

## Original Research Article

# Morphologic and morphometric analysis of glenoid cavity of human scapula

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**Received:** 01 February 2018

**Revised:** 27 April 2018

**Accepted:** 28 April 2018

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### ABSTRACT

**Background:** To study the morphometry and morphology of glenoid cavity of dried scapula bone and in CT scan of glenoid cavity. The present study aimed at calculating three dimensions i.e. vertical diameter, horizontal diameter of the upper segment and horizontal diameter of the lower segment of the glenoid cavity and describing the incidence of its different shapes.

**Methods:** This study was done on 100 dry, unpaired adult human scapulae of unknown sex. 50 scapulae belongs to right side and 50 scapulae belongs to left side obtained from Department of Anatomy, SRM Medical College and Research Institute. The above mentioned diameters are measured using Vernier caliper and the mean dimensions are calculated, morphological variations are studied. 3D CT images of scapulae, obtained from Department of Radiology, SRM Medical college and Hospital, Potheri, were also analysed.

**Results:** In the current study, various dimensions and incidence of various shapes of glenoid cavity were measured. The incidence of both pear and inverted comma shape in right side is greater than in left whereas the incidence of oval shape in left side is greater than right side. The SI diameter of right glenoid is greater than the left, which is statistically significant. The Antero-posterior diameters (AP-1, AP-2, AP-3) of right glenoid is greater than the left, but not statistically significant.

**Conclusions:** The knowledge of the above said variations of glenoid cavity is important in manufacturing the glenoid component of shoulder prosthesis, repair of Bankart's lesion, procedures like posterior glenoid osteotomy.

**Keywords:** 3D CT image of glenoid, Glenoid cavity of scapula morphometry, Glenoid notch, Prosthesis, Shape of glenoid cavity, Shoulder arthroplasty

### INTRODUCTION

Shoulder joint is the most frequently dislocated joint in the body. The lateral angle of scapula has a shallow, pyramidal articular surface-the glenoid cavity also known as glenoid fossa of the scapula. The vertical diameter of glenoid cavity is the longest and it is broader below than above.<sup>1</sup> Various shapes of glenoid cavity have been described based on presence of notch on anterior glenoid

rim.<sup>2</sup> Glenoid cavity is small and allows only restricted area for limited fixation devices. Several conditions can cause shoulder pain and disability, and lead patients to consider shoulder joint replacement surgery. They are osteoarthritis, rheumatoid arthritis, post-traumatic arthritis, rotator cuff tear arthropathy, avascular necrosis (osteonecrosis), severe fractures. In shoulder replacement surgery, the damaged parts of the shoulder joint are removed and replaced with artificial components, called a

prosthesis. The treatment options are either replacement of just the head of the humerus bone (ball) known as Hemiarthroplasty or replacement of both the ball and the socket (glenoid) known as total shoulder arthroplasty (Figure 1).<sup>1</sup>

For this reason, knowledge of the morphology of glenoid cavity is important in designing and fitting of glenoid components for total shoulder arthroplasty.<sup>1</sup> The morphology of the glenoid cavity is highly variable and important. Appropriate fixation of glenoid component of scapula is essential to evade loosening which is the common indication of revision surgery.<sup>3</sup>



**Figure 1: Prosthesis used in shoulder joint replacement surgery.**

## METHODS

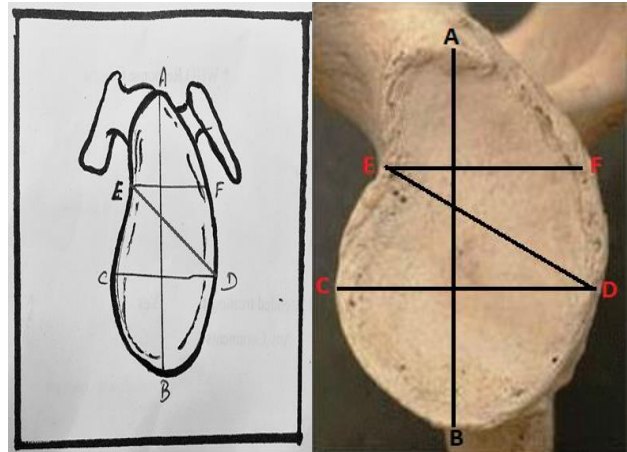
This study was done on 100 dry, unpaired adult human scapulae of unknown sex. 50 scapulae belonged to the right side and 50 to the left side from Department of Anatomy, SRM Medical college and Research institute. Only the bones with clear and intact glenoid cavity were used for the study. The age and sex were not known.

Materials used are Vernier calliper, piece of white sheet, lead pencil. All measurements were manually performed with the aid of Vernier callipers and were performed directly by placing the callipers on the glenoid surface. 3D CT Image of scapula obtained from Department of Radiology, SRM Medical college and Hospital, Potheri.

Following diameter of glenoid cavity were measured and analysed (Figure 2).

Superior-inferior diameter (SI): distance from the inferior point on the glenoid margin to the most prominent point of the supraglenoid tubercle, which is also the maximum height of the glenoid cavity,

Anterior-posterior diameter (AP1): measured from maximum breadth of the articular margin of the glenoid cavity.



A-B: Superior-Inferior diameter (SI), C-D: Anterior-Posterior diameter 1 (AP-1), E-F: Anterior-Posterior diameter 2 (AP-2), E-D: Anterior-posterior diameter 3 (AP3)

**Figure 2: Various diameters of the glenoid cavity.**

Anterior-posterior diameter (AP2): maximum breadth of the top half of the glenoid cavity at the peak of the glenoid notch.

Anterior-posterior diameter (AP3): anterior-posterior diameter between the peak of glenoid notch and the most posterior rim where the maximum width of the glenoid. Following shapes of glenoid cavity were analysed:

- Inverted comma shaped,
- Pear shaped,
- Oval shape.

The shape was made by the slightly raised rim of the glenoid cavity. A piece of white sheet was placed on the glenoid cavity and held firmly in position to trace the shape of the glenoid cavity. The side of a lead pencil was rubbed along the rim of the glenoid cavity to get a tracing of the shape of the glenoid cavity on the paper. variations in shape of the glenoid cavity were classified based on the presence of notch and without notch as inverted comma shaped, pear shaped and oval shape. 3D CT images are obtained, to obtain reproducible images from the 3D reconstructed scapula, true anterior and posterior views were obtained by rotating the 3D image through cranio-caudal axis until glenoid appeared as simple line and rotating this image through the lateral to medial axis until the inferior part of coracoid process reach the upper part of glenoid in the anterior view and until the acromion reach the upper part of glenoid in the posterior view.

## Statistical analysis

The mean and standard error of the glenoid cavity in various dimensions were calculated. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 15.0. Group and descriptive statistics were calculated. The morphometric values of the two sides were analyzed using an unpaired t-test.

**RESULTS**

In the present study, the data were obtained in 50 scapulae of the right and 50 scapulae of left. The morphometry of both right and left glenoids were assessed for 100 scapulae and various types of glenoid cavity based on their shape were observed in present study.

**Morphology of glenoid cavity**

Various shapes of glenoid cavity were observed and classified (Figure 3).



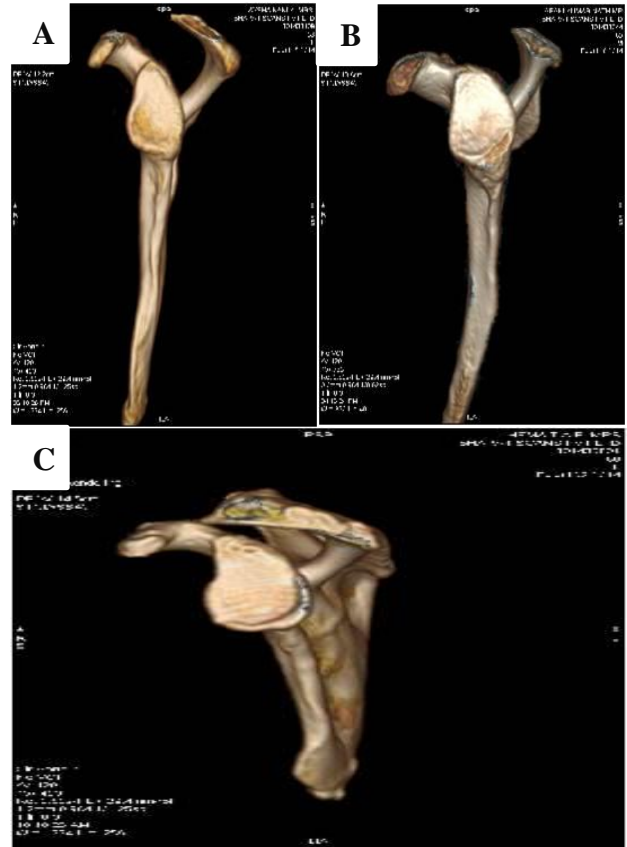
**Figure 3: Various shapes of glenoid cavity.**

- Type 1 (with notch) : A. Inverted comma shape and pear shape.
- Type 2 (without notch) : Oval shape

Comparison between shape of 50 right and 50 left glenoid cavity were done :  $\chi^2=0.64$ , p value-0.72 (Table 1). Hence the incidence of both pear and inverted comma shape in right side is greater than in left whereas the incidence of oval shape in left glenoid is greater than right.

Morphology of glenoid cavity of scapula from 3D CT images were obtained (Figure 4) 5 right and 5 left glenoid

and various shapes were identified. Out of 5 right glenoid, 2 were Inverted comma shape, 2 pear shape and 1 oval shape. Out of 5 left glenoid, 4 were Inverted comma shape, 1 pear shape, no oval shape was found. Hence Inverted comma shape was common in left glenoid.



**Figure 4: CT image of a glenoid cavity. A) Pear shaped glenoid. B) Oval shaped glenoid. C) Inverted comma shaped glenoid.**

**Table 1: Comparison between shape of 50 right and 50 left glenoid cavity.**

Shape	Right	Left
Pear	56%	52%
Inverted comma	36%	32%
Oval	8%	16%

**Morphometry of glenoid cavity of scapula**

The SI diameter of right is greater than the left, which is statistically significant. The AP-1, AP2, AP3 diameter of right is greater than that of left. But not statistically significant (Table 2).

**Comparison of CT images of right and left glenoid**

The SI, AP1, AP2, AP3 diameter of CT image of right glenoid is greater than the left glenoid cavity of scapula (Table 3).

**Table 2: Morphometry of glenoid cavity of scapula.**

Comparison of measurements of right and left glenoid									
Parameter	Range		Mean		Standard deviation		Statistical significance		P Value
	Right	Left	Right	Left	Right	Left	Right	Left	
SI diameter	21-40 mm	24-40 mm	33.1	31.6	4.1	3.4	Present	Present	0.045
AP-1 diameter	14-28 mm	16-25 mm	21.4	20.5	4.4	2.8	None	None	0.191
AP-2 diameter	10-23 mm	11-19 mm	15.6	14.8	3.2	1.7	None	None	0.128
AP-3 diameter	15-22 mm	16-20 mm	19.2	18.8	1.9	1.2	None	None	0.230

**Table 3: Comparison of CT images of right and left glenoid.**

Parameter	Range		Average	
	Right	Left	Right	Left
SI diameter	30-39mm	27-36mm	35.86mm	30.6mm
AP-1 diameter	19-28mm	19-24mm	24.04mm	21.52mm
AP-2 diameter	15-25mm	13-19mm	19.92mm	15.84mm
AP-3 diameter	22-29mm	21-28mm	25.94mm	23.86mm

**DISCUSSION**

The present study was compared with several authors who have attempted to determine the glenoid diameters in the course of their research.

**Comparison of morphology of glenoid**

In this study of 50 right scapulae, 50 left scapulae 36 % of the glenoids had a distinct notch and were inverted comma-shaped, while on the left, 32 % of the glenoids were inverted comma shaped. Mamatha T et al, found right glenoid with distinct notch was 34% and that of left was 33% and Hina B Rajput et al observed inverted comma shaped glenoid in 35% of right and 39% in left glenoids, both the study values were closer to the present study.<sup>1,2</sup>

In this study 56% of the right glenoids were pear-shaped with an indistinct notch and 52% on the left side were pear-shaped.

Mamatha T et al, observed 46% of right glenoid was pear shaped and that of left it was 43%, Hina B Rajput et al observed 49% of right glenoid and 46% of left glenoid was pear shape and the present study is higher than the above author’s work.<sup>1,2</sup>

In the present study done on 100 scapulae irrespective of side, 54 (54%) scapulae found to be pear shaped.

Coskun N et al, studied 90 scapulae irrespective of side and found, that in 28% the notch was well expressed and found to be pear shaped, which was lesser than the present study and in the study done by Prescher and Klumpen in 236 scapulae, 55% of scapulae showed

distinct notch and found to be pear shaped which was similar to the present study.<sup>5</sup>

On the right side 8% were oval and on the left side 16% were oval without any recognizable notch. The comparison between right and left showed that more glenoids on the left did not show any notch and were oval in shape, similar to Mamatha T et al, 20% of glenoid were oval on right whereas 24% on left which is higher than that of present study, Hina B Rajput et al observed 16% of right and 15% of left glenoid were oval, incidence of left glenoid is similar to that of present study which showed 16% of left glenoid were oval.<sup>1,2</sup>

In the present study of 100 cases 12% were oval glenoid

Prescher and Klumpen observed that 45% of the glenoids irrespective of side did not have a notch and were therefore oval in shape.<sup>5</sup> In the study of eighty eight shoulders, Shortt et al found 85% ovoid glenoids. Coskun N et al, studied 90 scapulae irrespective of side and found that in 72% of the specimens the glenoid notches were absent or oval shaped.<sup>4</sup>

**Comparison of morphometry of glenoid**

In the present study the average superior-inferior diameter of the right glenoid was 33.1±4.1mm and the average superior-inferior diameter of the left glenoid was 31.6±3.4mm. The Right glenoid value is slightly more, it is statistically significant.

This shows that the length of the right glenoid is slightly greater than that of the left. But in the study done by Mamatha T et al, the superior-inferior diameter of left glenoid was 33.92mm and right glenoid was 33.67mm.<sup>1</sup>



Hina B Rajput et al, in his study the (SI) diameter of right and left glenoid, the average of right glenoid was  $34.76 \pm 3\text{mm}$  and of left glenoid was  $34.43 \pm 3.21\text{mm}$  both the studies are similar to the present study.<sup>2</sup> In the present study the SI diameter of 100 scapulae irrespective of side was  $32.7 \pm 3.7$ .

Iannotti et al, of the 140 glenoid irrespective of side to be  $39 \pm 3.5\text{mm}$  which was more than the value of the present study ( $32.7 \pm 3.7$ ).<sup>6</sup> Mallon et al and Von Schroeder et al, reported the SI diameter of 28, 30 glenoid respectively to be  $35 \pm 4.1\text{mm}$  and  $36 \pm 4\text{mm}$  respectively.<sup>7,8</sup> Karelse et al, found the SI diameter to be  $35.9 \pm 3.6\text{mm}$ .<sup>9</sup> The average SI diameter of the glenoid measured by Churchill et al, irrespective of side was  $35.1 \pm 2.0\text{mm}$ , and that measured by Ozer et al, was  $36.25 \pm 2.8\text{mm}$ , Coskun N et al and Karelse et al, found the Superior-Inferior diameter of the glenoid to be  $36.33\text{mm}$  and  $35.9 \pm 3.6\text{mm}$  respectively, Piyawinijwong S et al found it to be  $35.8 \pm 2.6\text{mm}$ , all these values are slightly higher than the study, whereas glenoid measured by Frutos LR was  $33.62 \pm 1.3\text{mm}$  which is closer with the present study (Table 11, Graph 12).<sup>10,11,4,9,12,13</sup>

In present study the average anterior-posterior diameter (AP-1) of the lower half of the glenoid of the right side was  $21.4 \pm 4.4\text{mm}$  and that of the left side was  $20.5 \pm 2.8\text{mm}$ . The combined average on both sides was  $20.95 \pm 3.6\text{mm}$ . In a study done by Mamatha T et al, the average AP-1 diameter of both right and left glenoid, found to be  $23.35\text{mm}$  and  $23.05\text{mm}$ , Rajput HB, observed the AP-1 of the right glenoid was  $23.31 \pm 30\text{mm}$  and that of left was  $22.92 \pm 2.80\text{mm}$ .<sup>1,2</sup> These values are similar to the present study. In a study done by Churchill et al, irrespective of side recorded the average AP-1 diameter to be  $23.6 \pm 1.5\text{mm}$  in 344 scapulae and that observed by Frutos LR, in 103 scapulae irrespective of side and found it to be  $22.31 \pm 1.49\text{mm}$  and Ozer et al in 186 scapulae found to be  $22.72 \pm 1.9\text{mm}$ , all these values were close with the present study whose diameter was  $20.95 \pm 3.6\text{mm}$ .<sup>10,11,13</sup> Mallon et al, found the AP-1 diameter to be  $24 \pm 3.3\text{mm}$ , Iannotti et al, recorded  $29 \pm 3.2\text{mm}$ , Schroeder V et al, observed it to be  $28.6 \pm 3.3\text{mm}$  and Karelse et al, found the AP-1 diameter to be  $27.2 \pm 3\text{mm}$ , all these measurements were higher than what was observed in the present study.<sup>6-9</sup>

The average anterior-posterior diameter (AP-2) of the upper half of the right glenoid was  $15.6 \pm 3.2\text{mm}$  and that of the left glenoid was  $14.8 \pm 1.7\text{mm}$  in the current study. This suggested that the right glenoid cavity was slightly broader than the left glenoid cavity. The combined average on both sides was  $15.2 \pm 2.4\text{mm}$ . This was very close with what was observed by Mamatha T et al, AP-2 of right and left glenoid found to be  $16.27 \pm 2.0\text{mm}$  and  $15.77 \pm 1.96\text{mm}$  even in this study the right glenoid is higher than the left.<sup>1</sup> Even the present study values are close with that of Rajput HB et al, whose AP-2 diameter of right glenoid was  $16.2 \pm 3.23\text{mm}$  and that of left glenoid was  $15.24 \pm 2.04\text{mm}$ .<sup>2</sup>

Iannotti et al, done a study in 140 scapulae and found the AP-2 diameter of glenoid irrespective of side which was  $23 \pm 2.7\text{mm}$  and Piyawinijwong S et al found to be  $26 \pm 0.26\text{mm}$ . All these values are higher than the present study.<sup>6,12</sup>

The range for the AP-3 diameter of the right glenoid cavity was  $15\text{mm}$ - $22\text{mm}$  and the mean for the same was  $19.2\text{mm}$ . The AP-3 diameter for the left glenoid varied from  $16\text{mm}$ - $20\text{mm}$ , while the mean for the left glenoid was  $18.8\text{mm}$ .

Hence AP3 diameter of right is greater than that of left. But not statistically significant. Rajput HB et al, observed the average Anterior-Posterior diameter (AP-3) of the right glenoid was  $23.08 \pm 3.15\text{mm}$  and that of the left glenoid was  $22.64 \pm 2.13\text{mm}$  in our study.<sup>2</sup>

This suggests that the right glenoid cavity was broader than the left glenoid cavity. The combined average of AP-3 diameter of both sides was  $19.0 \pm 1.5\text{mm}$ .

Piyawinijwong S et al, recorded the average AP-3 diameter of 96 scapulae irrespective of side and found to be  $27.8 \pm 1.8\text{mm}$  which was higher than the current study whose AP-3 diameter was  $19 \pm 1.2\text{mm}$ .<sup>12</sup>

The glenoid morphometric measurements from 3D CT images obtained are compared with those from a previous report by Kwon YW et al.<sup>14</sup> In their study the maximum glenoid length irrespective of side was  $37.8\text{mm}$  and the maximum glenoid width was  $26.8\text{mm}$  which was higher than the present study in which the maximum glenoid length (SI diameter) irrespective of side was  $33.23\text{mm}$  and the maximum glenoid width (AP-1 diameter) irrespective of side was  $24.9\text{mm}$ . Information about various 3D CT parameters of glenoid anatomy, would seem to be important information to improve the design of the glenoid component.

Knowledge of the shape and dimensions of the glenoid are important in the design and fitting of glenoid components for total shoulder arthroplasty. An understanding of variations in normal anatomy of the glenoid is essential while evaluating pathological conditions like osseous Bankart lesions and osteochondral defects.

From the result and the discussion it can be implied that the values observed in the present study, though coinciding with that of some of the studies are mostly less than that recorded by many of the observers. The average supero-inferior glenoid diameter in our study is  $31$ - $32\text{mm}$ , however these anatomical specimens were non-arthritic which mean that the average supero-inferior glenoid diameter in an arthritic glenoid would be lesser due to bone loss.

Moreover, the diameter would further decrease following reaming of the glenoid. This implies that the smaller

dimensions of the glenoid cavities may have to be taken into consideration while designing and fitting glenoid components for the total shoulder arthroplasty.

## CONCLUSION

By observing the tables in the discussion it can be implied that the values observed in the present study though coinciding with that of some of the studies, are mostly less than that recorded by many of the observers. The average supero-inferior glenoid diameter in our study is 31-32mm, however these anatomical specimens were non-arthritis which mean that the average supero-inferior glenoid diameter in an arthritis glenoid would be lesser due to bone loss. Moreover, the diameter would further decrease following reaming of the glenoid. This implies that the smaller dimensions of the glenoid cavities may have to be taken into consideration while designing and fitting glenoid components for the total shoulder arthroplasty.

## ACKNOWLEDGEMENTS

Authors would like to thank Dr. Christilda Felicia (Professor, Department of Anatomy), Dr. S. Sundarapandian (Professor, Department of Anatomy), Dr. A. Ashma for guiding throughout study.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the Institutional Ethics Committee*

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**Cite this article as:** Raaj MS, Felicia C, Sundarapandian S, Ashma KA. Morphologic and morphometric analysis of glenoid cavity of human scapula. Int J Res Med Sci 2019;7:52-7.