.

## METHODS

This cross-sectional study included children with ASD in special schools in the Mangaluru city of South India from 2019 to 2020. The Yenepoya University Ethics Committee (protocol no.: YUEC/2016/252, date: 28.10.2016), and access to schools was arranged through the school head. Dental camps were organized at autistic centers, and parents of children were invited. Informed consent was obtained from the parents who agreed to participate in the study. To ensure an optimum home environment and comfort, children were examined at their respective schools. A close-ended questionnaire was developed for Kannada and English.

After obtaining informed consent from the parents and school authorities, a team of qualified examiners, including a psychiatrist, physician, and dentist, visited the school twice. Children were screened for autism using the childhood autism rating scale. Eligible participants aged between 3 and 18 years, diagnosed with ASDs, or children whose parents had ASDs were included in the study. The study excluded children who experienced fever in the past 2 weeks, severe malnutrition, asthenia or bleeding gums.

Demographic details, such as name, age, and sex, of the patient were recorded in the study proforma. And intra-oral examinations were performed. Clinical examinations were carried out in the medical rooms of the schools with the aid of a headlight, disposable dental mirrors, and a tongue blade. At baseline, children were examined for the calculus index (CI), debris index (DI), dental caries status index [decayed, missing, and filled teeth (DMFT)], and oral hygiene index-simplified (OHI-S) (10). The CI/DI scores ranged from 0 to 3, where 0 score indicates no debris/calculus, and the 3 showed debris/calculus covering more than two-thirds of the tooth surface (11).

Weekly diet charts and parent's perception of the oral health status were assessed using a questionnaire. Diet counseling, including diet modification, was conducted for the parents. At the end of the third month, the oral health status of children with autism was re-evaluated using the CI, DI, OHI-S (1964), and DMFT index (1938) for dental caries. Children who were unwell and not willing to participate were excluded.

### Statistical Analysis

The collected data and completed questionnaires were compiled, tabulated, and analyzed using Statistical Package for the Social Sciences (version 18.0) software. The association between baseline and 3-month follow-up of oral hygiene behaviors and oral health services was investigated using an independent sample t-test, chi-square test, One-Way analysis of variance, and Tukey's post-hoc tests.

## RESULTS

In the present study, A total of 20 eligible participants aged between 3 and 18 years, diagnosed with ASDs, or children whose parents had ASDs were included in the study. The participant group comprised 12 (60%) males and 8 (40%) females, with a mean age of 10.2 [standard deviation (SD) ±4.2] years among children with autism. The baseline mean CI-S, DI-S, DMFT, and OHI-S scores were 0.13 (SD ±0.23), 0.35 (SD ±0.27), 2.40 (SD ±3.18), and 0.46 (SD ±0.37), respectively (Table 1).

Following a 3-month follow-up period, significant decreases ($p<0.05$) were observed in both the DI-S and OHI-S scores among the participants (0.06±0.13 and 0.18±0.28, respectively), indicating an improvement in dental caries experience and oral hygiene (Table 1). However, no

**Table 1.** Frequency and association of oral health parameters in children with autism (n=20)

| Oral health parameters | 3 months | n | Mean | SD | Median | IQR | $^{\$}$p-value |
|---|---|---|---|---|---|---|---|
| Calculus index | Before | 20 | 0.135 | 0.234 | 0.000 | (0-0.17) | 0.317 |
| | After | 20 | 0.118 | 0.174 | 0.000 | (0-0.17) | |
| Debris Index | Before | 20 | 0.344 | 0.279 | 0.335 | (0.0425-0.67) | *0.001 |
| | After | 20 | 0.066 | 0.135 | 0.000 | (0-0) | |
| DMFT | Before | 20 | 2.400 | 3.185 | 0.500 | (0-4) | 0.977 |
| | After | 20 | 2.100 | 3.110 | 0.500 | (0-4) | |
| OHI-S | Before | 20 | 0.462 | 0.376 | 0.585 | (0.17-0.67) | *0.001 |
| | After | 20 | 0.184 | 0.281 | 0.084 | (0-0.17) | |

DMFT: Decayed, missing and filled teeth, OHI-S: Oral hygiene index-simplified, SD: Standard deviation, IQR: Interquartile range, *Significant ($p<0.05$), $^{\$}$Wilcoxon signed-rank test

significant difference was observed between baseline and follow-up CI-S and DMFT scores.

Parental perceptions regarding their children's oral hygiene status were assessed, and the results are presented in Figure 1. The majority of children exhibited positive oral health behaviors and were taken to dental visits. Although there was no specific age requirement for dental visits, most children visited the dentist as needed. Approximately 80% of children reported brushing their teeth at least once daily, with the majority performing this task independently.

When evaluating attitudes and knowledge related to oral health, most parents expressed satisfaction with keeping their child's oral health in good condition (Table 2). However, it was noted that half of the parents lacked proper knowledge regarding teeth and gums.

## DISCUSSION

The present study aimed to investigate the experiences of dental caries and parents' perceptions of the oral health

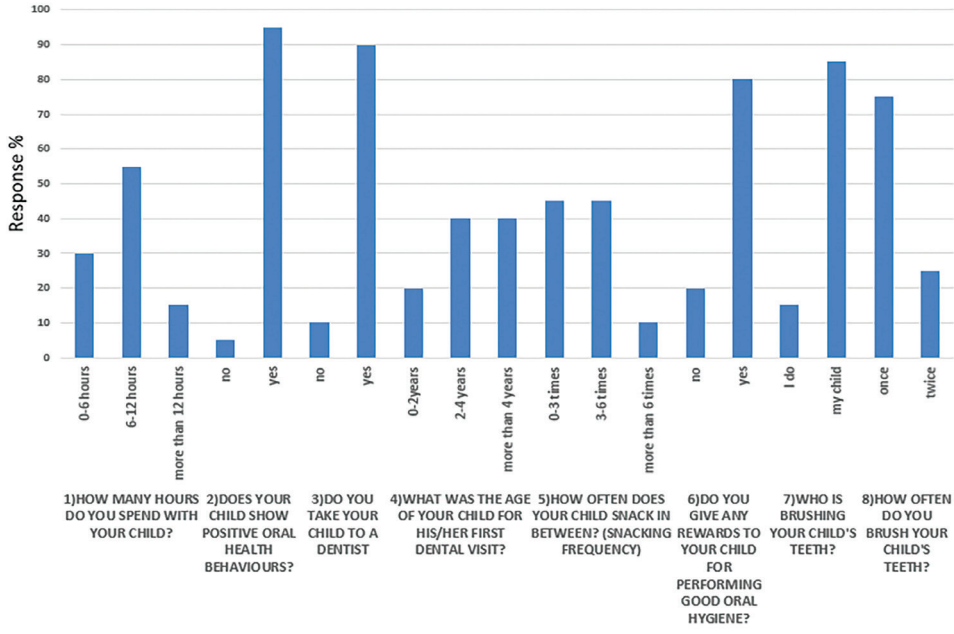


**Figure 1.** Parents responses regarding their perceptions of their children's oral hygiene status

**Table 2.** Parents responses concerning oral health-related attitudes and knowledge based on Likert's scale

| Sl no | Question | Parents response % | | | | |
|---|---|---|---|---|---|---|
| | | Strongly agreed | Agreed | Neutral | Disagree | Strongly disagree |
| 1 | It is important to me that my child's teeth are healthy. | 70 | 30 | 0 | 0 | 0 |
| 2 | It is important to me that my child has no cavities in his/her teeth. | 30 | 60 | 5 | 5 | 0 |
| 3 | It is important to me that my child's teeth get brushed. | 45 | 25 | 25 | 5 | 0 |
| 4 | It is important to me that my child's teeth get flossed. | 0 | 25 | 70 | 5 | 0 |
| 5 | I am satisfied with how much I know about taking care of teeth and gums. | 0 | 45 | 40 | 5 | 10 |
| 6 | I think it is the parent's job to make sure their children have good dental health. | 25 | 55 | 20 | 0 | 0 |
| 7 | Poor dental health affects my child's general health. | 30 | 55 | 15 | 0 | 0 |
| 8 | Dental problems like cavities, affect my child's quality of life. | 10 | 85 | 5 | 0 | 0 |
| 9 | I would like to receive information about dental health. | 30 | 55 | 15 | 0 | 0 |
| 10 | A dental health educator should talk to my child about dental health. | 20 | 75 | 5 | 0 | 0 |

status of children with ASD in South India. The findings shed light on the oral health challenges faced by this population and provide insights into the effectiveness of dental interventions and counseling in improving oral health outcomes.

Maintaining good oral health is integral to overall well-being, as any disruption in oral health can have direct repercussions on physical and mental activities, thereby influencing one's social life. For children, adopting healthy habits can help prevent or minimize the occurrence of oral cavities. Children with developmental disorders require special attention to ensure proper oral hygiene. Unfortunately, oral healthcare remains one of the most neglected health needs for children with autism. This finding may be attributed to the intricate nature of oral health and the need for advanced techniques to effectively manage plaque control (12).

The baseline data revealed overall poor oral hygiene among children with autism, as indicated by the mean CI-S, DI-S, DMFT, and OHI-S scores. It has been observed that the majority of the children had good oral hygiene (mean OHI-S =0.46) compared with other children, which decreased after 3 months of follow-up (mean OHI-S =0.18), showing a highly statistically significant difference. These findings are not consistent with the study conducted by Richa et al. (13) and Jaber (14) who reported that majority of autistic children had poor or fair oral hygiene. Poor oral hygiene in children with autism is attributed to low powers of concentration and lack of motor skills. Ameer et al. (15) pointed out that a lack of manual coordination among disabled children is a factor in the difficulty of oral hygiene maintenance. In general, there is a wide range of tooth brushing abilities related to coordinated muscular movements, innate skills, ability to understand instructions, and age. The complex nature of oral health care and unique challenges faced by individuals with autism, such as limited cognitive ability and difficulties in understanding and managing oral hygiene practices, contribute to these findings (13,14,16,17).

During the 3-month follow-up period, significant improvements were observed in the DI-S and OHI-S scores, indicating a reduction in dental caries experience and an improvement in oral hygiene. These findings suggest that dental interventions and counseling provided to parents were effective in promoting positive oral health behaviors and enhancing oral hygiene practices among children with autism (18). Similar findings have been reported in previous studies, emphasizing the importance of tailored interventions and parental involvement in improving oral health outcomes in this population (13,14). The DMFT index indicated decayed teeth, which is similar to findings from studies in other countries. Some of the reasons given for the increased occurrence of dental caries in this group of individuals include frequent use of sugar-containing medicine, dependence on a caregiver for regular oral hygiene, reduced clearance of foods from the oral cavity, impaired salivary function, preference for carbohydrate-rich foods, a liquid or puréed diet, and oral aversions.

The age of children is also associated with the prevalence of dental caries. With an increase in age, dental caries also increase. Recent studies have shown that autistic children of parents with high incomes had more dental caries (19,20). The use of a proper brushing technique and frequency can influence dental caries-free status in permanent teeth (21,22). Irregular brushing practice can increase caries frequency by 2.01 times in children with autism compared with regular brushing children. Food consumption patterns can also influence caries status. Namal et al. (19) showed that regular eating junk food and processed sugar can increase the dental caries experience by 5.01 times, and parents bring their child to a dentist only when the dental problem is more than 36% (23). A study conducted by Desai et al. (24) reported that children with autism had higher levels of dental caries. In contrast, McMillion et al. (25) showed that patients with ASD have more negative dental caries experience than other people.From the results obtained from this study, regarding parent's perception of oral health of their children, most of the parents said that they spent 6-12 hours with their child (55%), 95% said their child showed positive oral health behaviors, 90% said they took their child to a dentist, 80% rewarded the child for maintaining good oral hygiene, 85% reported that their child brushed their teeth own, and 75% said the frequency of brushing was once with most of the children snacking at least three times in between meals (90%). However, only 20% of children attempted to visit a dentist before the child reached two years of age. This result showed that parents were aware of the importance of oral health for autistic children and gave less importance to regular visits to a dental professional. Positive parental perceptions regarding their children's oral hygiene status are encouraging. The majority of parents reported positive oral health behaviors, including regular dental visits and daily toothbrushing. These findings indicate that parents are actively involved in promoting oral health and recognize the importance of maintaining good oral hygiene for children with autism. However, it is worth noting that a significant proportion of parents lacked proper knowledge regarding teeth and gums. This highlights the need for oral health education programs targeting parents of children with autism to improve their knowledge and empower them to take a more active role in their children's

oral health care (26,27). Most parents agreed that their child's oral health is important to them (70%) and that poor oral health affects their child's QoL (85%). Moreover, 55% of them agreed to receive information about dental health and 75% agreed that a dental health educator should talk to their child about dental health. Children with autism require support, continuous motivation, and supervision when brushing their teeth, making caregivers' perspective a crucial factor influencing the oral health of these children.

The results of this study underscore the importance of a comprehensive multidisciplinary approach to the healthcare of children with autism. While children with autism typically receive treatment from various healthcare professionals, the involvement of dentists in multidisciplinary teams can have a significant impact on the integration of oral healthcare into the child's daily life. Dentists can play a crucial role in training and educating parents and caregivers, developing personalized oral hygiene plans, and providing regular preventive professional oral health care. This collaborative approach can improve oral hygiene and improve QoL for children with autism (28). It has been reported that many dental practitioners are unwilling or unable to provide this necessary care due to financial or training constraints. Brickhouse et al. (29) reported that the most frequently reported barrier to dental care in this group was lack of cooperation by the child. Lai et al. (28) reported that public transport was another potential barrier to dental care in India. Parents suggested that the ability to wait might depend on the child's mood, the size of the waiting room, and the length of waiting time in the dental clinic.

Educating and motivating patients to perform effective oral hygiene can be challenging but immensely rewarding when successful efforts. Children with autism have difficulty managing their oral hygiene because they lack the cognitive ability to understand and remember what needs to be done. Maintaining good oral health is particularly challenging among individuals with autism because of limited access to care and competing demands. Lack of oral hygiene has been implicated as a fundamental factor in the development of periodontal diseases and dental caries in children with special health care needs. These results may be related to the low physical abilities of the participants, inadequate understanding of oral health management, difficulties in conveying oral health needs, anxiety about oral health procedures, and dependence on other people such as parents or employees with assisted living services.

Children with autism usually receive a comprehensive multidisciplinary approach, including psychologists, neurologists, psychiatrists, speech therapists, and physiotherapists. However, we would like to recommend the involvement of dentists in the multidisciplinary approach. Dentists may play an important role in integrating oral health care into the child's day-to-day life by training and educating parents and caregivers, and providing regular preventive professional oral health care. This can contribute to good oral hygiene and better QoL for children with autism.

It is important to acknowledge the limitations of this study. First, the study sample was limited to a specific region in South India and had a small sample size, which may have affected the generalizability of the findings. Further studies with larger and more diverse samples are required to validate the results. Second, the study relied on parent-reported data, which may have introduced some biases. Future studies should incorporate objective oral health measures, such as clinical examinations. Lastly, the follow-up period was relatively short-term (three months), and longer-term studies are warranted to assess the sustainability of the observed improvements in oral health outcomes.

## CONCLUSION

This study provides valuable insights into the experiences of dental caries and parental perceptions of oral health in children with ASDs in South India. Overall, this study contributes to the growing body of literature addressing the oral health challenges faced by children with ASDs. The findings highlight the need for targeted dental interventions, routine parental counseling, and comprehensive oral health care to address the specific needs of this vulnerable population. By implementing tailored interventions and promoting parental involvement, oral health outcomes can be improved, leading to better oral hygiene and an enhanced social and quality of life.

### ETHICS

**Ethics Committee Approval:** This cross-sectional study included children with ASD in special schools in the Mangaluru of South India from 2019 to 2020. The Yenepoya University Ethics Committee (protocol no.: YUEC/2016/252, date: 28.10.2016) approval was taken prior to conducting the study.

**Informed Consent:** Informed consent was obtained from the parents who agreed to participate in the study.

### Authorship Contributions

Surgical and Medical Practices: S.K.H., O.R., S.S.B., Concept: S.K.H., O.R., S.S.B., Design: S.K.H., O.R., B.S.K., Data Collection or Processing: S.K.H., O.R., S.S.B., B.S.K., Analysis or Interpretation: S.K.H., O.R., S.S.B., B.S.K.,

Literature Search: S.K.H., B.S.K., Writing: S.K.H., O.R., S.S.B., B.S.K.

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Research

# Evaluation of Knowledge of Family Physicians on the Diagnosis and Treatment of Anaphylaxis and Adrenaline Auto-injector Use in Türkiye

## Türkiye'de Çalışan Aile Hekimlerinin Anafilaksi Tanı-tedavisi ve Adrenalin Otoenjektör Kullanımı Konusunda Bilgi Düzeylerinin Değerlendirilmesi

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## ABSTRACT

**Objective:** Anaphylaxis is a life-threatening reaction characterized by sudden symptoms affecting different organ systems, and healthcare professionals must recognize and urgently treat anaphylaxis. In this study, we aimed to evaluate the knowledge and attitudes of family physicians in Türkiye about the diagnosis and treatment of anaphylaxis, use of adrenaline auto-injector, and factors affecting these attitudes.

**Methods:** This was a cross-sectional descriptive survey study. An online questionnaire was administered to family physicians to evaluate their knowledge levels regarding the diagnosis and treatment of anaphylaxis and the use of AAI.

**Results:** The study was completed with 207 participants, mean age was 33.8±8.5 years and mean professional experience was 8.5±8.3 years. 93.7% of the participants stated that the first-line treatment of anaphylaxis was adrenaline, 85.5% the correct route of adrenaline administration was intramuscular, 79.2% the right place of adrenaline administration, 75.4% the dose of adrenaline in children, 61.8% of them answered the adrenaline dose correctly in adults. 51.2% of the participants stated that they knew about the use of AAI, and 24.6% had received training on this subject. The average number of professional years of participants who knew that the first-line treatment was adrenaline, the correct route and place of administration of adrenaline, and knew how to use auto-injectors were statistically significantly lower (p=0.031, p<0.001, p<0.001, p=0.041, respectively). Family physicians who received post-graduation training on anaphylaxis; the rate of knowing that the first-line treatment of anaphylaxis was adrenaline, the correct route and place of administration of adrenaline, and the rate of knowing the use of auto-injectors were statistically significantly higher (p=0.013, p=0.037, p=0.024, p=0.011, respectively).

**Conclusion:** The most significant outcome of our study is family physicians' knowledge of the diagnosis and treatment of anaphylaxis is higher when their training at medical faculty and specialist training is more recent and when they undergo post-graduation training. With post-graduation training programs, family physicians can become more competent in life-threatening anaphylaxis. However, physicians' knowledge of adrenaline auto-injector therapy is insufficient. Family physicians should be trained on the use of this essential and life-saving drug for those at risk of anaphylaxis.

**Keywords:** Anaphylaxis, family physicians, knowledge, adrenaline auto-injector

## ÖZ

**Amaç:** Anafilaksi, farklı organ sistemlerini etkileyen ani semptomlarla karakterize, yaşamı tehdit eden bir reaksiyondur. Tüm sağlık profesyonellerinin anafilaksiyi tanıması ve acil olarak tedavi etmesi gerekir. Bu çalışmada Türkiye'de çalışan ile hekimlerinin, anafilaksi tanı ve tedavisi ile adrenalin otoenjektör kullanımı konusundaki bilgi ve tutumlarını ve bu tutumları etkileyen faktörleri değerlendirmeyi amaçladık.

**Gereç ve Yöntem:** Çalışma, kesitsel tanımlayıcı tarama çalışması olarak planlandı. Aile hekimlerine, anafilaksi tanı ve tedavisi ile adrenalin otoenjektörlerinin kullanımı ile ilgili bilgi düzeylerini değerlendirmeyi amaçlayan çevrimiçi bir anket uygulandı.

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## ÖZ

**Bulgular:** Çalışma 207 katılımcı ile tamamlandı, ortalama yaş 33,8±8,5 yıl ve ortalama mesleki deneyim 8,5±8,3 yıldı. Katılımcıların; %93,7'si anafilaksinin ilk tedavisinin adrenalin olduğunu, %85,5'i doğru adrenalin uygulama şeklinin kas içi olduğunu, %79,2'si adrenalinin doğru uygulama yerini, %75,4'ü çocuk hastalarda uygun adrenalin dozunu, %61,8'i erişkin hastalarda uygun adrenalin dozunu doğru olarak biliyordu. Katılımcılardan %51,2'si adrenalin otoenjektör kullanımını bildiğini, %24,6'sı bu konuda eğitim aldığını belirtti. İlk tedavinin adrenalin olduğunu, adrenalinin doğru uygulama yolu ve yerini bilen, otoenjektör kullanmayı bilen katılımcıların meslek yılı ortalamaları istatistiksel olarak anlamlı derecede düşüktü (sırasıyla p=0,031, p<0,001, p<0,001, p=0,041). Anafilaksi konusunda mezuniyet sonrası eğitim alan aile hekimlerinin; ilk tedavinin adrenalin olduğunu, adrenalinin doğru veriliş yolu ve yerini bilme oranı, otoenjektör kullanımını bilme oranı istatistiksel olarak anlamlı derecede yüksekti (sırasıyla p=0,013, p=0,037, p=0,024, p=0,011).

**Sonuç:** Çalışmamızın en önemli sonucu, aile hekimlerinin tıp fakültesi ve uzmanlık eğitimlerinin daha yeni olması ve mezuniyet sonrası eğitim almaları durumunda anafilaksi tanı ve tedavisi konusundaki bilgilerinin daha yüksek olmasıdır. Bu nedenle hizmet içi eğitim programları ile hekimler hayatı tehdit eden anafilaksi konusunda daha yetkin hale gelebilir. Hekimlerin adrenalin oto-enjektör tedavisi konusundaki bilgileri yetersizdir. Anafilaksi riski taşıyanlar için bu temel ve hayat kurtarıcı ilacın kullanımı konusunda aile hekimlerine yönelik eğitim planlanmalıdır.


**Anahtar Kelimeler:** Anafilaksi, aile hekimleri, bilgi, adrenalin otoenjektörü

## INTRODUCTION

Anaphylaxis is a life-threatening condition characterized by the acute onset of symptoms involving different organ systems, and it requires immediate medical intervention. All healthcare professionals need to recognize and treat anaphylaxis (1). With correct and rapid treatment, the risk of mortality can be minimized.

Estimated prevalence is 0.3-5.1% according to diagnostic criteria used in previous studies (2). Although the frequency of hospitalization due to food-and drug-induced anaphylaxis has increased in recent years, death from anaphylaxis remains very infrequent and stands at 0.35-1.06 deaths per million people per year, with no increase observed in the last 10 years (2,3).

The clinical signs and symptoms of anaphylaxis are highly variable, depending on the organ and system affected. Skin and mucosal symptoms occur most frequently (>90% of cases), followed by symptoms involving the respiratory and cardiovascular systems (>50% of cases) (1). The prevalence of various causes of anaphylaxis is age-dependent and varies in different geographical regions. Food, drug, and Hymenoptera venom are the most common factors of anaphylactic reactions (4,5). Anaphylaxis in children is most commonly caused by food, and bronchospasm is a common symptom. There is usually a background of atopy and asthma. In adults, venom- and drug-induced anaphylaxis are more common, and hypotension is more likely to occur (6).

In patients with previous anaphylaxis, it is essential to educate the patient and family about allergen avoidance. Adrenaline auto-injectors (AAI) should be recommended for emergency use in appropriate patients, and patients should be educated about their use (1). It is important that family physicians performing primary health care recognize and treat the signs and symptoms of anaphylaxis, a rare but life-threatening condition.

In this study, we aimed to evaluate the knowledge and attitudes of family physicians in Türkiye about the diagnosis and treatment of anaphylaxis and use of AAI and the factors affecting these attitudes.

## METHODS

The study was conducted as a cross-sectional descriptive survey between June 2022 and August 2022. The questionnaire was prepared by a specialist family physician and pediatric allergist based on current information. The survey, consisting of 31 questions prepared online using the Google Forms application, was sent to family physicians via social media (WhatsApp) and e-mail. The first part of the survey included the purpose and content of the study and the information and consent of the researchers. Participants who provided consent answered the survey questions fully.

The contents of the questions in the survey were as follows:

1. Questions to determine demographic information, such as gender, age, and professional years.

2. Questions about whether he received post-graduation education on anaphylaxis.

3. General information about anaphylaxis (most common causes of anaphylaxis), diagnosis (clinical symptoms), and questions about experience (previous encounter with an anaphylaxis patient and treatment of an anaphylaxis patient).

4. Questions about anaphylaxis treatment (positioning of the anaphylaxis patient, first-line drug in anaphylaxis, method-place-dose of adrenaline administration).

5. Question about whether the institution where you work has the necessary drugs and equipment for anaphylaxis treatment.

6. There are questions to determine their knowledge and experience regarding the use of AAI.

### Study Population

Family physicians actively working in Türkiye were included. The study was completed with 207 participants who participated in the survey.

### Statistical Analysis

The data were analyzed using International Business Machines Statistical Package for the Social Sciences statistics 22.0. Kolmogorov-Smirnov test was used for the

normal distribution of data. The mean differences between two groups with variables that are not distributed normally was assessed using Mann-Whitney U test. The distribution of categorical variables between groups were analyzed using $\chi^2$ (chi-square) test. Mean, standard deviation, median (1st and 3rd, 4st), frequency, and percentage are descriptive statistics. The threshold of statistical significance was regarded as $p<0.05$.

### Ethical Issues

This study was approved by the Bezmialem Vakıf University Rectorate Non-interventional Research Ethics Committee (approval number: 2021/173, date: 19.05.2021). The study was conducted according to the principles of the Declaration of Helsinki.

## RESULTS

The study was completed with 207 participants, and 58.5% (n=121) of them were female. Their mean age was 33.8±8.5 years (range 24-67 years), and their mean professional experience was 8.5±8.3 years (range 1-43 years). The rate of postgraduate training on anaphylaxis was 40.6% (n=84). Approximately half of the participants (47.3%, n=98) encountered anaphylaxis patients, and 38.6% (n=80) took part in the treatment of anaphylaxis patients. In Family Health Centers, the availability of drugs and equipment was assessed to evaluate the capacity of treating patients with anaphylaxis (Figure 1). Adrenaline was present in 98.6% (n=204), and the least available drug was glucagon (30%, n=62).

### General Information About Anaphylaxis and Its Affecting Factors

The majority of participants correctly identified the most common cause of anaphylaxis in children and adults (food in children 76.8%, n=159, drugs in adults 79.2%, n=164). Furthermore, 30.4% of family physicians knew that all of the signs and symptoms given in the questionnaire could be during anaphylaxis (n=63). This rate was not statistically significantly associated with age, professional experience, and post-graduate education (p=0.564, p=0.426, p=0.454 respectively). The proportion of family physicians who were involved in the treatment of patients with anaphylaxis was significantly higher than that of those who were not involved in the treatment (p=0.03). The signs and symptoms most associated with anaphylaxis were dyspnea (96.6%, n=200), hypotension (94.7%, n=196), and angioedema (94.2%, n=195). The ratio of family physicians to signs and symptoms in the questionnaire regarding anaphylaxis is shown in Figure 2.

### Knowledge and Factors Affecting Anaphylaxis Treatment

Participants knew correctly as correct position to be given to the patient during anaphylaxis (if there is no respiratory distress, lay the patient on his back and raise his feet at an angle of 30-45 degrees) in an 81.6% ratio. 93.7% of the participants stated that the first-line treatment of anaphylaxis was adrenaline, 85.5% the correct route of adrenaline administration was intramuscular, 79.2% the right place of administration of adrenaline, 75.4% the dose of adrenaline in children, and 61.8% of them answered the adrenaline dose correctly in adults.

The average age and professional years of the participants who knew the right route of adrenaline administration and the right place of administration of adrenaline were statistically significantly lower ($p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, respectively). The average number of professional years of physicians who knew that the first drug to be administered was adrenaline was statistically significantly less (p=0.031). The results are shown in Table 1.

Family physicians who received post-graduation training on anaphylaxis; the rate of knowing that the first drug to be administered in the treatment of anaphylaxis was adrenaline, the correct route of administration of adrenaline, and the right place of administration of adrenaline were significantly higher (p=0.013, p=0.037, p=0.024, respectively).

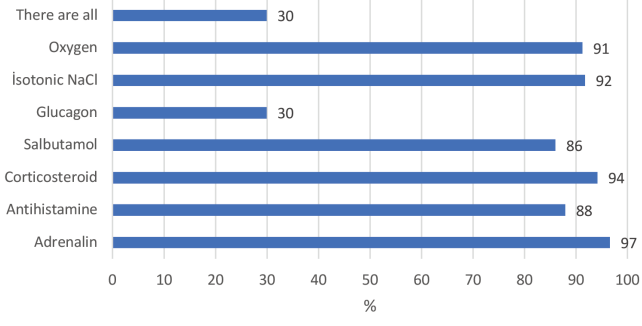


**Figure 1.** Available drugs and materials to be used in anaphylaxis

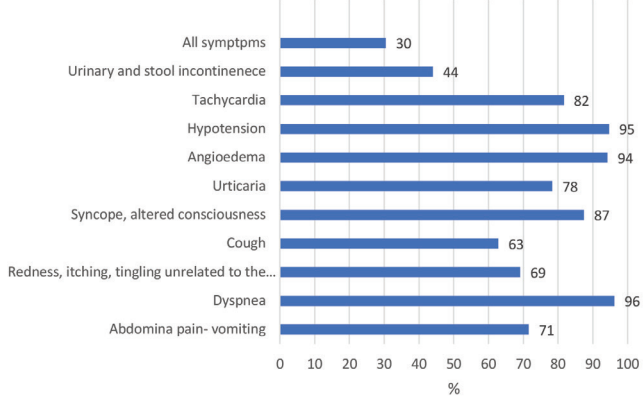


**Figure 2.** Rate of attributing signs and symptoms to anaphylaxis

Family physicians giving correct answers to questions about the diagnosis and treatment of anaphylaxis; the statistical relationship between age, professional year, post-graduate training in anaphylaxis, and participation in anaphylaxis treatment is presented in Table 1.

### Knowledge and Factors Affecting the Use of AAI

The mean age and professional experience of family physicians who stated that they knew how to use auto-injectors were lower (p=0.006, p=0.041, respectively). The rate of knowing the use of auto-injectors was significantly higher among those who received postgraduate education on anaphylaxis (p=0.011).

The statistical relationships between family physicians' AAI usage information, age, professional experience, post-graduate training on anaphylaxis, and participation in anaphylaxis treatment are presented in Table 2.

**Table 1.** Comparison of the knowledge levels of family physicians according to age, professional experience, post-graduate education, and involvement in anaphylaxis treatment

| | | Knowing all the symptoms | Knowing that the first drug is adrenaline | Understanding the right route of adrenaline administration | Accurately determining the place of adrenaline administration | Knowing the dose of adrenaline in children | Knowing the dose of adrenaline in adults | Understanding how to position correctly |
|---|---|---|---|---|---|---|---|---|
| **Age years (mean ± SD) Median (Q1-Q3)** | Know | 33.8±7.7<br>31 (28-38) | 33.4±8.3<br>30 (28-36) | 32.3±7.4<br>30 (28-34) | 32.3±7.1<br>30 (28-34) | 33.6±8.1<br>31 (28-37) | 33.1±8.5<br>30 (28-35) | 33.8±8.7<br>30 (28-37) |
| | Don't know | 33.6±8.9<br>30 (28-35.75) | 37.3±11.1<br>32 (30-44) | 41.7±10.1<br>39.5 (32.75-50.25) | 39±11.1<br>35 (29-49) | 34±9.8<br>30 (27-37) | 34.6±8.5<br>31 (28-40) | 33.3±7.3<br>31.5 (28-36.25) |
| | p* | 0.564 | 0.076 | <0.001 | <0.001 | 0.466 | 0.174 | 0.791 |
| **Professional years (mean ± SD) Median (Q1-Q3)** | Know | 8.6±7.3<br>6 (3-12) | 8.3±8.1<br>5 (3-11) | 7.1±7.1<br>5 (3-9) | 7.1±6.8<br>5 (3-9) | 8.3±7.7<br>5 (3-11) | 7.9±8.1<br>5 (3-9) | 8.5±8.4<br>5 (3-10) |
| | Don't know | 8.4±8.6<br>5 (3-10) | 11.5±9.6<br>9 (5-15) | 16.3±9.9<br>14 (9-23) | 18.6±10.8<br>10 (4-22) | 9±9.7<br>4 (3-11) | 9.4±8.4<br>5 (3-13) | 8.1±7.3<br>5 (3-11) |
| | p* | 0.426 | 0.031 | <0.001 | <0.001 | 0.554 | 0.185 | 0.891 |
| **Post-graduate education n (%)** | Yes<br>No | 28 (33.3)<br>35 (28.5) | 83 (98.8)<br>111 (90.2) | 77 (91.7)<br>100 (81.3) | 73 (86.9)<br>91 (74.0) | 60 (71.4)<br>96 (78.0) | 54 (64.3)<br>74 (60.2) | 71 (84.5)<br>98 (79.7) |
| | p** | 0.454 | 0.013 | 0.037 | 0.024 | 0.278 | 0.549 | 0.376 |
| **Previously, treating patients with anaphylaxis, n (%)** | Yes | 34 (42.5) | 75 (93.8) | 68 (85.0) | 64 (80) | 65 (81.3) | 55 (68.8) | 65 (81.3) |
| | No | 29 (22.8) | 119 (93.7) | 109 (85.8) | 100 (78.7) | 91 (71.7) | 73 (57.5) | 104 (81.9) |
| | p** | 0.003 | 0.989 | 0.869 | 0.828 | 0.119 | 0.104 | 0.908 |
| **Total, n (%)** | | 63 (30.4) | 194 (93.7) | 177 (85.5) | 164 (79.2) | 156 (75.4) | 128 (61.8) | 169 (81.6) |

*Mann-Whitney U test, **chi-square test, SD: Standard deviation

**Table 2.** Comparison of AAI usage information by age, professional year, and post-graduate education

| | | Understanding the use of AAI | I prescribe AAI |
|---|---|---|---|
| **Age years (mean ± SD) Median (Q1-Q3)** | Yes | 31.5±5.8<br>30 (28-33) | 33.4±7.9<br>31 (28-36) |
| | No | 36±10<br>32 (28-43.5) | 33.9±9.1<br>30 (28-38) |
| | p* | 0.006 | 0.864 |
| **Professional years (mean ± SD) Median (Q1-Q3)** | Yes | 6.5±5.5<br>5 (3-8.25) | 8.4±7.9<br>5 (3-11) |
| | No | 10.5±10<br>6 (3-15) | 8.8±8.7<br>5 (3-10) |
| | p* | 0.041 | 0.782 |
| **Post-graduate education, n (%)** | Yes<br>No | 52 (61.9)<br>54 (43.9) | 46 (54.8)<br>69 (56.1) |
| | p** | 0.011 | 0.849 |
| **Total** | | 106 (51.2) | 115 (55.6) |

*Mann-Whitney U test, **Chi-square test, AAI: Adrenaline auto-injector, SD: Standard deviation

## DISCUSSION

Anaphylaxis is an acute life-threatening emergency condition that requires immediate treatment to prevent further progression and complications. In our country, some medical interventions, including childhood and adult vaccination practices and intramuscular injections, are carried out at family health centers that are established for primary health care. Therefore, it is vital for family health centers to possess essential medications and equipment as well as for family physicians to be competent in the diagnosis and treatment of anaphylaxis.

### Knowledge of Family Physicians Regarding Anaphylaxis Diagnosis, Treatment and AAI

Approximately one-third of the participants in our study knew that all symptoms and clinical findings may occur during anaphylaxis. These results indicate that the multiorgan and multisystem findings of anaphylaxis are not sufficiently valuable. Under these circumstances, underdiagnosis and undertreatment may occur. Many studies have reported the underdiagnosis and undertreatment of anaphylaxis (7,8).

Nearly all family physicians in our study (93.7%) considered adrenaline as a first-line treatment for anaphylaxis. This ratio is similar to a study on family physicians in our country (9), whereas two other studies report significantly lower percentage of 50% (10,11). Research on different health professionals reported similar and lower ratios (12-19).

Most of our participants knew the correct route (85%) and location (79%) of adrenaline administration, although their knowledge of the correct dose (for pediatric dose 75% and for adult dose 61%) was inadequate. Nevertheless, the ratios in 2 other studies on family physicians in our country were lower (9,11). Similar or lower results have been reported in studies including different health professionals (12,17-23). Most of our participants were informed about the correct positioning of patients with anaphylaxis, whereas the literature results were lower (19).

The average professional experience of participants who knew adrenaline was a first-line drug in the treatment of anaphylaxis and could administer adrenaline by correct route and location was significantly lower in our study. This may be the result of more recent and up-to-date education for younger physicians. Additionally, the former recommendation of subcutaneous administration of adrenaline in the treatment of anaphylaxis may have an impact on the less accurate knowledge of senior physicians regarding the correct administration route. The research proposes that at any age, adrenaline reaches the maximal plasma concentration when administered IM rather than SC route (24,25). Thus, adrenaline is recommended to be administered to the lateral thigh by the IM route according to current guidelines (1,26). Another study on family physicians in our country found significantly higher rates of knowledge of the correct route and site of administration of adrenaline in the group with less professional experience, whereas no significant difference was determined for the knowledge of adrenaline as first-line treatment (9). In another study including general practitioners, no difference was demonstrated accordingthe general practitioners no difference according to professional experience in terms of knowledge of adrenaline as a first-line treatment and its proper route of administration (10). On the contrary, in a comprehensive survey conducted on healthcare professionals in Mexico, the most correct answers were among those with professional experience over 30 years (19).

Anaphylaxis is a recurring condition, so AAI must be prescribed to those that experience anaphylaxis, and they should be trained on how to use it. Healthcare professionals who care for patients at risk of anaphylaxis should also be educated on the use of AAI. Half of the family physicians in our study stated that they knew how to use and obtain adrenaline auto-injector and would prescribe it to patients with anaphylaxis. Nevertheless, only a quarter of the participants had undergone training on the use of adrenaline auto-injector. Our survey was conducted online and was based on the statements of the physicians; their proficiency could not be evaluated. Therefore, comparisons with other studies are not applicable. Knowledge regarding the correct use of AAI was found to be inconclusive in studies conducted on healthcare professionals working in primary, secondary, or tertiary healthcare centers in our country and worldwide (27-30). The rate of prescribing adrenaline to patients who develop anaphylaxis has increased over time (31) but is still insufficient (32-35).

### Factors Affecting the Knowledge of Family Physicians About Anaphylaxis Diagnosis, Treatment, and AAI

In our survey, the rate of knowledge of adrenaline as the first-line treatment in anaphylaxis, the correct route and site of administration of adrenaline, the use of adrenaline auto-injector, and how to obtain it was higher among family physicians who had undergone training on anaphylaxis during residency and after graduation. This finding clearly indicates the need for post-graduate education programs on anaphylaxis to allow physicians to update their knowledge. Less than half of our participants had undergone postgraduate education on anaphylaxis. This

is considered inadequate. When the proficiency levels of those who underwent training and those who did not are compared, the necessity for periodic and comprehensive training for updating should be considered. In a similar study of different healthcare professionals, the ratio of family physicians to receive training on anaphylaxis was lower than that of other groups (12).

Most family physicians referred patients with anaphylaxis to pediatric or adult allergy and immunology clinics. The guidelines recommend the referral of patients with anaphylaxis to allergy and immunology specialists for confirmation of the suspected trigger, counseling on preventive measures, and use of allergen immunotherapy (i.e., bee venom) when necessary (1,26).

## CONCLUSION

The most significant outcome of our study is family physicians' knowledge of the diagnosis and treatment of anaphylaxis is higher when their training at medical faculty and residency is more recent and when they undergo post-graduate training. Therefore, in-service training programs may increase the competency of physicians in handling life-threatening anaphylaxis. The physicians' knowledge of adrenaline auto-injector treatment is inadequate. Family physicians should be trained on the use of this basic life-saving drug for those at risk of anaphylaxis.

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### ETHICS

**Ethics Committee Approval:** This study was approved by the Bezmialem Vakıf University Rectorate Non-Interventional Research Ethics Committee (approval number: 2021/173, date: 19.05.2021). The study was conducted according to the principles of the Declaration of Helsinki.

**Informed Consent:** Participants who provided consent answered the survey questions fully.

### Authorship Contributions

Surgical and Medical Practices: Concept: L.B., G.K.E., S.S.Ç., S.A., A.Ö., M.A.N., Design: L.B., G.K.E., S.S.Ç., S.A., A.Ö., M.A.N., Data Collection or Processing: L.B., M.Y., Analysis or Interpretation: L.B., A.T., Literature Search: L.B., Writing: L.B., M.Y.

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Research

# The Main Determinant of Operative Time in Diagnostic Lymphadenectomy: Lymph Node Depht

## Tanısal Lenfadenektomide Ameliyat Süresinin Ana Belirleyicisi: Lenf Nodu Derinliği

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## ABSTRACT

**Objective:** We evaluated patients who underwent excisional peripheral lymph node biopsy in terms of histopathologic findings, palpability of lymph nodes, incision depth, and surgery duration, together with demographic and clinical characteristics of the patients.

**Methods:** This prospective study was conducted over an 18-month period at a university research hospital. The total number of 42 patients who attended the oncologic surgery outpatient clinic for excisional lymph biopsy was included in the study.

**Results:** Reactive lymph nodes were found in most benign cases (n=15/25), but the most common malignancy in the malignant group was B-cell lymphoma (n=5/17). When the lymph node was clinically non-palpable and had a size of up to 3.5 cm, the incision was deeper ($p<0.05$).

**Conclusion:** It would be a useful approach to add the depth of peripheral lymph nodes to the ultrasound reports together with other necessary data to assist the surgeon so that the exact location of the node can be more precisely predicted, and unnecessary incision size, depth, elongation of the duration of the surgery, and complications can be avoided. Collaboration between the surgeon, radiologist, and pathologist is a very important corner stone not to underdiagnose a malignancy and to avoid complications.

**Keywords:** Lymphadenopathy, complications, biopsy, surgical duration

## ÖZ

**Amaç:** Eksizyonel periferik lenf nodu biyopsisi yapılan hastalar histopatolojik bulgular, lenf nodlarının palpabilitesi, insizyon derinliği ve ameliyat süresi ile hastaların demografik ve klinik özellikleri açısından değerlendirildi.

**Gereç ve Yöntem:** Bu çalışma prospektif bir araştırma olarak tasarlanmış ve bir üniversite araştırma hastanesinde 18 aylık bir süre boyunca yürütülmüştür. Eksizyonel lenf biyopsisi için onkolojik cerrahi polikliniğine başvuran toplam 42 hasta çalışmaya dahil edildi.

**Bulgular:** Benign olguların çoğunda reaktif lenf nodları (n=15/25) saptanırken, malign grupta en sık görülen malignite B-hücreli lenfoma (n=5/17) idi. Klinik olarak palpe edilemeyen lenf nodu ve boyutu 3,5 cm'ye kadar olan grupta insizyon daha derindi ($p<0,05$).

**Sonuç:** Cerraha yardımcı olmak için gerekli diğer verilerle birlikte ultrason raporlarına periferik lenf nodu derinliğinin eklenmesi çok yararlı bir yaklaşım olacaktır, böylece nodun tam yeri daha kesin olarak tahmin edilebilir ve gereksiz kesi boyutu, derinliği, ameliyat süresinin uzaması ve komplikasyonlardan kaçınılabilir. Cerrah, radyolog ve patoloğun işbirliği, bir maligniteye eksik tanı koymamak ve komplikasyonlardan kaçınmak için çok önemli bir köşe taşıdır.

**Anahtar Kelimeler:** Lenfadenopati, komplikasyonlar, biyopsi, ameliyat süresi

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## INTRODUCTION

Human secondary lymphoid organs consist of approximately six hundred lymph nodes, spleen, tonsils, adenoids, and Peyer's patches. These sites are tissues where B and T-cells interfere with antigens (1,2). More than one centimeter enlargement and changes in lymph node consistency are generally defined as lymphadenopathy (3,4). The most common location of lymphadenopathies is the head and neck region, followed by the inguinal region, and axilla. Nearly 25% of patients have generalized lymphadenopathies, which may be a sign of systemic and serious pathology (5). Reactive lymph node hyperplasia, lymphadenopathy due to infection (viral, bacterial, fungal or parasitic), granulomatous lymphadenitis, local or distant metastatic lymphadenopathies, and primary lymphoproliferative disorders, such as B-cell lymphoma and Hodgkin's lymphoma, are the most common clinical manifestations of peripheral lymphadenopathy. All peripheral lymphadenopathies should be evaluated carefully not to under diagnose a malignant disease. Patient history, physical examination, laboratory test, and radiologic imaging results should be requested. The characteristics of swollen lymph nodes often provide valuable clues about the nature of the underlying diseases. Acute, painful, and soft lymphadenopathy is a common sign of localized or systemic infection. In cases of elastic, conglomerated, and painless enlarged lymph nodes, primary lymphomas should be suspected. Metastatic peripheral lymphadenopathies are usually hard in texture and generally painless, and are attached to surrounding tissues. When the specific cause of the peripheral lymph congestion is not determined, excisional peripheral lymph node biopsy should be executed. Although this approach is the most reliable method for diagnosing underlying diseases, the excision procedure is inconvenient, time-consuming, and difficult for patients (6). In a retrospective study, excisional peripheral lymph node biopsies in the cervical area were regarded as unnecessary because 45% of the cases were benign (7).

New approaches are being developed regarding the use of molecular and serologic markers, as well as advanced imaging methods, such as ultrasound and computed tomography, in the diagnosis of peripheral lymph node pathologies. With the increase in technological and interventional opportunities, the use of less invasive methods, such as fine-needle aspiration biopsy and ultrasound-guided fine-needle aspiration biopsy, compared with excisional biopsy has been brought to the agenda. However, there is no consensus on a diagnostic method that can be used in place of the reliability of excisional biopsy and its ability to guide correct diagnosis among clinicians and clinical guidelines (6).

In this research article, we evaluated patients who underwent excisional peripheral lymph node biopsy in terms of histopathologic findings, palpability of the lymph nodes, incision depth, and surgery duration, together with demographic and clinical characteristics of the patients.

## METHODS

The data for this study were prospectively collected over an 18-month period between September 2021 and May 2023 at a university research hospital and evaluated retrospectively. This research was carried out in accordance with the Principles of the Declaration of Helsinki. This study was approved by Sakarya University Faculty of Medicine Non-Invasive Ethics Committee (no: E-71522473-050.01.04-241712-159, date: 02.05.2023). Patients attending an oncologic surgery outpatient clinic for excisional lymph biopsy were included in the study. Demographic and clinical data of the patients together with comorbidities such as smoking and diabetes mellitus were questioned. Lymph node location, surgical duration, and incision depth were recorded during the excision procedure. All surgical procedures were performed by one surgeon. In all cases, peripheral lymph node excision was performed under local anaesthesia. Histopathological reports of the lymph nodes were also examined.

### Statistical Analysis

Data were analyzed using SPSS version 26 (IBM Corporation). The descriptive statistics on the distribution of responses to independent variables are presented as numbers and percentages for categorical variables and mean, standard deviation, and median for numerical variables. The conformity of continuous variables to the normal distribution assumption was evaluated by Kolmogorov-Smirnov test. For binary and multiple comparisons, the chi-square test, Fisher's Exact test for categorical variables, One-Way ANOVA test or Kruskal-Wallis method for quantitative variables were used. The results were interpreted as significant when $p<0.05$ with 95% confidence interval.

## RESULTS

A total of 42 patients were included in the study, including 19 (45.2%) females and 23 (54.8%) males. The mean age of the patients was 53.7±16.8 years, Palpable lymph nodes were detected in 19 (45.2%) of the patients. When the characteristics of peripheral lymph nodes and surgery were examined; the mean diameter of the lymph node was

2.61±1.14 cm, the mean incision size was 3.95±1.29 cm, the mean depth of the incision was 4.27±1.45 cm. and the mean operation time was 34.48±11.25 minutes. The peripheral lymph nodes were mostly located in the inguinal region in 18 (42.9%) and in the axillary region in 18 (42.9%) of the patients (Table 1).

Histopathological examination revealed that 17 (40.5%) patients had malignancies. The most relevant comorbidities were diabetes mellitus 11 (26.2%) and smoking 11 (26.2%). In addition, complications developed in 8 (19.0%). All demographic, clinical, and surgical data are presented in Table 1. Reactive lymph nodes (n=15) were identified in most benign cases (n=25), whereas B-cell lymphoma (n=5) was a common malignancy (n=17) in the malign group of patients (Table 2).

Comparison of the depth of the incision applied to the patients during surgery with the demographic and clinical characteristics of the patients is presented in Table 3. The incision depths of female patients were deeper than that of male patients, but the differences were not significant. Interestingly, statistical analyses yielded that the incision depth was significantly different in patients between the

**Table 1.** Demographic and clinical characteristics of patients (n=42)

| | | | |
|---|---|---|---|
| **Age** | | 53.69±16.78 (min-max: 19-91) | |
| Body mass index (kg/cm$^2$) | | 23.76±1.96 (min-max: 19-28) | |
| Lymph node diameter (cm) | | 2.61±1.14 (min-max: 1-6) | |
| Duration of surgery (min) | | 34.48±11.25 (min-max: 17-52) | |
| Length of incision (cm) | | 3.95±1.29 (min-max: 2-6.3) | |
| Depth of incision (cm) | | 4.27±1.45 (min-max: 2.3-6.5) | |
| | | **n** | **%** |
| **Gender, (n, %)** | Female | 19 | 45.2 |
| | Male | 23 | 54.8 |
| **Age group, (n, %)** | 18-50 years | 17 | 40.5 |
| | 51 years and older | 25 | 59.5 |
| **Excision area (n, %)** | Neck | 6 | 14.3 |
| | Axilla | 18 | 42.9 |
| | Inguinal | 18 | 42.9 |
| **Lymp node location(s) (n, %)** | Neck | 5 | 11.9 |
| | Axilla + inguinal | 8 | 19.0 |
| | Inguinal | 7 | 16.7 |
| | Neck + axilla + inguinal | 12 | 28.6 |
| | Axilla + inguinal | 6 | 14.3 |
| | Neck + axilla | 1 | 2.4 |
| | Neck + inguinal | 3 | 7.1 |
| **Palpabl, (n, %)** | Yes | 19 | 45.2 |
| | No | 23 | 54.8 |
| **Lymph node size (cm), (n, %)** | 0-3.5 cm | 36 | 85.7 |
| | 3.6 and above | 6 | 14.3 |
| **Malignancy, (n, %)** | Yes | 17 | 40.5 |
| | No | 25 | 59.5 |
| **Diabetes mellitus (n, %)** | Yes | 11 | 26.2 |
| | No | 31 | 73.8 |
| **Smoking frequency (n, %)** | Where | 11 | 26.2 |
| | No | 31 | 73.8 |
| **Complication(s), (n, %)** | Yes | 8 | 19.0 |
| | No | 34 | 81.0 |

Min-max: Minimum-maximum

**Table 2.** Histopathological results of the excised lymph nodes

| Histopathology | | n | % |
|---|---|---|---|
| **Malign n=17, 40.5%** | B-cell lymphoma | 5 | 11.9 |
| | Hodkin lymphoma | 4 | 9.5 |
| | Follicular lymphoma | 3 | 7.1 |
| | Mantle cell lymphoma | 2 | 4.8 |
| | High grade prostate adeno Ca | 1 | 2.4 |
| | Marginal zone lymphoma | 1 | 2.4 |
| | Urothelial carcinoma metastasis | 1 | 2.4 |
| **Benign n=25, 59.5%** | Reactive lymph node | 15 | 35.8 |
| | Follicular hyperplasia | 2 | 4.8 |
| | Chronic lymphadenitis | 2 | 4.8 |
| | Dermatopathic lymphadenopathy | 1 | 2.4 |
| | Granulomatous lymphadenitis | 1 | 2.4 |
| | Caseous granuloma | 1 | 2.4 |
| | Necrotizing granulomatous lymphadenitis | 1 | 2.4 |
| | Non-necrotizing granulumatous lymphadenitis | 1 | 2.4 |
| | Non-specific | 1 | 2.4 |

Ca: Cancer

**Table 3.** Comparison of the demographic and clinical characteristics of patients with incision depth

| | | Incision depth (avg ± std) | p-value |
|---|---|---|---|
| **Gender** | Woman | 4.37±1.5 | 0.698 |
| | Male | 4.19±1.39 | |
| **Age (years)** | 18-50 | 4.83±1.45 | **0.048** |
| | 51 years and over | 4.02±1.42 | |
| **Body mass index** | | 23.76±1.96 | 0.232 |
| **Excision area** | Neck | 3.58±1.26 | **0.035** |
| | Axilla | 3.88±1.41 | p<0.001 |
| | Inguina | 4.89±1.36 | **0.044** |
| **Lymph node size (cm)** | 0-3.5 cm | 4.43±1.46 | **0.043** |
| | 3.6 and above | 3.85±1.45 | |
| **Palpability** | Palpable | 2.76±0.58 | **<0.001** |
| | Non-palpable | 5.52±0.47 | |
| **Incision length (cm)** | | 3.95±1.29 | **<0.001** |
| **Duration of surgery (min)** | | 34.48±11.25 | **<0.001** |
| **Malignancy** | Yes | 3.89±1.45 | 0.066 |
| | No | 4.53±1.41 | |
| **Diabetes mellitus** | Yes | 4.49±1.46 | 0.565 |
| | No | 4.19±1.45 | |
| **Smoking** | Yes | 4.87±1.22 | 0.052 |
| | No | 4.05±1.48 | |
| **Complication(s)** | Yes | 5.47±0.35 | **0.008** |
| | No | 3.99±1.47 | |

Avg ± std: Average ± standard

ages of 18-50, patients with peripheral lymph nodes mostly located in the neck area. It was clearly observed that patients with greater incision depth were more likely to develop complications (p<0.008). One of the most remarkable findings was that when the lymph node was clinically non-palpable and its size was up to 3.5 cm, the incision was deeper (p<0.001). In addition, statistically significant differences were found between the incision depth, the size of the incision and the duration of the surgery (p<0.05).

The palpability of peripheral lymph nodes was compared with the demographic and clinical characteristics of the patients (Table 4). When the lymph node was nonpalpable, the lymph node size was smaller as expected (p=0.043). It was also clearly determined that the duration of the surgery, depth of the incision, and size of the incision were significantly associated with nonpalpable lymph nodes (p<0.001).

The comparison of the presence of malignancy in peripheral lymph nodes with the demographic and clinical characteristics of the patients were given in Table 5. The mean age of the malign patients was 60.82±17.43 years (p<0.021) and patients who were older than 51 years had significantly more malign cases compared to the younger age group (p<0.013). In malign lymph nodes, the node diameter was larger (p<0.03).

**Table 4.** Comparison of the demographic and clinical characteristics of patients with the palpability of the lymph nodes

| | | Non-palpable | Palpable | |
|---|---|---|---|---|
| | | n (%) | n (%) | p-value |
| **Gender** | Woman | 10 (23.81) | 9 (21.43) | 0.523 |
| | Male | 13 (30.95) | 10 (23.81) | |
| **Age (years)** | | 52.53±19.89 | 55.11±12.43 | 0.626 |
| **Age group** | 18-50 | 11 (26.19) | 6 (14.29) | 0.227 |
| | 51 years and over | 12 (28.57) | 13 (30.95) | |
| **Body mass index** | | 23.48±2.35 | 24.11±1.33 | 0.308 |
| **Excision area** | Neck | 3 (7.14) | 3 (7.14) | 0.129 |
| | Axilla | 7 (16.67) | 11 (26.19) | |
| | Inguinal | 13 (30.95) | 5 (11.90) | |
| **Lymp node location(s)** | Neck | 3 (7.14) | 2 (4.76) | 0.783 |
| | Axilla | 4 (9.52) | 4 (9.52) | |
| | Inguinal | 5 (11.90) | 2 (4.76) | |
| | Neck + axilla + inguinal | 5 (11.90) | 7 (16.67) | |
| | Axilla + inguinal | 4 (9.52) | 2 (4.76) | |
| | Neck + axilla | 0 (0.00) | 1 (2.38) | |
| | Neck + inguinal | 2 (4.76) | 1 (2.38) | |
| **Lymph node diameter (cm)** | | 2.41±0.89 | 2.86±1.39 | 0.123 |
| **Lymph node size (cm)** | 0-3.5 cm | 21 (50.00) | 15 (35.71) | **0.043** |
| | 3.6 and above | 2 (4.76) | 4 (9.52) | |
| **Duration of surgery (min)** | | 44.09±3.93 | 24.84±2.89 | **<0.001** |
| **Depth** | | 5.52±0.47 | 2.76±0.58 | **<0.001** |
| **Incision (cm)** | | 5.03±0.55 | 2.66±0.44 | **<0.001** |
| **Malignancy** | Yes | 7 (16.67) | 10 (23.81) | 0.152 |
| | No | 16 (38.10) | 9 (21.43) | |
| **Diabetes mellitus** | Yes | 7 (16.67) | 4 (9.52) | 0.051 |
| | No | 16 (38.10) | 15 (35.71) | |
| **Smoking** | Yes | 9 (21.43) | 2 (4.76) | **0.038** |
| | No | 14 (33.33) | 17 (40.48) | |
| **Complication(s)** | Yes | 8 (2.38) | 1 (2.38) | **0.004** |
| | No | 15 (35.71) | 18 (42.86) | |

**Table 5.** Comparison of demographic and clinical characteristics between patients with and without histopathological results

| | | Benign | Malign | p-value |
|---|---|---|---|---|
| | | n (%) | n (%) | |
| **Gender** | Woman | 13 (30.95) | 6 (14.29) | 0.227 |
| | Male | 12 (28.57) | 11 (26.19) | |
| **Age (years)** | | 48.84±14.78 | 60.82±17.43 | **0.021** |
| **Age group** | 18-50 | 13 (30.95) | 4 (9.52) | **0.013** |
| | 51 years and over | 12 (28.57) | 13 (30.95) | |
| **Body mass index** | | 23.68±2.04 | 23.88±1.91 | 0.747 |
| **Excision area** | Neck | 3 (7.14) | 3 (7.14) | 0.696 |
| | Axilla | 12 (28.57) | 6 (14.29) | |
| | Inguinal | 10 (23.81) | 8 (19.05) | |
| **Lymp node location(s)** | Neck | 3 (7.14) | 2 (4.76) | 0.388 |
| | Axilla | 6 (14.29) | 2 (4.76) | |
| | Inguinal | 4 (9.52) | 3 (7.14) | |
| | Neck + axilla + inguinal | 7 (16.67) | 5 (11.90) | |
| | Axilla + inguinal | 3 (7.14) | 3 (7.14) | |
| | Neck + axilla | 0 (0.00) | 1 (2.38) | |
| | Neck + inguinal | 2 (4.76) | 1 (2.38) | |
| **Lymph node diameter (cm)** | | 2.30±0.88 | 3.09±1.36 | **0.030** |
| **Palpability** | No | 16 (38.10) | 7 (16.67) | 0.152 |
| | There is | 9 (21.43) | 10 (23.81) | |
| **Lymph node size (cm)** | 0-3.5 cm | 23 (54.76) | 13 (30.95) | 0.168 |
| | 3.6 and above | 2 (4.76) | 4 (9.52) | |
| **Duration of surgery (min)** | | 36.52±10.61 | 31.47±11.80 | 0.056 |
| **Depth** | | 4.53±1.41 | 3.89±1.45 | 0.066 |
| **Incision (cm)** | | 4.14±1.29 | 3.69±1.27 | 0.275 |
| **Diabetes mellitus** | Yes | 8 (19.05) | 3 (7.14) | 0.061 |
| | No | 17 (40.48) | 14 (33.33) | |
| **Smoking** | Yes | 4 (9.52) | 7 (16.67) | **0.041** |
| | No | 21 (50.00) | 10 (23.81) | |
| **Complications** | Yes | 7 (16.67) | 1 (2.38) | **0.044** |
| | No | 18 (42.86) | 16 (38.10) | |

## DISCUSSION

Peripheral lymphadenopathies can be classified as localized or generalized (swollen lymph nodes in more than one region). Generalized lymphadenopathies are almost always a sign of serious systemic disease. Diagnostic difficulties are usually observed in localized lymphadenopathies (3,8). Excisional peripheral lymph node biopsy is generally indicated for situations such as the presence of unexplained localized or generalized lymphadenopathies and persistent lymphadenopathy despite antibiotic treatment at the end of 3-4 weeks follow-up period (8,9). Although many studies have tried to develop algorithms that use excisional biopsy as the last option and highlight other diagnostic methods, no consensus has yet been reached on this issue. Histopathologic evaluation provides important data about the importance of cautious evaluation of peripheral lymphadenopathies. In our patients, malignant cases constituted approximately 40% of the cases, with B-cell lymphoma being the most common malignancy. Gül et al. (9) evaluated 67 excisional peripheral lymph node biopsy cases and reported that the number of malignant cases was 34%.

Fine-needle aspiration biopsy guided by ultrasound provides promising results. The use of immunohistochemical methods and molecular techniques leads to more accurate and specific results for the histopathological evaluation

of fine-needle aspiration biopsy samples (10). It has been reported that the sensitivity and specificity of fine-needle aspiration is between 85-95% and 98-100%, respectively (11,12). Although fine-needle aspiration seems reliable, malignant cases can be missed in cases of heterogeneity and early or partial sampling of the lymph nodes (8). Fine-needle aspiration biopsy may be useful in differentiating between benign and malignant tumors, but diagnosis insufficiency is frequently encountered. In addition, excisional biopsy is required for definitive diagnosis of lymphoma. Therefore, excisional biopsy has been indicated as the "gold standard" in the diagnosis of lymphadenopathy (7,9,13).

Excisional biopsy is a diagnostic method that can be performed safely with minimal morbidity and mortality (7). However, surgical complications are still possible. Therefore, excisional peripheral lymph node biopsy maintains its diagnostic validity even when used in unnecessary situations (3,8,10). We determined that approximately 20% of our patients developed surgical complications associated with increased incision depth and nonpalpable lymph nodes. Furthermore, as previously revealed, elongation of the surgical duration increases the risk of surgical site infections (14). In our research, we found that the presence of non-palpable lymph nodes was related to the prolonged duration of the surgery, increased size and depth of the incision, and which, in turn, resulted in complications. It would be a useful approach to add the depth of peripheral lymph nodes to the ultrasound reports together with other necessary data to assist the surgeon so that the exact location of the node can be more precisely predicted, and unnecessary incision size, depth, elongation of the duration of the surgery, and complications can be avoided. When lymph nodes are nonpalpable and small in diameter, wire marking can be a useful method to reduce complications. The use of methylene blue, indocyanine green, or tatoo may help shorten the operating time under ultrasound guidance, especially for less experienced surgeons. As a limitation, the data would be more expensive if this research were performed with a larger sample group. Another limitation of this study was that a comparison of wire-marked lymph node excision with regular excision was not performed.

## CONCLUSION

Peripheral lymphadenopathy requires very careful evaluation of patient. Collaboration between the surgeon, radiologist, and pathologist is a very important corner stone not to underdiagnose a malignancy and to avoid complications.

### ETHICS

**Ethics Committee Approval:** This study was approved by Sakarya University Faculty of Medicine Non-Invasive Ethics Committee (no: E-71522473-050.01.04-241712-159, date: 02.05.2023).

**Informed Consent:** Retrospective study.

### Authorship Contributions

Surgical and Medical Practices: A.Ş., F.M., Concept: A.Ş., F.M., Design: A.Ş., F.M., Data Collection or Processing: A.Ş., F.M., Analysis or Interpretation: A.Ş., F.M., Literature Search: A.Ş., F.M., Writing: A.Ş., F.M.

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

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Research

# Is the Treatment of Persistent Idiopathic Coccydynia a Nightmare?

## İnatçı İdiyopatik Koksidininin Tedavisi Bir Kabus mu?

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## ABSTRACT

**Objective:** This study aimed to assess the outcomes of total coccygectomy compared with steroid injection and rectal manipulation in patients with persistent idiopathic coccydynia.

**Methods:** This retrospective study analyzed patients who underwent either total coccygectomy or rectal manipulation with fluoroscopy-guided steroid injection between 2018 and 2021 at two medical centers. The patients were divided into two groups: Group A, consisting of 13 patients who underwent total coccygectomy, and group B, consisting of 16 patients who received rectal manipulation and fluoroscopy-guided steroid injection.

**Results:** There were no significant differences in visual analog scale (VAS) scores between the groups before treatment. However, 10 days after treatment, group B exhibited a significantly lower VAS score [1 (0-4)] than group A [3.7 (2-7)]. There were no significant differences in VAS scores between group A and group B at the one-month, three-month, and six-month follow-up assessments after treatment.

**Conclusion:** Total coccygectomy and steroid injection with rectal manipulation are effective treatment options for idiopathic coccydynia.

**Keywords:** Coccyx, injection, resection, manipulation, outcome

## ÖZ

**Amaç:** Bu çalışmanın amacı, persistan idiyopatik koksidini olgularında total koksigektominin sonuçlarını steroid enjeksiyonu ve rektal manipülasyon tedavisiyle karşılaştırarak değerlendirmektir.

**Gereç ve Yöntem:** Bu retrospektif çalışmada, 2018 ve 2021 yılları arasında iki tıp merkezinde total koksigektomi veya floroskopi kılavuzluğunda steroid enjeksiyonu ile rektal manipülasyon uygulanan hastalar analiz edildi. Hastalar, total koksigektomi uygulanan 13 hastadan oluşan grup A ve rektal manipülasyon ile floroskopi kılavuzluğunda steroid enjeksiyonu uygulanan 16 hastadan oluşan grup B olmak üzere iki gruba ayrıldı.

**Bulgular:** Tedavi öncesinde gruplar arasında görsel analog skala (VAS) skorlarında istatistiksel olarak anlamlı fark yoktu. Bununla birlikte, tedaviden on gün sonra, grup B, grup A'ya [3,7 (2-7)] kıyasla önemli ölçüde daha düşük bir VAS skoru [1 (0-4)] sergiledi. Tedavi sonrası bir aylık, üç aylık ve altı aylık takip değerlendirmelerinde grup A ve grup B arasında VAS skorlarında anlamlı fark yoktu.

**Sonuç:** Total koksijektomi ve rektal manipülasyon ile beraber steroid enjeksiyonu, idiyopatik koksidini için etkili tedavi seçenekleridir.

**Anahtar Kelimeler:** Kuyruk sokumu, enjeksiyon, rezeksiyon, manipülasyon, sonuç

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## INTRODUCTION

The coccyx, also known as the tailbone, is the most distal part of the vertebral column. Pain in this region is commonly referred to as coccydynia or coccygodynia (1,2). Typically occurs as a result of direct axial trauma to the tailbone, such as during a fall (3). Differential diagnoses include abnormal mobility with postural changes, difficult childbirth, chordoma or intradural tumors, pilonidal cyst, adjacent organ pathologies, and lumbar stenosis. Idiopathic coccydynia accounts for approximately one-third of all cases (4), and the cause of this condition cannot be identified. The underlying causes of coccydynia can be attributed to localized pressure on the prominent coccyx or inflammation of the ligaments attached to the coccyx (5). Although coccydynia can affect individuals of all ages, it is more commonly observed in women than men (6).

Conservative treatment is typically the initial approach for coccydynia, with non-surgical interventions being utilized in approximately 90% of cases (7). Various treatment options are available, including the use of orthopedic ring cushions, anti-inflammatory medications, hot water baths, local anesthetic or steroid injections, extracorporeal shock wave therapy (ESWT), and ganglion impar blocks. These interventions aim to alleviate symptoms and provide relief for patients with coccydynia.

Persistent coccydynia poses a challenge for clinicians because conservative methods can sometimes be ineffective. Orthopedists generally avoid surgery on the coccyx for two primary reasons. First, the area is susceptible to infection. Second, there is no consensus regarding the preferred surgical technique. However, the combined technique described by Seker et al. (8), involving rectal manipulation and fluoroscopy-guided steroid injection, has emerged as a safe and straightforward conservative treatment option.

This retrospective study included two groups of patients. The first group included individuals diagnosed with persistent idiopathic coccydynia who underwent total coccygectomy. The second group comprised patients who received treatment through rectal manipulation and fluoroscopy-guided steroid injection. This study aimed to compare the clinical outcomes between the two groups and assess the effectiveness of the two treatment methods. The hypothesis of the study was that total coccygectomy would yield clinical outcomes comparable to or better than those achieved through rectal manipulation and fluoroscopy-guided steroid injection.

## METHODS

This retrospective study analyzed patients who underwent total coccygectomy or rectal manipulation with fluoroscopy-guided steroid injection between 2018 and 2021 at two medical centers. The inclusion criteria for the study were as follows; absence of known direct etiological factors for pain, such as trauma, disc disease, postpartum pain, infection, or neoplastic processes; history of chronic coccydynia lasting for more than six months, and irresponsive to conservative treatment, which included non-steroidal anti-inflammatory drugs (NSAIDs), cushion use, and ESWT. A total of 29 patients met the inclusion criteria. The study was approved Erzurum Governorship Provincial Health Directorate Erzurum Regional Training and Research Hospital Ethics Committee (decision no: 2021/04-64, date: 15.02.2021), and informed consent was obtained from patients who agreed to participate.

The patients were categorized into two groups: Group A (n=13) underwent total coccygectomy at center 1 and group B (n=16) received a combination of rectal manipulation with fluoroscopy-guided steroid injection at center 2. The total coccygectomy procedures in group A were performed by the same surgical team using the method described by Key and Missouri (9), and all patients received spinal anesthesia. The rectal manipulation and fluoroscopy-guided steroid injection procedures in group B were also conducted by the same team at center 2, with all patients receiving sedative anesthesia.

In this retrospective study, it has been conducted an evaluation and comparison of the effectiveness of the two treatment modalities. Visual analog scale (VAS) scores were recorded at various time points, including before the procedure and during post-procedure follow-up visits at the $10^{th}$, $1^{st}$, $3^{rd}$, and $6^{th}$ month.

### Surgical Procedure

During the procedure, the patient was positioned in the prone position. A midline longitudinal incision, approximately 5 cm in length, was made in the sacrococcygeal region. Subsequently, electrocautery was used to subperiosteally expose the distal sacrum and coccyx. The entire coccyx was surgically removed. The surgical site was thoroughly irrigated with pulsatile lavage using normal saline solution (3L). The different tissue layers were closed in anatomical order. A waterproof adhesive dressing was applied to protect the wound. Cefazolin was administered preoperatively in a prophylactic manner. Patients allergic to penicillin received clindamycin antibiotic therapy, which was

adjusted according to body weight. During surgery, patients use orthopedic ring cushions until the sutures are removed, which typically occurs 3 weeks after the surgery.

### Rectal Manipulation and Fluoroscopy-guided Steroid Injection

The patients underwent the combined manipulation technique while under sedative anesthesia, positioned in the lateral decubitus position. This procedure involved several steps. First, the anterior coccygeal region of the levator ani muscle was massaged for a duration of 3 min, following the technique proposed by Thiele (10). Subsequently, the coccyx was subjected to repetitive movements for 1 min to stretch it. Finally, the coccyx was mobilized according to the method described by Maigne (11) and held in a hyperextended position for 1 min.

After manipulation, a 10-cc solution was prepared under fluoroscopic guidance. The solution consisted of 1 cc (40 mg) of methylprednisolone acetate, 3 cc (60 mg) of prilocaine hydrochloride, and 6 cc (30 mg) of bupivacaine hydrochloride. A 10% portion of the solution (1 cc) was injected into the sacrococcygeal joint, while the remaining solution was injected into the soft tissues at the back of the coccyx.

After the procedure, patients were placed on orthopedic ring cushions for a period of 3 weeks.

### Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL, USA) at a significance level of 0.05. Mean and standard deviation were used for descriptive statistics. The Shapiro-Wilk test was used to test normality. The groups were compared using the Mann-Whitney U test.

## RESULTS

The sample consisted of 29 patients. Group A consisted of 13 patients (eight women and five men). Group B consisted of 16 patients (ten women and six men). Group A had a median age of 44 [minimum (min): 21-maximum (max): 67)]. Group B had a median age of 41.5 (min: 23-max: 71). The two groups were similar in terms of demographic characteristics (Table 1).

Groups A and B had mean preoperative VAS scores of 5.1 (range 3-8) and 5.1 (range 2-8), respectively. There were no significant differences in VAS scores between the groups. Group B had a significantly lower VAS score [1 (0-4)] than group A [3.7 (2-7)] 10 days after treatment (p=0.0007).

There was no significant difference in VAS scores between group A [1.9 (range 0-5)] and group B [1.3 (0-3)] one month after treatment. There was no significant difference in VAS scores between group A [0.5 (range 0-2)] and group B [0.8 (range 0-3)] three months after treatment. There was no significant difference in VAS scores between group A [0.1 (range 0-1)] and group B [0.5 (range 0-2)] six months after treatment (Table 2).

## DISCUSSION

The results showed that rectal manipulation with fluoroscopy-guided steroid injection and total coccygectomy had similar clinical outcomes.

There are various conservative treatment options for coccydynia, which depend on factors such as the physician's expertise, pain severity, and duration of symptoms. These options include oral NSAIDs and different physical therapy techniques. Most patients with coccydynia are initially treated conservatively. However, if pain persists despite conservative treatment, surgical resection may be necessary. It has been reported that the success rate of coccygectomy

**Table 1.** Demographic characteristics

| | Group A | Group B | p-value |
|---|---|---|---|
| **Age median (range)** | 44 (21-67) | 41.5 (23-71) | 0.759 |
| **Gender (N)** | | | |
| Male | 5 | 6 | 0.958 |
| Female | 8 | 10 | |

**Table 2.** Comparison of visual analog scale scores

| | Group A Mean (SD) | Group B Mean (SD) | p-value |
|---|---|---|---|
| **Pretreatment VAS score** | 5.1 (1.3) | 5.1 (1.6) | 0.946 |
| **Posttreatment VAS score** | | | |
| 10$^{th}$ day | 3.7 (1.2) | 1 (1.2) | 0.0007 |
| 1$^{st}$ month | 1.9 (1.1) | 1.3 (0.9) | 0.2 |
| 3$^{rd}$ month | 0.5 (0.6) | 0.8 (0.8) | 0.17 |
| 6$^{th}$ month | 0.1 (0.3) | 0.5 (0.8) | 0.06 |

VAS: Visual analog scale, SD: Standard deviation

ranges from 54% to 100% (12,13). In this study, we found that total coccygectomy (group A) was a success rate of 69.2%.

Numerous post-coccygectomy complications, such as superficial tissue infections and wound healing problems (14). In this study, superficial wound infections were observed in four patients from group A (total coccygectomy). However, these complications have been effectively managed through the use of oral antibiotics and regular dressing changes. There were no infections in group B. Although coccygectomy may seem like a simple procedure, the potential complications can make orthopedic surgeons hesitate to perform surgical interventions in patients with persistent coccydynia. Furthermore, surgery is a tendency in cases of idiopathic coccydynia. As a result, there has been a growing focus on nonsurgical treatment methods among researchers in this field in recent years.

Patel et al. (3) conducted a study that highlighted the significance of spasticity on pelvic floor muscles in patients with coccydynia. They demonstrated that local massage can alleviate tonic spasm believed to be responsible for pain. Building on this concept, Seker et al. (8) combined three manual therapy methods proposed by Maigne and Chatellier (15) with steroid injection (11). They compared the clinical outcomes of this combined method with those of steroid injection alone. The results indicated that the proposed method had a more pronounced effect on reducing VAS scores. In our study, we also implemented the new combined method in group B patients.

In this study, it has been conducted that a comparison of VAS scores at various time points after treatment, including 10 days, 1 month, 3 months, and six months. It was found that 10 days after treatment, group B had significantly lower VAS scores compared to group A. In group A, there was a significant reduction in VAS scores after treatment compared with before treatment, which can be attributed to the healing of the soft tissues in the surgical area. However, one month, three months, and six months after treatment, there were no significant differences in VAS scores between groups A and B. Both treatment methods yielded satisfactory results in terms of pain reduction.

This study has several limitations that should be acknowledged. First, the study was conducted retrospectively, which may have introduced biases and limitations in data collection and analysis. Second, the sample size was small, which could have affected the generalizability of the findings. Third, the participants were recruited from only two medical centers, which might have influenced the objectivity of the study and limited the diversity of the patient population. However, considering that one-third of coccydynia cases are idiopathic, recruiting an adequate number of participants from a single center alone can be challenging. Additionally, it is worth noting that patients with persistent coccydynia and a high body mass index (BMI) have been reported to experience lower post-treatment satisfaction (16). Unfortunately, our study did not include a comparison of BMI between the two groups, which is a limitation that should be considered.

## CONCLUSION

Both total coccygectomy and steroid injection with rectal manipulation are effective treatment options for idiopathic coccydynia. However, according to the current study, steroid injection using rectal manual therapy may be a better treatment option because coccygectomy carries a substantial risk of infection.

### ETHICS

**Ethics Committee Approval:** The study was approved Erzurum Governorship Provincial Health Directorate Erzurum Regional Training and Research Hospital Ethics Committee (decision no: 2021/04-64, date: 15.02.2021).

**Informed Consent:** Informed consent was obtained from patients who agreed to participate.

### Authorship Contributions

Surgical and Medical Practices: E.Ş., M.C.T., Concept: M.N.T., M.C.T., Design: M.N.T., E.Ş., M.C.T., Data Collection or Processing: E.Ş., M.C.T., Analysis or Interpretation: M.N.T., Literature Search: M.N.T., E.Ş., Writing: M.N.T., E.Ş.

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

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Research

# Comprehensive Review of Cranial Cavernous Malformations: Results of a Single-center Study of 31 Cases

## Kraniyal Kavernöz Malformasyonlar Üzerine Kapsamlı Bir İnceleme: 31 Olguluk Tek Merkezli Bir Çalışmanın Sonuçları

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## ABSTRACT

**Objective:** To evaluate the demographic, clinical, radiological features, and surgical outcomes of 31 patients who underwent surgery for cranial cavernous malformations (CCM).

**Methods:** A retrospective analysis was conducted on 31 patients who underwent CCM between July 2020 and January 2024. Data included demographic and clinical, radiological, intraoperative, and histopathological findings, and postoperative complications. Detailed neurological examinations were performed before and after surgery. All patients underwent preoperative computed tomography and magnetic resonance imaging (MRI), and the lesions were evaluated using the Zabramski classification. Surgeries aimed at total resection using neuronavigation, intraoperative MRI, and ultrasonography when needed. The average follow-up duration was 25.3 months.

**Results:** Thirty-three transcranial microsurgical excisions were performed in 31 patients (48% male, 52% female; mean age 30.8 years). Lesions were most commonly parietal (39%) and frontal (26%). Clinical findings included epilepsy (62%), headache (20%), and focal neurological deficits (6%). According to Zabramski, 42% were type I, 52% were type II, and 6% were type III. Total excision was achieved in 94% of the patients, with 6% requiring a second operation. Postoperative seizures were absent in 74% of patients with epilepsy. The average length of hospital stay was 5.7 days, with no permanent neurological deterioration or mortality.

**Conclusion:** Surgical resection is effective for treating symptomatic CCM. Total resection cases should be closely monitored due to the risk of recurrence. A conservative approach is recommended for asymptomatic, deep-seated, or eloquent lesions, and radiosurgery is considered for high surgical risk cases. Multidisciplinary and personalized treatment protocols can improve outcomes in patients with CCM.

**Keywords:** Cavernoma, cavernous angioma, cavernous hemangioma, surgery, vascular malformation

## ÖZ

**Amaç:** Bu çalışmada, kraniyal kavernöz malformasyon (CCM) nedeniyle opere edilen 31 hastanın demografik, klinik, radyolojik özelliklerini ve cerrahi sonuçlarını değerlendirmek amaçlanmıştır.

**Gereç ve Yöntem:** Temmuz 2020 ve Ocak 2024 arasında CCM nedeniyle ameliyat edilen 31 hastanın yaş, cinsiyet, semptomlar, nörolojik bulgular, radyolojik veriler, intraoperatif ve histopatolojik bulgular, postoperatif komplikasyonlar ve takip sonuçları retrospektif olarak incelendi. Tüm hastalara preoperatif bilgisayarlı tomografi ve manyetik rezonans görüntüleme (MRG) yapıldı; lezyonlar Zabramski sınıflamasına göre değerlendirildi. Cerrahiler total rezeksiyon hedeflenerek yapıldı ve bazı olgularda nöronavigasyon, intraoperatif MRG ve ultrasonografi gibi yardımcı teknikler kullanıldı. Ortalama takip süresi 25,3 aydı.

**Bulgular:** Otuz bir hastaya 33 transkraniyal mikrocerrahi eksizyon uygulandı. Hastaların %48'i erkek, %52'si kadın olup, yaş ortalaması 30,8 idi. Lezyonlar en sık pariyetal (%39) ve frontal (%26) bölgelerdeydi. Klinik bulgular en sık epilepsi (%62), baş ağrısı (%20), fokal nörolojik defisit (%6) idi. Zabramski sınıflamasına göre %42 tip I, %52 tip II, %6 tip III olarak değerlendirildi. Yirmi dokuz hastada (%94) total eksizyon sağlandı.

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## ÖZ

Epilepsi hastalarının %74'ünde postoperatif nöbet görülmedi. Hastanede yatış süresi ortalama 5,7 gündü. Kalıcı nörolojik kötüleşme veya eksitus görülmedi.

**Sonuç:** Semptomatik CCM tedavisinde cerrahi rezeksiyon etkilidir. Total çıkarılamayan olgular yakın takip edilmelidir. Asemptomatik, derin veya eloquent bölge lezyonları için konservatif yaklaşım önerilirken, yüksek cerrahi risk durumlarında radyocerrahi düşünülebilir. Multidisipliner yaklaşımlar ve kişiye özel tedavi protokolleri, CCM hastalarının yaşam kalitesini ve prognozunu iyileştirebilir.


**Anahtar Kelimeler:** Kavernoma, kavernöz anjiyoma, kavernöz hemanjiyoma, cerrahi, vasküler malformasyon

## INTRODUCTION

Cavernous malformations, also known as cavernoma and cavernous hemangiomas, are well-demarcated, mulberry-like hamartomas typically located within cerebral hemispheres. These lesions lack intervening neural tissue and lack arteries and draining veins (1). The prevalence of cranial cavernous malformations (CCM) in the general population ranges from 0.4% to 0.8%, accounting for 10-25% of all vascular malformations (2).

Clinically, CCMs can present with hemorrhage, epilepsy, headache, focal neurological deficits, and, rarely, mass effects. However, 20-50% of cases remain asymptomatic and are incidentally detected during imaging studies. The symptoms and clinical findings vary according to the presence of hemorrhage, lesion size, and location. Although CCMs can occur in any part of the central nervous system, 70-80% are found supratentorially (3). These malformations can occur sporadically, be familial, or be induced by radiation. Familial forms typically present with multiple CCMs, whereas sporadic cases usually exhibit a single CCM (4). The standard treatment for CCMs is total resection via microsurgery; stereotactic radiosurgery is considered for cases unsuitable for surgery, and observation is preferred for asymptomatic cases (3).

The current study aimed to retrospectively evaluate the characteristics and surgical outcomes of 31 patients who underwent surgery for CCM.

## METHODS

In this study, we conducted a retrospective analysis of 31 patients who underwent surgery for CCM at our clinic between July 2020 and January 2024, with complete medical records available. Patients were followed for an average duration of 25.3 months (range: 3-47 months).

Patients were assessed according to demographic, clinical, and radiological characteristics. Data collected included age, sex, family history, presenting symptoms, neurological examination findings, preoperative and postoperative radiological findings, intraoperative findings, histopathological features, postoperative complications, and follow-up outcomes. Detailed neurological examinations were performed during preoperative and postoperative follow-ups, incorporating the Glasgow Coma scale, cranial nerve examinations, motor and sensory examinations, and the presence and frequency of seizures. All patients underwent preoperative cranial computed tomography (CT) and magnetic resonance imaging (MRI). Functional MRI was performed for CCMs located in eloquent cortical areas, such as the motor and speech regions (Figure 1). Radiological evaluations on CT included the presence of acute hemorrhage or calcification, whereas MRI assessments were based on the Zabramski classification (4), lesion size, and location (Figure 2).

All patients underwent their initial surgery. Surgical procedures aimed at total resection, including the hemosiderin ring, were performed under general anesthesia with antibiotic prophylaxis. Depending on lesion location and size, adjunctive techniques, such as neuronavigation, intraoperative MRI, and ultrasonography, were utilized in select cases. All surgical specimens underwent histopathological examination and were confirmed to be consistent with CCM. In the postoperative period, patients were evaluated with MRI to assess for residual lesions or hemorrhage.

This study was approved by University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee (decision no: 91, date: 14.02.2024), and all data were reviewed retrospectively.

### Statistical Analysis

Statistical analyses were performed using SPSS software.

## RESULTS

In total, 33 transcranial microsurgical excision procedures were performed in 31 patients with CCM. Fifteen patients (48%) were male, with a mean age of 30.8 years (range: 7-68 years). The most common presenting symptom was seizures (62%), with an average duration of symptom onset of 26.6 months. Lesions were most frequently located

in the parietal region (39%). In 3 patients (9.7%), cranial CT findings were normal, while 5 patients (16.1%) had acute hemorrhage, and 9 patients (29%) had calcifications (Figure 3A, B). Preoperative digital subtraction angiography was performed in 3 patients, all of which were negative. According to the Zabramski classification, the most common type was type II CCM (52%). Patient characteristics, clinical findings, lesion locations, and radiological features are summarized in Table 1.

Total excision was achieved in 29 patients (94%), while 2 patients (6%) with subtotal excision experienced hemorrhage at 4 and 6 months postoperatively, requiring reoperation. Total excision of the residual CCM was achieved in the second operation. Three patients (2 parietal, 1 temporal) developed facial paralysis in the postoperative period, which resolved during follow-up after discharge. One patient with a left parietal lesion developed a right lower extremity motor deficit (2/5 muscle strength) postoperatively, which resolved after 2 days. Another patient with a parietal lesion required evacuation of an epidural hematoma on the third postoperative day because of the development of a hematoma during craniotomy, but no permanent neurological deficit occurred. In a patient with an intraorbital lesion (Figure 3C, D), postoperative improvement in proptosis was observed. In a patient with a brainstem lesion case (Figure 3E, F), sixth cranial nerve paralysis persisted postoperatively, as did right hemiparesis in a patient with a parietal lesion. No new deficits were observed in other patients during the postoperative period. Among the 19 patients with drug-resistant epilepsy, 14 (74%) experienced no seizures postoperatively and 5 (26%) experienced a reduction in seizure frequency. The average length of hospital stay was 5.7 days. No patient experienced

**Table 1.** Patient characteristics, clinical findings, and radiological features

| Characteristics | Number of patients (%) |
|---|---|
| **Gender** | |
| Male | 15 (48%) |
| Female | 16 (52%) |
| **Clinical findings** | |
| Seizure | 19 (62%) |
| Headache | 6 (20%) |
| FND | 2 (6%) |
| Syncope | 2 (6%) |
| Sixth CN palsy | 1 (3%) |
| Proptosis | 1 (3%) |
| **Lesion localization** | |
| Frontal | 7 (23%) |
| Parietal | 12 (39%) |
| Temporal | 5 (16%) |
| Occipital | 2 (6.5%) |
| Third ventricle | 2 (6.5%) |
| Pons | 1 (3%) |
| Intraorbital | 1 (3%) |
| Multiple (frontal and parietal) | 1 (3%) |
| **Zabramski classification** | |
| Type I | 13 (42%) |
| Type II | 16 (52%) |
| Type III | 2 (6%) |

CN: Cranial nerve, FND: Focal neurological deficit

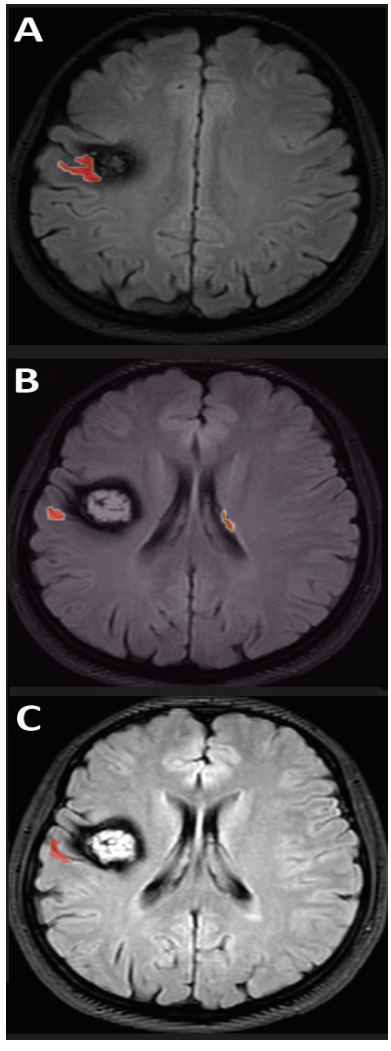


**Figure 1. A-C.** In case 29 from Table 2, preoperative functional magnetic resonance imaging axial sections revealed a lesion measuring 22x16x19 mm. The lesion was located less than 10 mm from the speech center and more than 10 mm from the motor centers for the left hand and left foot, respectively

permanent neurological deterioration or mortality. The demographic and clinical characteristics, radiological data, and surgical outcomes of the patients are presented in Table 2.

## DISCUSSION

CCMs are one of the four principal types of vascular malformations in the central nervous system, along with developmental venous anomalies (DVA), arteriovenous malformations, and capillary telangiectasias. They are the second most common vascular malformations associated with hemorrhage (5). The exact prevalence of CCMs is not well-defined due to their often asymptomatic nature; however, they are reported to occur in 0.4-0.8% of the general population (2). While CCMs were initially classified as rare, their detection has increased with the widespread use of MRI in neuroimaging studies (6). CCMs are dynamic lesions that can develop *de novo*, change in size, or remain stable over time (7). Patients are typically diagnosed between the second and fourth decades of life. The incidence is nearly equal between men and women; however, men aged 30 years tend to be more symptomatic, whereas women are more symptomatic between the ages of 30 and 60 years (1). In our study, the male-to-female ratio was nearly equal, with a mean age of 29.5 years for men and 32 years for women.

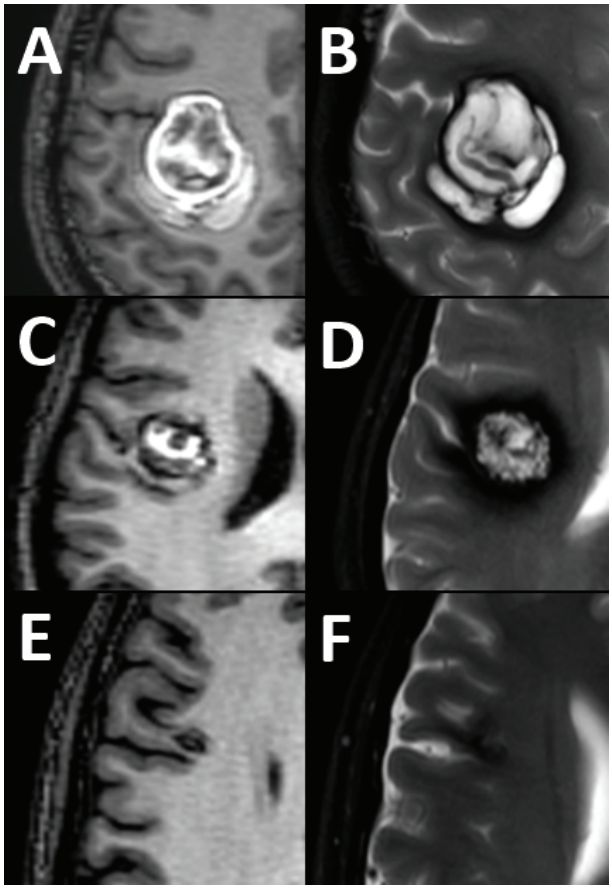


**Figure 2. A, B.** In case 3 from Table 2, preoperative magnetic resonance imaging axial sections, respectively in T1- and T2-weighted images, demonstrate a hyperintense type I cavernous malformation measuring 35x29x31 mm located in the right parietal region. **C, D**. In case 29 from Table 2, preoperative magnetic resonance imaging axial sections, respectively in T1- and T2-weighted images, depict a heterogeneously intense type II cavernous malformation with a "popcorn" appearance, measuring 22x16x19 mm in the right frontal region. **E, F.** In case 14, as shown in Table 2, preoperative magnetic resonance imaging axial sections, respectively, in T1- and T2-weighted images, revealed a hypointense type III cavernous malformation measuring 12x8x7 mm located in the right frontal region

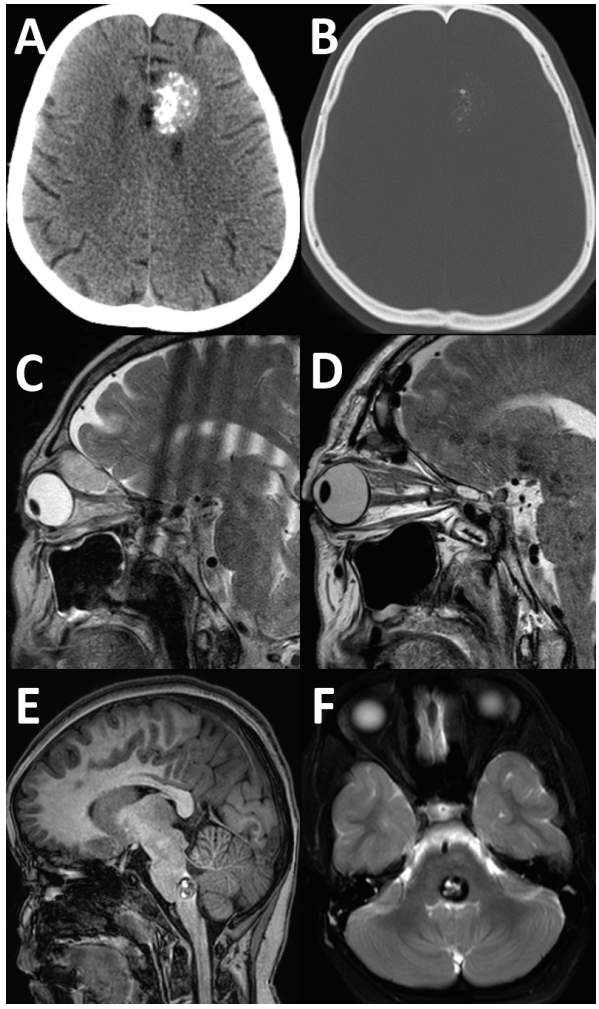


**Figure 3. A, B.** In case 5 from Table 2, preoperative computed tomography axial sections, respectively in parenchymal and bone window images, show a calcified lesion measuring 24x29x30 mm located subependymally in the right cerebral hemisphere's frontal lobe. **C, D.** In case 27 in Table 2, preoperative and postoperative T2-weighted magnetic resonance imaging sagittal sections, respectively, demonstrate a lesion measuring 25x18x12 mm with cerebrospinal fluid-equivalent hyperintensity that displaces the superior orbital muscle group laterally, causing exophthalmos, and show complete excision of the lesion. **E, F**. In case 25 from Table 2, preoperative T1-weighted sagittal and T2-weighted axial magnetic resonance imaging, respectively, demonstrate a lesion measuring 13x11x10 mm located posterior to the pontobulbar junction in the brainstem

**Table 2.** Demographics, clinical, and radiological characteristics and surgical outcomes of patients with cranial cavernous malformations

| Patient | Gender /age (years) | Localization | Symptom | Lesion size (mm) | Pre/postoperative GCS | Zabramski classification | Preoperative acute hemorrhage | Calcification on CT | Resection | Follow-up (month) | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F/27 | Occipital | Seizure | 12x13x13 | 15/15 | Type I | Yes | Yes | Total | 47 | Seizure control is achieved |
| 2 | F/32 | Parietal | Seizure | 18x13x19 | 15/15 | Type II | No | Yes | Total | 46 | Seizure control is achieved |
| 3 | M/36 | Parietal | Paresis | 35x29x31 | 15/15 | Type I | No | Yes | Total | 43 | Operated because of postoperative epidural hematoma. Paresis improved |
| 4 | M/22 | Parietal | Seizure | 15x12x14 | 15/15 | Type I | No | Yes | Total | 42 | Seizures reduced |
| 5 | F/55 | Frontal | Headache | 24x29x30 | 15/15 | Type II | No | Yes | Total | 40 | Stable |
| 6 | M/32 | Parietal | Seizure | 8x11x10 | 15/15 | Type II | No | No | Total | 37 | Seizure control is achieved |
| 7 | M/39 | Parietal | Seizure | 25x26x22 | 15/15 | Type I | Yes | No | Total | 36 | Seizure control is achieved |
| 8 | M/30 | Frontal | Seizure | 8x9x11 | 15/15 | Type II | No | No | Total | 35 | Seizure control is achieved |
| 9 | M/17 | Parietal | Seizure | 10x10x8 | 15/15 | Type II | No | Yes | Total | 35 | Seizures reduced |
| 10 | F/15 | Temporal | Headache | 14x7x9 | 15/15 | Type II | No | No | Total | 34 | Stable |
| 11 | F/25 | Parietal | Seizure | 19x8x11 | 15/15 | Type II | No | No | Total | 33 | Postoperative temporary facial paralysis resulting in seizure control |
| 12 | F/36 | Temporal | Seizure | 14x12x16 | 15/15 | Type II | No | No | Total | 32 | Seizures reduced |
| 13 | F/35 | Parietal | Headache | 25x19x23 | 15/15 | Type I | No | No | Total | 30 | Postoperative right lower extremity paresis (2/5) developed and resolved after 2 days |
| 14 | M/35 | Frontal | Seizure | 12x8x7 | 15/15 | Type III | No | No | Total | 29 | Seizure control is achieved |
| 15 | M/35 | Occipital | Seizure | 13x12x10 | 15/15 | Type II | No | No | Total | 27 | Seizure control is achieved |
| 16 | M/41 | Temporal | Headache | 17x13x7 | 15/15 | Type I | No | No | Total | 27 | Stable |
| 17 | F/26 | Parietal | Paresis, paresthesia | 25x20x21 | 15/15 | Type I | No | No | Total | 26 | Paresis persists |
| 18 | F/26 | Frontal | Seizure | 7x5x6 | 15/15 | Type III | No | No | Total | 25 | Seizures reduced |
| 19 | M/13 | Parietal | Seizure | 43x27x27 | 15/15 | Type I | No | No | Subtotal | 24 | Re-operation due to residual lesion six months later, seizure control was achieved |

**Table 2.** Continued

| Patient | Gender /age (years) | Localization | Symptom | Lesion size (mm) | Pre/postoperative GCS | Zabramski classification | Preoperative acute hemorrhage | Calcification on CT | Resection | Follow-up (month) | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | M/34 | Third ventricle | Syncope | 13x16x15 | 14/15 | Type I | Yes | No | Total | 19 | Stable |
| 21 | F/20 | Temporal | Seizure | 17x13x18 | 15/15 | Type I | Yes | Yes | Subtotal | 19 | Reoperation due to residual lesion after 4 months, seizures were reduced |
| 22 | M/11 | Parietal | Seizure | 16x11x13 | 15/15 | Type II | No | No | Total | 18 | Seizure control is achieved |
| 23 | F/41 | Frontal | Seizure | 16x13x15 | 15/15 | Type I | No | No | Total | 17 | Seizure control is achieved |
| 24 | F/21 | Frontal | Headache | 15x12x13 | 15/15 | Type II | No | No | Total | 17 | Stable |
| 25 | F/7 | Pons | Sixth CN paralysis | 13x11x10 | 15/15 | Type II | No | No | Total | 17 | The sixth CN palsy persists |
| 26 | M/15 | Frontal and posterior | Seizure | 25x20x20 | 15/15 | Type I | Yes | Yes | Total | 11 | Seizure control is achieved |
| 27 | F/68 | Intraorbital | Proptosis | 25x18x12 | 15/15 | Type II | No | No | Total | 6 | Proptosis improved |
| 28 | M/31 | Frontal | Seizure | 13x15x10 | 15/15 | Type II | No | No | Total | 5 | Seizure control is achieved |
| 29 | F/29 | Parietal | Seizure | 22x16x19 | 15/15 | Type II | No | Yes | Total | 3 | Postoperative temporary facial paralysis, seizure control, improved speech |
| 30 | F/50 | Temporal | Syncope | 7x6x9 | 15/15 | Type II | No | No | Total | 3 | Temporary facial paralysis |
| 31 | M/52 | Third ventricle | Headache | 14x17x12 | 15/15 | Type I | No | No | Total | 3 | Stable |

CN: Cranial nerve, CT: Computed tomography, F: Female, GCS: Glasgow Coma scale, M: Male

The majority of CCMs are sporadic (approximately 70-90%), but familial cases are not uncommon (10-30%) (1). Sporadic CCMs usually present as a single lesion, and 24-86% are reported to occur in association with DVAs (8). Familial CCMs exhibit autosomal dominant inheritance involving mutations in one of the following *CCM* genes: *CCM1 (KRIT1)* on chromosome 7q, *CCM2 (MGC4607)* on chromosome 7p, and *CCM3 (PDCD10)* on chromosome 3p (3). These genes encode proteins that interact at cellular junctions and in the endothelial cell cytoskeleton. The absence or dysfunction of these proteins leads to impaired endothelial cell junctions and increased vascular permeability (9). Among these, the *CCM3* gene is associated with a higher risk of hemorrhage and earlier disease onset (10).

Radiation-induced CCMs can emerge 5-20 years after radiation therapy. Advanced age and higher radiation doses during treatment are associated with a shorter latency period for CCM development. Radiation may induce CCM formation by initiating neoangiogenesis through increased levels of vascular endothelial growth factor and other vasculogenic factors or by directly causing DNA damage. Radiation-induced CCMs tend to occur at a younger age compared with non-radiation-induced CCMs, with a higher likelihood of multiple lesions, symptomatic presentation, and increased hemorrhage risk (11).

CCMs are macroscopically well-defined soft, dark red, or purple lesions. Due to very slow blood flow, thrombosis and calcification are common. Histologically, they are characterized by enlarged capillary vessels lined with a thin and weak epithelium and lacking elastic fibers and muscle layers, predisposing them to hemorrhage (6). The primary

histological feature distinguishing CCMs from capillary telangiectasias is the absence of intervening cerebral tissue between the lesions. Surrounding tissues typically exhibit gliosis and hemosiderin deposition (1).

CCMs can affect any part of the brain, and their clinical manifestations vary according to location. In symptomatic patients, the most common presentations include seizures (40-70%), focal neurological deficits without hemorrhage (25-50%), hemorrhage (25-50%), and non-specific headaches (10-30%) (12). Patients with at least one CCM and evidence of a seizure onset zone near the CCM are classified as having "definite CCM-related epilepsy" (13). Recurrent microhemorrhages around CCMs, resulting in perilesional gliosis and inflammation-both of which are epileptogenic-are believed to cause seizures in patients with CCM. These patients have a high risk of developing epilepsy after their first seizure. The risk of developing seizures after an incidental CCM diagnosis is low at 0.9% per patient-year, whereas the recurrence rate of seizures is 5.5% per patient-year in patients with seizure (14). The initiation of antiepileptic treatment should be considered for the first seizure attributed to CCM (15). Post-surgery, 75-81% of epilepsy cases achieve seizure freedom. Patients who underwent total resection had a 36.6-fold higher likelihood of achieving seizure control. Factors that increase the likelihood of successful epilepsy treatment include recent seizure onset (within the past year), CCM size 1.5 cm, and the presence of a single CCM (16). In our series, seizures were the most common symptom (62%). Postoperatively, 74% of patients experienced no further seizures, of whom 57% had lesions larger than 1.5 cm and 50% had a seizure history of more than 1 year. The remaining 26% experienced a reduction in seizure frequency and number.

The annual hemorrhage risk for patients without a history of hemorrhage is 0.7-1.1% per lesion, and it increases to 4.5% in those with a prior history (2). The hemorrhage risk depends on the location, size, presence of DVAs, and sex of the lesion. Deep-seated CCMs have a higher hemorrhage risk than superficial CCMs. The hemorrhage risk of infratentorial and supratentorial CCMs was 3.8% and 0.4%, respectively (17). Nikoubashman et al. (18) proposed a simple three-tier classification for evaluating the hemorrhage risk of CCMs in clinical practice: high risk (23.4%) if the CCM contains acute or subacute blood breakdown products; moderate risk (3.4%) if it lacks these products; and low risk (1.3%) for tiny lesions visible on T2 but barely or not at all visible on T1-weighted and T2-weighted images. Seizures and familial forms have been suggested as potential risk factors for hemorrhage, but there is insufficient evidence in the literature to support this hypothesis (19). The phenomenon of "temporal clustering," where untreated CCMs have a high initial re-hemorrhage rate that decreases 2-3 years after the previous hemorrhage, has been reported. This should be considered when determining appropriate treatment strategies for patients with CCM (12).

CCMs cannot be visualized on angiographic examination due to the lack of feeding arteries and draining veins. As a result, these lesions were historically referred to as "cryptic vascular malformations" or "angiographically occult vascular malformations" (1). Apart from detecting associated DVAs or capillary telangiectasias, angiography has limited diagnostic and therapeutic value for CCMs. In our series, digital subtraction angiography was performed preoperatively for differential diagnosis in three patients, all of whom had negative angiographic results. CT is not ideal for diagnosing CCMs, detecting only 30-50% of lesions (6). Non-calcified, non-hemorrhagic, and small CCMs may not be visible on CT. When visible, they may appear as hyperdense, calcified lesions or exhibit a mass effect (20). In our series, preoperative CT revealed calcifications in 29% of the patients, and lesions were not detected in 9.7%.

MRI is the most sensitive and specific imaging modality for diagnosing and monitoring CCMs, and it significantly outperforms CT (19). Hemoglobin breakdown products such as methemoglobin, hemosiderin, and ferritin allow CCMs to be visualized on MRI. According to the Zabramski classification, CCMs can be categorized into four types based on MRI characteristics. Type I CCMs appear hyperintense on T1 and T2 sequences because of subacute hemorrhage content characterized by a dense hemosiderin core. Type II CCMs exhibit a "popcorn" appearance with heterogeneous intensity on the T1 and T2 sequences. They are surrounded by gliotic tissue and contain loculated hemorrhage areas. Type III lesions are seen in familial forms and appear isointense on T1, T2, and gradient echo sequences due to chronic hemorrhage. Type IV lesions resembling capillary telangiectasias appear as small, punctate hypointense signals on gradient echo and susceptibility-weighted imaging sequences (4). In our series, type II CCMs were the most common (52%), followed by type I CCMs (42%). Functional MRI measures changes in cerebral blood flow related to brain activity, which aids in the resection of CCMs located in eloquent areas without increasing morbidity (19). In our study, we utilized functional MRI to aid in the complete resection of lesions located in motor or speech areas, avoiding potential complications. Gadolinium-enhanced T1-weighted sequences rarely show enhancement and are primarily useful for evaluating associated DVAs or capillary telangiectasias and for differentiating hemorrhagic or calcified neoplasms,

particularly hemorrhagic metastases, oligodendrogliomas, and pleomorphic xanthoastrocytoma (15).

The definitive treatment for CCMs is total resection via microsurgery. For single asymptomatic CCMs located in accessible, non-eloquent regions, surgical resection may be considered to prevent future hemorrhage, especially given the high cost and time commitment of follow-up, or in patients requiring anticoagulant therapy. Additionally, surgical resection is recommended for persistent seizures, progressive neurological deficits, first-time severe hemorrhage in non-eloquent regions, or second-time hemorrhage in eloquent areas (15,19). The surgical approach should minimize damage to surrounding neural tissue while ensuring complete resection of the lesion, including the epileptogenic perilesional brain tissue, as partial resection is associated with a high risk of recurrence (21). The use of intraoperative neuromonitoring, ultrasound, navigation, and MRI has improved total resection rates and reduced surgical complications and risks (16). In our study, we used these adjunctive techniques in some cases to minimize complications and increase the total resection rate. Chang et al. (22) reported a total resection rate of 96.2%, 0% mortality, and 97.4% neurological improvement in a series of 79 patients with eloquent and deep-seated supratentorial CCMs. Rapid growth (43%), mass effect (71%), and extralesional hemorrhage (29%) are common in third ventricle CCMs, which can lead to hydrocephalus, visual disturbances, and endocrine and hypothalamic symptoms, necessitating surgical resection despite the challenges and risks associated with accessing and resecting this region (23). Surgical treatment may be considered for deep-seated CCMs in the thalamus and basal ganglia in the presence of recurrent hemorrhage or progressive neurological deficit. However, these surgeries carry significant risks, with long-term surgical morbidity and mortality rates of 10% and mortality at 1.9% (24). Brainstem CCMs pose greater challenges due to their proximity to nuclei, corticospinal and spinothalamic tracts, and the reticular formation; a comprehensive meta-analysis of 1,390 cases reported a mortality rate of 1.5% and a long-term deterioration rate of 16% for these surgeries (25). Our series reported a total resection rate of 94%; two patients (6%) underwent reoperation for residual lesions, achieving total resection in the second surgery. No patient experienced permanent neurological deterioration or mortality. Many sporadic CCMs are associated with DVAs. When resecting CCMs, it is crucial to preserve the DVA to avoid serious complications, such as edema, hemorrhage, and venous infarction. For incidentally discovered asymptomatic CCMs, particularly those in eloquent, deep, or brainstem regions, a conservative approach with annual MRI follow-up is recommended (15).

If CCMs are located in eloquent areas with an unacceptable surgical risk, radiosurgery may be considered. However, the disadvantage of this approach is that it takes 1-3 years to achieve full efficacy, during which the risk of hemorrhage persists (26). In a series of symptomatic CCMs treated with radiosurgery because of the impossibility of surgery, the risk of hemorrhage decreased from 32.5% in the first 2 years to 10.8% and then to 1.06% by the end of 2 years (27). On the other hand, the risk of hemorrhage in CCMs decreases significantly by itself 2 years after the first hemorrhage, and the positive radiosurgery results may reflect the natural course of these lesions. Additionally, permanent neurological deficits have been reported in 7.3-22.2% of cases following radiosurgery (28). The benefits of radiosurgery for the treatment of CCMs remain unproven and continue to be a topic of debate (19). In our series, 2 patients had a history of radiosurgery (one 4.5 years prior and the other 10 years prior), but no improvement in symptoms or lesion size was observed.

A phase 2 study involving the beta-blocker propranolol suggested that it might be beneficial in reducing the frequency of clinical events in symptomatic familial CCMs, but the study design was not sufficiently robust (29). Laboratory studies have shown a relationship between vitamin D deficiency and aggressive CCM behavior, but there is no evidence that vitamin D supplementation prevents CCM symptoms (30). Ongoing laboratory research aims to identify potential pharmacological targets to stabilize or prevent CCM formation. These treatments require careful clinical evaluation for safety and efficacy (15).

Our relatively small sample size and retrospective study design may limit the validity of our results. Additionally, the lack of a control group and the potential biases inherent in retrospective analyses restrict the generalizability of the findings. Future studies should involve larger, prospective cohorts.

## CONCLUSION

Surgical resection remains the most effective treatment for symptomatic CCMs. Cases in which total resection is not achieved require close follow-up because of the high risk of recurrence. A conservative approach is recommended for asymptomatic lesions located in deep or eloquent regions, whereas radiosurgery may be considered in cases with high surgical risk. Multidisciplinary approaches and personalized treatment protocols can significantly improve the prognosis and quality of life of patients with CCM.

## ETHICS

**Ethics Committee Approval:** This study was approved by University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee (decision no: 91, date: 14.02.2024).

**Informed Consent:** Since this study is retrospective, patient consent is not required.

### Authorship Contributions

Surgical and Medical Practices: B.E., E.A., O.H., B.T., Concept: B.E., S.D., O.B., O.H., B.T., Design: B.E., S.D., T.Ö.K., Y.K., M.Ç., Data Collection or Processing: S.D., T.Ö.K., Y.K., O.B., M.Ç., Analysis or Interpretation: B.E., E.A., Y.K., O.H., M.Ç., B.T., Literature Search: S.D., E.A., T.Ö.K., O.B., Writing: B.E., S.D., E.A., T.Ö.K., Y.K., O.B., O.H., M.Ç., B.T.

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Research

# Use of Volumetric Apparent Diffusion Coefficient to Distinguish Between Obstructive and Non-obstructive Azoospermia: A Case-control Study

## Obstrüktif ve Obstrüktif Olmayan Azoospermi Ayrımında Volumetrik Görünür Difüzyon Katsayısının Kullanımı: Bir Olgu Kontrol Çalışması

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## ABSTRACT

**Objective:** It is suggested that the use of non-invasive and cost effective imaging modalities, including magnetic resonance imaging (MRI), can be beneficial for detecting areas with spermatogenesis and predicting the presence of sperm in testicles, thereby improving the management of patients with azoospermia.

**Methods:** This descriptive and analytical study included 38 patients with azoospermia who presented to the Firoozgar and Hazrat Rasoul Akram Hospitals in Tehran, Iran. The patients underwent MRI, testicular biopsy, and hormonal examination. The data were analyzed and compared between the patients with obstructive azoospermia (OA) and non-obstructive azoospermia (NOA).

**Results:** The present study included 76 testicles from 38 patients with OA (n=14) and NOA (n=24). According to our findings, the patients with OA and NOA did not differ significantly in testosterone (OA: 4.78, NOA: 5.33, p=0.755) and prolactin levels (OA: 10.75, NOA: 9.77, p=0.540). However, those with NOA had significantly higher levels of follicle-stimulating hormone (OA: 4.66, NOA: 20.61, p<0.001) and luteinizing hormone (OA: 3.15, NOA: 12.40, p<0.001), as well as apparent diffusion coefficient (ADC) (OA: 0.96, NOA: 1.16, p<0.001). Moreover, the patients with OA had a significantly higher testis volume (20.37 $cm^3$) compared with those with NOA (8.16 $cm^3$, p<0.001). Additionally, there were significant correlations between pathological grade and the variables of testicular volume (correlation coefficient: 0.672, p<0.001) and ADC (correlation coefficient: 0.480, p<0.001). Finally, the multivariate regression analysis showed a significant relationship between testicular volume and pathological grade. The receiver operating characteristic curves show the performance of ADC [area under curve is 0.954 (95% confidence interval; 0.912-0.995)] between OA and NOA.

**Conclusion:** The MRI-related parameters of ADC and testicular volume help differentiate and diagnose OA and NOA.

**Keywords:** Genital diseases, infertility, azoospermia, multiparametric magnetic resonance imaging, volumetric apparent diffusion

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## ÖZ

**Amaç:** Manyetik rezonans görüntüleme (MRG) dahil olmak üzere invaziv olmayan ve uygun maliyetli görüntüleme yöntemlerinin kullanımının, spermatogenez bulunan alanları tespit etmek ve testislerde sperm varlığını tahmin etmek için yararlı olabileceği ve böylece azoospermili hastaların yönetimine katkı sağlayacağı öne sürülmektedir.

**Gereç ve Yöntem:** Bu tanımlayıcı ve analitik çalışmaya, İran'ın Tahran şehrindeki Firoozgar ve Hazrat Rasoul Akram Hastaneleri'ne başvuran 38 azoospermili hasta dahil edildi. Hastalara MRG, testis biyopsisi ve hormonal muayene uygulandı. Veriler analiz edildi ve obstrüktif azoospermili (OA) ve non-obstrüktif azoospermili (NOA) hastalar arasında karşılaştırma yapıldı.

**Bulgular:** Çalışmaya OA (n=14) ve NOA (n=24) tanısı almış 38 hastaya ait 76 testis dahil edildi. Bulgularımıza göre, OA ve NOA tanılı hastalarda testosteron (OA: 4,78, NOA: 5,33, p=0,755) ve prolaktin düzeyleri (OA: 10,75, NOA: 9,77, p=0,540) arasında anlamlı bir fark yoktu. Ancak NOA'lı hastalarda folikül uyarıcı hormon (OA: 4,66, NOA: 20,61, p<0,001) ve luteinize edici hormon (OA: 3,15, NOA: 12,40, p<0,001) düzeyleri ve görünür difüzyon katsayısı (ADC) (OA: 0,96, NOA: 1,16, p<0,001) anlamlı derecede daha yüksekti. Ayrıca OA'lı hastaların testis hacmi (20,37 $cm^3$) NOA'lı hastalara (8,16 $cm^3$, p<0,001) göre anlamlı derecede daha yüksekti. Ayrıca patoloji derecesi ile testis hacmi (korelasyon katsayısı: 0,672, p<0,001) ve ADC (korelasyon katsayısı: 0,480, p<0,001) değişkenleri arasında anlamlı korelasyonlar vardı. Son olarak, çok değişkenli regresyon analizi testis hacmi ile patoloji derecesi arasında anlamlı bir ilişki olduğunu gösterdi. Alıcı işletim karakteristik eğrileri OA ve NOA ayrımında ADC'nin performansını göstermektedir [eğri altında kalan alan: 0,954 (%95 güven aralığı: 0,912-0,995)].

**Sonuç:** ADC ve testis hacmi gibi MRG ile ilişkili parametrelerin OA ve NOA'yı ayırt etmede ve teşhiste yardımcı olduğu görülmüştür.


**Anahtar Kelimeler:** Genital hastalıklar, kısırlık, azoospermi, multiparametrik manyetik rezonans görüntüleme, volumetrik görünür difüzyon

## INTRODUCTION

As a cause of male infertility, azoospermia is present in 1% of the general population. However, it has been reported in 10-15% of infertile men (1). According to the World Health Organization, investigating male infertility should include a complete medical history and physical examination (2).

Azoospermia can be divided into two general categories: obstructive azaospermia (OA) and non-obstructive azaospermia (NOA), which are critical for differentiation (3). OA can be predicted by normal levels of follicle-stimulating hormone (FSH) and normal volume of both testicles because incomplete spermatogenesis is usually associated with elevated FSH levels in blood samples. However, 29% of men with normal FSH levels exhibit incomplete spermatogenesis (4).

OA and NOA can be differentiated by testicular biopsy. Moreover, the sperm retrieved during the procedure can be successfully used for intracytoplasmic sperm injection (5). In addition to clinical and laboratory investigations, imaging modalities can be used as complementary approaches to illustrate the exact anatomy of the area and the extent of pathology. It has been shown that ultrasound is highly beneficial for investigating the causes of azoospermia, especially OA (6). Additionally, other imaging modalities, such as computed tomography or magnetic resonance imaging (MRI), can be used (7). For example in case of "non-diagnostic" or "inconclusive" findings in ultrasound, MRI of the testicles can be of considerable diagnostic value (8). Up to now, limited studies have investigated the application of functional MRI modalities, such as diffusion-weighted imaging (DWI), magnetic transmission imaging, and hydrogen 1 magnetic resonance spectroscopy (H1MRS), in detecting and localizing the site of spermatogenesis in infertile testes (9).

However, it has been suggested that DWI sequence and apparent diffusion coefficient (ADC) calculation can be beneficial diagnostic tools, providing information regarding structural changes in tissues at the cellular level, leading to a better understanding of tissue characteristics (10,11).

In general, limited studies have investigated the clinical use of DWI sequences in evaluating testicular pathologies, including the diagnosis and localization of non-palpable testicles; differentiating between normal, benign, and malignant lesions; and diagnosing varicocele and testicular torsion (12). ADC values for biological tissues are influenced by several factors, since the interaction of water molecules with tissue components, cell membranes, intracellular organelles, cytoskeleton, and macromolecules restricts their movement (13,14). Thus, the present study aimed to use ADC to distinguish between OA and NOA.

## METHODS

### Study Design and Setting

This study was conducted based on the Strengthening the Reporting of Observational Studies in Epidemiology Statement (15). In this study, patients with azoospermia were referred to the urology clinics of Firoozgar and Hazrat Rasoul Akram Hospitals in Tehran, Iran, using an easy sampling method. The initial proposal for the study was approved by the Institutional Review Board (IRB) and Ethics Committee of the University of Medical Sciences of Iran (approval ID: IR.IUMS.FMD.REC.1399.284, date: 18.07.2020). This study used recorded patient data, and no intervention was administered to the included population.

### Participants

After obtaining written informed consent, the participants were selected and enrolled in the study according to the inclusion criteria. First, demographic characteristics, number of marriages, history of having children, and history of scrotal and inguinal surgeries were obtained from the patients and recorded in the questionnaire.

### Inclusion and Exclusion Criteria

Azoospermia patients are based on the results of two semen analysis tests, the necessary hormone tests [testosterone, luteinizing hormone (LH), and FSH, and having a testicular ultrasound]. Patients were unwilling to participate in the study, had single testicle, and were unable to perform MRI.

### Data Measurement

According to history, (history of having children and history of vasectomy or scrotal or inguinal surgeries), patients were divided into two groups, obstructive and non-obstructive azoospermia. To increase the accuracy of patient grouping, two criteria (FSH and testicle size) were used in the ultrasound analysis. The groups included the obstructive azoospermia group, which comprised people with normal-sized testicles and normal or slightly increased FSH, and the nonobstructive azoospermia group, comprising patients with reduced testicular size (less than 13 mL) and increased FSH.

Less than one month after MRI, patients were subjected to unilateral or bilateral testicular sampling. The results of the pathological examination of the samples obtained without the knowledge of MRI or other information of the patients were reported, and the patients were divided into 5 different pathological groups. The effects of body mass index (BMI) data, FSH, testosterone, prolactin, LH, testicle volume (TV), age, and testicle size on the occurrence of azoospermia were then evaluated and analyzed.

### MRI Protocol

The patients were then subjected to multi-parametric testicular MRI using the Philips 1.5 Tesla (T) system (Ingenia, Philips Healthcare, Netherlands) in the supine position using a multi-channel coil (torso coil). The MRI results were reported by two expert radiologists without any other information about the patient. To determine testis volume and ADC using MRI, testis volume was calculated twice using Lambert's experimental formula (length x height x width x0.71) in cubic centimeters. Then, to determine the final testicular size, the average of the two measurements was considered. The height and width of the testicles were measured in the axial scan, and the length of the testicles was evaluated on sagittal T2-weighted images. Each ADC value was measured three times in a round region of interest (ROI) with an area of approximately 100 square mm. In the ADC map, ADC was measured quantitatively in the middle portion of the testes, and two measurements were made at different levels just above and below the middle portion. The average ADC value was determined from the average of three measurements. In small and atrophied testes, the ROI area in the middle part and the maximum size of the testis parenchyma were measured without taking the outer part of the extra testis. The ability to distinguish obstructive from non-obstructive azoospermia using T2-weighted sequence DWI data, and ADC values was evaluated and analyzed by the software, and the results were recorded on the checklist.

### Histopathological Grading

For this purpose, the biopsied testicle samples were examined by pathologists that were unaware of the MRI findings. Patients with azoospermia were divided into two groups: obstructive azoospermia (normal spermatogenesis and hypo spermatogenesis) and non-obstructive azoospermia (maturation arrest and sertoli cell-only syndrome or del Castillo syndrome and tuberous sclerosis). Based on consultation with pathologists, regardless of whether the patient was obstructed or nonobstructed, the testicle samples were divided into one of these 5 groups, including normal spermatogenesis, hypospermatogenesis, maturation arrest, Sertoli cell-only syndrome, and tuberous sclerosis.

### Statistical Analysis

The sample size was measured based on the literature review, which included 30 patients (16). Data were analyzed using Statistical Package for the Social Sciences version 26. To compare the mean of quantitative variables between the two groups, student's t-test (normally distributed random variables based on the result of Kolmogorov-Smirnov test) and non-parametric Mann-Whitney U test (non-normally distributed variables) were used. The Kruskal-Wallis test and Spearman rank correlation coefficient were used according to pathological findings. Finally, logistic regression was used to predict testicular pathological factors. A significance level of 0.05 was considered.

## RESULTS

Finally, 14 (28 testicles) and 24 patients (48 testicles) were diagnosed as obstructive and non-obstructive. The average ages of patients with and without obstructive azoospermia was 36.32±7.62 and 36.11±8.89 years, respectively (p=0.12).

A significant difference was found between patients with and without obstructive azoospermia in terms of FSH and

LH levels (p<0.05). However, there were no significant differences in testosterone, prolactin, and TV (Table 1).

Based on testicular MRI findings, TV was significantly higher in patients with obstructive azoospermia than in those without (p<0.001), and the mean ADC was lower in patients with obstructive azoospermia (p<0.001) (Table 2).

Based on pathological examination, non-obstructive azoospermia, normal pathology, and tubular sclerosis were not observed in any of the patients with obstructive azoospermia.

The pathology of maturation arrest and sertoli cell-only syndrome formed approximately 79% of the pathologies of non-obstructive azoospermia patients (34 testicles out of 43 testes), and the pathology of hypospermatogenesis and maturation arrest accounted for approximately 76% of the pathology of obstructive azoospermia patients (19 testicles out of 25 testicles).

A significant difference was observed between patients with and without obstructive azoospermia in terms of pathological findings and ADC, TV, and testis volume (p=0.003) (Table 3). There was a positive and significant correlation between the ADC score on MRI and the pathological score (r=0.48, p<0.001). Moreover, the ADC score had a negative and significant correlation with the testis volume (r=-0.676, p<0.001) (Figures 1,2). Receiver operating characteristic curves showing the performance of ADC [area under curve (AUC) is 0.954 confidence interval 95%; 0.912-0.995] between OA and NOA (Figure 3).

## DISCUSSION

In the present study, patients with OA had a lower ADC than those with NOA. Compatible with our findings, two studies showed that normal testes had a lower ADC compared with testes with NOA in histopathological investigations (17,18). Moreover, our findings showed that the volume of testis measured in MRI was a significant predictor of pathological findings. According to studies comparing MRI findings between patients with NOA and age-matched controls, the volume of the testis is a significant predictor of spermatozoa in microscopic testicular embryo extraction (microTESE) (19), and patients with NOA and hypospermatogenesis

**Table 1.** Demographic factors of patients according to the type of azoospermia

| Variables | Obstructive (n=28) | Non-obstructive (n=48) | p-value |
|---|---|---|---|
| Age (years), mean ± SD | 36.32±7.62 | 36.11±8.89 | 0.12 |
| Married, n (%) | 20 (71.4) | 40 (83.3) | 0.08 |
| BMI, mean ± SD | 26.2±3.02 | 28.7±2.54 | 0.009 |
| Testosterone, mean ± SD | 4.78±3.03 | 5.23±3.88 | 0.755 |
| Prolactin, mean ± SD | 10.75±5.73 | 9.77±2.25 | 0.54 |
| FSH, mean ± SD | 4.26±2.9 | 20.61±12.86 | <0.001 |
| LH, mean ± SD | 3.15±1.62 | 12.4±7.35 | <0.001 |
| TV, mean ± SD | 1.31±0.48 | 1.19±0.4 | 0.398 |

SD: Standard deviation, FSH: Follicle-stimulating hormone LH: Luteinizing hormone, TV: Testicle volume

**Table 2.** MRI findings in terms of the type of azoospermia

| Variable | Obstructive | Non-obstructive | p-value |
|---|---|---|---|
| Testicular volume, mean ± SD | 20.37±6.6 | 8.16±3.99 | <0.001 |
| ADC, mean ± SD | 0.96±0.15 | 1.16±0.23 | <0.001 |

MRI: Magnetic resonance imaging, SD: Standard deviation, ADC: Apparent diffusion coefficient

**Table 3.** Frequency of testicular pathology in patients with and without obstructive azoospermia according to ADC in MRI

| Pathology findings | Obstructive (n=28) | Non-obstructive (n=48) | p-value |
|---|---|---|---|
| Normal | 4 (14.3) | 0 | 0.003 |
| Hypospermatogenesis | 15 (53.6) | 4 (8.3) | |
| Maturation arrest | 2 (7.1) | 20 (41.7) | |
| Sertoli-cell-only syndrome | 4 (14.3) | 14 (29.2) | |
| Tubular sclerosis | 0 | 5 (10.4) | |

ADC: Apparent diffusion coefficient, MRI: Magnetic resonance imaging

have significantly higher ADCs than the normal population (20,21). However, the current study compared patients with OA and NOA instead of a normal control group. On the other hand, MRI and ADC have been used to determine the degree of testicular damage in patients with varicocele (22).

According to our findings, patients with NOA had significantly lower testis volume than those with OA. Compatible with our findings, Regent et al. (23) in Poland showed that patients with NOA had significantly lower testicular volumes than those with OA.

Moreover, another study showed that the FSH and LH levels were significantly higher in patients with NOA than in those with OA, whereas no significant difference was reported in prolactin levels (24). Studies have also shown that MRI is superior to other diagnostic modalities, especially diffusion kurtosis imaging, DWI, and H1MRS, in diagnosing the cause of obstruction in patients with OA (17,25-27). Furthermore, the level of testicular tissue phosphocholine measured by H1MRS was 3 times lower in areas where only sertoli cells were present compared with areas with normal spermatogenesis (28).

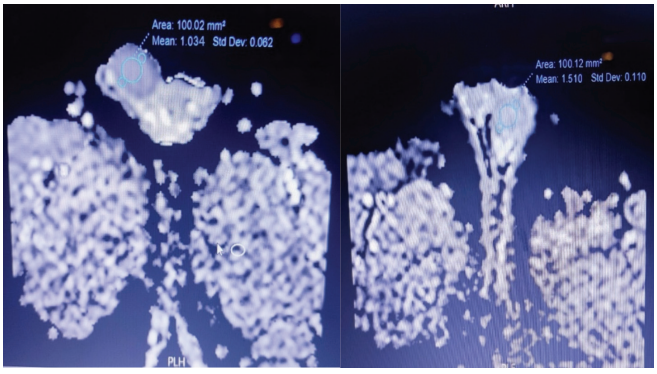


**Figure 1.** Examples of ADC value measurement in ADC map of testicles

ADC: Apparent diffusion coefficient

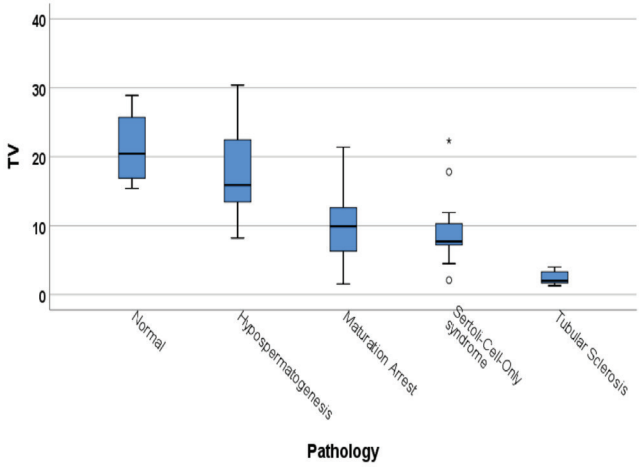


**Figure 2.** TV changes according to testicular pathological findings in patients with azoospermia

TV: Testicle volume

On the other hand, the present study reported a significant relationship between MRI findings and testicular pathology in patients with azoospermia. Compatible with our findings, a study reported a significant relationship between ADC measured by DWI technique and testicular pathology in patients with OA and NOA, showing a positive and significant correlation between ADC value and pathological grade (29). Moreover, the present study reported a significant difference in pathological grade between the patients with OA and NOA azoospermia, showing a significantly lower pathological grade in patients with OA compared with those with NOA. This finding confirmed the correctness of the pathological classification used in the present study. In addition, this classification used the FSH level and testis volume as pre-accepted diagnostic criteria. These variables also showed significant intergroup differences.

The present study revealed a significant relationship between ADC values and testicular pathology. Moreover, pathologies with higher ADC values were associated with higher levels of damage to spermatogenesis. These findings are consistent with two other studies on a similar topic (23,29). It is hypothesized that reduced cell volume in

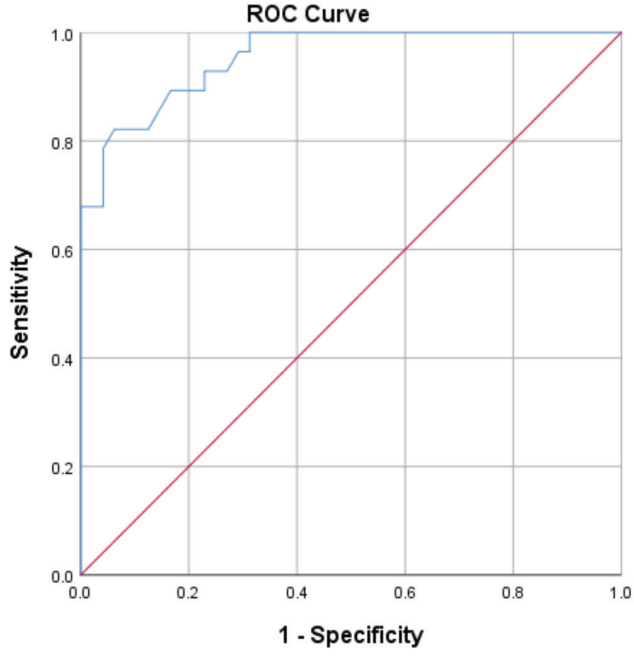


**Figure 3.** ROC curves showing the performance of the apparent diffusion coefficient [AUC is 0.954 (CI 95%; 0.912-0.995)] between obstructive and non-obstructive azoospermia

ROC: Receiver operating characteristic, AUC: Area under curve, CI: Confidence interval

severe pathologies of spermatogenesis and the absence of different cell lines in testicular parenchyma allow for the free movement of water molecules, thereby increasing their diffusion. However, the hypersignalisation of DWI and decreased ADC reported in patients with testicular malignancies in the present study can be explained by the hypercellularity of tumoural tissue and impedance against the movement of water molecules.

Our results showed no significant correlation between ADC and age. However, the size of the testis and testicular parenchyma decreases with age (17), owing to the loss of germ cells and Sertoli cells, leading to reduced length and diameter of the seminiferous tubules (26). Other changes include the formation of peritubular fibrotic tissue, thickening of the tunica propria (the outermost layer of the venom), and increased numbers of Leydig cells, which increase resistance (30).

Finally, this study reported that patients with OA had significantly higher BMIs than those with NOA. Although obesity has been proven to play an important role in oligospermia and azoospermia, defective spermatogenesis due to reduced androgen levels can also explain the decreased muscle mass observed in patients with NOA. Moreover, hypoandrogenism can cause obesity in men (31).

Our study has some limitations; one of the important ones is the small sample size and the non-random sampling method, which introduces bias. Moreover, without a comparison with a healthy control group, the study findings on testicular volume and ADC values in patients with OA and NOA might lack context. Therefore, it is suggested that a large number of participants in a cohort with case-control design study with healthy subjects can be provided clearer guidance regarding the use of this imaging protocol.

## CONCLUSION

DWI-based imaging modalities and calculation of quantitative diffusion values, such as ADC, can be beneficial in differentiating OA from NOA. According to our findings, the ADC value and volume of the testis were significantly related to the testicular pathological grade reported in histopathological examinations. Among all study variables, only testis volume had a predictive value for pathological grade.

### Acknowledgements

This article is taken from the student thesis of the radiology residency program, approved by the Ethics Committee of the Research and Technology Vice-Chancellor of Iran University of Medical Sciences. All those who have cooperated in the implementation of this research are appreciated. The authors declared no conflict of interest.

### ETHICS

**Ethics Committee Approval:** The initial proposal of the work was approved by the Institutional Review Board (IRB) and Ethics Committee of the of Iran University of Medical Sciences Iran (approval ID: IR.IUMS.FMD.REC.1399.284, date: 18.07.2020).

**Informed Consent:** This was a retrospective study which informed consent of patients was waived by the Institutional Review Board (IRB) and Ethics Committee of the of Iran University of Medical Sciences.

### Authorship Contributions

Surgical and Medical Practices: F.M., M.A.G., R.M., Concept: M.G., M.M., Design: M.M., Data Collection or Processing: M.M., F.M., M.A.G., Analysis or Interpretation: S.S, Literature Search: M.M., Writing: M.G., M.M.

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

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Research

# Stereotactic Body Radiation Therapy For Medically Inoperable Stage I Non-small Cell Lung Cancer

## Medikal İnoperabl Evre I Küçük Hücreli Dışı Akciğer Kanserinde SBRT Sonuçları

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## ABSTRACT

**Objective:** The primary treatment for stage I non-small cell lung cancer (NSCLC) in medically inoperable patients is stereotactic body radiation therapy (SBRT). The current study aimed to retrospectively analyze patients who underwent SBRT.

**Methods:** A total of 188 patients with stage I NSCLC treated with SBRT between 2014 and 2020 were enrolled. Local control (LC), progression-free survival (PFS), overall survival (OS), and treatment-related toxicities were analyzed.

**Results:** Patients were mostly male (65.7%, n=71), with a median age of 68 (56-88). Based on tumor size and location, 69 patients (63.9%) received between 50 and 60 Gy in 5 fractions, 26 patients (24.1%) received 54 Gy in 3 fractions, 11 patients (10.2%) received 60 Gy in 8 fractions, and 2 patients (1.8%) received 60 Gy in 3 fractions. The median follow-up time was 32 months (12-47 months). Locoregional relapse occurred in 11 patients, among whom 4 (3.7%) developed distant metastasis. The 3-year LC, OS, and PFS rates were 89.5%, 83%, and 72%, respectively. Advanced age and presence of chronic obstructive pulmonary disease were associated with a decreased 3-year OS. In smokers and those with large tumor volumes, PFS decreased to 3 years. No grade 3 or 4 treatment-related toxicities were observed.

**Conclusion:** SBRT is a fast, safe, and valuable therapeutic approach for patients with early-stage medically inoperable NSCLC, providing significant tumor control rates with low toxicity.

**Keywords:** Stereotactic body radiation therapy, radiotherapy, non-small-cell lung cancer, SBRT, NSCLC

## ÖZ

**Amaç:** Stereotaktik vücut radyoterapisi (SBRT), medikal inoperabl evre I küçük hücreli dışı akciğer kanseri (KHDAK) tedavisinde ana yaklaşımdır. Bu çalışmada, SBRT ile tedavi edilen medikal inoperabl evre I KHDAK hasta sonuçlarını retrospektif olarak analiz etmeyi amaçladık.

**Gereç ve Yöntem:** 2014 ile 2020 tarihleri arasında SBRT uygulanan evre I KHDAK tanılı 108 hastanın lokal kontrol, progresyonsuz sağkalım, genel sağkalım ve tedaviye bağlı toksisite sonuçları analiz edildi.

**Bulgular:** Hastaların %65,7'si erkek ve ortalama yaş 68 (56-88) idi. Tümör büyüklüğü ve lokalizasyonuna göre; 69 hastaya (%63,9) 5 fraksiyonda 50-60 Gy, 26 hastaya (%24,1) 3 fraksiyonda 54 Gy, 11 hastaya (%10,2) 8 fraksiyonda 60 Gy, 2 hastaya (%1,8) 3 fraksiyonda 60 Gy radyoterapi uygulandı. Ortalama takip süresi 32 aydı (12-47 ay). On bir hastada lokal nüks ve 4 hastada (%3,7) uzak metastaz gelişti. Üç yıllık lokal kontrol, progresyonsuz sağkalım ve genel sağkalım oranları sırasıyla %89,5, %72 ve %83 idi. İleri yaş ve kronik obstrüktif akciğer hastalığı varlığı azalmış 3 yıllık genel sağkalım ile ilişkili bulundu. Sigara içme öyküsü ve büyük tümör volümü ise azalmış 3 yıllık progresyonsuz sağkalım ile ilişkili idi. Tedaviye bağlı 3. ve 4. derece toksisite gözlenmedi.

**Sonuç:** SBRT erken evre medikal inoperabl KHDAK hastaları için yüksek tümör kontrol oranları ve düşük toksisite sonuçları ile hızlı ve güvenli bir tedavi yaklaşımıdır.

**Anahtar Kelimeler:** Stereotaktik vücut radyoterapisi, radyoterapi, küçük hücreli dışı akciğer kanseri, SBRT, KHDAK

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## INTRODUCTION

Lung cancer is the second most common type of cancer in both women and men (1). Despite progress in diagnosis and treatment approaches. Non-small cell lung cancer (NSCLC) is the most frequent type of lung cancer and has multiple histological subtypes. It accounts for approximately 85% of all diagnosed lung cancer cases, with a 5-year survival of approximately 25% (2). Although the typical treatment for early-stage NSCLC is surgical resection, a notable percentage of these patients are not suitable for surgery due to comorbidities, such as heart disease, loss of pulmonary parenchyma, and chronic obstructive pulmonary disease (COPD), particularly among heavy smokers and the elderly.

Stereotactic body radiation therapy (SBRT) has become the standard of care for patients with early-stage NSCLC who are medically inoperable, after a series of trials proved its effectiveness and safety profile (3). SBRT allows reaching high radiation doses. In this way, it is possible to achieve lower rates of normal tissue complications along with improved local control (LC) and survival outcomes (4-7). In the SPACE trial comparing conventional fractionated radiotherapy to SBRT, no differences were observed in overall survival (OS) and progression-free survival (PFS), despite the imbalances in terms of known prognostic factors between the two treatment arms, which favored the conventional radiotherapy arm (8). Moreover, quality of life was better and toxicity was lower with SBRT. On the other hand, the positive effects of SBRT compared with conventional radiotherapy have been confirmed by other studies and meta-analyses (9,10).

In the current study, we retrospectively analyzed the LC, PFS, OS, and treatment-related adverse events (AEs) in patients with medically inoperable early-stage NSCLC who underwent SBRT.

## METHODS

### Patient Selection and Follow-up

In this retrospective study, patients with medically inoperable T1-2aN0M0 NSCLC who received SBRT between 2014 and 2020 were examined. The multidisciplinary team ascertained inoperability based on the presence of medical comorbidities and pulmonary function tests. Diagnosis, in cases in which biopsies are not feasible, are non-diagnostic results or are declined by the patient, was made using clinical and imaging findings by the multidisciplinary team.

Positron emission tomography computed tomography (CT) scans were obtained 3-4 months after the completion of SBRT for each patient. Patients were followed for a 3-month period during first 2-years then 6-months period, including physical examination and thorax CT in each follow-up visit. Treatment-related AEs were documented in accordance with the common terminology criteria for adverse events version 5 (CTCAEv5).

### Radiotherapy Specifications

Breath-hold CT, slow CT, and 4D CT methods with 1-2 mm slice thickness scanning were used for treatment planning. Additionally, the breath-hold technique was primarily employed in lower lobe tumors. Planning target volume (PTV) margins from the internal target volume were customized from 5 mm to 10 mm in all directions based on tumor location and CT technique. Treatment was administered with Truebeam linac (Varian Systems, USA) or volumetric modulated arc therapy on a Synergy® Linac (Elekta AB, Stockholm, Sweden). According to the American Association of Physicists in Medicine study, dose fractionation plans were prescribed to achieve a biologically effective dose (BED) of at least 100 Gy (alpha/beta ratio=10), and it was chosen based on target location and size (4). All BED calculations were based on the prescribed dose, with the entire PTV receiving at least 95% of the prescribed dose. 54 Gy in 3 fractions or 60 Gy in 5 fractions or 60 Gy in 3 fractions were prescribed for peripheral locations, whereas 50-60 Gy in 5-8 fractions for larger peripheral and central locations. Treatment was delivered every other day. All patients were treated using stereotactic radiation techniques under an image-guided radiation treatment protocol (5).

### Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences software. Descriptive statistical methods were used to evaluate the data. Fisher's exact test and Fisher-Freeman-Halton exact test were used to compare qualitative data. The conformity of quantitative data to the normal distribution was assessed using graphical inspections and the Shapiro-Wilk test. If the two groups did not have a normal distribution, the Mann-Whitney U test was used for comparison. Kaplan-Meier analysis was used for survival analysis. Statistical significance was defined as $p<0.05$.

This retrospective study was approved by the İstanbul University Ethics Committee (decision no: 2020/11, date: 02.07.2020).

## RESULTS

In total, 108 patients with a median age of 68 (56-88 years) were examined in this cohort. Of the patients, 65.7% (n=71)

were male, 82.4% (n=89) were smokers, and 21.3% (n=23) had COPD. The eastern cooperative oncology group performance status was evaluated; 37 (34.3%) had a score of 0, and 68 (63%) had a score of 1. In 70 patients (64.8%), biopsies were performed, and histological analysis revealed that 29.6% (n=32) had squamous cell carcinoma and 35.2% (n=38) were diagnosed with adenocarcinoma. Among the 38 patients (35.2%) who could not undergo biopsy, treatment decisions were made by the multidisciplinary team as previously described (Table 1).

The median gross tumor volume (GTV) (in cc) was 8.9 cc (0.3-77 cc), and the median PTV (in cc) was 16.35 cc (0.4-94.6 cc). Radiotherapy was administered with 54 Gy given in 3 fractions for small peripherally located lesions in 26 patients (24.1%) and 60 Gy given in 3 fractions for small peripherally located lesions to 2 patients (1.8%). 50-60 Gy in 5 fractions (50 Gy in five fractions for one patient, 55 Gy in five fractions for one patient, 60 Gy in five fractions for 67 patients) for larger peripherally located tumors and small centrally located tumors in 69 patients (63.9%), and 11 patients (10.2%) with centrally located tumors total dosed 60 Gy with 8 fractions. The breath-hold technique was used in 52 patients (48,1%), 4D CT in 30 patients (27.8%), and slow CT in 26 patients (24.1%).

The median follow-up time was 32 months (12-47 months). Twenty-four deaths (22.2%), comprising twelve cases from intercurrent disease (not related to radiation-induced toxicity), 1 case of lung cancer, and 11 cases of unknown cause. Eleven patients developed locoregional relapse (seven with local relapse only, three with regional relapse only, and one with both local and regional relapse), and the local control rate was 89.5%. Four patients (3.7%) developed distant metastasis. OS and PFS at 3 years were 83% and 72% respectively (Figure 1,2).

In the univariate analysis, sex, smoking history, tumor location, tumor volume, and radiation therapy (RT)

**Table 1.** Patient characteristics and tumor characteristics

| | | n (%) |
|---|---|---|
| **Gender** | Male | 71 (65.7) |
| | Female | 37 (34.3) |
| **Age** | Mean ± SD | 69.43±6.36 |
| | Median (min-max) | 68 (56-88) |
| **Performance status (ECOG)** | 0 | 37 (34.3) |
| | 1 | 68 (63) |
| | 2 | 3 (2.8) |
| **Family History** | Yes | 51 (47.2) |
| | No | 57 (52.8) |
| **Smoking history** | Yes | 89 (82.4) |
| | No | 19 (17.6) |
| **Biopsy** | No | 38 (35.2) |
| | Yes | 70 (64.8) |
| **Histology** | Adenocarcinoma | 38 (35.2) |
| | SCC | 32 (29.6) |
| | No biopsy | 38 (35.2) |
| **COPD** | No | 85 (78.7) |
| | Yes | 23 (21.3) |
| **Tumor location** | Peripheral | 60 (55.6) |
| | Central | 48 (44.4) |
| **Tumor location (Lobe)** | RUL | 30 (27.8) |
| | RML | 8 (7.4) |
| | RLL | 24 (22.2) |
| | LUL | 29 (26.9) |
| | LLL | 17 (15.7) |

ECOG: Eastern cooperative oncology group, SD: Standard deviation, SCC: Squamous cell carcinoma, COPD: Chronic obstructive pulmonary disease, RUL: Right upper lobe, RML: Right Middle lobe, RLL: Right lower lobe, LUL: Left upper lobe, LLL: Left lower lip, min-max: Minimum-maximum

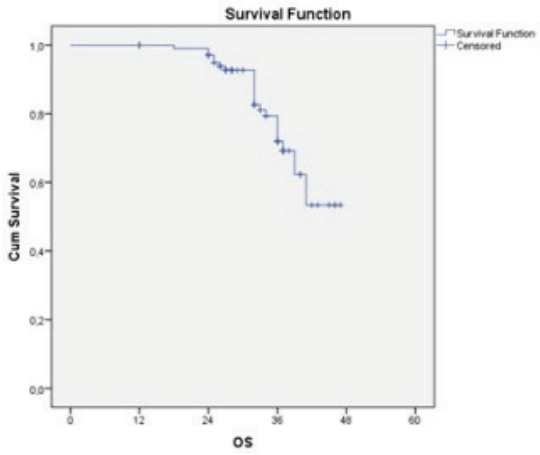


**Figure 1.** Overall survival analysis
OS: Overall survival

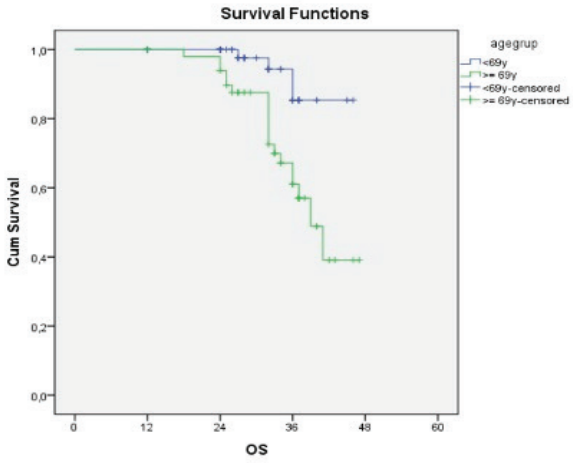


**Figure 3.** Association between age and overall survival
OS: Overall survival

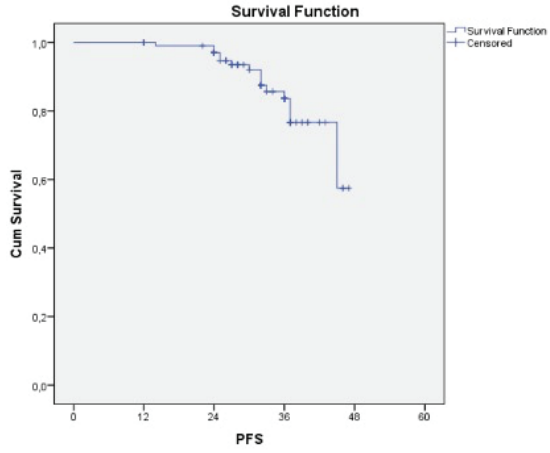


**Figure 2.** Progression-free survival analysis
PFS: Progression-free survival analysis, cum: Cumulative

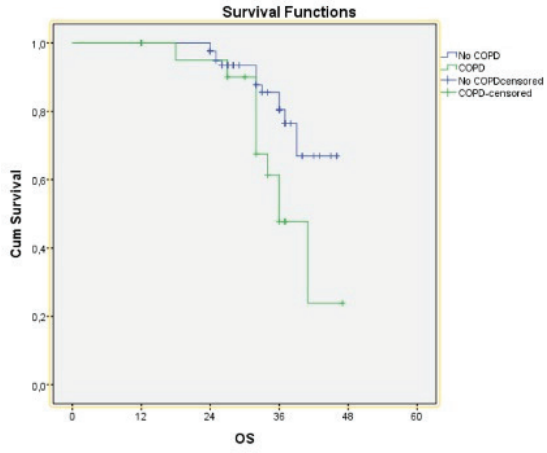


**Figure 4.** Association between COPD and overall survival
OS: Overall survival, COPD: Chronic obstructive pulmonary disease

technique had no statistically significant impact on 3-year OS. However, patients ≥69 years of age had lower 3-year OS rate than<69 years of age (61% vs 85%, p=0.04) (Figure 3). Additionally, the 3-year OS rates of those with COPD were 47% and 85% in patients without COPD, which was found to be statistically significant (p=0.013) (Figure 4).

In the univariate analysis, age, sex, COPD, tumor location, and RT technique had no statistically significant impact on 3-year PFS rate. However, 3-year PFS was significantly associated with tumor volume and smoking history. Tumor volumes ≥9 cc had a lower 3-year PFS compared to those <9 cc (70% vs 94%, p=0.004). Patients with a smoking history had a lower 3-year PFS (69% vs 87%, p=0.002).

There were no grade 3 and 4 treatment-related AEs, and in 60.2% (n=65) of the cases, no side effects were observed according to the CTCAEv5. Mild esophagitis (grade I) was observed in 16 patients (14.8%), whereas 26 (24.1%) experienced mild fatigue during treatment. Grade 2 radiation pneumonia was observed in 20.4% (n=22) of cases, with seven cases being radiologically proven and 15 cases presenting both symptomatic and radiologically proven. Among these 22 patients, 15 had centrally located tumors and seven had peripherally located tumors (p=0.042). Chest wall pain was observed in only one patient. 4D-CT, breath-hold CT, and slow CT showed no differences in efficacy and side effects.

## DISCUSSION

In this retrospective analysis, the OS and PFS at 3 years were 83% and PFS at 3 years was 72%. These results indicate

that SBRT for medically inoperable patients is a safe and effective treatment method, with high rates of survival and disease control, high tolerability, and low rates of treatment-related AEs.

Kann et al. (6) reported local failure rates of 8.2% and 9.7% at 2-years for inoperable and operable early stage NSCLC in a comprehensive study involving 952 patients from five institutions. Kestin et al. (11) also reported a 9% local failure rate in a retrospective analysis of 483 patients with early-stage NSCLC treated with SBRT. One of the factors that may affect local control is tumor size. Kestin et al. (11) found an association between GTV size and local recurrence (LR) (p=0.02), with a 2-year LR rate of 3% for sizes <2.7 cm, vs. 9% for those 2.7 cm (p=0.03). Although statistically insignificant, Kann et al. (6) reported a higher LR rate for T2 tumors than for T1 tumors. Similarly, we observed a relationship between 3-year PFS rates and tumor volume, with a 94% PFS rate for tumor volumes <9 cc in contrast to 70% for those ≥9 cc (p=0.004).

Another component that may be associated with local control and survival rates is BED 10. Previous studies have demonstrated better oncological outcomes with a BED ≥100 Gy in contrast to <100 Gy across various treatment methods and schedules (12-17). On the other hand, higher doses achieved with SBRT do not appear to be associated with high levels of toxicity, and BED <180 Gy was shown to be safe for stage I NSCLC (15). In our study, we used BED >100 Gy for all patients 3 or 5 or 8 fractions, and observed very low rates of toxicities. Furthermore, we observed no differences in side effects and efficacy among breath-hold, 4D CT, and slow CT techniques. Although breath-hold techniques were generally expected to result in fewer side effects, the lack of difference in our study may be attributable to low tumor volumes.

A phase II prospective study at MD Anderson Cancer Center reported the 7-year results of 65 patients with medically inoperable stage I NSCLC who were treated with 50 Gy in 4 fractions. The 7-year PFS and OS were 38.2% and 47.5%, respectively. Moreover, only three patients (4.6%) developed grade 3 treatment-related AEs (18). Notably, this represents the longest follow-up data in a prospective SBRT trial. In our study, the 3-year-OS and PFS were 83% and 3-year PFS was 72%.

COPD, which is an independent risk factor for lung cancer, also represents a negative prognostic factor in these patients. In a single-center cohort of 176 patients with stage I NSCLC and severe COPD, Palma et al. (19) reported a 3-year OS of 47% after SBRT. We demonstrated that the 3-year-OS of patients with COPD was 47%, which was significantly lower than that of patients without COPD (85%) (p=0.013). However, a retrospective study in Japan reported no significant difference in OS or cause-specific survival between patients with and without COPD after SBRT (20).

Smoking is the most significant preventable risk factor for lung cancer as known. Furthermore, it may impact survival time. Previous studies have shown that survival rates may decrease with smoking, and quitting smoking, even at the time of diagnosis, may improve survival. We found a significant association of 3-year PFS rates but not OS. Therefore, it is crucial to follow up on patients' smoking status during treatment and encourage active smokers to be quit.

Radiation pneumonitis (RP) developed in 22 of the patients in our cohort, which is consistent with the findings of a previous study (21). Additionally, we found that central tumor location was a significant predictor of RP. However, there are conflicting data regarding the relationship between RP and tumor location; Kita et al. (22) identified central tumor location as an independent risk factor for developing RP, whereas Yamashita et al. (23) did not find any such correlation. In other studies, tumor size was shown to be an important factor for the development of RP (24).

This study has several limitations. Due to its retrospective nature, these data is prone to limitations and potential biases. In addition, lacking a comparative group, the observed outcomes may be influenced by various factors, increasing the risk of bias. Moreover, more than a quarter of patients were treated without biopsy confirmation. Consequently, while the trial can provide insights into the benefits and risks of treatment, its findings should be interpreted with caution.

## CONCLUSION

SBRT remains a valuable therapeutic approach for patients with early-stage medically inoperable NSCLC, with high tumor control rates and minimal toxicity.

### ETHICS

**Ethics Committee Approval:** This retrospective study was approved by the İstanbul University Ethics Committee (decision no: 2020/11, date: 02.07.2020).

**Informed Consent:** Since it was a retrospective study, no consent was required.

### Authorship Contributions

Surgical and Medical Practices: E.K.U., Concept: E.K.U., H.M., Design: E.K.U., H.M., Data Collection or Processing: E.K.U., H.M., Analysis or Interpretation: E.K.U., H.M.,

Literature Search: E.K.U., M.B.K., M.F., M.K.B., Writing: E.K.U., M.B.K., M.F., M.K.B., Ö.U.

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

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Research

# The Effect of Smoking on the Functional Gain After Inpatient Rehabilitation in People with Spinal Cord Injury

## Sigara İçmenin Omurilik Yaralanması Olan Kişilerde Yatan Hasta Rehabilitasyonu Sonrası Fonksiyonel Kazanca Etkisi

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## ABSTRACT

**Objective:** This study aimed to investigate the effect of cigarette smoking on functional recovery during inpatient rehabilitation for spinal cord injury.

**Methods:** A total of 78 persons with spinal cord injury admitted to a rehabilitation hospital were included in this prospective observational study. The participants were divided into two groups: smokers and nonsmokers. Functional independence measurement (FIM) scores at baseline and discharge were recorded. The Hospital Anxiety and Depression scale (HADS) was used to assess emotional status.

**Results:** Thirty-four people (43%) participants were cigarette smokers. Mean ages were 41.29±14.03 and 41.39±16.79 years for the smokers and non-smokers, respectively. Mean disease durations were 5.82±4.13 and 5.20±4.42 months in the smokers and non-smokers, respectively. Baseline FIM scores were 29.97±14.49 and 36.00±15.48 in the smoker and non-smoker groups, respectively (p=0.84). A statistically significant improvement in FIM scores was observed in both groups at discharge (p=0.001). The increase in FIM scores were 10.94±9.58 and 17.52±11.05 in the smoker and nonsmoker groups, respectively (p=0.007). FIM gain was higher in the non-smoker group (p=0.007). The mean HADS anxiety scores were 5.91±4.03 and 7.41±4.3 in the smoker and non-smoker groups, respectively (p=0.12). The mean HADS depression scores were 5.59±3.9 and 6.20±3.70 in the smoker and non-smoker groups, respectively (p=0.47).

**Conclusion:** A significant functional improvement was observed in both smokers and nonsmokers with spinal cord injury after inpatient rehabilitation. Functional recovery was higher in the non-smoker group.

**Keywords:** Spinal cord injury, functional recovery, rehabilitation outcome, smoking

## ÖZ

**Amaç:** Bu çalışmanın amacı omurilik yaralanmasında sigara içiminin yatarak rehabilitasyon sonrasında fonksiyonel iyileşmeye etkisini araştırmaktır.

**Gereç ve Yöntem:** Bu prospektif gözlemsel çalışmaya omurilik yaralanması nedeniyle rehabilitasyon hastanesine başvuran 78 kişi dahil edildi. Katılımcılar sigara içenler ve içmeyenler olarak iki gruba ayrıldı. Başlangıçta ve taburculuk öncesi fonksiyonel bağımsızlık ölçümü (FIM) skorları kaydedildi. Duygusal durumun değerlendirilmesinde Hastane Anksiyete ve Depresyon ölçeği (HADÖ) kullanıldı.

**Bulgular:** Otuz dört kişi (%43) sigara içiyordu. Sigara içen ve içmeyen grupların ortalama yaşları sırasıyla 41,29±14,03 ve 41,39±16,79 yıldı. Ortalama hastalık süreleri sigara içen ve içmeyen grupta sırasıyla 5,82±4,13 ve 5,20±4,42 ay idi. Başlangıç FIM skorları sigara içen ve içmeyen grupta sırasıyla 29,97±14,49 ve 36,00±15,48 idi (p=0,84). Taburculuk sırasında her iki grupta da FIM skorlarında istatistiksel olarak anlamlı iyileşme vardı (p=0,001). FIM puanlarındaki artış sigara içen ve içmeyen grupta sırasıyla 10,94±9,58 ve 17,52±11,05 idi (p=0,007). Sigara içmeyen grupta FIM kazancı daha yüksekti (p=0,007). Ortalama HADS anksiyete puanı sigara içen ve içmeyen grupta sırasıyla 5,91±4,03 ve 7,41±4,3 idi (p=0,12). Ortalama HADS depresyon puanı sigara içen ve içmeyen grupta sırasıyla 5,59±3,9 ve 6,20±3,70 idi (p=0,47).

**Sonuç:** Yatarak rehabilitasyon sonrasında omurilik yaralanması olan hem sigara içen hem de sigara içmeyen kişilerde önemli bir fonksiyonel iyileşme bulundu. Sigara içmeyen grupta fonksiyonel iyileşme daha yüksekti.

**Anahtar Kelimeler:** Omurilik yaralanması, fonksiyonel iyileşme, rehabilitasyon sonucu, sigara içme

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## INTRODUCTION

There are approximately 20 million people who smoke cigarettes in Türkiye, and annually almost 100,000 individuals die due to smoking and smoking-associated factors. This ratio constitutes 1/3 of the total deaths due to other reasons (1). Within the South-East Anatolian Project, among people older than 15 years, the proportion of female smokers was 11.8% and that of male smokers was 49.7% in Türkiye. The cigarette smoking ratio was found to be higher among males, in middle ages, with higher education levels, and living in cities (2). In American adults, the smoking ratio decreased to 18.1% in the last 30 years as of 2012 (3). The prevalence of smokers were approximately 22% in the United States of America (4,5). The percentage was as high as 54% in a spinal cord injury (SCI) rehabilitation unit in Türkiye (6). Smokers usually have poorer general health. Smoking is associated with a worse health sense, more work day loss, and an increased burden on health systems (7).

SCI occurs suddenly due to a trauma to the spine. The severity of spinal cord damage varies in each case. Prognosis is poorer in patients with complete injuries (8). However, the level of injury is important in terms of functional recovery, and the strongest predictor of outcomes is injury severity in SCI (9). In addition to SCI severity and level, other factors affecting functional healing are age, education level, comorbidities, spasticity, and recovery of deep tendon reflexes or delayed plantar response (10,11). The current study aimed to investigate the effect of cigarette smoking on functional gain after inpatient rehabilitation for SCI.

## METHODS

This is a prospective observational study. Seventy-eight patients aged >17 years with SCI who underwent inpatient rehabilitation were enrolled in this single-center study. Individuals with injury duration >12 months and those with accompanying traumatic brain injury were excluded. Patients were divided into two groups: currently smokers and non-smokers. Two individuals who quit smoking 15 or 30 years ago were evaluated in the non-smokers group due to the long cessation period. On the other hand, two individuals with a history of smoking 60 pack/year and 9 pack/year were evaluated in the currently smoker group because the smoking cessation period was <1 year.

Neurological severity was assessed using the American Spinal Cord Injury Association Impairment scale (AIS). Functional status was evaluated using functional independence measurement (FIM) at admission and discharge. The Hospital Anxiety and Depression scale (HADS) was used to assess the patients' anxiety and depression status at admission. All patients received rehabilitation 5 days a week.

Ethical approval Approved by the Clinical Research Ethics Committee of İstanbul Physical Medicine and Rehabilitation Training and Research Hospital with (protocol number 2024-3, date: 02.07.2024). All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (instutional and national) and with the Helsinki Declaration of 1964 and its later amendments. Informed consent was obtained from all patients prior to their inclusion in the study. This article does not contain any studies with animal subjects. All authors declare that there are no conflicts of interest.

### American Spinal Cord Injury Association Impairment Scale

AIS helps classify neurological severity in 5 categories after SCI. AIS A refers to complete injury in which no sensory or motor function is preserved in sacral segments. AIS B indicates incomplete injury without motor function below the injury level. However, sensory function is preserved below the neurological level and extends through sacral segments. AIS C shows incomplete lesions in which motor function is preserved below the neurological level, and most key muscles below the neurological level have a muscle strength <3. AIS D indicates incomplete injury with preserved motor function below the neurologic level. Moreover, most key muscles below the neurological level have a muscle strength ≥3. AIS E indicates that sensory and motor functions are normal below this level (12).

### Functional Independence Measurement

FIM is a widely used scale with 18 items that help assess disability. Self-care, sphincter control, locomotion, communication, and social communication were evaluated in the motor and cognition subscales. Each item was scored on a 7-point scale. Higher scores indicate a more independent function. FIM motor scores can be used to measure the functional status of patients with SCI (13). FIM scores are adapted for use in Türkiye (14).

### Hospital Anxiety and Depression Scale

HADS is an easy and reliable test that can help screen anxiety and depression. The test is used for both hospitalized patients and outpatients (15). HADS can be completed in 2-5 minutes. The test has a two-factor structure with 14 items. Each item was scored on a four-point scale. Total score differed between 0 and 21. Scores between 0 and 7 indicate normal emotional status. However, scores >7 indicate anxiety or depression (16). The reliability of the

Turkish version of HADS in individuals with traumatic SCI has been studied (17).

### Statistical Analysis

The Kolmogorov-Smirnov test with the Lilliefors significance correction or Shapiro-Wilk test was used to determine whether the data were normally distributed. Continuous variables were summarized as an arithmetic mean ± standard deviation or a median (interquatile range). Categorical data were summarized as frequency and analyzed using the Likelihood ratio test and Fisher's Exact test. The means of the two groups were compared using the Mann-Whitney U test or unpaired-sample t-test. Multivariate binary logistic regression analysis was performed to identify risk factors for polypharmacy. The p-value for a factor to be included in the regression model was 0.05 using the forward conditional method, and the p-value for exclusion was 0.1. The suitability of the regression model was reviewed using the Hosmer-Lemeshow test. The regression model was considered statistically suitable if the p-value determined using the Hosmer-Lemeshow test was <0.05. The 95% confidence intervals were calculated for the odds ratios [Exp(B)]. Wald statistical analysis was conducted to determine the significance of coefficient B. P<0.05 was considered significant. The software package used for data management was PASW Statistic 18.

## RESULTS

There were no significant differences in age, body mass index, education level, injury duration, marital status, or gender distribution between the groups (p>0.05). The length of hospital stay was significantly longer in smokers than in non-smokers (Table 1). Clinical features related to the etiology, neurological severity, and associated problems are presented in Table 2. Frequencies of patients with traumatic SCI and motor complete patients were significantly higher in smokers. There were no statistically significant differences in emotional status scores between the groups upon admission (p>0.05).

The total number of smokers who quit smoking was 4 (5%). The cigarette consumption ratio was 27.76±18.50 (2-76) pack/year among smokers. FIM and HADS scores are summarized in Table 3. There was significant functional recovery after inpatient rehabilitation in both groups (p<0.0001). Gain in FIM scores in the currently smoker group was significantly lower than that in the non-smokers (p=0.004). The cut-off value (14.28) was calculated for the arithmetic mean (95%) upper confidence limit of the smoker group. If the FIM gain is below this cut-off value, functional recovery is insufficient; the gain above was considered sufficient. Accordingly, insufficient functional recovery was detected in 35 (44.9%) patients.

The binary logistics regression analysis revealed that neurologic severity, spinal cord lesion level, and smoking were risk factors for insufficient functional recovery after inpatient rehabilitation (Nagelkerke $R^2$=0.368, Hosmer-Lemeshow test p=0.975). The risk of insufficient functional recovery was 12.56 times higher in patients with tetraplegia than paraplegia; 3.34- times higher in smokers than non-smokers; and 3.28 times higher in patients with motor complete lesions (AIS A or B) (Table 4).

## DISCUSSION

In this study, significant functional recovery was observed after inpatient rehabilitation in both non-smokers and smokers with SCI. However, functional gain was lower in the current smoker group at discharge (p=0.007). Although there was no significant difference between the groups in terms of functional independence at admission, functional status was better in the non-smoker group at discharge (p<0.05). Paraplegia, incomplete lesions, and/or non-smoking were indicators of better functional recovery.

There are injury- and patient-related factors that affect functional improvement in SCI. It was suggested that age and sex were patient-related predictors, whereas injury

**Table 1.** Demographic and clinical characteristics

| | Non-smokers (n=44) | Smokers (n=34) | p-value |
|---|---|---|---|
| Age (years) | 41.4±16.8 | 41.3±14.3 | 0.979* |
| BMI (kg/m²) | 25.3 (22.9-27.8) | 24.7 (21.8-26.2) | 0.279$^{\pi}$ |
| Sex (F/M) (n) | 12/32 | 5/29 | 0.176$^{\S}$ |
| Marital status (married/single) (n) | 32/12 | 25/9 | 0.937$^{\S}$ |
| Education duration (years) | 5.0 (5.0-9.5) | 5.0 (5.0-8.0) | 0.935$^{\pi}$ |
| Injury duration (mos) | 4.0 (2.0-6.8) | 5.0 (3.0-8.0) | 0.205$^{\pi}$ |
| Length of stay (days) | 63.5 (59.0-78.3) | 71.0 (61.0-85.5) | 0.026$^{\pi}$ |

*Unpaired-sample t-test, $^{\S}$Likelihood ratio, $^{\pi}$Mann-Whitney U test, BMI: Body mass index, F: Female, M: Male

**Table 2.** Clinical characteristics

| | | Non-smokers (n=44) | Smokers (n=34) | p-value |
|---|---|---|---|---|
| Etiology | Falls | 17 | 19 | 0.065* |
| | Traffic accidents | 10 | 10 | |
| | Violance and others | 17 | 5 | |
| Traumatic/non-traumatic ratio | | 33/11 | 32/2 | **0.018§** |
| SCL level | (Tetraplegia/paraplegia) | 5/39 | 9/25 | 0.085§ |
| Neurologic severity (AIS) | Motor complete (AIS A, B) | 13 | 23 | **0.001§** |
| | Motor incomplete (AIS C, D) | 31 | 11 | |
| Associated problems | Pulmonary problems | 4 | 4 | 0.723π |
| | Pain | 31 | 27 | 0.366§ |
| | Spasticity | 17 | 20 | 0.076§ |
| | Heterotopik ossification | 0 | 3 | 0.079π |
| | Deep venous trombosis | 1 | 1 | 0.999π |
| | Intestinal problems | 5 | 5 | 0.740π |
| | Pressure ulcer | 5 | 6 | 0.519π |

Data are presented as case number. *Pearson's chi-square test, §Likelihood ratio test, πFisher Exact test
AIS: American Spinal Cord Injury Association Impairment scale

**Table 3.** Functional and emotional status

| | Non-smokers (n=44) | Smokers (n=34) | p-value |
|---|---|---|---|
| Admission FIM | 31.0 (27.3-43.3) | 28.0 (20.8-35.5) | **0.032** |
| Discharge FIM | 55.5 (44.3-68.5) | 37.5 (29.8-53.5) | **0.002** |
| FIM gain | 17.0 (8.5-23.5) | 9.0 (4.0-13.5) | **0.004** |
| HADS-A | 7.0 (4.0-10.0) | 6.0 (2.0-9.3) | 0.194 |
| HADS-D | 6.0 (4.0-8.0) | 5.0 (2.8-7.3) | 0.418 |

The Mann-Whitney U test was used in the statistical analysis. P<0.05 was considered significant.
FIM: Functional independence measurement, HADS-A: Hospital Anxiety and Depression scale- anxiety, HADS-D: Hospital Anxiety and Depression scale-depression

**Table 4.** Regression model for sufficiency of functional recovery

| Independent variable | B | SE | Wald | df | p-value | Odds ratio | 95% CI | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower limit | Upper limit |
| Neurologic severity (1) | 1.18 | 0.56 | 4.51 | 1 | 0.034 | 3.28 | 1.09 | 9.81 |
| SCL level (1) | 2.53 | 1.11 | 5.18 | 1 | 0.023 | 12.56 | 1.42 | 110.97 |
| Smoking (1) | 1.20 | 0.57 | 4.51 | 1 | 0.034 | 3.34 | 1.09 | 10.16 |
| Constant | -1.10 | 0.40 | 7.65 | 1 | 0.006 | 0.33 | - | - |

Neurological severity (1): (1) AIS A or B, (0) AIS C or D; Spinal cord lesion (neurologic) level (1): (1) Tetraplegia, (0) paraplegia; Smoking (1): (1) Smoker, (0) Non-smoker.
SE: Standard error, df: Degrees of freedom, CI: Confidence interval

severity was a injury-related predictor of recovery after SCI (8,11,18). Aging has been reported as a factor that leads to poor neurological and functional healing in individuals with complete SCI due to blunt trauma (8). On the other hand, it is concluded that there was no relationship between advanced age and recovery in patients with incomplete SCI. The baseline AIS value was suggested as an indicator of functional status in the first year after injury in a previous study. The same study revealed that patients with baseline AIS motor scores >50 had better functional outcomes (18). Previously, better motor recovery was found in patients with incomplete traumatic cervical SCI who were non-smokers after injury (19).

In another study, factors related to functional recovery as measured by FIM were reported as baseline AIS motor scores assessed within 72 hours after injury, education level,

comorbidities, spasticity, and age in patients with central cord syndrome (11).

Smoking is one of the most common risk factors of lyfestyle in terms of morbidity, especially with the three important organ system damage, cardiovascular, respiratory, and urinary systems, in SCI (20). It was concluded that each smoking year increased cardiovascular morbidity by 3.1%, respiratory system morbidity by 3.5%, and urinary system morbidity by 6% in patients with complete injury. The same study revealed that smoking is a serious health threat among patients with SCI. Smoking may cause pulmonary system complications in patients with SCI (21). There was no difference between the groups in terms of pulmonary complications. Because of the relatively short injury duration, the effects of smoking on the other systems were not evaluated in this study.

Currently-smokers were 49% of people with SCI in this study. The prevalence of cigarette smoking differs between 22% and 35% in SCI (4,5,22). Demirel et al. (6) reported smoking frequencies of 54% and 42% in individuals with SCI and controls, respectively. Smoking ratio is higher among patients with SCI than in the normal population (23). Previously, it was reported that the cigarette smoking ratio among patients with SCI was similar to that of healthy adult males in Türkiye (2).

Weaver et al. (4) concluded that 22% of the participants were still smoking cigarettes, whereas 51% had quit smoking in a study performed on 1210 veterans with chronic SCI with a mean injury duration of 20.7 years. In another study, it was reported that 22.6% of the individuals were still smoking, 49.2% were not smoking, and 28.2% had quit smoking in a previous study involving 1076 adults suffering from traumatic SCI, with injury duration ≥1 year (14).

Patients who continue to smoke have higher lung problems, pain, depression, and alcohol consumption than those who never smoked, and for this reason, smoking is a risk factor for other health problems in SCI as in the normal population (4).

In our study, no relationship was found between smoking and neither the frequency of pain nor emotional status. Previously, it was reported that smoking increased the intensity of neuropathic pain in two individuals struggling with neuropathic pain due to SCI, and the pain decreased after they quit smoking. This condition can be explained by the effect of nicotinic receptors on pain perception (16).

There are some strengths and limitations to this study. The strength of this study is that it is the first to investigate the relationship between smoking and functional gain in patients with SCI after inpatient rehabilitation. The limitations of this study are the relatively small number of patients and the lack of long-term follow-up.

## CONCLUSION

Smoking had negative effects on functional recovery after inpatient rehabilitation for SCI. Smoking cessation is beneficial for individuals with SCI.

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### ETHICS

**Ethics Committee Approval:** Ethical approval Approved by the Clinical Research Ethics Committee of İstanbul Physical Medicine and Rehabilitation Training and Research Hospital with (protocol number 2024- 38, date: 02.07.2024).

**Informed Consent:** Informed consent was obtained from all patients prior to their inclusion in the study.

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

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# Evaluation of Pre- and Postprocedural Oxidative Stress with TAC-TOS Score in Patients with Atrial Fibrillation Undergoing Atrial Fibrillation Ablation

## Atriyal Fibrilasyon Ablasyonu Yapılan Atriyal Fibrilasyonlu Hastalarda Preoperatif ve Postprosedural Oksidatif Stresin TAK-TOD Skoru ile Değerlendirilmesi

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## ABSTRACT

**Objective:** The balance between free oxygen and nitrogen species and physiological antioxidant mechanisms is crucial for maintaining vital tissue functions. Notably, oxidative stress affects the pathophysiology of many diseases, including atrial fibrillation (AF). We investigated the role of oxidative stress in AF and the effects of ablation procedures on oxidative stress.

**Methods:** A total of 40 patients who underwent cryoballoon or radiofrequency ablation for pulmonary vein isolation were enrolled in the study. Patients with well-known diseases associated with increased oxidative stress were excluded. The total antioxidative capacity and total oxidative status (TOS) values before and six months after the procedure were examined and evaluated according to rhythm status.

**Results:** After six months, there was a statistically significant difference in TOS compared with the preprocedure values (1880.05±1016.19 vs. 1418.32±1075.11, p=0.001). The postprocedural TOS value was significantly lower in the sinus rhythm group than in the patient group with AF (1237.48±1036.34 vs. 2270.88±870.20, p=0.013). However, there were significant differences between the paroxysmal and persistent AF groups according to preprocedural rhythm status (4.87±5.77 vs. 20.43±23.23, p=0.009). We did not find any association between C-reactive protein levels and the presence of arrhythmia after the procedure (11.29±16.19 vs. 13.70±25.47, p=0.662).

**Conclusion:** Oxidative stress, as evaluated by TOS values, can be a prognostic parameter for AF recurrence after ablation.

**Keywords:** Arrhythmia, atrial fibrillation, catheter ablation, oxidative stress

## ÖZ

**Amaç:** Serbest oksijen ve nitrojen türleri ile fizyolojik antioksidan mekanizmalar arasındaki denge, dokuların yaşamsal fonksiyonlarının devamlılığı için çok önemlidir. Oksidatif stres, atriyal fibrilasyonun (AF) yanı sıra birçok hastalığın patofizyolojisinde önemli rol oynamaktadır. Bu çalışmada oksidatif stresin AF üzerindeki rolü ve ablasyon prosedürlerinin oksidatif stres üzerine etkisi araştırılmıştır.

**Gereç ve Yöntem:** Pulmoner ven izolasyonu için kriyoballon veya radyofrekans ablasyon uygulanan toplam 40 hasta çalışmaya dahil edildi. Oksidatif stresi artırdığı bilinen hastalıkları olan hastalar çalışma dışı bırakıldı. İşlem öncesi ve işlemden altı ay sonraki total antioksidan kapasite ve total oksidatif durum (TOD) değerleri incelendi ve ritim durumuna göre değerlendirildi.

**Bulgular:** Altı ay sonra, işlem öncesi değerlerle karşılaştırıldığında TOD açısından istatistiksel olarak anlamlı bir fark vardı (1880,05±1016,19 vs. 1418,32±1075,11, p=0,001). İşlem sonrası TOD değeri sinüs ritmindeki hasta grubunda AF ritmindeki hasta grubuna göre istatistiksel olarak anlamlı derecede düşük bulundu (1237,48±1036,34 vs. 2270,88±870,20 p=0,013). İşlem öncesi ritim durumuna göre tanımlanan paroksismal ve

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## ÖZ

persitan AF grupları arasında anlamlı fark olmasına rağmen (4,87±5,77 vs. 20,43±23,23 p=0,009). C-reaktif protein ile işlem sonrası aritmi varlığı arasında herhangi bir ilişki bulunamadı (11,29±16,19 vs. 13,70±25,47, p=0,662).

**Sonuç:** TOD değerleri ile değerlendirilen oksidatif stres, ablasyon işleminden sonra AF tekrarlamasında prognostik bir parametre olabilir.


**Anahtar Kelimeler:** Aritmi, atriyal fibrilasyon, kateter ablasyon, oksidatif stress

## INTRODUCTION

Atrial fibrillation (AF) is the most common arrhythmia in clinical practice. Despite clinical advances in cardiology, the burden of AF remains a concern, especially in the elderly population. Several mechanisms and other clinical conditions are associated with the onset and persistence of AF, including hypertension, coronary artery disease, heart valve disease, and heart failure. AF shares common pathophysiological mechanisms with these pathologies. One of these mechanisms is inflammation and oxidative stress (OS) (1).

The balance between free oxygen and nitrogen species reactive oxygen species/reactive nitrogen species and physiological antioxidant mechanisms is crucial for maintaining the vital functions of tissues (2).

Reactive radicals produced during inflammatory processes, mainly from mitochondria, are the main sources of pro-oxidants generated in neutrophil respiratory bursts (3,4). These species have the potential to damage proteins, polynucleotides, and other tissues (5). Several physiological mechanisms counteract the harmful effects of free oxygen radicals in tissues. An imbalance between free radicals and antioxidant defense mechanisms is referred to as "OS". Although there is no gold standard method for evaluating OS, modalities such as measuring reactive radicals in leukocytes by flow cytometry; measuring modified forms of lipids, proteins and DNA; measuring enzymatic redox proteomics and markers; and measuring the total antioxidant capacity of body fluids are suggested (3). OS has been implicated in many pathophysiological conditions, such as aging, atherosclerosis, carcinogenesis, neurodegenerative diseases, pulmonary diseases, and arthritis (6-10).

The relationship between AF and OS is another research topic in this field. Although the role of OS in the pathophysiology of AF has been investigated, arrhythmia itself has been found to be associated with increased OS (11-15). It has been shown that inflammatory markers begin to increase in the early stages of new-onset AF (16). Moreover, previous studies have shown that the maintenance of sinus rhythm rates is low in patients with high basal inflammatory marker levels (17,18).

The present study aimed to investigate the relationship between AF and OS levels in patients with AF who underwent AF ablation.

## METHODS

### Study Population

The study included 40 patients with paroxysmal (n=22) and persistent (n=18) AF in two tertiary hospitals who were symptomatic and underwent AF ablation. Patients were classified into the paroxysmal and persistent AF groups based on the international guidelines (19). Patients underwent cryoablation (n=24) and radiofrequency (RF) (n=16) ablation according to the clinician's decision. Patients with congestive heart failure, end-stage renal disease, > moderate valvular heart disease, hypertrophic cardiomyopathy, or a history of myocardial infarction that affected the ejection fraction were excluded. Patient demographic data, such as age and sex, and clinical data, including medical treatment, were recorded. The study protocol complied with the ethical standards specified in the 1964 Declaration of Helsinki and was approved by the Clinical Research Ethics Committee (decision no: 2021-20-29, date: 18.10.2021) of University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital. Informed consent was obtained from the patients regarding the ablation procedure and their participation in the study.

### Biomarker Analysis

Fasting blood samples were collected before and 6 months after the ablation. The samples were centrifuged at 80 °C. The total anti-oxidant capacity (TAC) and total oxidative status (TOS) were evaluated using the method developed by Erel (20). The method's philosophy involves measuring the amount of ferric ions oxidized by oxidants in the medium and measuring the buffering capacity of the serum via the spectrophotometric measurement of O-dianisidine radicals from the $Fe^{2}$+ O-dianisidine complex. This molecule reacts with hydrogen peroxide, releasing free oxygen radicals into the environment. The end product is a yellowbrown-colored dianicidine radical [2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)], which allows spectrophotometric

measurement of color changes according to the buffering capacity of the environment. There was a reverse correlation between color change and antioxidant capacity. The reaction kinetics were calibrated using a standard method called the "Trolox equivalent".

### Catheter Ablation

Prior to the procedure, optimal antiarrhythmic and anticoagulant treatment compliance was ensured in the patients. All patients underwent transesophageal echocardiography under pseudoanalgesia to rule out intracardiac thrombi. Two venous lines for the coronary sinus catheter and ablation catheter and one arterial line for the pigtail catheter for guidance to the atrial septostomy were placed. After transseptal puncture, pulmonary vein isolation was achieved using a Medtronic Arctic Front Advance Cardiac Cryoablation System in patients who underwent cryoballoon ablation and a Biosense Webster Thermocool Smarttouch SF Uni-Directional Navigation Catheter in patients who underwent RF ablation. All septostomy procedures were performed under the guidance of transesophageal echocardiography. Procedural success was evaluated by assessing intrinsic and exit blocks via stimulation of the pulmonary veins and coronary sinus. All patients were in sinus rhythm at the end of the procedure.

### Postprocedure Follow-up

Patients were discharged with reorganized medical treatment and anticoagulation therapy according to the guidelines. Patients and their concurrent clinical conditions were followed for 6 months. After six months, the rhythm status was evaluated using 12-lead surface electrocardiograms, and biomarker samples were obtained. Patients with symptoms of palpitations without documented arrhythmia were evaluated using Holter monitoring.

### Statistical Analysis

The normality of the data was assessed using the Kolmogorov-Smirnov test. Continuous variables are expressed as means and standard deviations, whereas categorical variables are expressed as numbers and percentages. Comparisons between two groups were performed using the independent samples t-test or the Mann-Whitney U test, depending on the distribution of the data. Comparisons of the TAC and TOS before and after ablation were performed using the Wilcoxon signed-rank test. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

### Demographic and Clinical Data

Forty patients with paroxysmal (n=22) or persistent (n=18) AF that were symptomatic under medical treatment at two tertiary hospitals were enrolled in this study. Twenty-two patients were male and 18 were female. Demographic and clinical data are presented in Table 1.

### Comparison of Persistent and Paroxysmal AF (PAF) Patients

There were no significant differences in demographic or clinical data, except for thyroid-stimulating hormone and

**Table 1.** Clinical and demographic characteristics of the study population

| | |
|---|---|
| Age (years) | 55.30±12.04 |
| **Gender (n, %)** | |
| Male | 22 (55) |
| Female | 18 (45) |
| Cryoballoon ablation rate (n, %) | 27 (67.5) |
| RF ablation (n, %) | 13 (32.5) |
| **Six-month rhythm (n, %)** | |
| Sinus rhythm (n, %) | 33 (82.5) |
| Atrial fibrillation (n, %) | 7 (17.5) |
| Paroxysmal (n, %) | 22 (55) |
| Persistent (n, %) | 18 (45) |
| Beta blocker (n, %) | 36 (90) |
| Amiodarone (n, %) | 22 (55) |
| Propafenone (n, %) | 11 (27.5) |
| Calcium channel blockers (n, %) | 4 (10) |
| Digoxin (n, %) | 0 |
| Hypertension (n, %) | 21 (52.5) |
| Cerebrovascular disease (n, %) | 2 (5) |
| Coronary artery disease (n, %) | 10 (25) |
| Diabetes mellitus (n, %) | 7 (17.5) |
| Hemoglobin (g/dL) | 12.92±1.78 |
| Glucose (mg/dL) | 92.17±8.31 |
| C-reactive protein (mg/dL) | 11.66±17.52 |
| Urea (mg/dL) | 29.74±8.52 |
| Creatinine (mg/dL) | 0.84±0.17 |
| TSH (mIU/L) | 2.07±1.82 |
| TOS preprocedural | 1880.05±1016.19 |
| TOS postprocedural | 1418.32±1075.11 |
| TAC preprocedural | 0.44±0.30 |
| TAC postprocedural | 0.56±0.39 |

RF: Radiofrequency, TAC: Total antioxidative capacity, TOS: Total oxidative stress, TSH: Thyroid stimulating hormone

creatinine levels, between the two groups. Compared with PAF, cryoballoon ablation was significantly preferred (19 vs. 8, p=0.004), whereas RF ablation was more frequently performed in the persistent AF group (4 vs. 10, p=0.013). C-reactive protein (CRP) levels were significantly lower in patients in the PAF group than in patients in the persistent AF group (4.87±5.77 vs. 20.43±23.23, p=0.009).

There were no significant differences in preprocedural TOS (1805.17±1186.31 vs. 1874.26±1040.31, p=0.856), postprocedural TOS (1379.45±1212.38 vs. 1516.56±1146.69, p=0.888), preprocedural TAC (0.076± 0.71 vs. -0.214±0.46, p=0.153), or postprocedural TAC between the paroxysmal and persistent AF groups (-0.035±0.79 vs. 0.14±0.57, p=0.423). Table 2 shows the clinical and biochemical features of patients with persistent and PAF.

### Comparison of Patients with Sinus Rhythm and AF

At the 6- month follow-up, sinus rhythm was sustained in 33 patients, and 7 patients had AF. The mean age of patients with an AF rhythm was significantly greater than that of patients with a sinus rhythm (66.57±9.07 vs. 52.91±11.30 years, p=0.005). Patients with sinus rhythm had lower blood urea levels than those with AF did (27.86±7.67 vs. 38.59±6.87, p=0.002).

Postprocedural TOS was significantly lower in the sinus rhythm group than in the patient group with AF rhythm (1237.48±1036.34 vs. 2270.88±870.20 p=0.013).

In both groups, preprocedural TOS (1779.94±1036.08 vs. 2352.02±819.78, p=0.179), preprocedural TAC (0.41±0.32 vs. 0.57±0.15, p=0.167), postprocedural TAC (0.56±0.41 vs. 0.55±0.34, p=0.986), and CRP (11.29±16.19 vs. 13.70±25.47, p=0.662) values were similar (Table 3).

### Comparison of Patients by the Type of Ablation Procedure

Preprocedural TOS (1611.19±968.14 vs 2379.37±939.34 p=0.021) and postprocedural TOS (1093.13±888.31 vs. 2022.25±1160.09 p=0.014) were significantly lower in patients who underwent cryoballoon ablation than in those who underwent RF ablation (Table 4).

**Table 2.** Demographical and clinical data of the paroxysmal and persistent AF groups

| | Paroxysmal AF (n=22) | Persistent AF (n=18) | p-value |
|---|---|---|---|
| Age (years) | 55.14±12.47 | 55.50±11.86 | 0.926 |
| **Gender (n, %)** | | | |
| Male | 9 (40.9) | 13 (72.2) | |
| Female | 13 (59.1) | 5 (27.8) | |
| Cryoballoon ablation (n, %) | 19 (86.4) | 8 (44.4) | **0.004** |
| RF ablation (n, %) | 4 (18.2) | 10 (55.6) | **0.013** |
| Beta blocker (n, %) | 21 (95.5) | 15 (83.3) | 0.204 |
| Amiodarone (n, %) | 9 (40.9) | 13 (72.2) | **0.045** |
| Propafenone(n, %) | 9 (40.9) | 2 (11.1) | **0.036** |
| Calcium channel blockers (n, %) | 1 (4.5) | 3 (16.7) | 0.204 |
| Hypertension (n, %) | 11 (50) | 10 (55.6) | 0.736 |
| Cerebrovascular disease (n, %) | 2 (9.1) | 0 | 0.492 |
| Coronary artery disease (n, %) | 5 (22.7) | 5 (27.8) | 0.731 |
| Diabetes mellitus (n, %) | 3 (13.6) | 4 (22.2) | 0.680 |
| Hemoglobin (g/dL) | 13.20±1.72 | 12.57±1.86 | 0.279 |
| Urea (mg/dL) | 28.04±8.39 | 31.38±8.43 | 0.168 |
| Creatinine (mg/dL) | 0.78±0.15 | 0.89±0.15 | **0.038** |
| TSH mIU/L | 1.74±1.85 | 2.51±1.72 | **0.038** |
| C-reactive protein (mg/dL) | 4.87±5.77 | 20.43±23.23 | **0.009** |
| TOS preprocedural | 1805.17±1186.31 | 1874.26±1040.31 | 0.856 |
| TOS postprocedural | 1379.45±1212.38 | 1516.56±1146.69 | 0.888 |
| TAC preprocedural | 0.076±0.71 | -0.214±0.46 | 0.153 |
| TAC postprocedural | -0.035±0.79 | 0.14±0.57 | 0.423 |

RF: Radiofrequency, TAC: Total antioxidative capacity, TOS: Total oxidative stress, TSH: Thyroid stimulating hormone, AF: Atrial fibrillation

**Table 3.** Demographic and clinical data, oxidative status, and antioxidant capacity according to rhythm status

| | Sinus rhythm (n=33) | Atrial fibrillation (n=7) | p-value |
|---|---|---|---|
| Age (years) | 52.91±11.30 | 66.57±9.07 | **0.005** |
| **Gender (n, %)** | | | 0.122 |
| Male | 20 (60.6) | 2 (28.6) | |
| Female | 13 (39.4) | 5 (71.4) | |
| Cryoballoon ablation (n, %) | 22 (69.7) | 4 (57.1) | 0.519 |
| RF ablation (n, %) | 11 (33.3) | 3 (42.9) | 0.631 |
| Hypertension (n, %) | 16 (48.5) | 5 (71.4) | 0.270 |
| Cerebrovascular disease (n, %) | 1 (3) | 1 (14.3) | 0.215 |
| Coronary artery disease (n, %) | 7 (21.2) | 3 (42.9) | 0.230 |
| Diabetes mellitus (n, %) | 6 (18.2) | 1 (14.3) | 0.805 |
| Hemoglobin (g/dL) | 13.14±1.74 | 11.87±1.74 | 0.049 |
| C-reactive protein (mg/dL) | 11.29±16.19 | 13.70±25.47 | 0.662 |
| Urea (mg/dL) | 27.86±7.67 | 38.59±6.87 | **0.002** |
| Creatinine (mg/dL) | 0.82±0.16 | 0.93±0.18 | 0.127 |
| TSH mIU/L | 2.18±1.88 | 1.31±1.25 | 0.288 |
| TOS preprocedural | 1779.94±1036.08 | 2352.02±819.78 | 0.179 |
| TOS postprocedural | 1237.48±1036.34 | 2270.88±870.20 | **0.013** |
| TAC preprocedural | 0.41±0.32 | 0.57±0.15 | 0.167 |
| TAC postprocedural | 0.56±0.41 | 0.55±0.34 | 0.986 |

RF: Radiofrequency, TAC: Total antioxidative capacity, TOS: Total oxidative stress, TSH: Thyroid stimulating hormone

**Table 4.** Oxidative parameters of patients according to the type of ablation procedure

| | Cryoballoon ablation (n=26) | RF ablation (n=14) | p-value |
|---|---|---|---|
| TOS preprocedural | 1611.19±968.14 | 2379.37±939.34 | **0.021** |
| TOS postprocedural | 1093.13±888.31 | 2022.25±1160.09 | **0.014** |
| TAC preprocedural | 0.39±0.30 | 0.53±0.28 | 0.164 |
| TAC posprocedural | 0.55±0.39 | 0.57±0.42 | 0.919 |

TAC: total anti-oxidant capacity, TOS: Total oxidative stress, RF: Radiofrequency

When all patients were compared before the ablation procedure and at six months, there was a statistically significant difference in TOS compared with preprocedure values (1880.05±1016.19 vs. 1418.32±1075.11, p<0.001). Pre- and postoperative TAC did not change in the entire study population (0.44±0.30 vs. 0.56±0.39 p=0.098).

## DISCUSSION

The relationship between AF and OS is complex. There is increasing evidence that AF is associated with high systemic and cardiac OS. However, whether OS causes AF or whether AF increases OS remains to be determined. Although existing studies suggest that OS plays an important role in the development of AF, there is limited evidence that OS decreases after ablation.

In our study, we found lower OS levels according to TOS after ablation than before the procedure. Subgroup analyses could not be performed due to the sample size and the transition between groups at the end of the 6$^{th}$ month due to the rhythm status. However, when postprocedure TOS values were evaluated according to rhythm status, OS seemed to be associated with the presence of arrhythmia.

Neuman et al. (12) reported a positive correlation between the presence of AF and the levels of oxidative and inflammatory markers in their 2007 study. In a study investigating the effects of AF recurrence after ablation, Shimano et al. (14) reported that AF recurrence was correlated with serum reactive oxidative metabolites. According to a study conducted by Henningsen et al. (13), high sensitivity-C-reactive protein (hs-CRP) and IL-6 may have predictive value for the recurrence of AF after successful catheter ablation. In contrast, the antioxidant capacity evaluated by TAC was not directly associated with the presence of arrhythmia. These findings related to anti-oxidant capacity were consistent with the data of our

study. In contrast, there was no relationship between AF recurrence and CRP levels.

Tascanov et al. (21) investigated the relationships among TOS, DNA damage, and PAF. A series of 56 patients with PAF were compared with healthy controls. They reported that hs-CRP, TOS, and 8-hydroxy-2-deoxyguanosine levels were greater in the PAF group. They also suggested that TOS and DNA damage could be used to identify patients at greater risk for AF. A similar study conducted by Neuman et al. (12) in patients with persistent AF revealed that the levels of reactive oxygen metabolites were greater in patients with AF than in controls. In both studies, it was not clear whether OS caused AF or increased OS. In our study, although TOS decreased significantly in patients in sinus rhythm at the end of the 6- month period compared with before the procedure, no significant change was observed in patients who developed AF. These findings suggest that AF increases OS.

The levels of inflammatory markers are increased in patients with AF. This result was due to the presence of cytokines. Many inflammatory cytokines increase fibrosis by promoting the proliferation of cardiac fibroblasts, promoting their differentiation into myofibroblast, and increasing collagen deposition (22). In our study, we also measured and compared the levels of CRP, a well-known inflammatory marker. Although there were significant differences between the paroxysmal and persistent AF groups according to preprocedural rhythm status, no association was noted between CRP levels and ARF after the procedure. Similarly, a study by Neuman et al. (12) involving 40 male subjects with or without permanent or permanent AF revealed that OS was significantly associated with AF, whereas inflammatory markers were not. Conway et al. (23) reported that CRP predicted initial but not long-term cardioversion success. The fact that AF is associated with OS but not inflammatory markers indicates that OS plays a more prominent role than inflammation in the maintenance of AF rather than its initiation.

Catheter ablation techniques play an increasingly important role in the clinical management of AF. Currently, two main catheter ablation methods are used for the treatment of AF. RF ablation provides pulmonary vein potential for isolation. The second approach is cryoablation, a frozen balloon atrial isolation technique that provides bidirectional isolation of the atrial pulmonary venous potential by freezing the balloon into the pulmonary vein. Both techniques have been shown to have similar clinical efficacy (24). On the other hand, postprocedural inflammatory responses and therefore OS responses may differ. Schmidt et al. (25) compared myocardial enzymes and inflammation markers using different catheter ablation methods and reported a more significant increase in hs-CRP levels after RF ablation than after cryoablation. However, the authors did not find a significant difference in the duration of postoperative inflammation between the two methods. Rienstra et al. (26) followed >900 patients for 5 years and reported that recurrence was greater in patients with higher inflammation parameters, but there are no conclusive results on whether there are differences in the inflammation indices after different catheter ablation methods and whether inflammation is associated with postoperative AF recurrence. In our study, we did not find any differences between the two ablation techniques in terms of long-term OS parameters. Although our sample size was small, we did not find any significant difference between the two techniques in terms of AF recurrence.

Other findings from our study also deserve further investigation. Patients who failed ablation were older and had higher urea levels. Although these patients also had higher creatinine levels, the difference from patients who underwent successful ablation did not reach statistical significance. Similarly, patients with persistent AF had higher creatinine levels, highlighting the importance of traditional risk factors for AF occurrence and treatment.

### Study Limitations

There are several limitations in our study. There was essentially no control group because the characteristics of the study population necessitated further treatment. Ethically, a control group could not be recruited because the research was conducted on a patient population in need of advanced treatment. Second, because of the sample size, we could not evaluate the data in fixed cohorts. According to the rhythm status, there were transitions between the groups; therefore, we evaluated the data cross-sectionally. Although the patients were followed closely, their rhythm status at the 6- month follow-up was evaluated according to the rhythm holter performed according to the patient's complaints and control electrocardiography. Rhythm holders were not used for any of the patients. Additionally, the treatment modality (cryoballoon ablation vs. RF ablation) was selected according to the clinician's recommendation.

## CONCLUSION

Oxidative markers are associated with sinus rhythm restoration after ablation therapy. Current AF treatment is primarily based on stroke prevention, rate, and rhythm control. A better understanding of AF pathogenesis may also reveal new treatment options that may help delay or ideally suppress AF progression. However, increasing

pathophysiological and clinical knowledge can guide more rational choices regarding patient selection and treatment options. Future research should focus on translating our basic understanding of the role of OS in AF pathophysiology into more focused preventive strategies and more effective treatment options, for which the possible causal relationship between OS and AF still needs to be clarified; hence, studies with larger patient populations are needed to investigate the association between OS and AF recurrence.

### Acknowledgements

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### ETHICS

**Ethics Committee Approval:** The study protocol was in accordance with the ethical standards stated in the 1964 Helsinki Declaration and was approved by the Clinical Research Ethics Committee of University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital (decision no: 2021-20-29, date: 18.10.2021).

**Informed Consent:** Informed consent was obtained from the patients regarding the ablation procedure and their participation in the study.

### Authorship Contributions

Concept: E.O., A.S.E., A.K., N.I., V.S.Ş., Design: E.O., A.S.E., M.E.A., A.K., F.N.T.Ç., Data Collection or Processing: E.O., A.S.E., M.E.A., C.Y., N.I., V.S.Ş., F.N.T.Ç., Analysis or Interpretation: E.O., A.S.E., M.E.A., C.Y., A.K., N.I., V.S.Ş., F.N.T.Ç., Literature Search: A.S.E., M.E.A., A.K., F.N.T.Ç., Writing: E.O., A.S.E., A.K.

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

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# Effectiveness of Surgical Treatment for Far-lateral Lumbar Disc Herniation: A Single Surgeon's Perspective

## Far-lateral Lomber Disk Hernisinde Cerrahi Tedavinin Etkinliği: Tek Cerrahın Bakış Açısı

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## ABSTRACT

**Objective:** Far-lateral lumbar disc herniation (FLLDH), also called extraforaminal or intraforaminal disc herniation, affects nerve roots located outside the boundaries of the spinal canal, unlike central or posterolateral disc herniation. Only 10% of patients with FLLDH benefit from conservative treatment. In this study, we aimed to explore the experiences and mid-term surgical outcomes of patients who underwent extraforaminal microdiscectomy for FLLDH via a midline incision.

**Methods:** The study data were retrospectively extracted from medical records between April 01, 2020 and February 1, 2023. Patients were assessed according to age, gender, pain localization, preoperative motor deficits, reflex changes, symptom duration, FLLDH level, preoperative visual analog scale (VAS) score, and 3- and 6-month postoperative VAS scores.

**Results:** In this study, we enrolled a total of 12 patients, comprising 6 females and 6 males, with a mean age of 53.8±12.6 (range, 25-67) years. The mean preoperative duration of symptoms was 35.5±14.5 (range, 17-65) days. Although the mean VAS score of our patients was 9.25 before the operation, it was 0.3 at 6 months postoperatively.

**Conclusion:** Although FLLDH is less prevalent, surgical intervention is more commonly used because of the indications of increased pain severity. Microdiscectomy is the gold standard for effectively managing distant lateral disc herniation and consistently demonstrates remarkably superior outcomes compared with conventional lumbar disc hernia surgery.

**Keywords:** Microdiscectomy, lumbal disc herniation, pain, extraforaminal

## ÖZ

**Amaç:** Ekstraforaminal veya intraforaminal disk herniasyonu olarak da adlandırılan far-lateral lomber disk herniasyonu (FLLDH), daha yaygın olan merkezi veya posterolateral disk herniasyonlarının aksine, spinal kanalın sınırları dışında bulunan sinir köklerini etkiler. FLLDH'si olan hastaların sadece %10'u konservatif tedaviden fayda görmektedir. Çalışmamızda FLLDH nedeniyle orta hat kesisinden ekstraforaminal mikrodiskektomi uygulanan hastaların deneyimlerini ve orta dönem cerrahi sonuçlarını araştırıyoruz.

**Gereç ve Yöntem:** Çalışma verileri, hastaların 01 Nisan 2020 ile 1 Şubat 2023 tarihleri arasındaki tıbbi kayıtlarından retrospektif olarak elde edildi. Hastalar yaş, cinsiyet, ağrı lokalizasyonu, ameliyat öncesi motor defisitler, refleks değişiklikleri, semptom süresi, düzeyine göre değerlendirildi. FLLDH, ameliyat öncesi vizüel analog skala (VAS) skorunun yanı sıra ameliyat sonrası 3 aylık ve 6 aylık VAS skorlarına göre değerlendirildi.

**Bulgular:** Çalışmamıza ortalama yaşları 53,8±12,6 (25-67) yıl olan 6'sı kadın, 6'sı erkek olmak üzere toplam 12 hasta dahil edildi. Ameliyat öncesi ortalama semptom süresi 35,5±14,5 (aralık, 17-65) gündü. Hastalarımızın ameliyat öncesi ortalama VAS skoru 9,25 iken ameliyat sonrası 6. ayda 0,3 olarak tespit edildi.

**Sonuç:** FLLDH daha az görülmekle birlikte, ağrı şiddetinin arttığına dair belirtiler nedeniyle tedavisinde cerrahi müdahale ön plana çıkmaktadır. Mikrodiskektomi, far-lateral lomber disk hernisinin etkili bir şekilde yönetilmesinde altın standart olarak duruyor ve geleneksel lomber disk hernisi cerrahisine kıyasla sürekli olarak dikkat çekici derecede üstün sonuçlar ortaya koyuyor.

**Anahtar Kelimeler:** Mikrodiskektomi, lomber disk hernisi, ağrı, ekstraforaminal

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## INTRODUCTION

Far-lateral lumbar disc herniation (FLLDH), also referred to as extraforaminal or intraforaminal lumbar disc herniation, occurs when the nucleus pulposus protrudes through the annulus fibrosus and extends toward the outermost lateral aspect of the spinal column. Unlike the more frequently encountered central or posterolateral disk herniation, the far-lateral herniation typically impacts the nerve roots located outside the confines of the spinal canal (1,2).

Studies have demonstrated that distant lateral disc hernias account for 7-12% of all lumbar disc herniations (3,4). These hernias are most frequently observed at the L3-4 and L4-5 levels, whereas their occurrence is rare at the L2-3 and L5-1 levels (5).

Symptoms arising from FLLDH are contingent on the specific nerve root affected and can exhibit variability from one individual to another. Common manifestations include localized back pain, sciatica, numbness, tingling, and weakened lower limb sensations. Diverging from central disc herniations, which may exert pressure on the cauda equina, far lateral disc herniations tend to evoke more focal symptoms that are confined to a distinct root level (6).

In the context of treatment, akin to all lumbar disc herniations, the primary approach revolves around conservative measures, including rest, anti-inflammatory medication, and physical therapy, when managing distant lateral lumbar disc herniation (7). Regrettably, a significant proportion of patients do not experience favorable outcomes through these interventions. The decision to pursue surgical intervention for distant lateral disc herniation is influenced by several factors, such as the precise location of the disc and the surgeon's individual expertise and background (8,9).

In this study, we aimed to explore the experiences and mid-term surgical outcomes of patients who underwent extraforaminal microdiscectomy for FLLDH via a midline incision. We also examined the benefits of the surgical technique employed, as reported by these patients.

## METHODS

The study, which was designed as a retrospective cohort investigation, was initiated after obtaining approval from the University of Health Sciences Türkiye, Bursa City Hospital Clinical Research Ethics Committee (decision no: 2023-14/4, date: 16.08.2023). The study data were retrospectively extracted from the medical records of patients between April 01, 2020 and February 1, 2023.

Patients were assessed according to age, gender, pain localization, preoperative motor deficits, reflex changes, symptom duration, FLLDH level, preoperative visual analog scale (VAS) score, as well as 3-3-month and 6-month postoperative VAS scores. Notably, no perioperative or postoperative complications were observed among any of the patients. Comprehensive follow-up was conducted over a period of 12 months for all participants.

### Surgical Procedure

After anesthesia administration, the patient is positioned appropriately. Prior to commencing the procedure, C-arm fluoroscopy is used to precisely determine the level and extent of the skin incision. After creating a midline skin incision of approximately 3 cm, the fascia is incised along the midline, and the paravertebral muscles are meticulously detached subperiosteally. Subsequently, a Taylor retractor was positioned adjacent to the facet joint, and its placement was verified under fluoroscopic guidance. After visualizing the upper edge of the transverse process, the lateral edge of the pars interarticularis, and the facet joint complex, the operative field is further magnified using a microscope. Depending on the region of the extruded disc, a section of bone is excised from the lateral aspect of the pars interarticularis using Kerrison rongeur. In cases where appropriate, bone is removed from the upper-lateral surface of the facet joint. Then, meticulous dissection around the transverse ligament exposes the root and dorsal root ganglion, enhancing their visibility after the surrounding adipose tissue is gently cleared. To ensure unimpeded root movement, adjacent tissues are meticulously excised, and fragmentectomy was performed to access and remove the extruded disc segment. If necessary, microdiscectomy is performed to access the disc space. After confirming the relaxation of the root and establishing hemostasis, the procedure was concluded.

### Statistical Analysis

IBM SPSS 21.00 packaged software was used for data analysis. Descriptive statistics were used to evaluate the data. Categorized data are presented as frequency-percentage ratios, and quantitative data are presented as mean and standard deviation.

## RESULTS

In our study, we enrolled a total of 12 patients, including 6 females and 6 males, with a mean age of 53.8±12.6 (range, 25-67) years. The distribution of lesions among the patients was as follows: 50% (6 patients) had lesions at the L4-L5 level, 25% (3 patients) at the L3-L4 level, and another 25% (3 patients) at the L5-S1 level. The mean preoperative duration of symptoms was 35.5±14.5 (range, 17-65) days, and the mean operative time was 77.9±17.5 (range, 70-90) minutes.

A 12-month follow-up period was maintained for all patients (Table 1). Notably, no complications emerged during the perioperative and postoperative phases, and no recurrence was observed. All patients were discharged within 1 day after surgery.

Before surgery, patients reported a mean VAS score of 9.25±0.8 (range, 8-10), which significantly decreased in the early postoperative period. Assessment of the VAS score at the third and sixth postoperative months revealed that most patients achieved a VAS score of 0 by the sixth postoperative month.

## DISCUSSION

In 1974, Abdullah et al. (10) described the clinical features of FLLDH. The mean age of the patients was 53 years, which was consistent with the study of Abdullah et al. (10).

Distant lateral disc herniation places direct pressure on the dorsal root ganglion, resulting in notably intense radicular pain within the dermatome. This phenomenon is attributed to ganglion compression and subsequent sensory nerve pressure, which distinguishes from medial disc herniation (Figure 1) (10).

**Table 1.** Demographic and clinical characteristics of the patients

| | Mean ± SD/n (%) | Min-max |
|---|---|---|
| Age (years) | 53.8±12.6 | 25-67 |
| **Gender** | | |
| Female | 6 (50%) | |
| Male | 6 (50%) | |
| **Pain location** | | |
| Knee | 2 (16.6%) | |
| Above the knee | 1 (8.4%) | |
| Below the knee | 6 (50%) | |
| Ankle | 3 (25%) | |
| **Hernia level** | | |
| L3-4 | 3 (25%) | |
| L4-5 | 6 (50%) | |
| L5-S1 | 3 (25%) | |
| Preoperative symptom duration (days) | 35.5±14.5 | 17-65 |
| **Surgical approach** | | |
| Fragment excision | 9 (75%) | |
| Fragment excision + disc excision | 3 (25%) | |
| Operative time (minutes) | 77.9±17.5 | 70-90 |
| **VAS score** | | |
| Preoperative | 9.25±0.8 | 8-10 |
| Postoperative | 3.41±1.6 | 2-8 |
| Postoperative 3-month | 1.08±0.9 | 0-3 |
| Postoperative 6-month | 0.3±0.4 | 0-1 |

SD: Standard deviation, min-max: Minimum-maximum, VAS: Visual analog scale

The symptoms exhibited by our patients generally correlated with the specific level of lumbar disc herniation. One patient reported leg pain radiating below the knee, two experienced knee pain, three described ankle pain, and six complained of pain beneath the knee.

In our patient cohort, FLLDH predominantly occurred at the L4-5 level, which aligns with existing literature findings. However, it is noteworthy that the occurrence of FLLDH at the L5-S1 level was relatively more frequent than that reported in the literature (5).

As with all lumbar disc herniations, the primary treatment option is conservative. However, it is important to note that approximately 90% of far lateral disc herniations do not respond positively to conservative treatment, necessitating surgical intervention (11,12).

The relatively shorter preoperative duration of symptoms can be attributed to the increased severity of pain in cases of FLLDH compared with classical lumbar disc herniation. This finding also underscores the increased risk of developing chronic neuropathic pain (13). Our study revealed that patients underwent surgery, on average, 35.5±14.5 days after the onset of their initial symptoms.

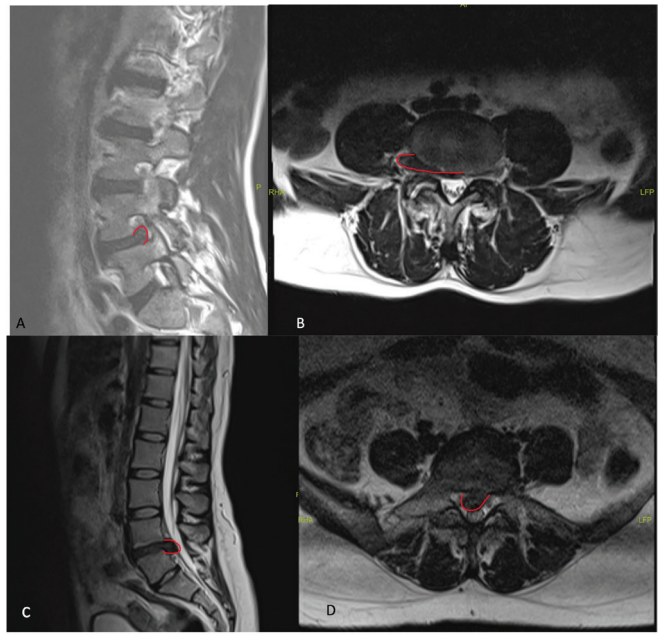


**Figure 1.** A: T2 saggital MRI, L4-5 right far-lateral lumbar disc hernaition; B: T2-axial MRI, L4-5 right far-lateral lumbar disc herniation; C: T2-saggital MRI, L4-5 right clasic lumbar disc hernaition; D: T2-saggital MRI, L4-5 right far-lateral lumbar disc herniation
MRI: Magnetic resonance imaging

In the literature, research into approaches for treating far lateral disc hernias gained significant momentum through the mid-1980s. During this period, hemilaminectomy was demonstrated to facilitate access to the far lateral disc hernias (14,15). As time has progressed, the significance of maintaining spinal stability has become increasingly apparent in various spinal surgical techniques. Consequently, numerous techniques have been delineated for surgery involving far lateral disc herniation over the years. Of note, the extraforaminal microsurgical approach, which we also used, was initially introduced by Reulen et al. (16).

The overarching goal of the approaches described thus far is to execute discectomy while minimizing tissue damage. In recent years, microdiscectomy has emerged as the gold standard for the surgical management of distant lateral disc herniations (17,18). For surgeons which are in the early stages of gaining experience, a keen grasp of anatomical orientation is of paramount importance. Anatomical orientation is effectively achieved by dissecting the paravertebral muscles from the spinous process following a median incision-a technique common to all lumbar disc surgeries. This approach is particularly harnessed in FLLDH surgery, thereby leveraging the familiarity of surgeons with this technique. This exposure facilitates visualization of the lateral and pars interarticularis facets, thereby enhancing surgical orientation and minimizing potential complications.

In contrast, Al-Khawaja et al. (19) suggested that the subperiosteal approach is associated with reduced discomfort compared with the intramuscular approach, owing to its influence on only a single muscle (20).

Recent surgical procedures employed for addressing far lateral disc herniation include the conventional midline approach, as well as partial or complete resection of the pars interarticularis and/or inferior facet. Although the operative time might appear somewhat extended based on existing literature, it is suggested that this is relatively manageable for surgeons who have accrued newfound expertise (20,21). We applied this approach, which has been used recently, to all our patients. In addition, Kotil et al. (22) similar to the study, fragment excision alone was performed in 75% of patients, whereas both fragment excision and disc excision were performed in 25% of patients.

Contemporary studies have predominantly assessed the advantages of FLLDH surgery through metrics like the Oswestry disability index or VAS score (1,20,23,24). In our investigation, we used the VAS score. Notably, the mean VAS score before surgery stood at 9.25±0.8, which substantially improved to a mean score of 0.3±0.4 during the 6-month postoperative evaluation. Intriguingly, our study demonstrated the most noteworthy enhancement in VAS score, as per the available literature.

## CONCLUSION

Although FLLDH is less prevalent, surgical intervention takes precedence in its management because of the indications of increased pain severity. Microdiscectomy is the gold standard for effectively managing distant lateral disc herniation and consistently demonstrates remarkably superior outcomes compared with conventional lumbar disc hernia surgery.

### ETHICS

**Ethics Committee Approval:** The study, which was designed as a retrospective cohort investigation, was initiated after obtaining approval from the University of Health Sciences Türkiye, Bursa City Hospital Clinical Research Ethics Committee (decision no: 2023-14/4, date: 16.08.2023).

**Informed Consent:** Retrospective study.

### Authorship Contributions

Surgical and Medical Practices: D.B., Concept: D.B., Design: D.B., Data Collection or Processing: M.Z.Ç., Analysis or Interpretation: M.Z.Ç., Literature Search: M.Z.Ç., Writing: D.B.

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

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# Evaluation of Hand Hygiene Beliefs and Practices Among Healthcare Workers in a Training and Research Hospital

## Bir Eğitim Araştırma Hastanesinde Sağlık Çalışanlarında El Hijyeni İnancı ve Uygulamalarının Değerlendirilmesi

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## ABSTRACT

**Objective:** Hand hygiene is an essential step in preventing healthcare-associated infections. Gaining information and improving hand hygiene among healthcare workers can contribute to the prevention of nosocomial infections. Although studies in the literature emphasize hand hygiene compliance, data on hand hygiene beliefs are limited.

**Methods:** This study was a descriptive research among employees between May and July 2022. Data obtained from surveys called the Hand Hygiene "belief scale" and "practice inventory" administered to healthcare workers were collected.

**Results:** A total of 1556 healthcare workers were interviewed. As the education level increased, a significant increase was found in the belief in hand hygiene and its importance scale. Women have a higher belief in hand hygiene than men. The hand hygiene belief scale scores of healthcare workers working in outpatient clinics were higher than those of healthcare workers in the emergency room and intensive care. Compliance with hand hygiene decreases with increasing risk and workload. When the shift times were evaluated, daytime workers scored higher on the belief scale than night workers.

**Conclusion:** Our study revealed that hand hygiene was affected by factors such as education, profession, gender, length of service, shift time, and department. Therefore, unit-specific or individual plans are required.

**Keywords:** Health care associated infections, hand hygiene, hand hygiene beliefs and practices, infection control, infection

## ÖZ

**Amaç:** El hijyeni sağlık hizmeti ilişkili enfeksiyonların önlenmesinde önemli adımlardan biridir. Sağlık çalışanlarının el hijyeni konusunda bilgilendirilmesi ve iyileştirmeler yapılması hastane enfeksiyonlarının önlenmesine katkı sağlayacaktır. Literatürde el hijyenine uyumu vurgulayan çalışmalar mevcutken, el hijyeni inançlarına ilişkin veriler sınırlıdır.

**Gereç ve Yöntem:** Çalışmamız Mayıs ve Temmuz 2022 tarihleri arasında tanımlayıcı bir araştırma olarak planlandı. Sağlık çalışanlarına uygulanan El Hijyeni "inanç ölçeği" ve "uygulama envanteri" adlı anketlerden elde edilen veriler toplandı.

**Bulgular:** Toplam 1556 sağlık çalışanıyla görüşme yapıldı. Eğitim düzeyi arttıkça el hijyenine olan inanç ve önem ölçeğinde anlamlı bir artış tespit edildi. Kadınların el hijyenine olan inancının erkeklere göre daha yüksek olduğu belirlendi. Polikliniklerde çalışan sağlık çalışanlarının el hijyeni inanç ölçeği puanları, acil servis ve yoğun bakımda çalışan sağlık çalışanlarına göre daha yüksekti. Risk ve iş yükünün artmasıyla birlikte el hijyenine uyum azalmaktaydı. Vardiya sürelerini değerlendirdiğimizde; gündüz çalışanların inanç ölçeğinde gece çalışanlarına göre daha yüksek puanları vardı.

**Sonuç:** Çalışmamız el hijyeninin eğitim, meslek, cinsiyet, hizmet süresi, vardiya süresi, çalışılan bölüm gibi faktörlerden etkilendiğini göstermektedir. Bu nedenle üniteye özel veya bireysel planlamaların yapılması gerekmektedir.

**Anahtar Kelimeler:** Sağlık bakımı ilişkili enfeksiyonlar, el hijyeni, el hijyeni inanç ve uygulamaları, enfeksiyon kontrolü, enfeksiyon

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## INTRODUCTION

Hand hygiene is an essential step in preventing healthcare-associated infections. Therefore, evaluating the hand hygiene practices of healthcare professionals, identifying deficiencies, and taking regulatory steps, any improvements made to hand hygiene knowledge and processes will help prevent infections.

Although many studies in the literature emphasize hand hygiene compliance (1,2), data on hand hygiene beliefs are limited (3). The hand hygiene belief survey (4) questions the belief in the necessity of hand hygiene practice and is useful for identifying the causes of problems in hand hygiene behavior.

Our study aims to understand the beliefs and behaviors of healthcare professionals regarding hand hygiene practices and to provide guidance in establishing appropriate attitudes and practices by examining them in detail. For this purpose, the impact of descriptive factors such as age, years of service, gender, educational status, marital status, service, and professional groups of healthcare workers on hand hygiene beliefs and practices was evaluated and presented.

## METHODS

This descriptive research was conducted among University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital employees between May and July 2022. The universe consisted of all hospital employees, and data were obtained from people selected through convenience sampling. The research sample comprised healthcare professionals from different departments with different levels of experience. The study complied with the principles of the Declaration of Helsinki, and approval was received from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (decision no: 2024-01-08, date: 22.01.2024).

The data obtained from the surveys called the Hand Hygiene "belief scale" and the "practice inventory" (4,5) were collected from 1556 healthcare workers who were not on leave and volunteered to participate in the research through one-on-one interviews with the participants. In the survey, 17.1% of the healthcare professionals were assistant physicians, 52.6% were nurses-medical officers-midwives, 14% were specialist doctors, and 5.9% were associate professors or professors.

During data collection, volunteers were informed that the scales should be filled out completely and carefully and that the study data would be used only for scientific purposes. To avoid affecting healthcare professionals, the participants were asked to answer the form individually. Each healthcare worker took an average of 15 minutes to complete the form. The authors obtained informed consent from all participants in this study.

Age, years of service, department, hand hygiene practice inventory (HHPI), and hand hygiene belief scale (HHBS) were applied to healthcare workers. The HHPI and HHBS were developed by de Mortel (4) in 2009, and their validity and reliability in Turkish were established by Karadağ et al. (6). While the HHPI evaluates hand hygiene practice through a 14-item survey, the HHBS evaluates belief in hand hygiene through a 22-item survey. Both data collection tools were collected by rating and scoring the respondents' answers. The HHPI total score varies between 14-70 points, and a high score indicating compliance with hand hygiene.

In the HHBS, eight items (numbered 5, 8, 10, 16, 17, 18, 19, and 20) were reverse-scored, and the total score varied between 22 and 110. An increase in the total score indicates a positive belief in hand hygiene (6).

### Statistical Analysis

Number Cruncher Statistical System 2020 (Kaysville, Utah, USA) program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, first quartile, third quartile, frequency, percentage, minimum, maximum) were used to evaluate the study data. The suitability of quantitative data for normal distribution was tested using the Shapiro-Wilk test and graphical analysis. Mann-Whitney U test was used to compare two groups of quantitative variables that did not show normal distribution. Kruskal-Wallis and Dunn-Bonferroni tests were used to compare more than two groups of quantitative variables that did not show normal distribution. Spearman's correlation analysis was used to evaluate the relationships between quantitative variables. Statistical significance was set as $p<0.05$.

## RESULTS

Within the scope of the research, a total of 1556 healthcare workers, 33% (n=514) of whom were male and 67% (n=1042) of whom were female, were interviewed at University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital between May and July 2022. The ages of the participants ranged from 21 to 69 years, and the average age was 32.18±9.40. The demographic characteristics of the participants are given in Table 1. distribution of participants' answers to the HHBS questions is given in Table 2.

**Table 1.** Demographic characteristics

| Variables | | n (%) |
|---|---|---|
| **Gender** | Male | 514 (33.0) |
| | Female | 1042 (67.0) |
| **Age** | Mean ± SD | 32.18±9.40 |
| | Median (min-max) | 28 (21-69) |
| **Marital status** | Single | 944 (60.7) |
| | Married | 612 (39.3) |
| **Educational background** | Literate | 44 (2.8) |
| | Primary education | 22 (1.4) |
| | Secondary education | 53 (3.4) |
| | License | 76 (4.9) |
| | Associate degree | 815 (52.4) |
| | Degree | 351 (22.6) |
| | Doctorate | 195 (12.5) |
| **Department** | Emergency department | 121 (7.8) |
| | Operating theater | 63 (4.0) |
| | Pharmacy | 4 (0.3) |
| | Physiotheraphy | 12 (0.8) |
| | Laboratory | 21 (1.3) |
| | Audiometry | 2 (0.1) |
| | Out-patient clinic | 164 (10.5) |
| | Radiology | 45 (2.9) |
| | Inpatient service | 496 (31.9) |
| | Intensive care unit | 383 (24.6) |
| | Others | 245 (15.7) |
| **Occupation** | Assistant doctor | 266 (17.1) |
| | Associate professor/ professor | 92 (5.9) |
| | Pharmacist | 4 (0.3) |
| | Nurse/health officer/ midwife | 819 (52.6) |
| | Technician | 36 (2.3) |
| | Cleaning staff | 3 (0.2) |
| | Specialist | 218 (14.0) |
| | Secretary | 12 (0.8) |
| | Other | 106 (6.8) |
| **Years of service** | 0-5 years | 872 (56.0) |
| | 6-10 years | 203 (13.0) |
| | 11-15 years | 130 (8.4) |
| | 16-20 years | 121 (7.8) |
| | 21 years and above | 230 (14.8) |
| **Shift hours** | Only night time | 67 (4.3) |
| | Only daytime | 522 (33.5) |
| | Work in shifts | 967 (62.1) |

SD: Standard deviation, min-max: Minimum-maximum

The scores of the subjects participating in the study from the "Importance" sub-dimension of the HHBS ranged from 14 to 70, with an average score of 61.85±9.32 points. The scores they received from the belief sub-dimension ranged between 8 and 40, and the average score was determined as 19.61±7.96. The total scores they received from the HHBS sub-dimensions range between 50 and 110; the average score is 81.46±9.34 (Table 3).

When the internal consistency of the HHBS was examined, for the importance sub-dimension, $\alpha$=0.963; for the belief sub-dimension, $\alpha$=0.897; and the Cronbach's alpha coefficient of the total HHBS was 0.774. Accordingly, we can conclude that our scale is reliable. The scores obtained from the responses to the HHBS were compared according to descriptive characteristics (Table 3). The scores of women from the Belief sub-dimension of the HHBS and the total scores of the scale were higher than those of men (p=0.005; p=0.001; p<0.01). It was found that the subscale scores of those with low education levels were lower than those with secondary education, associate degree, bachelor's degree, master's degree, and doctorate (p=0.001; p<0.01).

The scores of those working in the emergency room and intensive care unit on the belief subscale were lower than those working in other departments.

A significant difference was found between the scores of the participants from the importance sub-dimension of the HHBS according to their profession (p=0.020; p<0.05). The scores of nurses from the subscale were higher than those of staff and doctors (p=0.020; p<0.05). A difference was also detected between the scores of the participants from the belief sub-dimension of the HHBS (p=0.037; p<0.05). In this sub-dimension, the scores of the staff in this sub-dimension are significantly higher than doctors and nurses (p=0.037; p<0.05). The scores of employees with 0-5 years of experience on the subscale are significantly higher than those with 11-15 years, 16-20 years, and 21 years and above (p=0.001; p<0.01).

As a result of pairwise comparisons made to determine the source of the difference, the subscale scores of permanent night workers were significantly lower than those of shift and permanent day workers (p=0.001; p=0.001; p<0.01). Table 4 presents the distribution of participants' answers to the HHPI scale questions. There is no significant differences in the participants' total scores in the HHPI regarding gender, age, marital status, educational status, department they worked in, profession, length of service, and shift hours (p>0.05) (Table 5). A relationship was also detected between the participants' ages and their total HHBS scores (as age increased, the total score from the HHBS increased) (p=0.019; p<0.05).

**Table 2.** Distribution of participants' answers to hand hygiene belief scale questions

| | I strongly disagree | | I disagree | | I am not sure | | I agree | | Absolutely, I agree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Hand hygiene training is an important part of the curriculum. | 17 | 1.1 | 19 | 1.2 | 79 | 5.1 | 398 | 25.6 | 1043 | 67.0 |
| The importance of hand hygiene is emphasized in the service where I practice clinically. | 20 | 1.3 | 18 | 1.2 | 96 | 6.2 | 487 | 31.3 | 935 | 60.1 |
| My clinical consultant/service chief emphasized the importance of hand hygiene. | 21 | 1.3 | 23 | 1.5 | 99 | 6.4 | 493 | 31.7 | 920 | 59.1 |
| I have a responsibility to be a role model for other healthcare professionals. | 22 | 1.4 | 25 | 1.6 | 102 | 6.6 | 507 | 32.6 | 900 | 57.8 |
| When my workload is heavy, completing my duties is more important than paying attention to hand hygiene. | 444 | 28.5 | 273 | 17.5 | 126 | 8.1 | 423 | 27.2 | 290 | 18.6 |
| Performing hand hygiene is recommended situations may reduce the patient mortality rate. | 30 | 1.9 | 36 | 2.3 | 115 | 7.4 | 518 | 33.3 | 857 | 55.1 |
| Performing hand hygiene when indicated may reduce costs associated with hospital-acquired infections. | 21 | 1.3 | 15 | 1.0 | 94 | 6.0 | 499 | 32.1 | 927 | 59.6 |
| Because patients' needs take priority, I cannot always perform hand hygiene in the recommended situations. | 422 | 27.1 | 276 | 17.7 | 223 | 14.3 | 409 | 26.3 | 226 | 14.5 |
| Preventing nosocomial infections is an important part of the role of healthcare professionals. | 23 | 1.5 | 20 | 1.3 | 89 | 5.7 | 474 | 30.5 | 950 | 61.1 |
| I take the behavior of experienced healthcare professionals as an example when it comes to performing hand hygiene. | 768 | 49.4 | 517 | 33.2 | 139 | 8.9 | 92 | 5.9 | 40 | 2.6 |
| An infectious disease contracted in healthcare institutions may threaten my life or career. | 23 | 1.5 | 22 | 1.4 | 113 | 7.3 | 527 | 33.9 | 871 | 56.0 |
| I believe that I have the power to change wrong/bad practices in the work environment. | 38 | 2.4 | 38 | 2.4 | 184 | 11.8 | 551 | 35.4 | 745 | 47.9 |
| Failure to maintain hand hygiene may be considered negligence in indicated situations. | 36 | 2.3 | 31 | 2.0 | 191 | 12.3 | 611 | 39.3 | 687 | 44.2 |
| Hand hygiene is a habit for me in personal life. | 20 | 1.3 | 9 | 0.6 | 113 | 7.3 | 514 | 33.0 | 900 | 57.8 |
| I am confident that I can effectively apply my knowledge of hand hygiene in my clinical work. | 23 | 1.5 | 9 | 0.6 | 120 | 7.7 | 542 | 34.8 | 862 | 55.4 |
| Remembering to perform hand hygiene in recommended situations requires effort. | 678 | 43.6 | 549 | 35.3 | 158 | 10.2 | 120 | 7.7 | 51 | 3.3 |
| It would bother me to warn a healthcare professional about hand washing. | 504 | 32.4 | 433 | 27.8 | 268 | 17.2 | 246 | 15.8 | 105 | 6.7 |
| Providing hand hygiene slows down the build-up of immunity against diseases. | 458 | 29.4 | 313 | 20.1 | 213 | 13.7 | 376 | 24.2 | 196 | 12.6 |
| Dirty sinks may be a reason not to wash hands. | 430 | 27.6 | 352 | 22.6 | 304 | 19.5 | 326 | 21.0 | 144 | 9.3 |
| Lack of a suitable cleaning product can be a reason for not cleaning hands. | 444 | 28.5 | 442 | 28.4 | 267 | 17.2 | 276 | 17.7 | 127 | 8.2 |
| Providing hand hygiene after caring for a wound can protect against infections. | 26 | 1.7 | 23 | 1.5 | 121 | 7.8 | 549 | 35.3 | 837 | 53.8 |
| Cleaning hands after going to the toilet reduces the risk of transmitting infectious diseases. | 24 | 1.5 | 9 | 0.6 | 118 | 7.6 | 477 | 30.7 | 928 | 59.6 |

**Table 3.** Hand hygiene belief scale scores according to descriptive characteristics

| | | Importance | | Belief | | Total score | |
|---|---|---|---|---|---|---|---|
| | | Mean ± SD | Median (min-max) | Mean ± SD | Median | Mean ± SD | Median (min-max) |
| **Gender** | Male | (min-max) | Mean ± SD | Median | 19 (8-40) | 79.7±9.44 | 78 (54-103) |
| | Female | (min-max) | 64 (14-70) | 20.01±7.85 | 21 (8-40) | 82.33±9.18 | 80 (50-110) |
| | p-value | [a]**0.027*** | | [a]**0.001**** | | [a]**0.599** | |
| **Educational background** | Literate | 63.77±12.95 | 70 (14-70) | 12.84±8.57 | 8 (8-40) | 76.61±6.77 | 78 (54-100) |
| | Primary education | 46.32±11.7 | 47 (16-70) | 22±7.15 | 24 (8-40) | 68.32±6.03 | 70 (52-78) |
| | Secondary education | 60.77±8.03 | 61 (42-70) | 20.34±6.83 | 21 (8-36) | 81.11±9.4 | 78 (66-106) |
| | License | 61.46±7.77 | 62 (42-70) | 18.78±6.95 | 20 (8-31) | 80.24±7.4 | 79 (64-99) |
| | Associate degree | 62.35±7.9 | 64 (14-70) | 19.75±7.68 | 21 (8-40) | 82.1±8.88 | 80 (50-110) |
| | Degree | 62.4±9.37 | 66 (14-70) | 19.8±8.1 | 22 (8-40) | 82.21±9.36 | 80 (54-105) |
| | Doctorate | 60.52±12.31 | 65 (14-70) | 20.07±8.76 | 20 (8-40) | 80.59±11.09 | 78 (54-104) |
| | p-value | [b]**0.001**** | | [b]**0.001**** | | [b]**0.001**** | |
| **Department** | Emergency department | 62.03±8.44 | 65 (14-70) | 18.26±7.62 | 17 (8-40) | 80.29±9.22 | 78 (54-105) |
| | Operating theater | 62.14±8.85 | 66 (41-70) | 19.08±8.13 | 21 (8-33) | 81.22±9.25 | 78 (66-103) |
| | Phsiotheraphy | 58.33±17.26 | 65.5 (14-70) | 23.08±7.6 | 23 (8-40) | 81.42±13.24 | 86 (54-93) |
| | Laboratory | 63.9±6.12 | 66 (45-70) | 22.95±8.41 | 25 (8-36) | 86.86±8.67 | 87 (69-104) |
| | Out-patient clinic | 61.77±8.01 | 63 (14-70) | 21.05±7.72 | 23 (8-40) | 82.83±9.33 | 81 (54-103) |
| | Radiology | 61.09±9.75 | 62 (33-70) | 20.29±7.93 | 22 (8-32) | 81.38±9.26 | 80 (60-101) |
| | Inpatient service | 62.43±8.38 | 65 (14-70) | 19.79±7.7 | 21 (8-40) | 82.22±9.18 | 80 (54-109) |
| | Intensive care unit | 62.16±9.46 | 66 (14-70) | 18.56±7.92 | 20 (8-40) | 80.72±8.93 | 78 (50-106) |
| | Others | 60.25±11.48 | 62 (14-70) | 20.15±8.5 | 22 (8-40) | 80.4±9.96 | 79 (52-110) |
| | p-value | [b]**0.462** | | [b]**0.003**** | | [b]**0.062** | |
| **Occupation** | Medical doctor | 61.88±10.13 | 66 (14-70) | 19.14±8.37 | 20 (8-40) | 81.02±9.85 | 78 (52-109) |
| | Nurse | 62.36±7.92 | 64 (14-70) | 19.65±7.61 | 21 (8-40) | 82.02±8.79 | 80 (50-110) |
| | Other staff | 59.13±12.11 | 61 (14-70) | 21.12±7.99 | 23 (8-40) | 80.25±10.06 | 79 (54-104) |
| | p-value | [b]**0.020*** | | [b]**0.037*** | | [b]**0.055** | |
| **Years of service** | 0-5 years | 62.72±8.24 | 65 (14-70) | 18.63±7.72 | 20 (8-40) | 81.35±8.56 | 78 (50-109) |
| | 6-10 years | 61.1±9.4 | 63 (14-70) | 19.5±7.75 | 21 (8-40) | 80.6±9.86 | 78 (54-103) |
| | 11-15 years | 60.39±11.32 | 63.5 (14-70) | 21.37±7.91 | 23 (8-40) | 81.76±10.79 | 80.5(54-105) |
| | 16-20 years | 61.24±9.53 | 64 (14-70) | 21.62±7.71 | 24 (8-40) | 82.86±10.05 | 82 (54-104) |
| | 21 years and above | 60.35±11.26 | 62 (14-70) | 21.4±8.53 | 24 (8-40) | 81.75±10.41 | 80 (54-110) |
| | p-value | [b]**0.060** | | [b]**0.001**** | | [b]**0.068** | |
| **Shift hours** | Only night time | 57.73±11.08 | 56 (30-70) | 19.52±7.38 | 21 (8-32) | 77.25±9.4 | 76 (58-97) |
| | Only daytime | 62.55±8.3 | 65 (14-70) | 20.31±8.05 | 22 (8-40) | 82.85±9.14 | 81 (54-110) |
| | Work in shifts | 61.76±9.64 | 65 (14-70) | 19.25±7.93 | 20 (8-40) | 81.01±9.33 | 78 (50-109) |
| | p-value | [b]**0.005**** | | [b]**0.018*** | | [b]**0.001**** | |

SD: Standard deviation, min-max: Minimum-maximum, [a]Mann-Whitney U test, [b]Kruskal-Wallis test & Dunn-Bonferroni test, **p<0.01, *p<0.05

## DISCUSSION

In general, our study revealed that, as in similar studies (1), the attitudes and beliefs of healthcare professionals regarding hand hygiene differed depending on their education level, profession, and department. Women had a higher belief in hand hygiene than men. In the study conducted by Sax et al. (7), female gender was a positive factor in compliance with hand hygiene. As the education level increased, a significant increase was found in the belief in hand hygiene and its importance scale. As expected, healthcare professionals with higher education levels had

a better perception of hand hygiene. Other studies on the subject (8,9) have also shown that the attitudes and beliefs of healthcare professionals regarding hand hygiene are affected by factors such as education level and profession.

Our results demonstrate that the HHBS of healthcare professionals working in outpatient clinics differs from those working in emergency rooms and intensive care units. It has also been reported in other studies (10) that stressful environments and intense workloads cause negative attitudes toward hand hygiene. The large number of patients, limited time, and the need to intervene quickly in the emergency department may have reduced the employees' belief in hand hygiene. In a previous study, compliance with hand hygiene decreased significantly when more than 30 hand hygiene procedures were required per hour (11). Compliance with hand hygiene is reduced with increased risk and workload for patients.

Those with short work experience have higher belief scale scores than those with longer work experience. This may be attributed to the fact that those with long-term work experience are overwhelmed by the workload. In contrast, those with fewer years of working experience may have new and more dynamic knowledge about hand hygiene. When the shift times were evaluated, daytime workers scored higher on the belief scale than night workers. This may be due to the small number of healthcare workers at night, who are exhausted and work without sleep. An increase in workload at night may explain the difference in the scale scores. Studies on hand hygiene compliance have shown that hand hygiene compliance is significantly affected by diurnal working hours. Despite continuing education and hand hygiene guidelines emphasizing the importance of hand hygiene, hand hygiene compliance remains low among healthcare personnel during night shifts (12). The fact that the education level and professional level of healthcare professionals affect their attitudes and beliefs about hand hygiene makes it important to consider this when preparing theoretical and practical training programs and to individualize the employees in a way that suits their level and meets their unique needs and beliefs (1,3,4,6,7,13-15).

Although education and profession play a role in shaping the attitudes and beliefs of healthcare professionals regarding hand hygiene, other influential factors should not be ignored. Some studies have suggested that the effectiveness of hand hygiene training programs does not depend solely on the education level of healthcare professionals (16). Increasing knowledge about hand hygiene may not necessarily mean improving handwashing practices (17). Sax et al. (7) suggested that not only education but also a combination of strategic interventions are required to increase compliance with hand hygiene. This result indicates that education and profession are not the only determinants of effective hand hygiene practices among healthcare professionals. It is essential to consider a multifaceted approach that includes education and training programs and behavior change strategies to promote and maintain good hand hygiene practices in healthcare settings.

When developing hand hygiene training programs for healthcare professionals, many factors must be considered and adapted to specific needs and beliefs. It is necessary to recognize that education alone may not be sufficient to encourage behavioral change and improve hand hygiene practices (5,18,19). Behavioral sciences could also be used to increase healthcare workers' compliance with infection control practices. Behavior change can be achieved by knowing that behavior is affected by more than one level of influence and that it affects and is affected by the social environment (20).

Since improvement efforts in hospitals are perceived as an addition to existing workloads, healthcare workers may exhibit resistance to hand hygiene practices. It may be recommended to find good role models among leaders and colleagues, to use supervision and feedback, and to use visual and auditory reminders of hand hygiene in the workplace (21). An ergonomic structure should be improved in hospital environments, and access to sinks and disinfectants should be provided. Some institutions have also achieved improved compliance through structured training programs and easy access to hand hygiene products (22). Overall, the findings of this study provide insight into healthcare professionals' beliefs and experiences regarding hand hygiene and promote a culture of effective hand hygiene practices in healthcare settings.

### Study Limitations

The fact that the study was conducted in a single center is a limitation of the study.

## CONCLUSION

Our study presents data on healthcare workers' beliefs and practices regarding hand hygiene, which is crucial for patient safety and infection control. The results show that hand hygiene is affected by factors such as education level, profession, gender, length of service, shift time, and department. It should be remembered that various factors may affect compliance and belief, and it is recommended

that these factors be considered when preparing compliance programs. Healthcare institutions may need to develop practices by determining their needs and making unit-specific or individual adaptation plans. Additionally, our findings contribute to our understanding of the staff working in tertiary hospitals in our country and could be a guide for other healthcare institutions.

### ETHICS

**Ethics Committee Approval:** The study complied with the principles of the Declaration of Helsinki, and approval was received from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (decision no: 2024-01-08, date: 22.01.2024).

**Informed Consent:** The authors obtained informed consent from all participants in this study.

### Authorship Contributions

Surgical and Medical Practices: A.İ.S., S.B.K., Ö.P., K.K.Y., Concept: A.İ.S., Ş.N.K., Y.E.Ö., S.B.K., K.K.Y., Design: A.İ.S., Ş.N.K., Y.E.Ö., D.B., S.B.K., Ö.P., K.K.Y., Data Collection or Processing: A.İ.S., D.B., S.B.K., Ö.P., K.K.Y., Analysis or Interpretation: A.İ.S., Ş.N.K., Y.E.Ö., D.B., K.K.Y., Literature Search: A.İ.S., Ş.N.K., Y.E.Ö., S.B.K., K.K.Y., Writing: A.İ.S., Ş.N.K., Y.E.Ö., D.B., K.K.Y.

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Research

# Cross-cultural Adaptation, Reliability, and Validity of the Turkish Version of the American Orthopedic Foot and Ankle Society (AOFAS) Midfoot Scale

## Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) Orta Ayak Ölçeğinin Türkçe Versiyonunun Kültürlerarası Uyarlaması, Güvenilirliği ve Geçerliliği

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## ABSTRACT

**Objective:** The American Orthopedic Foot and Ankle Association (AOFAS) Midfoot scale is one of the most popular outcome measures for evaluating midfoot pathologies. We aimed to obtain a valid and reliable Turkish translation of the AOFAS Midfoot scale.

**Methods:** Fifty-seven patients with midfoot pathologies were included, and the mean age was 38.47±12.54. To appraise construct validity, correlations were applied with the visual analog scale (VAS), the Turkish version of the foot and ankle ability scale (FAAM), and the 12-item short form health survey.

**Results:** The AOFAS Midfoot-Turkish scale had adequate internal consistency (α=0.75) and test-retest reliability [intraclass correlation coefficient $(ICC)_{2,1}$=0.86 for function, and $ICC_{2,1}$=0.95 for total score]. The AOFAS Midfoot-Turkish scale total score had a moderate to strong correlation with VAS activity and FAAM-ADL, FAAM-Sports, and PCS-12 (rho=-0.69, p=0.001; rho=0.88, p=0.001, r=0.86, p=0.001, and r= 0.68, p=0.001, respectively). The lowest correlation was found between the AOFAS Midfoot-Turkish and the MCS-12 (rho=0.37, p=0.004).

**Conclusion:** The Turkish version of the AOFAS Midfoot scale is a reliable and valid outcome measurement instrument that can be used to evaluate Turkish-speaking individuals with various midfoot pathologies, especially Lisfranc injuries.

**Keywords:** Turkish, lisfranc, AOFAS, tarsal bones, tarsometatarsal joint, outcome measure, psychometrics

## ÖZ

**Amaç:** Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) orta ayak ölçeği, orta ayak patolojilerinin değerlendirilmesinde en popüler sonuç ölçütleri arasındadır. AOFAS Orta Ayak ölçeğinin geçerli ve güvenilir Türkçe çevirisine ulaşmayı amaçladık.

**Gereç ve Yöntem:** Çalışmaya orta ayak patolojisi olan 57 hasta dahil edildi ve yaş ortalaması 38,47±12,54 idi. İleri-geri çeviri prosedürü kullanıldı. İç tutarlılığı ölçmek için Cronbach alfa (α) kullanıldı. Yapı geçerliliğini değerlendirmek için görsel analog ölçeği (VAS), ayak ve ayak bileği yetenek ölçeği'nin (FAAM) Türkçe versiyonu ve 12-maddelik kısa form sağlık anketi ile korelasyonlar uygulandı.

**Bulgular:** AOFAS Midfoot-Türkçe ölçeği yeterli iç tutarlılığa (α=0,75) ve test-tekrar test güvenilirliğine fonksiyon için [sınıf içi korelasyon katsayısı $(ICC)_{2,1}$=0,86 ve toplam puan için $ICC_{2,1}$=0,95) sahipti. AOFAS Midfoot-Türkçe ölçeği toplam puanı, VAS-aktivite ve FAAM-ADL, FAAM-Sports ve PCS-12 ile orta ila güçlü bir korelasyona sahiptir (rho=-0,69, p=0,001; rho=0,88, p=0,001, r= 0,86, p=0,001 ve r= 0,68, p=0,001). En düşük korelasyon AOFAS Midfoot-Türkçe ile MCS-12 arasında bulundu (rho=0,37, p=0,004).

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**Sonuç:** AOFAS Orta Ayak ölçeğinin Türkçe versiyonu, Lisfranc yaralanmaları başta olmak üzere çeşitli orta ayak patolojileri olan Türkçe konuşan bireylerin değerlendirilmesinde kullanılabilecek güvenilir ve geçerli bir sonuç ölçüm aracıdır.

**Anahtar Kelimeler:** Türkçe, lisfranc, AOFAS, tarsal kemikler, tarsometatarsal eklem, sonuç ölçütü, psikometri

## INTRODUCTION

Foot and ankle injuries are the most common musculoskeletal disorders that greatly affect patients' quality of life (QoL) and functionality (1). Tarsometatarsal (Lisfranc) joint injuries are relatively rare (9-14/100.000/person-years), and missed diagnosis and inadequate treatment are common (2).

Many scales have been developed for academic or clinical purposes (3). The American Orthopedic Foot and Ankle Society (AOFAS) score is an extensively used clinical outcome measure, particularly designed to assess the foot and ankle (4). It has four anatomical subdivisions: proximal to distal, ankle to hindfoot, midfoot, and forefoot, including the hallux and lesser toes (5). It consists of objective and subjective items measuring pain, functionality, and alignment (5). The scales have been used for 30 years with unabated frequency (4).

The original scales are difficult to administer to non-English speakers. The different parts of scales are translated into various languages (6-9). The Turkish version of the AOFAS Hindfoot and Forefoot has been published (10,11). In this study, we aimed to present a reliable, valid, cross-culturally adapted Turkish version of the AOFAS Midfoot Scale.

## METHODS

### Procedure

Fifty seven patients with midfoot injuries who applied to the orthopedic clinic between July 2021 and July 2022 and met the inclusion criteria included in the study. Informed consent was obtained from the participants. The local Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee approved the study (decision no: 2021-13-02, date: 05.07.2021). The study was registered in a clinical trial (NCT05246488).

The eligibility and exclusion criteria are presented in Figure 1. The sociodemographic and medical data of the patients were recorded. Exceeding the recommendation of at least five patients per item, 57 patients were included, including 8.14 patients for each of the seven items on the AOFAS Midfoot scale (12).

### Measures

#### AOFAS Midfoot Scale

The seven-item AOFAS Midfoot scale is a questionnaire specifically designed for the midfoot. The scale consists of three subsections: pain, function, and alignment, and is represented by 40, 45, and 15 points, respectively. Between 0 and 100, higher scores indicate better results (5).

#### Visual Analog Scale (VAS)

The VAS was used to evaluate pain subjectively. Patients used a 10- cm line, which ranged from no pain (0) to the most acute pain (10), to assess their pain levels at rest, during activity, and at night. Measuring the marking projection on the ruler yields the score (13).

#### Foot and Ankle Ability Measure (FAAM)

FAAM is a PROM used to evaluate region-specific physical functions. The questionnaire was divided into two subscales: Activity of daily living (FAAM-ADL/21- items) and sports (FAAM-Sports/7- items). The questionnaire was evaluated using a 5- point Likert scale, ranging from "none at all" to "unable to do". The item scores for the FAAM-ADL subscale, which ranges from 0 to 84, and the FAAM-Sports subscale, which ranges from 0 to 32, were converted into percentage scores. Higher scores represent the higher function (14).

#### Short Form-12 Health Survey (SF-12)

The SF-12 is a simpler form of the SF-36 questionnaire that evaluates perceived health-related QoL. The questionnaire

| ELIGIBILITY CRITERIA | EXCLUSION CRITERIA |
|---|---|
| Those between the ages of 18 and 65 | Those who are under 18 years of age and over 65 years of age |
| Those who have the ability to read and write Turkish and follow simple instructions, | Those with hearing and vision pathologies and those who cannot mobilize independently |
| Those diagnosed with midfoot/ tarsometatarsal joint pathologies | Those with acute trauma, wounds, and infections in the lower extremity |
| Those who have surgical treatment of Lisfranc injuries with at least 1 year of follow-up | Those with a history of peripheral neuropathy, heterotopic ossification, and post-traumatic arthritis in the lower extremity |

**Figure 1.** Eligibility and exclusion criteria

| AOFAS-Orta Ayak Türkçe Skalası | |
|---|---|
| **I. AĞRI** | **(40 puan)** |
| • Hiç yok | 40 |
| • Hafif ve nadiren | 30 |
| • Orta derecede ve her gün | 20 |
| • Ciddi ve neredeyse her zaman | 0 |
| **II. FONKSİYON** | **(45 puan)** |
| **Aktivite kısıtlılıkları, destek ihtiyacı** | |
| • Kısıtlılık yok, destek ihtiyacı yok | 10 |
| • Günlük yaşam aktivitelerinde kısıtlılık yok, eğlence aktivitelerinde kısıtlılık, destek ihtiyacı yok | 7 |
| • Günlük yaşam aktivitelerinde ve eğlence aktivitelerinde kısıtlılık, baston kullanma | 4 |
| • Günlük yaşam aktivitelerinde ve eğlence aktivitelerinde ciddi kısıtlılık, walker, koltuk değneği, tekerlekli sandalye kullanma | 0 |
| **Ayakkabı gereksinimleri** | |
| • Modaya uygun ve geleneksel ayakkabı, tabanlık kullanımı yok | 5 |
| • Rahat ayakkabı, tabanlık kullanımı var | 3 |
| •Modifiye edilmiş ayakkabı veya breys kullanımı var | 0 |
| **Maksimum yürüme mesafesi, kilometre** | |
| • 3 km'den fazla (20 dakikadan fazla) | 10 |
| • 2-3 km (15-20 dakika) | 7 |
| • 500 m-1,5 km (5-10 dakika) | 4 |
| • 500 metreden az (5 dakikadan az) | 0 |
| **Yürüme yüzeyi** | |
| • Her zeminde zorlanmadan yürüme | 10 |
| • Engebeli zemin, merdiven ve yokuşlarda hafif zorlanma | 5 |
| • Engebeli zemin, merdiven ve yokuşlarda ciddi zorlanma | 0 |
| **Yürüme bozukluğu** | |
| • Hiç yok veya çok hafif | 10 |
| • Orta derecede | 5 |
| • Belirgin | 0 |
| **III. DİZİLİM** | **(15 puan)** |
| • İyi, plantigrade ayak, orta ayak dizilimi iyi | 15 |
| • Orta, plantigrade ayak, orta ayağın diziliminde hafif bozukluk var, semptom yok | 8 |
| • Kötü, nonplantigrade ayak, ciddi dizilim bozukluğu var, semptom var | 0 |
| **VI. TOPLAM PUAN** | **(100 puan)** |
| Ağrı puanı + Fonksiyon puanı + Dizilim puanı | |
| Toplam puan / 100 | |

**Figure 2.** Turkish version of the American orthopaedics foot and ankle society midfoot scale

comprises 12 items, with seven items focusing on the physical components (PCS-12) and five items addressing the mental components (MCS-12). For each metric, scores range from 0 to 100; a higher score is correlated with a higher QoL (15).

### Study Protocol

Dr. Harold Kitaoka permitted the translation of the scale into Turkish. The cross-cultural adaptation was conducted in five phases following the Beaton guidelines (16). During the first phase, two translators translated the scale into Turkish. These translators were 8-years experienced physiotherapists and blinded and unbiased researchers who both were native Turkish speakers. In the second phase, a bilingual individual compared and reviewed both translations. During the third phase, the Turkish version was subjected to back-translation into English by two proficient native English speakers who also had a strong command of Turkish. During the fourth phase, a committee of four translators compared the back-translated version of the AOFAS Midfoot scale with the original English version. During the translation process, the translators realized that the term "blocks" is not used to describe distance in daily Turkish. Akbaba et al. (10) replaced the term "blocks" with the phrase "200 meters" and included duration in the Turkish translation of the AOFAS ankle-hindfoot scale. Therefore, "blocks" was replaced with "200 meters" and walking duration was added to the scale. The pre-final version of the AOFAS Midfoot Turkish (AOFAS Midfoot-T) scale was developed for field testing. Thirty appropriate patients with midfoot injuries were given the pre-final version during the final phase (Figure 2). After filling out the form, patients were interviewed regarding any challenging questions or unfamiliar terminology.

Measurement error, internal consistency, and test-retest reliability were used for measuring reliability. Construct validity was evaluated using hypothesis testing, measuring the degree of correlation between the AOFAS Midfoot-T and VAS scores, as well as the Turkish versions of FAAM, PCS-12, and MCS-12. The hypothesis stated that the total AOFAS Midfoot-T score had a strong positive correlation (correlation coefficient of 0.70 or greater) with the FAAM

score because they measured similar constructs. Additionally, it was expected that the total AOFAS Midfoot-T score would have a moderate negative correlation (correlation coefficient between 0.50 and 0.70) with VAS scores because they measure related but dissimilar constructs. Furthermore, it was predicted that the total AOFAS Midfoot-T score would have a moderate positive correlation (correlation coefficient between 0.50 and 0.70) with the PCS-12 score because they measure related but dissimilar constructs. Lastly, it was anticipated that the total AOFAS Midfoot-T score would have a weak positive correlation (correlation coefficient between 0.30 and 0.50) with the MCS-12 score because it measures unrelated constructs.

The VAS, validated Turkish versions of the FAAM and SF-12, AOFAS Midfoot-T scale, and VAS were completed by all patients. All patients successfully completed the subjective component of the AOFAS Midfoot-T scale. The clinician evaluated the quantitative component of the AOFAS Midfoot-T scale. The second assessment, in which patients re-applied the AOFAS Midfoot-T scale, was performed within a week following the first evaluation to determine the test-retest reliability of the translated form. No intervention was administered during this timeframe to reduce the likelihood of immediate clinical changes. The reliability analysis was restricted to patients who indicated "no clinical change".

### Statistical Analysis

All statistical analysis were conducted using the Statistical Package for the Social Sciences version 20.0 (SPSS Inc., Chicago, IL, USA). The statistical significance level was $p<0.05$. The ICC was computed to assess the test-retest reliability. Reliability with an ICC exceeding 0.75 was deemed excellent (17). The internal consistency of the AOFAS Midfoot-T scale was assessed by calculating Cronbach's alpha ($\alpha$) coefficient upon the initial completion of the scale. An $\alpha$ value ranging from 0.70 to 0.95 was considered acceptable reliability (17). The measurement error was evaluated using the standard error of measurement (SEM). The square root of (1-ICC) was multiplied by the standard deviation of the scores to calculate the SEM. MDC95 was determined by multiplying the SEM by 1.96 and then multiplying the result by the square root of 2. The investigation of construct validity involved testing predetermined hypotheses and analyzing the Pearson correlation coefficient. The correlation strength was classified as weak when it was less than 0.50, moderate when it was between 0.5 and 0.70, and strong when it was greater than 0.70 (18). The floor (score 0-10) and ceiling effects (score 90-100) at the time the form was initially completed were evaluated by determining the percentage of patients who, concerning the total number of patients, scored the lowest or highest values on the questionnaire. A floor or ceiling effect was identified at a threshold of more than 15% (19).

**Table 1.** Demographics and general patient assessment data

| **Characteristics (n=57)** | **Mean ± SD** |
|---|---|
| Age (years) | 38.47±12.54 |
| Body mass index (kg/m$^2$) | 26.99±4.37 |
| **Sex [n (%)]** | |
| Female | 30 (52.6) |
| Male | 27 (47.4) |
| **Education [n (%)]** | |
| Primary education | 6 (10.5) |
| Secondary education | 8 (14.0) |
| Higher education | 24 (42.1) |
| Bachelor's degree and higher | 19 (33.4) |
| **Affected side [n (%)]** | |
| Right | 35 (61.4) |
| Left | 22 (38.6) |
| **Surgery [n (%)]** | |
| Yes | 7 (12.28) |
| No | 50 (87.71) |
| **Visual analog scale (score)** | |
| Rest | 1.08±0.50 |
| Activity | 1.80±0.66 |
| Night | 1.18±0.54 |
| **Foot and ankle ability measure (score)** | |
| Activity in daily living | 79.43±7.58 |
| Sports | 29.22±3.77 |
| **Short form-12 (score)** | |
| Physical component summary | 54.11±4.78 |
| Mental component summary | 55.18±6.62 |

SD: Standard deviation

## RESULTS

### Translation and Cross-cultural Adaptation

There were no difficulties in the forward and backward translation, and the Turkish version was consistent with the original scale. However, the term "blocks" is not used to indicate distance in Turkish; thus, "blocks" was replaced with "200 meters" and walking duration was added to the scale. Preliminary tests indicate that patients perceived all questions correctly. The required time to complete the AOFAS Midfoot-T scale is approximately 10-15 minutes. 57 patients with a mean age of 38.47±12.54 years participated in the first and second assessments. The sociodemographic

and medical characteristics of the patients are presented in Table 1.

### Reliability

The Turkish version's internal consistency was adequate for the first administration, with an α of 0.75. Cronbach's coefficient for the function subscale was 0.84 for the initial application of the Turkish translation. The means and standard deviations in the first and second applications of the Turkish version are given in Table 2. The $ICC_{2,1}$ was 0.86 (0.76-0.91) and 0.95 (0.94-0.97) for the function subscale and total score, respectively. The SEM and $MDC_{95}$ were determined as 2.24 and 6.20 for the function subscale and 8.20 and 22.66 for the total score of the AOFAS Midfoot-T scale.

### Validity

The FAAM-ADL and FAAM-Sports (r=0.88, p=0.001 and r=0.86, p=0.001, respectively; Hypothesis-1) met the a priori criteria of a strong positive relationship. In addition, the a priori criterion of a negative correlation was met for the VAS-rest, VAS-activity, and VAS-night (r=-0.60, p=0.001, r=-0.69, p=0.001, and r= -0.57, p=0.001, respectively; Hypothesis-2). There was a moderate positive correlation between the AOFAS Midfoot-T total score and PCS-12 (r=0.68, p=0.001, Hypothesis-3). There was a weak positive correlation between the total SHEDS-T score and the MCS-12 subscale (r=0.37, p=0.004, Hypothesis-4) (Table 3). All findings (100%) that supported the hypotheses indicated good construct validity. During the test and retest examinations, the floor and ceiling effects as well as the total number of questions answered were the same. In the first application of the AOFAS Midfoot-T scale, floor and ceiling effects were calculated as 0% and 47%.

**Table 2.** Test-retest reliability of the Turkish version of the AOFAS Midfoot scale

| AOFAS midfoot scale items | First assessment Mean ± SD (95 % CI) (n=57) | Second assessment Mean ± SD (95 % CI) (n=57) | Test-retest reliability ICC (95% CI) |
|---|---|---|---|
| **Pain (0 to 40)** | 35.08±5.70 | 35.08±5.70 | 1 |
| **Function (0 to 45)** | 41.54±6.01 | 40.98±7.25 | 0.86 (0.76-0.91) |
| **Alignment (0 to 15)** | 14.54±1.69 | 14.54±1.69 | 1 |
| **Total Score (0 to 100)** | 81.43±11.60 | 81.70±4.31 | 0.95 (0.94-0.97) |

AOFAS: American Orthopedics Foot and Ankle Society, CI: Confidence interval, ICC: Intraclass correlation coefficient, SD: Standard deviation

## DISCUSSION

This study aimed to present a culturally adapted, reliable, and valid Turkish translation of the AOFAS Midfoot scale for use in the evaluation of Turkish-speaking individuals with midfoot pathologies. The AOFAS Midfoot-T was found to have adequate test-retest reliability (ICC=0.95), internal consistency (Cronbach's α coefficient=0.75), and validity. According to the current findings, the AOFAS Midfoot-T scale does not demonstrate a ceiling or floor effect, and the MDC95 values for the total score of the translated version were 22.66. Changes less than these MDC95 values during consecutive applications of the Turkish form may reflect measurement errors rather than a real change in foot function.

The results were consistent with the AOFAS Midfoot study using the Persian version (α=0.75) (9) and the Lisfranc injury patients (α=0.75) (20). However, the α value was specified neither in the original study (5). The ICC had excellent internal reliability between measurements administered over 5- to -7 days for the Turkish version ($ICC_{2,1}$=0.95). Similar to the present study, both the Persian version of the

**Table 3.** Construct validity of the Turkish version of the AOFAS Midfoot scale

| Variables | AOFAS Midfoot scale | | | |
|---|---|---|---|---|
| | Pain | Function | Alignment | Total |
| **Visual analog scale** | | | | |
| Rest | -0.54 (0.001)** | -0.64 (0.001)** | -0.12 (0.35) | -0.60 (0.001)** |
| Activity | -0.70 (0.001)** | -0.68 (0.001)** | -0.21 (0.10) | -0.69 (0.001)** |
| Night | -0.52 (0.001)** | -0.57 (0.001)** | -0.18 (0.16) | -0.57 (0.001)** |
| **Foot and ankle ability measurements** | | | | |
| Activity in daily living | 0.72 (0.001)** | 0.87 (0.001)** | 0.51 (0.001)** | 0.88 (0.001)** |
| Sports | 0.69 (0.001)** | 0.86 (0.001)** | 0.53 (0.001)** | 0.86 (0.001)** |
| **Short form-12** | | | | |
| Physical component summary | 0.58 (0.001)** | 0.69 (0.001)** | 0.64 (0.001)** | 0.68 (0.001)** |
| Mental component summary | 0.33 (0.01)* | 0.36 (0.005)** | 0.01 (0.95) | 0.37 (0.004)** |

Pearson correlation test. p<0.05*, p<0.01**, AOFAS: American Orthopedics Foot and Ankle Society,

scale ($ICC_{2,1}$=0.96) showed excellent test-retest reliability (9). However, Ponkilainen et al. (20) did not specify test-retest reliability. In the study where all subgroup translations were presented in the same study, the AOFAS midfoot Arabic scale ICCs ranged from 0.405-0.542, and good structural validation was reported (8).

In the present study, the $MDC_{95}$ values were 6.20 for the function subscale and 22.66 for the total score of the AOFAS Midfoot-T. Since it was not calculated in other studies in the literature, the $MDC_{95}$ value of the AOFAS Midfoot-T scale could not be compared with other studies in the literature (5,8,9). On the other hand, a ceiling effect was confirmed for the AOFAS Midfoot-T scale (%47) and the study was conducted in patients with Lisfranc injury (%28) (20).

Region-specific patient-reported outcome measures (PROM), such as FAAM (14), VAS foot and ankle (21), and the European Foot and Ankle Society Score (22), may have psychometric and reliable properties that will correct the uncertainty and loss of reliability experienced by AOFAS in evaluating the results of foot and ankle pathologies alone.

The Patient-reported Outcomes Measurement Information System (PROMIS) is a series of person-focused measurements that evaluate and track health status. PROMs assess the individuals' QoL or functionality and the patient's health perception, thereby providing important clinical and scientific information (23). Consequently, orthopedic communities are increasingly using PROMIS. Although traditional imaging and physical examination findings are a priority for clinicians, they may not reflect patient satisfaction and functionality. There is a great need for reliable PROMs translated into multiple languages (24).

Richter et al. (21) noted that regardless of the popularity of the AOFAS scores, the scoring was not validated, resulting in problematic evaluation material in cases of incomplete responses to the survey. Malviya et al. (25) stated that the evaluations had limited accuracy due to insufficient response options for each component. Guyton exposed these theoretical limitations with statistical evidence (26).

Hunt and Hurwit (27) noted that among the different outcome measurement instruments they reviewed in the foot and ankle clinical literature, the AOFAS scales remained highly used compared with other validated scales. They also emphasized that although a change in philosophy is needed in the use of reliable scales, the most valid scale should be preferred in clinical practice (27). As we underline, although there is a consensus that the use of AOFAS scales should decrease or should not be used alone, there is no consensus on which scale to use or to combine. Since the use of AOFAS subscales remains popular, we present the Turkish version in order to obtain clinically and academically reliable results.

Although the use of different PROMs is encouraged and the limitations of the use of AOFAS scores have been mentioned, a recent article advocated the use of completely patient-reported AOFAS. The completely patient-reported Dutch version of the AOFAS scale showed sufficient construct validity, internal consistency, test-retest reliability, and responsiveness and was suitable for use in research settings (28).

Despite all the aforementioned limitations, the AOFAS scoring system has been used in more than half of the studies examining midfoot injuries in recent years (29). Moreover, the AOFAS Midfoot score has been preferred as the primary scoring system in many studies on midfoot injuries (30).

The strength of the study is that the most common outcome scale for midfoot pathologies was translated into Turkish, with sufficient samples from both genders and a wide range of pathologies (e.g. Lisfranc injury, navicular bone fracture, midfoot arthritis). The main criticisms of the original AOFAS scoring, such as being not validated, not containing sufficient response options, small changes in the answers causing a large difference in the total score, and the drawbacks of using them alone, are also the main limitations of our study.

## CONCLUSION

The Turkish version of the AOFAS Midfoot Scale is semantically and linguistically sufficient to evaluate patient-reported outcomes both clinically and scientifically for Turkish-speaking individuals with all developmental or traumatic midfoot pathologies, especially Lisfranc injuries. Although the AOFAS scales are old and widespread, the PROMIS scales, which offer a holistic evaluation opportunity by providing objective and subjective patient evaluations and having a consensus, should be preferred.

### ETHICS

**Ethics Committee Approval:** Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee approved the study (decision no: 2021-13-02, date: 05.07.2021).

**Informed Consent:** Informed consent was obtained from the participants.

### Authorship Contributions

Surgical and Medical Practices: N.Z., A.K., A.D., E.B., Concept: N.Z., E.B., Design: N.Z., E.B., Data Collection or Processing: N.Z., Y.Ş., A.K., T.B., M.U.Ç., A.D., Analysis or

Interpretation: N.Z., T.B., Literature Search: N.Z., Y.Ş., A.K., T.B., Writing: N.Z., Y.Ş., A.K., T.B.

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

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Research

# Examining the Relationship Between Perceived Readiness for Hospital Discharge and Quality of Perioperative Nursing Care in Ambulatory Surgery Patients

## Günübirlik Cerrahi Hastalarının Hastaneden Taburcu Olmaya Hazır Olma Algıları ile Perioperatif Hemşirelik Bakımı Kalitesi Arasındaki İlişkinin İncelenmesi

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## ABSTRACT

**Objective:** Quality monitoring is a necessity in ambulatory surgery and is increasingly common. Since nurses are the health professionals that patients encounter most during the short time they spend in the hospital, the effect of their quality of care on patient outcomes should be determined. This study aimed to evaluate the relationship between ambulatory surgery patients' perceptions of readiness for discharge and the quality of perioperative nursing care.

**Methods:** This descriptive and correlational study included 124 patients who underwent ambulatory surgery at a training and research hospital in İstanbul between October 2023 and March 2024. Data were collected using the Good Perioperative Nursing Care scale (GPNCS) and Readiness for Hospital Discharge scale (RHDS) before patients were discharged.

**Results:** The mean age of the patients in the study was 43.14±15.88 years, of which 56.5% were male and 62.1% were married. The mean total GPNCS and RHDS scores of the patients were 117.48±20.79 and 7.26±1.48, respectively. It was determined that 50.8% of the patients were not ready for discharge, and there was a significant relationship between not being ready for discharge and the adequacy of discharge education. A statistically significant, positive, and moderate relationship was found between the GPNCS and RHDS total score averages (r=0.633, p<0.001).

**Conclusion:** Findings showed that patients after ambulatory surgery, and the quality of perioperative nursing care affected the perception of readiness for discharge. In this regard, to facilitate patient recovery, nurses should plan appropriate interventions to improve the quality of perioperative care.

**Keywords:** Ambulatory surgery, patient discharge, nursing, quality of healthcare

## ÖZ

**Amaç:** Günümüzde giderek yaygın hale gelen günübirlik cerrahide kalite izlemi yapılması bir gerekliliktir. Hemşireler hastaların hastanede geçirdikleri kısa süre içinde en fazla karşılaştıkları sağlık profesyonelleri olduğu için sundukları bakım kalitesinin hasta sonuçlarına etkisi belirlenmelidir. Bu çalışma, günübirlik cerrahi hastalarının hastaneden taburcu olmaya hazır olma algıları ile perioperatif hemşirelik bakım kalitesi arasındaki ilişkinin değerlendirilmesi amacıyla yapıldı.

**Gereç ve Yöntem:** Tanımlayıcı ve ilişki arayıcı tipteki araştırma, Ekim 2023-Mart 2024 tarihleri arasında İstanbul ilinde bir eğitim ve araştırma hastanesinde günübirlik cerrahi girişim geçiren 124 hasta ile gerçekleştirildi. Veriler hastalar taburcu olmadan önce Kaliteli Perioperatif Hemşirelik Bakım skalası (KPHBS) ve Taburcu Olmaya Hazır Olma ölçeği (TOHOÖ) ile toplandı.

**Bulgular:** Çalışmadaki hastaların yaş ortalaması 43,14±15,88 yıl olup %56,5'i erkek, %62,1'i evliydi. Hastaların KPHBS ve TOHOÖ toplam puan ortalamaları sırasıyla 117,48±20,79 ve 7,26±1,48'dir. Araştırmaya katılan hastaların %50,8'nin taburculuğa hazır olmadığı ve taburculuğa hazır olmama ile taburculuk eğitiminin yeterliliği arasında anlamlı ilişki olduğu belirlendi. KPHBS ve TOHOÖ toplam puan ortalamaları arasında istatistiksel olarak anlamlı, pozitif yönde ve orta düzeyde ilişki bulundu (r=0,633, p<0,001).

**Sonuç:** Çalışmanın sonuçları günübirlik cerrahi sonrası hastaların orta düzeyde taburculuğa hazır olduğunu ve perioperatif hemşirelik bakım kalitesinin taburculuğa hazır olma algısını etkilediğini gösterdi. Bu doğrultuda, hastaların iyileşme sürecini kolaylaştırmak için hemşireler perioperatif bakım kalitesini artıracak uygun girişimleri planlamalıdır.

**Anahtar Kelimeler:** Ayaktan cerrahi, hastanın taburcu olması, hemşirelik, sağlık hizmeti kalitesi

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## INTRODUCTION

The primary objective of healthcare systems is to deliver safe, high-quality care. Care lies at the core of nursing knowledge, skills, and practices, making it a fundamental component of healthcare services (1). Nurses are the primary caregivers patients interact with during hospital stay, and nursing care is a significant determinant of overall satisfaction with healthcare quality (2). Defining and evaluating nursing care quality can be challenging despite its widespread conceptual use. Nursing care quality, as perceived by patients, encompasses meeting physical and emotional needs, responding to their wishes, ensuring comfort and convenience, providing accurate information, and maintaining a pleasant environment. Patients' experiences and satisfaction are often used when evaluating the quality of nursing care (2,3). The significance of assessing the quality of care in the field of surgery is underscored by its status as a primary treatment option, associated costs, and potential for serious morbidity and mortality (4).

Surgical intervention is a major event that can evoke various care needs, emotions, and fears in patients. The perioperative period encompasses three distinct phases: preoperative, intraoperative, and postoperative, with nursing care directly affecting surgical and patient outcomes (5). Perioperative nurses are tasked with prioritizing patient safety, which entails creating and maintaining a sterile surgical environment, providing perioperative education to patients, monitoring their physical and emotional well-being, and coordinating care throughout the surgical process (6).

During the perioperative period, patients may find it challenging to articulate their needs due to their vulnerability and reliance on the surgical team. To enhance the quality of nursing care, patients should be encouraged to evaluate the care they receive and express their needs freely. Studies indicate that patients often require support in managing symptoms such as pain and nausea during this period, as well as access to information and respectful treatment after surgery (5). Furthermore, research highlights the impact of factors such as inadequate surgical information, fear of adverse outcomes, poor communication between surgical teams and patients, and the manner in which patients are approached, all of which influence patient satisfaction (7). Despite reports of low satisfaction regarding patient involvement in the surgical process and information provision, patients generally perceive the quality of perioperative care to be satisfactory (8).

Perioperative care has undergone significant transformations in recent years, marked by advancements in surgical and anesthesia techniques, as well as the adoption of accelerated postsurgical recovery protocols aimed at minimizing complications and shortening hospital stays. These developments have facilitated the shift of surgical interventions from traditional inpatient to ambulatory surgery settings (9). Ambulatory surgery entails the discharge of patients from the hospital within 24 hours of the procedure, allowing them to recuperate at home with minimal disruption to their daily routines while mitigating the risks associated with prolonged hospitalization. The growing preference for ambulatory surgery is driven by its low incidence of major adverse events and mortality rates, coupled with high levels of patient satisfaction, even for more complex surgical procedures. However, this increasing demand necessitates ongoing monitoring of care quality and evaluation of patient outcomes to ensure optimal outcomes (4,10).

Common quality indicators in ambulatory surgery include pain management, nausea and vomiting control, fatigue alleviation, physical comfort, emotional well-being, patient satisfaction levels, complication development, waiting times before and after surgery, discharge timing, readiness for hospital discharge, and the occurrence of unplanned hospital readmissions (10).

Readiness for hospital discharge entails assessment of readiness to leave the hospital and manage their condition at home (11,12). Evaluating patients' readiness for discharge helps prevent premature discharge, reduces post-discharge complications, alleviates strain on medical resources, and reduces costs (13). Nurses predominantly oversee essential discharge preparation tasks, such as assessing and planning for needs, providing education, and coordinating post-discharge care. Factors influencing readiness for discharge include individual characteristics like age, gender, education, and marital status, as well as nursing-related factors, such as nurse availability, interaction time, and communication quality (14,15). Research indicates that patients under the care of experienced nurses often exhibit higher readiness for discharge (11) and that the quality of nursing care processes is correlated with satisfaction levels and discharge readiness (16,17).

There is limited literature exploring the readiness of patients undergoing ambulatory surgery for discharge and the factors influencing this readiness. Although studies have indicated the impact of discharge education provided by nurses and surgical teams on discharge readiness (13,18), its correlation with the quality of perioperative nursing care

remains unexplored. Given the abbreviated postoperative care duration in ambulatory surgery, patients may have greater physical and emotional needs upon discharge than anticipated. Understanding the influence of nursing care quality on discharge readiness is crucial for identifying areas for improvement in the perioperative care process and planning patient-centered care.

This study aimed to investigate the relationship between patient perceptions of readiness for hospital discharge and the quality of perioperative nursing care during ambulatory surgery.

## METHODS

### Study Design

This research adopted a descriptive and correlational approach.

### Sample and Settings

The study population comprised patients who underwent ambulatory surgery at a training and research hospital in İstanbul between October 2023 and March 2024. During the previous year, 370 patients underwent ambulatory surgery at our hospital. The inclusion criteria of the sample were age >18 years, undergoing ambulatory surgery with an operating room stay of >1 h, and a hospital stay of 24 h. Patients undergoing general surgery and urologic procedures met the criteria described above at the hospital where the study was conducted. Patients who did not consent to participate, were illiterate, or remained in the hospital for more than 24 h despite being scheduled for ambulatory surgery were excluded. The result of Turan et al.'s (19) study (2021) was applied to estimate the sample size using power analysis, with an effect size of 0.41, significance level of 5%, effect size of 0.5, and power of the study at (1-b) 80%. The total sample size required was 124 patients.

### Data Collection Tools

Data collection involved the use of a descriptive information form, "Good Perioperative Nursing Care scale", (GPNCS) and "Readiness for Hospital Discharge scale". Patients, who were monitored in relevant clinics after ambulatory surgery, were briefed about the study before discharge and requested to complete the data collection forms.

**Descriptive Information Form:** This form, developed by the researchers in line with the literature (1,3,14,15), encompasses sociodemographic characteristics, as well as inquiries regarding receipt and adequacy of discharge education, and availability of post-discharge care support, comprising 15 questions.

**GPNCS:** This 34-item, 5-point Likert scale evaluates the quality of perioperative nursing care. Dönmez and Özbayır (20) performed adaptation of the scale to Turkish society. The following expert suggestions, the scale was refined from 34 to 32 items. The score is derived by summing responses, with seven sub-dimensions indicating quality of perioperative nursing care: physical care, providing information, supporting, respect, personnel characteristics, environment, and nursing process. Scores ranged from 32 to 160, with higher scores denoting superior nursing care quality. In a previous study, Dönmez and Özbayır (20) reported a Cronbach's alpha reliability coefficient of 0.92 for GPNCS. In the current study, the Cronbach's alpha reliability coefficient of the scale was 0.97, and its sub-dimensions were determined as 0.86 for physical care, 0.83 for providing information, 0.73 for support, 0.86 for respect, 0.79 for personnel characteristics, 0.85 for environment, and 0.83 for nursing process sub-dimensions.

**Readiness for Hospital Discharge Scale Short Form (RHDS):** The scale, developed by Weiss et al. (2014) (21), assesses patients' readiness for discharge and was subjected to a Turkish validity and reliability study conducted by Kaya et al. (2018) (22). Comprising eight items in four dimensions, the scale assesses personal status, knowledge, coping ability and expected support. Patients scoring ≥7 in each dimension are considered ready for discharge, whereas those scoring <7 are deemed unready. Additionally, patients were categorized based on their scores as having very high (9-10), high (8-8.9), medium (7-7.9), or low (<7) readiness levels. The scale exhibits a Cronbach's alpha reliability coefficient of 0.74 and employs a 10-point Likert scale (22). In the current study, the scale demonstrated high internal consistency, with a Cronbach's alpha coefficient of 0.95.

### Ethical Permissions

Approval for this research was obtained from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (decision no: 2023-19-03, date: 02.10.2023). Institutional permission was obtained from the hospital where the research was conducted. Patients were briefed on the study objectives and procedures and provided written informed consent.

### Statistical Analysis

Data analysis was performed using Statistical Package for the Social Sciences 21.0. Descriptive statistics, such as mean, standard deviation, frequency, percentage, minimum, and maximum, were used. The Kolmogorov-Smirnov test was used to assess the normal distribution of continuous variables. Intergroup comparisons of continuous

variables used the Mann-Whitney U test for two groups and the Kruskal-Wallis test for multiple groups. Spearman's correlation tests determined relationships between scales, with correlation coefficients classified as very weak (0.00-0.25), weak (0.26-0.49), moderate (0.50-0.69), strong (0.70-0.89), or very strong (0.90-1.00). A significance level of $p<0.05$ was considered statistically significant.

## RESULTS

The results indicate that the average age of the patients enrolled in the study was 43.14±15.88 years. Among the included patients, 56.5% were male, 62.1% were married, 36.3% were high school graduates, 66.1% did not have a chronic disease, and 20.2% had hypertension. The predominant type of surgical intervention in the current study was general surgery, accounting for 89.5% of cases, with laparoscopic appendectomy surgery being the most common procedure performed (46.8%). The average operating time was 62.17±16.35 minutes, and patients spent an average of 86.53±18.66 minutes in the operating room. Regarding post-discharge care, 90.3% of patients reported having someone available to assist with home care. All patients reported receiving discharge education, with 89.5% finding it adequate. However, 61.3% of the patients expressed feeling somewhat prepared for discharge (Table 1).

When examining the mean total and sub-dimensions scores of the patients on the GPNCS, the mean score for the physical care sub-dimension was 37.23±6.83, for giving information it was 18.23±4.07, for supporting it was 13.90±3.27, for respect it was 11.27±2.02, for personnel characteristics it was 14.54±2.85, for environment it was 14.82±2.91, and for nursing process it was 7.48±1.55, while the mean total score was 117.48±20.79. Regarding the RHDS, the mean total score was 7.26±1.48, with the personal status sub-dimension scoring a mean of 7.27±1.44, the knowledge sub-dimension scoring a mean of 7.30±1.73, the coping ability sub-dimension scoring a mean of 7.19±1.72, and the expected support sub-dimension scoring a mean of 7.27±1.76 (Table 2).

There was a positive and moderate correlation between the mean total score of the GPNCS and the RHDS ($r=0.633$, $p<0.001$). A similar correlation was also found between all sub-dimensions of both scales. Additionally, among patients who scored 7 points or higher on the RHDS, 49.2% were deemed ready for discharge, whereas 50.8% of those scoring below 7 points were considered not ready for discharge. Furthermore, a moderate and positive correlation was identified between the mean total score of the GPNCS and the RHDS in patients ready for discharge ($r=0.455$, $p=0.000$). Moreover, a low to moderate positive correlation was observed among all sub-dimensions of the scales, as well as between their mean total scores and all sub-dimensions ($p<0.05$) (Table 3).

Although no relationship was discerned between the mean total scores of the GPNCS and the RHDS in patients who were not deemed ready for discharge, a relationship was observed between several sub-dimensions. Specifically, correlations were found between giving information and knowledge ($r=0.271$, $p=0.032$), personnel characteristics and knowledge ($r=0.339$, $p=0.006$), environment and personal status ($r=0.310$, $p=0.014$), environment and knowledge ($r=0.441$, $p=0.001$), nursing process and personal status

**Table 1.** Characteristics of patients (n=124)

| Variable | Mean ± SD | Min-max |
|---|---|---|
| **Age (years)** | 43.14±15.88 | 18-79 |
| | **n** | **%** |
| **Gender** | | |
| Male | 70 | 56.5 |
| Female | 54 | 43.5 |
| **Marital status** | | |
| Married | 77 | 62.1 |
| Single | 36 | 29 |
| Divorced/widowed/separated | 11 | 8.9 |
| **Education level** | | |
| Literate | 8 | 6.5 |
| Primary/secondary school | 44 | 35.4 |
| High school | 45 | 36.3 |
| University or higher | 27 | 21.8 |
| **Chronic disease** | | |
| Yes | 42 | 33.9 |
| No | 82 | 66.1 |
| **History of surgery** | | |
| Yes | 64 | 51.6 |
| No | 60 | 48.4 |
| **Surgery type** | | |
| Abdominal | 114 | 89.5 |
| Urogenital | 13 | 10.5 |
| **Living with someone at home** | | |
| Yes | 112 | 90.3 |
| No | 12 | 9.7 |
| **Feeling ready for discharge** | | |
| Extremely ready | 3 | 2.4 |
| Very ready | 33 | 26.6 |
| Somewhat ready | 76 | 61.3 |
| Not ready | 12 | 9.7 |

SD: Standard deviation, Min: Minimum, Max: Maximum

(r=0.288, p=0.022), and nursing process and knowledge (r=0.365, p=0.003) sub-dimensions. Additionally, a correlation was noted between the mean total score of the GPNCS and the knowledge sub-dimension of the RHDS (r=0.343, p=0.006) (Table 4).

There were no significant relationships between the sociodemographic characteristics of the patients and the scales, as well as the variables associated with the surgical process and the scales (p>0.05). However, a notable correlation was observed only between patients who were not deemed ready for discharge and the adequacy of discharge education (Z=-2.676, p=0.007).

## DISCUSSION

Evaluating patients' readiness for discharge is a pivotal aspect of the discharge planning process (11). Nurses, being the primary point of contact for patients, play a crucial role in facilitating the discharge process. In ambulatory surgery, where patients have short hospital stays, nurses are tasked with efficiently preparing patients for discharge within a limited timeframe. Patients who are not adequately prepared for discharge are at increased risk of complications. Perioperative nursing care practices significantly contribute to preventing complications and ensuring favorable patient

**Table 2.** Mean scores for Good Perioperative Nursing Care scale (GPNCS) and Readiness for Hospital Discharge scale Total and Sub-dimensions (RHDS) (n=124)

| | Number of items | Min-max | Mean ± SD |
|---|---|---|---|
| **Good Perioperative Nursing Care scale** | | | |
| Physical care | 10 | 20-50 | 37.23±6.83 |
| Giving information | 5 | 5-25 | 18.23±4.07 |
| Support | 4 | 4-20 | 13.90±3.27 |
| Respect | 3 | 6-15 | 11.27±2.02 |
| Personnel characteristics | 4 | 4-20 | 14.54±2.85 |
| Environment | 4 | 4-20 | 14.82±2.91 |
| Nursing process | 2 | 2-10 | 7.48±1.55 |
| Total GPNCS | 32 | 50-160 | 117.48±20.79 |
| **Readiness for Hospital Discharge scale** | | | |
| Personal status | 2 | 3-10 | 7.27±1.44 |
| Knowledge | 2 | 2-10 | 7.30±1.73 |
| Coping ability | 2 | 1-10 | 7.19±1.72 |
| Expected support | 2 | 1-10 | 7.27±1.76 |
| Total RHDS | 8 | 2-10 | 7.26±1.48 |

SD: Standard deviation, Min: Minimum, Max: Maximum

**Table 3.** Correlation between sub-dimensions and total scores of the Good Perioperative Nursing Care scale (GPNCS) and Readiness for Hospital Discharge scale scores in patients ready for discharge (n=61)

| **Scales** | | **Readiness for Hospital Discharge scale Patients scoring ≥7** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Personal status** | | **Knowledge** | | **Coping ability** | | **Expected support** | | **Total RHDS** | |
| | | **r** | **p** | **r** | **p** | **r** | **p** | **r** | **p** | **r** | **p** |
| **Good Perioperative Nursing Care scale** | Physical care | 0.386 | 0.002 | 0.422 | 0.001 | 0.369 | 0.003 | 0.338 | 0.008 | 0.425 | 0.001 |
| | Giving information | 0.378 | 0.003 | 0.440 | 0.000 | 0.369 | 0.003 | 0.354 | 0.005 | 0.441 | 0.000 |
| | Support | 0.511 | 0.000 | 0.413 | 0.001 | 0.354 | 0.005 | 0.350 | 0.006 | 0.512 | 0.000 |
| | Respect | 0.328 | 0.010 | 0.419 | 0.001 | 0.365 | 0.004 | 0.400 | 0.001 | 0.404 | 0.001 |
| | Personnel characteristics | 0.286 | 0.026 | 0.357 | 0.005 | 0.441 | 0.000 | 0.457 | 0.000 | 0.479 | 0.000 |
| | Environment | 0.260 | 0.043 | 0.321 | 0.012 | 0.356 | 0.005 | 0.315 | 0.014 | 0.300 | 0.019 |
| | Nursing process | 0.257 | 0.046 | 0.391 | 0.002 | 0.340 | 0.007 | 0.354 | 0.005 | 0.338 | 0.008 |
| | Total GPNCS | 0.408 | 0.001 | 0.444 | 0.000 | 0.386 | 0.002 | 0.388 | 0.002 | 0.455 | 0.000 |

RHDS: Readiness for Hospital Discharge Scale, GPNCS: Good Perioperative Nursing Care Scale, r: Spearman correlation test

**Table 4.** Correlation between sub-dimensions and total scores of the Good Perioperative Nursing Care scale (GPNCS) and Readiness for Hospital Discharge scale (RHDS) scores in patients who were not ready for discharge (n=63)

| Scales | | Readiness for Hospital Discharge scale Patients scoring <7 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Personal status | | Knowledge | | Coping ability | | Expected support | | Total RHDS | |
| | | r | p | r | p | r | p | r | p | r | p |
| Good Perioperative Nursing Care Scale | Physical care | 0.225 | 0.077 | 0.237 | 0.061 | -0.007 | 0.095 | -0.175 | 0.170 | 0.096 | 0.454 |
| | Giving information | 0.089 | 0.489 | 0.271 | 0.032 | -0.090 | 0.481 | -0.265 | 0.360 | 0.002 | 0.988 |
| | Support | -0.050 | 0.698 | 0.095 | 0.457 | 0.045 | 0.726 | -0.046 | 0.720 | 0.073 | 0.570 |
| | Respect | -0.003 | 0.978 | 0.190 | 0.136 | -0.102 | 0.428 | -0.160 | 0.211 | 0.025 | 0.844 |
| | Personnel characteristics | 0.221 | 0.081 | 0.339 | 0.006 | 0.108 | 0.399 | -0.023 | 0.860 | 0.210 | 0.099 |
| | Environment | 0.310 | 0.014 | 0.441 | 0.000 | -0.008 | 0.950 | -0.071 | 0.582 | 0.213 | 0.093 |
| | Nursing process | 0.288 | 0.022 | 0.365 | 0.003 | 0.006 | 0.960 | -0.177 | 0.165 | 0.145 | 0.257 |
| | Total GPNCS | 0.212 | 0.095 | 0.343 | 0.006 | -0.043 | 0.736 | 0.184 | 0.148 | 0.112 | 0.380 |

RHDS: Readiness for Hospital Discharge Scale, GPNCS: Good Perioperative Nursing Care Scale, r: Spearman correlation test

outcomes (6). This study aimed to assess the impact of the quality of perioperative nursing care among patients undergoing ambulatory surgery on their readiness for discharge. The results of the study revealed a positive and moderate correlation between the quality of perioperative nursing care and readiness for discharge, indicating that patients with higher evaluations of care quality were more ready for discharge.

The average score for perioperative nursing care quality among patients was 117.48±20.79. A comparison with existing literature utilizing the GPNCS revealed noteworthy differences. For instance, Özkan et al. (2023) (23) reported a mean score close to the scale maximum in their study involving patients undergoing general or orthopedic surgery, with an average score of 140.0±16.9. Similarly, higher score averages compared to this study were observed in a study by Şahin and Başak (2018) (24), with averages of 129.49±13.84. Notably, this study's sub-dimension mean scores for physical care, personnel characteristics, and environment were comparatively lower. This variance may be attributed to the busy nature of the operating room in the study institution, and healthcare professionals believe that ambulatory surgery patients have fewer needs due to undergoing minor surgical interventions. Although no prior studies have assessed the quality of perioperative nursing care specifically in ambulatory surgery patients, Gezer and Arslan (2021) (9) reported above-average satisfaction levels among such patients with nursing care. Similarly, Jun and Oh (2016) (10) found a comparable satisfaction level, particularly regarding trust and technical professionalism. The relatively lower perception of perioperative nursing care quality in the current study compared with that of inpatient surgical procedures may be due to nurses having less interaction time with patients in the ambulatory surgery setting.

In this study, the mean score of the RHDS was determined as 7.26±1.48, indicating that patients felt moderately ready for discharge following ambulatory surgery. This finding is consistent with the results of Nurhayati et al. (2019) (25) study (7.11±0.59) involving inpatients who underwent general surgery. Similarly, Baksi et al. (2020) (26) and Zhao et al. (2020) (27) found that patients who underwent various surgical procedures, such as laryngectomy and craniotomy, were moderately discharged. However, other studies have reported varying levels of readiness for discharge, ranging from low to high (12,19). In the current study, patients were observed to have a moderate level of readiness across the sub-dimensions of the scale. Although not significant, the average score for the coping ability dimension was slightly lower than the other dimensions. This dimension encompasses questions regarding patients' preparedness for managing home demands and personal care post-discharge. The patients' relatively lower perception of readiness for coping highlights a significant finding that the ambulatory surgery team should consider because it poses a potential risk for readmission or hospitalization (15).

In the current study, 49.2% of the patients were deemed ready for discharge based on the RHDS. When comparing this finding with the limited literature available, it is consistent with Mabire et al. (2019) (11), who observed that 47.8% of patients in both internal and surgical clinics were ready for discharge. However, when examining the relevant literature concerning patients undergoing ambulatory surgery, our results are notably lower than previous findings. Qiu et al. (2019) (13) reported a readiness rate for discharge of 95.36%, whereas You et al. (18) found it to be 98.8% after ambulatory surgery. This discrepancy in comparison with other studies could be attributed to differences in the composition of the study groups, as the participants in the

current study may have undergone less complex surgical procedures, such as cataract surgery.

Although this study did not reveal a significant relationship between patients' sociodemographic characteristics and their readiness for discharge, previous research has indicated that factors such as age, literacy, availability of support for home care, previous hospitalization experiences, and length of hospital stay can influence readiness for discharge (12,17,28). However, in the current study, a correlation was only found between patients who were not ready for discharge and the adequacy of the discharge education provided. This finding aligns with the results of Durmaz and Özbaş (2023) (14).

In this study, a positive relationship was observed between the quality of perioperative nursing care among patients undergoing ambulatory surgery and their readiness for discharge. This particular finding lacks comparison in the existing literature. Discharge education is a crucial nursing intervention during the discharge preparation process, addressing a significant need among ambulatory surgery patients and significantly affecting patient satisfaction. The quality of education is a key determinant of patient readiness for discharge (15). Qiu et al. (2019) (13) and You et al. (2019) (18) examined the correlation between the quality of discharge education and readiness for discharge among ambulatory surgery patients, both reporting a positive correlation. Similarly, findings from studies including inpatients undergoing surgical interventions echo these results (27). Another study involving patients from internal and surgical clinics concluded that the content and nurses' skills in delivering discharge education were associated with patients' readiness for discharge (28). Additionally, this study revealed a positive relationship between the giving information sub-dimension of the GPNCS and the knowledge sub-dimension of the RHDS, further supporting these findings. This underscores the significance of education for patients undergoing ambulatory surgery, emphasizing the importance of adequately informing patients during the perioperative period to enhance their readiness for discharge and subsequent self-care at home.

Determining patient satisfaction with nursing care is crucial for meeting patients' needs and assessing the quality of care. When patients' expectations regarding nursing care are fulfilled, their participation in treatment and care practices becomes smoother (29). Therefore, the association between patient satisfaction with nursing care and readiness for discharge has been investigated in various studies. Baksi et al. (2021) (17) identified a positive correlation between nursing care satisfaction and readiness for discharge among surgical patients, whereas Schmocker et al. (2015) (30) found that patient satisfaction in areas such as the communication with physicians and nurses and overall hospital experience influenced their readiness for discharge. Additionally, a study observed that patients under the care of nurses with greater professional experience were more ready for discharge, suggesting that experienced nurses provided higher-quality care during the discharge preparation process (11). In this regard, the current study is in line with the existing literature.

A moderate correlation was observed between the personnel characteristic sub-dimension of the GPNCS and the knowledge sub-dimension of the RHDS among patients who were not ready for discharge. Although patients may not feel ready for discharge, positive interactions with healthcare professionals during the perioperative period can positively influence their knowledge. Healthcare professionals who demonstrate expertise, strong communication, and interpersonal skills, allocate sufficient time for patient care, and provide reassurance typically yield better patient outcomes (3,8).

Although no comparable studies exist in the literature, a positive association was identified between the environment sub-dimension of the GPNCS and the personal status and knowledge sub-dimensions of the RHDS. Similarly, a positive correlation was found between the nursing process sub-dimension of the GPNCS and the personal status and knowledge sub-dimensions of the RHDS. A clean and orderly clinic environment and comfortable patients are considered indicators of quality care (3,5). Moreover, an environment free from distractions is crucial for effective patient education. Therefore, a relationship between patients' positive environmental perceptions during the perioperative period and their personal status and knowledge at discharge is expected.

In addition to the relationship between patients' readiness for discharge and the quality of discharge education and nursing care satisfaction, a few studies have suggested that nursing practices, such as care coordination and one-on-one time with patients, contribute to patients' overall readiness for discharge, although their impact on specific sub-dimensions remains unclear (16,28). The role of nurses in discharge management for patients undergoing ambulatory surgery, as highlighted by the effect of the nursing process observed in this study, is vital for ensuring smooth transitions for both patients ready for discharge and those who are not.

**Study Limitations**

This study is the first in the literature to explore the relationship between perioperative care quality and

readiness for discharge after ambulatory surgery. Moreover, it is confined to data from patients who underwent general and urologic surgery at a single center.

## CONCLUSION

The findings of this study indicate that patients undergoing ambulatory surgery exhibit moderate readiness for discharge, with their perception of perioperative care quality significantly influencing this readiness. Given that patients who are unprepared for discharge may face heightened risks and adaptation challenges that impede recovery, enhancing the quality of care provided by nurses to ambulatory surgery patients can foster readiness for discharge and positive patient outcomes.

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### ETHICS

**Ethics Committee Approval:** Permission for the study was obtained from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee of the university (decision no: 2023-19-03, date: 02.10.2023).

**Informed Consent:** Patients were briefed on the study objectives and procedures and provided written informed consent.

### Authorship Contributions

Concept: B.G., C.K.S., Design: B.G., Data Collection or Processing: C.K.S., Analysis or Interpretation: B.G., Literature Search: B.G., C.K.S., Writing: B.G.

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

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Case Report

# Cardiac Memory-induced T-wave Inversions After Temporary Ventricular Pacing

## Geçici Ventriküler Pacing Sonrası Kardiyak Hafızaya Bağlı T Dalgası İnversiyonları

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## ABSTRACT

Cardiac memory refers to T-wave inversions (TWI) on electrocardiograms (ECGs) after an episode of abnormal ventricular activation or wide electrical activity of ventricular muscles (QRS complex). We present the case of a 62-year-old woman with symptomatic bradycardia due to sinus pause. She immediately underwent temporary transvenous ventricular pacing. In the following days, intrinsic normal sinus rhythm was resumed at 69 bpm and a narrow QRS was observed (97 ms). Additionally, deep TWI was observed in leads II, III, aVF, and V3-V6. The distribution of TWI, normal echocardiogram and laboratory results, non-significant coronary angiogram, and recent right ventricular pacing correspond to possible cardiac T-wave memory. Follow-up 12-lead ECG four weeks later showed that T-wave morphology returned to normal baseline. This further confirmed the final diagnosis of cardiac memory-induced TWI. Recognizing cardiac memory-induced TWI is important for physicians to facilitate proper evaluation and management of TWI and prevent unnecessary further cardiac diagnostic tests.

**Keywords:** Cardiac memory, T-wave inversion, wide QRS, ventricular pacing, bradycardia

## ÖZ

Kardiyak hafıza, anormal ventriküler aktivasyon veya geniş QRS epizodundan sonra elektrokardiyogramlarda (EKG) görülen T dalgası inversiyonlarını (TWI) ifade etmektedir. Bu yazıda, sinüs duraklamasına bağlı semptomatik bradikardisi olan 62 yaşında bir kadın hasta sunuldu. Hastaya hemen geçici transvenöz ventriküler pacing uygulandı. Takip eden günlerde, intrinsik normal sinüs ritmi 69 bpm'de devam etti ve dar QRS gözlendi (97 ms). Ek olarak, II, III, aVF ve V3-V6'da derin TWI gözlendi. TWI dağılımı, normal ekokardiyogram ve laboratuvar sonuçları, anlamlı olmayan koroner anjiyogram ve yakın zamandaki sağ ventrikül pacing'i olası kardiyak T dalgası hafızasına karşılık gelmektedir. Dört hafta sonra takipte çekilen 12 derivasyonlu EKG, T dalgası morfolojisinin normal başlangıca döndüğünü gösterdi. Bu, kardiyak hafızaya bağlı TWI'nin nihai tanısını doğrulamıştır. Kardiyak hafızaya bağlı TWI'nin tanınması, doktorlar için TWI'nin doğru değerlendirilmesi ve yönetimini kolaylaştırmak ve gereksiz ileri kardiyak tanısal testleri önlemek açısından önemlidir.

**Anahtar Kelimeler:** Kardiyak hafıza, T dalgası inversiyonu, geniş QRS, ventriküler pacing, bradikardi

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## INTRODUCTION

The typical definition of cardiac memory refers to the T-wave changes [usually T-wave inversions (TWI)] on the electrocardiogram (ECG) after an episode of abnormal ventricular activation or wide QRS complex that appears after the pattern of normal ventricular activation returns (1,2). TWI as cardiac memory manifestations often mimic other pathological conditions that may manifest as TWI, such as myocardial infarct or ischemia, myopericarditis, takotsubo cardiomyopathy, and cerebrovascular accident (1,2). Here we report a case of cardiac memory manifesting as new-onset TWI after ventricular pacing in a patient with symptomatic bradycardia due to sinus pause.

## CASE REPORT

A 62-year-old female presented to the emergency room with intermittent chest pain and dizziness. She had a history of uncontrolled hypertension for one year. On arrival, blood pressure was 144/76 mmHg, heart rate was 20-30 beats per minute (bpm), respiratory rate was 22 breaths per minute, and oxygen saturation was 97% on free air. Other physical examinations were within normal limits. A 12-lead ECG showed periodic sinus pause at a rate of 30 bpm (Figure 1). Bedside echocardiography revealed normal left ventricle systolic function (ejection fraction sof 68% by teicholz) and no abnormal wall motion. Serial troponin levels were negative. Electrolytes (sodium, potassium, chloride, calcium, and magnesium) and thyroid function tests were within the normal range. She was diagnosed with symptomatic bradycardia due to sinus pause, and temporary transvenous ventricular pacing was immediately performed. A12-lead ECG was obtained after temporary pacing insertion, which showed a right ventricular paced rhythm (QRS width 150 ms) at 75 bpm (Figure 2). The patient was then scheduled for permanent pacemaker (PPM) implantation because of symptomatic bradycardia (sinus pause) with no potential causes.

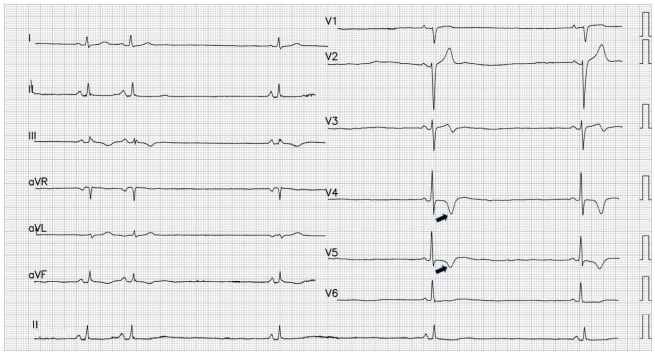


**Figure 1.** Electrocardiogram on arrivasl showed periodic sinus pause with a rate of 30 bpm, narrow QRS complex, and T-wave inversions in V4-V5 (arrows)

On the following days, intrinsic normal sinus rhythm was resumed at a rate of 69 bpm and narrow QRS (97 ms) was observed on ECG (Figure 3). Additionally, deep TWI was observed in leads II, III, aVF, and V3-V6 (Figure 3). She was asymptomatic at this time. However, suspicion of myocardial ischemia or infarction is raised. Repeat echocardiography revealed no wall motion abnormality. Troponin and electrolytes were within the normal range. Coronary angiography was then performed before PPM implantation. There was no significant stenosis found on angiography (Figure 4). Finally, due to the T-wave direction in sinus rhythm following (remembering) the QRS complex direction during the previous episode of wide QRS or abnormal ventricular activation (ventricular pacing), TWI was concluded to be a manifestation of cardiac memory after ventricular pacing. A dual chamber PPM DDDR was implanted successfully. She was then discharged with no symptoms. Follow-up ECG at the outpatient clinic four weeks later showed that T-wave morphology had returned to normal baseline (Figure 5).

Written informed consent for the publication of this case report and accompanying images was obtained from the patient.

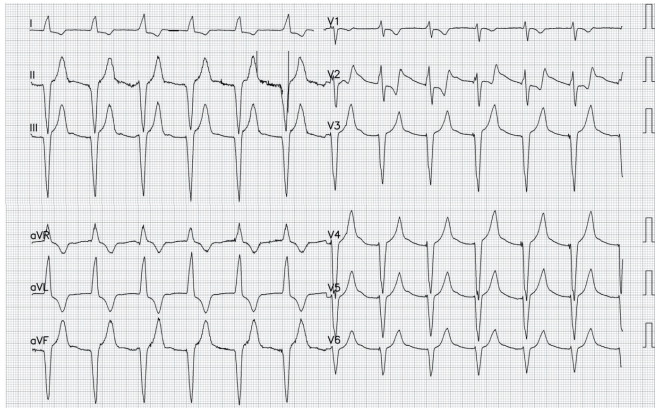


**Figure 2.** Electrocardiogram after temporary pacing insertion showed right ventricular paced rhythm (QRS width 150 ms) at 75 bpm

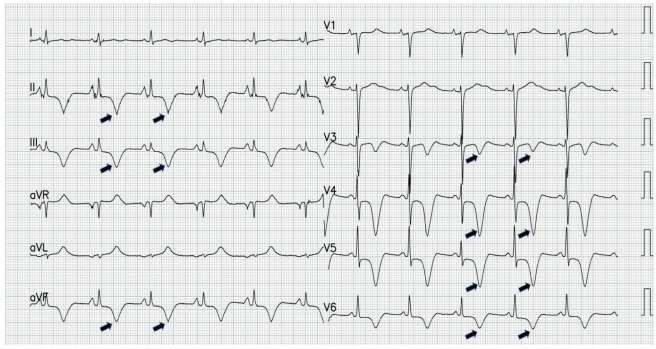


**Figure 3.** Electrocardiogram on the following days showed intrinsic sinus rhythm with a normal rate of 69 bpm, narrow QRS (97 ms), and deeper T-wave inversions were observed in leads II, III, aVF, and V3 through V6 (arrows)

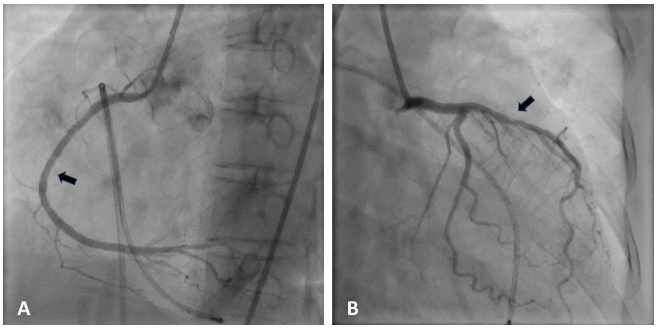


**Figure 4.** Coronary angiography revealed (A) irregularity at mid right coronary artery (arrow), and (B) non-significant stenosis at the proximal to mid left anterior descending artery (arrow). A temporary pacing lead was seen in the right ventricle

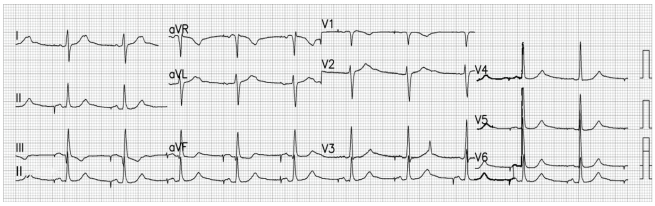


**Figure 5.** Follow-up electrocardiogram at the outpatient clinic four weeks later showed atrial paced-ventricular sensed rhythm with narrow QRS (99 ms) and normal T-wave morphology

## DISCUSSION

Cardiac memory is a common but rarely recognized phenomenon in which T-waves in a sinus or intrinsic rhythm follow or remember the QRS vector from a previous abnormal activation (1,3). It manifests on ECG or vector cardiogram as TWI during any intrinsic or sinus rhythm with normal ventricular activation that occurs after periods of abnormal myocardial activation (e.g. after ventricular pacing, ventricular tachycardia, left bundle branch block, intermittent ventricular preexcitation, and pre-excitation ablation) (4,5). Cardiac memory is associated with prolonged repolarization in the initial active area (1). The cellular mechanisms of cardiac memory are currently unclear, but changes in several ion channels, cell coupling, and receptors, including the temporary outward current, Ito, ICa, Na/Ca exchanger, IKr, stretch-activated receptors, AT1 receptors, and redistribution of gap junctions, have been reported (1,3,6).During intrinsic sinus rhythm with a normal rate, a new and deeper TWI (Figure 3) in this patient appeared in the lead with a negative QRS complex during the previous ventricular paced rhythm (leads II, III, aVF, and V3 to V6). The distribution of TWI, normal echocardiogram and laboratory results, non-significant coronary angiogram, and recent right ventricular pacing correspond to possible cardiac t-wave memory. TWI on arrival might be caused by bradycardia (Figure 1).

Cardiac memory may persist for several weeks after ventricular conduction returns to normal (1). Attenuation of the TWI in this patient was documented four weeks later on a follow-up 12-lead ECG in which T-wave morphology returned to normal baseline. This further confirmed the final diagnosis of cardiac memory-induced TWI.

Once other causes of TWI are ruled out, cardiac memory-induced TWI does not require specific treatment (5). In patients without pacemakers, cardiac memory may imply intermittent ventricular preexcitation, intermittent left bundle branch block, or paroxysmal ventricular tachycardia, and ambulatory heart rhythm monitoring may be appropriate to determine the potential causes (4,5). Cardiac memory in this patient was most likely secondary to temporary ventricular pacing; hence, no further workup or treatment was necessary.

Recognizing cardiac memory as a potential cause of TWI is essential to prevent unnecessary hospitalization, further cardiac diagnostic workup, or cardiac catheterization. T-wave morphological analysis can help distinguish ischemia-induced from cardiac memory-induced TWI after right ventricularpacing. A study by Shvilkin et al. (7) demonstrated that the combination of 1) positive T-wave in aVL and isoelectric or positive T-wave in lead I and 2) maximum TWI in the precordial lead greater than that in the inferior lead, as shown in this patient, has a sensitivity of 92% and specificity of 100% for cardiac memory-induced TWI from right ventricular pacing.

Cardiac memory is a pattern of T-wave changes, usually TWI, following the resolution of abnormal ventricular activation or wide QRS rhythm. Recognizing the cardiac memory phenomenon is essential for physicians to facilitate appropriate evaluation and management, which may help avoid unnecessary hospitalization and further cardiac diagnostic tests.

### ETHICS

**Informed Consent:** Written informed consent was obtained from the patient for publication of this case report and accompanying images.

### Authorship Contributions

Surgical and Medical Practices: E.P.B.M., D.A.R., R.J., B.B.D., M.R.A., Concept: E.P.B.M., D.A.R., B.B.D., Design: E.P.B.M., D.A.R., R.J., M.R.A., Data Collection or Processing: E.P.B.M., D.A.R., M.R.A., Analysis or Interpretation: E.P.B.M., D.A.R., R.J., B.B.D., Literature Search: E.P.B.M., D.A.R., M.R.A., Writing: E.P.B.M., D.A.R., R.J., B.B.D., M.R.A.

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

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