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ORIGINAL ARTICLE

Assessment of acromial morphology in association with rotator cuff tear using magnetic resonance imaging

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KEYWORDS

Acromioal morphology;
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Abstract *Purpose:* To identify the morphological characteristics of the acromion associated with RCT using MRI. Also, to recognize which type of the acromion could be risk factor for full thickness RCT.

Materials and methods: Fifty-six patients with RCT (either partial or full thickness tear) and 30 control volunteers were enrolled in this study. Their shoulders were imaged by MRI. The acromial shapes were classified into type I (flat), type II (curved), type III (hooked) and type IV (convex). Additional measurements including acromial thickness, acromio-humeral distance (AHD), acromial index (AI) and lateral acromial angle (LAA) were performed for further assessment.

Results: Type-II was the most commonly encountered acromial shape in both patients with RCT (44.6%) and control group (43.3%) with no significant difference in the incidence of each acromial shape between the two groups ($P > 0.05$). The acromial thickness, AHD, AI and LAA were significantly different in patients with RCT compared to control group ($P < 0.001$). Full thickness tear was significantly associated with type-III ($P < 0.05$).

Conclusion: Type-III acromion (hooked shaped) could be a risk factor for full thickness RCT.

1. Introduction

The acromion is a posterior shoulder landmark, formed as a posterolateral extension of the scapular spine, superior to the glenoid. It articulates with the clavicle and is the origin of the deltoid and trapezius muscles (1). Variation in the shape of the acromion can endorse variety of pathologies such as impingement syndrome and rotator cuff tear (RCT) (2). Rotator cuff disorder is one of the most common disorders of the shoulder. It is a common cause of chronic shoulder pain in adults. The specific etiology of a RCT has not been fully

Abbreviations: RCT, rotator cuff tear; AHD, acromio-humeral distance; AI, acromial index; LAA, lateral acromial angle.

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elucidated, but it has been considered to result from a combination of intrinsic and extrinsic factors. Intrinsic factors include degenerative changes, hypovascularity, and microstructural collagen fiber abnormalities. Recognized extrinsic factors include subacromial impingement, tensile overload and repetitive use (3).

The pathogenesis of RCT seems to be related to the morphology of the acromion which is usually assessed through the five commonly used parameters on standard plain radiographs including the acromial type, acromial slope, acromial tilt, lateral acromial angle and acromial index (4). However, with only a plain radiograph of the acromion in the supraspinatus outlet view, it is notoriously difficult to image the acromion and distinguish the hooked from the non-hooked acromion with anterior spurs (5,6).

The magnetic resonance imaging (MRI) makes it possible to depict the shape of acromion in its longitudinal axis with better evaluation of the acromial morphological factors including the acromial shape, acromial thickness, acromio-humeral distance, and lateral acromial angle and acromial index. These factors are suggested to influence the status of the rotator cuff (7,8). The acromial shape can be classified into four types: type I (flat), type II (curved), type III (hooked) (4–6) and type IV (convex) (Fig. 1) (7).

The aim of this study is to identify the morphological characteristics of the acromion associated with RCT using MRI and also, to recognize which type of the acromion could be risk factor for full thickness RCT.

2. Materials and methods

This study was carried out in the period from January 2011 to August 2012 in the Radiology department of our institution and included 56 patients with RCT either partial or full thickness (patients group). The exclusion criteria included previous surgery, fractures and/or dislocation, infections or tumors of the shoulder and cases with acromial spurs. All patients were imaged by MRI according to their side of complaint. Patients with bilateral RCT ($n = 6$) were stepped aside due to bilateral traumatic injury of both shoulders in 3 patients, bilateral acromial spurs in 2 patients and bilateral previous surgery in one patient. In order to study the incidence of each acromial shape, age- and sex-matched 30 asymptomatic volunteers without RCT were included as the control group. An official permission to carry out the study was obtained from the local medical research ethics committee. Written informed consent was obtained from all study participants.

2.1. Imaging procedures

All MRI images of our study were performed by using 1.5-Tesla unit system (Signa Horizon SR 120; General Electric Medical Systems, Milwaukee, WI, USA). A dedicated shoulder array coil was used. When imaging the shoulder with MRI, patients were placed in a supine position with their arms on the sides of the body in partial external rotation. Initially, the localizer images were obtained, followed by coronal oblique, sagittal oblique and axial images. The coronal oblique plane was selected parallel to the course of the supraspinatus tendon itself for optimal visualization of the tendon. The used MRI sequences and parameters were tabulated in Table 1.

Types of the acromion were evaluated in the T2 weighted (T2WI) sagittal oblique images. This sagittal oblique plane was parallel to the glenoid surface with selection of the images obtained just lateral to the acromioclavicular joint. Acromial morphology was classified into four types: type-I (flat), type-II (curved), and type-III (hooked) and type-IV (convex or upturned) (Fig. 1) (7–10).

The obtained images were retrieved from our institutional picture archiving and communication system (Millenmed Company, FDA approved for PACS) and assessment of the acromial type at parasagittal MR images was achieved mathematically by using the mathematical classification scheme for MR images, where a line connecting the most caudal margins of the acromial undersurface was manually drawn and its length was measured. This line was then divided with the help of two orthogonal lines, into three segments of equal lengths. Then, the angle between the anterior third and the posterior two thirds of the acromion was measured. If this angle was of 10° or less, type I acromion was considered. If it was between 11° and 20°, type II acromion was recognized. If this angle was more than 20°, then the angle between the posterior third and the anterior two thirds was furtherly measured. If this latter angle was 10° or less, type III acromion was defined and if more than 10° this would be type IV acromial shape (Fig. 2) (11). Acromial thickness was also measured at the widest portion of the acromion on the perpendicular plane to the

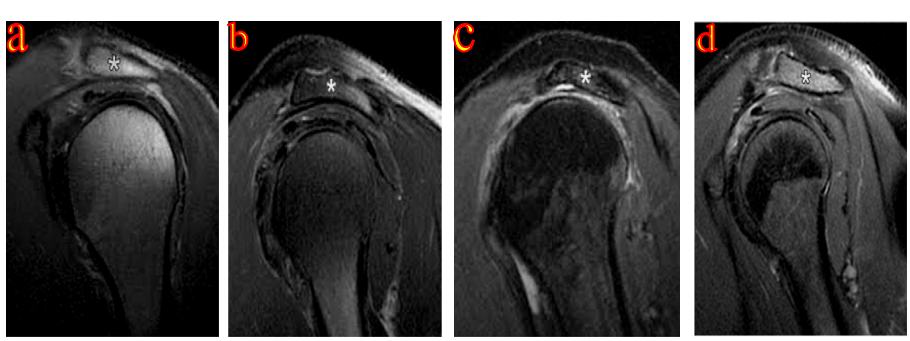

Fig. 1 *Types of acromial shape*. Type-I or flat type (a), type-II or curved type (b), type-III or hooked type (c) and type-IV acromion shape or convextype (d) (Quoted from Morag, et al. (7)).

Table 1 The MRI sequences and parameters used in our study.

Pulse sequence	FOV (cm)	Slice thickness (mm)	Matrix	TR/TE (ms)
Axial T2 fat suppression	14	4	512 × 512	5177/34
Coronal oblique T1	14	4	512 × 512	622–678/24
Coronal oblique T2 with fat suppression	14	4	512 × 512	3730–4456/34
Sagittal oblique T2	14	4	512 × 512	2400–2423/87
Sagittal oblique T1	14	4	512 × 512	518–624/12

FOV: field of view, TE: echo time, TR: repetition time, cm: centimeter, mm: millimeter, ms: millisecond.

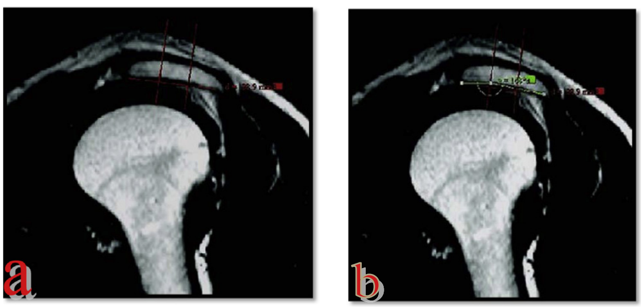

Fig. 2 *Mathematical determination of acromial morphology*. A line connecting most caudal points of acromial undersurface was drawn on parasagittal T2-weighted MR image, and with help of two orthogonal lines, acromion was divided into three segments of equal lengths (a). Then, the angle between anterior third and posterior two-thirds is measured (b) (Quoted from Mayerhoefer et al. (11)).

long axis of the acromion on the sagittal oblique plane just lateral to the acromioclavicular joint (3).

Additionally, to get more information about the morphological characteristics and variations of the acromion, three measurements were manually obtained through the coronal oblique plane of T2WI: (I) the acromio-humeral distance (AHD) as the shortest distance, in millimeters (mm), between the undersurface of the acromion and the superior surface of the humeral head (Fig. 3-a), (II) acromial index (AI) = (A/B ratio) by dividing the distance from the superior and inferior osseous margins of the glenoid cavity to the lateral border of the acromion (A) by the distance from the superior and inferior osseous margins of the glenoid cavity to the most lateral part of the proximal part of the humerus (B) (Fig. 3-b) and (III) the lateral acromial angle (LAA) was measured as the angle between the line through the mid substance of the acromion and the bony outline of the glenoid cavity immediately posterior to the acromio-clavicular joint (Fig. 3-c) (12).

The RCT was diagnosed by MRI. The patients group with RCT was classified into full thickness tear and partial thickness tear. The most specific sign of a full thickness RCT was visualization of a complete defect in any tendon of rotator cuff muscles, extending from the articular surface completely through to the bursal surface. Partial thickness tears involved a spectrum of findings and were broadly classified into 3 different types according to the portion of the tendon that was abnormal: articular-sided tears, bursal-sided tears, and interstitial tears.

2.2. *Statistics*

The SPSS for Windows version 18.0 software package (SPSS Inc, Chicago, IL) was used for statistical data analysis. Data were expressed as mean ± standard deviation (SD) as well as number and percent. In addition, the student *t*-test, chi-square, fisher's exact, and the analysis of variance (ANOVA) with Dunnett test were used for comparison and correlation of the data. $P < 0.05$ was considered statistically significant.

3. Results

Fifty-six patients with RCT were enrolled in this study. They were 29 males and 27 females. Their ages ranged from 47 to 75 years with a mean of 61 ± 20 years. A control group of 30 age- and sex-matched asymptomatic volunteers without RCT was added. They were 16 males and 14 females. Their ages ranged from 45 to 76 years with a mean 0f

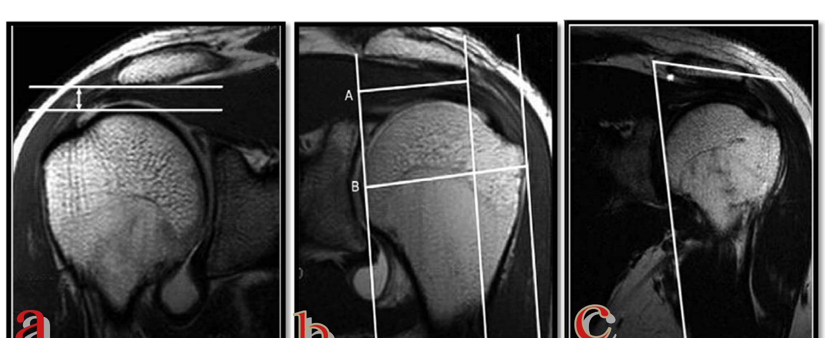

Fig. 3 Methods of measuring acromio-humeral distance (AHD) (a), the acromial index (AI) (b) and the lateral acromial angle (LAA) **(c)** (Quoted from Lee et al. (12)).

Table 2 Distribution of acromial shapes in patients with RCT in relation to age and sex.

Parameters	Types of acromial shapes in patients with RCT ($n = 56$)				Test statistics	P-value
	Type I ($n = 16$)	Type II ($n = 25$)	Type III ($n = 13$)	Type IV ($n = 2$)		
Age (in years)						
< 65 ($n = 26$)	10 (38.5%)	10 (38.5%)	4 (15.4%)	2 (7.6%)	5.666	0.1290
⩾65 ($n = 30$)	6 (20.0%)	15 (50.0%)	9 (30.0%)	0 (0%)		
Sex						
Males ($n = 29$)	8 (27.6%)	13 (44.8%)	7 (24.2%)	1 (3.4%)	0.046	0.997
Females ($n = 27$)	8 (29.6%)	12 (44.4%)	6 (22.3%)	1 (3.7%)		

<: less than; **⩾:** more than or equal to; *n*: number of patients; %: percent.

Table 3 Distribution of different acromial shapes in both patients and control groups.

Acromial shape	Patient group ($n = 56$)		Control group ($n = 30$)		*X*	*P*
	n	%	*n*	%		
Type I	16	28.6	9	30	0.1290	0.612
Type II	25	44.6	13	43.3		
Type III	13	23.2	5	16.7		
Type IV	2	3.6	3	10		

%: percent, *n*: number of patients, *x*: Fisher exact test.

Table 4 Acromial measurements of patients with RCT in comparison to those of control group.

Parameters	Patient group ($n = 56$)	Control group ($n = 30$)	t-Test	P-value
Acromial thickness (mm)	8.6 ± 1.8	7.5 ± 0.9	3.2	0.002*
AHD (mm)	7.57 ± 1.2	9.2 ± 1.6	5.330	< 0.001*
AI	0.72 ± 0.2	0.53 ± 0.1	5.419	< 0.001*
LAA (°)	69.75 ± 6.2	75.8 ± 5.1	4.641	< 0.001*

n: number of patients, (°): degrees, *t*: student's *t*-test, AHD: Acromio-humeral distance, AI: acromial index, LAA: Lateral acromion angle.
* Significant ($P < 0.05$), mm: millimeter.

60.5 ± 18 years. We identified four distinct types of acromial shapes mainly on sagittal oblique T2WI. The actual acromial shape was recognized as high signal intensity without subacromial spurs.

In our study, type-IV acromial shape was not encountered in patients equal to or older than 65 years, while type II was present in half of them (50%). In patients younger than 65 years ($n = 26$), type-I and type-II acromial shapes were the most commonly encountered types (38.5% for each). Furthermore, type-II was the most commonly encountered type in both of males (44.8%) and females (44.4%), while type-IV was the least encountered type in both sexes (3.7% for each). All age and sex differences were not significant ($P > 0.05$) (Table 2).

In our study, there is no significant difference in the incidence of acromial shapes between the patient group and the control group ($P = 0.612$). The most commonly encountered type of acromial shapes among both the patients and control groups was type-II (44.6% and 43.3% respectively). On the other hand, type-IV acromial shape showed the lowest incidence in the patients and control groups (3.6% and 10% respectively), Table 3. Furthermore, acromions in patients group were significantly thicker than those in the control group ($P = 0.002$). Additionally, in patients with RCT, the mean AHD was smaller, the mean AI was bigger, and the mean LAA was smaller when compared to the control group. All these differences were significant ($P < 0.001$ for each), as shown in Table 4.

Additionally, a multivariate statistical analysis of type III acromion demonstrated significantly thicker acromion ($P < 0.001$), shorter AHD ($P < 0.001$), larger AI ($P < 0.001$) and smaller LAA ($P < 0.001$) of type III acromion in patients with RCT when compared to those of control group as shown in Table 5.

Moreover, type-III acromion was significantly associated with full thickness RCT ($P = 0.016$). On the other hand, type-IV acromion shape was not recognized in patients with full thickness RCT and it was recognized in only two (5.2%) patients with partial thickness RCT as shown in Table 6 and Fig. 4.

In the current study, we reported only one case of os acromial which was of type-III acromial shape associated with partial thickness tear of the supraspinatus tendon.

3.1. Cases

The figures (from Figs. 5–9) demonstrate a sample of selected cases of our study, each figure outlines one case.

Table 5 Comparison between different acromial shapes in patients with RCT and the control group regarding acromial measurements including; acromial thickness, AHD, AI and LAA.

	Type I (n = 12)	Type 11 (n = 25)	Type III (n = 13)	Type IV (n = 2)	Control group (n = 30)	ANOVA P-value
Acromial thickness (mm)	8.03 ± 1.3	8.25 ± 1.7	9.2 ± 1.7	8.43 ± 1.8	7.5 ± 0.9	0.025*
AHD (mm)	8.85 ± 1.4	7.50 ± 1.4	5.92 ± 1.4	8.82 ± 1.4	9.2 ± 1.6	< 0.001*
AI	0.68 ± 0.2	0.69 ± 0.2	0.73 ± 0.1	0.67 ± 0.2	0.53 ± 0.9	< 0.001*
LAA (°)	74.76 ± 53	70.65 ± 4.5	67.2 ± 4.8	74.61 ± 4.2	75.8 ± 5.1	0.033*
Dunnett test						
	P1 (type I versus control)	P2 (type II versus control)	P3 (type III versus control)	P4 (type IV versus control)		
Acromial thickness (mm)	0.66	0.42	< 0.001*	0.40		
AHD (mm)	0.45	0.75	< 0.001*	0.67		
AI	0.25	0.52	< 0.001*	0.54		
LAA (°)	0.87	0.46	0.035*	0.64		

n: number of patients, (°): degrees, AHD: Acromio-humeral distance, AI: acromial index, LAA: Lateral acromion angle.
* Significant (P < 0.05), mm: millimeter.

Table 6 Association of different acromial shapes with rotator cuff tear in the studied patients (n = 56).

Acromial shape	Partial thickness tear (n = 38; 67.9%)	Full thickness tear (n = 18; 32.1%)	Fisher's exact test
Type I (n = 16)	12 (31.6%)	4 (22.2%)	0.541
Type II (n = 25)	19 (50.0%)	6 (33.3%)	0.376
Type III (n = 13)	5 (13.2%)	8 (44.5%)	0.016*
Type IV (n = 2)	2 (5.2%)	0 (0%)	1.000

%: percent, n: number of patients.
* Significant (P < 0.05).

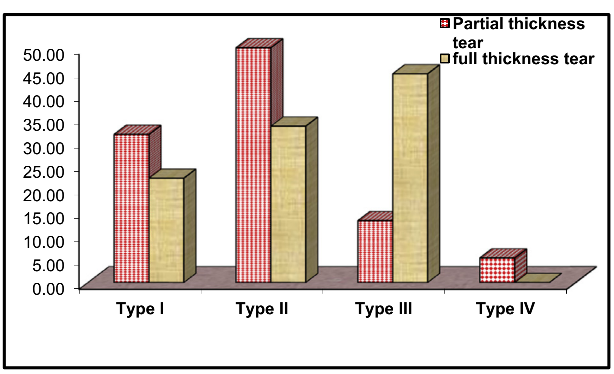

Fig. 4 *Association of different acromial shapes with rotator cuff tear in the studied patients (n = 56)*. It demonstrated that type-III acromion is significantly associated with full thickness RCT (P = 0.016).

4. Discussion

The pathogenesis of RCT remains controversial. The acromion portion of the scapula and its morphology may be attributing to variety of shoulder disorders such as RCT (2). Several studies reported correlations between acromial morphology and the extent of RCT. Some surgeons place great emphasis on acromial morphology and others feel that acromial shape is a result of cuff tear pathology rather than the cause (13). The clinical significance of acromial shape was first described by Bigliani et al., (5) who highlighted the significance of anterior acromial down sloping for the development of RCT. According to these authors, acromions can be divided into a physiologic non-pathologic flat (type-I) and convex (type-IV) acromions, and pathologic curved (type-II), and especially hooked (type-III) acromions (11,14). This classification system is based on the anterior slope of the acromion taken from a supraspinatus outlet radiograph in the sagittal plane only. Outlet views are often technician-dependent and difficult to interpret in terms of acromial shape (6).

We designed the existing study to recognize the morphologic characteristics of different acromial shapes in patients with either partial or complete thickness RCT by using MRI in order to elucidate the relationship between acromial shapes and RCT that could provide a useful guidance regarding the diagnosis and management of RCT. Therefore, we used the mathematic classification scheme for MR images (11) based on T2W images in sagittal oblique plane and selection of the images obtained just lateral to the acromio-clavicular joint for demonstration of the longest dimension of the acromion with consequently better identification of the acromial shapes. In addition, we obtained further acromial measurements (AHD, AI and LAA) on coronal oblique plane of T2W images.

The development of different acromial shapes is likely both genetic and acquired. With acquired causes, only age has been positively correlated with progression from flat to curved or hooked (5). Similar to previous studies

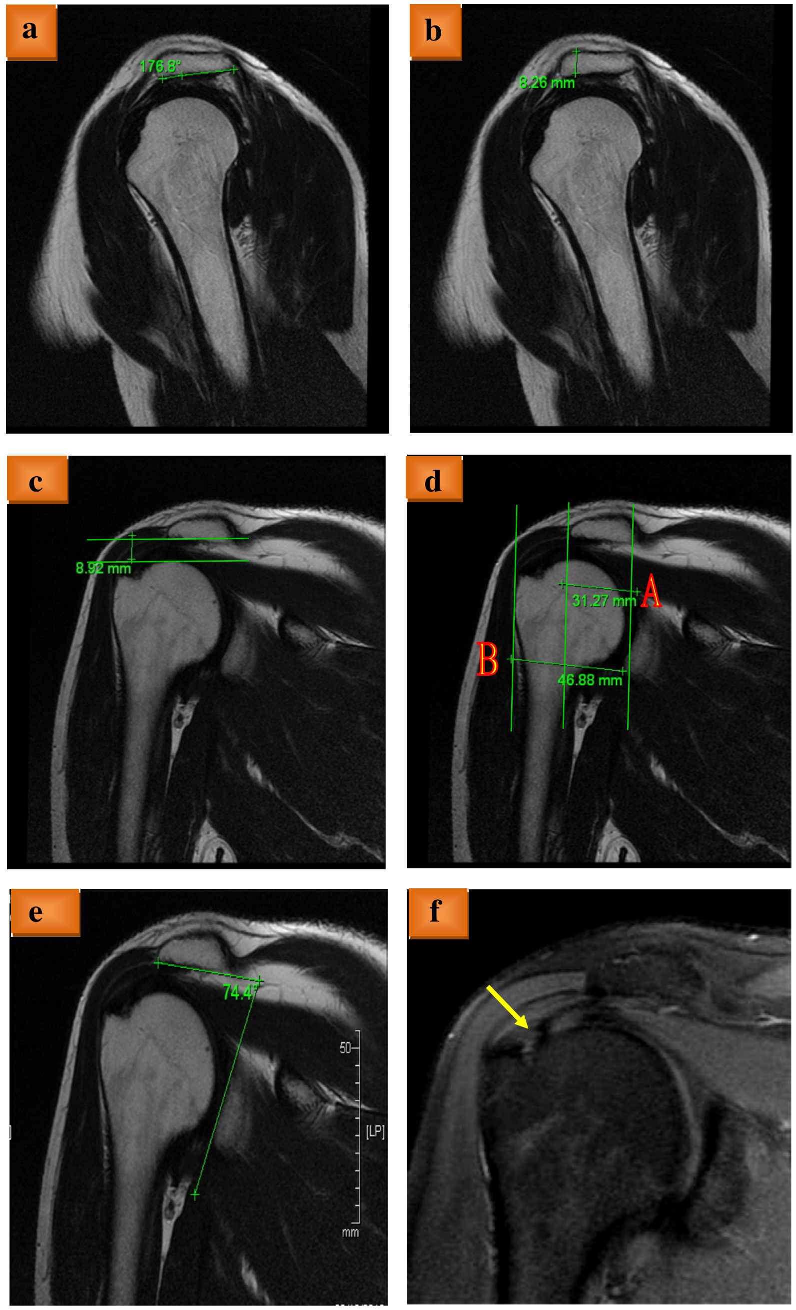

Fig. 5 (a–f): Revealed type I acromial shape in a male patient aged 46 years associated with focal full thickness RCT. The sagittal oblique T2WI (a) showed the measurement of the angle between the anterior third and posterior two thirds of acromion (180–176.8° = 3.2°; less than 10°) and by using the mathematical classification scheme for MR images, type I acromial shape was recognized. Also, sagittal oblique T2WI (b) showed the acromial thickness (8.26 mm). In addition, on coronal oblique T2W images, the acromial measurements were obtained including: the AHD (8.92 mm) (c), the AI (A/B = 31.27/46.88 = 0.667) (d) and the LAA (74.4°) (e). Furthermore, the coronal oblique T2WI with fat suppression (f) represented a focal full thickness RCT which is seen in the tendon of the supraspinatus muscle of the rotator cuff (a yellow arrow).

(2,3,5,13,15), in the current study we noticed that type-II acromial shape is the most commonly encountered type among both patients and control groups (44.6% and 43.3% respectively). In contrary, type-IV acromion shape recorded the lowest incidence in both patients and control groups (3.6% and 10% respectively). In patients' group, although there is no significant difference in age and sex ($P > 0.05$) distribution of different acromial shapes, we noticed that type-IV acromial shape was not seen in patients older than 65 years while, type II was present in half of them (50%). There was no significant differences between different acromial shapes regarding age and sex ($P > 0.05$).

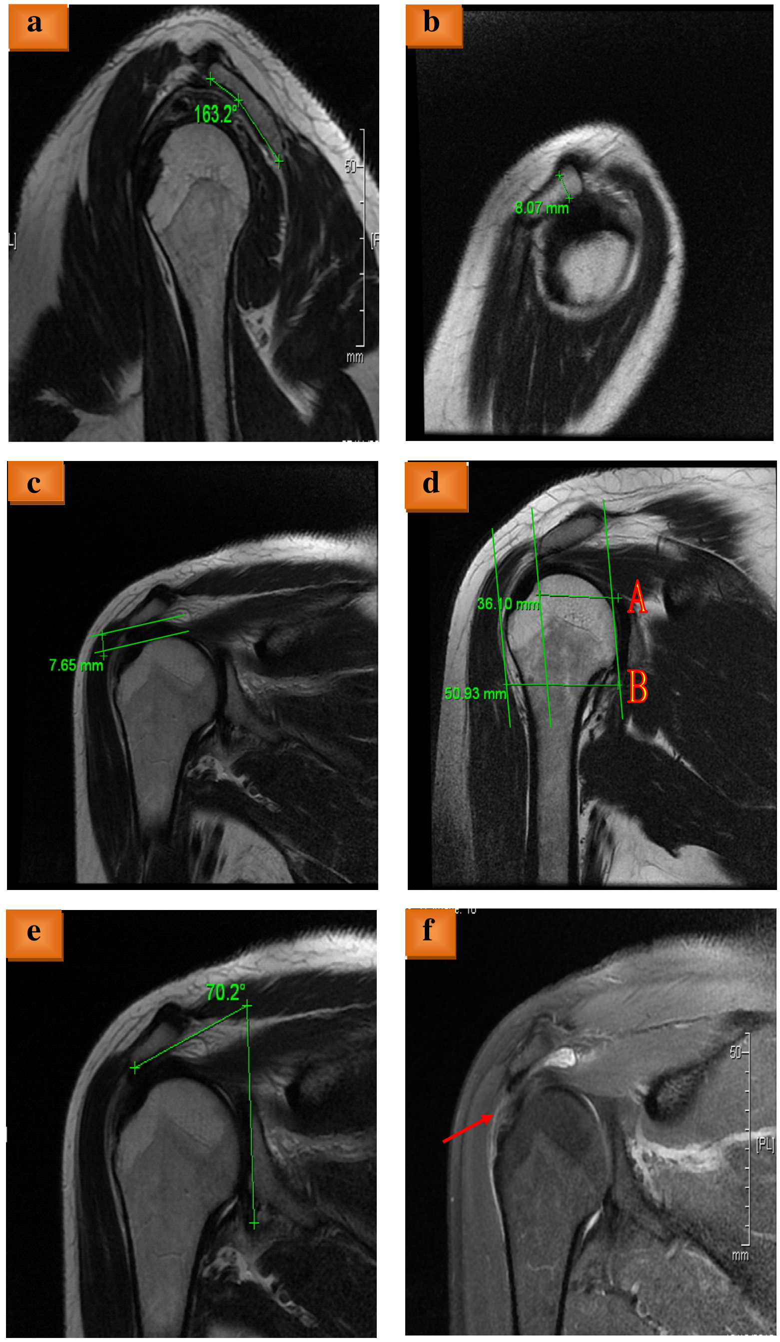

Fig. 6 (a–f): Represented type II acromial shape in a female patient aged 56 years associated with partial thickness RCT. The sagittal oblique T2WI (a) showed the measurement of the angle between the anterior third and posterior two thirds of acromion (180–163.2° = 16.8°; more than 10° and less than 20°) and according to the mathematical classification scheme for MR images, type II acromial shape was identified. Also, the sagittal oblique T2WI (b) showed the acromial thickness (8.07 mm). Additionally, on coronal oblique T2 W images, the acromial measurements were obtained including: the AHD (7.65 mm) (c), the AI (A/B = 36.10/50.93 = 0.708) (6 d) and the LAA (70.2°) (e). Moreover, the coronal oblique T2WI with fat suppression (f) demonstrated a partial thickness RCT in the tendon of the supraspinatus muscle of the rotator cuff appears as linear hyperintense signal (the red arrow).

In a previous study done by Paraskevas, et al. (15) they noted that type-I acromion was significantly more common in females (13 or 56.5% vs. 10 or 43.4%), whereas type III was significantly more common in males (9 or 56.2% vs. 7 or 43.7% in females).

In the current study, the mean acromion thickness in patients with RCT was significantly thicker than in control group ($P = 0.002$). Although this is in accordance with the conclusion of previous studies, (15,16) there is a slight difference regarding the mean acromial thickness in patients with RCT. Where it was 8.8 mm in the study by Paraskevas et al. (15),

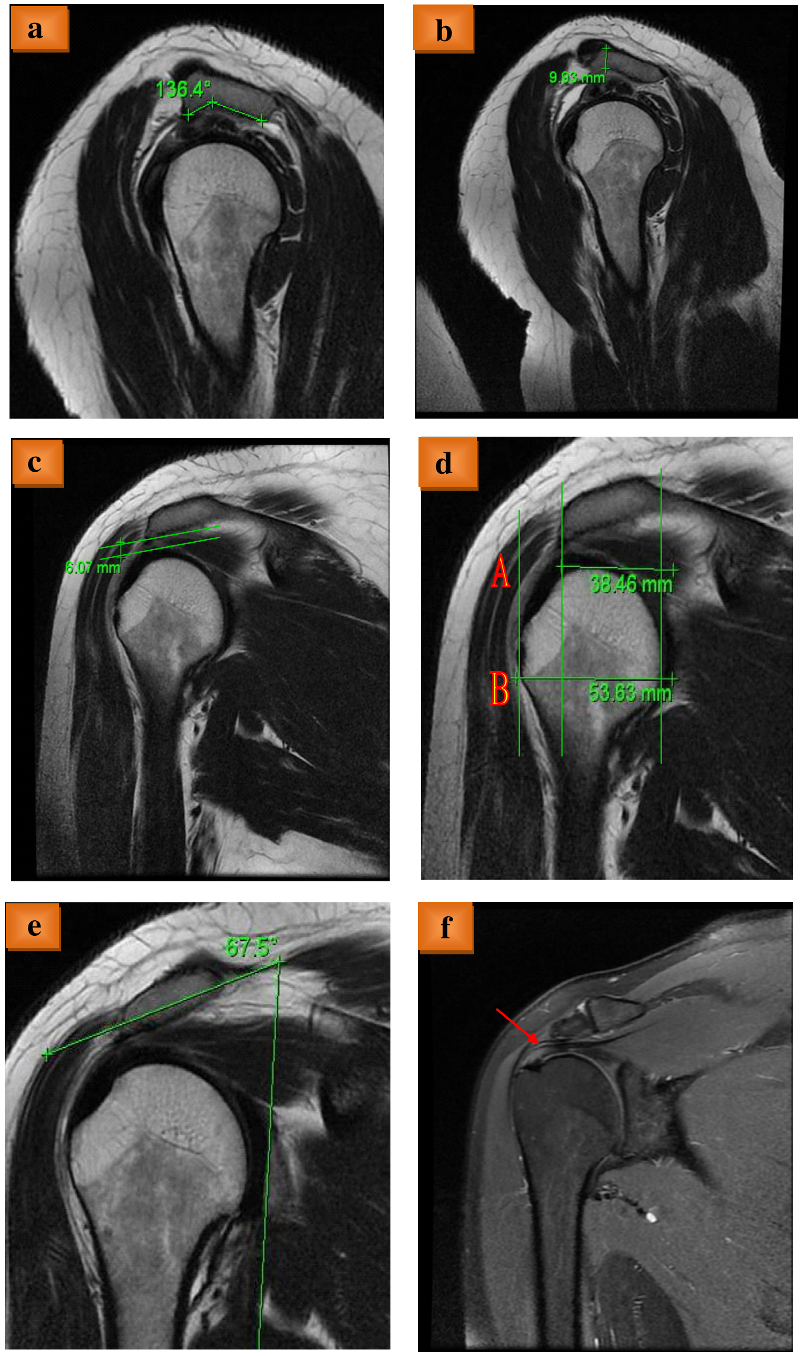

Fig. 7 (a–f): Demonstrates type III acromial shape in a male patient aged 65 years associated with partial thickness tear. The sagittal oblique T2WI (a) showed the measurement of the angle between the anterior third and posterior two thirds of acromion (180–136.40° = 43.6°; more than 20°) and according to the mathematical classification scheme for MR images, type III acromial shape was identified. Also, the sagittal oblique T2WI showed the acromial thickness (9.93 mm) (b). Additionally, on coronal oblique T2W images, the acromial measurements were obtained including: AHD (6.07 mm) (c), the AI (A/B = 38.46/53.63 = 0.72) (d) and the LAA (67.5°) (e). Moreover, the coronal oblique T2WI with fat suppression (f) demonstrated a partial thickness RCT which is seen in the tendon of the supraspinatus muscle of the rotator cuff (red arrow).

8.5 mm in the study of Collipal et al. (16) and 8.3 mm in the study of Oh et al. (3) but in our study it was 8.6 mm.

Variations of the acromial morphology, those named as "congenital and osteal etiological factors", may contribute to RCT and play subsidiary roles in diagnosing the rotator cuff injury. They include: acromial shape, lateral acromial extension or acromial index, the angle between the undersurface of the acromion and the glenoid or lateral acromial angle, and the distance from acromion to humeral head (17). Nyffeler et al. (18) firstly described the concept of AI, which could

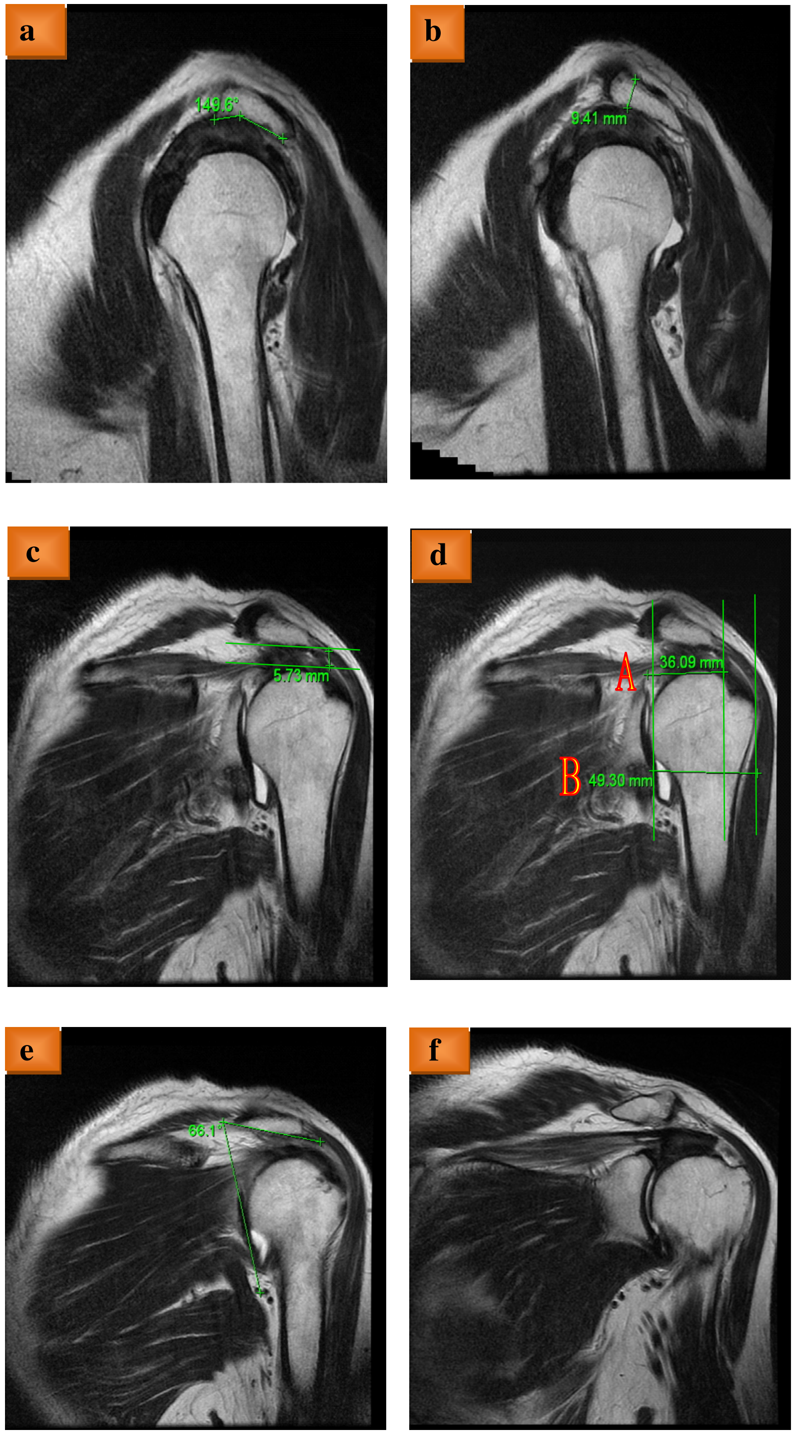

Fig. 8 (a–f): Demonstrated type III acromial shape in a male patient aged 69 years associated with full thickness RCT (articular side). The sagittal oblique T2WI (a) showed the measurement of the angle between the anterior third and posterior two thirds of acromion (180–148.6° = 31.4°; more than 20°) and according to the mathematical classification scheme for MR images, type III acromial shape was identified. Also, the sagittal oblique T2WI showed the acromial thickness (9.41 mm) (b). Additionally, on coronal oblique T2W images, the acromial measurements were obtained including: the AHD (5.73 mm) (8 c), the AI (A/B = 36.09/49.30 = 0.732) (d) and the LAA (66.1°) (e). Moreover, the coronal oblique T2WI with fat suppression (f) demonstrated a full thickness RCT in the tendon of the supraspinatus muscle with separation from its insertion in the superior facet of the greater tubercle of the humerus.

directly express the lateral extension degrees of acromion. In addition, it could be considered as the coverage degree of acromion onto the subacromial tissue. Furthermore, Banas et al. (19) firstly identified the concept of LAA, which was defined as the slope of the inferior surface of the acromion relative to the scapular glenoid plane. Additionally, the AHD that was measured as the smallest interval from the inferior surface of the acromion to the superior aspect of the humerus has an

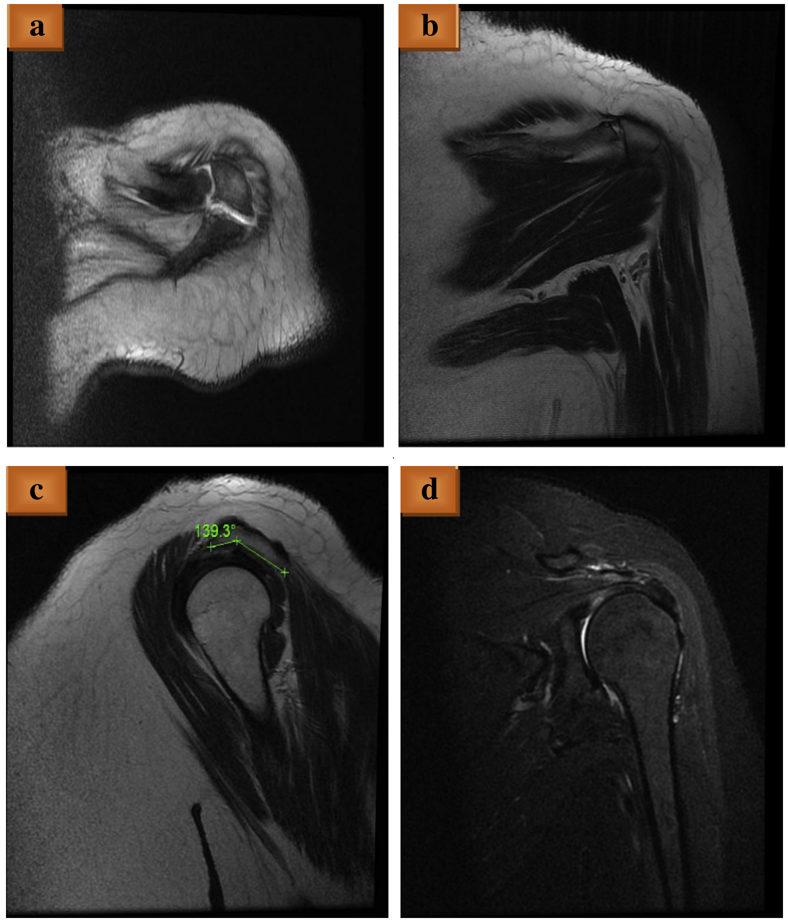

Fig. 9 (a–d): Revealed type III acromial shape in a female patient aged 47 years associated with os acromiale with subsequent partial thickness tear (articular side). The upper most axial sections of the upper shoulder at axial T2WI with fat suppression (a), demonstrated an unfused lateralmost ossification centers of acromion indicative of os acromiale. Coronal T2WI (b) showed the appearance of os acromiale which may be mistaken for normal acromioclavicular joint or acromial fracture. The sagittal oblique T2WI (c) showed the measurement of the angle between the anterior third and posterior two thirds of acromion (180–139.3° = 40.7°; more than 20°) and according to the mathematical classification scheme for MR images, type III acromial shape was identified. Fuerthermore, coronal T2WI with fat suppression (d) showed a partial thickness tear in the tendon of the supraspinatus muscle.

important clinical significance. As several soft tissues pass through this arch, such as infraspinatus, supraspinatus, and subacromial bursa, narrowing of this distance indicates the superior migration of humeral head which has been associated with the tearing of the rotator cuff tendons, especially the supraspinatus tendon (17).

The acromial measurements of the AI and the LAA determine the shape of the acromion, which may represent a useful marker to confirm the relationship with RCT (12). As our aim was to evaluate the acromial morphological variations in association with RCT, additional acromial measurements were added. These measurements revealed a significantly thicker acromion ($P = 0.002$) with significantly shorter AHD, larger AI and a smaller LAA ($P < 0.001$ for each parameter) in patients with RCT when compared to normal control. Furthermore, on comparing these measurements between each of the four acromial types in patients with RCT and the control group, we found that all these acromial measurements, including acromial thickness, AHD, AI and LAA, were significantly different between only type-III acromial shape and the control group. Additionally, Guishan and Ming (17) discussed the clinical significance of measuring the AI, LAA and AHD and they considered such measurements as morphological variations of the acromion and named them as ‘‘congenital and osteal etiological Factors’’ for RCT.

Type-III (Hooked), and type-II (curved) acromia are strongly associated with RCT and may contribute by causing tractional damage to the tendon. On the contrary, type-I (flat) acromia may have an insignificant involvement in cuff disease and accordingly may be best treated conservatively (5). Paraskevas, et al., (15) studied the clinical significance of the shape of the anterior third of acromion in relation to the impingement syndrome as well as to RCT. They reported that, in hooked acromia, the reduced dimensions of the subacromial space can explain such relation which more often leads to impingement of the rotator cuff tendon and subsequent tear production.

In the present study, we found a significant correlation of type-III acromial shape with full thickness RCT ($P = 0.016$). However, other studies (3,6) reported that the incidence of type-III acromial shape in patients with RCT is not highly significant and it does not always correlate with the occurrence of RCT, but the RCT size is significantly larger in type-III acromion rather than in other acromial shapes. Furthermore, in our study type-IV acromion shape was not recognized in patients with full thickness RCT and it was only present in two (5.2%) patients with partial thickness RCT. Also, the involvement of type-I acromion with RCT patients was not significant.

The shape and size of the acromion are due to fusion of the three ossification centers called meta-acromion, meso-acromion and pre-acromion which are recognizable at the age of 18 years. During that age another nucleus, the basi-acromion, has fused entirely with the spine of the scapula. Thereafter, the meta-acromion fuses to the scapula, while the pre-acromion and meso-acromion fuse at first to each other and then from the twenty first to twenty second years onwards to other portions of the scapula and the entire process is completed in the mid twenties (20). If these ossification centers persist, different types of os acromiale could be recognized. These types include the os acromiale commune, which is a result of failure in fusion between the meta-acromion and meso-acromion, and the os acromiale terminale, which is a consequence of failure in fusion between the pre-acromion and meso-acromion. Non-fusion of the meso-acromion with the meta-acromion is the most common type of os acromiale (21).

In the current study, we reported only one case of os acromiale. Its MR images demonstrated the existence of an unfused bony ossicle lateral to the lateral end of clavicle that was best recognized on axial images. Through using the mathematical classification scheme for MR images, type III acromion was recognized on sagittal images with its anterior inferior hook reducing the subacromial space with subsequent impingement and partial thickness tear of the supraspinatus tendon (Fig. 9). Os acromiale is one of the rare causes of rotator cuff tears and impingement syndrome. When the deltoid muscle contracts, it can cause inferior displacement of an unfused acromion fragment, thus impinging the rotator cuff. Furthermore, abnormal motion of the unstable segment at the fibrous union site may cause pain and rotator cuff tearing. The os acromiale can also decrease the volume of the sub-acromial space and cause impingement syndromes in some cases. Os acromiale is commonly unilateral and more frequent in type III acromial shape. Detection of the os acromiale on MR images is best achieved via using the axial sequence that includes the acromion (22).

There are some limitations to our study. First, the rotator cuff tendons may be mechanically irritated by some other morphological factors which were not included in this study. Second, small number of patients is another limitation. So, further studies with more considerable number of patients are recommended to elucidate these factors and completely confirm the relationship between acromial morphology and RCT.

In summary, acromial shapes are classified into four types. On MRI, acromial shapes are better recognized by using the mathematical classification scheme for MR images obtained just lateral to the acromio-clavicular joint. Our findings highlighted the morphological characteristics of different acromial shapes which may have value in diagnosing and treating subacromial pathologies. Such morphological characteristics include measurements of the acromio-humeral distance, acromial index and the lateral acromial angle by using T2W MRI coronal oblique images. These measurements may be a valuable adjuvant in assessment of patients who thought to have or to be at risk for rotator cuff disease. Moreover, type III acromial shape (in patients with RCT) revealed a significantly thicker acromion ($P < 0.001$), shorter AHD, larger AI and smaller LAA compared to the normal control, while the other types of acromial shapes demonstrated non significant differences of these measurements between patients and control groups. So, the small lateral acromial angle (less than 69.8°) and large acromial index (larger than 0.72) could be considered as risk factors for RCT. Additionally, a significant correlation is found between type-III (hooked) acromion and full thickness RCT. Therefore, type-III (hooked) acromion could be a risk factor for full thickness RCT. Furthermore, os acromiale is a rare predisposing factor of RCT.

Conflict of interest

The authors have no conflict of interest to declare.

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