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Morphologic and morphometric study of acromion process and glenoid cavity of scapula among north Indian population: A cross sectional study

Vibhash Kumar Vaidya[1], Akhil Sathyan[1], Swati Bang[2], AnandKumar Mishra[3*]

[1] Assistant professor, Department of Anatomy, Varun Arjun Medical College &Rhohilkhand Hospital, Banthara, Shahjahanpur, Uttar Pradesh- 242307

[2] Senior Resident, Department of Anatomy, ESIC Medical & Hospital, Faridabad, Haryana

[3] Assistant professor, Department of Anatomy, Maharshi Vashishtha Autonomous state Medical College, Basti, Uttar Pradesh- 272124

Corresponding author: Dr.Anand Kumar Mishra, Assistant professor, Department of Anatomy, Maharshi Vashishtha Autonomous state Medical College, Basti, Uttar Pradesh- 272124, Email id- dranandnishra87@gmail.com

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Abstract:

Background:The various shapes and dimensions of the acromion process and glenoid fossa is valuable for clinicians and orthopaedic specialists. This knowledge aids in addressing a range of medical and surgical issues related to the shoulder joint, such as osteoarthritis, subacromial impingement syndrome, joint instability, and osseous Bankart's lesion. Additionally, it assists in selecting the right size of prosthesis for shoulder arthroplasty, thus minimizing associated morbidity.

Aim: To observe the shape and to measure the various diameters of acromion process andglenoid fossa in adult dry human scapulae.

Materials and Methods: A cross-sectional observational study was conducted at the Department of Anatomy, Varun Arjun Medical College & Rohilkhand Hospital, Shahjahnpur, and Maharshi Vashishtha Autonomous State Medical College, Basti, Uttar Pradesh. A total of 104 dry, unpaired scapula bones were analyzed, comprising 54 from the right side and 50 from the left side. The study focused on examining various shapes of the acromion process and glenoid fossa. Measurements including the length and width of the acromial process and glenoid fossa, as well as the acromio-coracoid distance and acromio-glenoid distance, were taken using Vernier calipers and recorded in millimeters (mm).

Results:In this study, we explored three types of acromion process variations: Type 2 (curved) in 47 cases (45.2%), Type 3 (hooked) in 30 cases (28.8%), and Type 1 (flat) in 27

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cases (25.96%). We also categorized the shapes of the glenoid fossa: pear-shaped in 38 cases (36.54%), oval in 42 cases (40.4%), and inverted comma in 24 cases (23.1%). Mean measurements showed the breadth of the acromion process at 34.9 ± 5.03 mm on the right side and 35 ± 5.7 mm on the left side, with the Acromioglenoid distance recorded at 27.4 ± 4.3 mm on the right side and 28 ± 4.6 mm on the left side.

Conclusion:This study aims to outline key morphological features of the acromion process and glenoid fossa in the North Indian population, crucial for shoulder stability and formation. Understanding these structures, including variations, can assist orthopedic surgeons in precise interventions and prosthetic selection for shoulder surgeries, improving surgical outcomes and enhancing anatomical knowledge of the glenohumeral joint.

Key points: Acromion, Glenoid, Gleno-humeral joint, Humerus, Morphometry, Shoulder, Scapula

Introduction:

The scapula, also known as the shoulder blade, is a paired bone forming part of the shoulder girdle. Positioned posterior-laterally against the chest wall, it spans from the second to the seventh rib. The scapula features three angles (medial, lateral, and superior), along with three borders (medial, lateral, and superior). It consists of two surfaces, namely the anterior or costal surface and the posterior or dorsal surface. Notably, the scapula bears three prominent processes: the acromion, coracoid, and spinous processes. The lateral angle of the scapula is truncated and contains the glenoid fossa, facing forward, laterally, and slightly upward. [1]

The shape of the acromion process holds significance due to its connection to conditions affecting the pectoral girdle. Variations in acromial morphology, predominantly concerning its shape and tilt, are thoroughly examined for potential pathology [2]. Consequently, these variations are categorized into three types: type I, characterized by a flat shape; type II, exhibiting a curved structure; and type III, displaying a hooked form. While type I is the most prevalent, types II and III are deemed pivotal in the onset of subacromial impingement syndrome [3, 4].Meanwhile, the morphological variability of the glenoid cavity is notable, characterized by a notch in its upper and anterior portions. This glenoid notch influences the shape of the glenoid cavity, resulting in variations such as pear-shaped, oval, or inverted comma-shaped [5, 6].

The glenoid fossa, located on the lateral border of the scapula, has two important bony landmarks: the supra-glenoid tubercle at its upper margin and the infra-glenoid tubercle at its lower margin. The supra-glenoid tubercle is situated within the shoulder joint capsule, while

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the infra-glenoid tubercle is outside of it. This fossa forms the gleno-humeral joint with the head of the humerus. Although the articular surface of the glenoid fossa is smaller and concave compared to the convex surface of the humeral head, they are covered with cartilage. However, their congruence varies in different joint movements, leading to a loosely packed joint, except possibly in abduction and lateral rotation [1, 6]. The shoulder joint is prone to dislocation, with stability influenced by the dynamic action of rotator cuff muscles and the static support of ligaments, labrum, and joint capsule. Misalignment between the humerus and glenoid surfaces can predispose to instability and, consequently, rotator cuff pathologies [7, 8].Dislocations can sometimes coincide with fractures of the glenoid cavity [9]. When managing such cases, prostheses and arthroplasty become necessary. Understanding the typical anatomical features and potential variations in the shape and size of the glenoid cavity is crucial for grasping the mechanics of the shoulder joint fully.

Understanding the various shapes and dimensions of the acromion process and glenoid fossa is valuable for clinicians and orthopaedic specialists. This knowledge aids in addressing a range of medical and surgical issues related to the shoulder joint, such as osteoarthritis, subacromial impingement syndrome, joint instability, and osseous Bankart's lesion. Additionally, it assists in selecting the right size of prosthesis for shoulder arthroplasty, thus minimizing associated morbidity.

Among northern region of India, research on the combined study of the acromion process and glenoid fossa is limited. Therefore, this study was undertaken to examine the shapes of the acromion process and glenoid fossa, as well as to measure the different diameters of the glenoid fossa in adult dry human scapulae.

Materials and methods:

An observational cross-sectional study was carried out at Department of Anatomy,Varun Arjun medical college &Rohilkhand hospital, Shahjahnpur, and Maharshi Vashishtha Autonomous state medical college, basti, U.P. Spanning from January to April 2024. A total of 104 dry, unpaired scapula bones were examined, with 54 originating from the right side and 50 from the left side. These bones were sourced from adult specimens, though their specific genders and ages were undisclosed. The study focused on dry, intact scapulae possessing typical anatomical characteristics. Specimens displaying osteoarthritic alterations, signs of past trauma, or skeletal disorders were excluded from the investigation.

Using convenient sampling and referencing Singh A et al. [10], the minimum sample size was determined. The sampling formula utilized was $N=z^2\alpha\times p\times q/L^2$, where N represents the

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sample size, p denotes the percentage, q=1-p, the type I error α=5%, and the permissible error L=15% of p. Consequently, the estimated sample size derived was 104.

Study Procedure:

The specimens were anonymised, randomly coded and delinked from any identity sources (ICMR National guidelines for biomedical and health research involving human participants, ICMR, 2017, sec 5, Box 5.2) [11].Various morphometric parameters of acromion process and Glenoid fossa, as illustrated in [Table/Fig-1], and several bony distances. These measurements were conducted using a digital verniercaliper and are presented in millimeters (mm) in [Table/Fig-2A, B, C, D]

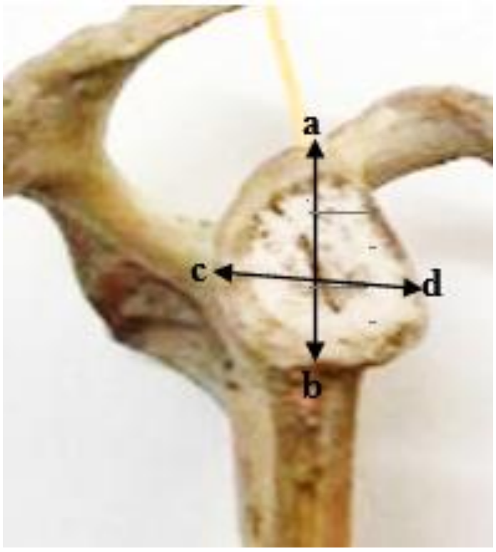
According to Bigliani et al. [12], the acromion process exhibits morphological diversity, categorized into three types: flat (type 1), curved (type 2), and hooked (type 3). Meanwhile, the shapes of the glenoid fossa, as outlined by Schrmpf M et al. [13], were classified into three groups based on the presence or absence of a notch on the anterior margin:

a) Oval shape: characterized by the absence of a notch.
b) Pear shape: featuring the presence of an indistinct notch.
c) Inverted comma shape: marked by the presence of a distinct notch.

Parameters	Dimension of various bony landmarks
Length of acromion process	Maximum distance between the tip and the posterior border of acromion process
Breadth of acromion process	Maximum distance between the medial and lateral borders at the midpoint of acromion process
Acromiocoracoid distance	Distance between the tip of acromion process and tip of coracoid process
Acromioglenoid distance	Space between tip of acromion process and the supraglenoid tubercle
Superior- Inferior Glenoid Diameter	maximum distance from the inferior point on the glenoid margin to the most prominent point of the supra-glenoid tubercle
Anterior-Posterior Glenoid Diameter	maximum breadth of the articular margin of the glenoid cavity perpendicular to the glenoid cavity height

[Table/Fig-1]: Morphometric parameters measured for the acromion process and glenoid fossa [4, 14].

[Table/Fig-2]:**A**. Exhibits the length of acromion process, **B**. Breadth of acromion process, **C.** Acromiocoracoid distance, **D.** Acromioglenoid distance.



[Table/Fig-3]:Measurement of the Superior- Inferior Glenoid Diameter (a-b) and Anterior-Posterior (AP) Glenoid Diameter (c-d)

[Table/Fig-4]: Morphological classification of glenoid fossa according to Schrmpf M et al. [13]**a**. Oval shape, **b**. Pear shape, **c**. Inverted comma shape

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Statistical analysis:

Each measurement was conducted thrice by a single researcher. The collected data was then organized and analyzed using SPSS version 22.0. Mean, minimum, and maximum values for all parameters were calculated along with their standard deviations. Subsequently, the values obtained from the right and left sides were subjected to an unpaired t-test for comparison. A p-value of ≤ 0.05 was deemed statistically significant.

Results:

In this present observational study, we investigated three variations of the acromion process. Type 2, characterized as curved, were identified in more common 47 cases (45.2%), while type 3, featuring a hooked formation, was present in 30 cases (28.8%) and type 1, exhibiting a flat structure, was observed in 27 cases (25.96%). Additionally, the shapes of the glenoid fossa classified on the basis of presence or absence of the glenoid notch. The most prevalent shape observed was pear-shaped, accounting for 38 cases (36.54%). Following this, the oval shape was noted in 42 cases (40.4%), while the inverted comma shape was identified in 24 cases (23.1%), the morphological variability has been described in [Table/Fig-5, 6] as graphical representation as well as photographic images has been displayed in [Table/Fig-4].

Types of Acromion process	Right N (%)	Left N (%)	Total N (%)
Type 1 (Flat)	10 (9.6%)	17 (16.3%)	27 (25.96%)
Type 2 (curved)	25 (24.04%)	22 (21.2%)	47 (45.2%)
Type 3 (hooked)	18 (17.3%)	12 (11.6%)	30 (28.8%)

[Table/Fig-5]:Various types of Acromion process

Shapes of Glenoid fossa	Right N (%)	Left N (%)	Total N (%)
Oval	19 (18.24%)	23 (22.12%)	42 (40.4%)
Pear	21 (20.2%)	17 (16.35%)	38 (36.54%)
Inverted comma	11 (10.6%)	13 (12.5%)	24 (23.1%)

[Table/Fig-6]:Various shapes of glenoid fossa

The mean measurements for the parameters were as the breadth of the acromion process measured at 34.9 ± 5.03 mm on the right side and 35 ± 5.7 mm on the left side. Similarly, the Acromioglenoid distance was recorded as 27.4 ± 4.3 mm on the right side and 28 ± 4.6 mm on the left side. These findings indicate statistically significant differences. Comprehensive

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descriptive analyses for all parameters, including diameters of the acromion process and glenoid fossa, as well as distances of Acromiocoracoid and Acromioglenoid, have been presented in [Table/Fig-7], along with corresponding p-values.

Parameters	Right		Left		p- value
	Range (in mm)	Mean ± SD (in mm)	Range (in mm)	Mean ± SD (in mm)	
Length of acromion process	14.4- 52.1	37.4 ±6.02	15.1- 51.4	38.8 ± 5.8	0.8
Breadth of acromion process	18- 31.06	24.8 ± 2.7	20- 32.1	25.6 ± 2.5	0.002*
Acromiocoracoid distance	24.1- 48.5	34.9± 5.03	23.8- 48.8	35± 5.7	0.4
Acromioglenoid distance	17.7- 35.9	27.4 ± 4.3	18- 36	28 ± 4.6	0.001*
Superior- Inferior Glenoid Diameter	27.1 – 44.2	35.5 ± 3.4	27.03- 43.9	34.6 ± 3.2	0.04*
Anterior-Posterior Glenoid Diameter	19.1- 30.1	23.5 ± 2.2	18.8- 30.5	24.1 ± 2.7	0.0002*

[Table/Fig-7]:The range and mean dimension with standard deviation of length, breadth of acromion process, Acromiocoracoid&Acromioglenoid distances and Superior- Inferior & Anterior-Posterior Glenoid Diameters (in mm) on both sides; Paired student's t-test, *level of significant p-value <0.05.

Discussion:

Scapular morphology exhibits frequent variability, which underscores the significance of its measurements in diagnosing shoulder girdle pathologies. The diversity in shoulder anatomy among individuals, along with factors like overall fitness, conditioning, and varying degrees of shoulder laxity, complicates the precise assessment of pathological conditions. Consequently, the development of shoulder implants involves meticulous consideration of anthropometric measurements of the scapula, aiming to address various shoulder joint disorders effectively [7, 15].

Acromian process of Scapula: The acromion process of the scapula plays a crucial role in shaping and stabilizing the shoulder joint. Various factors, including genetics and acquired conditions, influence the shape of the acromion. Aging is the primary acquired factor, often

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leading to changes from a flat to a curved or hooked acromion. However, differences in acromial shape can also be attributed to ethnic variations, reflecting inherent anatomical differences within demographic groups [3, 12]. In the present study average acromion length and width were determined to be (37.4 ± 6.02 mm on the right side & 38.8 ± 5.8 mm left side)and (24.8 ± 2.7 mm on right side & 25.6 ± 2.5 mm left side) respectively. Anetzbergeret al. observed mean acromial length as 47.00 mm. In a separate investigation, Singh et al. [2] presented average measurements for acromion length and width, recording 46.1 mm and 23.2 mm respectively, which closely align with the findings of this current study. Additionally, similar research conducted by Coskun et al. [17] documented acromion dimensions, with a length of 44.7 mm and a width of 32.0 mm.

In the classification by Bigliani et al. [12], three primary types of acromial morphology are identified: type I (flat), type II (curved), and type III (hooked). In present study, we observed that type I (flat) occurred in 25.96%, type II (curved) in 45.2%, and type III (hooked) in 28.8% of cases. Singh et al. [1] found type I (flat) in 22.5%, type II (curved) in 38.8%, and type III (hooked) in 38.8% in their research. According to Coskun et al. [17], type I (flat) was present in 10%, type II (curved) in 73%, and type III (hooked) in 17%. It is widely acknowledged that rotator cuff lesions are primarily associated with type III (hooked) acromion morphology.

Glenoid fossa: The predominant shape of the glenoid fossa commonly noted was pear-shaped, with oval and inverted comma shapes also observed bilaterally. Several authors, including Mamatha T et al.[18], Rajput HB et al. [19], Akhtar MJ et al. [20], , and Sinha P et al. [21], consistently reported the pear-shaped glenoid cavity as the most prevalent. They observed a recurring pattern of pear, inverted comma, and oval shapes. The Comparison of various shapes of glenoid fossa is displayed in [Table/Fig-8].

SN	Author (Year)	Sample size	Oval		Pear		Inverted comma	
			Right	Left	Right	Left	Right	Left
1	Mamatha T et al. [18] (2011)	202	20%	24%	46%	43%	34%	33%
2	Rajput HB et al. [19] (2012)	100	16%	15%	49 %	46 %	35%	39%
3	Akhtar MJ et al. [20] (2016)	228	13.5%	13.7%	51.6%	49%	34.9%	37.3%

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4	Sinha P et al. [21] (2016)	53	8%	13%	23%	42%	9%	6%
5	Present study	104	18.2%	22.1%	20.2%	16.4%	10.6%	12.5%

[Table/Fig-8]: Comparison of various shapes of glenoid fossa.

After obtaining measurements of the glenoid fossa, the data from this study were compared to findings from other researchers [Table/Fig-9]. In this investigation, the average superior-inferior (SI) diameter of the right glenoid was recorded as 35.5± 3.4mm, and for the left glenoid, it was 34.6 ± 3.2mm. The average anterior-posterior (AP) diameter of the right glenoid measured 23.5 ± 2.2mm, while for the left glenoid, it was 24.1 ± 2.7 mm. Notably, the left glenoid was observed to be narrower than the right. When combining data from both sides, the average diameter was calculated as 23.2 ± 2.44 mm.[Table/Fig-9] shown the comparative analysis of SI and AP diameters of Glenoid fossa.

SN	Author (Year)	Sample size	SIG Diameter (mm)		APG Diameter (mm)	
1	Von Schroeder et al. [22] (2001)	30	36 ± 4		29 ± 3	
2	Frutos LR [23] (2002)	103	Male 36.08 ± 2	Female 31.2 ± 1.7	Male 26.3 ± 1.5	Female 22.3 ± 1.4
3	Ozer et al. [24] (2006)	186	Male 38.7 ±2.7	Female 33.8 ± 3.1	Male 27.3 ± 2.4	Female 22.7 ± 1.7
4	Coskun et al. [17] (2006)	90	36.3 ± 3		24.6 ± 2.5	
5	Karelse et al. [25] (2007)	40	35.9 ± 3.6		27.2 ± 3.0	
6	Mamatha et al. [18] (2011)	202	Right 33.7± 2.8	Left 33.9 ± 2.9	Right 23.4 ± 2	Left 23 ± 2.3
7	Rajput et al. [19] (2012)		Right 34.8 ± 3	Left 34.4 ± 3.2	Right 23.3 ± 3	Left 22.9 ± 2.8
8	Kavita et al. [26] (2013)	129	Right 35.2 ± 3	Left 34.7 ± 2.8	Right 25 ± 2.7	Left 24.9 ± 2.4
9	Yadav Y et al. [14] (2020)	66	Right 33.7± 3.3	Left 24.2 ± 2.6	Right 33.3 ± 2.8	Left 23 ± 2.3

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10	Present study	104	Right 35.5± 3.4	Left 34.6 ± 3.2	Right 23.5 ± 2.2	Left 24.1 ± 2.7

[Table/Fig-9]: Morphometric comparison of SI and AP diameters of Glenoid fossa

Conclusion:

The significance of the acromion process and glenoid fossa in shoulder joint stability and formation is paramount. This study aims to document the foundational morphological and morphometric characteristics of these structures within the North Indian population. Such data, including acromion process morphometrics and variations, can aid orthopedic surgeons in precise surgical interventions around the shoulder joint. The insights garnered from this research will enhance orthopedic understanding of the glenohumeral joint's anatomy, facilitating more informed surgical approaches and assisting in selecting appropriately sized prostheses for shoulder arthroplasty.

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