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Research Article

Morphological and morphometric analysis of glenoid cavity of dry human scapula

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ABSTRACT

Background & Objectives: One of the important joints in human body is the Shoulder Joint. The glenoid cavity of scapula articulates with the head of humerus to form the shoulder joint. An understanding of normal glenoid cavity is important to analyze the stability of the glenohumeral joint, to design prostheses for shoulder arthroplasty, so this study was done to observe the morphological features of the glenoid cavity of dry scapula.

Materials and Methods: A college based observational cross-sectional descriptive study was carried out on all 50 dry scapulae (22 right and 28 left) of unknown age and sex available in the Department of Anatomy, of Chitwan Medical College Teaching Hospital, Chitwan, Nepal. Required bony landmarks were well identified, marked and different parameters of glenoid cavity were measured using digital vernier calliper (Precision Tool Corporation, Pune, Maharashtra, India: 150mm/6 inch; Stainless Steel Hardened Model). For observing the shape, the edge of glenoid cavity was highlighted with coloured chalk. Statistical analysis was done using SPSS 21 software and the findings were reported as frequency and distribution.

Results: In the current study, pear shaped glenoid cavity (62%) were most frequently seen, followed by oval shape glenoid cavity (28%). Inverted comma (5%) was the shape that was least observed. The results also illustrated that the superior-inferior glenoid cavity diameter of right side was 34.87± 2.50 mm and 36.48±1.97 mm on left side. The average anterior- posterior diameter (Anterior –Posterior 1 and Anterior- Posterior 2) of right glenoid cavity was 24.47±1.54 mm and 17.47± 1.56 mm and that of left side was 25.45±

1.35 and 18.74± 1.17mm. The average glenoid cavity index on right side was 70.05± 2.42 mm and that of left side was 69.77± 2.41 mm.

Conclusions: The knowledge about the diverse shape and dimensions of glenoid are highly crucial during designing and fitting of glenoid component for total shoulder arthroplasty. It is also useful when evaluating a variety of clinical diseases, such as Bankart lesions, osteochondral abnormalities, and rotator cuff illness.

Keywords: Glenoid cavity, Glenoid cavity index, Scapula, Shoulder Arthroplasty, Shoulder joint

INTRODUCTION

Scapula is a paired, large, flat, triangular bone of the pectoral girdle. It is situated posterolaterally on the thoracic cage spanning from second to seventh ribs. It has three angles (superior, inferior and lateral), three borders (superior, medial and lateral) and two surfaces (costal and dorsal surface). Its lateral angle is truncated and is characterized by the presence of the glenoid cavity (GC) or Glenoid fossa, which articulates with the head of the humerus and form a most dynamic joint in the body called glenohumeral joint. When the arm is by the side of the body, GC is directed forward, laterally, and slightly upwards. However, when the arm is above the head, it is directed straight upwards. Supero-inferiorly, it extends between the supra and infra glenoid tubercles [1].

A notch is present on its anterosuperior aspect, which is responsible for the different shapes of GC. When the glenoid notch is indistinct, GC appears piriform or pear-shaped; when it is distinct, it gives an inverted comma shape to GC. Moreover, when the glenoid notch is absent, GC appears oval in shape [2,3].

The vertical diameter of glenoid cavity is longer than transverse diameter with its lower transverse diameter broader than upper transverse diameter. The upper and lower margin of glenoid cavity is termed as supraglenoid tubercle and infraglenoid tubercle respectively.

The morphology and morphometry of the glenoid fossa demand attention in shoulder arthroplasty for the treatment of glenoid fractures and in prosthetics for glenoid design and reconstruction [4].

The present study was done on the dry scapula available at the department of anatomy at Chitwan medical college to observe on morphology of glenoid cavity in dry scapula.

MATERIALS AND METHODS

A college-based observational, cross-sectional descriptive study was conducted from July 2022 to August 2022 in the Department of Anatomy, Chitwan Medical College, Bharatpur, Chitwan, Nepal. A total of 50 scapulae of unknown gender, from both the right and left sides, available in the Department of Anatomy were included in the study. Total enumerative sampling technique was used for sample inclusion.

Only completely ossified, dry, unbroken, and well-demarcated scapulae were included in the study. Damaged scapulae were excluded. Ethical clearance was obtained from the Institutional Review Committee with reference number CMC-IRC/079/080-005.

All parameters of the glenoid cavity were measured in millimeters using a digital vernier caliper (Precision Tool Corporation, Pune, Maharashtra, India; 150 mm/6 inch; stainless steel hardened model). All

anatomical landmarks were identified and marked with colored chalk. Each measurement was taken three times by the same observer to minimize inter-observer error. The mean of the three readings was recorded as the final value and entered into EpiData, and statistical analysis was performed using SPSS version 21.

Following parameters of the glenoid cavity (GC) were measured:

Superior–Inferior Diameter of the Glenoid Cavity (SI): The maximum linear distance measured from the most prominent point on the supraglenoid tubercle (superior point) to the inferior point on the glenoid margin, marked as a blue line as shown in Figure1.

Antero–Posterior 1 Diameter of the Glenoid Cavity (AP1): The maximum breadth of the articular margin of the glenoid cavity, measured perpendicular to the SI diameter, marked as a yellow line as shown in Figure 1. This measurement was used for calculating the Glenoid Cavity Index.

Antero–Posterior 2 Diameter of the Glenoid Cavity (AP2): The maximum breadth of the upper half of the glenoid cavity, measured at the midpoint between the superior rim and the mid-equator, marked as a red line as shown in Figure 1.

Glenoid Cavity Index (GCI): The GCI was calculated for each scapula using the following formula:

$$GC = \frac{Anterior-Posterior\ glenoid\ diameter\ (AP1)}{Superior-Inferior\ glenoid\ cavity\ diameter\ (SI)} \times 100$$

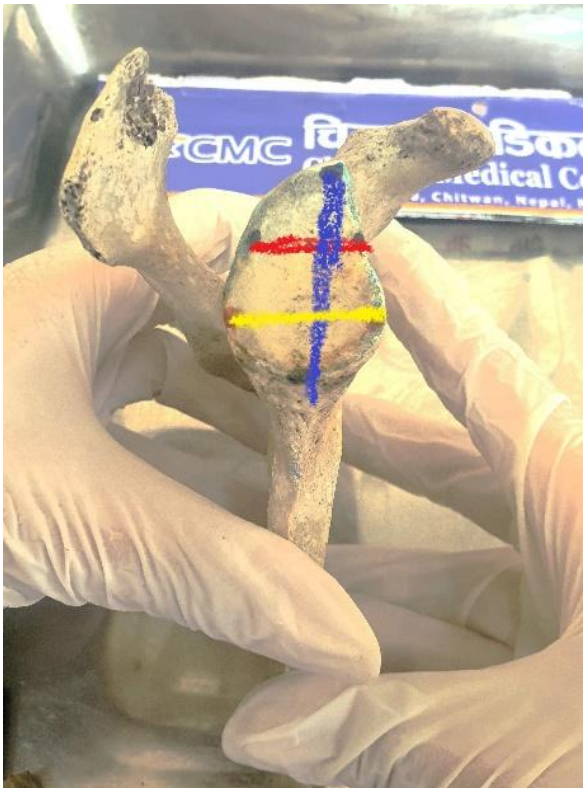

Figure 1: Landmarks for measurement of S-I (blue marked line), A-P 1(red marked line) and A-P2 diameter (yellow marked line)

Morphological Analysis of the Glenoid Cavity: The shape of the glenoid cavity was determined by highlighting the margin of the glenoid cavity using colored chalk. A tracing of the glenoid cavity shape was obtained by firmly pressing the GC margin onto a piece of white paper. Based on the tracing, the shape of the glenoid cavity was categorized into one of the following three types:

- Type I (Pear-shaped/Pyriform): Observed when the glenoid notch is indistinct.

- Type II (Oval-shaped): Observed when the glenoid notch is absent.

- Type III (Inverted comma-shaped): Observed when the glenoid notch is distinct.

RESULTS

In the present study, total 50 scapular glenoid cavities were studied, out of which 22 (44%) were of right side and 28 (56%) were of left side.

Table1: Morphometric measurements of glenoid cavity of scapula (n=50)

Parameters	Total (n=50)			Right Glenoid cavity (n=22)			Left Glenoid cavity (n=28)		
	Mean ± SD (mm)	Min (mm)	Max (mm)	Mean ± SD (mm)	Min (mm)	Max (mm)	Mean ± SD (mm)	Min (mm)	Max (mm)
SI	35.77±2.34	30.58	39.32	34.87±2.50	30.58	38.39	36.48±1.97	32.33	39.22
AP1	25.02±1.50	20.92	28.69	24.47±1.54	20.92	26.58	25.45±1.35	22.56	28.69
AP2	18.18±1.48	13.98	21.82	17.47±1.56	13.98	19.92	18.74±1.17	15.47	21.82
GC	69.21±2.39	64.01	75.59	70.05±2.42	65.88	74.46	69.77±2.41	64.01	75.59

Table-2: Morphological percentage of glenoid fossa of right and left sided scapula (n=50)

Shapes of glenoid fossa	Right side scapula Number (%)	Left side scapula Number (%)	p-value	Total Number (%)
Type I or Pear	11 (35.5%)	20 (64.5%)	> 0.05	31 (62.0%)
Type II or Oval	8 (57.1%)	6 (42.9%)	> 0.05	14 (28.0%)
Type III or Inverted	3 (60.0 %)	2 (40.0%)	> 0.05	5 (5.0%)

Table 1 illustrates the morphometric measurements of different parameters of right and left glenoid cavity. The mean and standard deviation of glenoid cavity in various dimension and glenoid cavity index were calculated. The superior- inferior diameter of the glenoid cavity on right side varied from 30.58 mm to 39.32 mm, with an average of 34.87±2.50 mm. On the left side the superior- inferior diameter varied from 32.33 to 39.22 with a mean of 36.48± 1.97 mm. In the present study, the anterior-posterior glenoid diameter (A-P1) of right and left varied from 20.92 mm to 26.58 mm and 22.56 to 28.69 mm respectively. The average AP-1 diameter of right glenoid was 24.47± 1.54 mm and the average AP-1 diameter of left glenoid was 25.45± 1.35 mm. The anterior- posterior glenoid diameter (A-P2) for the right glenoid was 13.98-19.92 mm, while the mean for right glenoid was 17.47± 1.56 mm. The range for AP-2 diameter of left glenoid was 15.47- 21.82 mm and the mean of the same side was 18.74±1.17 mm. The glenoid cavity index of right side varied from 65.88- 74.46 mm with an average of 70.05± 2.42 mm. On the left side the glenoid cavity index with an average of 69.77±2.41 mm, with a mean of mm. In all the above measurements, bilateral differences were not statistically significant (p -value of > 0.05).

Table 2 show that the most common shape of glenoid cavity recorded in the present study was type I or pear shape 31 (62.0%) followed by the type II or oval shape 14 (28.0%). The least common shape was type III or inverted common shapes 5 (5.0%).

Figure 2: Type-I pear shaped glenoid cavity

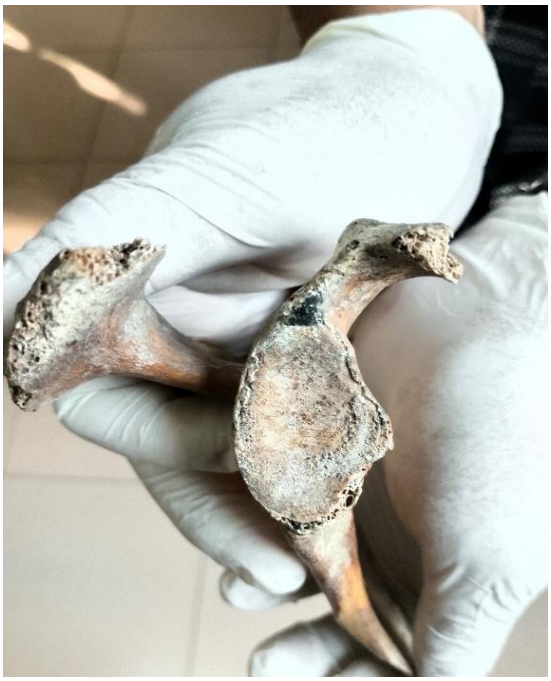

Figure 3: Oval shaped glenoid cavity

Figure 4: Inverted comma shaped glenoid cavity

On the right side, glenoid cavity with the pear shape were 11 (35.5%) in number out of the total 22 scapula examined. The incidence of oval shaped glenoid was 8(57.1%). 3 (60.0%) glenoid on right side were found to have the inverted comma shape.

On the left side, out of 28 glenoid cavities examined 20 (64.5%) were found to have pear shaped. The number of glenoid having oval shape on left side was 6 (42.9%). Inverted comma shaped glenoid were 2 (40%) in number in the left side.

DISCUSSION

Numerous studies regarding the morphometry and morphology of the glenoid cavity have been conducted worldwide by various researchers on various racial and demographic groups using a range of techniques, including radiographic measurements in living patients, direct measurement on embalmed cadavers, and direct measurement of dry scapulae [5-10].

Human scapulae that had been dried out were used in this study. There were a number of variations and similarities in the measurements and glenoid cavity shape after comparing and analyzing the results of the current investigation with those acquired by the different professionals [2,3].

In present study, the average superior inferior diameter of glenoid cavity was 35.77±2.34 mm, right side was 34.87±2.50 mm and left side 36.48±1.97mm. Lannotti et al., reported the superior- inferior (SI) diameter of the glenoid cavity in their study was 39 ± 3.5mm which was much more than the present value [5]. The differences observed may be due to ethnic variation, genetic factors, nutritional status, and measurement techniques.

In present study the measured mean values of A-P1 diameter were 25.02±1.50 mm in total, 24.47±1.54 mm on the right side and 25.45±1.35 mm on the left side. Values of AP-1 glenoid diameter of left side were slightly higher than right side in present study but this difference is not statistically significant (p value > 0.05). Almost Similar values of AP-1 diameter of right side were reported by other

Table 3: Comparison between SI, A-P1 and A-P2 by various authors

Authors	No. (right/left)	SI (mean±SD) mm		A-P 1 (mean ±SD) mm		A-P2 (mean ±SD) mm	
		Right	Left	Right	Left	Right	Left
Lannotti et al.	-	39 ± 3.5	-	-	-	-	-
Rajput HB et al.	R=43 L=57	34.76±3.0	34.43±3.21	23.31±3	22.92±2.80	15.10±2.54	13.83±2.45
Akhtar MJ et al.	R=126 L=102	36.03±3.15	35.52±3.12	23.67±2.53	23.59±2.47	16.30±2.16	16±2.34
Mamatha T et al.	-	33.67±2.82	33.92±2.87	23.35±2.04	23.02±2.30	16.27±2.01	15.77±1.96
Sinha P et al.	R=21 L=32	33.64 ± 3.01	34.44±3.27	23.22±2.85	23.31±3.12	18.07±2.64	18.01±2.56
Mahto AK et al.		2.42cm± 0.13	2.25cm± 0.14	3.62 cm±0.17	3.32 cm±0.18	-	-
Santosh Kumar A et al.	R=53 L=54	37.03±3.55	36.52±4.12	24.61±3.53	24.56±4.47	16.31±3.16	16.2±3.6
Present study	R=22 L=28	34.87±2.50	36.48±1.97	24.47±1.54	25.45±1.35	17.47±1.56	18.74±1.17

Table 4: Comparison of shape of glenoid cavity by different authors

Authors	Shape of glenoid cavity		
	Pear	Oval	Inverted comma
Akhtar et al. (n=228)	50.44%	13.6%	35.96%
Aigbogun et al.(n=107)	57%	15%	35%
Singh R (n=172)	50%	29.65%	20.35%
Archana et al (n=100)	44%	22%	34%
Sinha et al (n=53)	22.64%	7.54%	4.43%
Gamal Hamed ESH et al (n=68)	45.99%	23.53%	30.86%
Present study (n=50)	35.5%	57.1%	60%

Table 5: Comparison of glenoid cavity index by different others

Authors	Glenoid cavity index (GC, %)	
	Right	Left
Akhtar MJ et al	66.13±8.67	66.73±7.47
D Santosh Kumar A et al	65.13±7.67	65.73±8.47
Gamal Hamed ESH et al	73.67±9.08	76.71±8.37
Aigbogun EO et al	69.59±5.52	67.11±6.031
Present study	70.05±2.42	69.77±2.41

studies done in India like Rajput HB et al., Akhtar MJ et al., Mamatha T et al., Sinha P et al., Mahto AK et al., [11,12,13,14,15], while D Santosh Kumar A et al., reported higher values [16]. Similar studies have also been conducted in Egyptian and Nigerian populations, which showed variations in dimensions compared to the present study [17,18]. This contrary could be due the geographical, topographical and racial variation. Other comparative findings discussion is shown in Table 3, 4 & 5 respectively.

Anterio-posterior-2 diameter reported by present study as mean on right side was

17.47±1.56 mm, on left side18.74±1.17 mm and in total 12.96±1.84 mm. Values of left AP-2 glenoid diameter were slightly higher than right side. and this difference was found statistically significant (p≥0.05). The values of AP-2 diameter reported by present study were much less than the values reported by other Indian studies done by Singh R [8] showed 15.3± 2.1, another study done by Rajan YS 24.56±4.47 [4]. This difference could be racial.

The mean values of Glenoid cavity index of present study were; on right side 70.05±2.42, on left side 69.21±2.39 and in total glenoid fossa 70.12±7.13. Values of GCI of present study were found to be higher than the other values reported by other Indian authors (Akhtar MJ et al., and D Santosh Kumar A et al., [6,7]. While the values of GCI reported by Gamal Hamed ESH et al., in Egyptian scapula and Aigbogun EO et al., in Nigerian scapulae was higher than the present study [17,18]. This contrary could be due to topographical and racial variation. The present study findings showed, that the most commonly occurring glenoid shape was pear followed by oval and inverted comma shape on both the side. In relation to this study, many other authors reported pear shaped glenoid cavity as common shape [6-8] followed by inverted comma and oval shape [9,10].

CONCLUSIONS

The knowledge about the diverse shape and dimensions of glenoid are highly crucial during designing and fitting of glenoid component for total shoulder arthroplasty. It is also useful when evaluating a variety of clinical diseases, such as Bankart lesions, osteochondral abnormalities, and rotator cuff illness. Since only a small number of scapulae were used in the current study, further studies with larger sample sizes including radiological and cadaveric data are recommended to provide more comprehensive anatomical information and improve clinical applications such as prosthesis design and surgical planning.

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REFERENCES

1. Johnson D, Ellis H. Gray's Anatomy: The Anatomical Basis of Clinical Practice. London: Churchill Livingstone; 2009.
2. Churchill RS, Brems JJ, Kotschi H. Glenoid size, inclination, and version: an anatomic study. J Shoulder Elbow Surg 2001; 10:327-32.
3. Prescher A, Klümpen T. The glenoid notch and its relation to the shape of the glenoid cavity of the scapula. J Anat 1997; 190:457-60.
4. Rajan YS, Kumar SK. Morphometric study on bicipital groove among South Indian

population. J Clin Diagn Res 2016;10(7):AC01-3.

5. Iannotti JP, Gabriel JP, Schleck SL, Evans BG, Misra S. The normal glenohumeral relationships: an anatomical study of one hundred and forty shoulders. J Bone Joint Surg Am 1992; 74:491-500.
6. Akhtar M, Kumar B, Fatima N, Kumar V. Morphometric analysis of glenoid cavity of dry scapulae and its role in shoulder prosthesis. Int J Res Med Sci 2016; 4:2770-76.
7. Ankushrao SD, Dombe DD. Morphological and morphometrical study of scapulae in Western Indian population. Ind J Clin Anat Physiol 2017;4(3):298-303.
8. Singh R. Surgical anatomy of the glenoid cavity and its use in shoulder arthroplasty among the North Indian population. Cureus 2020;12(12): e11940.
9. Singh A, Singh A, Agarwal P, Gupta R. A morphological and morphometric study of glenoid fossa of scapula and its implication in shoulder arthroplasty. Int J Anat Radiol Surg 2019;8(3):AO06-AO09.
10. Sinha P, Bhutia KL, Tamang B, Sarda RK. Morphometric study of glenoid cavity of dry human scapula. Int J Med Res Prof 2016;2(3):86-90.
11. Rajput HB, Vyas KK, Shroff BD. A study of morphological patterns of glenoid cavity of scapula. Natl J Med Res 2012;2(4):504-07.
12. Mamatha T, Pai SR, Murlimanju BV, Kalthur SG, Pai MM, Kumar B. Morphometry of glenoid cavity. Online J Health Allied Sci 2011;10(3):01-04.
13. Mahto AK, Omar S. Dimensions of glenoid fossa of scapula: implications in the biomechanics of implant design. Int J Sci Stud 2015;3(4):146-48.
14. Gamal Hamed ESH. Morphometry of glenoid fossa in adult Egyptian scapulae. Int J Anat Res 2015;3(2):1138-42.
15. Aigbogun EO, Oladipo GS, Oyakhire MO, Ibeachu PC. Morphometry of the glenoid cavity and its correlation with selected geometric measurements of the scapula. Bangladesh J Med Sci 2017;16(4):572-79.