Morphological Variants and Dimensional Analysis of Human Acromion Process

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Abstract: ***Introduction**: The acromion process forms the highest part of the shoulder and projects over the glenoid cavity. Morphometric details of the acromion process of scapula are of great significance since it is commonly involved in the impingement syndrome of the shoulder joint. The anterior third of the acromion process, the coracoacromial ligament and the coracoid process form the coracoacromial arch. Morphological variations of the acromion process & its relationship with the glenoid cavity and coracoid process is the most relevant factor determining the height of subacromial space. **Material and Methods**: The observations study is done on the basis of classification of acromion process given by Bigliani. 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. Morphological and osteometric measurements of acromion process were studied and compared with the previous studies. **Results**: Based on morphological appearance, Type 1 (flat) acromion process was observed in 43.8% on right and 21.9% on left side. Type2 (curved) acromion was found in 50% on right side and 59.4% on left sided scapulae. Type 3 (hook shaped) acromion was observed in 6.3% cases on right side and in 18.8% on left sided scapulae. The length of acromion process on right side was found to be 46.23±5.48mm and it was found to be 44.89±4.71 mm on left sided scapulae. Mean breadth of acromion process was found to be 23.98±2.31 and it was found to be 23.27±2.28mm on right and left side respectively. Mean acromioglenoid distance was found to be 28.57±2.95mm on right side and 29.26±5.25mm on left side. **Conclusion**: The knowledge of the data with reference to shape and various distances of acromion process is useful to orthopaedic surgeons while carrying out surgical repairs around shoulder joint. In the present study, we have taken other morphometric measurements into consideration. With the help of the morphometric measurements, it is possible for orthopaedic surgeon operating on the shoulder to place the prosthesis accurately. Additionally, these parameters may assist in understanding the etiopathogenesis of rotator cuff tear and impingement syndrome.*

Keywords: Scapulae, Acromion process, Acromioglenoid distance, Acromiocoracoid distance, Shoulder joint

1. Introduction

Human scapula is one of the most interesting bones of the shoulder girdle which presents many variations. It is a flat triangular bone that lies on the posterolateral aspect of the thorax overlying the second to seventh ribs [1]. Normally scapulae rests at a position on the posterior thorax approximately two inches from the midline. The scapula is also rotated internally from vertical, and is upwardly rotated 10 to 20 degree from vertical [2]. The scapula is composed of a spine, neck, body and glenoid cavity [3]. It has three borders, three processes and three angles. The glenoid cavity is oriented at the lateral angle of the scapula [4]. The convex posterior surface of the scapula is unevenly divided by the spine into an upper small supraspinous fossa and a lower much larger infraspinous fossa. The concave costal surface of the scapula has a large subscapular fossa [5].

The scapular spine, originating from the posterior surface of the scapula, is prolonged to a powerful and flattened acromian process located on the boundary between the superior quadrants of the scapula [6]. The acromion process forms the highest part of the shoulder and projects over the glenoid cavity. Its cranial part is convex, rough, subcutaneous, and it is the proximal origin of some fibres of deltoid muscle. Its lateral margin is thick and irregular, with three to four tubers that give origin to deltoid tendons. Acromion's medial margin is shorter than the lateral one, has apart that gives insertion to the trapezius muscle, and shows an oval and central small articular surface for acromial end of clavicle. Its apex, which is meeting point of the two margins, is thin and gives attachment to coracoacromial ligament [7].

Bigliani [8] pioneered a classification of the acromion process on the basis of morphology. He classified the acromion radiologically into three types-Type 1 (flat), Type 2 (curved) and Type 3 (hooked). Additionally relative percentages of the three types were also reported, 18.6% for type1, 42% for type2 and 38.6% for type3. It was also found that the occurrence of the rotator cuff tears tend to be closely associated with type3 that is hook type of acromion process.

Three types of acromion were observed in study conducted by Naweke cl: type 1 (flat), type 2 (curved), and type 3 (hooked). In these three types of acromion, type 3 (hooked) acromion was found to have increased prevalence in rotator cuff tears. In sexual dimorphism, the males have a greater percentage of type 3 (hooked) acromion than females. However the females have greater percentage of type 1 (flat) acromion than males [9].

Morphometric details of the acromion process of scapula are of great significance since it is commonly involved in the impingement syndrome of the shoulder joint [6]. The acromion process projects forward almost at right angles, from the lateral end of the spine of the scapula [10]. It is one of the components of the coracoacromial arch which forms the superior boundary of the subacromial space [11].

The anterior third of the acromion process, the coracoacromial ligament and the coracoid process form the coracoacromial arch. This arch is fairly a non-elastic structure and it comprises of a subacromial space that is 1-1.5 cm wide and has the subacromial bursa, the myotendinous rotator cuff and the tendon of the long head of the biceps muscle [6]. Morphological variations of the acromion process & its relationship with the glenoid cavity and coracoid process is the most relevant factor determining the height of subacromial space [11].

The variations of the acromion process must be kept in mind during surgery around the shoulder joint [12]. The knowledge regarding the shape and various distances of the acromion process is of relevance to the orthopedicians during surgical repair around the shoulder joint and the morphometric analysis of the acromion process should be used as a base to increase the knowledge anatomical basis of about the disease that appears in this region [6].

The proposed study envisages to carry out the morphological and osteometric assessment of human scapula in Indian population.

2. 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 acromion process: Shape of the acromion process was observed as either flat, curved or hook shaped (Figure 1).
2. Maximum length of acromion process: It was measured from the tip of the acromion process to the midpoint of posterior border of acromion process (Figure 2).
3. Maximum breadth of acromion process: Distance between lateral and medial border at midpoint of acromion process (Figure 2).
4. Acromiocoracoid distance: This distance was measured between tip of the acromion process and tip of the coracoid process (Figure 3).
5. Acromioglenoid distance: It was measured from tip of the acromion process to the supraglenoid tubercle of scapula (Figure 4).

The osteometric evaluation of scapula was carried out by using Digital Vernier Calliper (Figure 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.

Flat

Curved

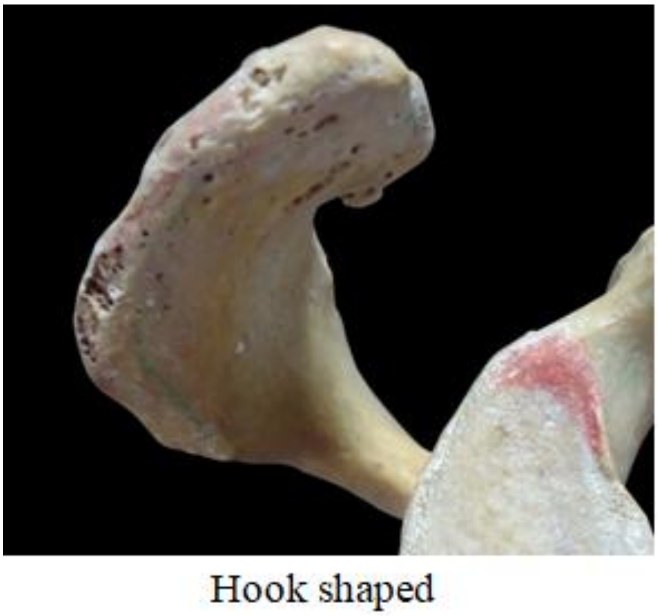


Figure 1: Various shapes of acromion process

Figure 2: Photograph showing parameters of acromion process

(h) Length of acromion process
(i) Breadth of acromion process

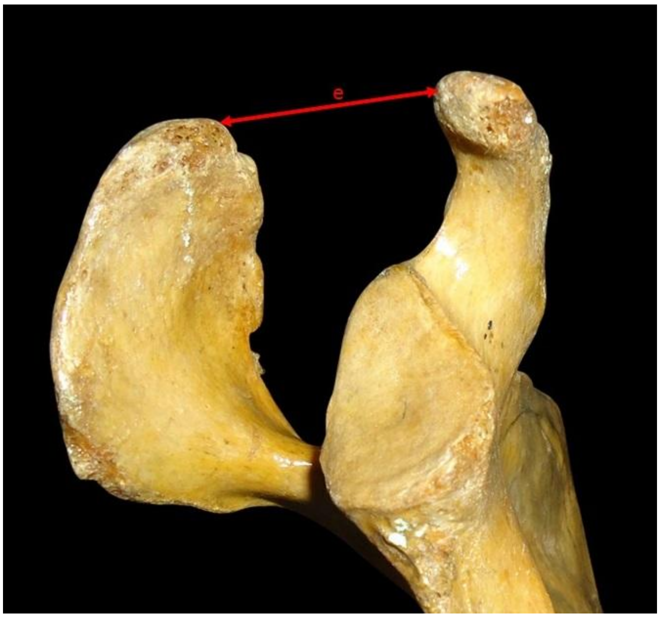


Figure 3: Photograph showing Acromio-coracoid distance

(e) Acromiocoracoid distance

Figure 4: Photograph showing Acromio-glenoid distance

(f) Acromioglenoid distance

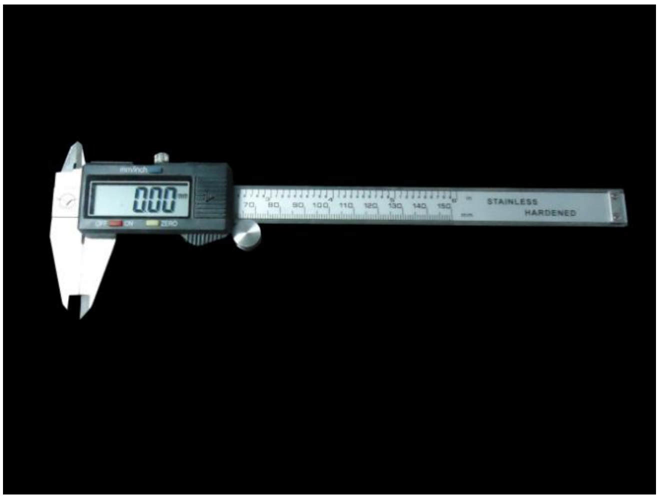


Figure 5: Digital Vernier calliper

3. 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 Acromion Process:** Based on morphological appearance, **s**hapes of acromion process were categorized as either curved, flat or hook shaped (Fig.1). Results were compared on right and left side as shown in Table 1. Type 1 (flat) acromion process was observed in 43.8% on right and 21.9% on left side. Type2 (curved) acromion was found in 50% on right side and 59.4% on left sided scapulae. Type 3 (hook shaped) acromion was observed in 6.3% cases on right side and in 18.8% on left sided scapulae. Bar diagram1 and Pie diagram1 depict various shapes of acromion process in the present study.

2. **Maximum Length and Breadth of Acromion Process:** Mean length of acromion process on right side was found to be 46.23±5.48mm and it was found to be 44.89±4.71 mm on left sided scapulae. Range of maximum length of acromion process was 29.32-56.07mm and 35.66-53.35mm on right and left side respectively with "p" value 0.299. Mean breadth of acromion process was found to be 23.98±2.31 and it was found to be 23.27±2.28mm on right and left side respectively. Range of breadth of acromion process was 19.62-28.21 mm and 18.70-28.60 mm on right and left side with "p" value of 0.223 as given in Table 2. Bar diagram 2 depicts the dimensions of acromion process in right and left sided scapulae.

3. **Correlation of Acromial Length with Other Parameters: Maximum length of acromion process** was found to be highly correlated ($p<0.0001$) with maximum breadth of acromion process, vertical diameter of glenoid cavity, maximum scapular length, maximum scapular width (Table 3).

4. **Acromiocoracoid Distance:** Acromiocoracoid distance was measured from tip of acromion process to the tip of coracoid process. Mean acromiocoracoid distance was found to be 38.48±4.03mm on right side and 35.51±3.83mm on left sided scapulae and the difference between to the two sides showed high statistically significance (p= 0.004) as shown in Table 4. Bar diagram 3 depicts the comparison of acromiocoracoid distance in right and left sided scapulae.

5. **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 4 depicts the comparison of acromioglenoid distance in right and left sided scapulae.

6. 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.

Table 1: Shape of acromion process in right and left sided scapulae

Shape of acromion process	Right (n=32)	Left (n=32)	p Value
Curved	16 (50%)	19 (59.38%)	0.615
Flat	14 (43.75%)	7 (21.88%)	0.110
Hook Shaped	2 (6.25%)	6 (18.75%)	0.256

Table 2: Parameters of acromion process

Parameters	Mean±SD (mm) Range= Min.-Max. (mm)		p Value
	Right (n=32)	Left (n=32)	
Maximum length	46.23±5.48 (29.32-56.07)	44.89±4.71 (35.66-53.35)	0.299
Maximum breadth	23.98±2.31 (19.62-28.21)	23.27±2.28 (18.70-28.60)	0.223

Table 3: Correlation of maximum length of acromion process with other parameters

Parameter	Maximum scapular width	Vertical diameter of glenoid cavity	Maximum scapular length	Maximum breadth of acromion process
Maximum length of acromion process (p<0.0001)	0.463 p<0.0001	0.504 p<0.0001	0.515 p<0.0001	0.479 p<0.0001

Table 4: Acromiocoracoid distance

Parameter	Mean±SD (mm) Range= Min.-Max. (mm)		p Value
	Right (n=32)	Left (n=32)	
Acromiocoracoid distance	38.48±4.03 (29.50-44.92)	35.51±3.83 (24.58-41.67)	0.004*

Table 5: Acromioglenoid distance

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

Table 6: Comparison of measurements of acromion process by various authors

Studies	Year	Maximum length (mm)		Maximum breadth (mm)	
		Right	Left	Right	Left
Collipal et al [15]	2010	69.12±3.5	63.15±7.1	25.12±1.8	24.12±2.9
Mansur et al [27]	2012	46.46±5	45.57±5.21	26.63±3.55	27.23±3.06
Singh et al [12]	2013	46.4±5.2	45.8±5.3	23.2±2.6	23±2.4
Musa et al [24]	2014	45.99±5.90	45.72±6.62	23.36±2.99	22.68±2.84
Naidoo et al [28]	2015	43.68±7.9	41.37±7.8	___	___
El Din et al [16]	2015	52.33±4.19	53.28±4.11	32.09±3.21	32.01±3.69
Gosavi et al [10]	2015	44.3±5.89	43.1±6.11	23.08±2.74	22.48±2.82
Saha et al [11]	2017	41±6.6		21.8±2.93	
Nweke et al [9]	2017	46.2±5.57	43.39±5.49	24.15±2.36	23.69±2.59
Present study		46.23±5.48	44.89±4.71	23.98±2.31	23.27±2.28

Table 7: Comparison of morphological variations of acromion process by various authors

Studies	Year		Type1 (Flat)	Type2 (Curved)	Type3 (hooked)
Edelson et al [29]	1992	Both sides	22%	62%	16%
Gallino et al [30]	1998	Both sides	20.6%	72.5%	6.9%
Sangiampong et al [31]	2007	Right	3.8%	91.1%	5.1%
		Left	2.7%	96.0%	1.3%
El din et al [16]	2013	Right	25%	61.25%	13.75%
		Left	28.75%	55%	16.25%
Singh et al [12]	2013	Both sides	22.5%	38.8%	38.8%
Schetino et al [7]	2013	Both sides	5.20%	57.9%	36.9%
Musa et al [24]	2014	Right	36.9%	47.9%	15.06%
		Left	38.3%	49.3%	12.32%
Akram et al [32]	2014	Both sides	13.4%	45%	41.6%
Gosavi et al [10]	2015	Right	7.69%	88.46%	3.84%
		Left	17.33%	77.33%	5.33%
Pawar et al [13]	2016	Right	46.15%	48.07%	5.76%
		Left	35.84%	49.05%	15.09%
Nweke et al [9]	2017	Right	6.73%	77.89%	15.38%
		Left	7.27%	84.55%	8.18%
Present study		Right	43.75%	50%	6.25%
		Left	21.88%	59.38%	18.75%

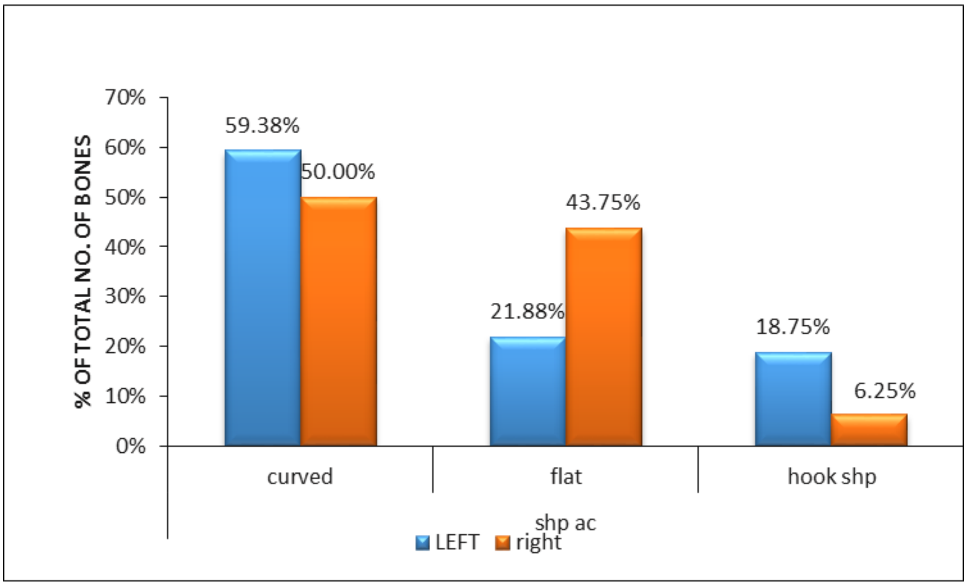
Table 8: Comparison of the acromiocoracoid (ACD) and acromioglenoid (AGD) distances by various authors

Studies	Year		ACD distance (mm)	AGD distance (mm)
Gumina et al [33]	1999	Both sides	----	----
Schroeder et al [25]	2001	Both sides	----	----
Coskun et al [23]	2006	Both sides	17.8	-----
Paraskevas et al [34]	2008	Both sides	28.1	17.7
Collipal et al [15]	2010	Right	39.76±5.2	28.24±2.7
		Left	39.55±5.4	28.43±2.7
Mansur et al [27]	2012	Right	39.03±6.20	39.39±5.32
		Left	31.83±3.66	31.97±3.96
Singh et al [12]	2013	Right	37.1±5.5	26.6±4.4
		Left	37.9±5.2	27.6±3.6
Kavita et al [3]	2013	Right	-----	-----
		Left		
Rajan et al [35]	2014	Right	-----	-----
		Left	-----	-----
Musa et al [24]	2014	Both sides	15.48	
El din et al [16]	2015	Right	31.10±3.55	27.11±3.08
		Left	31.58±3.09	27.67±3.00
Gosavi et al [10]	2015	Both sides	26.9	22.68
Gupta et al [6]	2015	Right	31.8±4.3	25.3±2.9
		Left	30.3±5.5	24.3±4.9
Naidoo et al [28]		Right	25.63±4.3	20.96±3.2
		Left	24.24±4.4	20.88±4.5

	2015	Male	25.93±4.3	21.53±4.5
		Female	23.50±4.1	20.04±2.8
		Black	24.90±4.4	20.91±3.9
		White	25.87±5.7	21.14±4.0
Lingamdenne et al [36]	2016	Both sides	31.85±4.4	24.46±3.68
Nweke et al [9]	2017	Both sides	40.02±6.9	30.25±4.05
Saha et al [11]	2017	Both sides	28.43±5.3	26.21±3.3
Present study		Right	38.48±4.03	28.57±2.95
		Left	35.51±3.83	29.26±5.25

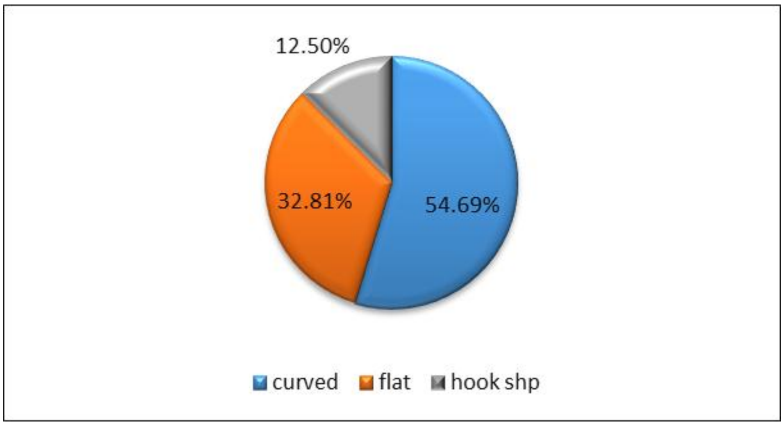
Bar Diagram-1

Shapes of Acromion Process

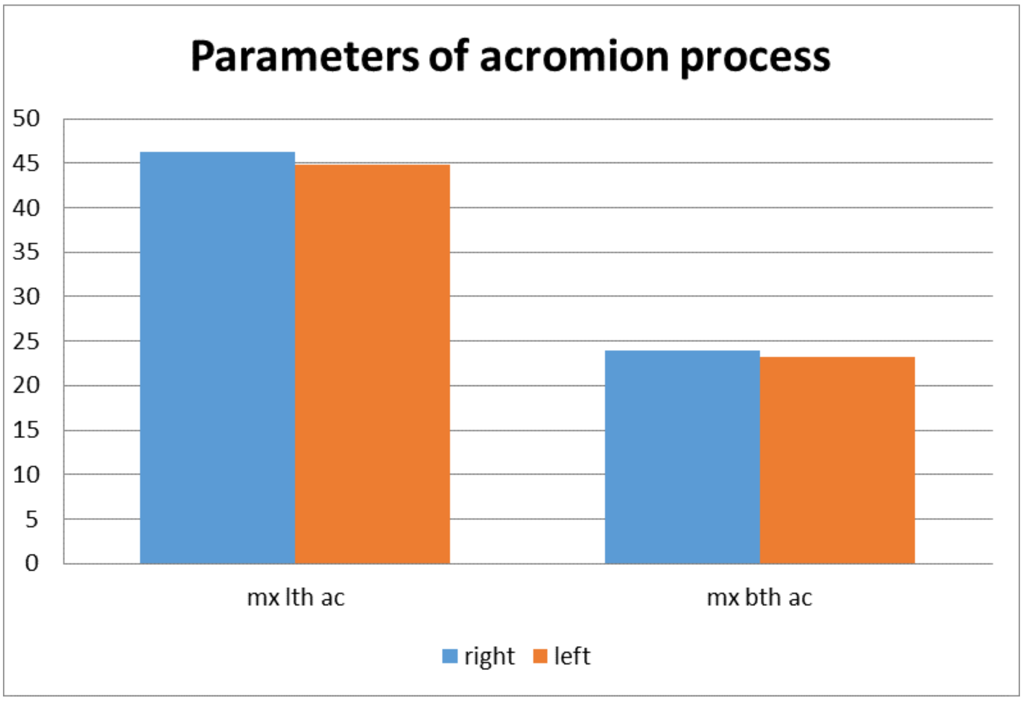


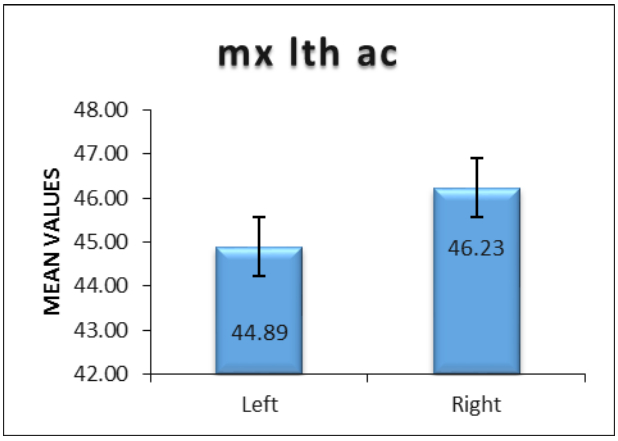
Pie Diagram-1

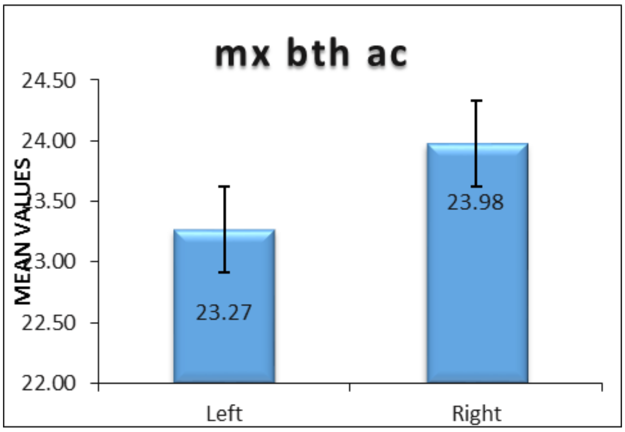
Shape of Acromion Process



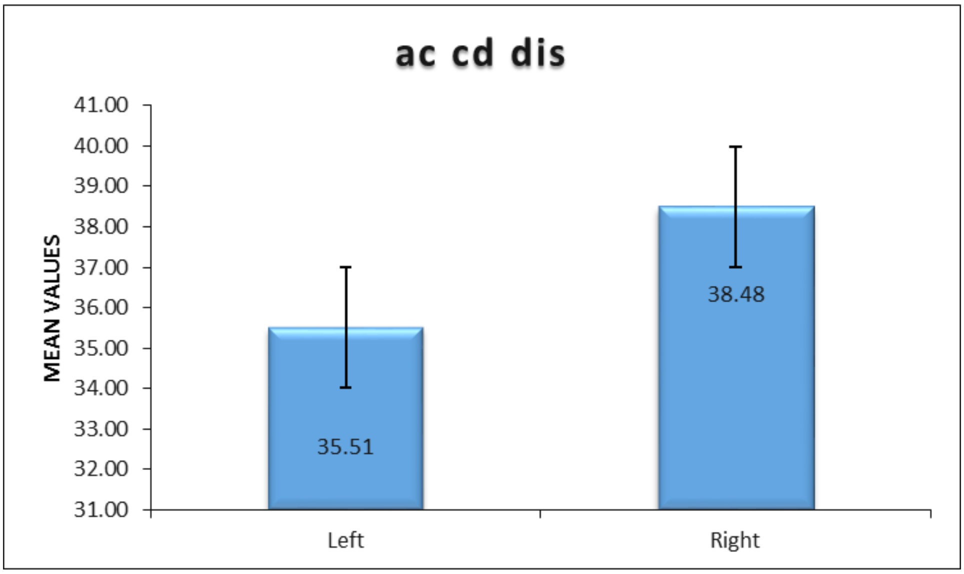
Bar Diagram-2



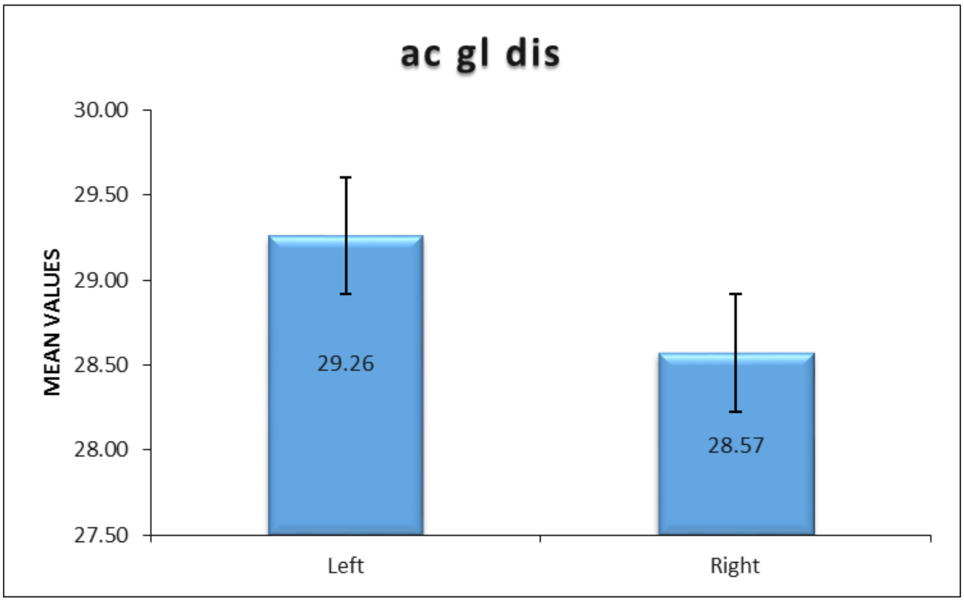




Bar Diagram-3 (Acromiocoracoid Distance)



Bar Diagram-4 (Acromioglenoid Distance)



4. 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 [13]. The morphometric analysis of scapular dimensions provides pertinent information for various surgical procedures involving fixation of scapular fractures, resection and reconstruction of scapula tumour and reestablishment the stability of glenohumeral joint [14].

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

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.

Table 6 depicts the dimensions of acromion process in populations across various countries.

It is evident that the dimensions of acromion process noted in the current investigations are distinctly at significant variance with the results of other studies [15]

[16]. Interestingly, the values of other authors do show some similarity with the observations of the present study.

It is a well-established fact that osteometric values are linked with genetic profile of the individual and is also subject to racial influence. Morphometric study of the acromion can be used as an auxiliary mean to facilitate knowledge about the disease in this area [11].

Distances of acromion process from palpable bony landmarks are relevant for placement of parts in the arthroscopic procedures of the shoulder joint [11].

Table 7 depicts the shapes of the acromion process observed by various authors. The current study revealed that morphological shapes of the acromion process were type 2 (curved), type 1 (flat) and type 3 (hook shaped) in order of descending frequency.

The knowledge of the data with reference to shape and various distances of acromion process is useful to orthopaedic surgeons while carrying out surgical repairs around shoulder joint. This information may also be of relevance to the anthropologists in elucidating the evolution of erect posture and bipedal gait [11].

It has been previously stated that the hook type of acromions are most often found in rotator cuff tears and have a tendency to cause impingement [8].

This was opposed by a study where it was concluded that hook shaped acromion process is not prone to develop rotator cuff tear [17].

Moreover it was argued that acromial morphology is acquired as a result of rotator cuff tear [18]. Therefore it was concluded that etiopathogenesis of rotator cuff tear continues to be debated. Further majority of rotator cuff tear are result of subacromial impingement and acromioplasty is based on that concept [19].

Nicholson et al [20] supported this view by reporting that acromial shape was independent of age and a primary anatomy characterstics and that anterior acromial spur formation is a age dependent process, a result other than cause of rotator cuff tear.

In yet another detailed study [21] on acromial morphology of patients with subacromial impingement and supraspinatous tendon tears. They concluded that a low lateral acromial angle and a large lateral extension of acromion are associated with a higher prevalence of impingement and rotator cuff tears. Dwivedi et al [22] performed a correlative study between Bigliani's acromion types and shoulder pathologies. They found in their study that the curved acromion was commonest. In their study – Patients with subacromial impingement were younger as compared to rotator cuff pathology group. This was anticipated as incidence of rotator cuff tear increases with age. A limitation in their study was that only one aspect of acromion morphology was studied i. e. Type.

In the present study, we have taken other morphometric measurements into consideration. With the help of the morphometric measurements, it is possible for orthopaedic surgeon operating on the shoulder to place the prosthesis accurately. Additionally, these parameters may assist in understanding the etiopathogenesis of rotator cuff tear and impingement syndrome.

Table 8 depicts the distances between the various landmarks of the scapula. These measurements were compared with the previous studies.

The values of acromiocoracoid distance recorded in the present study display significant variance from results of earlier studies [23] [24].

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 [25].

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 [25].

Coracoacromial distance constitutes a key factor for understanding etiology of shoulder pain [24]. Narrower gap increases the risk for occurrence of rotator cuff rupture [21].

Acromioglenoid distance is an important factor in the diagnosis of impingement syndrome. Shortening of acromioglenoid distance may predispose to impingement syndrome [26].

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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