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**Original article**

# Morphological and Osteometric Assessment of Glenoid Cavity in North Indian Population

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## ABSTRACT

**Introduction:** 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 such as pear shaped, oval or inverted comma. Awareness of variations in the shape and size of glenoid cavity is helpful to orthopaedic surgeons in order to decide the appropriate size of glenoid component in shoulder arthroplasty.

**Material and Methods:** The study was conducted on sixty-four dry adult human scapulae of unknown age and sex with a view to elucidate the morphological and osteometric details. Various shapes and dimensions of the glenoid cavity were observed and compared with the previou studies.

**Results:** Pear shaped glenoid cavity was found to be 59.38% cases on right and 59.38% cases on left side. Inverted comma shape was found to be 31.25% on right sided and 21.88% on left sided scapulae. Oval shaped glenoid cavity was observed in 9.38% on right and 18.75% on left sided scapulae. Mean vertical diameter of glenoid cavity on right side was 37.44±2.28mm and it was found to be 35.71±3.19mm on left sided scapulae with a "p" value of 0.015 which is significant as per analysis. Mean transverse diameter was found to be 24.80±1.98mm and 23.60±2.58mm on right and left sided scapulae respectively.

**Conclusion:** In the present study, the shape of glenoid cavity was found to be pear shaped, Inverted comma shaped and oval shaped in descending order of frequency. Precise knowledge about the shape and morphological variations of the glenoid cavity is vital for successful shoulder arthroplasty. In order to avoid loosening of the joint which may require revision surgery. Dimensions of glenoid cavity are crucial for designing glenoid components for shoulder arthroplasty.

The Parameters of glenoid cavity are vital in planning prosthetic sizing, positioning and design for total shoulder arthroplasty.

**Keywords:** Glenoid, morphology, shoulder.

## INTRODUCTION

Human scapula is one of the most interesting bones of the shoulder girdle which presents many variations. 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 such as pear shaped, oval or inverted comma. The vertical diameter of the glenoid cavity is the longest and it is broader below than above[1]. A thorough knowledge of normal anatomy and variations in the anatomy of the glenoid

cavity of the scapula is important in evaluating the pathological conditions like Bankart's lesions and osteochondral defects[2].

The glenoid with its variable anatomy, minimal bone stock and inherent instability makes addressing the glenoid, One of the most difficult procedures in orthopaedics. Awareness of variations in the shape and size of glenoid cavity is helpful to orthopaedic surgeons in order to decide the appropriate size of glenoid component in shoulder arthroplasty[3]. The scapula may be involved in fractures, dislocation, arthritis, tumours and developmental anomalies.The surgical procedures involving scapula include arthroplasty and arthrodesis of glenohumeral joint, acromioplasty for rotator cuff disorders and scapulothoracic tenodesis for winging[4]. Indications for shoulder arthroplasty currently include severe proximal humeral fractures, primary glenohumeral osteoarthritis, post traumatic arthritis, shoulder girdle tumors, osteonecrosis and failed shoulder arthroplasty[5]. The detailed anatomical knowledge of the scapula is relevant for surgical procedures involving this bone including arthroscopic operations, hardware fixation, drill hole placement and prosthetic positioning[6]. The proposed study envisages to carry out the morphological and osteometric assessment of human scapula in Indian population. Literature pertaining to detailed osteometric analysis of Scapula is limited.

## MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi.

### Materials:

The study was conducted on sixty-four dry adult human scapulae of unknown age and sex with a view to elucidate the morphological and osteometric details.

Inclusion criteria:

1. Adult Human Scapulae
2. Bones with normal gross morphology

Exclusion criteria:

1. Bones showing gross deformity or defect
2. Broken scapulae
3. Scapulae showing degenerative changes

### Methods:

All the scapulae were carefully studied and the observations were noted using the following parameters:

1. Shape of the glenoid cavity: Shape of the glenoid cavity was categorised as either Inverted comma shaped, Pear shaped, Oval shaped (Fig: 1).
2. Vertical diameter of glenoid cavity: vertical diameter was measured from the most prominent point on the supraglenoid tubercle to the inferior margin on inferior glenoid margin (Fig: 2).
3. Transverse diameter of glenoid cavity: measured as maximum breadth of the articular margin of the glenoid cavity (Fig: 2).
4. Acromioglenoid distance: It was measured from tip of the acromion process to the supraglenoid tubercle of scapula (Fig: 3).
5. Coracoglenoid distance: It was measured as minimum distance from tip of the coracoid process to the anterior margin of the glenoid cavity (Fig: 4).



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The osteometric evaluation of scapula was carried out by using Digital Vernier Calliper
(Fig:5) sensitive to 0.1mm. The observations were carefully recorded and discussed in the light of previous literature.

**STATISTICAL EVALUATION**

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov-Smirnov test. If the normality was rejected, then non parametric test was used.

Statistical tests were applied as follows-

1.Quantitative variables were compared using Unpaired t-test/Mann-Whitney Test (when the data sets were not normally distributed) between the two groups.

2.Qualitative variables were correlated using Chi-Square test /Fisher's exact test.

3. Pearson correlation coefficient/Spearman rank correlation coefficient was used to assess the association of various quantitative parameters.

A p value of $<0.05$ was considered statistically significant.

The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.



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**Fig: 1 Various shapes of the glenoid cavity**

**Inverted** **Pear** **Oval**

**Comma**


**Fig: 2 Photograph showing parameters of glenoid cavity**

(c) Vertical diameter of glenoid cavity

(d) Transverse diameter of glenoid cavity



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**Fig: 3 Photograph showing Acromio-glenoid distance**

(f) Acromioglenoid distance


**Fig: 4 Photograph showing Coraco-glenoid distance**

(g) Coracoglenoid distance

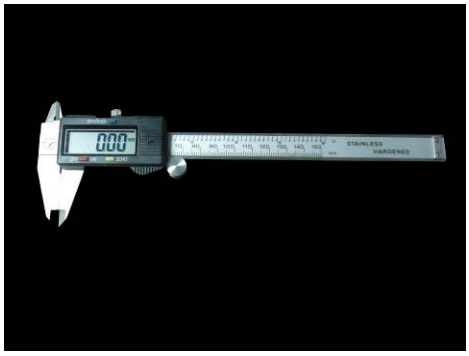

**Fig: 5 Digital Vernier calliper**



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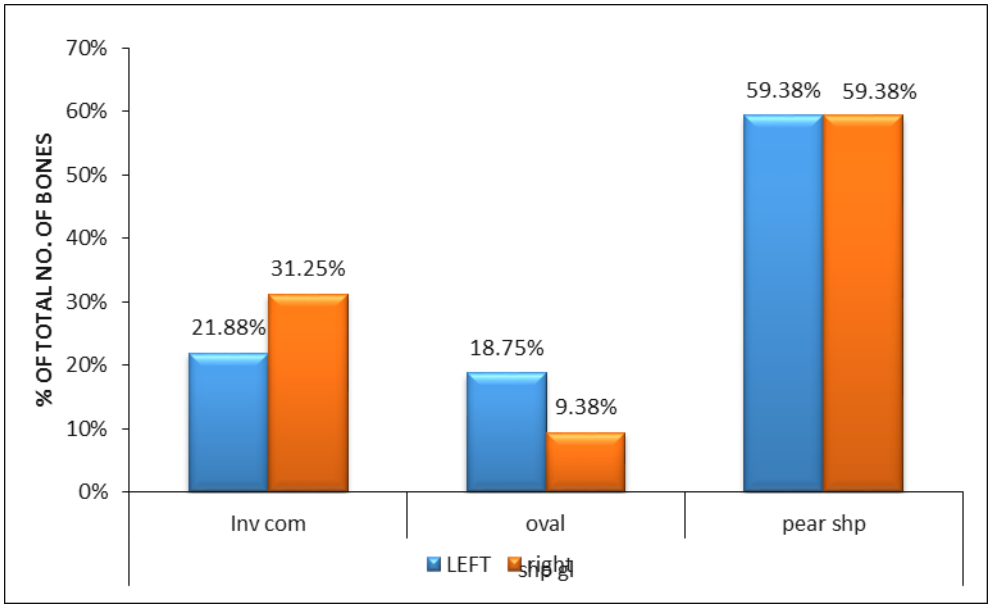
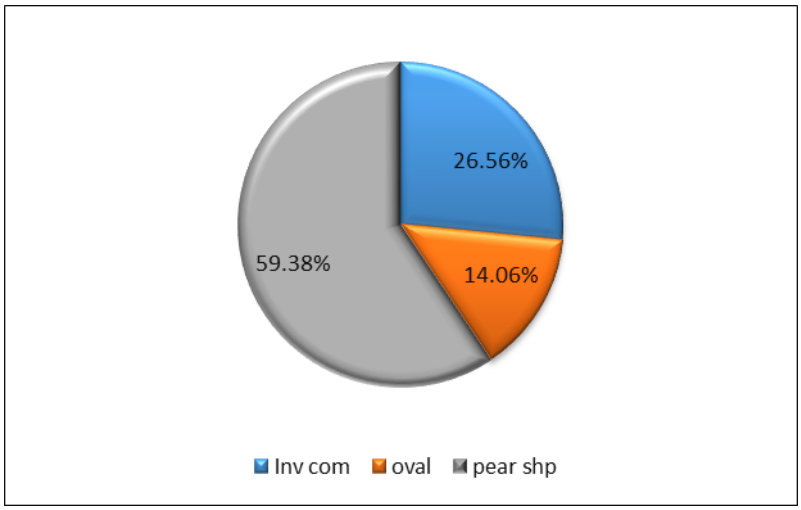
**BAR DIAGRAM-1**

**SHAPES OF GLENOID CAVITY**




**PIE DIAGRAM-1**

**SHAPES OF GLENOID CAVITY**




**BAR DIAGRAM -2**



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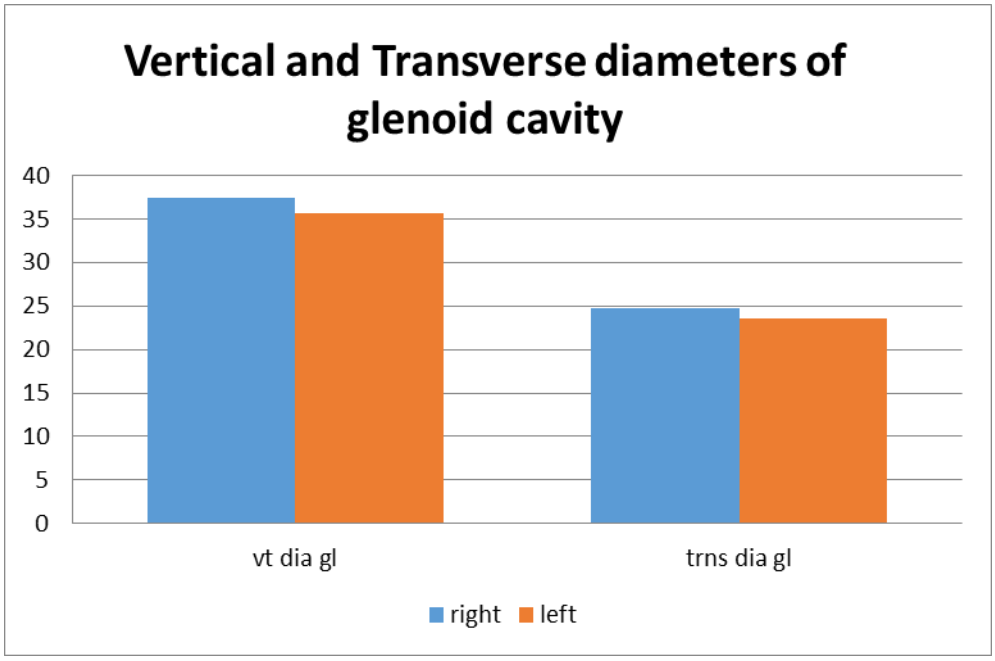
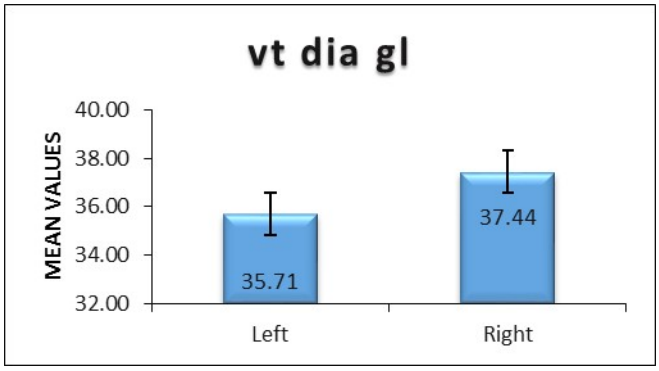
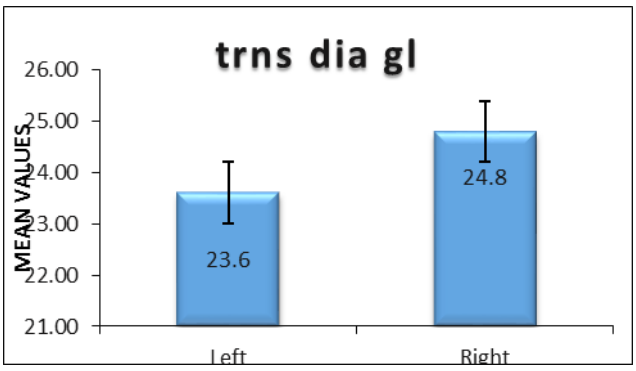
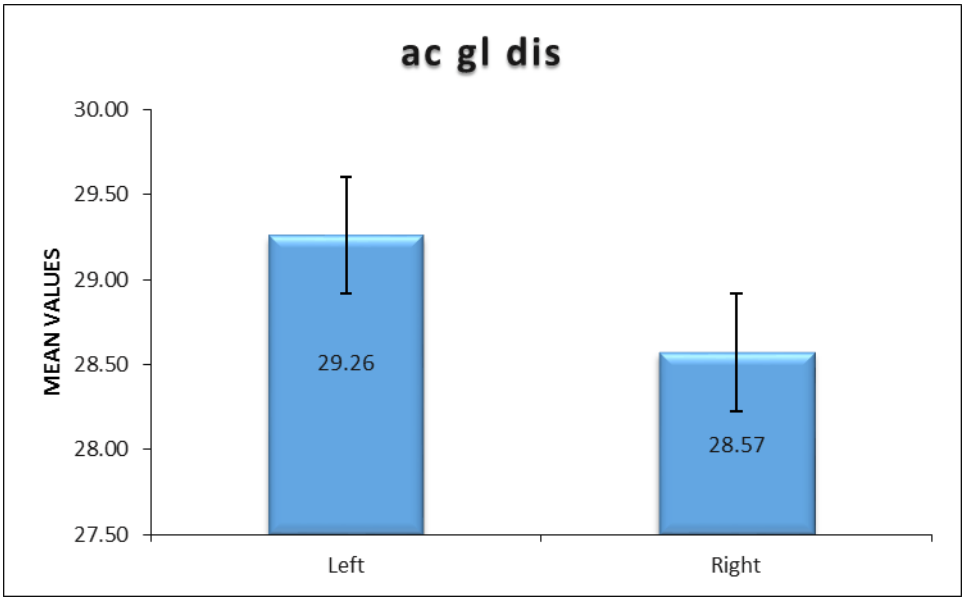



**BAR DIAGRAM-3 (ACROMIOGLENOID DISTANCE)**



**BAR DIAGRAM-4 (CORACOGLENOID DISTANCE)**

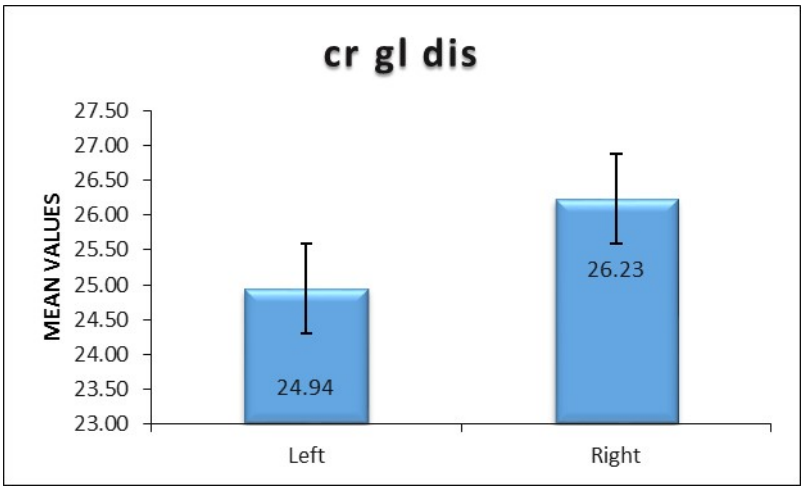



**Table-1: Shape of glenoid cavity in right and left sided scapulae**

| **Shape of glenoid cavity** | **Right (n=32)** | **Left (n=32)** | **p Value** |
|---|---|---|---|
| Pear Shaped | 19(59.38%) | 19(59.38%) | 0.799 |
| Inverted comma shaped | 10(31.25%) | 7(21.88%) | 0.571 |
| Oval Shaped | 3(9.38%) | 6(18.75%) | 0.474 |

**Table-2: Vertical and Transverse diameters of glenoid cavity**

| **Parameters** | **Mean±SD(mm) Range= Min.-Max.(mm)** | | **p Value** |
|---|---|---|---|
| | **Right(n=32)** | **Left(n=32)** | |
| Vertical diameter | 37.44±2.28 (32.12-41.65) | 35.71±3.19 (24.66-40.18) | 0.015* |
| Transverse diameter | 24.80±1.98 (20.39-29.66) | 23.60±2.58 (16.15-28.34) | 0.042* |

**Table 3: Correlation of vertical diameter of glenoid cavity with other parameters**

| **Parameter** | Length of coracoid process | Maximum scapular length | Maximum scapular width |
|---|---|---|---|
| Vertical diameter of glenoid cavity (p<0.0001) | 0.464<br>p<0.0001 | 0.543<br>p<0.0001 | 0.47<br>p<0.0001 |

**Table 4: Correlation of transverse diameter of glenoid cavity with other parameters**

| **Parameter** | Maximum width of scapula | Vertical diameter of glenoid cavity | Thickness of coracoid process | Breadth of coracoid process |
|---|---|---|---|---|
| Transverse diameter of glenoid cavity (p<0.0001) | 0.543<br>p<0.0001 | 0.494<br>p<0.0001 | 0.512<br>p<0.0001 | 0.536<br>p<0.0001 |

**Table-5: Acromioglenoid distance**

| **Parameter** | **Mean±SD(mm)**<br>**Range= Min.-Max.(mm)** | | **p Value** |
|---|---|---|---|
| | **Right(n=32)** | **Left(n=32)** | |
| Acromioglenoid Distance | 28.57±2.95<br>(24.63-37.29) | 29.26±5.25<br>(21.95-42.63) | 0.520 |



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**Table-6: Coracoglenoid distance**

| Parameter | Mean±SD(mm) Range= Min.-Max.(mm) | | p Value |
|---|---|---|---|
| | Right(n=32) | Left(n=32) | |
| Coracoglenoid distance | 26.23±3.05 (16.36-31.34) | 24.94±2.75 (19.72-30.53) | 0.081 |

**Table 7: Correlation of coracoglenoid distance with other parameters**

| Parameter | Length of coracoid process |
|---|---|
| Coracoglenoid distance ($p<0.0001$) | 0.467 $p<0.0001$ |

**Table 8: Comparison of shapes of glenoid cavity on right and left sided by various authors.**

| Studies | Year | Inverted Comma | | Pear | | Oval | |
|---|---|---|---|---|---|---|---|
| | | Right | Left | Right | Left | Right | Left |
| Prescher et al[18] | 1997 | 55% | | | | 45% | |
| Coskun et al[12] | 2006 | __ | | 28% | | 72% | |
| Mamatha et al[19] | 2011 | 34% | 33% | 46% | 43% | 20% | 24% |
| Rajput et al[20] | 2012 | 35% | 39% | 49% | 46% | 16% | 15% |
| EL-Din et al[11] | 2013 | 16.25% | 20% | 35% | 27.40% | 48.75% | 52.50% |
| Patil et al[21] | 2014 | 34.62% | 32.5% | 47.12% | 45% | 18.27% | 22.5% |
| Gosavi et al[9] | 2014 | 12.9% | 11.2% | 54.83% | 45.0% | 32.25% | 43.75% |
| Gupta et al[13] | 2015 | 40% | 37% | 43% | 40% | 17% | 23% |
| Hassanein et al[3] | 2015 | 31.58% | 30% | 44.74% | 46.67% | 23.68% | 23.33% |
| Chhabra et al[1] | 2015 | 21.82% | 12.62% | 47.28% | 54.92% | 32.40% | 30.90% |
| Reddy et al[2] | 2016 | 36.21% | 39.40% | 53.45% | 54.54% | 10.34% | 6.06% |
| Akhtar et al[10] | 2016 | 34.92% | 37.25% | 51.59% | 49.02% | 14.49% | 13.73% |
| Present Study | | 31.25% | 21.88% | 59.38% | 59.38% | 9.38% | 18.75% |



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**Table 9: Comparison of dimensions of glenoid cavity by various authors**

| Studies | Year | | Vertical diameter (mm) | Transverse diameter (mm) |
|---|---|---|---|---|
| Ianotti et al[22] | 1992 | Both Sides | 39±3.5 | 29±3.2 |
| Mallon et al[23] | 1992 | Both sides | 35±4.1 | 24±3.3 |
| Schroeder et al[4] | 2001 | Both Sides | 36±4.0 | 28.6±3.3 |
| Mamatha et al[19] | 2011 | Right | 33.67±2.82 | 23.25±2.04 |
| | | Left | 33.92±2.87 | 23.02±2.30 |
| Rajput et al[20] | 2012 | Right | 34.76±3.00 | 23.31±3.00 |
| | | Left | 34.43±3.21 | 22.92±2.80 |
| Gosavi et al[9] | 2014 | Right | 35.03±5.25 | 24.17±2.57 |
| | | Left | 35.03±3.41 | 23.9±2.66 |
| Patil et al[21] | 2014 | Right | 33.68±4.32 | 23.29±2.34 |
| | | Left | 32.09±4.11 | 24.10±2.95 |
| Reddy et al[2] | 2016 | Right | 34.28 | 24.72 |
| | | Left | 34.36 | 23.93 |
| Present study | | Right | 37.44±2.28 | 24.80±1.98 |
| | | Left | 35.71±3.19 | 23.60±2.58 |

**Table-10: Comparison of the acromioglenoid (AGD) and coracoglenoid (CG) distances by various authors**

| Studies | Year | | AGD distance (mm) | CG distance (mm) |
|---|---|---|---|---|
| Gumina et al[24] | 1999 | Both sides | ---- | 16.23 |
| Paraskevas et al[25] | 2008 | Both sides | 17.7 | ----- |
| Collipal et al[26] | 2010 | Right | 28.24±2.7 | --- |
| | | Left | 28.43±2.7 | --- |
| Mansur et al[27] | 2012 | Right | 39.39±5.32 | ---- |
| | | Left | 31.97±3.96 | ---- |
| Singh et al[28] | 2013 | Right | 26.6±4.4 | ---- |
| | | Left | 27.6±3.6 | ---- |
| Musa et al[29] | 2014 | Both sides | | |
| Gosavi et al[30] | 2015 | Both sides | 22.68 | ---- |
| Gupta et al[31] | 2015 | Right | 25.3±2.9 | ---- |
| | | Left | 24.3±4.9 | ---- |
| Naidoo et al[32] | | Right | 20.96±3.2 | ---- |
| | | Left | 20.88±4.5 | ---- |



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| | | | | |
|---|---|---|---|---|
| | 2015 | Male | 21.53±4.5 | ---- |
| | | Female | 20.04±2.8 | ---- |
| | | Black | 20.91±3.9 | ---- |
| | | White | 21.14±4.0 | ---- |
| Lingamdenne et al[33] | 2016 | Both sides | 24.46±3.68 | ---- |
| Nweke et al[34] | 2017 | Both sides | 30.25±4.05 | ---- |
| Saha et al[35] | 2017 | Both sides | 26.21±3.3 | ---- |
| Present study | | Right | 28.57±2.95 | 26.23±3.05 |
| | | Left | 29.26±5.25 | 24.94±2.75 |

**RESULTS**

The present investigation focussed on the morphology and osteometric details of sixty-four human scapulae. The study was conducted on right and left sided scapulae. The observations were categorized to compare the right and left sided parameters.

1. **SHAPE OF THE GLENOID CAVITY:** Morphological appearance (Fig.1) of glenoid cavity was examined in order to define its shape and was categorized as either Pear shaped, Inverted comma or oval shaped based on morphological appearance. Further the right and left sided bones were compared as depicted in Table1. Pear shaped glenoid cavity was found to be 59.38% cases on right and 59.38% cases on left side. Inverted comma shape was found to be 31.25% on right sided and 21.88% on left sided scapulae. Oval shaped glenoid cavity was observed in 9.38% on right and 18.75% on left sided scapulae. Bar diagram1 and Pie diagram1 depict incidence of various shapes of the glenoid cavity observed in the present study.
2. **VERTICAL AND TRANSVERSE DIAMETERS OF GLENOID CAVITY:** Mean vertical diameter of glenoid cavity on right side was 37.44±2.28mm and it was found to be 35.71±3.19mm on left sided scapulae with a "p" value of 0.015 which is significant as per analysis. Range of vertical diameter for right and left sided scapulae were 32.12-41.65 and 24.66-40.18mm respectively. Mean transverse diameter was found to be 24.80±1.98mm and 23.60±2.58mm on right and left sided scapulae respectively. Range of transverse diameter was 20.39-29.66mm and 16.15-28.34mm on right and left side respectively as shown in Table 2. The difference between the two sides was statistically significant (p=0.042). Bar diagram 2 depicts the vertical and transverse diameters of glenoid cavity in right and left sided scapulae.

**CORRELATION OF GLENOID DIMENSIONS WITH OTHER PARAMETERS :**

**Vertical diameter of glenoid cavity** in present study is statistically highly correlated ($p<0.0001$) with length of coracoid process, maximum scapular length and maximum scapular width (Table 3).

**Transverse diameter of glenoid cavity** showed correlation ($p<0.0001$) with breadth and thickness of the coracoid process, maximum scapular width and vertical diameter of glenoid cavity (Table 4).

3. **ACROMIOGLENOID DISTANCE:** Mean acromioglenoid distance was found to be 28.57±2.95mm on right side and 29.26±5.25mm on left side with a "p" value of 0.520. Range was 24.63-37.29 mm and 21.95-42.63 mm on right and left sided scapulae respectively as depicted in Table 5. Bar diagram 3 depicts the comparison of acromioglenoid distance in right and left sided scapulae.



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4. **CORACOGLENOID DISTANCE:** Mean coracoglenoid distance was noted 26.23±3.05 mm and 24.94±2.75 mm on right and left sided scapulae respectively with "p" value 0.081. The range was 16.36-31.34 mm on right side and 19.72-30.53 mm on left side respectively as depicted in Table 6. Bar diagram 4 depicts the comparison of coracoglenoid distance in right and left sided scapulae.

**Coracoglenoid distance** was found to be highly correlated ($p<0.0001$) with length of the coracoid process (Table 7).

The present study was directed towards exploration of morphological variants of glenoid cavity and acromion process. The study also highlighted the osteometric assessment of scapula and its components.

**DISCUSSION**

The human scapula is a flat triangular bone situated posteriorly. Glenoid cavity is head of the scapula. Anatomical basis and variations in shape of glenoid is fundamentally important in clinical practice. Knowledge about shape of glenoid cavity is essential in designing and fitting of glenoid component during total shoulder arthroplasty[7]. The morphometric analysis of scapular dimensions provides pertinent information for various surgical procedures involving fixation of scapular fractures, resection and reconstruction of scapula tumor and reestablishment the stability of glenohumeral joint[8].

The present study was conducted to evaluate the morphometric measurements of human scapula in dry bones to provide baseline data.

The morphometric study was carried out highlighting the dimensions of the scapula and its various components such as glenoid cavity, acromion process and coracoid process including the acromiocoracoid, acromioglenoid and coracoglenoid distances.

The current study also attempted to explore any difference of data between the two sides (right and left). It is expected that the observations of present study will contribute as an anatomical reference for researchers and clinicians.

The data pertaining to each parameter was compared to the findings of previous researchers. In many aspects, the observations of the present study correspond reasonably well with the data of earlier studies. However, the discrepancies could possibly be due to racial dissimilarities and regional variations.

**GLENOID CAVITY**

Table: 8 depicts the comparison of the shape of the glenoid cavity in earlier studies and the current investigation has been prepared. Many Indian authors have seen that the commonest shape in the Indian sub-continent is the pear shaped glenoid cavity[2][9][10]. Interestingly a study conducted on Egyptian scapulae revealed that the commonest shape was oval[11]. Similarly a study on Turkish scapulae also revealed a similar oval shape of the glenoid cavity[12].

In the present study, the shape of glenoid cavity was found to be pear shaped, Inverted comma shaped and oval shaped in descending order of frequency.

Precise knowledge about the shape and morphological variations of the glenoid cavity is vital for successful shoulder arthroplasty. In order to avoid loosening of the joint which may require revision surgery[13].

Table: 9 highlights the comparison of dimensions of glenoid cavity by various authors. The difference in these values in various studies can possibly be attributed to racial variations.

Morphometric details of glenoid cavity are clinically relevant in orthopaedic joint replacement, glenohumeral instability and management of rotator cuff tears[14].

Dimensions of glenoid cavity are crucial for designing glenoid components for shoulder arthroplasty[15].

The Parameters of glenoid cavity are vital in planning prosthetic sizing, positioning and design for total shoulder arthroplasty[16].

Table 10 depicts the distances between the various landmarks of the scapula. These measurements were compared with the previous studies.

The values of acromioglenoid distances observed in the current study exhibited variance with earlier studies. Notably the acromioglenoid distance was recorded to be much lower by Schroeder et al[4].Further, much higher values of coracoglenoid distance was reported by Schroeder et al[4].The exclusiveness of our study lies in the fact that all the three measurements viz. coracoacromial, coracoglenoid and acromioglenoid distances have been recorded whereas most of the earlier studies have focussed on one or two of these parameters. Bar diagram 5 depicts the comparison of acromiocoracoid, acromioglenoid and coracoglenoid distances on right and left sided scapulae.

Furthermore, precise information pertaining to dimensions of glenoid cavity is significant in understanding the recurrent shoulder dislocation and pathomechanics of rotator cuff diseases.

Accurately measured distances with reference palpable osseous landmarks is useful for portal placement while carrying out shoulder arthroscopy[4].

Acromioglenoid distance is an important factor in the diagnosis of impingement syndrome. Shortening of acromioglenoid distance may predispose to impingement syndrome[17].

The current study revealed differences in the various morphometric parameters of scapula when compared to previous studies. This could possibly be explained on the basis of racial variations.

An attempt has been made to provide a baseline data on morphological and osteometric details of human scapula in Indian subjects.

One of the salient highlights of the current investigation is the correlation between various osteometric parameters. High statistical significance observed in correlation between some osteometric parameters supports their suitability for application in predicting the dimensions of implants for shoulder arthroplasty.

It is also expected that these results may prove beneficial in medicolegal investigation and may be utilized for scapular reconstruction as well.

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