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Morphology and morphometric study of dry scapula, with emphasis on the glenoid fossa and acromion process in Chennai city, South India

Azhagiri R[1], Anitha M[2], Hemapriya J[3], Ganesan Murugaperumal[4], Sumathi G[5]

[1]Associate Professor, Department of Anatomy, ESIC Medical College and PGIMSR, KK Nagar, Chennai, The Tamil Nadu Dr. MGR Medical University, [2]Assistant Professor, [5]Professor and Head, Department of Microbiology, Sri Muthukumaran Medical College Hospital and Research Institute, Dr. M.G.R Medical University, Chikkarayapuram, Chennai, Tamil Nadu, [3]JR(ACAD)MD Lab Medicine, Department of Medicine, ESI Model Hospital and PGIMSR, Indraprastha Guru Gobind University, New Delhi, [4]Professor and Head, Department of Anatomy, Sree Balaji Medical College and Hospital, Bharath University, Chennai, Tamil Nadu, India

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ABSTRACT

Background: The morphology and morphometry of the scapula and its glenoid fossa and acromion process play a significant role in the mechanics of shoulder joint. A variable morphology is found in glenoid fossa that has clinical implications. **Aims and Objectives:** The aim of the study was to evaluate the morphology and morphometry of dry scapula with emphasis on glenoid fossa and acromion process. **Materials and Methods:** A cross-sectional study was conducted at the department of anatomy, for a period of 6 months from January 2021 to June 2021. A total of 100 unpaired dry scapula were included in the study. The morphology and dimensions were measured. The dimensions were summarized as mean and standard deviation. Statistical analysis was done Chi-square test and student's t-test based on the variable types. **Results:** Out of 100 scapulae studied, 48 were right sided and 52 were left sided. The mean of maximum length of the right scapula was 149.58±10.33 mm and the left side was 148.63±10.33 mm. Among the glenoid cavities, 54 were inverted comma shaped, 30 were pear shaped, and 16 were oval shaped. In one right-sided scapula Bony Spur Extends from Base of coracoid process to supra Scapular Notch. **Conclusion:** Size and shape of the glenoid cavity are directly related to the dislocation of shoulder joint and may affect the results of total shoulder arthroplasty and rotator cuff surgeries. The present study analyzed the morphological types and diameters of the glenoid cavity in adult scapulae to improve the efficacy and minimize the failure rates in shoulder arthroplasty particularly those involving the glenoid component of the shoulder joint.

Key words: Acromion process; Coracoid process; Glenoid cavity; Morphology; Morphometry; Scapula

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INTRODUCTION

Scapula is a bone forms shoulder girdle and is one of the bones that have variations. It is a flat triangular bone that overlies on the posterolateral aspect of the chest wall over the second to the seventh rib. Its lateral angle becomes truncated and broadened that bears the glenoid cavity which articulates with the head of the humerus in the shoulder joint. The glenoid cavity which is also known as the head of the scapula is connected to the plate like body by an anatomical neck which is most distinct at its dorsal and inferior aspects. When the arm is swing by the side of the body, the glenoid cavity is directed slightly upwards forwards and laterally and when the arm is raised above the head level it is directed almost straight upwards. Scapula possesses three processes and three angles, the acromion, coracoid and the spinous process; the superior, inferior and lateral angles respectively. It also has medial, lateral and

Address for Correspondence:
Dr. Azhagiri R, Associate Professor, Department of Anatomy, ESIC Medical College and PGIMSR, The Tamil Nadu Dr. MGR Medical University, Chennai - 600 078, Tamil Nadu, India. **Mobile:** 9789141908. **E-mail:** girihanshi1@gmail.com

superior borders and two surfaces which are the anterior or costal surface and the posterior or dorsal surface.[1]

There is a notch present on its antero superior part, that is, on the anterior glenoid rim which gives its different shape. When this glenoid notch is indistinct its shape is piriform or pear or tear drop, when it is distinct it looks like inverted comma shape and when it is absent its oval shape.[2] Variations in the superior transverse scapular ligament and the suprascapular notch are the most recognized possible predisposing factors for suprascapular notch (SSN) entrapment.[3]

The disproportionate sizes of the head of the humerus and the small, shallow glenoid cavity combined with a lax articular capsule give this joint a wide range of movements but make the joint inherently unstable.[2]

The shoulder joint is the most frequently dislocated joint in the body. Dynamic factors of the rotator cuff muscles and the static factors of the glenohumeral ligaments, the labrum and the joint capsule play a role in gleno-humeral joint stability. Alignment of the humerus and the glenoid articular surfaces is one of the predisposing factors for glenohumeral joint instability, which is one of the predisposing factors for rotator cuff pathology.[4]

Dislocations may also be associated with fracture of the glenoid cavity; for the management of this, prostheses and arthroplasty are required. The knowledge of variations in shape and size of the glenoid fossa are required for better understanding of shoulder joint arthroplasty. These are prerequisites for 2. complete understanding of the mechanics of shoulder joint. This information has clinical application in shoulder arthroplasty, gleno-humeral instability, and rotator cuff tear management.[5]

The variations in the morphology of glenoid fossa are influenced by genetic and environmental factors.[6] The shoulder is the third most common joint that requires reconstruction following knee and hip.[7]

Therefore, it is mandatory to understand its complex anatomy, which in turn facilitates prompt fabrication of Glenoid implants and screws. Thorough knowledge on the morphometry and morphology of the glenoid fossa is essential in the understanding, investigation and management of demographic diseases pertaining to shoulder such as glenohumeral arthritis, rotator cuff disorders, shoulder dislocations, and fractures.[7]

Therefore, it is mandatory to understand its complex anatomy, which, in turn, facilitates prompt fabrication of Glenoid implants and screws.[8] Thorough knowledge on the morphometry and morphology of the glenoid fossa is essential in the understanding, investigation and management of demographic diseases pertaining to shoulder such as glenohumeral arthritis, rotator cuff disorders, shoulder dislocations, and fractures.[9]

The knowledge of the shape and dimensions of the glenoid cavity are important in the design and fitting of glenoid component for total shoulder arthroplasty. So deep understanding of variations in normal anatomy of glenoid cavity is essential while dealing with its clinical correlation.

The objective of the study was to obtain anthropometric data of dry human scapulae and the diameters and shapes of the glenoid cavity in the South Indian population and evaluate their clinical significance.

Aims and objectives

The objective of the study was to evaluate the morphology and morphometry of dry scapula with emphasis on glenoid fossa and acromion process.

MATERIALS AND METHODS

An observational cross-sectional study was conducted in the department of anatomy, Chennai, during 2021 to June 2021, after taking approval from the Institutional Ethical committee. A morphometric and morphological analysis of 100 adult dry and undamaged human scapulae (48 right side and 52 left sides) was conducted in the South Indian population (Chennai region of Tamil Nadu) to evaluate the parameters of the Glenoid fossa and its relevant clinical significance.

The morphological evaluation was done, and the linear measurements were taken using a Vernier Caliper and recorded in millimeter. The age and sex of the scapulae are unknown. The following parameters were assessed in the study: Various shapes of the Glenoid Fossa were observed (Pear, Oval and Notch type). Acromion and coracoid processes were classified into Type I (flat), II (curved) and III (hooked).[10] Vertical glenoid diameter was taken along the maximum vertical length of the glenoid fossa between its superior and inferior borders. Horizontal glenoid diameter was taken along the maximum horizontal breadth of the glenoid fossa around its midpoint between the anterior and posterior borders.

The mean, standard deviation, and the P-value correlating the shape and morphometry were calculated separately for the right and the left glenoid cavity. The comparisons in the morphology of the right and left sides were made using statistical analysis.

Inclusion criteria

- Dry, complete, and both right- and left-sided adult scapulae will be included in the study.

Exclusion criteria

- The specimens which are partially broken or have any deformity will be excluded from the study.
- Specimens with osteoarthritic changes, showing any previous trauma sign or skeletal disorders will be excluded from the study.
- Children scapula is excluded from the study.

Statistical analysis

In the present study, data were analyzed in Microsoft Excel to determine the incidence as percentages. For each morphology and morphometric parameters, maximum; minimum; mean and standard deviation were also calculated. Although it was a descriptive type of analysis, so test of significance was done using Chi-square test and Student's t-test based on the variable types.

RESULTS

Among the total 100 scapulae studies, 48 were right sided and 52 were left sided (Figure 1). Morphological study was done and measurements were taken. Morphometric analysis was done.

The mean of maximum length of the right scapula was 149.58±10.33 mm and the left side was 148.63±10.33mm, the difference was not statistically significant. The mean of maximum breadth of the right scapula was 101.40±5.96 mm and the left side was 103.65±7.12 (Table 1).

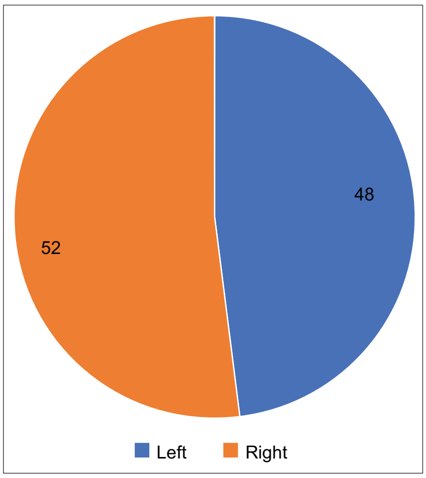

Figure 1: Number of scapula studied (N=100)

Table 1: Comparison of measurements of the right and left whole scapula (N=100)

Whole scapula	Side of the scapula	Mean	Std. Deviation	P value
Maximum length	Right	149.58	10.334	0.636
	Left	148.63	9.648	
Maximum breadth	Right	101.40	5.965	
	Left	103.65	7.121	0.090

The mean of maximum length of the right glenoid cavity was 35.17±2.62 mm and the left side was 34.73±2.42 mm, the difference was not statistically significant. The mean of maximum breadth of the right glenoid cavity was 24.12±1.99 mm and the left side was 23.73±1.64 mm, the difference was not statistically significant. The mean of maximum breadth of the upper half of the right glenoid cavity was 17.92±2.57 mm and the left was 17.21±2.56 (Table 2).

Among the glenoid cavities, 54 were inverted comma shaped, 30 were pear shaped, and 16 were oval shaped.

The mean of maximum length of the right acromion process was 47.08 ±5.25 mm and left side was 43.90±5.72 mm, the difference was statistically significant (P=0.005). The mean of maximum breadth of the right acromion process was 23.73±2.65 mm and left side was 22.94±1.95, the difference was not statistically significant. The acromion-coracoid distance of the right side was 40.60±4.47 mm and the left was 42.15±5.12. The difference was not statistically different. The mean of acromion-glenoid distance on the right side was 29.58±4.13 and on the left side 32.58±3.83. The difference in means was statistically significant (P=0.000) (Table 3).

The inner surface of coracoid process was smooth in 60% of the scapula and rough in 40% of the scapula (Figures 2-5).

On comparison of shape parameters between right and left sides, the most common shape of tip of acromion process was intermediate and square. Majority of the

Table 2: Comparison of measurements of the right and left glenoid cavity (N=100)

Glenoid cavity	Side of the scapula	Mean	Std. Deviation	P value
Maximum length	Right	35.17	2.625	
	Left	34.73	2.421	0.383
Maximum breadth	Right	24.12	1.997	
	Left	23.73	1.647	0.296
Breadth of the upper half	Right	17.92	2.573	
	Left	17.21	2.560	0.167

Table 3: Comparison of measurements of the right and left acromion process (N=100)

Acromion process	Side of the scapula	Mean	Std. Deviation	P value
Maximum length	Right	47.08	5.254	0.005
	Left	43.90	5.721	
Maximum breadth	Right	23.73	2.658	0.094
	Left	22.94	1.951	
Acromion-coracoid distance	Right	40.60	4.473	0.110
	Left	42.15	5.124	
Acromion-glenoid distance	Right	29.58	4.132	0.000
	Left	32.58	3.836	

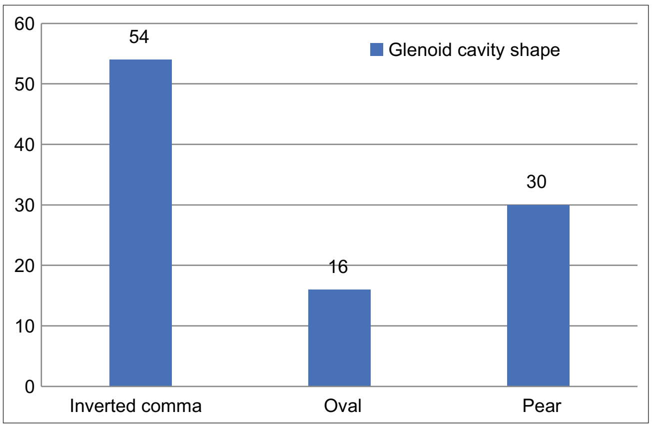

Figure 2: Shape of glenoid cavity (N=100)

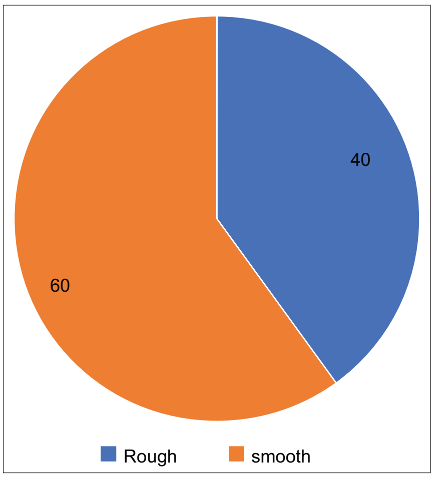

Figure 3: Inner surface of coracoid process (N=100)

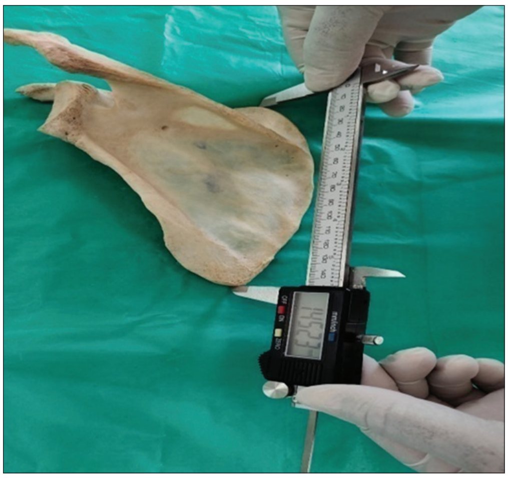

Figure 4: Measuring length of scapulae using Vernier caliper

Figure 5: Glenoid cavity inverted comma shaped

Table 4: Comparison of shape parameters between right and left sides (N=100)

Shape parameters	Right (n=52)	Left (n=48)	P value
Shape of tip of acromion process			
Intermediate	21	19	
Square	19	21	0.656
Cobra	12	8	
Curvature of coracoid process			
Flat	4	6	0.804
Slightly curved	8	8	
Curved	26	24	
Hooked	14	10	
Under surface (Inferior) of coracoid process			
Smooth	32	28	
Rough	20	20	0.743
Notch of Glenoid cavity			
Present	34	35	
Absent	3	8	0.028
Slight notch	15	5	

coracoid process were curved and the under surface was smooth. Majority of the scapulae had glenoid cavity notch. The presence of notch was statistically significant compared between right and left sides (P=0.028) (Table 4).

Table 5 compares the morphometric features of glenoid cavity between the right and left sides. Other morphological features included, in one right-sided scapula Bony Spur Extends from Base of coracoid process to supra Scapular Notch (Figures 6 and 7). Margins of acromion facet were prominent in two scapula shallow suprascapular notch that was present in three scapula and more prominent upper lip of crest of spine in one scapula. Margins of glenoid cavity were prominent in five scapulae, deepened cavity seen in one and one lateral margin of glenoid cavity had a tubercle. Numerous foramina in supraspinous fossa were observed in two scapulae and deep supra spinous fossa in one scapula.

Table 5: Morphometry of glenoid cavity (mm)

Parameter	Side of the scapula (Mean±SD)		P value
	Right	Left	
Inverted comma	(N=28)	(N=26)	
Maximum length	35.75±2.35	35.12±2.32	0.323
Maximum breadth	24.29±1.96	23.96±1.69	0.519
Breadth of upper half	17.86±2.7	17.31±2.38	0.433
Pear	(N=16)	(N=14)	
Maximum length	34.5±3.43	34.57±2.28	0.948
Maximum breadth	23.63±2.13	23.43±1.65	0.782
Breadth of upper half	18.13±2.16	17.57±3.18	0.577
Oval	(N=8)	(N=8)	
Maximum length	34.5±0.93	33.75±2.96	0.506
Maximum breadth	24.5±1.93	23.5±1.6	0.278
Breadth of upper half	17.75±3.15	16.25±1.91	0.269

Figure 6: Wide suprascapular notch

Figure 7: Bony Spur extending from upper end of anterior margin of suprascapular notch and partially converting into suprascapular foramen

DISCUSSION

In the current study, the sex of the scapulae was not known therefore, male and female bones could not be measured separately. In the present study, the mean maximum length of right acromion was found to be 47.08±5.25 mm and the left side was 43.90±5.72 mm. In a similar study, Mansur et al.[11] recorded length of acromion to be 46.46 mm on the right side and 45.57 mm on the left side in Nepalese population, Whereas Dhindsa and Gupta[12] reported that the mean maximum length of acromion was found to be on Right=43.47 and Left=42.74). Lingamdenne and Marapaka[13] reported mean length of 43.22 mm in South Indian population. On the contrary, Gupta et al.[14] reported a larger left acromial length. Singh et al.[15] found the acromial length to be longer on the right side which was in accordance with findings of this study.

In the present study, the mean maximum breadth of right acromion was 23.73 mm and left side was 22.94 mm. Dhindsa and Gupta[12] reported the mean maximum breadth of right acromion was 24.86 and on left 24.06. Lingamdenne and Marapaka[13] reported mean breadth of 24.64 mm in South Indian population which are similar to this study, while Mansur et al.[11] recorded breadth of acromion to be 26.63 mm on the right side and 27.23 mm on the left side in Nepalese population, which is not similar to this study.

In the present study, the mean acromion-glenoid distance was found to be on the right 40.60 mm and left 42.15 mm. Contrary to this study, Dhindsa and Gupta[12] reported that the mean acromion-glenoid distance was found to be on Right=30.03 mm and Left 30.27 mm. The acromion-glenoid distance measured by Mansur et al., 16 was 31.83 mm and 31.97 mm on the right and left side, respectively, in Nepalese population 24.46 mm in South Indian population by Lingamdenne and Marapaka.[13]

In the present study, the mean right acromion-coracoid distance was found to be 29.58 mm and on the left side 32.58 mm. in a similar study Lingamdenne and Marapaka[13] reported 31.85 mm in South Indian population. In contrast Dhindsa and Gupta[12] reported that the mean right acromion-coracoid distance was 36.14 mm and Left=37.96 mm. Mansur et al.[11] recorded it as 39.03 on the right side and 39.39 mm on the left side in Nepalese population. Singh et al., 16 reported it to be 37.5 mm in North Indian Population.

The larger distance acromion-glenoid and acromion-coracoid length which were seen on the left side in this study, on the contrary, Gupta et al.[14] observed these parameters to be greater on the left side.

This study found that shape of tip of acromion process was intermediate (40%) square (40%), and cobra (20%). The shape of the coracoid process was found to be curved type coracoids process (50%), hooked (24), and flat (10%). The inner surface of coracoid process was smooth in 60% of the scapula and rough in 40% of the scapula. Whereas a study done by Moosa et al.,[16] who reported that the shape of tip of acromion process was cobra (23%), square (31%), and intermediate (46%). Types of inferior surface smooth (74%) and rough (26%). They have found the highest frequency of curved type of acromion process followed by flat and hooked type, respectively.

The study findings show that the most commonly occurring glenoid shape is inverted comma followed by pear and oval shape on both the side. In contrast to this study, many other authors reported Pear shaped glenoid cavity as common shape, Akhtar et al., 9 and Ankushrao and Dombe,[17] Singh[18] observed Pear shaped glenoid cavity as a common shape followed by inverted comma and oval shape in Indian scapulae, while Singh et al.[19] and Sinha et al.[20] reported pear shape as common shape followed oval shape and inverted comma.

In the present study, the mean of maximum length of the right glenoid cavity was 35.17 mm and the left side was 34.73 mm, the values of glenoid cavity diameter of the right side were higher then left side. Similarly, Singh et al.[19] measured that the values of glenoid cavity length were 34.84 mm on the right side and on the left side were 33.48 mm followed by other authors Sinha et al.[20] were almost similar with the present study. While Akhtar et al.[8] and Mahto and Omar[21] reported higher values 36.03 mm, 37.03 mm, and 36.2 mm, respectively, in comparison to the present study. Values of glenoid cavity diameter of the left side were reported higher then right side in the study by Mamatha et al.[22] and Sinha et al.[20]

In the present study, the mean of maximum length of the right scapula was 149.58±10.33 mm and the left side was 148.63±10.33mm, which was close to the findings observed in Tamil Nadu population by Rajeswari and Ramalingam[23] showed that the mean length of scapula was 141.34 mm with a SD of 8.5 mm. However, studies in European, Turkish and Egyptian population had slightly different morphometry. El-Din andAli,[7] Coskun et al.,[24] and Flower and Garson,[25] the present study findings were similar to studies done by various Indian studies morphometry such as breadth scapular morphometry 99.32 mm) and Krishnaiah[26] showed (length scapular morphometry 143.25 mm and breadth scapular morphometry 105.59 mm).

In the result of this study, one right-sided scapula bony spur extended from base of coracoid process to supra scapular notch (SSN). Shoulder injuries may be a main cause of the formation of bony spurs. Similarly, Polguj et al.[27] and Zhang et al.[28] reported the presence of a bony findings in the right side. However, in contrast, Toneva and Nikolova[29] reported in the left scapula, whereas Agrawal et al.[30] were not observed this type of morphology of the SSN.

The significant finding of this study suggests that both right and left bone parameters should be measured. The morphometry of GC helps in the analysis of frequent dislocation of the glenohumeral joint and complications of rotator cuff disease. The procedures for total shoulder arthroplasty also suffer from complexities when they encounter anatomical variants such as bony defects of the anterior and/or posterior margins of GC. These defects lead to incomplete restorations of this joint.[24]

There can be differences in nationality and race. Accordingly, correct knowledge of the variations in glenoid morphology and morphometry is critical for a better understanding of clinical applications and shoulder pathology for the design and fitting of glenoid components for shoulder arthroplasty. The above details on glenoid cavity structure and proportions support orthopedics and prosthetists.

Limitations of the study

The study was under taken only a period of six months.

CONCLUSION

A definite knowledge regarding the normal morphology is needed. The significant finding of this study suggests the both right and left bone parameters should be measured. Study of morphology and measurement of scapulae plays an important role in clinical significance for proper maintenance of posture and functioning of shoulder. The clinicians need to be familiar with the appearance of suprascapular notch on dry bones, so that he/she can interpret its morphology and morphometry. This will help them to correlate the association between various morphological measurements of the suprascapular notch which will assist them to decide the modality of the treatment.

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Authors' Contributions:
AR- Concept and design of the study, data collection, prepared first draft of manuscript, and interpreted the results; **AM-** Tabulation of results, statistical analysis; **HJ**- Data analysis, literature review; **GM-** Revision of the manuscript; **SG-** Manuscript drafting

Work attributed to:
ESIC Medical College and PGIMSR, KK Nagar, Chennai, Tamil Nadu, India

ORCID ID:
Dr. Azhagiri R - https://orcid.org/0000-0002-4497-0004
Dr. Anitha Malar- https://orcid.org/0000-0003-1440-7218
Dr. Hemapriya J- https://orcid.org/0000-0001-9847-6856
Dr. Ganesan Murugaperumal- https://orcid.org/0000-0001-7323-5503
Dr. Sumathi G - https://orcid.org/0000-0002-1731-4394

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