THE ROLE OF MRI IN ASSESSMENT OF ACROMIAL MORPHOLOGY IN ASSOCIATION WITH ROTATOR CUFF TEAR

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ABSTRACT:

Background: *The pathogenesis of rotator cuff tear (RCT) remains controversial. The acromion portion of the scapula and its morphology may be attributable for a variety of shoulder disorders such as RCT.*

Aim of the work: *The purpose of this article is to throw light on the role of MRI in the assessment of morphological characteristics of different acromial shapes in association with RCTs.*

Patients and Methods: *This study was carried out at Ain Shams Teaching Hospital Radiodiagnosis Department. We used MRI prospectively to image the shoulders of patients who presented to the radiology department with suspected RCT. Their ages ranged between 24 and 73 years with a mean age 48 years. Data were tabulated and manipulated using SPSS (vi 16), and the level of significance was less than 0.05.*

Results: *Significant correlation between partial thickness tear and type I acromion was found (p value 0.02). Type-III acromion was the most commonly encountered acromial shape in patients with full thickness tear, yet no significant correlation was found (P > 0.05). The acromial thickness, AHD, AI and LAA were significantly different in patients with RCT compared to control group (P < 0.001).*

Conclusion: *Thicker acromion, shorter AHD, smaller LAA and larger AI are associated with rotator cuff tear. The types of acromion showed no significant correlation with full thickness tear.*

Keywords: *Magnetic resonance imaging, acromial morphology, rotator cuff tear.*

INTRODUCTION:

MRI of the shoulder provides detailed images of structures within the shoulder joint, including bones, tendons, muscles, and vessels. MRI is a noninvasive medical test that helps diagnose and treat medical conditions. It uses a powerful magnetic field, radio-frequency pulses, and a computer to produce detailed pictures of organs, soft tissues, bone, and virtually all other internal body structures. MRI does not use ionizing radiation (X rays). Detailed MRI allows physicians to evaluate various parts of the body and determine the presence of certain diseases [(1)].

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. Variation in the shape of the acromion can lead to a variety of pathologies such as impingement syndrome and rotator cuff tear[(2)].

Subacromial impingement and rotator cuff tears are common and often require surgical treatment. The underlying causes are still poorly understood. Whether intrinsic degenerative changes in the tendons or extrinsic mechanical compression by the acromion are responsible for rotator cuff tears is still a matter of debate [(3)].

The acromial shape can be classified into four types: type I (flat), type II (curved), type III (hooked), and type IV (convex). In some studies, a type-III acromion has been found to be associated with a higher prevalence of rotator cuff tears (Bigliani et al. 1986, 1991, MacGillivray et al. 1998)[(3)] whereas not all authors have found this (Ozaki et al. 1988, MacGillivray et al. 1998) [(3)]

Banas et al. (1995) described the frontal plane slope of the acromion on MRI and found a lower lateral acromial angle (LAA) in patients with rotator cuff disease. Balke et al. observed that the acromion of patients with a rotator cuff tear appeared to have a more lateral extension than that of patients with an intact cuff, and described the acromion index (AI). Despite the numerous studies that have been carried out in an attempt to support or refute Neer's original theory of extrinsic mechanical impingement as the primary etiology of rotator cuff disease, the role of the acromion is still unclear. [(3)]

We therefore evaluated 5 commonly used parameters of acromial morphology (acromial type, acromio-humeral distance, acromial thickness, lateral acromial angle, and acromion index) and their relationship to subacromial impingement and rotator cuff tears.

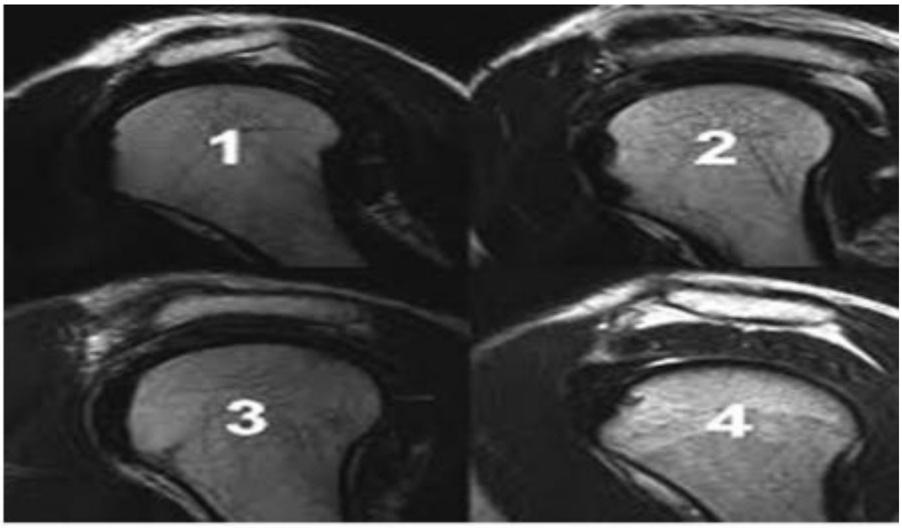

Figure (1): Types of acromial shape: 1, type I or flat type; 2, type II or curved type; 3, type III or hooked type; and 4, type IV acromion shape or convex type. [5]

PATIENTS AND METHODS:

This study was carried out in the Radiology department of Ain Shams hospital and included 60 patients presenting with chronic shoulder pain and suspected rotator cuff injury. These patients did not have previous surgery, fracture, or tumors of the shoulder. They underwent conventional MRI. Their ages ranged between 23 and73 years, with a mean age 48 years. 20 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 participant.

Imaging procedure:

All MRI images of our study were performed by using MRI 1.5T machine (Achieva abd Ingenia, Philips medical system, Eindhoven, Netherlands). A dedicated shoulder array coil was used. When imaging the shoulder 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.

Sequences:

Coronal oblique T1 (TSE, TR 450, TE 18, FOV 14, SL 4, MATRIX 205/512, NSA 3).

Coronal oblique T2 (TSE, TR 4000, TE 100, FOV 14, SL 4, MATRIX 201/512, NSA 2).

Coronal oblique PD-SPIR(TSE, TR 1800, TE 15, FOV 14, SL 4, MATRIX 201/512, NSA 2).

Axial PD-SPIR (TSE, TR 1800, TE 15, FOV 17, SL 4, MATRIX 179/512, NSA 3).

Axial T1 (TSE, TR 450, TE 18, FOV 14, SL 4, MATRIX 205/512, NS 3)

Sagittal oblique T2 (TSE, TR 4000, TE 100, FOV 16, SL 4, MTARIX 205/512, NSA 3).

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 degrees 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) [4]. Acromial thickness was also measured at the widest portion of the acromion on the perpendicular plane to the long axis of the acromion on the sagittal oblique plane just lateral to the acromioclavicular joint [5].

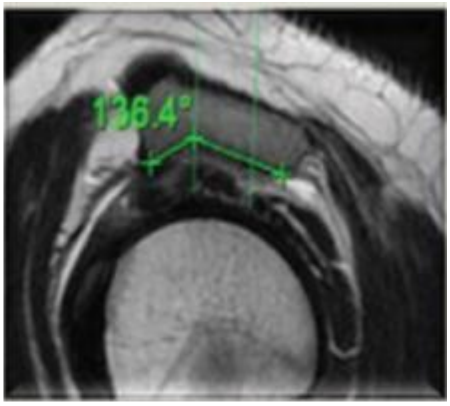

Figure (2): Mathematical determination of the acromial morphology. A line connecting most caudal points of the acromial undersurface was drawn on the parasagittal T2-weighted MRI, and with the help of two orthogonal lines, the acromion was divided into three segments of equal lengths. Then, the angle between the anterior third and the posterior two-thirds was measured.[1]

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 (figure 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). [6]

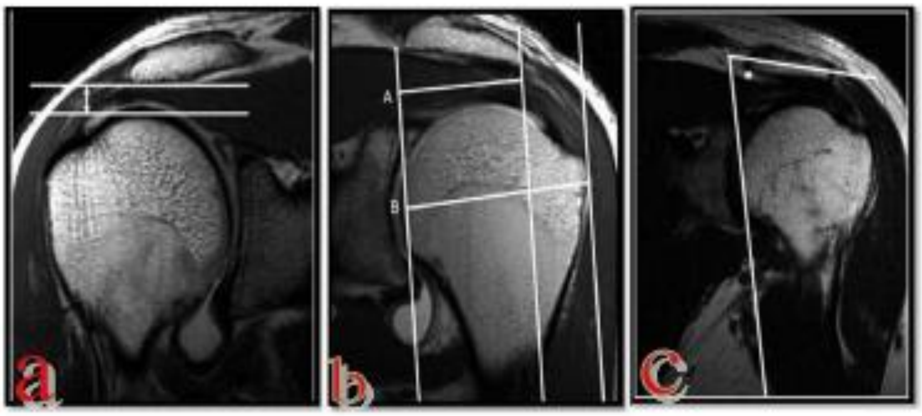

Figure (3): Methods of measuring acromio-humeral distance (AHD) (a), the acromial index (AI) (b) and the lateral acromial angle (LAA) (c) (Quoted from Lee et al. [6])

The RCT was diagnosed by MRI. The patients group with RCT was classified into full thickness tear, partial thickness tear and tendinopathy. 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 tear.[7]

Statistics:

Statistical analysis All collected data revised for completeness and accuracy. Precoded data were entered into the computer using the Statistical Package for the Social Sciences (SPSS) version 16 (SPSS Inc., Chicago, Illinois, USA), to be statistically analyzed. Data were summarized using the number and percent for qualitative variables. Comparison between qualitative variables was performed using the $\chi 2$ -test for qualitative variables. P-values less than 0.05 were considered to be statistically significant.

RESULTS:

This study included 60 patients with rotator cuff injury of which 32 were females and 28 were males. Their age ranged between 23 to 74 with mean age of 48. A control group of 20 patients with no rotator cuff injury were also included in the study. The age and sex distribution of the patients are demonstrated in tables 1 & 2.

Type III and type I acromion were the most encountered among male patients (32.1 % each) while type III was the most frequent in female patients (50%). Type IV however was the least frequent among male and female patients, respectively (7.1 & 3.1 %). In patients of 45 years of age and younger, type III was the most prevalent (50%), while in patients older than 45 years, type I & III were equally the most encountered (37.5 % each). All age and sex differences were not significant (P>0.005).

Table 1

Age	Acromion type				Test value	P-value	Sig.
	Type I	Type II	Type III	Type IV			
	No. = 19	No. = 13	No. = 25	No. = 3			
Mean ± SD	52.68 ± 12.69	48.08 ± 13.66	47.72 ± 12.81	38.00 ± 14.00	1.325•	0.275	NS
Range	24 – 72	27 – 64	24 – 73	28 – 54			
≤ 45 years (n=20)	4 (20%)	4 (20%)	10 (50%)	2 (10%)	3.328	0.344	NS
> 45 years(n=40)	15 (37.5%)	9 (22.5%)	15 (37.5%)	1 (2.5%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant •: One Way ANOVA test

Table 2

Gender	**Acromion type**				**Test value**	**P-value**	**Sig.**
	Type I	**Type II**	**Type III**	**Type IV**			
	No. = 19	**No. = 13**	**No. = 25**	**No. = 3**			
Female (n=32)	10 (31.2%)	5 (15.6%)	16 (50%)	1 (3.1%)	2.784*	0.426	NS
Male (n=28)	9 (32.1%)	8 (28.5%)	9 (32.1%)	2 (7.1%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant *: Chi-square test

Tables 3-5 show the distribution of acromial types in association with full thickness tears, partial thickness tears and tendinopathy. The current study revealed type III acromion shape were the most encountered in patients with full thickness tear (40%) while type I & II were the most encountered in patients with partial thickness tear (63 % & 53 % respectively). Additionally, type III & IV were the most seen in patients with tendinopathy (40% & 100 & respectively). Significant correlation between acromion types with partial thickness tear and tendinopathy was found (P value of 0.02 and 0.01 respectively) yet no significant correlation was found in patients with full thickness tear.

Table 3

Full tear	Acromion type				Test value	P-value	Sig.
	Type I	Type II	Type III	Type IV			
	No. = 19	No. = 13	No. = 25	No. = 3			
Absent	14 (73.7%)	9 (69.2%)	15 (60.0%)	3 (100.0%)	2.449*	0.485	NS
Present	5 (26.3%)	4 (30.8%)	10 (40.0%)	0 (0.0%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant *: Chi-square test

Table 4

Partial tear	**Acromion type**				**Test value**	**P-value**	**Sig.**
	Type I	**Type II**	**Type III**	**Type IV**			
	No. = 19	**No. = 13**	**No. = 25**	**No. = 3**			
Absent	7 (36.8%)	6 (46.2%)	19 (76.0%)	3 (100.0%)	9.757*	0.021	S
Present	12 (63.2%)	7 (53.8%)	6 (24.0%)	0 (0.0%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant *: Chi-square test

Table 5

Tendinopathy	Acromion type				Test value	P-value	Sig.
	Type I	Type II	Type III	Type IV			
	No. = 19	No. = 13	No. = 25	No. = 3			
Absent	18 (94.7%)	11 (84.6%)	15 (60.0%)	0 (0.0%)	15.820*	0.001	HS
Present	1 (5.3%)	2 (15.4%)	10 (40.0%)	3 (100.0%)			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant *: Chi-square test

Furthermore, acromions in patients group were significantly thicker than those in the control group. 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.

In the current study we reported one case of Os. Acromial of type I acromion shape in a patient presenting with shoulder pain and partial thickness tear of the supraspinatus.

DISCUSSION:

In our study we noticed that type III was the most encountered among patients with rotator cuff injury while type IV was the least encountered. Although there was no significant differences between different acromial shapes regarding age and sex (p > 0.2), Type III was most prevalent among females (50 %) while type I & III were equally encountered in male patients (32 % each). We also noticed that type I & III were seen more in patients above 45 years of age. The study done by Hassan et al.[1] also reported type III acromion as the most prevalent, however, it was more common in males than females, which did not match our study. They also noticed type III acromion more in patients aged above 45 years old. Similarly, there was no significant difference in terms of age and sex (P>0.2); with regard to the distribution of different acromial shapes in their study.

The current study revealed type III acromion shape were the most encountered in patients with full thickness tear (40%) while type I & II were the most encountered in patients with partial thickness tear (63 % & 53 % respectively). Significant difference between acromial shapes in partial thickness tear was found (p value = 0.02), yet no significant difference was found in full thickness tear. Pandey et al. [12] demonstrated no relationship between acromial morphology and supraspinatus tear (partial or full thickness; P = 0.06) with type II being the most prevalent in their study. The difference in results could be attributed to their larger sample size (105 patients with rotator tear compared to 60 in this study).

Paraskevas et al. [13] 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. Other studies [5,8] reported that the incidence of type III acromion 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 acromion shapes.

As our aim was to evaluate the acromial morphological variations in association with RCT; measurements of the different parameters were done for the patients' group and were compared to a control group (20 patients with no rotator cuff tear). These measurements revealed a significantly thicker acromion (mean 8.4 mm Vs 7.1 mm), shorter AHD (mean 7.6 mm Vs. 11.4 mm), larger AI (mean 0.68 Vs. 0.38) and lastly a smaller LAA (mean 76 Vs. 83). All p values were highly significant (<0.001) for each parameter.

Furthermore, on comparing these measurements between each of the four acromial types in patients with RCT and control group, we found significant difference between measurements of the patients and control groups among all types of acromion except for type IV, which only showed a higher AI in the patients group. This opposes the studies of Mohamed RE and Abo-sheisha DM [7], and Hassan et al. [1] where they only found significant difference between measurements in type III only.

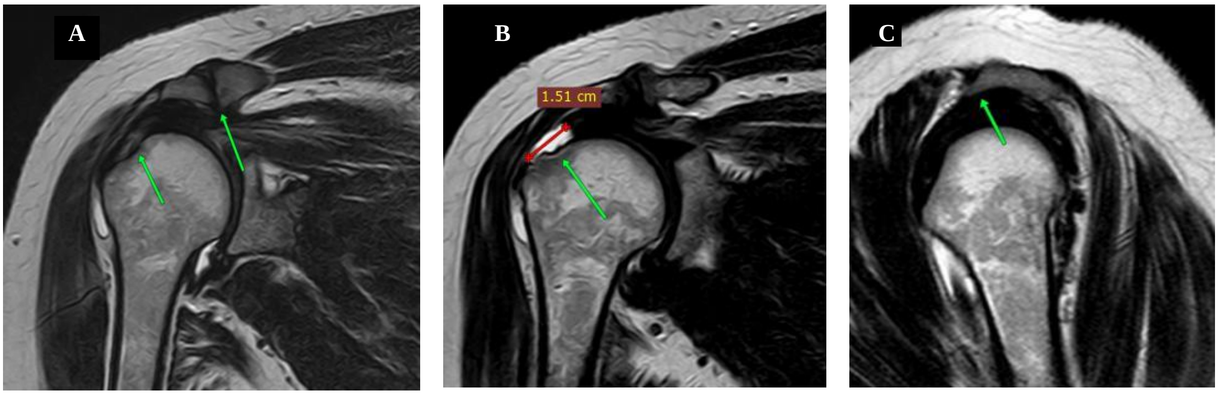

Figure (4): (a-c) 62 years old female patient presenting with shoulder pain, on conventional MRI coronal T2,STIR and sagittal T2 show hook shaped acromion with ACJ osteoarthritis and impingement of rotator cuff, complete tear of supraspinatus tendon with early muscle atrophy.

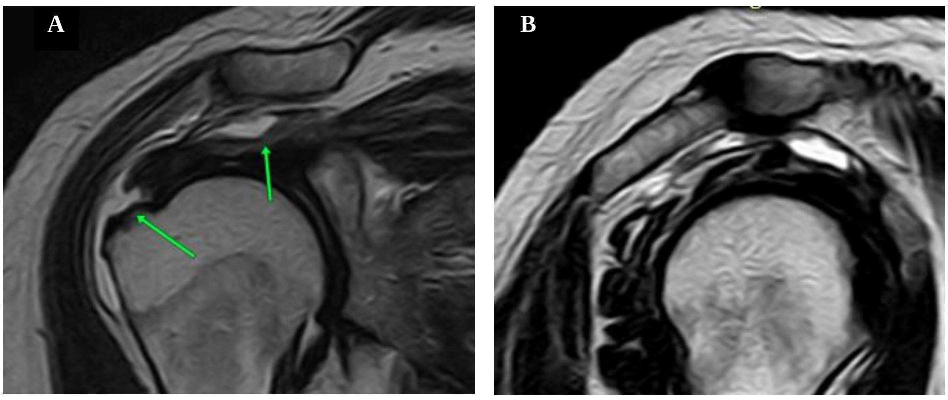

Figure (5): (a&b) A 49 years old female presenting with pain of the right shoulder and inability to raise her arm. Conventional MRI coronal T2 and sagittal oblique T2WI reveal; Full thickness tear of supraspinatus tendon with retraction and gap measuring about 0.8 cm, Type I acromion process, ACJ arthritis and subacromion bursitis indenting supraspinatus muscle.

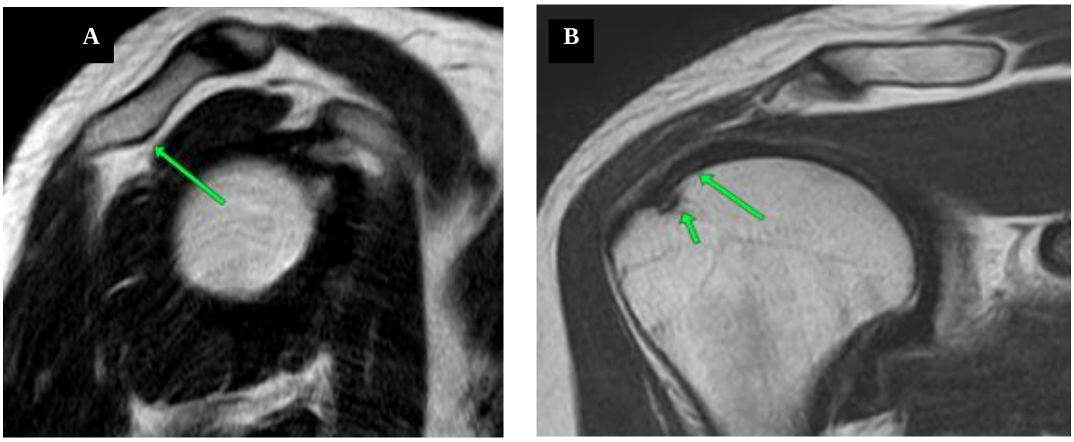

Figure (6): (a-b) 28 years old male complaining of right shoulder pain. Supraspinatus tendon altered signal yet intact fibers with subchondral cystic changes at insertion site denoting tendinopathy. Type IV acromion process was found.

In the current study, the mean acromion thickness in patients with RCT was significantly thicker than in control group (P = 0.00). Although this is in accordance with the conclusion of previous studies, there is a slight difference regarding the mean acromial thickness in patients with RCT. Where it was 8.6 mm in the study of Mohamed RE and Abo-sheisha DM [6] as well as the study of Hassan et al. [1] compared to 8.4 mm in our study. Also, the mean AHD was 7.5 mm in both their studies, compared to 7.6 mm in ours.

Banas et al. [9] and Balke et al. [3] showed a statistically significant correlation between the lateral acromial angle and cuff disease incidence as determined by MRI. Tetreault et al. [10] explained that the smaller the LAA, the smaller the volume for the shoulder components to fit, which results in increased pressure on the rotator cuff. When the lateral acromial angle was less than 70, the average age of patients with a complete rotator cuff tear was 54 years compared to an average age of 70 years in patients with cuff tears but an LAA greater than 70.

Although the LAA was higher than 70 in our study (mean 76) yet there was a statistically significant difference between the patient and the control groups. This was similar to the study of Hassan AA et al. [1] where they demonstrated a significant difference between patient and control groups, however, the LAA was 69 in their study. On the contrary, Maalouly et al. [11] found no statistically significant intergroup difference in terms of LAA.

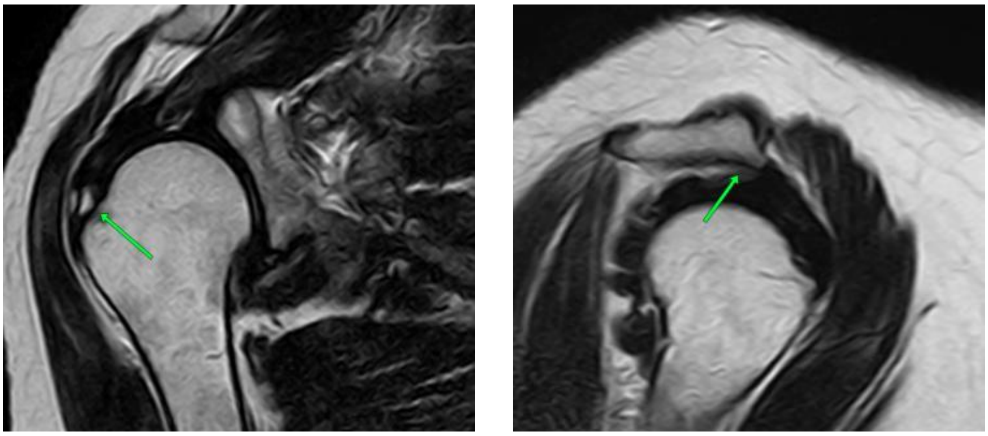

Figure (7): 37 years old female presenting with severe shoulder pain since once month. Coronal and saigttal T2 show supraspinatus partial thickness tear and acromion type III.

Os acromiale is one of the rare causes of RCTs 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 RCT. [1]

In the current study we reported one case of Os. Acromial of type I acromion shape in a patient presenting with shoulder pain and partial thickness tear of the supraspinatus. This matched the study of Mohamed RE and Abo-sheisha DM [7] where they reported a single case of Os. Acromial that was associated with partial thickness tear as well.

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.

Conclusion:

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 acromial thickness, 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.

Our study concluded no significant correlation between full thickness tears and different acromion types. However, Significant correlation between partial thickness tear and type I acromion was found. Patients with rotator cuff injury presented with significantly thicker acromion, shorter AHD, smaller LAA and larger AI, hence, these acromial parameters are valuable in assessing risk factors of rotator cuff disease. 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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دور الرنين المغناطيسي في تقييم الخصائص المورفولوجية من الأشكال الأخرمية المختلفة بالتعاون مع اصابة الكفة المدورة للكتف

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قسم الاشعة التشخيصية ـ كلية الطب ـ جامعة عين شمس.

خلفية البحث: لا يزال التسبب في تمزق الكفة المدورة مثيرًا للجدل. قد يُعزى جزء الأخرم من لوح الكتف وتشكله إلى مجموعة متنوعة من اضطرابات الكتف مثل تمزق الكفة المدورة.

الهدف من البحث: تهدف هذه الدراسة تقييم الخصائص المورفولوجية من الأشكال الأخرمية المختلفة بالتعاون مع الكفة المدورة للكتف باستخدام التصوير بالرنين المغناطيسي.

المرضى و طرق البحث: أجريت هذه الدراسة في قسم الاشعة التشخيصية بمستشفى عين شمس التعليمي. استخدمنا التصوير بالرنين المغناطيسي بأثر رجعي لتصوير أكتاف المرضى المترددون إلى قسم الأشعة و المشتبه في إصابتهم بتمزق في الكفة المدورة. تراوحت أعمارهم بين ٢٤ و ٧٣ سنة بمتوسط ٤٨ سنة. تم جدولة البيانات وعمل دراسة إحصائية لتحديد دقة النتائج، وكان مستوى الأهمية أقل من ٠.٠٥.

النتائج: تم العثور على ارتباط معنوي بين التمزق الجزئي للسمك والنوع الأول للأخرم ($P= 0.02$). كان الأخرم من النوع الثالث هو الشكل الأخرمي الأكثر شيوعًا في المرضى الذين يعانون من تمزق كامل السماكة ، ومع ذلك لم يتم العثور على ارتباط كبير($P > 0.05$). كانت قياسات سماكة الأخرم ، المسافة- الترقو عضدي، مؤشر الأخرم، وزاوية الأخرمية الجانبية مختلفة بشكل كبير في المرضى الذين يعانون من تمزق في الكفة المدورة مقارنة بمجموعة التحكم ($P<0.001$)

الاستنتاج: يرتبط الأخرم السميك ، المسافة الترقو-عضدي القصيرة ، زاوية الأخرمية الجانبية الأصغر ، ومؤشر الأخرم الأكبر بتمزق الكفة المدورة. لم تظهر أنواع الأخرم أي ارتباط معنوي بتمزق السماكة الكاملة للكفة المدورة.