

Study of Parameters of Glenoid Cavity of Dry Human Scapulae

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Abstract

Background: The scapula plays a critical role in upper-limb movement, with the glenoid cavity forming the articular surface of the shoulder joint. Variations in glenoid morphology can influence joint stability, biomechanics, and surgical outcomes.

Aim: To analyze the morphological variations and morphometric parameters of the glenoid cavity in dry human scapulae.

Methodology: A descriptive cross-sectional study was conducted on 90 dry human scapulae from the Department of Anatomy, ICARE Institute of Medical Sciences, West Bengal, India. Glenoid cavity shape and dimensions, along with scapular morphometry, were measured using a digital Vernier caliper. Statistical analysis compared right and left sides, with $p < 0.05$ considered significant.

Results: The glenoid cavity was most commonly oval (42.2%) and pear-shaped (34.4%), with inverted comma and irregular shapes less frequently. Morphometric analysis showed slight left-sided predominance in scapular dimensions, but glenoid cavity diameters (superior-inferior and anteroposterior) were essentially symmetrical, with no significant differences between sides ($p > 0.05$).

Conclusion: Glenoid morphology is predominantly oval or pear-shaped with bilateral symmetry in dimensions. Minor left-sided asymmetry in overall scapular size was observed. These findings provide baseline anatomical data relevant for orthopedic surgery, prosthetic design, and assessment of shoulder biomechanics.

Keywords: Scapula, Glenoid Cavity, Morphometry, Shoulder Biomechanics, Anatomical Variation.

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Introduction

The scapula or the shoulder blade is a complicated triangular flat bone that is placed on the posterolateral side of the thoracic cage and is over the second to seventh ribs. It is strategically located and its morphology is unique, which enables it to serve as the major chair of muscular attachments that direct upper-limb motion. Since it is involved in the construction of the shoulder girdle, any slight changes in size could affect the shoulder mechanics, stability of the joint, and injury predisposition [1]. Its anatomical characteristics, hence, continue to be vital to the study of clinicians, anatomists, as well as orthopedic surgeons.

The scapula has a convex posterior surface that is subdivided by the scapular spine into the small supraspinous fossa and the bigger infraspinous fossa respectively. Instead, the costal surface is highly concave and contains the wide subscapular fossa that contains the subscapularis muscle [2]. These grooves, in addition to the edges and angles of the scapula, serve to give it its typical three-dimensional structure and are critical in ensuring its mechanical strength in the process of upper-limb motion.

The scapula the spine, acromion and coracoid processes are also distinctly bony projections that further increase the functional importance of the scapula. The acromioclavicular joint is formed by the acromion and coracoid process functions as an attachment point of several ligaments and muscles [3]. As they are engaged in dynamic shoulder activity, deviations in their orientation or morphology could be significant in disorders like impingement syndromes, rotator cuff pathology, and traumatic injuries. Their geometry is appreciated to help in the diagnostic image as well as the planning of surgeries.

The scapula has also several distinct angles that have been seen to be superior, inferior, lateral, medial, acromial and coracoid angles, all of which add to the overall shape of the bone. These angles are created because of the intersection of anatomically important borders or projections, and their values assist in the evaluation of scapular symmetry and orientation. Since the shape and position of these angles can influence scapular kinematics, they can also be studied in anatomical studies and in clinical

analyses involving posture, deformity and congenital abnormalities [4].

One of these anatomical parts of interest is the lateral angle which harbours the glenoid cavity, a flat surface on the articular side that is involved in constituting the glenohumeral joint. The glenoid cavity, which is commonly referred to as the head of the scapula, is shallow and of different shapes, with the structural features of the cavity being the key to balancing the stability of the joint [5]. The depth, width, and contour of the glenoid cavity might influence the risk of dislocation, labral tears, and degenerative changes.

One of the most remarkable aspects of the glenoid cavity is its morphology that is expected to vary naturally. The glenoid rim often bears notch along its superior or anterosuperior margin leading to the cavity taking various shapes with appearances of either a pear shape, oval or inverted comma shape [6]. Such differences have clinical implications in that they can influence the fixation of the glenoid labrum and the balance of mechanical forces on the joint. The commonality and the size of such shapes in various populations is crucial in determining the prosthetic parts and the success of shoulder arthroplasty [7].

Precise information about scapular and glenoid size is also essential in the event of trauma. The displaced type of scapular fracture is not very common as it is a generally well-protected bone but must be carefully evaluated to have the best treatment [8]. Glenoid size, inclination, and version measurements are used in the determination of open reduction, internal fixation, and postoperative rehabilitation decisions. Dry bone measurement-based anatomical databases remain valuable sources of reference despite the current developments in medical imaging and surgical practice.

As the glenoid cavity has anatomical and clinical importance, the given study aims at examining and reporting several important parameters of the glenoid cavity in dry human scapulae. Morphometric studies of this type enable the setting of baseline information, the enhancement of anthropological and anatomical dimensions, and the formation of further sophisticated orthopedic strategies. Through the analysis of glenoid size, shape, and orientation differences, the proposed study will contribute to the better understanding of the shoulder biomechanics and provide important information in clinical practice.

Methodology

Study Design: This study is an observational, descriptive, cross-sectional osteological study conducted on dry human scapulae to evaluate various morphometric parameters of the glenoid cavity.

Study Area: The study was conducted in the Department of Anatomy at ICARE Institute of Medical Sciences and Research & Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India.

Study Duration: The study was carried out over a period for 1 year.

Study Participants: Dry human scapulae available in the departmental osteology collection.

Inclusion Criteria

- Fully ossified, dry human scapulae
- Scapulae without visible deformities or damage.
- Intact glenoid cavity margins allow accurate measurements.

Exclusion Criteria

- Scapulae showing fractures, deformities, erosion, or incomplete ossification.
- Scapulae with obscured or damaged glenoid margins that hinder measurement accuracy.
- Any scapula with pathological changes.

Sample Size: 90 dry human scapulae.

Procedure: 90 dry human scapulae were selected and examined to exclude damaged or deformed specimens. Each scapula was identified by side and inspected for the morphology of the glenoid cavity. Standard anatomical landmarks were marked, and all morphometric measurements—including scapular length, breadth, infraspinous length, spine length, and glenoid cavity diameters—were obtained using a digital Vernier caliper. The shape of the glenoid cavity was recorded as oval, pear-shaped, inverted comma, or other based on the presence of anterior or posterior notches. All measurements were taken in millimeters and documented systematically for further statistical analysis.

Statistical Analysis: All collected data were compiled and entered a spreadsheet for analysis. Descriptive statistics including mean, standard deviation, range, and percentage distribution were calculated for all morphometric parameters. Comparison between right and left scapulae was performed using appropriate statistical tests (e.g., unpaired t-test). A p-value < 0.05 was considered statistically significant. Statistical analysis was conducted using standard statistical software.

Results

Table 1 illustrated that the most frequent glenoid cavity is oval, with 42.2% of all scapulae studied bearing a glenoid cavity which is oval, 40% of these being on the right side and 44.4% on the left side. The cavities that follow at 34.4% are pear shaped and are represented in equal proportions on either side. Cavity shapes of inverted comma are not so common, constituting 16.6% in total, and the

least common were irregular types of cavities, 6.6%. In general, there is a significant symmetrical

representation of shapes of right and left scapulae among 90 specimens examined.

Table 1: Morphology (Shape) of Glenoid Cavity

Shape of Glenoid Cavity	Right Scapulae n (%)	Left Scapulae n (%)	Total n (%)
Oval	18 (40%)	20 (44.4%)	38 (42.2%)
Pear-shaped	16 (35.5%)	15 (33.3%)	31 (34.4%)
Inverted Comma-shaped	8 (17.7%)	7 (15.5%)	15 (16.6%)
Other/Irregular	3 (6.6%)	3 (6.6%)	6 (6.6%)
Total	45 (100%)	45 (100%)	90 (100%)

Table 2 shows the presence of descriptive statistics of different morphometrical parameters of the scapula, in millimeters, of the right and left sides. Comprehensively, the left scapula demonstrated a relatively higher mean value than the right in most of the parameters, including scapular length (137.1mm vs. 136.4mm), breadth (100.3mm vs. 99.6mm), infraspinous length (107.5mm vs. 106.7mm) and spine length (98.0mm vs. 97.2mm). There were also minimal differences in maximum supero-inferior and antero-posterior diameters with

the left (35.1 mm vs. 34.8mm SI; 24.4mm vs. 24.1mm AP Max; 17.0mm vs. 16.8mm AP Min). The standard deviations depict the moderate variability, and ranges are quite high of the individual differences with the measurements including approximately 14-32mm of AP diameters and 86-154mm of overall scapular sizes. Generally, the statistics indicate that the data has slight asymmetry with the left scapula with overlapping ranges across sides.

Table 2: Descriptive Statistics of Morphometric Parameters (in mm)

Parameter	Side	Mean \pm SD	Range (Min–Max)
Scapular Length	Right	136.4 \pm 7.8	122–152
	Left	137.1 \pm 8.1	123–154
Scapular Breadth	Right	99.6 \pm 5.9	88–112
	Left	100.3 \pm 6.2	89–113
Infraspinous Length	Right	106.7 \pm 6.3	94–122
	Left	107.5 \pm 6.1	96–123
Spine Length	Right	97.2 \pm 5.1	86–108
	Left	98.0 \pm 5.3	87–109
Maximum Supero-Inferior Diameter (SI)	Right	34.8 \pm 2.9	29–41
	Left	35.1 \pm 3.1	30–42
Maximum Antero-Posterior Diameter (AP Max)	Right	24.1 \pm 2.3	20–30
	Left	24.4 \pm 2.5	20–31
Minimum Antero-Posterior Diameter (AP Min)	Right	16.8 \pm 1.6	14–21
	Left	17.0 \pm 1.7	14–22

Table 3 shows a comparison of the diameter of glenoid cavity in right and left scapulae with superior-inferior (SI), anteroposterior (AP), maximum and minimum diameter respectively. The right mean SI diameter was 34.8 mm, the right AP maximum was 24.1 mm, and the right AP minimum was 16.8 mm. The statistical analysis indicat-

ed that the t-values were very small (0.47-0.58) and the p-values were very great (0.56-0.64) with all the parameters indicating the lack of significant difference between the right and left scapulae with any of the dimensions of the glenoid cavity. To sum up, the size of glenoid cavity is basically symmetrical in both directions.

Table 3: Comparison of Glenoid Cavity Diameters Between Right and Left Scapulae

Parameter (mm)	Right (Mean \pm SD)	Left (Mean \pm SD)	t-Value	p-Value	Significance
SI Diameter	34.8 \pm 2.9	35.1 \pm 3.1	0.47	0.64	NS
AP Maximum Diameter	24.1 \pm 2.3	24.4 \pm 2.5	0.56	0.57	NS
AP Minimum Diameter	16.8 \pm 1.6	17.0 \pm 1.7	0.58	0.56	NS

Discussion

The given research work has investigated the morphological changes and morphometric parameters of the scapula and the glenoid cavity specifically.

The most usual form of glenoid cavity was the oval shape, which was found in more than one-fourth of the scapulae which were studied, and then came the pear-shaped form in about one-third of these. Cavities in the form of inverted comma and irregular

forms were also less common, comprising less than 20 and approximately 7, respectively. These results indicate that simple geometric shapes mostly dominate the population under study which has been in corroboration with other anatomical research which has cited oval and pear-shaped glenoid shapes as the most common ones. The shapes distribution was very symmetric in right and left scapulas, which is in favor of the idea of the natural bilateral homogeneity of glenoid morphology. In 2008 Maman et al., (2020) [9] suggested 200 dry scapulae in Brazilian population and found that the glenoid cavities existed in various morphological groups amongst the scapulae.

The morphometric analysis of scapular measurements indicated a little higher meaning of majority of the parameters on the left side which included the scapular length, breadth, infraspinous length and spine length. Although these differences were of minor nature, they indicate a slight asymmetry in favor of the left scapula. The overlaps of the measurements between right and left sides were, however, great, which means that the differences that are observed do not seem to be significant and are probably within the normal anatomical variation. The fact that there is moderate variability between people further contributes to the need to consider population-level variability in surgical planning and prosthetic design. Others of the authors Kavita et al., (2013) [10] and Gosavi et al., (2014) [11] observed a very low inverted comma shaped glenoid cavity in the Indian population compared to pear and oval shaped

In the examination of the diameters of the glenoid cavity, the average superior-inferior and anteroposterior diameters were a bit higher on the left side, as the dimensions of the scapular. Statistical analysis, however, showed that the differences in sides were not significant thereby showing that there is no essential difference in the size of the glenoid cavities. The practical use of this symmetry includes orthopedic surgeries like shoulder arthroplasty in which similarity on both sides of the body can be used to preplan surgeries and select an implant. In their study, Lannotti et al., (2012) [12] demonstrated that the better- worse diameter of the glenoid cavity was $39 \pm 3.5\text{mm}$ which was significantly more than the current value.

The significance of oval and pear-shaped glenoid cavities is also clinically significant. Such shapes can affect the biomechanics of the shoulder joint especially in joint stability and articulation with the humeral head. The familiarity with standard glenoid shapes can help the surgeons to construct anatomically compatible implants and forecast the possibility of dislocation or degenerative alteration. The insignificance of the irregular and inverted comma-shaped cavities should not be ignored since such variations can provide a challenge during the

reconstruction process or radiology interpretation. Chhabra et al., (2015) [13] measured the right-side average SI diameter of 38.46 and left side, 39.03mm, in another study.

The minor asymmetry of scapular morphometry with the left one being the larger, might be explained by the dominance in the functions, habits of the activity, or the genetic variation. But these ranges overlap and show no important differences and hence the variations are small and would have no major functional implications. The comparative studies of various populations would help more in clarifying whether these asymmetries are specific to a population or are found everywhere and contribute more knowledge about scapular anatomy. Polguyet al., (2011) [14] have reported positive correlation between the dimensions of glenoid cavity and scapular geometry. These correlations are necessary in part reconstruction and comparison.

Finally, the glenoid cavity is majorly oval and pear-shaped with an equal distribution of each side. The morphometric parameters indicate slight left-sided dominance, although glenoid diameters are all but symmetrical, with a focus on bilaterality. The implications of these findings on clinical practice include, firstly, the importance of the awareness of anatomical variability and its applicability to the functioning of the shoulder joint and the design of a prosthesis, as well as to the development of a surgical plan.

Conclusion

To sum up, the current study illustrates that the shape of the glenoid cavity of the scapula mainly exhibits the shape of an oval and pear, and the shape is distributed between the right and the left sides mostly symmetrically. Morphometric analysis shows that there is a small left-lateral predominance in general scapular size, in terms of length, breadth, infraspinous length, and spine length but the differences are not significant and cannot be found statistically important. In the same fashion, the glenoid cavity diameters such as superior-inferior diameter and anteroposterior diameter are bilaterally symmetrical which underscores the natural consistency of scapular anatomy. The results will be beneficial baseline information to clinicians, anatomists, and orthopedic surgeons, guiding their surgical planning, prosthetic design, and evaluation of shoulder biomechanics, as well as highlighting the need to consider the natural variation in anatomy in clinical practice.

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