Morphometric Study of Glenoid Cavity of Human Scapula in Central India

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ABSTRACT

BACKGROUND
Deep knowledge of the shape and dimensions of the glenoid, and variations in normal anatomy of glenoid, are important in the design and fitting of glenoid component in total shoulder arthroplasty. It is also essential while dealing with the pathological conditions like osseous Bankart lesion, osteochondral defects, etc.

METHODS
The cross-sectional study was carried out on 122 undamaged dry adult human scapulae. Out of these 122 scapulae, 62 belonged to right side and 60 belonged to left side. Parameters studied were Maximum Scapular Length, Maximum Scapular Breadth, Vertical Glenoid Diameter (VGD), Transverse Glenoid Diameter I (TGD I), Transverse Glenoid Diameter II (TGD II) and Shape of the glenoid cavity.

RESULTS
The mean maximum scapular length observed was 140.77 ± 8.19 mm on right and 142.30 ± 7.99; the mean maximum scapular breadth was 100.70 ± 7.70 mm on right side and 99.88 ± 5.57 mm on the left; the mean vertical glenoid diameter was 36.09 ± 2.52 mm on the right and 36.40 ± 1.86 mm on the left side; the mean transverse glenoid diameter I (TGD I) was 24.40 ± 3.67 mm on the right side and 23.57 ± 3.41 mm on the left side; the mean transverse glenoid diameter II (TGD II) was 16.02 ± 2.94 mm on the right side and 16.37 ± 3.35 mm on the left side. In all the measurements bilateral differences were not statistically significant (p values >0.05). The most common shape of glenoid cavity recorded in the present study was pear shape (50.82%) followed by inverted comma shape (36.89%). The least common shape was oval (12.30%).

CONCLUSIONS
The parameters studied were with minimal regional differences when compared to those of other authors in India except that in shape which definitely differs from others.

KEY WORDS
Arthroplasty, Glenoid Notch, Instability, Glenoid Component, Central India

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BACKGROUND

Scapula a large, flat, triangular bone that lies on the posterior chest wall between the level of second and seventh ribs. It has two surfaces, three borders and three angles. The three angles are medial, inferior & lateral. The lateral angle is truncated & broad which is considered as head of scapula. It has shallow glenoid cavity which provides socket for head of humerus to form shoulder joint. It is pyriform in shape, narrower above as compared to lower part.[1] Glenoid cavity is connected to the plate like body by an anatomical neck which is most distinct at its dorsal and inferior aspects.[2]

The glenoid cavity shows variable morphology. There is a notch present on its anterosuperior part i.e. on the anterior glenoid rim which gives its different shape.[3,4]

According to Fick et al the glenoid notch is situated somewhat above the middle of the anterior margin of the cavity and can be very prominent, very shallow or absent. When the notch is present the shape of the cavity can be described as pear shaped or inverted comma shaped. When it is absent the cavity is round or oval shaped.[5]

The glenoid margin provides attachment to glenoid labrum, a fibro-cartilaginous rim except at the supra-glenoid tubercle. The glenoid labrum makes the glenoid cavity deep for the head of humerus. The fibrous capsule of shoulder joint is attached around the periphery of glenoid cavity outside the labrum, so it includes supraglenoid tubercle but excludes the infraglenoid tubercle. The laxity of fibrous capsule and shallow glenoid cavity provides great range of mobility to the joint, but loses its stability. The stability of the joint is maintained by various factors such as coraco-acromial arch, glenoid labrum and musculotendinous cuff. Most frequently shoulder joint is dislocated inferiorly as it is having less support in this region.[6]

Dislocation of joint is mostly associated with the fracture of glenoid cavity. For the management of such injuries, prosthesis, arthroplasty and rotator cuff tear repairs are frequently required. The treatment of choice also includes total shoulder replacement.[7-9]

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 the pathological conditions like osseous Bankart lesion and osteochondral defects.[10]

The present study was carried out with objective to obtain complete morphometric data about the glenoid cavity specifically the diameters and various shapes of glenoid cavity of the population of Central India to compare with other studies.

METHODS

The present study is a cross sectional study which has been carried out on 122 undamaged dry adult human scapulae, which were collected from the different students of the 1st year MBBS and Department of Anatomy, Jawaharlal Nehru Medical College, Sawangi (Meghe). Out of these 122 scapulae, 62 belong to right side and 60 belong to left side.

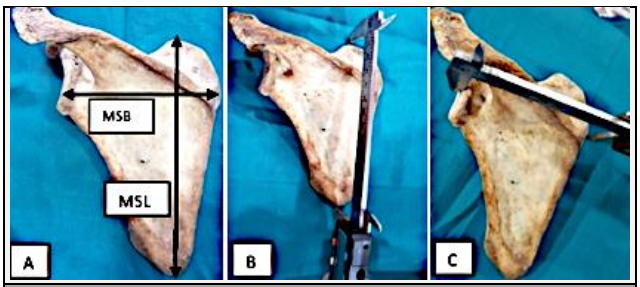

Figure 1. A. Double Arrow Showing Maximum Scapular Length (MSL) and Maximum Scapular Breadth (MSB), B. Measurement of Maximum Scapular Length (MSL) by Vernier Caliper, C. Measurement of Maximum Scapular Breadth (MSB) by Vernier Caliper

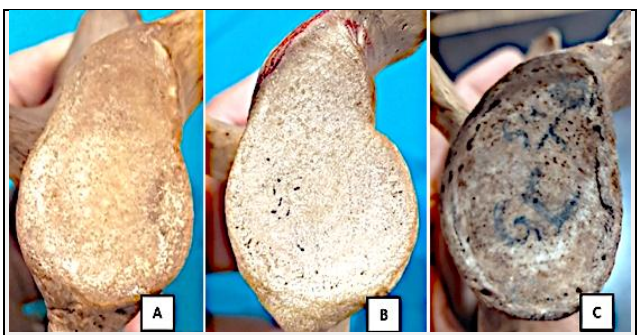

Figure 2. Different Shapes of Glenoid Cavity A. Pear Shaped, B. Inverted Coma Shaped, C. Oval.

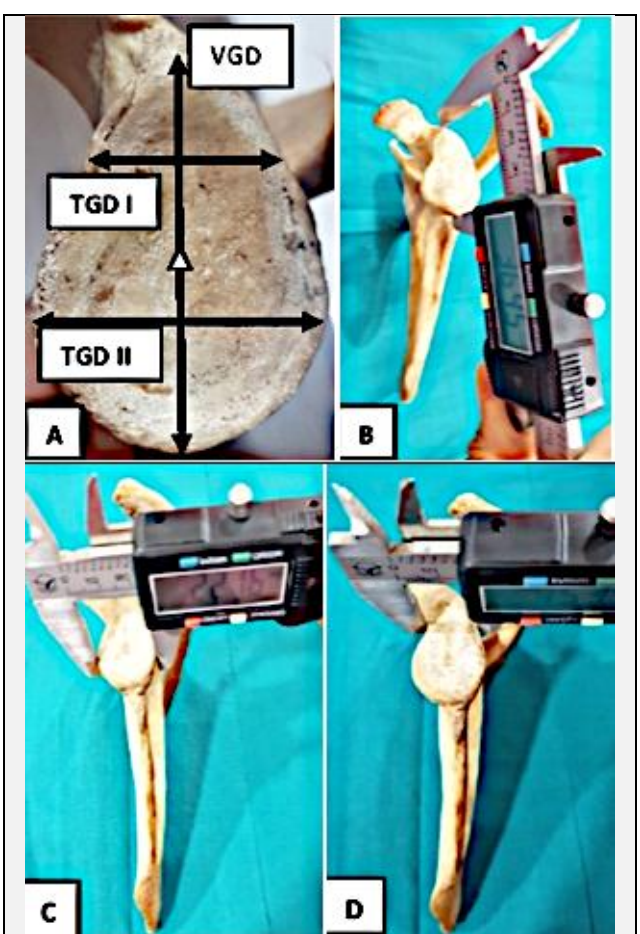

Figure 3. A. Various Diameters of Glenoid Cavity, B. Vertical Glenoid Diameter (VGD), C. Transverse Glenoid Diameter-I, (TGD-I), D. Transverse Glenoid Diameter-II (TGD-II)

Only those scapulae which are fully ossified, dried, macerated, clean and well demarcated are included in this study. While those with damage in the glenoid cavity or with any obvious pathology are excluded from this study. All parameters are measured by Digital Vernier caliper and are recorded in millimetres only. The following parameters of the glenoid cavity were studied-

Maximum Scapular Length (MSL)
Maximum distance between the summit of superior and inferior angle respectively. (Fig. 1)

Maximum Scapular Breadth (MSB)
Maximum distance from the root of the spine on the medial border and at the middle of the posterior border of glenoid cavity. (Fig. 1)

Vertical Glenoid Diameter (VGD)
Maximum distance between the most prominent point on the supra-glenoid tubercle to the inferior margin of the glenoid cavity. (Fig. 1)

Transverse Glenoid Diameter I (TGD I)
It is the maximum breadth of the articular margin of the glenoid cavity perpendicular to the glenoid cavity height. (Fig. 3)

Transverse Glenoid Diameter II (TGD II)
It is the antero–posterior diameter of the top half of the glenoid cavity at the mid –point between the superior rim and the mid-equator. Shape of the glenoid cavity: Shape made by the slightly raised rim of the glenoid cavity. (Fig. 3)

Shape of the Glenoid Cavity
The shape of the glenoid cavity was taken by tracing of slightly raised rim of the glenoid cavity on a white paper with the help of a lead pencil. Three types of glenoid were observed: (a) Pear shaped (b) Inverted comma shaped and (c) Oval shaped. (Fig. 2)

Statistical Analysis
Statistical analysis was done by using descriptive and inferential statistics using chi square test and z-test for difference between two mean and software used in the analysis were SPSS 24.0 version and GraphPad Prism 7.0 version and $p<0.05$ is considered as level of significance.

RESULTS

This study was carried out on 122 dry scapulae. The mean maximum scapular length was observed as 140.77 ± 8.19 mm in right and 142.30 ± 7 in left scapulae, the mean maximum scapular breadth was 100.70 ± 7.70 mm and 99.88 ± 5.57 mm on right and left scapulae respectively, the mean vertical glenoid diameter was 36.09 ± 2.52 mm on right and 36.40 ± 1.86 mm on left side, the mean Transverse glenoid diameter I (TGD I) was 24.40 ± 3.67 mm on right side and 23.57 ± 3.41 mm on left side, the mean Transverse glenoid diameter II (TGD II) was 16.02 ± 2.94 mm on right side and 16.37 ± 3.35 mm on left side. The most common shape of glenoid cavity recorded in the present study was pear shape (50.82%) followed by inverted comma shape (36.89%). The least common shape was oval (12.30%). In all the above measurements bilateral differences was not statistically significant (P values >0.05) (Table 1 & 2).

Parameters		Mean	S.D.	Std. Error Mean	z-Value
Maximum Scapular Length (MSL)	Right	140.77	8.19	1.04	1.03
	Left	142.30	7.99	1.03	p= 0.30, NS
Breadth of scapula	Right	100.70	7.70	0.97	0.67
	Left	99.88	5.57	0.71	p= 0.50, NS
Vertical Glenoid Diameter (VGD)	Right	24.40	3.67	0.46	1.29
	Left	23.57	3.41	0.44	p= 0.19, NS
Transverse Glenoid Diameter-I (TGD I)	Right	16.02	2.94	0.37	0.61
	Left	23.57	3.41	0.44	p= 0.53, NS
Transverse Glenoid Diameter-II (TGD II)	Right	16.02	2.94	0.37	0.61
	Left	16.37	3.35	0.43	p= 0.53, NS

Table 1. Different Parameters of Scapula and Glenoid Cavity

Shape of Glenoid	Right Side	Left Side	Total	χ2-Value
Pear Shaped	32 (51.61%)	30 (50%)	62 (50.82%)	
Inverted Comma	21 (33.87%)	24 (40%)	45 (36.89%)	0.83
Oval	9 (14.52%)	6 (10%)	15 (12.30%)	p= 0.66, NS
Total	**62 (100%)**	**60 (100%)**	**122 (100%)**	

Table 2. Comparison of Shape of Glenoid in Right and Left Side

DISCUSSION

Many anatomists, orthopaedic surgeons and researchers worked to determine the glenoid diameters in different populations by direct measurements of dry scapula, radiological measurement of scapula or radiographic measurements in living patients. All researchers worked in a similar way. The present study was undertaken to search for any similarity or difference with respect to the measurements of the glenoid cavity.

Maximum Scapular Length (MSL)
In present study the mean maximum scapular length was observed to be 140.77 ± 8.19 mm and 142.30 7.99 mm in right and left scapulae respectively, very nearer to the values obtained by Singal et al[11] and Krishnaiah et al[12] However our findings were quite different when compared to the Population variation may be the cause for these differences. The mean scapular length observed by Akhtar MJ et al[13] was 135.07 ± 14.23 mm and by Patel et al[14] in Gujarati population was 136.03 ± 11.49 mm in male scapulae and 119.63 ± 8.81 mm in female scapulae. The studies by Flower WH[15], Coskun et al[16], Wael Amin NED et al[17] on European, Turkish and Egyptian population respectively higher mean maximum scapular lengths than those of the present study. (Table 3)

Maximum Scapular Breadth (MSB)
The mean maximum breadth of scapula observed in the present study was 100.70 ± 7.70 mm which is very nearer to the values obtained by Flower W H[15] whose reported mean Maximum Scapular breadth was 101.42 mm and that by Patel et al[14] was 100.67 ± 8.51 mm in males. Singal et al[11] and Akhtar MJ et al[13] in found a mean maximum scapular breadth of 96.4 ± 7 mm and 97.55 ± 9.63 mm respectively which is lower than the present study. Patel et al also reported mean breadth of

scapula were 93.52 ± 4.38 mm in female scapulae. While higher values were reported by Krishnaiah et al,[12] Flower WH,[15] Wael Amin NED et al[17] in their studies. (Table 3)

Researcher	Sample Size	Mean Maximum Scapular Length (mm)	Mean Maximum Scapular Breadth (mm)
Flower W H[15]	200	155.54	101.42
Coskun et al[16]	90	98.8 ± 7	-
Patel et al[14]	Male: 40 Female: 22	136.03 ± 11.49 119.63 ± 8.81	100.67 ± 8.51 93.52 ± 4.38
Singal et al[11]	162	141.7 ± 8.9	96.4 ± 7
Krishnaiah et al[12]	50	143.27 ± 11.44	105.6 ± 5.08
Wael Amin NED et al[17]	160	151.16 ± 10.32	107.22 ± 9.74
Akhtar MJ et al[13]	228	135.07 ± 14.23	97.55 ± 9.63
Present study	Right: 62 Left: 60	140.77 ± 8.19 142.30 ± 7.99	100.70 ± 7.70 99.88 ± 5.57

Table 3. Comparison of Mean Maximum Scapular Length and Breadth by Different Researchers

In present study the mean vertical diameter of glenoid cavity was 36.09 ± 2.52 mm on right and 36.40 ± 1.86 mm on left side. In 2015 Wael Amin NED et al[17] studied 160 with 38.88 ± 2.63 mm vertical diameter on right side and 39.01 ± 2.49 mm on left side and Neeta et al[18] studied 126 scapula in which they reported the vertical diameter of the glenoid cavity 38.46 ± 2.81 mm on right (n=55) and 39.03 ± 3.18 mm on left (n=71) which is more than what reported in the present study while this measurement is less in the study by Patil GV et al[19] who reported 33.68 ± 4.32 mm on right (n=104) and 32.09 ± 4.11 mm on left (n= 120) and Mamatha et al[10] i.e. 33.67 ± 2.82 mm in right scapulae (n=98) and 33.92 ± 2.87 mm in left scapulae (n=104). The ethnic difference may be the reason for the difference in the findings. In this present study, the difference in the vertical diameter of right and left glenoid cavity was statistically non-significant. The mean vertical diameters of the glenoid cavity were compared with various other studies by various authors. Rajput et al,[9] measured in the right side was 34.76 ± 3.0 mm and in left side was 34.43 ± 3.21 mm. Sarwar et al[20] with sample size 100 came up with findings i.e. on right side 35.22 ± 3.26 mm and 34.53 ± 3.21 mm on left which was near similar as reported by Pranoti Sinha et al[21] (n= 51) reported 33.64 ± 3.01 mm and 34.44 ± 3.27 mm on right and left scapulae respectively. Churchill et al[4] Frutos LR,[22] Ozer et al[23] studied vertical diameters of glenoid cavity in males and females. (Table 4)

Transverse Glenoid Diameter- I (TGD-I)

In present study the mean Transverse Glenoid Diameter I (TGD I) was 24.40 ± 3.67 mm and 23.57 ± 3.41 mm on right and left side respectively with statistically nonsignificant difference between two sides. Findings of this study were similar to those reported by Mamatha et al,[10] Rajput HB et al.[9] Kavitha et al[24] Neeta et al[18] Sarwar et al[20], Pranoti Sinha et al,[21] Md. Jawed Akhtar et al.[13] Churchill et al[4] recorded mean Transverse glenoid diameter I of 23.6 ± 1.5 mm in female scapulae which was very close to our findings. Reported findings Churchill et al,[4] Frutos LR,[22] Ozer et al[23] showed difference in male and female i.e. smaller in females than males. (Table 4)

Transverse Glenoid Diameter -II (TGD-II)

The mean Transverse Glenoid Diameter -II in this study was 16.02 ± 2.94 mm on right side and 16.37 ± 3.35 mm on left side. These differences of right and left sides were also not significant statistically. Values lower than our study were reported by Rajput HB et al.[9] Our results are similar to Mamatha et al,[10] Kavitha et al,[24] Patil GV et al[19], Sarwar et al[20], Md. Jawed Akhtar et al[13] but the findings of Neeta et al[18] i.e. on right side 18.70 ± 2.22 mm and 18.6 ± 2.07 mm on left side are comparatively higher and the findings by Wael Amin NED et al[17] (2015) is highest amongst all i.e. 28.31 ± 2.38 mm of right and 27.99 ± 2.55 mm of left glenoid. (Table 4)

Researcher	Sample Size	VGD	TGD1	TGDII
Churchill et al[4] (2001)	Male: 200 Female: 144	37.5 ± 2.2 32.6 ± 1.8	27.86 ± 1.6 23.6 ± 1.5	-- --
Frutos LR[22] (2002)	Male: 65 Female: 38	36.08 ± 2.0 31.7 ± 1.7	26.3 ± 1.5 22.31 ± 1.4	-- --
Ozer et al[23] (2006)	Male: 94 Female: 92	38.71 ± 2.71 33.79 ± 3.08	27.33 ± 2.4 22.72 ± 1.72	-- --
Mamatha et al[10] (2011)	Right-98 Left- 104	33.67 ± 2.82 33.92 ± 2.87	23.35 ± 2.04 23.05 ± 2.30	16.27 ± 2.01 15.77 ± 1.96
Rajput HB et al[9] (2012)	Right-43 Left - 57	34.76 ± 3.0 34.43 ± 3.21	23.31 ± 3.0 22.92 ± 2.80	15.10 ± 2.54 13.83 ± 2.45
Kavitha et al[24] (2013)	Right-67 Left-62	35.2 ± 3.0 34.7 ± 2.8	25.07 ± 2.7 24.9 ± 2.0	16.8 ± 1.3 16.3 ± 2.0
Patil GV et al[19] (2014)	Right: 104 Left: 120	33.68 ± 4.32 32.09 ± 4.11	23.29 ± 2.34 24.90 ± 2.95	15.74 ± 1.75 16.81 ± 1.74
Neeta et al[18] (2015)	Right-55 Left-71	38.46 ± 2.81 39.03 ± 3.18	25.04 ± 2.69 24.85 ± 2.46	18.70 ± 2.22 18.6 ± 2.07
Wael Amin NED et al[17] (2015)	Right: 80 Left: 80	38.88 ± 2.63 39.01 ± 2.49	21.33 ± 2.49 21.69 ± 2.06	28.31 ± 2.38 27.99 ± 2.55
Sarwar et al[20] (2015)	Right: 50 Left: 50	35.22 ± 3.26 34.53 ± 3.21	23.95 ± 2.78 23.64 ± 2.37	16.16 ± 2.38 15.34 ± 2.17
Pranoti Sinha et al[21] (2016)	Right-21 Left- 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
Md. Jawed Akhtar et al[13] (2016)	Right: 126 Left: 102	36.03 ± 3.15 35.52 ± 3.12	23.67 ± 2.53 23.59 ± 2.47	16.30 ± 2.16 16 ± 2.34
Present study (2020)	Right-62 Left- 60	36.09 ± 2.52 36.40 ± 1.86	24.40 ± 3.67 23.57 ± 3.41	16.02 ± 2.94 16.37 ± 3.35

Table 4. Comparison of Mean Vertical, Transverse-I and Transverse-II Glenoid Diameter by Different Researchers

Authors	Sample Size	Pear Shaped	Inverted Comma	Oval
Mamatha et al. (2011)	Right - 98 Left - 104	46 43	34 33	20 24
Rajput HB et al[9] (2012)	Right - 43 Left - 57	49 46	35 39	16 15
Kavitha et al[24] (2013)	Right - 67 Left - 62	58 58	30 30	11 11
Gamal Hamed ESH[25] (2015)	Right - 38 Left - 30	44.74 46.67	31.58 30	23.68 23.33
Neeta et al[18] (2015)	Right - 55 Left - 71	47 55	31 32	22 13
Sarwar et al[20] (2015)	Right - 50 Left - 50	56 64	24 20	20 16
Pranoti Sinha et al[21] (2016)	Right - 21 Left - 32	23 42	08 13	9 6
Md. Jawed Akhtar et al[13] (2016)	Right - 126 Left - 102	51.59 49.02	34.92 37.25	13.49 13.73
Present study (2020)	Right - 62 Left - 60	51.61 50	33.8 40	14.52 10

Table 5. Comparison of Incidence of Different Shapes of Glenoid Cavity

Shape of Glenoid Cavity

The most common shape of glenoid cavity recorded in the present study was pear shape (50.82%) followed by inverted comma shape (36.89%). The least common shape was oval (12.30%). The observations regarding shape of glenoid from this study were similar to the results of Md. Jawed Akhtar et al[13] in which pear shaped glenoid was found in 51.59% of sample of the right side and 49.02% of the left side, which was most common type we observed and second most common type was inverted comma which was found 34.92% in right side and 37.25% in left side. Reports by Mamatha et al, Rajput HB et al[9] Kavitha et al[24] Neeta et al[18] Sarwar et al,[20] Pranoti Sinha et al[21] showed pear shaped glenoid was most common and inverted comma shaped glenoid was second most common type and oval shaped glenoid was least common but

Wael Amin NED[17] came up with different findings i.e. comma shaped glenoid as most common and pear shaped glenoid as second commonest type. Other researchers also reported different shapes in different population like German, Turkish and Egyptian. In German population, Prescher et al[8] reported pear shaped in 55% cases and oval shaped in 45%, in Turkish population Coskun et al[16] observed oval shaped in 72% and in 28% pear shaped glenoid while in 1/3rd Egyptian population the reason for propensity to Bankart lesion was found to be because of inverted comma shaped glenoid (30.88%) as reported by Gamal Hamed ESH.

CONCLUSIONS

The wide variation in glenoid morphology that adds uncertainties in glenoid component placement is a great challenge to shoulder arthroplasty. Knowledge about various shapes and dimensions of the glenoid is very important for designing the glenoid component for clinical applications such as joint surgeries, shoulder joint (glenohumeral) instability and rotator cuff tears management. It is also helpful during evaluation of different pathological conditions like rotator cuff disease, osteochondral defects, and Bankart lesion. As evident from study of various literatures, demographic variation in morphometry of scapulae is known. So, these types of studies may guide the clinician in decision making regarding pathology of glenohumeral joint and designing prosthesis.

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