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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

Arzu Abalay[1,2], Yakup Cemel[3], Berrak Varhan[1], Melek Güneş Yavuzer[4]

[1]İstinye University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, Türkiye
[2]Balıkesir Provincial Health Directorate, Edremit District Health Directorates Healthy Life Center, Balıkesir, Türkiye
[3]İstanbul Medipol University Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, Türkiye
[4]Haliç University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, Türkiye

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

Address for Correspondence: Arzu Abalay, İstinye University Faculty of Health Science, Department of Physiotherapy and Rehabilitation, İstanbul; Balıkesir Provincial Health Directorate, Edremit District Health Directorates Healthy Life Center, Balıkesir, Türkiye
Phone: +90 507 589 19 17 E-mail: arzuabalay@hotmail.com ORCID ID: orcid.org/0000-0001-7518-3647

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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 α error. In addition, after competition of the study, power analysis performed by G-Power indicated a power of 87% with 0.05 α 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 2nd and 5th metacarpophalangeal joints. Palm length was determined by measuring the distance between the 3rd 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

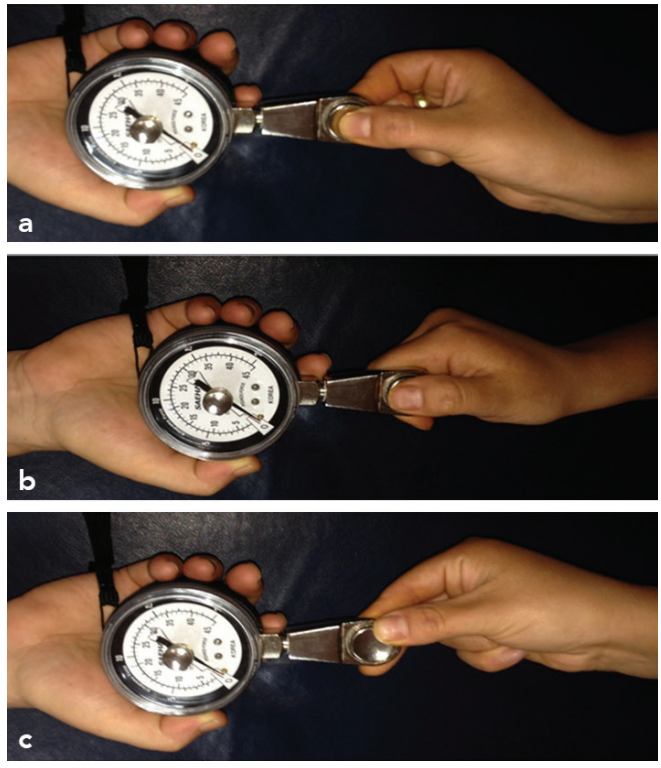

Figure 2. a. Fingertip grip strength measurement. b. Measurement of lateral grip strength. c. Palmar grip strength measurements

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 $p<0.05$.

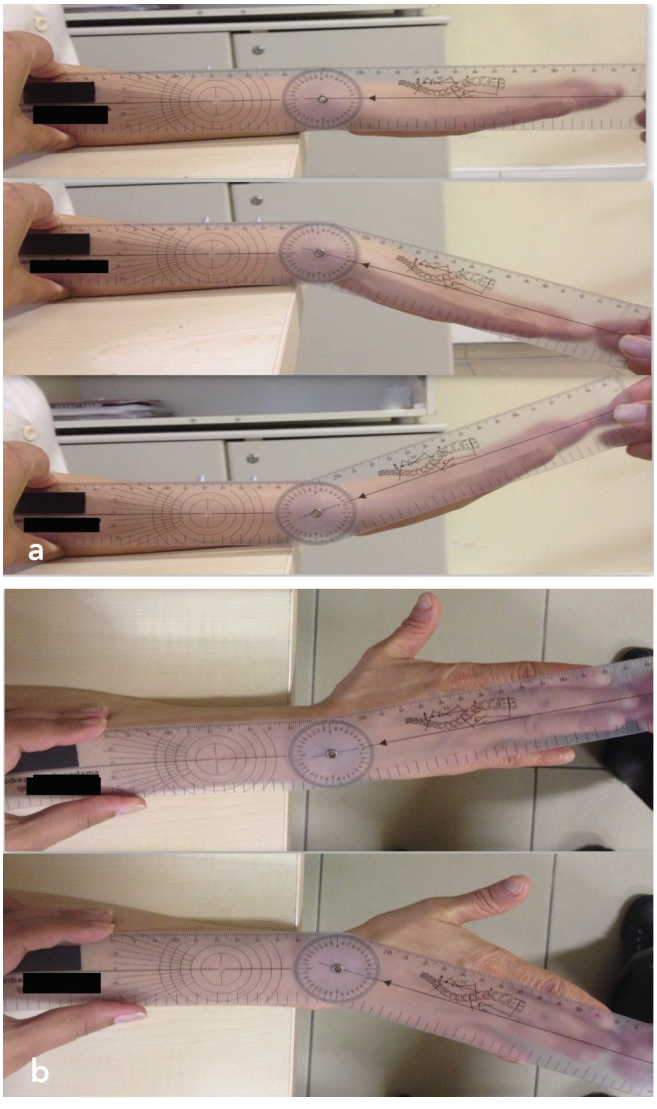

Figure 3. a. Joint position sense evaluation of flexion and extension. b. Joint position sense evaluation of radial and ulnar deviation

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.

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