

## MORPHOMETRIC EVALUATION OF GLENOID CAVITY AND OTHER DIMENSIONS OF DRY HUMAN SCAPULAE

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### ABSTRACT

**Introduction:** The scapula (shoulder blade) is a triangular flat bone that lies on the posterolateral aspect of the thorax. The scapula bears various angles namely superior, inferior, lateral, medial, acromial and coracoid angle. The three borders meet strategically to form the referenced three angles (lateral, superior, and inferior). Its lateral angle, truncated and broad, bears the glenoid cavity which articulates with the head of the humerus at the glenohumeral joint. The morphology of the glenoid cavity is highly variable. The glenoid rim presents a notch in its upper and front part

**Materials and Methods:** This study included thorough observation of 120 dry human scapulae, 67 from left side and 53 from right side, obtained from department of Anatomy, Sri Guru Ram Rai Institute of medical and health sciences Dehradun following standard guidelines. All the metric and non metric parameters were observed and recorded in tabulated form.

**Results:** The mean length of scapula of left side was observed as 127.35±12.35 and right side was 128.10±11.21. The total mean value for length of scapula was noted as 130.21±12.65. The mean breadth of scapula was recorded as 96.98±7.62mm. The mean value of scapular index was listed as 68.47±3.98. The mean of infraspinous length was recorded as 99.14±9.54 and the infraspinous index was 99.65±8.32. The mean AP glenoid diameter 1 was 24.54±2.65mm, the mean AP glenoid diameter 2 was 16.56±2.45mm and the mean AP glenoid diameter 3 was 17.09±2.75. The shape of the glenoid cavity was recorded as type 1(oval) 17.50%, Type2 (pear) 48.14%, Type3(inverted coma) and Type4(other).

**Conclusion:** To summarize, the present study provides a base line data of different scapular dimensions on the left and right sides. Knowledge of the measurements and indices of various parameters of scapula such as length, width and various parameters of glenoid cavity can be used for comparative anatomy and also for defining the race.

**KEY WORDS:** Scapular index, glenoid notch, infraspinous length.

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## INTRODUCTION

The scapula (shoulder blade) is a triangular flat bone that lies on the posterolateral aspect of the thorax, overlying the 2nd to 7th ribs. The convex posterior surface of the scapula is unevenly divided by the spine of the scapula into a small supraspinous fossa and a much large infraspinous fossa. The concave costal surface of the scapula has a large subscapular fossa. It has a triangular spine, its continuation the acromion process and the coracoid process. The scapula bears various angles namely superior, inferior, lateral, medial, acromial and coracoid angle. Superior angle It was measured as the angle where the superior border meets the medial or the vertebral border of the scapula [1].

Inferior angle: It was measured as the angle where the medial or the vertebral border of the scapula meets the lateral or the axillary border.

Lateral angle: It was measured as an open angle where the superior and the lateral or the axillary borders are wedged by the glenoid fossa.

Medial angle: It was measured as the angulation of the bone formed at the medial end of the anterior border of the crest of the spine of the scapula where the plate like body of the bone is bent between the medial borders of the supraspinous and the infraspinous fossae.

Acromion angle: It was measured as the angle where the lower border of the crest of the spine becomes continuous with the lateral border of the acromion process.

Coracoid angle: It was measured as the angle formed where the root of the coracoid process is bent sharply so as to project forward and slightly laterally. The body of the scapula is enclosed by the superior, medial, and lateral borders. The superior border is the shortest and the sharpest of the three borders and it ends at the scapular notch [2]. The medial border, also called the vertebral border, is the longest of the three borders; it exhibits either a concave, convex, or straight pattern The three borders meet strategically to form the referenced three angles [3, 4].

Its lateral angle, truncated and broad, bears the glenoid cavity which articulates with the head of the humerus at the glenohumeral joint and

may be regarded as the head of the scapula. The morphology of the glenoid cavity is highly variable. The glenoid rim presents a notch in its upper and front part [5]. Due to presence of this glenoid notch, various shapes of glenoid cavity are found like pear-shaped, oval or inverted comma shaped [6,7]. The knowledge of various dimensions of the scapula may be helpful in open reduction and internal fixation of significantly displaced scapular fractures [8].

## MATERIALS AND METHODS

The present study has been carried out on 120 dry human scapulae, which were collected from the department of Anatomy, Sri Guru Ram Rai Institute of medical and health sciences Dehradun. The macerated scapulae were randomly selected. The scapulae did not present with any external deformity. The age and sex of the scapulae were not taken into consideration. Out of the 120 scapulae 67 belongs to the left side and 53 to the right side. Each scapula was carefully examined for the shape of the glenoid cavity, its anterior and posterior margins and notches. Each scapula was also examined for its length, breadth, and other parameters. Presence of any accessory foramen. The photographs were taken by the Sony digital camera and anatomical parameters measured with the help of sliding digital Vernier caliper. All The measurements were recorded in millimeters. Each parameters was defined as follows:

Scapular length: Maximum vertical measurement from superior angle to inferior angle(A-B)

Scapular breadth: Measurement from angle at the medial border(point C)to the middle of the posterior border to glenoid cavity(D).

Infraspinous length: Measurement from point C to inferior angle, point B.

Length of spine: Measurement from angle at the medial border(point C)to the lateral border of acromion process(E).

Scapular index:  $(\text{Breadth}/\text{length}) \times 100$

Infraspinous index:  $(\text{Breadth}/\text{Infraspinous length}) \times 100$

Glenoid cavity

Shape: The shape of the glenoid cavity was observed and recorded as follows

Type 1(oval): The articular margin of glenoid cavity is more or less circular.

Type 2(pear): The anterior margin of glenoid cavity shows indistinct notch.

Type 3(inverted coma): The anterior margin of the glenoid cavity shows distinct notch.

Type 4(other): More or less recognizable glenoid notch at the both anterior and posterior margin of the glenoid cavity.

Maximum vertical diameter: Measured from supraglenoid tubercle to inferior glenoid margin (A-B).

Anteroposterior glenoid diameter 1: Maximum width of articular margin of glenoid cavity(C-D).

Anteroposterior glenoid diameter 2: Maximum width of articular margin of glenoid cavity at the glenoid notch (E-F).

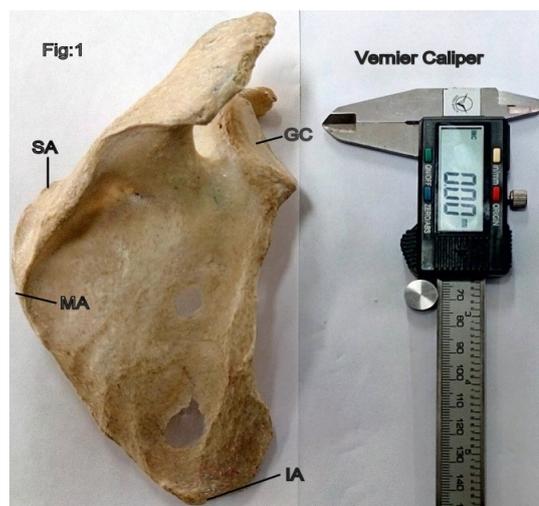
Anteroposterior glenoid diameter 3: Represents the width of the upper half of the glenoid cavity at the midpoint between the superior margin and the mid equator(G-H).

## RESULTS

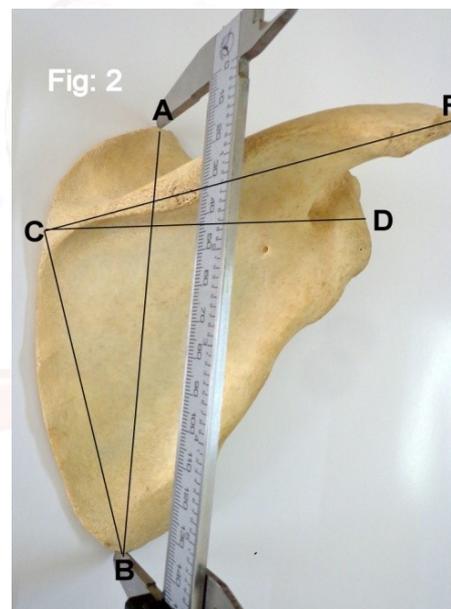
The values observed were tabulated and the mean value and Range were calculated for left and right side. The mean length of scapula of left side was observed as  $127.35 \pm 12.35$  and right side was  $128.10 \pm 11.21$ . The total mean value for length of scapula was noted as  $130.21 \pm 12.65$  [Tab. 1, Fig. 2]. The mean breadth of scapula was recorded as  $96.98 \pm 7.62$  mm [Tab. 1, Fig. 2]. The scapular index was recorded in the range of  $68.47 \pm 3.98$  (Left:  $69.03 \pm 3.75$ , Right:  $67.93 \pm 4.10$ ). The mean of infraspinous length was recorded as  $99.14 \pm 9.54$  and the infraspinous index was  $99.65 \pm 8.32$  [Tab. 1, Fig. 2]. For the glenoid cavity the mean vertical diameter was  $32.08 \pm 3.09$  mm (Left:  $30.93 \pm 4.10$ , Right:  $31.23 \pm 3.02$ ). The mean antero posterior glenoid diameter 1 was  $24.54 \pm 2.65$  mm, the mean anteroposterior glenoid diameter 2 was  $16.56 \pm 2.45$  mm and the mean antero posterior glenoid diameter 3 was noted as  $17.09 \pm 2.75$  [Tab. 2, Fig. 3].

The shape of the glenoid cavity was observed and recorded as type 1(oval) 17.50%, Type2 (pear) 48.14%, Type3 (inverted coma) and Type4 (other). [Tab. 3, Fig. 4a, 4b, 4c & 4d].

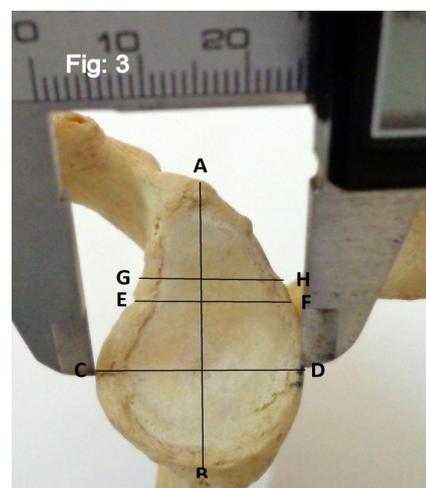
**Fig. 1:** Showing angles of scapula and vernier caliper. SA- superior angle, MA- medial angle, IA-inferior angle, GC-glenoid cavity.



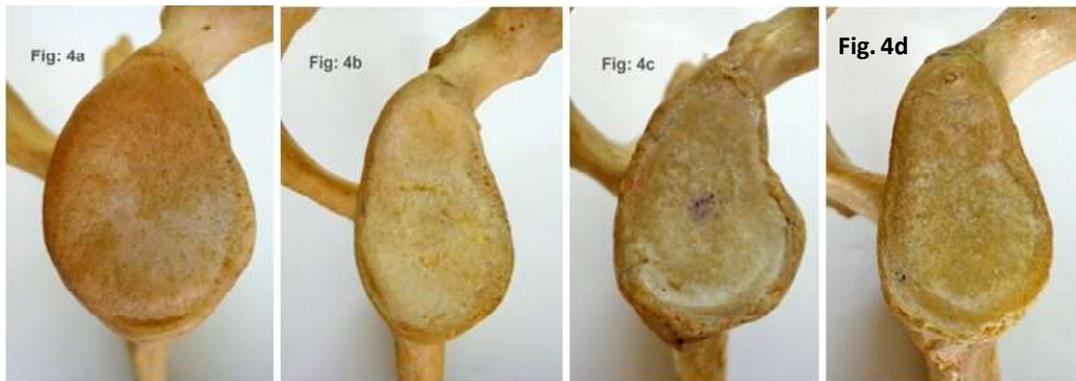
**Fig. 2:** Showing parameters of scapula .BC- infraspinous length, AB- length of scapula, CD-width of scapula, CF-length of spine.



**Fig 3:** Showing diameters of glenoid cavity .AB-vertical length, CD- anteroposterior (AP) diameter-1, EF- AP diameter-2, GH- AP diameter-3.



**Fig 4a, 4b, 4c, 4d:** Showing oval shape (Type-1), pear shape (Type-1), inverted coma shape (Type-3), & other (Type-4) glenoid cavity.



**Table 1:** Measurements of the various parameters of scapula.(N=120, Left-67,right-53).

Parameters	Range (mm)	Mean $\pm$ SD (mm)	Total (Mean $\pm$ SD) (mm)
<b>Length of scapula</b>	Left: 104.40-149.10 Right : 105.10-150.10	Left : 127.35 $\pm$ 12.35 Right : 128.10 $\pm$ 11.21	130.21 $\pm$ 12.65
<b>Width of scapula</b>	Left: 82.12-110.38 Right : 79.98-111.23	Left : 95.39 $\pm$ 7.13 Right : 96.41 $\pm$ 8.71	96.98 $\pm$ 7.62
<b>Scapular index</b>	Left: 54.29-83.76 Right : 53.31-82.54	Left : 69.03 $\pm$ 3.75 Right : 67.93 $\pm$ 4.10	68.47 $\pm$ 3.98
<b>Infraspinous length</b>	Left: 83.27-115.30 Right : 84.10-114.45	Left : 99.54 $\pm$ 9.76 Right : 98.94 $\pm$ 8.79	99.14 $\pm$ 9.54
<b>Infraspinous index</b>	Left: 76.87-125.98 Right : 75.12-123.65	Left : 99.89 $\pm$ 10.12 Right : 101.12 $\pm$ 9.98	99.65 $\pm$ 8.32
<b>Length of spine</b>	Left: 98.20-140.10 Right : 99.96-139.31	Left : 118.10 $\pm$ 10.59 Right : 119.21 $\pm$ 9.98	118.89 $\pm$ 10.10

**Table 2:** Measurements of the parameters of glenoid cavity of scapula.(N=120, Left-57,right-63).

Parameters	Range (mm)	Mean $\pm$ SD (mm)	Total (Mean $\pm$ SD) (mm)
<b>Vertical Glenoid Diameter(AB)</b>	Left: 25.10-36.33 Right : 26.32-35.14	Left : 30.93 $\pm$ 4.10 Right : 31.23 $\pm$ 3.02	32.08 $\pm$ 3.09
<b>Horizontal diameter-1 (CD)</b>	Left: 17.28-27.46 Right : 16.54-28.12	Left : 24.13 $\pm$ 2.98 Right : 23.31 $\pm$ 2.13	24.54 $\pm$ 2.65
<b>Horizontal diameter-2 (EF)</b>	Left: 13.28-21.87 Right : 13.96-19.34	Left : 18.13 $\pm$ 2.87 Right : 16.03 $\pm$ 2.65	16.56 $\pm$ 2.45
<b>Horizontal diameter-3 (GH)</b>	Left: 11.88-20.12 Right : 11.14-20.54	Left : 17.03 $\pm$ 2.54 Right : 16.13 $\pm$ 3.01	17.09 $\pm$ 2.75

**Table 3:** Morphological assessment of Glenoid cavity of scapula.(N=120, Left-57,right-63).

Morphology	No. of Scapula	Percentage (%)	Total	(%)
<b>Type 1</b>	Left: 11 Right :10	19.25 15.9	21	17.5
<b>Type 2</b>	Left: 28 Right :30	49 47.7	58	48.14
<b>Type 3</b>	Left: 16 Right :18	28 28.62	34	28.22
<b>Type 4</b>	Left: 2 Right :5	3.5 7.95	7	5.81

## DISCUSSION

The glenoid cavity of each scapula was observed for their status and their shapes, notches and

vertical and antero-posterior diameters and compared with other studies. The average Superior-Inferior (AB) diameter of the left side of glenoid cavity was revealed 30.93 $\pm$ 4.10 mm and of the right side was 31.23 $\pm$ 3.02. The total mean value of AB was recorded as 32.08 $\pm$ 3.09. The right AB value was slightly higher than the left (Table 7/Figure 3). The Aigbogun et al.[9] reported the incidence of this total mean value is 36.87 $\pm$ 3.94 while Akhtar et al [10] observed 35.80 $\pm$ 3.14.. These values are being considerably higher than those obtained in our study (32.08 $\pm$ 3.09). This difference can be explained

by the differing composition of the population examined. (Tab.7). Luis Rios Frutos [11], Sitha Piyawinijwong et al [12], had measured the AB diameter of the male and female glenoid separately. The average AB diameter of the male glenoid recorded by Luis Rios Frutos [11] was  $36.08 \pm 2.05$  mm, and by Sitha Piyawinijwong [12] was  $38.1 \pm 2.2$  mm. In our study the gender of scapula is not taken into consideration. The AB diameter of the female glenoid measured by Sitha Piyawinijwong et al<sup>12</sup> and Ozer et al [13] was  $33.6 \pm 3.0$  mm and  $33.79 \pm 3.08$  mm respectively 4, 5. These values were quite similar to those reported in the current study ( $32.08 \pm 3.09$  mm).

The average maximum Anterior-Posterior diameter (CD) of the glenoid Cavity was  $24.54 \pm 2.65$  mm in the current study. This value was quite similar to those reported by Akhtar et al. ( $23.63 \pm 2.50$  mm) in his study. Peter et al [14], Iannotti et al [15] had measured the CD diameter as  $25.07 \pm 2.55$  and  $29 \pm 3.2$  mm respectively. These values are higher than obtained in our study. (Table 7/Figure 3). These variations may be due to different races and regions. The average Anterior-Posterior diameter (EF) of the glenoid cavity in current study was  $16.56 \pm 2.45$  mm. It was recorded by Hina B Rajput [16] as  $15.24 \pm 2.04$  mm on the left side of scapula and  $16.2 \pm 3.23$  mm on right side. These observations are very close to our study. The average mean value of Anterior-Posterior diameter (GH) of the glenoid was  $17.09 \pm 2.75$  mm in our study. Mamatha et al [17] recorded the average GH diameter of the right glenoid was  $16.27 \pm 2.01$  mm and that of the left glenoid was  $15.77 \pm 1.96$  mm. Iannotti et al reported the mean GH value is  $23 \pm 2.7$  mm, which were higher than observed in the current study.

In the current study, the incidence of various shapes of the glenoid cavity has been measured and compared with other studies. Various types of glenoid cavity based on their shape were observed and recorded. In our study the oval shaped (type1) glenoid cavity were found 19.25% on the left side and 15.90% on right side. The pear shaped (type2) glenoids were 47.70% on the right side and 49.00% on the left side. The inverted comma shaped (type3) with a distinct notch were recorded 28.00% on the

left side and 28.62% on right side. This suggests that there is no significant difference in the presence of a notch on the right and left side. In 3.50% cases on the left side and 7.95% on the right side, there was indistinct notch on the anterior and posterior borders both (type4). (Table 3/Figure 4a, 4b, 4c, 4d). In our study the most common type of glenoid cavity were found is pear shaped (type2) followed by type 3. The least common type was found is type 4. Our observations are very similar to the other researchers (Table 8). The others metric parameters of scapula like breadth, length, infraspinous length were also measured and recorded in tabulated form. The findings of the present study were compared with various studies carried out on other races. Mean Scapular length observed in present study was  $130.21 \pm 12.65$  mm which is close to the values obtained by the Akhtar et al [10]. Chhabra N et al [18] study showed mean scapular length of  $141.94 \pm 12.76$  mm. and Singal et al [19] found of  $141.7 \pm 8.9$  mm. (Fig.2, tab.4). These values were higher than the values obtained in our study. Whereas that of Coskum et al [20] were found  $98.8 \pm 7$  mm, lower than the our study. This difference may have been as a result of studies carried out on different races and populations. The mean width of the scapula in the present study was recorded as  $96.98 \pm 7.62$  mm. It is quite similar to finding observed by Singal et al [19] & Peter Ericson et al [14], whereas it was recorded by the Chhabra N et al [18] by  $103.65 \pm 6.82$  mm, higher than the value obtained in this study. The mean scapular index obtained in present study was  $68.47 \pm 3.98$  mm. It was similar to Singhal et al infraspinous index of 68.5 mm. However the findings of the present study were quite higher when compared to Turner et al. (64.9 mm) and lower to Krishnaiah et al [21] (73.99 mm) (Tab.6). Mean Infraspinous length observed in the present study was  $99.65 \pm 8.32$  mm; the findings of present study coincide with those of chhabra et al [18]. (99.60 mm). The knowledge of different parameters of glenoid cavity is important for the orthopaedician to resurface the glenoid cavity during total shoulder arthroplasty. The information about various parameters like scapular length, breadth etc .are important for designing implants for the shoulder joint.

**Table 4:** Comparison of scapular length of this study with earlier studies.

No.	Authors	Scapula observed	Mean length of scapula (mm)
1	Present study	120	130.21±12.65
2	Chhabra N et al [18]	126	141.94±12.76
3	Peter Ericson et al [14]	50	141.49±9.74
4	Coskum et al [20]	90	98.8±7
5	Singal et al [19]	162	141.7±8.9

**Table 5:** Comparison of scapular breadth of this study with earlier studies.

No.	Authors	Scapula observed	Mean length of scapula(mm)
1	Present study	120	96.98±7.62
2	Chhabra N et al [18]	126	103.65±6.82
3	Peter Ericson et [14]	50	98.69±6.98
4	Flower WH [22]	200	101.42
5	Singal et al [19]	162	96.4±7

**Table 6:** comparison of observed values (scapular index) of this study with other studies.

No.	Authors	Scapula observed	Mean length of scapula(mm)
1	Present study	120	68.47±3.98
2	Turner et al [23]	25	64.9
3	Singhal et al [19]	162	68.5
4	Krishnaiah et al [21]	50	73.99

**Table 7:** Comparison of the different parameters of glenoid cavity of this study with other studies(In mm).

No.	Authors	Scapula observed	Mean SI diameter	Total Mean horizontal diameter		
				CD	EF	GH
1	Present study	120	32.08±3.09	24.54±2.65	16.56±2.45	17.09±2.75
2	Aigbogum [9]	200	36.87±3.94	25.15±3.60	-	-
3	Peter et al [14]	50	36.85±3.17	25.07±2.55	-	-
4	Swapna et al [24]	50	36.83±3.18	25.08±2.53	-	-
5	Akhtar et al [10]	228	35.80±3.14	23.63±2.50	-	16.17±2.24
6	Iannotti et al [15]	140	39±3.5	29±3.2	-	23±2.7

**Table 8:** Comparison between shapes of the Glenoid cavity (N=120, Left-57, right-63).

Authors	No. of Scapula	Type 1 (%)	Type 2 (%)	Type 3 (%)	Type 4 (%)
Present study	Left: 57	19.25	49	28	3.5
	Right :63	15.9	47.7	28.62	7.95
Sarwar et al [25]	Left: 50	16	64	20	-
	Right :50	20	56	24	-
Mamatha et al [17]	Left: 104	24	43	33	-
	Right :98	20	46	34	-
Rachna Agrawal [26]	Left: 67	25.37	44.78	29.86	-
	Right :64	35.94	50	14.04	-
Rajput et al [16]	Left: 57	15	46	39	-
	Right :43	16	49	35	-

To summarize, the present study provides a base line data of different scapular dimensions on the left and right sides. Knowledge of the measurements and indices of various parameters of scapula such as length, width etc. can be used for comparative anatomy and also for defining the race. These findings will also be useful during surgical procedures. Variations in the size and shape of the glenoid cavity which were observed in the current study will be helpful for orthopedic surgeons for the designing and fitting of glenoid components for total shoulder arthroplasty. It has also postulated that the glenoid cavity stability is to a reasonable extent associated with the relationship between glenoid cavity dimensions (glenoid index) than to the labrum.

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### Conflicts of Interests: None

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