Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(2), 2697-2712 | ISSN:2251-6727

A Morphological and Morphometric Analysis of a Acromion Process on Dry Human Scapulae.

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KEYWORDS

Acromion process, Spino-glenoid notch, Coraco-acromion ligament, Lateral acromion angle, Critical shoulder angle.

ABSTRACT:

INTRODUCTION

The acromion is one of the most variable portions of the scapula. It is associated with a variety of shoulder disorders. The morphology, morphometric and angular parameters of the acromion process can be beneficial in the surgical resection of the acromion process. Medical professionals and researchers need to have a thorough understanding of the morphometry and morphology of the acromion process.

AIMS AND OBJECTIVES

The present study aimed to measure the morphometric and morphological characteristics of the acromion process in dried human scapulae.

MATERIALS AND METHODS

A cross-sectional study was conducted on 77 undamaged adult dry scapulae with complete acromion processes from the Department of Anatomy, National Institute of Medical Science and Research (India), after ethical approval (Letter No. IEC/P-842/2024). Morphological measurements were visually analyzed. Linear measurements were taken using a digital vernier caliper (0.01 mm accuracy) and averaged; angular measurements were obtained using Digimizer 6.4.7software.

RESULT

We have observed that in the morphological characteristics, the quadrangular shape of the acromion was more common (53.2%). Examination of the inferior surface revealed that the majority of acromion had a rough surface (88.3%). Osteophytes were present in 85.7% on the acromion. In subacromial shape, rhomboid configuration was predominant (81.8%), followed by triangular (13.0%) and trapezoid (5.2%) shapes. In acromion angle, the L-shaped acromion was the most

Journal of Chemical Health Risks
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JCHR (2026) 16(2), 2697-2712 | ISSN:2251-6727

common (67.5%), followed by the C-shaped (29.9%) and double-C type (2.6%). The mean length of the acromion process was 33.03 ± 9.91 mm, with a median value of 35.20 mm and an average range of 4.48–51.10 mm. The mean width of the was 22.26 ± 3.93 mm. The mean thickness of the acromion process measured at three different points (T1, T2, and T3) was 5.15 ± 1.52 mm, 5.34 ± 1.82 mm, and 5.35 ± 1.86 mm, respectively. The mean acromion-coracoid distance (LAC) was 37.64 ± 7.15 mm, while the mean acromion-glenoid distance (LAG) was 28.76 ± 4.77 mm. The mean height of the coracoacromial arch was 16.92 ± 6.61 mm. The mean distance of the Spino glenoid notch (XY) was 17.36 ± 3.31 mm. The mean distance from the acromion tip to point X (LAX) was 34.73 ± 5.78 mm, and the mean distance from the coracoid to point Y (LCY) was 43.86 ± 4.91 mm. With respect to angular parameters, the mean lateral acromial angle (LAA) was 68.77 ± 14.03°, and the mean critical shoulder angle (CSA) was 30.30 ± 11.05°. The mean acromial slope (AS) and acromion tilt (AT) were 33.87 ± 9.43° and 37.01 ± 7.75°, respectively.

CONCLUSION

The remarkably low prevalence of Type III hooked acromion (2.6%) distinguishes this cohort from populations exhibiting higher rates of this pathological variant. Morphometric measurements revealed that mean values generally fall below established clinical risk thresholds. Lateral acromial angle of 68.77° approached but remained above the 70° risk threshold, suggesting intermediate biomechanical characteristics. Multiple linear regression identified lateral acromial angle as the strongest independent predictor of critical shoulder angle ($\beta = 0.451$, $p < 0.001$), validating this parameter's central role in determining shoulder joint biomechanics and rotator cuff loading characteristics. Significant side-wise variations in measurements suggest functional adaptation to dominant limb usage patterns and underscore the importance of bilateral shoulder assessment in clinical evaluation.

INTRODUCTION

The scapula is a bone that forms the shoulder girdle. It lies on the posterolateral aspect of the chest wall over the second to the seventh rib.[38]. The acromion is one of the most variable portions of the scapula. [1,3] The acromion process forms the acromioclavicular (AC) joint with the distal clavicle. The AC joint is stabilized by the acromioclavicular and coracoacromial ligaments, which protect the shoulder from excessive movement and injury. [22] The coracoacromial ligament extends from the tip of the acromion to the coracoid process, forming a protective coracoacromial arch over the shoulder joint.[34] Based on the inferior view and inclination of the acromion, Acromion types are classified as Type I (flat inferior surface), Type II (curved inferior surface), and Type III (hooked inferior surface). [15,52] Based on magnetic resonance imaging fourth type of acromion, which features a convex inferior surface.[52] Morphological variation of Inferior surface of the acromion process (whether smooth or rough), and the presence of enthesophytes (pulling osteophytes in the region of attachment of ligaments and tendons)[6,13] From the coracoids process the *coracohumeral ligament* (LCH) expands nearby the plane of the capsule to the tuberosity between the supraspinatus and subscapularis tendons and continues to the tendinous insertion of the cuff. *The coracoacromial ligament* (CAL) extends from coracoids to the anterior acromion. Together with coracoids, the anterior acromion and the distal part of the clavicle it creates the coracoacromial arc under which the supraspinatus extends to reach its insertion at the greater tuberosity. The supraspinatus (SSP) tendon and the tendons of the subscapularis (SCL), infraspinatus (ISP), and teres minor (TM) insert into the underlying glenohumeral capsule near the greater tuberosity The acromion, along with the coracoacromial ligament and AC joint, helps stabilize the shoulder, providing structural support during various arm movements. It also limits the excessive upward displacement of the humeral head, which could lead to dislocations or soft tissue damage.[12] The subacromial space is defined by four different bony landmarks, viz. The supraglenoid notch, acromial angle, anterior tip of the inferior surface of acromion and coracoid processes (sperner, 1995; standring).[15]

MATERIAL AND METHOD:

Our research focuses on making a precise morphological and morphometric examination of the acromion process in order to investigate its anatomical dimensions. The approach considered an accurate measurement of the acromion process that essentially indicates crucial variations in form and their functional consequences within different populations. To achieve accurate measurements, we used vernier calipers, which are very accurate tools for measuring small distances. The calipers were placed directly on the surface of the acromion process so that the contact points were against the anatomical landmarks. To ensure a repetitive and consistent measurement process. Each diameter of the acromion was recorded with meticulous detail in millimeters, thus giving a standardized unit of measurement that allows comparison across different specimens. The use of millimeters as the unit is particularly important for maintaining precision in our analysis and ensuring that our findings can be effectively communicated in the broader context of morphometric research. The angles of the acromion process were measured using a photometric method in which the bone was place that the camera-to-bone distance was approximately 25cm for all the samples, and the measurement protocol also includes the orientation of the scapula. The photos taken with the rough angle for all the samples was 30º-35º.The angular parameter were measured by software digimizer 6.4.4. These measurements contributed to our knowledge of acromion morphology and may have implications for the clinical practice of shoulder surgery, where the knowledge of acromion dimensions is crucial to surgical planning. Our methodology ensures reliable data that can support additional investigations into the functional adaptation of the shoulder girdle.

RESULT

The present study evaluated the morphological and morphometric characteristics of the acromion process in 77 dry human scapulae. The results are presented under different subheadings according to the study objectives. Morphological characteristics were assessed by visual examination, while morphometric and angular parameters were evaluated using digital vernier calipers and photometric methods.

The morphological characteristics of the acromion process are summarized in **Table 1.** Among the 77 scapulae studied, the quadrangular shape of the acromion was more common (53.2%) compared to the triangular shape (46.8%).

Based on **Bigliani's classification**, Type II (curved) acromion was the most frequently observed type, accounting for 64.9% of specimens, followed by Type I (flat) in 32.5%. Type III (hooked) acromion was the least common, observed in only 2.6% of scapulae.

Examination of the inferior surface revealed that the majority of acromia had a rough surface (88.3%), while a smooth inferior surface was observed in 11.7% of specimens. Osteophytes were present in 85.7% of scapulae and absent in 14.3%.

With respect to subacromial shape, rhomboid configuration was predominant (81.8%), followed by triangular (13.0%) and trapezoid (5.2%) shapes. Regarding the acromion angle, the L-shaped acromion was the most common (67.5%), followed by the C-shaped (29.9%) and double-C type (2.6%).

Table 1. Morphological Characteristics of Acromion (n = 77)

Parameter	**Categories**	**Frequency (n)**	**Percentage (%)**
Shape	Triangular	36	46.8
	Quadrangular	41	53.2
Type	Type I (Flat)	25	32.5

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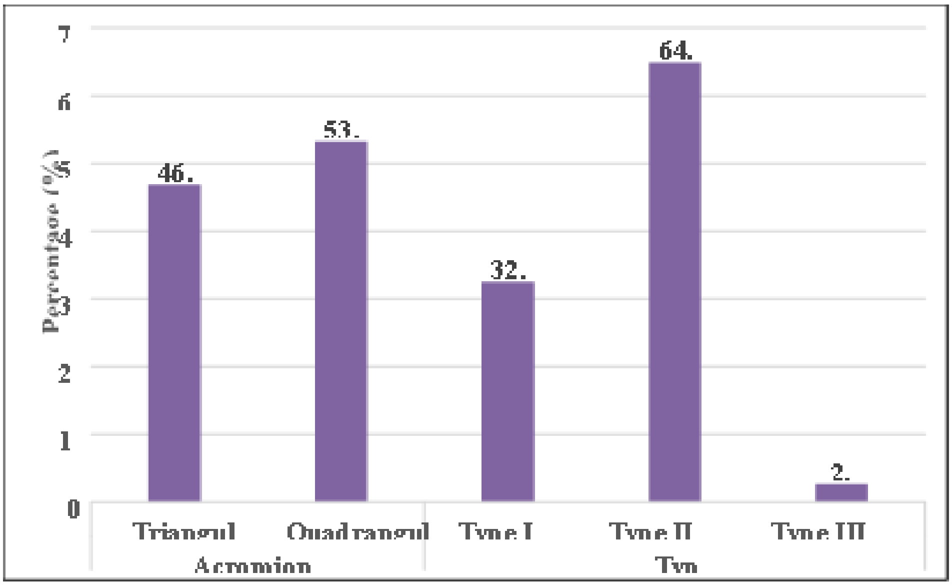
	Type II (Curved)	50	64.9
	Type III (Hooked)	2	2.6
Inferior Surface	Smooth	9	11.7
	Rough	68	88.3
Osteophytes	Present	66	85.7
	Absent	11	14.3
Subacromion Shape	Rhomboid	63	81.8
	Triangular	10	13.0
	Trapezoid	4	5.2
Acromion Angle	L-shape	52	67.5
	C-shape	23	29.9
	Double-C	2	2.6



Graph 1. Distribution of acromion shape & Type

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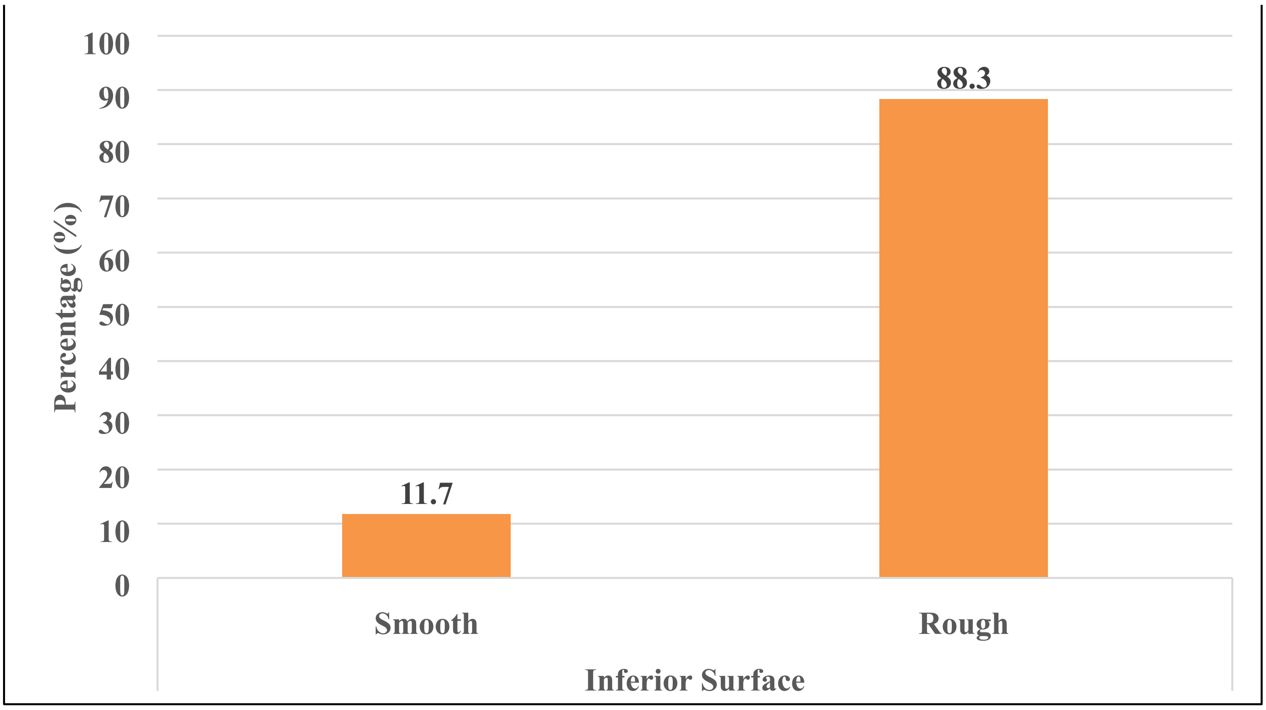
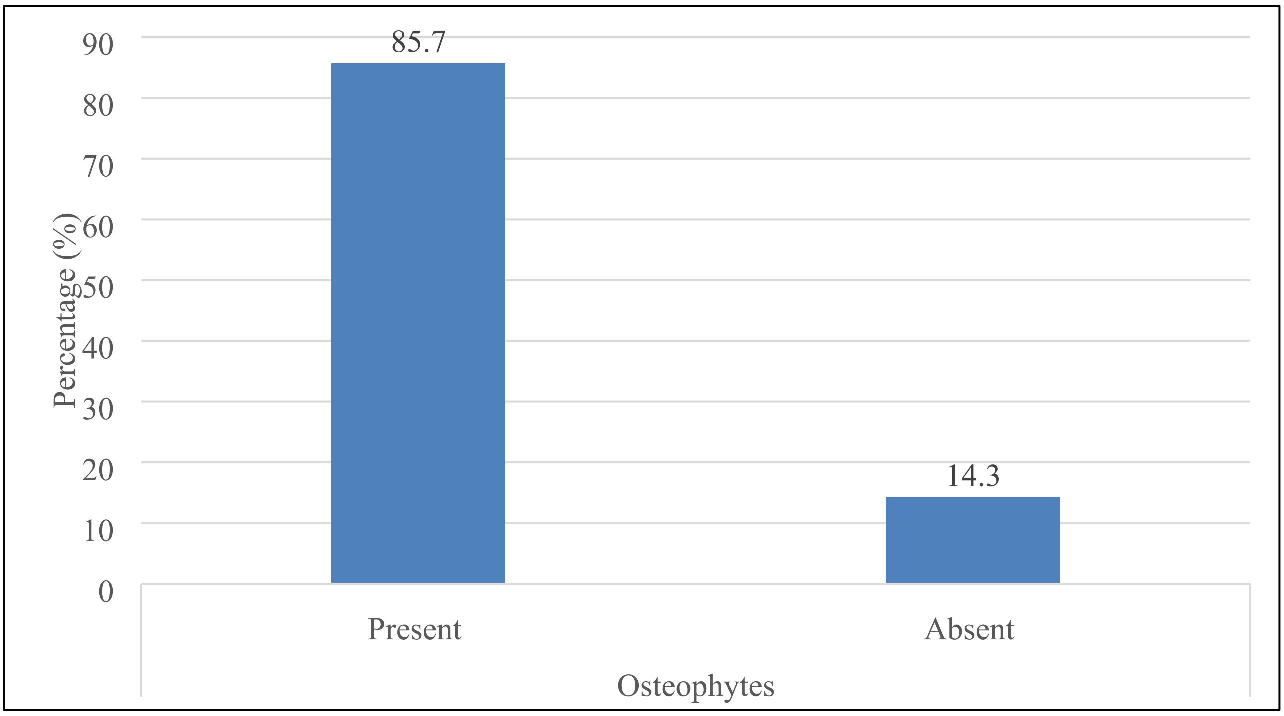


Graph 2. Distribution of acromion Inferior Surface



Graph 3. Distribution of acromion Osteophytes

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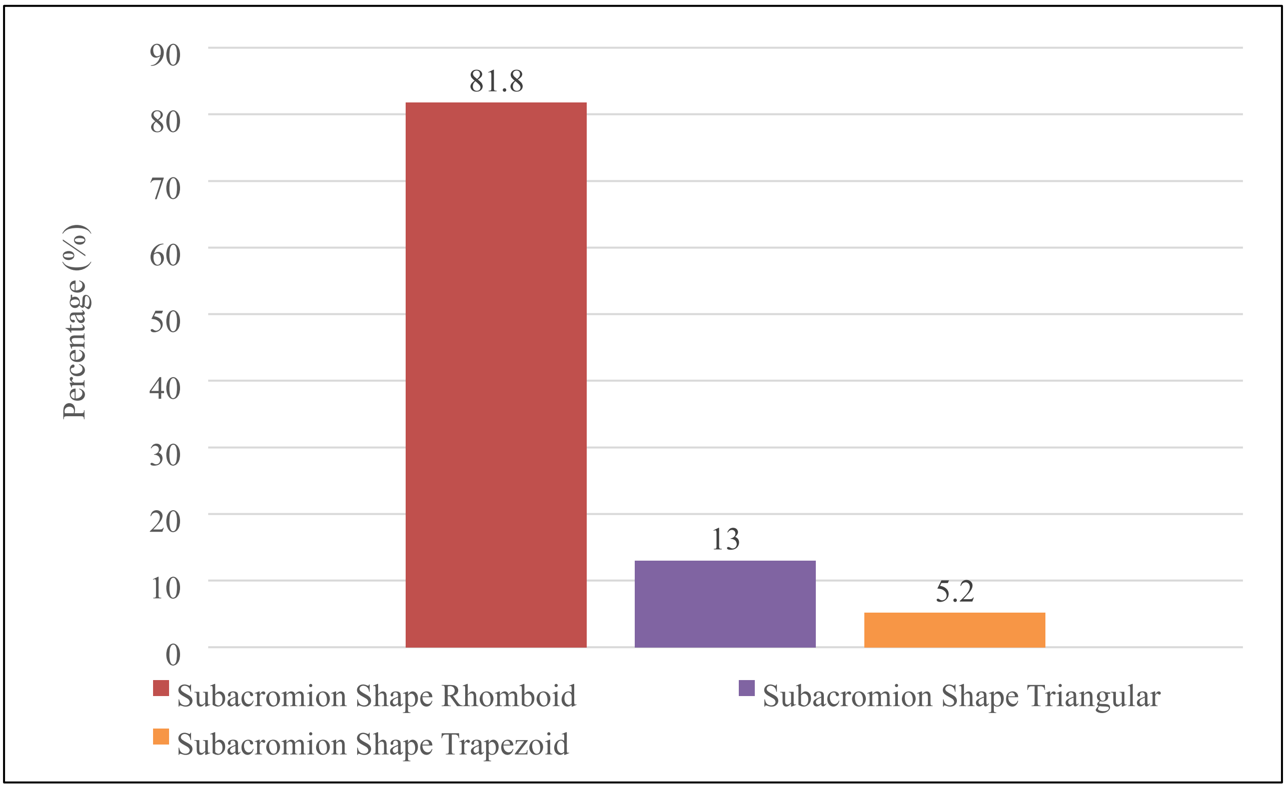
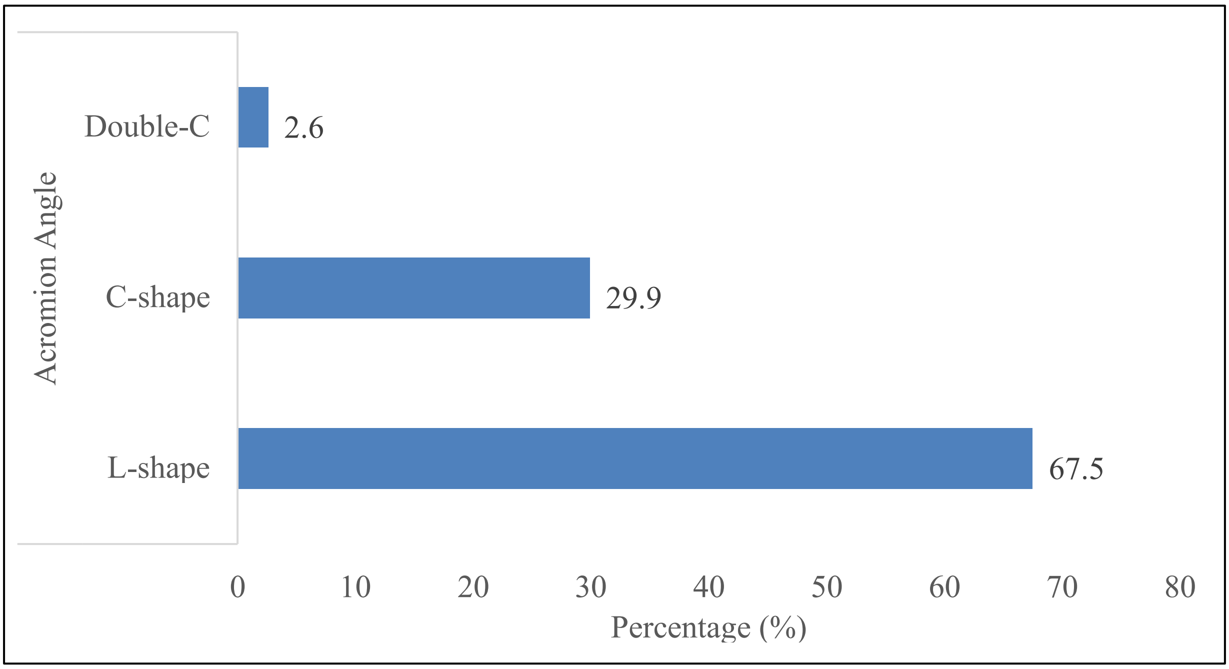


Graph 4. Distribution of Acromion Shape



Graph 5. Distribution of Acromion Angle

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Table 2. Comparison of the morphological characteristics of the acromion process between the right and **left sides (n = 77)**

	Category	Right (n=41)	Left (n=36)	Total (n=77)	χ^2 Value	pvalue
Shape	Triangular	16 (20.8%)	20 (26.0%)	36 (46.8%)	2.104	0.147
	Quadrangular	25 (32.5%)	16 (20.8%)	41 (53.2%)		
Type	Type I (Flat)	16 (20.8%)	9 (11.7%)	25 (32.5%)	3.651	0.161
	Type II (Curved)	25 (32.5%)	25 (32.5%)	50 (64.9%)		
	Type III (Hooked)	0 (0.0%)	2 (2.6%)	2 (2.6%)		
Inferior Surface	Smooth	7 (9.1%)	2 (2.6%)	9 (11.7%)	2.463	0.117
	Rough	34 (44.2%)	34 (44.2%)	68 (88.3%)		
Osteosphytes	Present	33 (42.9%)	33 (42.9%)	66 (85.7%)	4.293	0.117
	Absent	8 (10.4%)	3 (3.8%)	11 (14.3%)		
Subacromion Shape	Rhomboid	32 (41.6%)	31 (40.3%)	63 (81.8%)	4.309	0.116

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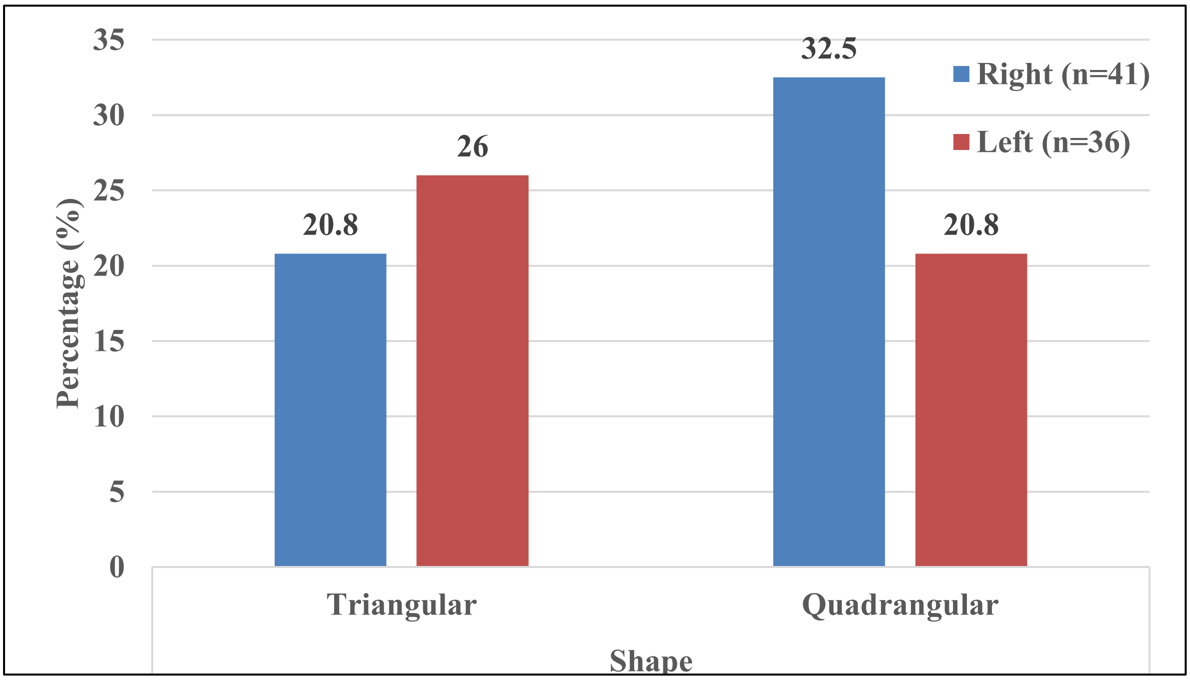
	Triangular	8 (10.4%)	2 (2.6%)	10 (13.0%)		
	Trapezoid	1 (1.3%)	3 (3.9%)	4 (5.2%)		
Acromion Angle	L-shape	31 (40.3%)	21 (27.3%)	52 (67.5%)	4.007	0.135
	C-shape	10 (13.0%)	13 (16.9%)	23 (29.9%)		
	Double-C	0 (0.0%)	2 (2.6%)	2 (2.6%)		

**Values are expressed as frequency and percentage. Chi-square test was applied for comparison between the right and left sides.*

** $p < 0.05$ was considered statistically significa*



Graph 6. Side-wise Distribution of Acromion Shapes

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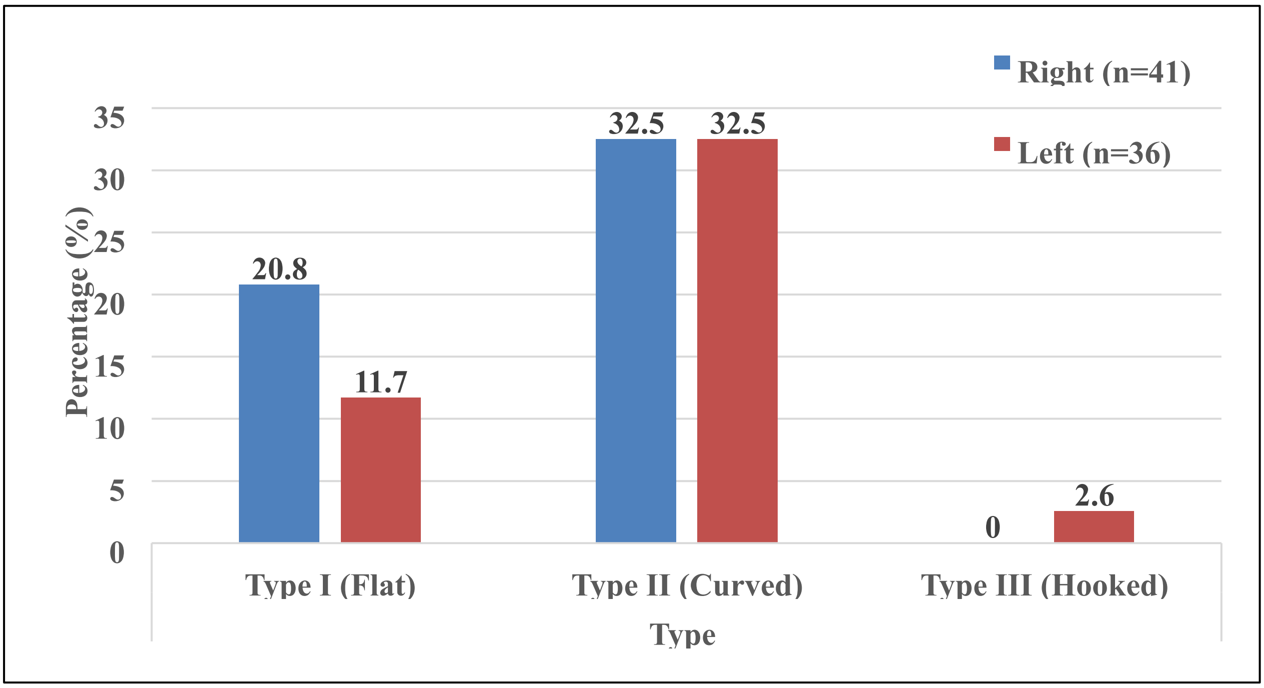
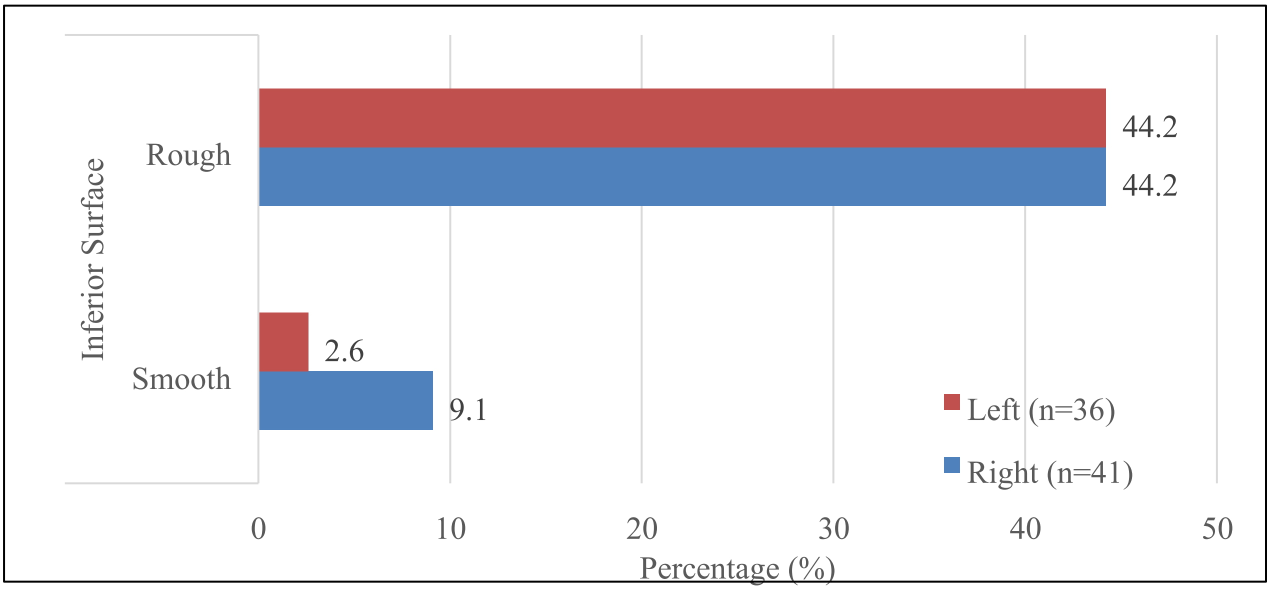


Graph 7. Side-wise distribution of types of Acromion angle



Graph 8. Side-wise Distribution of Inferior Surface Morphology of the Acromion Process

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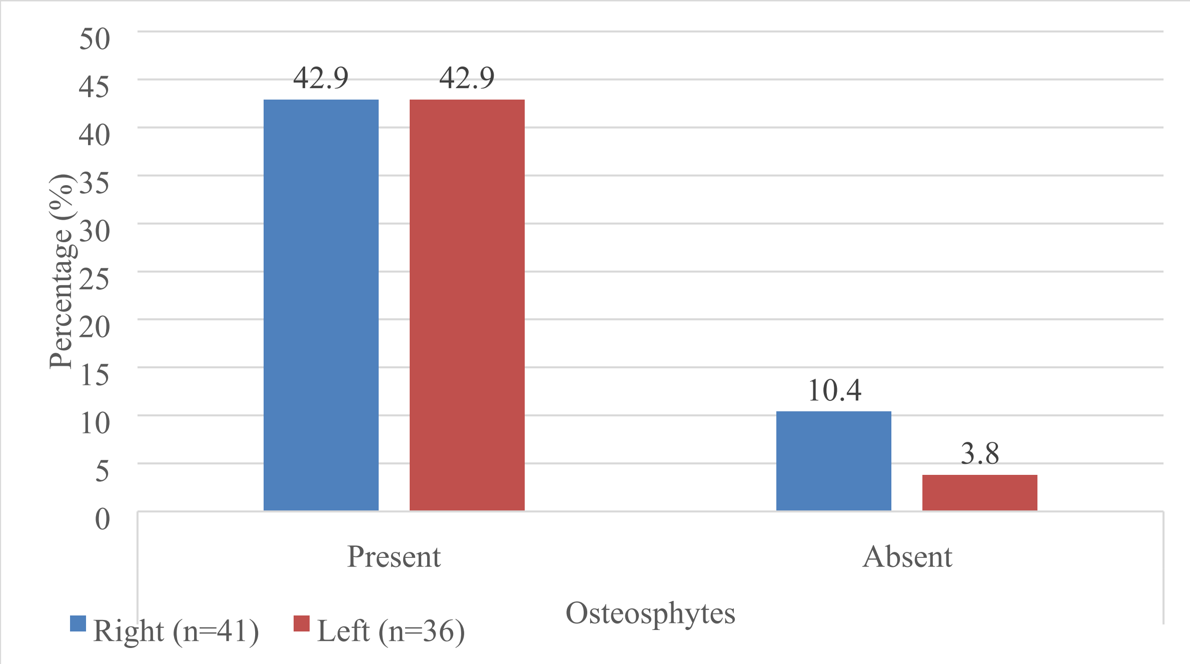
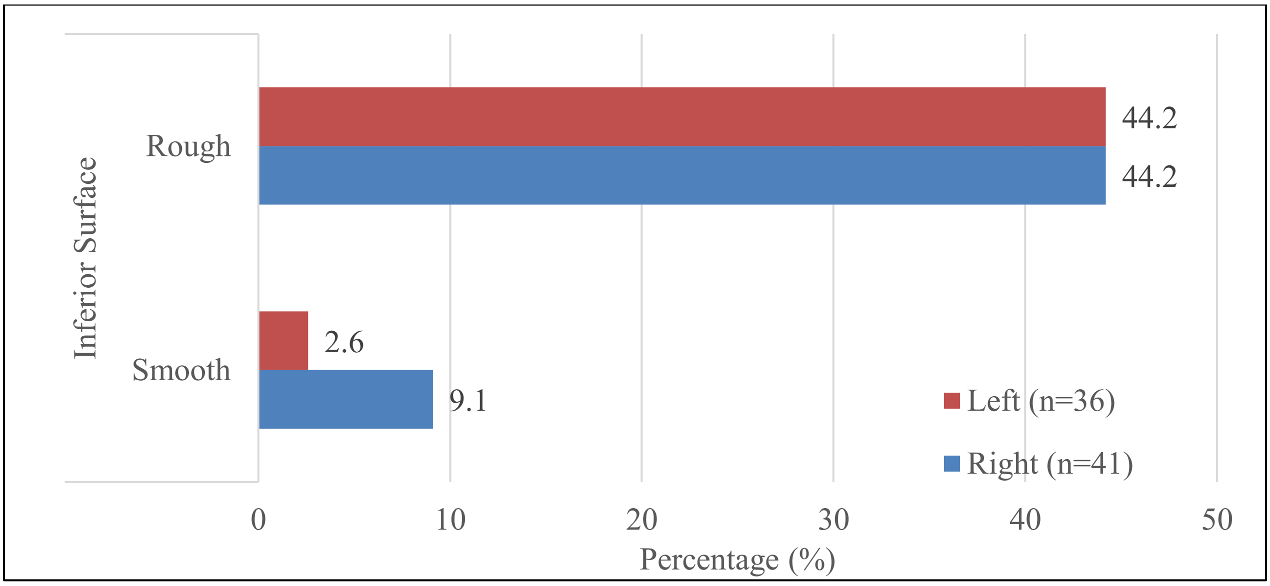
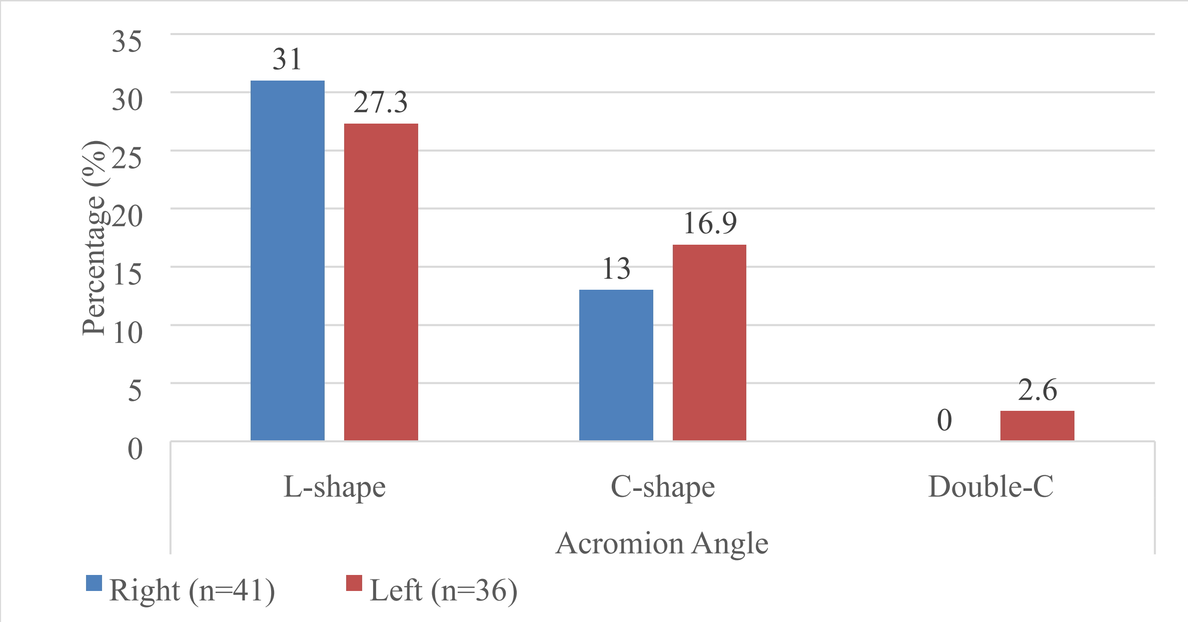


Graph 9. Side-wise Distribution of Osteophytes: Morphology of the Acromion Process



Graph 10. Side-wise Distribution of Sub acromion Shape Morphology of the Acromion Process



Graph 11. Side-wise Distribution of Acromion angle Morphology of the Acromion Process

Table 3. Descriptive statistics of morphometric and angular parameters of the acromion process (n = 77)

Parameter	Mean ± SD	Median	Range (Min–Max)
Length of acromion process (mm)	33.03 ± 9.91	35.20	4.48 – 51.10
Width of acromion process (mm)	22.26 ± 3.93	23.30	5.90 – 31.40
Thickness T1 (mm)	5.15 ± 1.52	5.20	2.50 – 9.20
Thickness T2 (mm)	5.34 ± 1.82	5.00	2.10 – 10.40
Thickness T3 (mm)	5.35 ± 1.86	5.20	2.00 – 10.00
LAC – Acromio–coracoid (mm)	37.64 ± 7.15	37.30	21.10 – 60.30
LAG – Acromio–glenoid (mm)	28.76 ± 4.77	29.00	20.40 – 50.30

HCA arch height (mm)	16.92 ± 6.61	18.20	1.00 – 28.20
XY – Spinoglenoid notch (mm)	17.36 ± 3.31	16.00	10.00 – 29.00
LAX – Acromion tip to X (mm)	34.73 ± 5.78	35.00	25.00 – 48.00
LCY – Coracoid to Y (mm)	43.86 ± 4.91	44.00	32.00 – 58.00
LAA – Lateral Acromial Angle (°)	68.77 ± 14.03	70.00	30.00 – 96.00
CSA – Critical Shoulder Angle (°)	30.30 ± 11.05	28.00	17.00 – 81.00
AS – Acromial Slope (°)	33.87 ± 9.43	33.00	15.00 – 61.00
AT – Acromion Tilt (°)	37.01 ± 7.75	36.00	24.00 – 56.00

Values are expressed as mean ± standard deviation, median, and range.

Table 4. Comparison of morphometric and angular parameters of the acromion between **right and left Acromion**

Parameter	**Right (Mean ± SD)**	**Left (Mean ± SD)**	**Test Used**	**p-value**
Length (mm)	33.03 ± 9.91	35.20 ± 9.90	Independent t-test	0.183
Width (mm)	22.26 ± 3.93	23.30 ± 3.93		0.278
Thickness T1 (mm)	5.15 ± 1.52	5.20 ± 1.52		0.660
Thickness T2 (mm)	5.34 ± 1.82	5.00 ± 1.86	Mann–Whitney U	0.025*
Thickness T3 (mm)	5.35 ± 1.86	5.20 ± 1.86		0.024*
LAC – Acromio–coracoid(mm)	37.64 ± 7.15	37.30 ± 7.15	Independent t-test	0.524
LAG – Acromio–glenoid (mm)	28.76 ± 4.77	29.00 ± 4.77	Mann–Whitney U	<0.001*

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HCA arch height (mm)	16.92 ± 6.61	18.20 ± 6.61		0.012*
XY – Spinoglenoid notch(mm)	17.36 ± 3.31	16.00 ± 3.31		0.012*
LAX – Acromion tip to X(mm)	34.73 ± 5.78	35.00 ± 5.78		0.031*
LCY – Coracoid to Y (mm)	43.86 ± 4.91	44.00 ± 4.91		0.041*
LAA – Lateral Acromial Angle (°)	68.77 ± 14.03	70.00 ± 14.03		<0.001*
CSA – Critical Shoulder Angle (°)	30.30 ± 11.05	28.00 ± 11.05		<0.001*
AS – Acromial Slope (°)	33.87 ± 9.43	33.00 ± 9.43	Independent t-test	0.422
AT – Acromion Tilt (°)	37.01 ± 7.75	36.00 ± 7.75		0.056

**Normality was assessed using the Shapiro–Wilk test. An independent t-test was applied for normally distributed variables, and a Mann–Whitney U test for non-normally distributed variables.*

** $p < 0.05$ statistically significant*

Table 5. Spearman's correlation between morphometric and angular parameters of the acromion process

Variables Compared		**Spearman's ρ (r)**	**p-value**	**Significance**
LAA	AS	−0.281	0.013	Significant*
CSA	LAA	0.034	0.771	Not significant
	AS	0.033	0.779	
	AT	0.104	0.369	
	LAC	−0.039	0.734	
	LAG	0.173	0.132	

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	HCA Arch	0.114	0.325	
AT	LAC	0.316	0.005	Significant
	LAG	0.313	0.006	
LAC	LAG	0.540	<0.001	Highly significant
LAG	HCA Arch	0.272	0.017	Significant

** Spearman's correlation coefficient (ρ) was used.*

**p < 0.05 = Significant ()*

**p < 0.01 = Significant ()*

**p < 0.001 = Highly significant*

Table 6A. Multiple Linear Regression Model Summary for Predictors of Critical Shoulder Angle (CSA)

Model	**R**	**R²**	**Adjusted R²**	**Std. Error of Estimate**	**Durbin–Watson**
1	0.517	0.267	0.205	9.851	0.956

ANOVA for the Multiple Linear Regression Model

Source	**Sum of Squares**	**df**	**Mean Square**	**F value**	**p-value**
Regression	2479.373	6	413.229	4.258	**0.001***
Residual	6792.757	70	97.039		
Total	9272.130	76			

* Statistically significant at $p < 0.05$

*Dependent Variable**:** Critical Shoulder Angle (CSA)

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Table 6B. Regression Coefficients for Predictors of Critical Shoulder Angle (CSA)

Variable	B	Std. Error	Standardized β	t value	p-value	VIF
Constant	56.558	12.632	-	4.477	<0.001*	-
LAC (Acromio–coracoid)	−0.390	0.188	−0.252	−2.072	0.042*	1.419
LAG (Acromio–glenoid)	0.258	0.282	0.111	0.913	0.364	1.422
HCA Arch Height	0.273	0.180	0.163	1.518	0.134	1.105
LAA (Lateral Acromial Angle)	−0.355	0.086	−0.451	−4.111	<0.001*	1.149
AS (Acromial Slope)	0.053	0.129	0.046	0.414	0.680	1.153
AT (Acromion Tilt)	−0.027	0.157	−0.019	−0.173	0.863	1.155

* *Dependent variable: Critical Shoulder Angle (CSA)*

* *Statistically significant at $p < 0.05$*

* *Multicollinearity was assessed using the Variance Inflation Factor (VIF); all VIF values were < 2, indicating the absence of multicollinearity.*

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DISCUSSION

A study of 77 dry human scapulae found quadrangular acromial shape (53.2%) and Type II curved morphology (64.9%) to be predominant, aligning with patterns in South Asian populations. The low prevalence of Type III hooked acromion (2.6%) distinguishes this cohort from others. Morphometric measurements revealed mean values below established clinical risk thresholds: acromial thickness (5.3 mm), critical shoulder angle (30.3°), and acromial slope (33.87°), indicating a relatively favorable morphometric profile for subacromial impingement syndrome and rotator cuff tear susceptibility.Lateral acromial angle (68.77°) approached the 70° risk threshold, suggesting intermediate biomechanical characteristics. Correlation analysis showed a negative relationship between lateral acromial angle and acromial slope ($r = -0.281$), indicating coordinated morphological variation affecting subacromial space dimensions. Regression analysis identified lateral acromial angle as the strongest predictor of critical shoulder angle ($\beta = 0.451$, $p < 0.001$).Significant side-wise variations in acromial thickness and angular parameters suggest functional adaptation to dominant limb usage, emphasizing bilateral shoulder assessment. The findings provide population-specific reference ranges for diagnostic imaging and surgical planning, and highlight the importance of individualized assessment for shoulder pathology risk stratification.