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Research Article

Clinical Significance of the Morphometric Structures of the Scapula with the Emphasis on the Glenoid Cavity

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Abstract

Aim: The aim of this study is to determine the average of the morphometric parameters of the scapula to accurate and successful analyzes in the clinic.

Material and Methods: A total of 24 dry bone scapula were included in the study. Parameters determined on the scapula; superio-inferior glenoid diameter (SIGD), anterio-posterior glenoid diameter 1 (APG1), anterio-posterior glenoid diameter 2 (APG2), anterio-posterior glenoid diameter 3 (APG3), scapula width (SW), scapula length (SL), basis-spina distance (BS), spina scapula width (SSW), acromiocoracoid width (AW), scapula margo lateralis length (SML), scapula margo medialis length 1 (SML 1), scapula margo medialis length 2 (SML 2), cavitas glenoidalis antero-posterior width (CGAPW), cavitas glenoidalis superio-inferior width (CGSIW), incisura scapula width (ISW), incisura scapula depth (ISD), the maximum length of proccessus coracoideus (MLPC), maximum proccessus coracoideus thickness (MPCK), the shortest distance between the lateral edge of the proccessus coracoideus tip and the anterior upper edge of the cavitas glenoidalis (PCL-CGK).

Results: Among the determined parameters, SSW, MSW, ISW, ISD, MPCU, MPCK, PCL-CGK were found to be in parallel with the analyzed literatures.

Conclusion: It is thought that the results of the analysis of the parameters determined in the study will add clinical depth to many surgical approaches such as glenohumeral arthrodesis, internal fixation, fracture stabilization, and rotator cuff tendinitis, in more accurate analysis of shoulder anomalies and fractures.

Keywords: Scapula, morphometry, cavitas glenoidalis

INTRODUCTION

The scapula articulating with the clavicle and humerus has a complex anatomical peculiarity due to its irregular shape and ossifies approximately seven different anatomical points, including the body and the processes (1). The lateral angle connecting the upper and outer lateral edges of the scapula is the thickest corner, possessing the glenoid cavity, which forms the concave articular surface of the shoulder joint (2,3). The superior margin is the shortest and thinnest edge comprising the scapular notch at the junction of the upper edge and the base of the coracoid process (3–5). The scapula reaches the shoulder girdle to the thorax and vertebral column via the musculotendinous structures medially (6).

The scapula plays a significant role clinically because the mobile parts of the upper extremity are connected to the trunk by this bone and clavicle. The scapula, clavicle, and humerus together form the joint with the widest range of motion in the body. The shoulder joint has approximately 170º anterior elevations, approximately 60º extensions, and approximately 120-180º rotations. The shoulder provides this range of motion with the simultaneous movement of five joints. These joints are the sternoclavicular, acromioclavicular, glenohumeral, scapulothoracic, and subacromial from medial to lateral (1,7–9). In addition, the scapula plays a major role in the strength, and energy of shoulder function. Muscles attached to the scapula play a role in scapular stabilization, and glenohumeral and scapulothoracic joint movements (10). With these in mind, revealing and analyzing the morphometric peculiarities of the scapula having such significance, with the emphasis on the glenoid cavity, will surely collocate a clinical perspective to many surgical approaches such as

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glenohumeral arthrodesis, internal fixation, and fracture stabilization, and rotator cuff tendinitis. It will also provide more accurate analysis in the field of physiotherapy and rehabilitation in anomalies and fractures of the shoulder. Therefore, this study aimed at documenting and analyzing the morphometric characteristics of the scapula, focusing primarily on the glenoid cavity.

MATERIAL AND METHOD

The study was conducted on 24 (16 right, 8 left) dried human scapula of unknown age and gender. Measurements were not taken from the partially broken, fragmented, and damaged parts of the dry bones. Permission was obtained from the Bolu Abant Izzet Baysal University Clinical Researches Ethics Committee. Decision No:2022/144 Date:07.06.2022 The measurements were performed by using a digital caliper nearest 0.1 mm (Baker 0-150 mm) on the osteometry board. Descriptive statistics for continuous variables in the study mean±sd and categorical variables are expressed as percentages (%). The results were evaluated using the R Studio (R Tools Technology, Inc. 4.1.1 USA) program. The t-test was used for independent group comparisons. The significance level was taken as $p<0.05$. The reference points of the parameters are as follows (2,6–11):

•Superio-Inferior Glenoid Diameter (SIGD): The maximum distance from the lower point of the glenoid margin to the most prominent point of the supraglenoid tubercle.

•Anterio-Posterior Glenoid Diameter 1 (APG1): The maximum width of the cavitas glenoidalis joint is perpendicular to the height of the cavitas glenoidalis.

•Anterio-Posterior Glenoid Diameter 2 (APG2): Anterio-posterior diameter of the upper half of the midpoint between the upper edge and the midline.

•Anterio-Posterior Glenoid Diameter 3 (APG3): Anterio-posterior diameter at the incisura glenoidalis crest.

•Scapula Width (SW): The maximum distance between the base of the spina and the center of the glenoid cavity.

•Maximum Scapula Width (MSW): The maximum length measured along the center of the cavitas glenoidalis and the base of the spina scapulae.

•Scapula Length (SL): The maximum distance between the angulus superior and the angulus inferior.

•Basis-Spina Distance (BS): The maximum distance between the base of the spina and the innermost part of the glenoid cavity.

•Spina Scapula Width (SSW): The maximum distance between the base of the spina and the most prominent part of the acromion.

•Acromiocoracoid width (AW): The maximum distance between the ventral part of the coracoid process and the most dorsal part of the acromion.

•Scapula Margo Lateralis Length (SML): The maximum distance between the lower point of the cavitas glenoidalis and the angulus inferior.

•Scapula Margo Medialis Length 1 (SML1): Scapula corpus width is taken 2 cm above margo inferior.

•Scapula Margo Medialis Length 2 (SML2): Scapula corpus width is taken 4 cm above margo inferior.

•Scapula Margo Medialis Length 3 (SML3): Scapula corpus width is taken 6 cm above margo inferior.

•Cavitas Glenoidalis Antero-Posterior Width (CGAPW): Anterio-posterior maximum distance.

•Cavitas Glenoidalis Superior-Inferior Width (CGSIW): The maximum length between the lowest point of the cavitas glenoidalis and the tip of the tuberculum supraglenoidale.

•Incisura Scapula Width (ISW): The distance between the point where incisura scapulae start in margo superior and the beginning of proceccus coracoideus.

•Incisura Scapula Depth (ISD): The distance between the line tangent to the Margo superior and the deepest point of the notch.

•Maximum length of processus coracoideus (MLPC)

•Maximum processus coracoideus thickness (MTPC)

•The shortest distance between the lateral edge of the apex of the processus coracoideus and the anterior upper edge of the cavitas glenoidalis (PCL-CGK)

•Scapular index (SI): (SW)/(SL)*100

•Infraspinate index (ISI): (SW)/(SML2) *100

•Glenoid index (GI): (CGAPW)/(CGSIW)*100

•Shape of the Cavitas Glenoidalis (SCG): According to the shape made by the slightly raised edge of the glenoid space, it is divided into a pear, oval and inverted comma.

•Shape of the Coracoglenoid Area (CAS): It was divided into three groups according to the shape of the region between processus coracoideus and cavitas glenoidalis. Type I; round, Type II; square and Type III; hook.

•Shape of the Incisura Scapula (SIS): Incisura scapulas were divided into 5 groups according to their shape and depth. Type I; deep and U-shaped, Type II; shallow and U-shaped, Type III; deep and V-shaped, Type IV; shallow and V-shaped, Type V; its notch is grouped into a hole shape.

The reference points of the measurements are shown in figure 1 and figure 2.

RESULTS

The morphometric measurements of the 24 scapular bones (16 right, 8 left) are shown in table 1 and table 2.

•The index values are respectively, SI; 65.8±4.07, II; 103.86±0.18, GI; 69.74±5.8.

•SCG; 87.5% pear, 8.3% oval ve 4.16% inverted comma.

•CAS; 33.3% round, 57.14% square, 9.52% hook.

•SIS; 12.5% type 1, 16.6% type 2, 37.5% type 3, 33.3% type 4.

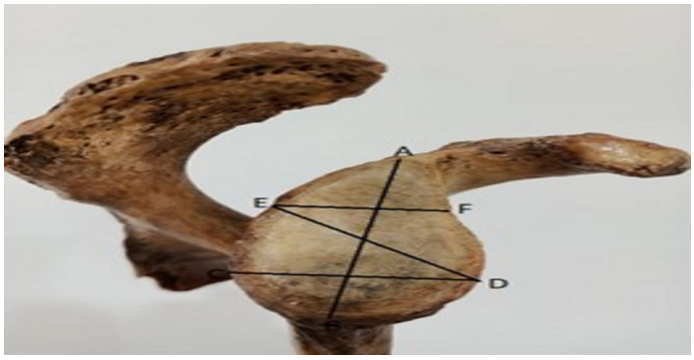

Figure 1. AB: Superio-Inferior Glenoid Diameter (SIGD), CD: Anterio-Posterior Glenoid Diameter 1 (APG1), EF: Anterio-Posterior Glenoid Diameter 2 (APG2), ED: Anterio-Posterior Glenoid Diameter 3 (APG3)

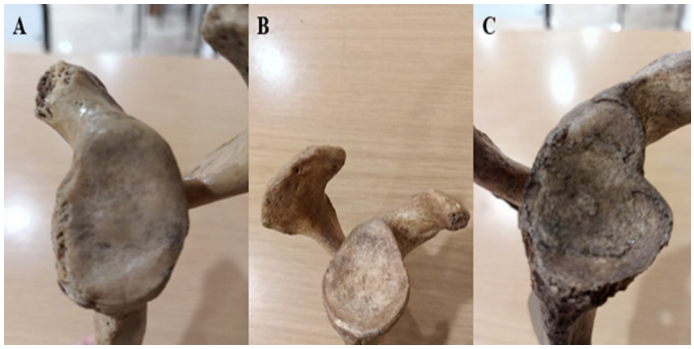

Figure 2. A: Oval, B: Inverted Comma, C: Pear

Figure 3.a. AD: Basis-spina distance (BS), BD: Scapula width (SW), CD: Spina scapula width (SSW), GM: Scapula margo medialis length 1 (SML1) FL: Scapula margo medialis length 2 (SML2), EH: Scapula margo medialis length 3 (SML3), NP: Scapula length (SL)

Figure 3.b. AB: Maximum scapula width (MSW), AC: Scapula margo lateralis length (SML)

Table 1. Morphometric measurements of the scapula

Parameters	Mean±SD (mm)	Mean±SD		p
	Total	Right	Left	
SIGD	37.9±0.31	37±0,3	38±0.34	0.9
APG1	24.7±0.27	24.1±0.2	25±0.32	0.5
APG2	20.1±0.31	19.3±0.28	21.8±0.29	0.6
APG3	29.4±0.55	28±0.2	30.6±0.93	0.9
SW	103.5±0.84	99.7±0.64	110.6±0.6	0.5
SL	150±1.17	149±0.72	161±1.05	0.4
BS	73±0.82	70±0.7	77.1±0.71	0.5
SS	144.5±1.05	139±0.9	150.6±1.24	0.9
SSW	144±1.2	150±1.2	139±0.9	0
AW	62±0.92	57.9±0.8	69.1±0.49	0.9
SML	134.3±0.93	134.2±0.6	134.4±1.33	1
SML1	50.1±0.51	49±0.4	51.4±0.52	0.6
SML2	110.6±1.1	108±0.6	114.1±1.53	0.5
SML3	101.5±0.71	99±0.51	106.7±0.82	0.5
MSW	154±1.05	149.6±0.72	161±1.05	0.8
CGAPG	26.2±0.26	26.1±0.26	26.5±0.26	1
CGSIG	37.7±0.3	38±0.29	37.1±0.3	0.5
ISW	658.9±4.07	85±2.31	91.6±1.93	0.3
ISD	2038.6±18.4	48.5±1.57	57.3±1.7	0.9
MPCU	697.4±5.8	443.4±2.7	451±3.8	0.6
MPCK	88.4±2.18	100±1.1	101.3±2.5	0.4
PCL-CGK	52.5±1.69	145±1.03	146±1.9	0.9

Table 2. Comparison of scapula width (SW) and scapula length (SL) by various authors

	SW	SL
Costa et al. (male-female)	102.43-90.81	151.143-132.63
Ülkir	101.5	150.4
Aydemir	105	147
El-Din et al.	107.22	151.16
Gosavi et al.	141.4	123.02
Chhabra et al.	103.65	98.69
Paraskevas et al.	101.9	147.6
Lingamdenne et al.	98.69±6.98	141.49±9.74
Piyawinijwong et al.	104±7.8	139.3±11.1
Kabakcı et al.	98.5	140.8
This study	104	150.2

Table 3. Comparison of the scapular index (SI), infraspinat index (ISI), and glenoid index (GI) by various authors (1,4,10,17,18,22–25)

	SI	ISI	GI
Ülkir	67.8	102.2	-
Kabakçı et al.	121.52	91.03	68.49
El-Din et al.	70.93	-	-
Chhabra et al.	73.32	99.60	-
Singhal et al.	68.5	94.6	-
Krishnaiah et al.	73.99	98.33	-
Parmar et al.	-	-	69.09
Polguj et al.	63.7	-	72.35
Dhindsa et al. (right-left)	-	-	70.37-68.59
This study	65.8	101.8	69.7

DISCUSSION

This study has documented and analyzed the morphometric characteristics of the scapula, particularly those of the glenoid cavity. Yet, various dimensions and incidences of the glenoid cavity have been measured and compared with the findings in the literature which contain various results (2,11-15). The average SIGD value has been documented as 37.9±3.1 (37.7±3 right, 38.5±3.4 left) mm in this study, indicating numerical differences. Similarly, research (11) has examined the right side of the 43 and left side of the 57 glenoid cavities of the scapula, finding these values as 34.76±3 mm and 34.43±3.21 mm, respectively, again showing a slight numerical difference. Another study (2) has reported those values on 202 dried scapula to be 33.67±2.82 mm on the right side and 33.92±2.87 mm on the left, revealing slightly lower values. Yet, three studies (12–14) have measured the same values in males and females as 36.08±2.05 mm, and 31.17±1.17 mm, respectively, the other studies' mean±std. Values as 36.3±3 mm, 35.9±3.6 mm. These values were lower than what was examined in the current study. The average SIGD of the male and female observed was 38.71±2.71 mm and 33.79±3.08 mm respectively (15). While the male value was higher than the female value was lower than the average SIGD value of the current study.

The average APG-1 value of the right scapula in this study was 24.1±2.2 mm while that of the left side was 25.8±3.2 mm, and the average of both sides was 24.7±2.7 mm in the current study. This suggests that the right glenoid was quite similar to the left glenoid. In two studies conducted in India; APG-1 on the right side was 23.31±3 mm and 23.35±2.04 mm respectively, and that on the left side was 22.92±2.80 mm and 23.02±2.30 mm (2,11), which were lower than what was examined in this study. The female and male APG-1 values were recorded in the East Anatolian population and Guatemalan contemporary rural and indigenous population; who were found to be 22.31±1.49 mm and 22.72±1.9 mm respectively female, that of the male values were 26.31±1.57 mm and 27.33±2.4 mm respectively (14,15). The APG-1 values were recorded in two studies examining glenoid cavity patterns and scapula pillars; 27.2±3 mm and 22.62+2.9 mm respectively. The average APG-1 of both sides was 24.7±2.7 mm in the current study and that value was between these values (11,13). In the current study, APG-2 and APG-3 values on the right side were 19.3±0.28 mm and 28.8±2.2 mm respectively, and on the left side values were 21.8±2.9 mm and 30.6±9.3 mm respectively. This suggests that the left glenoid cavity was broader than the right glenoid cavity. While the APG-2 and APG-3 values of the Indian population were 15.10±2.54 mm, 16.2±3.23 mm, respectively, on the right side, they were 13.83±2.45 and 15.24±2.04 mm, respectively, on the left side (11). This suggests that the right glenoid cavity was broader than the left glenoid cavity. unlike our study. Average values of the CGSIW and the CGAPW values were respectively. 37.7±3 mm and 26.2±2.6 mm in this study. A study conducted on the Turkish population stated that CGSIW and CGAPW are 25 and 35. respectively (6). These values were found to be quite close to the results of the study. In the current study, various SGC and the percentage of incidence were recorded at 88% of the pear, 8% of the oval, and 4% of the inverted comma-shaped.

In two studies investigating the SGC; in right and left sides respectively; firstly, the right side values are 35% and 34% of glenoids were inverted commas, 49% and 46% of glenoids were the pears and 16% and 20% of glenoids were oval-shaped, on the left side, 39% and 33% of glenoids were inverted commas, 46% and 43% of glenoids were the pears and 15% and 24% of glenoids were oval-shaped. This suggests that the large rate is pear-shaped in both studies (2,11).

The studies conducted by the Turkish adult population in 72% of the glenoid notches of the scapula were absent or oval-shaped, whereas in 28% the notch was well expressed and the glenoid cavity was pear-shaped (12).

These findings were higher than that of the current findings and on the contrary results, in terms of shape, which takes the largest rate. The literature data on the width and height of the scapula as mm are shown in table 3 (1,6,10,16–21).

When the data between the current study and the studies done by different authors in the literature are compared; there appear to be few similarities in scapula weight and height. The BS values in the Brazilian population (9) are 79.44 mm, and 69.6 mm respectively for males and females, for the same parameter in a study conducted on the Turkish population; it was found to be 81.9 mm (10). The result of this study, which did not discriminate between males and females of 72.6 mm.

In this study, the SSW values as 144 mm, which was very close to that reported in the Turkish population (6) 133 mm, and lower values in South India. Thais and Turkish population respectively as 123.35±7.8.124.9±9.3 and 81.9 mm (10,20,21). The AW values as 61.8 mm, which was lower than reported in the Egyptian population (17) 90.69 mm in males, and 77.9 mm in females. The SML values in the Turkish population (10) were 122.5 mm, which was very close to that reported in this study 143.3 mm.

These differences may be due to factors such as age, gender, race, and a variety of techniques like measurement methods. The literature data on the scapular index, infraspinat index, and glenoid index as % are shown in table 3.

The percentage values of SI, ISI, and GI are almost similar to literature data.

The number of bones in the laboratory where the study was conducted is limited. In addition, deformed bones were excluded from the study. Therefore, the number of bones used in the study and the age, gender and identity of these bones are not known.

Consequently, the parameters determined and analyzed in this study, and their interpretation with the literature, even though the number of scapula used hereby is limited to

a certain degree, will surely be helpful in the journey on particular physical therapy and rehabilitation of sports injuries. Yet, knowing the patterns of the glenoid cavity, in particular, will assist orthopedic surgeons in deciding on prosthesis design and application procedures in shoulder arthroplasty.

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Conflict of Interest: *The authors declare that they have no competing interest.*

Ethical approval: *Permission was obtained from the Bolu Abant Izzet Baysal University Clinical Researches Ethics Committee. Decision No: 2022/144 Date: 07.06.2022.*

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