# MAGNETIC RESONANCE IMAGING EVALUATION OF ROTATOR CUFF IMPINGEMENT

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**ABSTRACT**

**BACKGROUND**

Shoulder pain is a common clinical problem. Impingement syndrome of the shoulder is believed to be the most common cause of shoulder pain. The term 'impingement syndrome' was first used by Neer to describe a condition of shoulder pain associated with chronic bursitis and partial thickness tear of Rotator Cuff (RC). The incidence of Rotator Cuff (RC) tear is estimated to be about 20.7% in the general population. This study is intended to analyse various extrinsic and intrinsic causes of shoulder impingement.

**MATERIALS AND METHODS**

110 consecutive patients referred for MRI with clinical suspicion of shoulder impingement were prospectively studied. All the patients were evaluated for Rotator Cuff (RC) degeneration and various extrinsic factors that lead to degeneration like acromial shape, down-sloping acromion, Acromioclavicular (AC) joint degeneration and acromial enthesophyte. Intrinsic factors like degeneration and its correlation with age of the patients were evaluated.

**RESULTS**

Of the total 110 patients, 19 (17.3%) patients had FT RC tear and 31 (28.2%) had PT (both bursal and articular surface) tears. There was no statistically significant correlation (p=0.76) between acromion types and RC tear. Down-sloping acromion and enthesophytes had statistically significant association with RC tear (p=0.008 and 0.008, respectively). Statistically significant (0.008) correlation between the severity of AC joint degeneration and RC tears was noted. AC joint degeneration and RC pathologies also showed a correlation with the age of the patients with p values of <0.001 and 0.001, respectively.

**CONCLUSION**

No statistically significant correlation between RC pathologies with hooked acromion was found, that makes the role played by hooked acromion in FT RC tear questionable. AC joint degeneration association with RC tear is due to the association of both RC tear and AC joint degeneration with age of the patient. Down-sloping acromion, AC joint degeneration and enthesophytes proved to be independent variables significantly associated with RC tear.

**KEYWORDS**

Shoulder Impingement, MRI Shoulder, Rotator Cuff Impingement, Rotator Cuff Tear.

**HOW TO CITE THIS ARTICLE:** Chandrakanth KS, Nagolu H, Krishnakumar M. Magnetic resonance imaging evaluation of rotator cuff impingement. J. Evid. Based Med. Healthc. 2017; 4(51), 3116-3122. DOI: 10.18410/jebmh/2017/619

## BACKGROUND

Shoulder pain is a common clinical problem. Impingement syndrome of the shoulder is believed to be the most common cause of shoulder pain.[1] The term 'impingement syndrome' was first used by Neer[2] to describe a condition of shoulder pain associated with chronic bursitis and partial thickness tear of Rotator Cuff (RC). The incidence of Rotator Cuff (RC) tear is estimated to be about 20.7%[3] in the general population.

Four important extrinsic factors have been implicated in the external impingement of shoulder rotator cuff degeneration and tear like acromial shape, down-sloping acromion, acromioclavicular joint degeneration and acromial enthesophytes. All these factors either alone or in combination tend to reduce the subacromial space and entrap the rotator cuff tendon and subacromial bursa, especially in the abducted elevated posture of the arm, leading to impingement and subsequently tear of rotator cuff tendon. Initial studies by Neer et al and Bigliani et al were the basis of the popular theories of 'external impingement' as the cause of RC tear. While, the cause - and - effect relationship between external factors like acromial morphology and Subacromial Impingement (SAI) was studied by Neer, Bigliani et al[4] correlated the type of acromion with the incidence of full thickness RC tear and identified three types of acromial morphology; Type 1 - Flat, Type 2 - Curved, Type 3 - Hooked. A high (70%) prevalence of Full Thickness (FT) RC tears was noted to be associated with type 3 acromion. A fourth type of acromion shape (type 4) has also been recently described.[5] Acromion angle is also considered to be important factor in SAI leading to degeneration of RC and subsequent tear.[6] A low lying

*Financial or Other, Competing Interest: None.*
*Submission 11-05-2017, Peer Review 18-05-2017,*
*Acceptance 31-05-2017, Published 24-06-2017.*
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*DOI: 10.18410/jebmh/2017/619*

acromial position relative to the distal clavicle may decrease the space between the acromion and the humerus and may predispose certain individuals to shoulder impingement.[7] Spurs on anterior and inferior aspect of acromion arise at the acromial attachment of coracoacromial ligament and maybe strongly associated with the incidence of RC tear.[8] Subacromial spurs were considered to be more correlative marker of SAI changes and RC disease.[9] Although, these studies have been widely cited in the literature,[5] the recent investigations questioned their reliability and reproducibility.

With the introduction of USG and MRI of the shoulder, the radiological evaluation of shoulder disorders has undergone marked change. While ultrasound is mainly used as a screening tool in the evaluation of RC pathologies, MRI has established itself as the definitive modality in evaluating the RC as well as bony and other soft tissue structures around the shoulder. MRI findings have shown over the years that the incidence of RC tears increases linearly with age of the patient.[10] In the light of MRI findings, few authors have come up with 'intrinsic' theories as the cause of RC pathologies, which implicate intrinsic factors like age related RC degeneration, muscle weakness and overuse as the primary factors leading to RC tear. Studies by McCallister et al[11] showed good results of RC repair performed without acromioplasty and Budoff et al[12] noted that debridement of Partial Thickness (PT) tears of the RC without acromioplasty is clinically beneficial as well. The recent operative techniques to treat RC tears also employ tendon debridement alone and RC repair without acromioplasty,[11] further questioning the exact role of extrinsic factors in impingement.

In view of contradictory theories, it becomes imperative to re-emphasise the role played by various factors supposedly causing extrinsic impingement as they might still have important bearing on the management of RC pathology. The accuracy of MRI in diagnosing RC pathology and other shoulder pathologies has been studied extensively.[13-14] Hence, in this prospective study, the hypothesis that extrinsic factors are predominantly responsible for RC tear was tested. The aim of the study is evaluation of rotator cuff pathology on MRI and to study its association with various factors of extrinsic impingement like acromial shape, down-sloping acromion, acromioclavicular joint degeneration, acromial enthesophytes and intrinsic factors like age and degeneration of tendons.

## MATERIALS AND METHODS

The study was conducted in a tertiary care setup. Consecutive 110 patients over a period of 1 year 5 months from January 2015 to May 2016 were included in the study. The patients were referred to our department for MRI of shoulder with a clinical diagnosis or suspicion of impingement syndrome. Patients who had history of trauma to shoulder, postoperative status of the ipsilateral shoulder and patients with a known inflammatory arthritis of multiple joints were excluded from the study. Patients with contraindications for MRI examination were also excluded from the study. MRI was performed using a 1.5T super conducting machine (Intera, Philips). Dedicated phased array coil (SENSE coil) was used for improvement in the signal to noise ratio. All the images were reviewed on Philips work station by two radiologists with at least five years' experience. Each patient was evaluated for the following parameters- 1. RC morphology; 2. Acromion shape; 3. Lateral acromion angle; 4. Acromioclavicular joint degeneration; 5. Enthesophyte at the lateral margin of acromion process.

RC morphology was classified into 4 types using the following criteria- 1. Normal- Normal uniform signals in all the pulse sequences with smooth margins and normal thickness; 2. Degeneration/tendinosis - Increased signals in the tendon on T2W images, which are not approaching fluid signals and which became normal or showed only mild increase in signals on T1W images; 3. Partial thickness tear- Partial disruption of the RC tendon involving either bursal or articular surfaces and not involving both surfaces simultaneously and showing increased signals on T2W/fat suppressed T2W images, which approach fluid signals; 4. Full thickness tear- If there is abnormal fluid signals on T2W images in the RC tendon approaching both articular and bursal surfaces.

Shape of acromion process was evaluated using sagittal T1W images with the plane passing just lateral to the AC joint.[15] Anterior end of acromion process visible in the sagittal plane was divided into three parts using three points along the inferior cortex.[15] If all three points are along the straight line, it was considered as type I (flat). If there was a curvature in the middle part, it was considered type II (curved). If the acromion process showed a curve in the distal third, it was considered type III (hooked). If the inferior surface of the acromion is convex to the humeral head, it was considered type IV.

The lateral acromion angle in the coronal plane was measured by drawing a line through the midsubstance of clavicle and another line through the midsubstance of the acromion process.[16] The angle between the two lines is classified as neutral or non-down-sloping when the angle was 0 to 10 degrees, down-sloping when the angle was more than 10 degrees.

Acromioclavicular joint degeneration was graded on a 1-3 scale (mild, moderate and severe) according to the following criteria.[17] Grade 1 (mild)- Joint space narrowing and/or irregularity of the joint margins and/or presence of high signal in T2W images in the joint. Grade 2 (moderate)- Grade 1 plus the presence of subchondral cysts and/or bone sclerosis and/or small osteophytes (<2 mm) around the joint. Grade 3 (severe)- Features of Grade 2 plus the presence of large osteophytes (>2 mm) and/or soft tissue proliferation and/or mass effect on the RC beneath the AC joint. Joint was considered Grade 0 (normal) if the margins were smooth with none of the above-mentioned features.

All continuous data was represented by mean with standard deviation and categorical data was reported as absolute number of patients and/or percentage of the group studied and was compared using Chi-square test and Fisher exact test. All the analysis was done by using SPSS 14.0

version. A probability (p) value less than 0.05 was considered as significant.

## RESULTS

The study included 110 patients with 52 males and 58 female patients. Male:female ratio was 0.89 in the study population. The mean age of male subjects was 46 yrs. (range of 19 to 69 yrs.) and of female subjects was 50 yrs. (range of 25 to 68 yrs.).

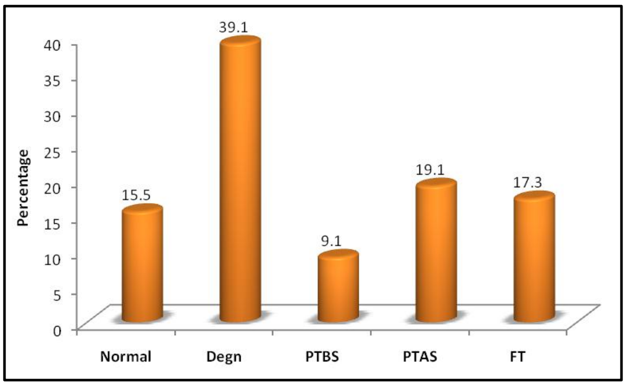


***Image 1. Frequency Distribution of RC Morphology***

The incidence of degeneration of RC was 39% (43 patients) (image 1). PT tears accounted for 28.2% of cases with 10 patients showing bursal surface tears and 21 patients showing acromial surface tears. Interestingly, of these PT tears, 67% were on the articular surface. FT tears accounted for 17.3% of pathologies (19 patients).

| Acromion Type | RC Findings | | | | | Total | P value |
|---|---|---|---|---|---|---|---|
| | Normal | Degeneration | PT BS Tear | PT AS Tear | FT Tear | | |
| I | 8 | 20 | 5 | 7 | 7 | **47** | 0.768 |
| II | 8 | 13 | 2 | 9 | 6 | **38** | |
| III | 1 | 9 | 3 | 4 | 6 | **23** | |
| IV | 0 | 1 | 0 | 1 | 0 | **2** | |
| **Total** | **17** | **43** | **10** | **21** | **19** | **110** | |

***Table 1. Distribution of Acromion Types with Respect to RC Morphology***

The distribution of individual acromion types in relation to RC pathologies is shown in Table 1. Type I acromion had the maximum incidence with 42% (46 of 110 patients). Type II acromion had a 34% incidence (38 of 110) and type III acromion had a 21% incidence (23 of 110 patients). The acromion types and RC pathologies were not associated (p=0.768). 26% (6 out of 23) patients with type III acromion showed FT RC tear. 56% (13 of 23) patients with type III acromion had PT or FT RC tear. 44% (17 of 23) patients with type II acromion had PT or FT RC tear. 40% (19 of 47) patients with type I acromion had PT or FT RC tear. Only 1 (5%) patient with normal RC morphology had type III acromion.

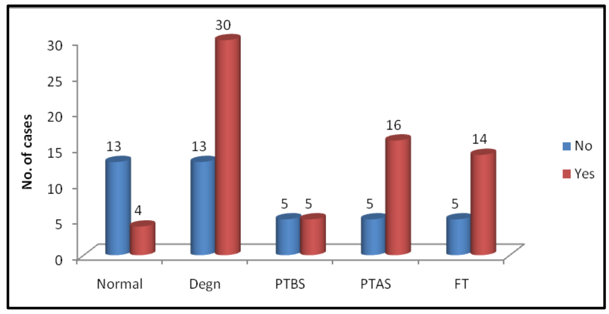


***Image 2. The Distribution of Individual Acromion Types in Relation to RC Pathologies***

There was a significant statistical correlation between acromial angle and incidence of RC tears (p=0.004) (image 2). 70% (35 of 50) of patients with RC tears had down-sloping acromion; 50% (35 of 69) of patients with down-sloping acromion had RC tears, whereas 36% (15 of 41) of patients without down-sloping acromion showed RC tears.

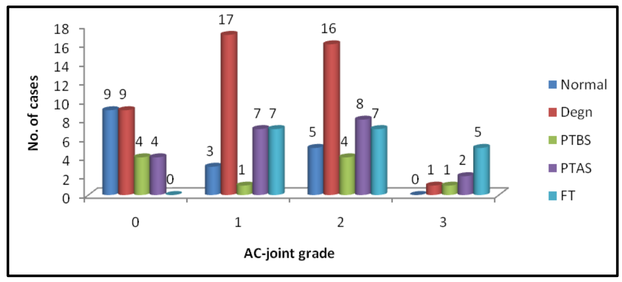


***Image 3. Relationship of AC Joint Degeneration with RC Pathology***

Likewise, AC joint degeneration had a significant (P=0.008) association with the RC pathology (image 3). Of the 9 patients with Grade III AC joint, 4 patients (55%) had FT tear. Of the 40 patients with grade II AC joint, 12 patients (30%) had PT tear of RC and 7 patients (17%) had FT tear of RC.

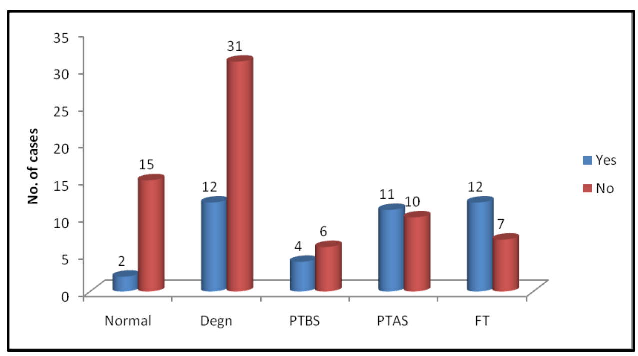


***Image 4. Correlation of Enthesophytes with RC Pathologies***

Enthesophytes showed a statistically significant correlation with RC pathologies (p=0.008). A total of 41 patients had enthesophytes and the incidence of RC tear in this population was 65% (27 patients). Patients with FT RC tear had a 63% (12 of 19 patients) incidence of enthesophyte (image 4).

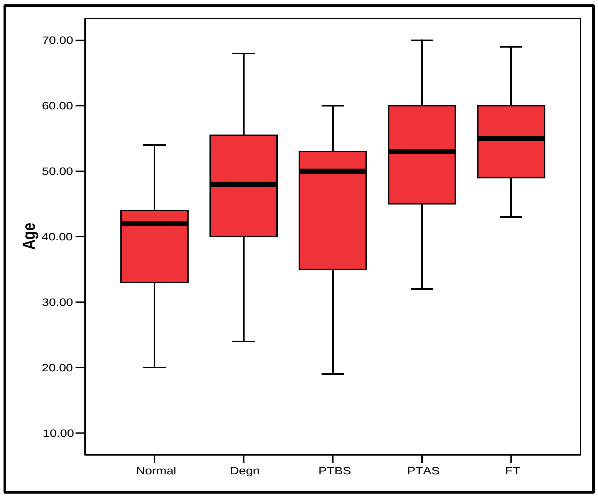


***Image 5. Box-Plot Chart Showing Correlation of RC Pathologies with Age of Patients***

The occurrence and severity of RC pathologies showed a statistically significant increase with increasing age of the patients (p=0.001). The mean age of patients with full thickness tear was significantly higher than those with degeneration or PT tears (image 5).

| AC Joint Grade | Number | Mean | Std. Deviation | P value |
|---|---|---|---|---|
| 0 | 26 | 39.1154 | 12.27136 | <0.001 |
| 1 | 35 | 50.1429 | 11.56858 | |
| 2 | 40 | 50.4750 | 10.28563 | |
| 3 | 9 | 53.7778 | 7.46287 | |
| **Total** | **110** | **47.9545** | **11.98040** | |

***Table 2. Correlation of AC Joint Degeneration with Age of Patient***

The mean age of the patients showing Grade III AC joint degeneration was 53.7 yrs., while that showing Grade I and II were 50.1 and 50.4 yrs., respectively (Table 2). The distribution of AC joint degeneration also showed statistically significant (p<0.001) association with age. With increasing age of the patient, the AC joint showed higher grade of degeneration.

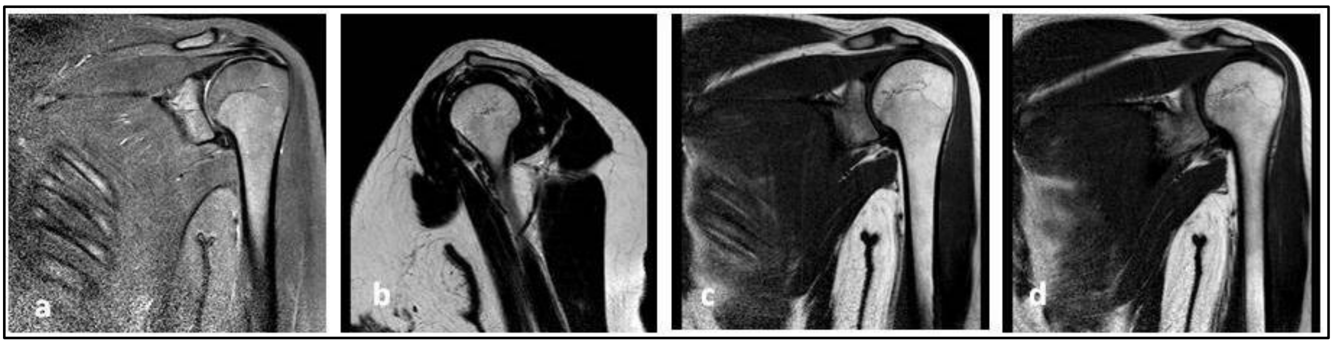


***Image 6. MR Images of 27 yrs. Old Showing (a) Normal RC Tendon, (b) Type I Acromion, (c) Non-Down-Sloping Acromion, (d) Grade 0 AC Joint***

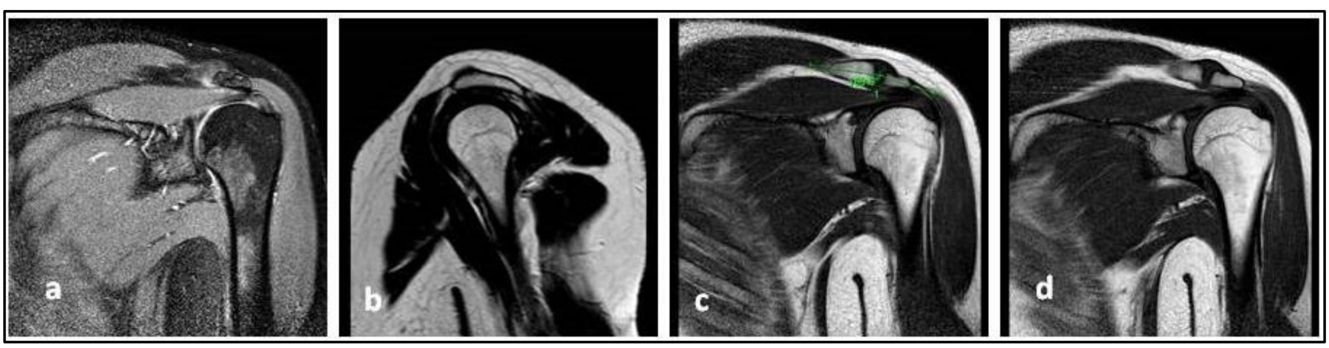


***Image 7. MR Images of 48 yrs. Old Showing (a) Degeneration of RC Tendon, (b) Type 2 Acromion, (c) Down-Sloping Acromion, (d) Grade 1 AC Joint Degeneration***

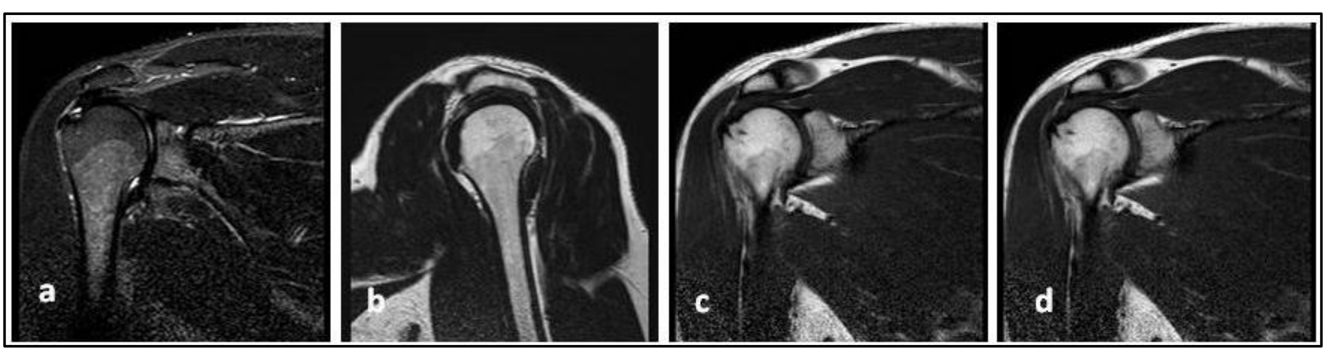


***Image 8. MR Images of 37 yrs. Old Showing (a) PT Tear of RC, (b) Type 3 Acromion, (c) Down-Sloping Acromion, (d) Small Enthesophyte***

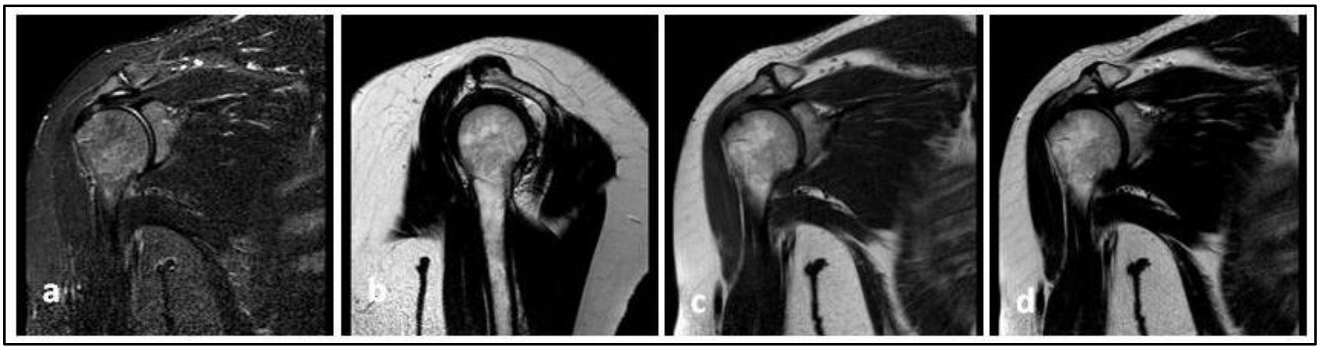

***Image 9. MR Images of 51 yrs. Old Showing (a) Bursal Surface PT Tear of RC Tendon, (b) Type 3 Acromion, (c) Down-Sloping Acromion, (d) Grade 3 AC Joint***

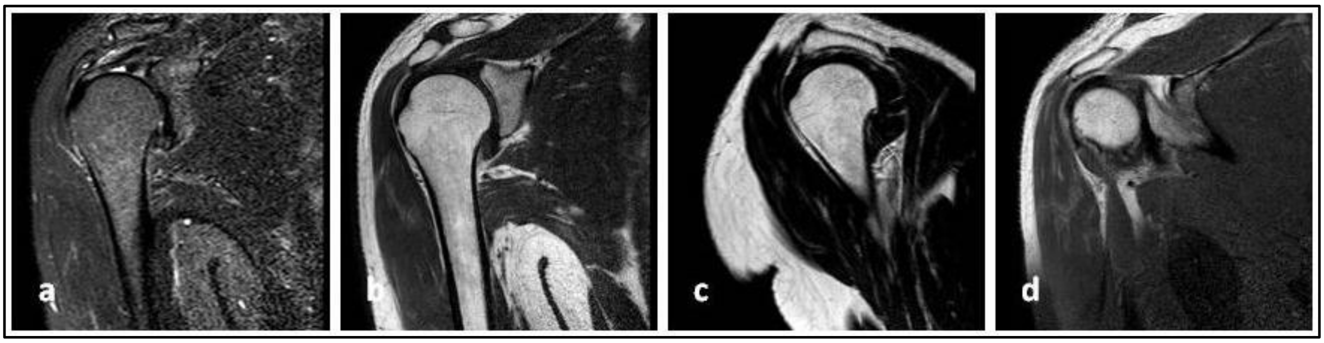

***Image 10. MR Images of 32 yrs. Old Showing (a) Articular Surface PT Tear of RC Tendon, (b) Down-Sloping Acromion, (c) Type 2 Acromion, (d) Enthesophyte***

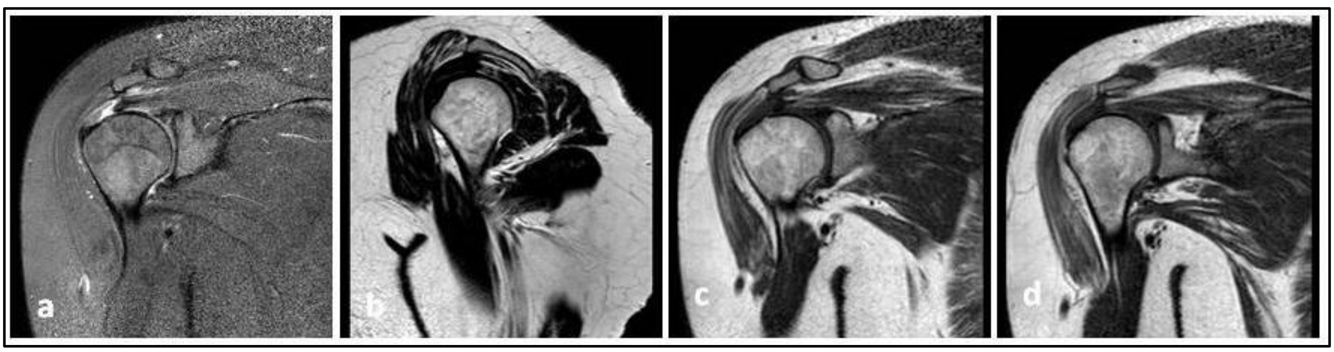

***Image 11. MR Images of 55 yrs. Old showing (a) FT Tear of RC, (b) Type 3 Acromion, (c) Down-Sloping Acromion, (d) Large Enthesophyte***

**DISCUSSION**

This prospective study attempted to verify the most cited theories of RC pathology- impingement by acromion and various processes that reduced subacromial space for the movement of RC tendon using MRI of shoulder joints.[3,4] In the present study population, the distribution of acromion types were as follows- 42% type I, 34% type II and 21% type III. Patients with FT RC tear showed 36% type I acromion, 31% type II acromion and 31% type III acromion. The prevalence of FT RC tear is 14%, 15% and 26% in patients with type I, type II and type III acromion, respectively. The mean acromial angle in acromion types were as follows- Type I acromion is 17.4°, Type II acromion is 17.2° and Type III acromion is 21.5°.

The results of our study correlated with the previous studies (Bigliani, Epstein et al) with increasing incidence of RC tear (both PT and FT) with type III acromion (56%), compared to type I (40%) and type II (44%), but it did not reach statistical significance. The explanation for this appears to be multifactorial. Our study population showed a relatively low frequency of type III acromion (21%) compared to Bigliani (39%) and Robert E Epstein (32%). The relatively low mean age of our study population compared to other studies may partly explain the relatively low 17.3% incidence of FT tear and 21% incidence of Type III acromion in our study group.

Needell et al[18] have shown that the incidence of RC tendon abnormalities clearly increases with patient's age. Present study also showed clear association of the RC pathologies with age of the patients as the mean age of patients having normal RC tendon was 39 yrs. and those with FT RC tear was 54 yrs.

Lateral acromion angle measured with respect to clavicle showed a statistically significant association (p value=0.004) with RC pathologies. 73% of patients with FT RC tear had down-sloping acromion, whereas 67% of patients with PT RC tear showed down-sloping acromion. This correlates well with the previously published data. Tuite et al[19] studied 101 patients using arch view radiograph and found the average acromion angle in patients with FT RC tear was 30 degrees, whereas in patients with instability without impingement, it was 20 degrees.

Two further factors showing statistically significant association with RC pathology were AC joint degeneration and enthesophytes. In our study population, 100% of patients with FT RC tear had AC joint degeneration. With Grade I AC joint degeneration, the incidence of RC pathology was 30%, which rose to 89% in patients with Grade III AC joint degeneration. Enthesophytes were seen in 54% of patients with RCT. Of the 41 patients with enthesophytes, 27 patients had RC tear (p=0.008) (images 6 to 11). The observations of this study were in agreement with previously published literature by Kessel et al[20] who found that one third of patients had pain in the superior aspect of the RC and these patients to be associated with AC joint degeneration. Excision of the outer end of clavicle and division of the coracoacromial ligament abolished the pain in these cases. Petersson et al[21] found 51% of patients with RC tear had distally pointing osteophytes of the AC joint, whereas only 14% of normal shoulder had AC joint osteophytes.

A statistically significant correlation between the age of the patient and RC tear (p=0.001) was found in this study. The incidence of RC tear was seen to increase with age of the patient. The mean age of patients with normal RC tendon was 39 yrs., those with PT RC tear was 51 yrs. and those with FT RC tear was 54 yrs. This finding is in concordance with Sher et al[10] who found that 54% of patients more than 60 yrs. old who were asymptomatic had a RC tear and concluded that the frequency of FT and PT tears increased significantly (p<0.001 and 0.05, respectively) with age. As noted earlier, AC joint degeneration showed a significant association with the age of the patients (p<0.001). Hence, this study implies that AC joint degeneration association with RC tear is due to the association of both RC tear and AC joint degeneration with age of the patient. The sex of the patient did not have any correlation with the RC pathology (p=0.17).

Glenohumeral joint effusion was found in 39 patients (35.4%) in present study population and was seen in all patients with full thickness RC tear. Glenohumeral joint effusion was nonspecific to impingement. Since, previous studies have shown that effusion has no correlation with either diagnosis or grade of impingement,[22] this was not tested in detail in present study.

Apart from acromial sloping and angle, os acromiale is an important anatomical variant that can be associated with impingement. Os acromiale is an accessory ossification center, which is seen in 5% of population, which can either be confused with acromial fracture and can also cause impingement if it is unstable owing to inferior traction during abduction of the deltoid.[23-25] However, none of the patients in our study showed evidence of os acromiale. Many other ligamentous and labral variants have been described in shoulder, which does not have direct causal effect on the impingement.[26,27]

Reduced acromiohumeral interval was shown to be associated with RC degeneration and tendinopathy. This is a reliable measurement in AP shoulder radiograph and is an indirect evidence of RC pathology, which in turn can be due to combined effect of intrinsic and extrinsic factors affecting impingement. On MRI, this interval is smaller and inaccurate than radiographs, causes of which can be multifactorial like different patient positions for MRI and radiographs with differing muscle tensions and geometric factors and hence was not considered in evaluation in present study.[28]

There were several limitations in present study. We could not correlate the findings on MRI with operative findings. This was partly due to the transient (floating) nature of the referred patient population. Comparison with various fluoroscopically-guided radiographic views of the acromion would have validated even more, our conclusion that hooked acromion is not associated with FT RC tear as radiographs were the basis of original classification. Also, we did not employ a blinding technique while evaluating the MR images, though strict criteria were used to interpret the images to minimise any bias.

## CONCLUSION

The purpose of this work is to review the relative roles played by various extrinsic factors supposed to be causally associated with rotator cuff tear. Our study found that there is a trend towards increasing RC pathologies with hooked acromion, but it was not statistically significant. This opens up the debate wide open about the role played by hooked acromion in FT RC tear. The study also showed that age is significant predictor of RC pathologies and relative low mean age, along with the relative low frequency of hooked acromion itself might have contributed to the low prevalence of FT tear in hooked acromion. Down-sloping acromion, AC joint degeneration and enthesophytes proved to be independent variables significantly associated with RC tear. The facts that majority of PT tears arise from articular surface and strong age dependent increase in the incidence of RC pathologies indicate that intrinsic degeneration of the RC tendon play a significant role in the aetiopathogenesis of RC tears.

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