ORIGINAL ARTICLE

Morphological variations of acromion process in rotator cuff tear using magnetic resonance imaging

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Abstract

Background: The acromion is one of the markers on the posterior shoulder. The pathophysiology of Rotator Cuff Tear (RCT) seems to be related with the shape of the acromion, which is often evaluated by its characteristics. *Aims and Objectives:* To use magnetic resonance imaging to determine the morphological features of the acromion connected with RCT. When remedying patients with rotator cuff disease and shoulder impingement syndrome, orthopaedicians must have a thorough understanding of the structure and configuration of the acromion. To detect the RCT with respect to morphology and type of acromion. The objective was to know the incidence and type of RCT with respect to morphology and type of acromion. *Material and Methods:* This study, which involved 48 patients with RCT, either partial- or full-thickness, was conducted at JSS Medical College and Hospital. In our retrospective analysis, we examined the acromial type, Acromial Thickness (AT), Lateral Acromial Angle (LAA), Acromio-Humeral Distance (AHD), Critical Shoulder Angle (CSA), and Acromial Index (AI) in 48 cases of RCT. *Results:* The age of our participants ranged from 20 to 76 years, with mean of 40.40 years and standard deviation of 14.35 years, suggesting considerable variability in age across the study sample. AI varied between 0.11 and 0.84, with a mean of 0.58 and a standard deviation of 0.16. AT varied from 0.36 to 1.47, with a mean of 0.72 and a standard deviation of 0.19. LAA varied from 52.46 to 95.26 degrees, with a mean of 77.04 degrees and a standard deviation of 8.19 degrees. AHD varied from 0.34 to 1.24 cm, with a mean of 0.81 cm and a standard deviation of 0.18 cm. CSA varied from 10.73 to 42.82 degrees with a mean of 32.82 degrees and a standard deviation of 5.55 degrees. *Conclusion:* In our study, in the context of RCTs, there was no correlation between the three acromial shapes and sex, regardless of the muscle that was injured. However, we identified a significantly higher incidence of full-thickness supraspinatus tears in the right shoulders of men aged 40–60 years with type 2 acromia.

Key words: Shoulder, Acromion, Rotator cuff

Introduction

Shoulder impingement syndrome is the most prevalent cause of shoulder discomfort, accounting to 30-35% of shoulder pain [1]. The prevalence of rotator cuff illness is approximately 10% in those under 20 and 62% in those over 80, regardless of the disease's symptomatology. Whether mechanical compression by the acromion (extrinsic etiology/anatomic) or degenerative changes of the tendons (intrinsic etiology/genetics) causes Rotator Cuff Tears (RCTs) remains a subject of debate in the literature [1].

In 1972, Neer originally proposed the idea of impingement of the tendinous rotator cuff by the anterior side of the acromion and the Coraco-acromial (CA) ligament, with sporadic involvement of osteophyte growth and bone spurring. The simplicity and breadth of the diagnosis shown by the recent questioning of the phrase "shoulder impingement syndrome" may have an influence on the capacity of doctors and therapists to effectively communicate about its treatment. Therefore, this will serve to explain the anatomical foundation of the impingements of the internal shoulder, subcoracoid, and subacromial [2].

Both intrinsic and extrinsic explanations are considered to be responsible for subacromial impingement. Although some writers favor one explanation over the other, the disease is most likely the result of a combination of the two. Acromioclavicular (AC) joint, CA ligaments, and the restricted space between the humeral head and anterior acromion cause extrinsic compression of the rotator cuff [2].

In 1983, Neer reported anterior acromioplasty was an effective treatment for 95% of RCT caused by mechanical impingement [3]. As a result, acromioplasty is now the go-to surgical procedure for impingement lesions, with notable rise in occurrence observed recently. More precise extrinsic factor evaluation leads to improved patient care [3]. The morphological variations and morphometric characteristics of the acromion in various populations are analyzed by several authors worldwide. These features have been evidenced to modify the CA arch's architecture to varying degrees. Therefore, while treating patients with shoulder impingement syndrome and rotator cuff disease, orthopedicians must have a thorough understanding of the morphology and morphometry of the acromion [4].

Material and Methods

Forty-eight patients aged more than 20 years and clinically diagnosed with RCT, with either partial- or full-thickness tear of the supraspinatous tendon, within a two-year period were selected using a convenience sampling method at JSS Medical College and Hospital.The exclusion criteria included previous surgery, fractures, and/or dislocations, and shoulder infections or tumors. A Siemens 1.5-Tesla system was used to procure Magnetic Resonance Imaging (MRI) images of the participants while employing a specific shoulder array coil. The patients were placed in the supine position with their arms at their sides with the shoulder coil in order to obtain an MRI of the shoulder. First, localizer images were acquired, followed by axial, coronal, and sagittal oblique views. For best tendon visibility, the coronal oblique plane was chosen to run parallel to the supraspinatus tendon's path. The institutional medical research ethics committee granted formal authorization to conduct the study. All research subjects provided written informed consent. We examined acromial type (Bigliani classification) and Acromial Thickness (AT), which is defined as the largest region of the acromion in a plane perpendicular to the long axis of the acromion, for each patient (Figure 1) in a retrospective analysis of 48 cases.

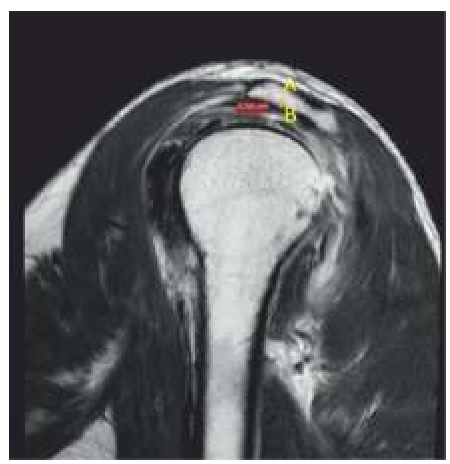

Figure 1: Acromial thickness (distance from A to B)

The shortest path between the line parallel to the inferior edge of the acromion and the line parallel to the superior portion of the humeral head is known as the Acromio-Humeral Distance (AHD) (Figure 2). The acromion-humeral interval depicts the volume under the surface of acromion. A decrease in acromion-humeral interval can be associated with impingement of shoulder and RCT.

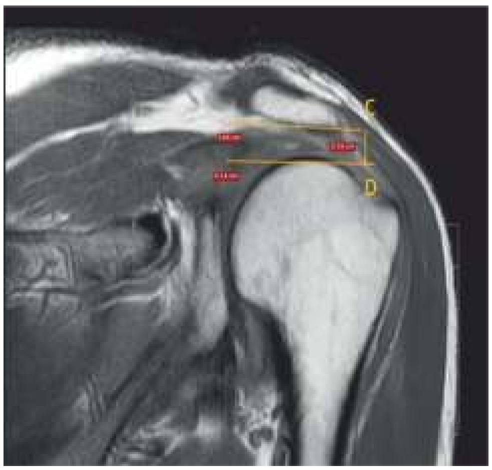

Figure 2: Acromio-humeral distance (distance from C to D)

An oblique coronal MRI slice taken immediately posterior to the acromioclavicular joint was used to assess Lateral Acromial Angle (LAA) (Fig. 3), which is defined as that between a line parallel to the acromion undersurface intersecting with another line parallel to the glenoid fossa intersected.

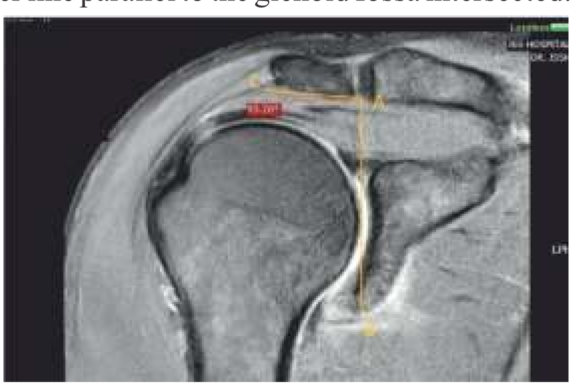

Figure 3: Lateral acromial angle (angle CAB)

Critical Shoulder Angle (CSA) is another criterion representing the lateral extension of acromion which is a combination of LAA and AI. Measurement of the CSA (Figure 4) was made by drawing a line parallel to the glenoid and a line passing from the inferior lateral edge of the glenoid to the inferior lateral edge of the acromion.

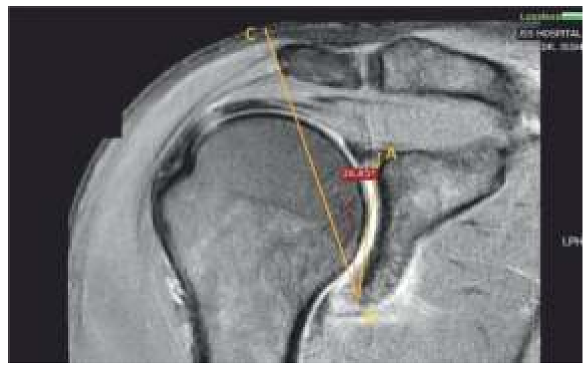

Figure 4: Critical shoulder angle (angle ABC)

The Acromion Index (AI) (Fig. 5) was estimated for each patient (with partial or full-thickness supraspinatus tendon tears) by dividing the distance from the osseous glenoid plane to the lateral border of the acromion by the distance from the osseous glenoid plane to the most lateral portion of the proximal humerus. It corresponds to a large lateral extension of acromion process over the humeral head.

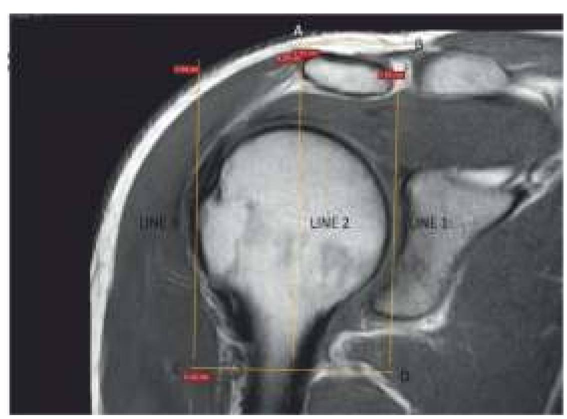

Figure 5: Acromion index (AB/CD)

Statistical methods: Frequency distribution and descriptive statistics were used to summarize the sociodemographic characteristics and acromial morphological parameters. Chi-square tests were performed to examine associations between categorical variables, while independent t-tests were applied to compare means between two groups. Pearson correlation analysis was conducted to explore relationships among continuous variables, with all significance levels set at $p < 0.05$. The statistical analysis was conducted using IBM Statistical Package for the Social Sciences 22.0 software.

Results

The study participants were predominantly males with age equal split between 20-39 years and 40-59 years and more prevalent full thickness rotator cuff tear.

Table 1 presents a comprehensive overview of frequency distribution across various parameters. In terms of sex, study participants were predominantly male 33 (69%), with women accounting for 15 (31%). The age distribution showed an equal split between the 20–39 years and 40–59 years categories, each accounting for 22 (46%) of the sample, with a smaller proportion aged 60–80 years at 4 (8%). In terms of affected side, the right side was more frequently involved 33 (77%) compared to the left side 11 (23%). In terms of diagnosis, full-thickness tear was slightly more prevalent at 26 (54%) compared to partial-thickness tear at 22 (46%). Lastly, the distribution of AC shape classifications showed that type 2 was the most common at 20 (42%), followed by type 1 at 15 (31%) and type 3 at 13 (27%).

Table 1: Frequency distribution for sociodemographic characteristics

Parameters		Frequency (n)	Percentage (%)
Sex	Female	15	31
	Male	33	69
Age (years)	20 - 39	22	46
	40 - 59	22	46
	60 - 80	4	8
Side	Left	11	23
	Right	37	77
Diagnosis	Full	26	54
	Partial	22	46
AC shape	type 1	15	31
	type 2	20	42
	type 3	13	27

AC: acromial

Descriptive statistics for acromial morphology parameters of the participants are given in Table 2. The participants' ages ranged from 20 to 76 years, with a mean of 40.40 years and a standard deviation of 14.35 years, suggesting considerable variability in age across the dataset. AI varied between 0.11 and 0.84, with a mean of 0.58 and a standard deviation of 0.16. AT, ranged from 0.36 to 1.47, with a mean of 0.72 and a standard deviation of 0.19. LAA ranged from 52.46 to 95.26 degrees, with a mean of 77.04 degrees and a standard deviation of 8.19 degrees. AHD varied from 0.34 to 1.24 cm, with a mean of 0.81 cm and a standard deviation of 0.18 cm. CSA ranged from 10.73 to 42.82 degrees, with a mean of 32.82 degrees and a standard deviation of 5.55 degrees.

Table 3 summarizes the association between acromion side and sex. The categories of sides are “Left” and “Right,” with the corresponding percentages of females and males. The chi-squared test revealed a significant association (χ^2=6.967, p=0.008) between acromion side and sex. This indicates a notable divergence in distribution, suggesting a potential directional bias in observation placement based on sex. Females were more prevalent on the left side 7 (15%), while males were predominant on the right side 29 (60%).

Table 2: Descriptive statistics for acromial morphologies

Parameters	Minimum	Maximum	Mean	Std. Deviation	95% confidence interval for mean	
					Lower bound	Upper bound
Age	20	76	40.4	14.34	36.23	44.56
AI	0.11	0.84	0.58	0.16	0.54	0.63
AT/cm	0.36	1.47	0.72	0.19	0.67	0.78
LAA/Degree	52.46	95.26	77.03	8.19	74.65	79.41
AHD/cm	0.34	1.24	0.81	0.18	0.76	0.86
CSA/degree	10.73	42.82	32.82	5.55	31.21	34.43

AI: Acromial index, AT: Acromial thickness, LAA: Lateral acromial angle, CSA: Critical shoulder angle, AHD: Acromio-humeral distance

Table 3: Association between acromion side and sex using Chi-squared test

Side	Sex			χ^2	p
	Female N (%)	Male N (%)	Total N (%)		
Left	7(15)	4(8)	11(23)	6.967	0.008
Right	8(17)	29(60)	37(77)		

Table 4 presents the cross tabulation of "Acromion Side" by "Age groups" and tests for any relationship between the two variables using the chi-squared test. The chi-squared test results indicate a Pearson chi-squared value of 0.525 with two degrees of freedom and a *p*-value of 0.769. As the *p*-value was significantly greater than the alpha value (0.05), the test showed no significant association between acromion side and age group. Thirty-seven (77%) participants had right-sided acromion, whereas only 11 (23%) had left-sided acromion.

As seen in Table 5, the chi-squared test results (χ^2=0.630, p=0.730) indicated no statistically significant association between "diagnosis" (full or partial) and "AC shape" (type 1, type 2, type 3). The majority of individuals with a full-thickness tear had AC shape type 2 11 (23%), as did those with a partial-thickness tear 9 (19%). However, the lack of any significant association suggests that diagnosis and AC shape were independent of each other in this sample of 48 individuals.

Table 6 provides a detailed breakdown of how diagnoses (full or partial) were distributed across sex (female and male). Based on chi-squared tests results (χ^2=0.494, p=0.482), there was no significant association between diagnosis (full or partial) and sex (female or male) in the studied sample (p>0.05). These findings implied that sex was not a significant factor influencing the type of diagnosis (full or partial) observed in the dataset.

Table 4: Association between acromion side and age group using Chi-squared test

Side	Age group (years)				χ^2	*p*
	20–39 N (%)	40–59 N (%)	60–80 N (%)	Total N (%)		
Left	4(8)	6(13)	1(2)	11(23)	0.525	0.769
Right	18(38)	16(33)	3(6)	37(77)		

Table 5: Association between diagnosis and AC shape, and its distribution using chi squared test

Diagnosis	AC shape				χ^2	*p*
	Type 1 N (%)	Type 2 N (%)	Type 3 N (%)	Total N (%)		
Full	7(15)	11(23)	8(17)	26(54)	0.630	0.730

AC: acromial

Table 6: Association between diagnosis and sex using Chi-squared test

Diagnosis	Sex			χ^2	*p*
	Female N (%)	Male N (%)	Total N (%)		
Full	7(15)	19(40)	26(54)	0.494	0.482
Partial	8(17)	14(29)	22(46)		

As seen in Table 7, the chi-squared test results showed that type of diagnosis (full or partial) did not appear to vary significantly across different age groups (20–39, 40–59, 60–80 years) in the analyzed sample. The findings suggested that age, as categorized in this study, did not influence whether an individual received a full or partial diagnosis. Twenty-six (54%) patients received a diagnosis of full thickness tear, whereas 22 (45%) received a diagnosis of partial thickness tear.

Table 8 presents a cross-tabulation of AC shape categories by sex. Among women, type 2 AC shape was the most prevalent (17%), followed by type 1 (10%) and type 3 (4%). In contrast, among males, type 2 AC shape was also most prevalent (25%) but with type 1 only slightly lower (21%) and type 3 closely trailing (23%). Overall, although there were differences in the distribution of AC shape categories between males and females, these differences were not statistically significant.

Table 7: Association between diagnosis and age group using Chi-squared test

Diagnosis	Age group (years)				χ^2	*p*
	20–39 N (%)	40–59 N (%)	60–80 N (%)	Total N (%)		
Full	11(23)	13(27)	2(4)	26(54)	0.397	0.82
Partial	11(23)	9(19)	2(4)	22(45)		

Table 8: Association between sex and acromial shape

Sex	AC shape				χ^2	*p*
	Type 1 N (%)	Type 2 N (%)	Type 3 N (%)	Total N (%)		
Female	5(10)	8(17)	2(4)	15(31)	2.266	0.322
Male	10(21)	12(25)	11(23)	33(69)		

AC: acromial

As seen in Table 9, there was a positive correlation between age and AT, ($r = 0.293$), indicating that as age increased, AT tended to increase. This correlation was significant at the 0.05 level. There was a negative correlation between age and AHD ($r = −0.317$), indicating that as age increased, AHD tended to decrease. This correlation was significant at the 0.05 level. There was a significant negative correlation between AI and AT ($r = −0.384$, significant at the 0.01 level, denoted by the double asterisk**). There was a significant positive correlation between AT and age ($r = 0.293$). There was a significant negative correlation between AT and AI ($r = −0.384$). There was a negative correlation between LAA and CSA ($r = −0.342$), indicating that as LAA increased, CSA tended to decrease. This correlation was significant at the 0.05 level. There was a positive correlation between CSA and AI ($r = 0.367$).

As seen in Table 10, the statistical analysis of the study parameters revealed significant sex differences in AT ($p = 0.04$) and LAA ($p = 0.01$). Conversely, no significant differences were found for AI ($p = 0.58$), AHD ($p = 0.39$), nor CSA ($p = 0.93$). Thus, sex differences were prominent in AT and LAA, but not in AI, AHD, or CSA.

Table 11 presents a comparison of mean values and standard deviations for various parameters between partial and full diagnosis groups. Each parameter's t-value and corresponding p-value were computed to assess the statistical significance of differences between the groups. Across all parameters (AI, AT, LAA, AHD, and CSA), the computed t-values ranged from −1.567 to 1.067, with associated p-values ranging from 0.333 to 0.913. Statistically, none of the parameters showed a significant difference in means between the partial and full diagnosis groups at the conventional significance level of 0.05. This result suggests that, based on the available data, there was insufficient evidence to conclude that these parameters differed significantly between patients with partial and full diagnoses. Therefore, the diagnostic categorization (partial vs. full) did not appear to influence the mean values of the measured parameters in this study.

Table 9: Correlation analysis of acromial morphologies

Parameter	Age	AI	AT	LAA (degrees)	AHD (cm)	CSA
Age	1	−0.17	0.293*	0.16	−0.317*	0.02
AI	−0.17	1.00	−0.384**	−0.23	0.25	0.367*
AT	0.293*	−0.384**	1.00	0.04	−0.18	0.10
LAA	0.16	−0.23	0.04	1.00	−0.03	−0.342*
AHD	−0.317*	0.25	−0.18	−0.03	1.00	−0.17
CSA	0.02	0.367*	0.10	−0.342*	−0.17	1.00

Acromial index (AI), acromial thickness (AT), lateral acromial angle (LAA), acromio-humeral distance (AHD), critical shoulder angle (CSA)

(*) denote significance at the 0.05 level, (**) denote significance at the 0.01 level

Table 10: Comparison of parameter means between sexes using independent *t*-tests

Parameter	Female		Male		*t*	*p*
	Mean	Standard Deviation	Mean	Standard Deviation		
AI	0.61	0.13	0.58	0.17	0.55	0.58
AT	0.65	0.14	0.77	0.20	−2.12	0.04*
AHD	0.77	0.26	0.82	0.13	−0.88	0.39
LAA	72.67	9.09	79.02	7.03	−2.65	0.01*
CSA	32.93	5.34	32.77	5.72	0.09	0.93

Acromial index (AI), acromial thickness (AT), acromio-humeral distance (AHD), lateral acromial angle (LAA), critical shoulder angle (CSA)

Table 11: Comparison of parameters between full thickness RCT and partial thickness RCT using independent t-tests

Parameter	Diagnosis				*t*	*p*
	Partial		Full			
	Mean	Standard Deviation	Mean	Standard Deviation		
AI	0.615	0.15583	0.5654	0.16427	1.067	0.846
AT	0.7014	0.21812	0.7538	0.1689	−0.939	0.913
LAA	75.3827	8.5219	78.4369	7.7916	−1.296	0.333
AHD	0.7905	0.17106	0.8242	0.19163	−0.639	0.723
CSA	32.1336	6.4456	33.4023	4.71612	−0.786	0.695

Acromial index (AI), acromial thickness (AT), lateral acromial angle (LAA), acromio-humeral distance (AHD), critical shoulder angle (CSA)

Discussion

Numerous imaging methods can be used to assess rotator cuff injuries. As MRI of the shoulder is an efficient diagnostic tool for rotator cuff injuries, we utilized it in present study to correlate the association between partial or full RCTs and acromial shape [5-8]. Raheem *et al*. did not find any significant association between sex and affected shoulder side ($p = 0.709$). Nevertheless, this result was in accordance with the findings of an earlier investigation [9]. However, in the current investigation, the chi-squared test indicated a significant association ($\chi^2 = 6.967$, $p = 0.008$) between an individual's sex and the side of the acromion.

Among patients with RCTs, Raheem *et al*. discovered that the most common kind of acromion morphology was flat [6]. He discovered no significant association between sex and acromial form, the results being same as those of previous research [6]. In contrast, Paraskevas *et al*. found a substantial association between female sex and flat acromial morphology [10], whereas male patients were more likely to have the hooked form.

Raheem *et al*. argued that osteological and hereditary variables may explain the differences seen in the above-mentioned investigations, as he discovered a significant relationship ($p = 0.030$) between sex, acromial morphology, and supraspinatus damage [6]. However, he found no evidence of a significant relationship between sex, muscle damage, and acromial morphologyfor the infraspinatus and subscapularis muscles. The present study found that there was no statistically significant association between diagnosis (full or partial) and acromial shape (type 1, type 2, type 3) ($\chi^2 = 1.771$, $p = 0.412$). According to the findings of studies by Balke *et al*. and Raheem *et al*., sex, acromial shape, and diagnosis (full or partial) were not significantly associated [11, 6]. In the current study, there was no sex-based difference in the distribution of diagnoses. Therefore, diagnosis (full thickness RCT or partial thickness RCT) was not significantly influenced by sex.

In a study of 100 patients by Koh, there was no statistically significant association between acromial morphology and RCT [12]. In contrast, Balke *et al*. found that hooked acromial form and incidence of RCTs were significantly associated [11], as supported by another research, which found that the hooked acromial form was the only form that had a significant association with RCTs [9]. However, a different study found no association between incidence of RCT and acromial morphology, even for the hooked form [8]. According to a systematic review and meta-analysis by Morelli *et al*., individuals with a type III (hooked) acromion were three times more likely to have RCT than individuals with type I or type II acromia [13].

In the current study, those with partial diagnoses more commonly had AC shape type 2 (19%), whereas most with full diagnoses had AC shape type 1 (25%). However, Raheem *et al*. found that women with flat acromia who were at least 50 years old had a noticeably increased prevalence of partial supraspinatus rips in their right shoulders. Sex and RCT do not seem to have substantial relationship, according to Raheem *et al*. [14].

This research demonstrated a statistically significant link between AI, LAA, and AT. Age also exhibited a statistically significant association between AT and LAA. There were no discernible sex and side differences [15]. Cohorts with age between 45–65 years are used in the majority of studies on this issue [16-20].

There is also a wide variations in relationship seen in other investigations like in studies by Balke *et al*. found that AI and LAA were correlated with age in one study [11], whereas in another, only LAA was correlated with age. In contrast, Banas *et al*. never found any association between age and LAA when they first described the latter [16]. Neither Kitay *et al*. [17] discover any relationship in their first investigation. Acromial morphology resulting from a spur was discovered to be a primary-generated structure rather than one connected to age in his study involving 20 cadavers [17].

Patients with RCT had a considerably thicker mean acromion than the control group (p=0.002), which comply with the findings of other research [10, 21], despite the fact that there was a little variation in the mean AT across RCT patients, with values of 8.8 mm, 8.3 mm, and 8.5 mm in studies by Paraskevas *et al*. [10], Oh *et al*. [21], and Kaur *et al*. [3], respectively, supporting earlier research. In our study, the average AT was 0.77 cm (7.7 mm).

The biomechanical theory put forth by Nyffeler *et al*. regarding the correlations between small AI, and osteoarthritis and between large AI and RCT has been challenged by numerous studies that found no difference in the AI of patients with calcifying tendinitis, partial-thickness RCTs, or full-thickness RCTs [22-23]. Nyffeler *et al*. found the fact that RCT patients have a high AI, particularly for full thickness rips [22]. In research conducted in Spain, Torrens *et al*. similarly showed comparable results, with sex-based AI differences in patients with RCTs, and a substantially larger AI value of 0.72 compared with 0.68 in patients without cuff disease [25]. High AI has been found to be one of the variables linked to the development and severity of rotator cuff injuries [25]. In RCT, we found AI to be 0.61 in females and 0.58 in males.

According to research by Banas *et al*., only in cuff rips does an exceptionally low LAA of less than 70° occur [18]. In their study, eight patients with complete RCTs had an average age of 54 years and LAAs less than 70°. In contrast, the remaining 18 patients had an average age of 70 years and LAAs greater than 70°. In a study by Kaur *et al*. [3], LAA exhibited a significant correlation with age; whereas in Banas *et al*. study, there was a moderate association (Pearson correlation coefficient=0.46). We believe that LAA can assist in distinguishing between impingement and RCTs, as well as between controls and RCTs. We found no relationship between age and LAA in the current study, with LAA being 72.6 in women and 79.02 in men with RCT on average.

In Kaur *et al*. study [3], CSA was found to be 34.6, which is in line with the results of many other authors who also found similar values, such as Gerber *et al*., Spiegl *et al*., and Bouaicha *et al*. [24-26]. Garcia *et al*. found that after arthroscopic surgery, a higher CSA significantly increased the risk of a full-thickness RCT [27]. Although CSA is a good radiographic predictor of rotator cuff pathology, according to Kirsch *et al*., it has no prognostic value for the outcome of arthroscopic repair of a traumatic full-thickness tears [21].

According to Weiner and Macnab [28], an AHD of less than 7 mm is considered evidence of a full-thickness tear of the supraspinatus tendon in over 90% of cases. The maximum value for AHD on MRI, according to Werner *et al*., should be less than 6 mm, or lower than on a traditional radiograph [29]. AHD was found to be considerably lower in the research of Kaur *et al*. [3]. In this study, we found that women with RCT had an AHD of 7.7 mm (0.77 cm), whereas this value was 8.2 mm (0.82 cm) in men with RCT. As per Zope *et al*, only supraspinatus partial tears ($p < 0.05$) were statistically significant, and the majority of RCTs were seen in those over 30 years [30].

Conclusion

In the context of RCTs in our study, there was no correlation between the three acromial shapes and sex. However, we identified a significantly higher incidence of full-thickness supraspinatus tears in the right shoulders of men aged 40–60 years with type 2 acromia. Sex differences were prominent in AT and LAA, but not in AI, AHD, or CSA. There was a positive correlation between age and AT, indicating that as age increased, AT tended to increase. There was a negative correlation between age and AHD, indicating that as age increased, AHD tended to decrease. There was a significant negative correlation between AI and AT. There was a negative correlation between LAA and CSA, indicating that as LAA increased, CSA tended to decrease. We found that the diagnostic categorization (partial vs. full) did not significantly influence the mean values of the measured parameters in this study.

References

1. Maalouly J, Tawk A, Aouad D, Abdallah A, Darwiche M, Abboud G, *et al*. Association of acromial morphological parameters and rotator cuff tears, and evaluation of the influence of age and gender on the parameters and impact on cuff tears: A study on a Middle Eastern population. *Asia Pac J Sports Med Arthrosc Rehabil Technol* 2020, 20:17-23.
2. Horowitz EH, Aibinder WR. Shoulder impingement syndrome. *Phys Med Rehabil Clin N Am* 2023;34(2): 311-314.
3. Kaur R, Dahuja A, Garg S, Bansal K, Garg RS, Singh P. Correlation of acromial morphology in association with rotator cuff tear: A retrospective study. *Pol J Radiol* 2019; 84:e459-63.
4. Prasad M, Rout S, Stephen PC. Acromion Morphology and morphometry in the light of impingement syndrome and rotator cuff pathology. *J Anatom Soc India* 2019; 68:27-33.
5. Gagey N, Ravaud E, Lassau JP. Anatomy of the acromial arch: correlation of anatomy and magnetic resonance imaging. *Surg Radiol Anat* 1993; 15(1):63-70.
6. Hassan A, Refaat M, El-Shazly I. The role of magnetic resonance imaging in the assessment of acromial morphology in association with rotator cuff tear. *Benha Med J* 2018, 35:157-162.
7. Mayerhoefer ME, Breitenseher MJ, Roposch A, Treitl C, Wurnig C. Comparison of MRI and conventional radiography for assessment of acromial shape. *AJR Am J Roentgenol* 2005; 184(2):671-675.
8. Kim JM, Kim YW, Kim HS, Lee SC, Chun YM, Joo SH, *et al*. The relationship between rotator cuff tear and four acromion types: cross-sectional study based on shoulder magnetic resonance imaging in 227 patients. *Acta Radiol* 2019; 60(5):608-614.
9. Mohamed R, Abo-Sheisha D. Assessment of acromial morphology in association with rotator cuff tear using magnetic resonance imaging. *Egypt J Radiol Nucl Med* 2014, 45:169-80.
10. Paraskevas G, Papaziogas B, Tzaveas A, Natsis K, Spanidou S, Kitsoulis P. Morphological parameters of the superior articular facets of the atlas and potential clinical significance. *Surg Radiol Anat* 2008; 30(8): 611-617.
11. Balke M, Schmidt C, Dedy N, Banerjee M, Bouillon B, Liem D. Correlation of acromial morphology with impingement syndrome and rotator cuff tears. *Acta Orthop* 2013; 84(2):178-183.
12. Koh KH, Laddha MS, Lim TK, Lee JH, Yoo JC. A magnetic resonance imaging study of 100 cases of arthroscopic acromioplasty. *Am J Sports Med* 2012; 40(2):352-358.
13. Morelli KM, Martin BR, Charakla FH, Durmisevic A, Warren GL. Acromion morphology and prevalence of rotator cuff tear: A systematic review and meta-analysis. *Clin Anat* 2019; 32(1):122-30.

14. Almokhtar AA, Qanat AS, Mulla A, Alqurashi Z, Aljeraisi A, Hegaze AH. Relationship between acromial anatomy and rotator cuff tears in Saudi Arabian population. *Cureus* 2020; 12(5):e8304.
15. Klasan A, Malcherczyk D, Neri T, Saul J, Schofer MD, Heyse TJ, *et al*. Reporting on acromion morphology: classifications demonstrate significant correlation. *JISAKOS* 2020; 5(2):83-87.
16. Balke M, Banerjee M, Vogler T, Akoto R, Bouillon B, Liem D. Acromial morphology in patients with calcific tendinitis of the shoulder. *Knee Surg Sports Traumatol Arthrosc* 2014; 22(2):415-421.
17. Kitay GS, Iannotti JP, Williams GR, Haygood T, Kneeland BJ, Berlin J.Roentgenographic assessment of acromial morphologic condition in rotator cuff impingement syndrome. *J Shoulder Elbow Surg* 1995; 4(6):441-448.
18. Banas MP, Miller RJ, Totterman S. Relationship between the lateral acromion angle and rotator cuff disease. *J Shoulder Elbow Surg* 1995; 4(6): 454-461.
19. Nyffeler RW, Werner CML, Sukthankar A, Schmid MR, Gerber C. Association of a large lateral extension of the acromion with rotator cuff tears. *J Bone Joint Surg Am* 2006; 88(4):800-805.
20. Hirano M, Ide J, Takagi K. Acromial shapes and extension of rotator cuff tears: Magnetic resonance imaging evaluation. *J Shoulder Elbow Surg* 2002; 11(6): 576-578.
21. Oh JH, Kim JY, Lee HK, Choi JA. Classification and clinical significance of acromial spur in rotator cuff tear: heel-type spur and rotator cuff tear. *Clin Orthop Relat Res* 2010; 468(6):1542-1550.
22. Kappe T, Cakir B, Lippacher S, Reichel H, Elsharkawi M. Intraarticular lesions in calcifying tendinitis: incidence and association with the acromion index. *Arch Orthop Trauma Surg* 2011; 131(3):325-329.
23. Torrens C, López JM, Puente I, Cáceres E. The influence of the acromial coverage index in rotator cuff tears. *J Shoulder Elbow Surg* 2007; 16(3):347-351.
24. Gerber C, Snedeker JG, Baumgartner D, Viehöfer AF. Supraspinatus tendon load during abduction is dependent on the size of the critical shoulder angle: a biomechanical analysis. *J Orthop Res* 2014; 32(7): 952-957.
25. Spiegl UJ, Horan MP, Smith SW, Ho CP, Millett PJ. The critical shoulder angle is associated with rotator cuff tears and shoulder osteoarthritis and is better assessed with radiographs over MRI. *Knee Surg Sports Traumatol Arthrosc* 2016; 24(7):2244-2251.
26. Bouaicha S, Ehrmann C, Slankamenac K, Regan WD, Moor BK. Comparison of the critical shoulder angle in radiographs and computed tomography. *Skeletal Radiol* 2014, 43(8):1053-1056.
27. Garcia GH, Liu JN, Degen RM, Johnson CC, Wong AC, Dines DM, *et al*. Higher critical shoulder angle increases the risk of retear after rotator cuff repair. *J Shoulder Elbow Surg* 2017; 26(2):241-245.
28. Weiner DS, Macnab I. Superior migration of the humeral head. A radiological aid in the diagnosis of tears of the rotator cuff. *J Bone Joint Surg Br* 1970; 52(3):524-527.
29. Werner CM, Conrad SJ, Meyer DC, Keller A, Hodler J, Gerber C. Intermethod agreement and interobserver correlation of radiologic acromiohumeral distance measurements. *J Shoulder Elbow Surg* 2008; 17(2): 237-240.
30. Zope AM, Kumar S, Zende UM. Role of magnetic resonance imaging in the evaluation of painful shoulder. *J Krishna Inst Med Sci Univ* 2024; 13(2): 31-43.

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