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Original Article

AN ANATOMICAL STUDY OF GLENOID CAVITY: ITS IMPORTANCE IN SHOULDER PROSTHESIS

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ABSTRACT

Introduction: Glenoid cavity of scapula has variable morphology and therefore its anatomy is of enormous importance for orthopaedic surgeon and prosthetic designers. Presence of notch in the antero-superior part of glenoid rim affects the morphology of glenoid labrum. Anatomical variations of glenoid cavity are also important for understanding the various pathologies involving the shoulder joint. Present study aims to determine various anthropometric measurements of scapula and glenoid cavity including the variations of its shape.

Materials and Methods: A total of 126 adult dry scapulae available in the Dept. of Anatomy, ACMS Delhi Cantt., India, and also procured from medical colleges in the vicinity were taken for the study.

Results: The mean length and breadth of scapula observed were 141.94±12.76 mm 103.65±6.82mm respectively. The mean length of the glenoid observed in the present study was 38.78±3.03 mm. The mean AP glenoid diameter 1 and 2 were 24.93±2.55mm and18.66±2.13 mm respectively. The mean Glenoid cavity Index (GCI) found in the present study was 64.29 ± 9.79 mm.

Conclusion: The dimensions of the glenoid observed in the present study were similar to those recorded in the studies done on other populations except for the shape. Higher percentage of glenoid cavities without a definitive notch was recorded in the present study compared to earlier studies. This fact may be taken into consideration while designing glenoid prostheses for the North Indian population.

KEY WORDS: Scapula, scapular length, scapular breadth, glenoid cavity, Glenoid cavity index.

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INTRODUCTION

Scapula, one of the most interesting bones of the shoulder girdle presents many variations. It is a flat triangular bone situated on the posterolateral aspect of thoracic wall between second and seventh rib. Superolateral aspect of the scapula has a glenoid cavity for articulation with the head of the humerus. The Glenoid cavity which is also regarded as the head of the scapula has a variable morphology. The glenoid rim presents a notch in its antero-superior part, due to which various shapes of glenoid cavity are described like pear-shaped, oval or inverted comma shape [1, 2, 3]. 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. The anatomical basis and variations of shape and size of glenoid cavity of scapula is of fundamental importance in understanding the rotator cuff disease, shoulder dislocation and to decide the proper size of the glenoid component in the shoulder arthroplasty. 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. This can be a predisposing factor in anterior dislocation of shoulder joint. Studies have also reported that the glenoid inclination is associated with full thickness rotator cuff tears.The basic modalities of treatment include repair of labrum, reinforcement of capsule by an overlapping repair and rearrangement of anterior muscles. Total shoulder repair is also being used as treatment [4,5,6]. The aim of the present study was to obtain anthropometric data of scapula and glenoid cavity specifically the diameters of the glenoid cavity and to study various shapes of glenoid cavity relevant to north Indian population which will help in better understanding and management of shoulder pathology.

MATERIALS AND METHODS

A total of 126 adult dry scapulae available in the Dept. of Anatomy, ACMS Delhi Cantt, India and also procured from medical colleges in the vicinity were taken for the study. The age and sex of the bones were not known. Out of these 71 scapulae were of left side and 55 were of right side. Those scapulae which were found to be damaged at the glenoidal end and ones showing obvious pathology like healed fractures were excluded from the study. All the measurements were carried out with the help of vernier calipers by placing the instrument directly on the surface of scapula and glenoid cavity. The measurements were recorded in millimeters.

The following morphometric measurements of scapula and glenoid were taken:

Maximum Scapular length: It was taken from point 'A' at summit of superior angle to point 'B' at summit of inferior angle. The points, 'A' & 'B' were marked on white sheet of paper fixed on the osteometric board.

Maximum Scapular breadth: It was taken from point 'D' i.e. middle of the outer border of glenoid cavity to point 'C' where the spine intersects the vertebral border.

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.

Anterior-Posterior glenoid diameter 1(AP-1): Represents the maximum breadth of the articular margin of the glenoid cavity perpendicular to the glenoid cavity height.

Anterior-Posterior glenoid diameter 2(AP-2): Represents the anteroposterior diameter (breadth) of the top half of the glenoid cavity at the mid-point between the superior rim and the mid equator

Shape of glenoid cavity: The shape of the glenoid cavity was recorded in the following manner. The side of the point of a lead pencil was rubbed along the rim of the glenoid cavity and tracing of the shape of the glenoid cavity was taken by firmly pressing it on a piece of white paper. On the basis of tracings obtained. Three types of glenoids were observed: Type 1or pear shaped, Type 2 or oval, Type 3 or inverted coma shaped.

Glenoid Cavity Index (GCI): It was calculated from the observed values of SI and AP1 of the glenoid cavity. The formula used for calculating the GCI is

$$\frac{\text{Antero-posterior glenoid diameter 1} \times 100}{\text{Supero-inferior glenoid diameter}}$$

Fig. 1: Photograph showing various points on scapula and glenoid taken for measurements.

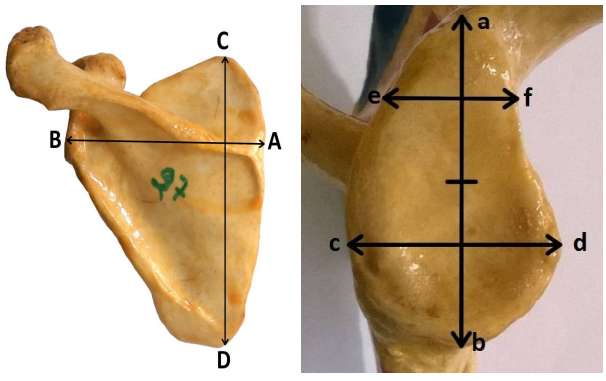

Fig 2: Photograph showing various shapes of the glenoid cavity.

Pear Shaped Oval shaped Inverted Coma shaped

RESULTS

A total of 126 scapulae were studied. Out of which 71 were of left side and 55 of right side. The mean and standard deviation of the scapula and glenoid cavity in various dimensions and GCI were calculated. The data was analyzed using the SSPS 15.The results of the study are represented as per Table 1.

Maximum Scapular Length: The length of scapula ranged from118 mm to 176 mm. The mean length of scapula and SD observed were 141.94 mm and 12.76 mm respectively. It was 141.94±12.76 mm on the left side and 141.93±12.88 mm on the right side.

Maximum Scapular Breadth: The breadth of scapula ranged from 86.5 mm to 121 mm. The mean and SD were 103.65 and 6.82 mm respectively. The average breadth of scapula observed was 103.76±7.16 mm on left side and 103.64± 6.41 mm on right side.

Supero-Inferior glenoid diameter (SI): The mean SI glenoid diameter observed in the present study was 38.78 mm with a SD of 3.03 mm. The SI diameter of left glenoid varied from 31.46 mm to 47.7 mm with a mean of 39.03±3.18 mm while the right glenoid varied from 30.5 mm to 45.24 mm with a mean of 38.46±2.81 mm.

Antero-Posterior glenoid diameter 1(AP- 1): The mean AP glenoid diameter 1 was 24.93±2.55 mm. On the left it varied from 19.01 mm to 31.64mm with a mean of 24.85±2.46 mm and on right side it varied from 18.48 mm to 33.89 mm with a mean of 25.04±2.69 mm.

Antero-Posterior glenoid diameter 2 (AP-2): The mean AP glenoid diameter 2 was 18.66± 2.13 mm. It varied from 14.99 mm to 26.09 mm on the left side with a mean and standard deviation of 18.6 mm and 2.07 mm respectively. On the right side it varied from 14.32 to 24.74 mm with a mean and SD of 18.70± 2.22 mm.

Shape of glenoid cavity: In the present study 54.92% (39) scapulae on the left had glenoid cavity of the shape of pear while on the right side this shape was found only in 47.2% (26).Next in order of frequency was oval shape which was found in 32.4%(23) scapulae on left side and 30.9% (17) on right side. The least common type of shape encountered in the present study was inverted comma type which was observed in 12.6% (09) scapulae on left side and 21.82% (12) on right side. (Table 2)

Glenoid Cavity Index (GCI): The correlation between breadth and length of glenoid is expressed as glenoid cavity index which was in the range of 62.5 to 89.6.The mean Glenoid cavity Index (GCI) was 64.3±4.44 mm. It was 63.67±3.76 mm on the left side and 65.11±5.11 mm on the right side.

Table 1: Shows the mean values of dimensions of scapula and glenoid cavity.

Sr No.	Measurements & Indices	Total Mean ± SD (mm)	Lt Mean ± SD (mm)	Rt Mean ± SD (mm)
1	Length of scapula	141.94 ± 12.76	141.94 ± 12.76	141.93 ± 12.88
2	Breadth of scapula	103.65 ± 6.82	103.67 ± 7.16	103.64 ± 6.41
3	SI glenoid diameter	38.78 ± 3.03	39.03 ± 3.18	38.46 ± 2.81
4	AP glenoid diameter 1	24.93 ± 2.55	24.85 ± 2.46	25.04 ± 2.69
5	AP glenoid diameter 2	18.66 ± 2.13	18.6 ± 2.07	18.70 ± 2.22
6	Glenoid cavity Index	64.3 ± 4.49	63.67 ± 3.76	65.11 ± 5.11

Table 2: Showing the various shapes of the glenoid cavity.

Sr No.	Shape	Lt sided (%)	Rt sided (%)
1	Pear shaped	39 (54.92)	26 (47.28)
2	Oval	23 (32.40)	17 (30.90)
3	Inverted comma	09 (12.68)	12 (21.82)

DISCUSSION

In this study various dimensions of scapula and glenoid cavity have been measured and compared with other studies. Similar studies have been carried out by several other authors also where they have attempted to determine the scapula and glenoid diameters on different

populations. This has been performed in a variety of ways which included direct measurements of dry scapulae, direct measurements of fresh or embalmed cadavers, radiographic measurements of scapulae harvested from cadavers and radiographic measurements in living patients. On comparing and evaluating data of the present study with that obtained by several authors several differences as well as similarities in the measurements of scapula and glenoid cavity were observed. This may be due to population variation and measurement techniques.

Maximum Scapular Length: The mean length of scapula observed in the present study was 141.94 mm with a SD of 12.76 mm. The findings of the present study coincided with the values obtained by Singhal et al [7] in Gujarati population & Krishnaiah et al [8] in people of Nalgonda region where they found a mean length of 141.7±8.9 mm and 143.27±11.44 mm respectively. However the findings of the present study were quite different when compared to studies done by Flower W H [9] on European race where he found an average length of 155.54 mm. Thus the scapular length of European region is higher than that of our study. This may be due to population variation.

Maximum Scapular Breadth: The mean scapular breadth found in the present study was 103.65mm with a SD of 6.82mm. These findings are very similar to those observed by Krishnaiah et al [8] in Nalgonda region & Flower WH [9] on European population where they found an average breadth of 101.42 mm & 105.6 mm respectively. However the values of the present study are higher when compared to the values obtained by Singhal et al [7] on Gujarati scapula where they observed a mean breadth of 96.4±7 mm.

Supero-Inferior glenoid diameter (SI): The mean SI glenoid diameter was 38.78±3.03 mm with a mean and SD of 39.03±3.18 mm on the left and 38.46±2.81 mm on the right side. The measurements of the SI diameter of right glenoid were slightly lower than the left. Rajput HB [6] & Mamatha et al [10] have reported the mean values of vertical diameter in the right glenoid cavity as 34.76 mm and 33.67 mm and left glenoid as 34.43 mm and 33.92 mm respectively. Both these values are lower than those obtained in the present study. Kavita et al [11] recorded mean SI diameters of 35.2±3.0 mm on right side and 34.7±2.8 mm on the left side. These values are also lower than those obtained in the present study. 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±2.2 mm, by Luis Rios Frutos was 36.08±2.05 mm and that measured by Ozer et al., was 38.71±2.71 mm.The SI diameter of the female glenoid measured by these three authors was 32.6±1.8 mm, 31.7±1.7 mm and 33.79±3.0 mm respectively [12-14]. All these three measurements on female glenoids were significantly lower than that reported in the present study. The findings of the present study were more or less in consonance with the measurements done by these authors on the male scapula. In their study side of scapula was not mentioned but in our study sex of the scapula was not known. (Table 3)

Table 3: Comparison of Superior-Inferior diameter by various authors.

Sr No.	Observers	No of specimens	Mean SI diameter(mm)
1	Rajput HB et al. 2012 [6]	Right- 43	34.76±3.0
		Left-57	34.43±3.21
2	Mamatha et al. 2011 [10]	Right-98	33.67±2.82
		Left -104	33.92 ±2.87
3	Kavita et al. 2013 [11]	Right-67	35.2±3.0
		Left-62	34.7±2.8
4	Churchill et al. 2001 [12]	Male-200	37.5 ± 2.2
		Female-144	32.6 ± 1.8
5	Luis Rios Frutos 2002 [13]	Male-65	36.08 ± 2.0
		Female-38	31.7±1.7
6	Ozer et al. 2006 [14]	Male-94	38.71 ±2.71
		Female 92	33.79±3.08
7	Present study	Right-55	38.46±2.81
		Left-71	39.03±3.18

Antero-Posterior glenoid diameter 1(AP-1): The mean AP glenoid diameter 1 in the present study was 24.93±2.55 mm. It was 24.85±2.46 mm on the left side and 25.04±2.69 mm on right side. This suggests that the right glenoid was broader than the left. Kavita et al [11] found combined mean AP glenoid diameter 1 as 24.9±2.5 mm with a mean of 24.9±2.0 mm on the left side and 25.07±2.7 mm on the right side. These findings

are quite similar to what was recorded in the present study. Rajput HB [6] & Mamatha et al [10] recorded an average AP glenoid diameter 1 of 23.31±3.0 mm and 23.35±2.04 mm on the right side and 22.92±2.80 mm and 23.05±2.30 mm on the left side. The findings of both these studies were lower than that observed in the present study. Churchill et al, Luis Rios Frutos and Ozer et al, [12-14] measured the AP glenoid diameter 1 of the male and female glenoid separately. The average AP glenoid diameter 1 of the male glenoid measured by Churchill et al. was 27.86±1.6 mm, by Luis Rios Frutos was 26.3±1.5mm and that measured by Ozer et al., was 27.33±2.4 mm. The AP glenoid diameter 1 of the female glenoid measured by these three authors was 23.6±1.5mm, 22.31±1.4 mm and 22.72±1.72 mm respectively. All these three measurements were significantly lower than that reported in the present study. (Table 4)

Table 4: Comparison of Antero-Posterior glenoid diameter 1 by various authors.

Sr No.	Observers	No of specimens	Mean AP diameter 1 (mm)
1	Rajput HB et al. 2012 [6]	Right- 43	23.31±3.0
		Left- 57	22.92±2.80
2	Mamatha et al. 2011 [10]	Right-98	23.35±2.04
		Left -104	23.05±2.30
3	Kavita et al. 2013 [11]	Right- 67	25.07±2.7
		Left-62	24.9±2.0
4	Churchill et al. 2011 [12]	Male-200	27.86±1.6
		Female-144	23.6±1.5
5	Luis Rios Frutos 2002 [13]	Male-65	26.3±1.5
		Female-38	22.31±1.4
6	Ozer et al. 2006 [14]	Male-94	27.33±2.4
		Female 92	22.72±1.72
7	Present study	Right-55	25.04±2.69
		Left-71	24.85±2.46

Anterior-Posterior glenoid diameter 2 (AP-2): In the present study the mean AP diameter 2 of left side was 18.6± 2.07 mm and on the right side it was 18.70±2.22 mm. The Anterior-Posterior diameter 2 (AP-2) of the upper half of the right glenoid observed by Rajput HB [6] & Mamatha et al [10] was 15.10±2.54 mm and16.27+2.01 mm while that of the left glenoid was 13.83±2.45 mm & 15.77+1.96 mm. Both these values were lower than what was observed in the present study. Kavita et al [11] found a mean width taken of the upper half of right glenoid cavity at 16.8±1.3 mm and left glenoid as 16.3±2.0 mm which was also quite different from the values recorded in the present study. The combined AP diameter 2 in the present study was 18.66±2.13 mm. This was much lower than what was observed by Iannotti et al [15] at 23±7.7 mm. 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 more than that recorded by many of the observers. (Table 5)

Table 5: Comparison of Anterior-Posterior glenoid diameter 2 by various authors.

Sr No.	Observers	No of specimens	Mean AP diameter2 (mm)
1	Rajput HB et al. 2012 [6]	Right- 43	15.10±2.54
		Left -57	13.83±2.45
2	Mamatha et al. 2011 [10]	Right -98	16.27±2.01
		Left-104	15.77±1.96
3	Kavita et al. 2013 [11]	Right-67	16.8±1.8
		Left-62	16.3±2.0
4	Iannoti et al. 1992 [15]	140	23.77±2.7
5	Present Study	Right -55	18.70±2.22
		Left-71	18.6±2.07

Shape of Glenoid cavity: In the current study pear shaped glenoid was found in 47% of samples on the right and 55% on the left. Rajput HB [6] & Mamatha et al [10] found an incidence of pear shaped glenoid in 49% & 46% on right side and 46% & 43% on left side respectively. In the studies done by Kavita et al [11] pear shaped glenoid cavity was found in 58%. Next in order of frequency in present study was oval shape which was found in 31% on right side and 32% on left side. Rajput HB [6] recorded an incidence of oval shape in 16% and 15% on the right and left glenoids respectively. Mamatha et al [10] recorded an incidence of 20% oval shape on the right side and 24% on left side while Kavita et al [11] found oval type in 30 % of the total samples which more or less coincided with findings of the present study. The least common type of shape encountered in the study was inverted comma type which was observed in 22 % on right side and 13% on left side. Rajput HB & Mamatha et al recorded an incidence of inverted comma shape in 35% & 34%, on right and 39% & 33% on left side.[6,10] These findings were quite different when compared to those found in the present study. (Table 6)

Table 6: Comparison of various shapes of glenoid cavity.

Sr No.	Observers	No of specimens	Pear Shape (%)	Oval (%)	Inverted coma (%)
1	Rajput HB et al. 2013 [6]	Right- 43	49	16	35
		Left -57	46	15	39
2	Mamatha et al. 2011 [10]	Right-98	46	20	34
		Left-104	43	24	33
3	Kavita et al. 2013 [11]	Right-67	58	30	11
		Left-62			
4	Present study	Right- 55	47	31	22
		Left-71	55	32	13

Glenoid Cavity Index (GCI): The mean Glenoid cavity Index (GCI) found in the present study was 64.3±4.44 mm. It was 63.67±3.76 mm on the left side and 65.11±5.11 mm on the right side. Dhindsa et al [16] observed mean of Glenoid cavity Index (GCI) of 70.37±4.08 mm on the right side and 68.59±4.36 mm on the left side. The combined mean of the Glenoid cavity Index (GCI) in the present study came out to be 64.3±4.44 mm. Polguj M et al [17] noted the combined GCI to be 72.35±5.55 mm. The values of both these studies are quite higher compared to our study.

CONCLUSION

Knowledge of the shape and dimensions of 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 osseus Bankart lesions and osteochondral defects. Most of the dimensions of the glenoid observed in the present study were more or less similar to those recorded in the studies done on other populations except for the shape. The current study recorded a higher percentage of glenoid cavities without a definitive notch there by accounting for higher percentage of oval shape as compared to other studies. While evaluating defects/lesions of the glenoid, this fact could be useful. Since the current study was performed on a limited number of scapulae, further cadaveric, radiological and clinical studies are indicated.

LIST OF ABBREVIATIONS

SD: Standard Deviation
mm: millimetre
GCI: Glenoid cavity index
SI: Superior-Inferior glenoid diameter
AP-1: Anterior-posterior diameter 1
AP-2: Anterior-posterior diameter 2

Conflicts of Interests: None

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