



Original Article:

Morphometry of Glenoid Cavity

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Abstract: Objectives: 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. **Methods:** This study was done on 202 dry, unpaired adult human scapulae of unknown sex belonging to the south Indian population. Three glenoid diameters were measured, the superior-inferior diameter, anterior-posterior diameter of the lower half and the anterior-posterior diameter of the upper half of the glenoid. Based on a notch present on the anterior glenoid rim, variations in the shape of the glenoid cavity were classified as inverted comma shaped, pear shaped and oval. **Results:** The average superior-inferior diameter on right and the left sides were 33.67±2.82mm and 33.92±2.87mm respectively. The average anterior-posterior diameter of the lower half of the right glenoid was 23.35±2.04mm and that of the left was 23.02±2.30mm. The mean diameter of the upper half of the right glenoid was 16.27±2.01mm and that of the left was 15.77±1.96mm. **Conclusion:** The dimensions of the glenoid observed in the present study were lesser than those recorded in the studies done on other populations. This fact may be taken into consideration while designing glenoid prostheses for the south Indian population. The current study recorded a higher percentage of glenoid cavities having the glenoid notch as compared to earlier studies. While evaluating defects/lesions of the glenoid, this fact could be useful.

Key Words: Glenoid cavity; Total shoulder arthroplasty; Glenoid notch

Introduction:

On the lateral angle of the scapula is a shallow, pyriform articular surface- the glenoid cavity also known as glenoid fossa of the scapula. The vertical diameter of the glenoid cavity is the longest and it is broader below than above. The shoulder joint is the most frequently dislocated joint in the body. Dislocations with fractures of the glenoid are also quite common in trauma. Along with repair of the labrum and reinforcing the capsule by an overlapping repair and rearrangement of anterior muscles,

total shoulder replacement is also being used as treatment.(1) Today's gold standard for primary glenoid replacement is a cemented all-polyethylene component.(2)

Various shapes of the glenoid cavity have been described based on the presence of a notch on the anterior glenoid rim. It has been found that if the notch is distinct, then the glenoid labrum is not fixed to the bony margin of the notch but bridges the notch itself. This could make the shoulder joint less resistant to dislocating forces.(3) The morphology of the glenoid cavity is highly variable. The shape of the glenoid cavity has been diversely described as teardrop or pear-shaped, round, ovoid and an inverted comma-shape depending on the presence or absence of a notch on the anterior glenoid rim. The notch is better marked in the early state of the bone, indicating the junction of the "coracoid" and "scapular" parts of the articular surface, and the part above the notch has a separate centre of ossification.(4) Anetzberger and Putz, classified the shape of the glenoid cavity as teardrop-shaped glenoid cavity, type IA and IB, with and without a notch respectively, from an elongated oval shape type II.(5)

A glenoid osteochondral defect occurs most often as a result of acute trauma and has higher association with instability, labral tear and intra-articular bodies.(6) Retrospective evaluation of roentgenograms of patients with unilateral shoulder instability showed the osseous Bankart lesion to present in 20% of cases. (7) Burkhart and De Beer, described an inverted-pear glenoid, in which a normally pear-shaped glenoid lost enough anterior-inferior bone to assume the shape of an inverted pear.(8) A bone loss of more than 21% of the superior-inferior glenoid length would cause instability even after correct soft tissue repair.(9) Radiographic study on patients with recurrent anterior shoulder instability showed osseous lesions of the glenoid in 78.8% of cases.(10) Sugaya et al., evaluated the osseous fragment quantitatively and its size was classified as large (>20% of glenoid fossa), medium (5-20%) or small (<5%).(11)

The purpose of the current study was to obtain the morphometrical data for the glenoid cavity of the scapula specifically, the diameters of the glenoid cavity, to study the various shapes of the glenoid cavity relevant to the South Indian population and

to compare the data obtained from the present study with earlier report.

Methods

This study was done on 202 dry, unpaired adult human scapulae of unknown sex. 98 scapulae belonged to the right side and 104 to the left side. Only the bones with clear and intact glenoid cavity were used for the study. The following parameters of the glenoid cavity were studied. (Fig.1)

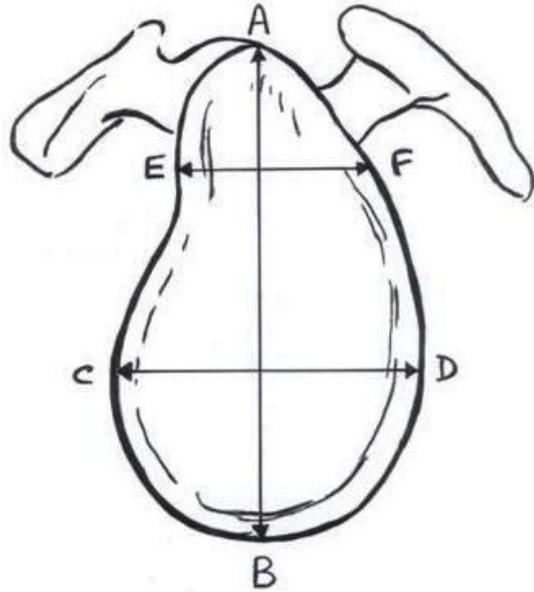


Fig.: Schematic diagram showing various diameters of the glenoid cavity. A-B: Superior-Inferior diameter (SI), C-D: Anterior-Posterior diameter 1 (AP-1), E-F: Anterior-Posterior diameter 2 (AP-2)

1. **Superior-Inferior glenoid diameter (SI):** Represents the maximum 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
2. **Anterior-Posterior glenoid diameter (AP-1):** Represents the maximum breadth of the articular margin of the glenoid cavity perpendicular to the glenoid cavity height
3. **Anterior-Posterior glenoid diameter (AP-2):** Represents the anterior-posterior diameter (breadth) of the top half of the glenoid cavity at the mid-point between the superior rim and the mid-equator.
4. **Shape of the glenoid cavity:** Shape made by the slightly raised rim of the glenoid cavity.

The diameters were measured in millimeters using sliding calipers. The shape of the glenoid cavity was recorded in the following way. 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 the point 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.

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. For comparison of the data obtained from the present study with earlier published reports. One sample t-test was employed.

Results:

In the present study, the Superior-Inferior diameter of the glenoid cavity on the right side varied from 25mm to 42mm, with

an average of 33.67 ± 2.82 mm. On the left side the Superior-Inferior diameter varied from 26mm to 40mm, with a mean of 33.92 ± 2.87 mm.

In this study, the AP-1 glenoid diameter of the right and left sides varied from 20mm to 28mm and 18mm to 28mm respectively. The average AP-1 diameter of the right glenoid was 23.35 ± 2.04 mm and the average AP-1 diameter of the left glenoid was 23.02 ± 2.30 mm. The range for the AP-2 diameter of the right glenoid cavity was 12mm to 22mm and the mean for the same was 16.27 ± 2.01 mm. The AP-2 diameter for the left glenoid varied from 12mm to 21mm, while the mean for the left glenoid was 15.77 ± 1.96 mm. (Table 1)

Table 1: 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	25-42 mm	26-40 mm	33.67 mm	33.92 mm	2.82	2.87	None	None	0.535
AP-1 diameter	20-28 mm	18-28 mm	23.35 mm	23.05 mm	2.04	2.30	None	None	0.286
AP-2 diameter	12-22 mm	12-21 mm	16.27 mm	15.77 mm	2.01	1.96	None	None	0.078

On the right side, out of the total 98 glenoid cavities examined 33 were found to have inverted comma shape. And the incidence of this shape was calculated to be 34%. The number of glenoids having pear shape on the right side was 45 and the incidence was found to be 46%. Oval glenoids were 20 in number on the right side and the incidence was 20%. On the left side, glenoids with the inverted comma shape were 34 in number out of the total 104 scapulae examined. The incidence of inverted comma shaped glenoid was 33%. 45 glenoids on the left side were found to have the pear shape and incidence of pear shaped glenoid was 43%. The oval glenoid cavities were 25 in number and the incidence of oval glenoid was 24% (Table-2 and Fig.2).

Table 2: Comparison between shape of right and left glenoid

Shape of glenoid	Incidence of shape	
	Right glenoid	Left glenoid
Inverted comma	34%	33%
Pear	46%	43%
Oval	20%	24%

Discussion:

In the present study an effort has been made to find the average diameters of the glenoid cavity of the scapula and the incidence of various shapes of the glenoid cavity in the South Indian population. Several authors have attempted to determine the glenoid diameters in the course of their research. This has been performed in a variety of ways, including direct measurement of dry scapulae, direct measurement of fresh or embalmed cadavers, radiographic measurement of scapulae harvested from cadavers and radiographic measurement in living patients. These studies have been performed on different populations. In evaluating the data presented in this study, a comparison to work by others reveals several differences as well as similarities.

In the present study the average superior-inferior diameter of the right glenoid was 33.67 ± 2.82 mm and the average superior-inferior diameter of the left glenoid was 33.92 ± 2.87 mm. Though the left glenoid value was slightly more, it was not statistically significant. This shows that the length of the right glenoid was slightly less than that of the left. The averages were compared to the values recorded in other studies (refer Table 3). Iannotti et al., reported the superior-inferior diameter of the glenoid to be 39 ± 3.5 mm which was more than the value got in the present study. (12) Mallon et al., and Von Schroeder et al., reported the SI diameter to be 35 ± 4.1 mm and 36 ± 4 mm respectively. (13,14) Both these values are higher than what was recorded in our study. Karelse et al., found the SI to be 35.9 ± 3.6 mm which was more than what was recorded in our study. (2)

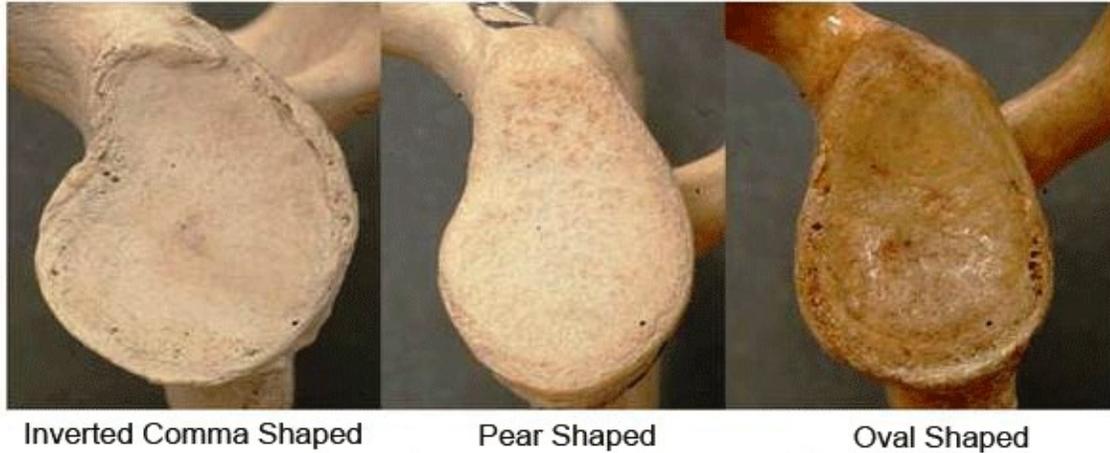


Fig. 2: Photograph showing various shapes of the glenoid cavity

Observers	No of specimens	Mean SI diameter
Mallon et al (1992) ¹³	28	35 ± 4.1mm
Iannotti et al (1992) ¹²	140	39 ± 3.5mm
Von Schroeder et al (2001) ¹⁴	30	36 ± 4mm
Churchill et al (2001) ¹⁵	Male-200	37.5 ± 2.2mm
	Female-144	32.6 ± 1.8mm
Luis Rios Frutos (2002) ¹⁶	Male-65	36.08 ± 2.0mm
	Female 38	31.17 ± 1.7mm
Ozer et al (2006) ¹⁷	Male - 94	38.71 ± 2.71mm
	Female- 92	33.79 ± 3.08mm
Karelse et al (2007) ²	40	35.9 ± 3.6mm
Present study (2009)	Right-98	33.67 ± 2.82mm
	Left-104	33.92 ± 2.87mm

Churchill et al., Luis Rios Frutos and Ozer et al., measured the SI diameter of the male and female glenoid separately. The average SI diameter of the male glenoid measured by Churchill et al., was 37.5 ± 2.2mm, SI diameter of male glenoid measured by Luis Rios Frutos was 36.08 ± 2.05 mm and that measured by Ozer et al., was 38.71 ± 2.71mm.(15-17) All these three measurements were significantly higher than that reported in the present study. The SI diameter of the female glenoid measured by these three authors namely Churchill et al., Luis Rios Frutos and Ozer et al., was 32.6 ± 1.8mm, 31.17 ± 0.17 mm and 33.79 ± 3.08 mm respectively.(15-17) The findings of the present study agree with these authors who have done the measurements on the female scapula. They had not mentioned the side of the scapula. In our study the sex of the scapulae was not known, therefore we could not measure them separately.

In our study the average anterior-posterior diameter (AP-1) of the lower half of the glenoid of the right side was 23.35 ± 2.04mm and that of the left side was 23.02 ± 2.30 mm. This suggests that the right glenoid is broader than the left glenoid. The combined average of both sides was 23.19 ± 2.1mm. This was very close to what was observed in the female glenoids studied by Churchill et al., Luis Rios Frutos and Ozer et al.(15-17) Churchill et al., recorded the average AP-1 diameter to be 23.6 ± 1.5mm, Luis Rios Frutos found it to be 22.31 ± 1.49mm and Ozer et al., got 22.72 ± 1.9mm. The values recorded for the AP-1 diameter for the male glenoids were 27.8 ± 1.6mm by Churchill et al., 26.31 ± 1.57mm by Luis Rios Frutos, and 27.33 ± 2.4mm by Ozer et al.,(15-17) All these three values were higher than our combined average of both right and left sides, 23.19 ± 2.1mm. The AP-1 diameter recorded by Mallon et al., which was 24 ± 3.3mm was quite close to what was re-

corded in the present study which was 23.19±2.1mm(13) Iannotti et al.,(12) recorded 29±3.2mm, Von Schroeder et al.,(14) got 28.6±3.3mm and Karelse et al.,(2) found the AP-1 diameter to be 27.2±3mm. All the three were higher than what was observed in the present study. (Refer Table. 4)

Observers	No of specimens	Mean AP-1 diameter
Mallon et al (1992) ¹³	28	24 ± 3.3mm
Iannotti et al (1992) ¹²	140	29 ± 3.2mm
Von Schroeder et al (2001) ¹⁴	30	28.6 ± 3.3mm
Churchil et al (2001) ¹⁵	Male-200	27.8 ± 1.6mm
	Female-144	23.6 ± 1.5mm
Luis Rios Frutos (2002) ¹⁶	Male-65	26.31 ± 1.5mm
	Female -38	22.31±1.4mm
Ozer et al (2006) ¹⁷	Male -94	27.33 ± 2.4mm
	Female -92	22.72 ± 1.72mm
Karelse et al (2007) ²	40	27.2 ± 3mm
Present study (2009)	Right-98	23.35 ± 2.04mm
	Left-104	23.02 ± 2.30mm

The average anterior-posterior diameter (AP-2) of the upper half of the right glenoid was 16.27 ± 2.01mm and that of the left glenoid was 15.77 ± 1.96mm 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 16.02 ± 2.0mm. This was much lower than what was observed by Iannotti et al 1992, which was 23 ± 2.7mm.(12)

Various types of glenoid cavity based on their shape were observed in the current study. The percentage of occurrence of various shapes of the glenoid cavity was recorded. We found that on the right side 34 % of the glenoids had a distinct notch and were inverted comma-shaped, while on the left side inverted comma shape was of 33 %. 46 % of the right glenoids were pear-shaped with an indistinct notch and 43 % on the left side were pear-shaped. On the right side 20% were oval and on the left side 24 % 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.

We compared our study to that of Prescher and Klumpen.(3) In our study the percentage of glenoids with the glenoid notch, that is, both indistinct and distinct was 80% on the right side and 76% on the left side as compared to the observation by Prescher and Klumpen 1997 who found it to be 55%. In our study the oval glenoids comprised only of 20% on the right side and 24% on the left side, were as Prescher and Klumpen ob-

served that 45% of the glenoids did not have a notch and were therefore oval in shape. Studies done on soft tissue specimens have shown that when the glenoid notch is distinct, the glenoid labrum is often not attached to the rim of the glenoid at the site of the notch.⁽³⁾ This can be a predisposing factor in anterior dislocation of shoulder joint.

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. A recent study by Mathew et al., in south India among type 2 diabetes mellitus patients recorded that 16.5% of them suffered from frozen shoulder, 5.48% from peri-arthritis of the shoulder and 3.55% from rotator cuff injury.⁽¹⁸⁾ An increase in the aging population accompanied by an increase in the incidence of type 2 diabetes mellitus, indicate that arthritic diseases of the shoulder may become more common in the near future in the south Indian population.

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 33-34 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. The standard available smallest glenoid component in the market is 40mm which may not fit the glenoid in our study population. This implies that the smaller dimensions of the glenoid cavities in the South Indian population may have to be taken into consideration while designing and fitting glenoid components for total shoulder arthroplasty in this population.

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