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MRI Role in the Evaluation of Rotator Cuff Injuries of Shoulder Joint

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Abstract
The shoulder joint is an incongruous ball and socket joint without any fixed axis of rotation, which has a wide range of motion in multiple planes hence stability is compromised for mobility. to describe magnetic resonance imaging features of rotator cuff injuries and to examine the influence of age and sex in the distribution of rotator cuff pathology among the population studied. This descriptive study was performed among patients referred to the Department of Radiodiagnosis, RMC GGH KAKINADA, for MRI shoulder with suspected shoulder injuries. The age distribution found in the study is between 14 and 74 years with the mean being 51.85. The frequency of cuff pathologies among males is 55% and in females is 45% in this study. The common presenting feature among the patients with rotator cuff disease is pain followed by stiffness of the joint. About 50% of patients had type II or type III acromion (25% each) thus resulting in supraspinatus tendon impingement. Coracohumeral distance reflects the space between the coracoid process and the humeral head occupied by the subscapularis tendon. Acromiohumeral distance is the space between the acromion and the humeral head which is occupied by the supraspinatus tendon. A reduction in this space can cause supraspinatus impingement. Magnetic Resonance Imaging is very useful in depicting rotator cuff disease for prompt diagnosis along with the predisposing factors like the acromion type and orientation, reduction in coracohumeral distance, reduced acromioclavicular distance and other associated features like effusion, bursitis and bone changes.

INTRODUCTION

The common disorders involving the rotator cuff tendons include impingement and tendinopathy. It is a dynamic process leading on from degeneration to tears in these tendons. There is an emerging consensus that the rotator cuff pathologies are multifactorial-Extrinsic and Intrinsic mechanisms[1]. Microtrauma causing stress on the tendon leading on to microtear is the basis of extrinsic mechanism[1]. According to the intrinsic mechanism, degeneration of the tendon and zones of critical vascularity predisposes tear in the tendon even on low energy mechanism.

A thorough understanding of the anatomy and function of the rotator cuff and of the consequences of rotator cuff disorders is essential for optimal treatment planning and prognostic accuracy. Identifying the disorder, understanding the potential clinical consequences, and reporting all relevant findings at rotator cuff imaging are also essential[2].

MRI has become the gold standard for detecting both subtle and obvious internal derangement and assessing overall joint structure. MRI can provide information about rotator cuff tears such as tear dimensions, tear depth or thickness and tear shape, the involvement of adjacent structures (e.g., rotator interval, long head of biceps brachii tendon etc.) and muscle atrophy, all of which have implications for rotator cuff treatment and prognosis. Information about coracoacromial arch and impingement as it relates to rotator cuff tears can also be obtained with MRI[5]. Artefacts generated by respiratory and cardiac motion are not a problem in MRI of the joints as they are in MR scanning of the body[3].

Currently, Magnetic Resonance Imaging with the advent of surface coils is becoming the modality for the imaging of soft tissues around the shoulder joint. Good knowledge regarding the MR characteristics of rotator cuff tendons and the abnormality in these tendons is necessary for appropriate diagnosis and planning of management.

It is in this backdrop., the objectives set out in this research programme will enable us to understand the pathological conditions of the rotator cuff tendons of the shoulder joint and also provide an insight into the intricacies involved in the MR imaging characteristics of the rotator cuff disorders and the predisposing factors of the same. In addition the gender and age distribution among the study group, presenting symptoms and the implication associated with cuff pathologies if any will be examined.

MATERIALS AND METHODS

This descriptive study was performed among patients referred to the Department of Radiodiagnosis, RMC GGH KAKINADA, for MRI shoulder with suspected shoulder injuries. Patients who were found to have rotator cuff injuries in the MRI examination were studied. This consists of 40 patients with Rotator cuff lesions detected on magnetic resonance imaging of the shoulder joint from November 2016-October 2018. The MRI was done on the advice of the referring doctor, and no patient was made to undergo MRI for the sole purpose of this study.

Inclusion Criteria:

- Patients who were suspected clinically with the possible shoulder injury referred for MRI evaluation and shown to have rotator cuff tendon abnormalities were included in the study.
- Cases of all age groups irrespective of sex

Exclusion Criteria:

- Postoperative patients.
- Known case of rotator cuff lesions on treatment.
- All patients with clinical evidence of rotator cuff lesions in whom an MRI
- examination is contraindicated were excluded for ,eg. Patients with any
- electrically, magnetically or mechanically activated implants (including
- cardiac pacemakers, biostimulators, neurostimulators, cochlear implants and
- hearing aids) etc. which are MRI incompatible.

Data Acquisition: After clinical evaluation, once the patient satisfies the inclusion and exclusion criteria for this study, he or she would undergo the MRI evaluation after taking a consent. All the MRI scans in this study were performed using 1.5 T MRI scanner (GE BRIVO) at RMC, Kakinada.

The patient is positioned in the supine position with external rotation of the arm. Adequate support for head and the limb is provided. Dedicated surface coil for the shoulder is used.

Statistical Methods: Data were entered into Microsoft excel sheet and was analysed using EPI Info 7 version software. Qualitative data was represented in the form of Frequency and Proportion.

RESULTS AND DISCUSSIONS

The age of patients with rotator cuff pathologies studied ranged from 14-74 years, with a mean of 51.85. Rotator cuff injuries among the study group showed a peak in 6th and 7th decade of life, 25% and 37.5% respectively. of the 40 patients studied, 22(55%) were males and 18 (45%) were females. The Mean age among males was 48.03, and the mean age among females was 58.56

Fig. 1:Complete tear of right supraspinatus tendon with torn fibersretraction gap 3cm)

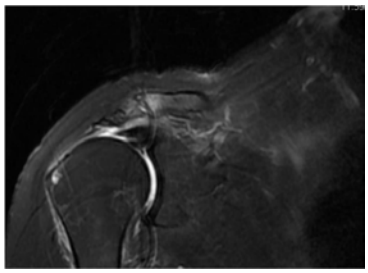

Fig. 2: Coronal t2 fs showing subchondral bone cyst in the greater tuberosity and partial tear of infraspinatus tendon

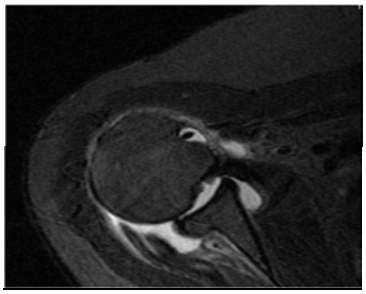

Fig. 3:Xial stir image showing fullthickness infraspinatus tendon tear With retraction of the ends, joint effusion, fluid around the Biceps and subscapularis tendon

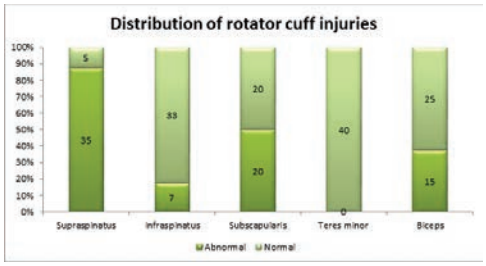

Fig. 4: Distribution of rotator cuff injuries

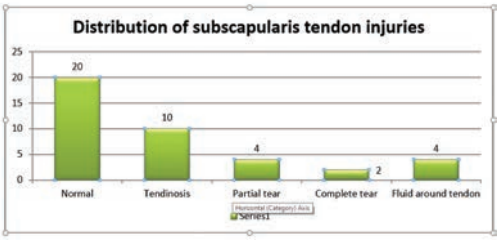

Fig. 5: Distribution of subscapularis tendon injuries

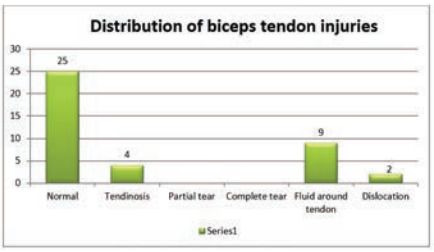

Fig. 6: Distribution of bicepd tendon injuries

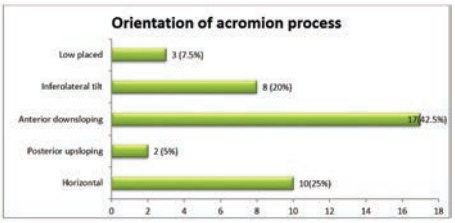

Fig. 7: Orientation of acromion process

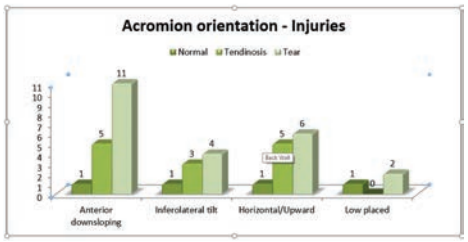

Fig. 8: Acromion orientation-Injuries

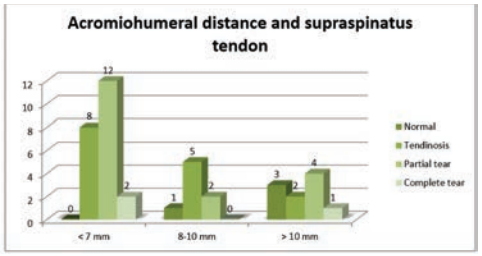

Fig. 9:Acromiohumeral distance and supraspinatus tendon

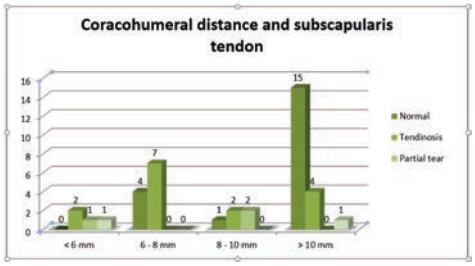

Fig. 10: Coracohumeral distance and subscapularis tendon

Table 1 : The following chart shows the various abnormalities in the supraspinatus tendon and the age range of occurrence in our present study

Status of Supraspinatus	Age Range (years)							Total
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	
Normal	1	1	0	2	1	0	0	5
Tendinosis	0	2	1	1	4	4	1	13
Partial tear	0	2	2	2	4	9	0	19
Complete tear	0	0	0	0	1	2	0	3
Total	1	5	3	5	10	15	1	40

Table 2 : The following chart shows the various abnormalities in the subscapularis tendon and the age range of occurrence in our study

Status of Subscapularis	Age Range (years)							Total
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	
Normal	1	3	1	1	7	6	1	20
Tendinosis	0	1	2	3	2	3	0	11
Partial tear	0	1	0	1	0	2	0	4
Complete tear	0	0	0	0	1	1	0	2
Fluid around tendon	0	0	0	0	0	3	0	3
Total	1	5	3	5	10	15	1	40

Table 3: The following chart shows the various abnormalities in the Infraspinatus tendon and the age range of occurrence in our study.

Status of Infraspinatus	Age Range (years)							Total
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	
Normal	1	5	3	4	6	13	1	33
Tendinosis	0	0	0	0	0	0	0	0
Partial tear	0	0	0	1	3	1	0	5
Complete tear	0	0	0	0	0	1	0	1
Fluid around tendon	0	0	0	0	1	0	0	1
Total	1	5	3	5	10	15	1	40

Clinical Presentation of Rotator Cuff Injuries: The most frequent complaint being pain among 18 subjects accounting for 45%. In descending order of frequency other complaints are stiffness of joint among 4(10%),difficulty in raising upper limbs among 5 subjects(12.5%),combination of pain and stiffness among 5 subjects(12.5%),weakness in 5(12.5%), inability to lift in 2 (5%), stiffness of joint among 4(10%)and pain with weakness in 1 subject (2.5%) of the forty patients, 21 presented with symptoms in the right side accounting for (52.5%) and 19 (47.5%) patients had disease on the left side.

Spectrum of Rotator Cuff Injuries: The most frequently affected tendon being supraspinatus (87.5%) and the least affected being teres minor(0%).In the decreasing order of frequency, the other tendons involved are subscapularis(50%), biceps(37.5%) and the infras pinatus(17.5%).

In patients with age >50 yrs, 14 (35%) patients show tears as compared to <50 years where 6 (15%) show tear in supraspinatus tendon. In patients, >50yrs of age, 9(22.5%) showed tendinosis and in <50 years 4(10%) showed tendinosis. Thus in this study tears and tendinosis appear to be common in older age groups than in younger patients, with tears being more common than tendinosis in older age groups.

Of the pathologies of the supraspinatus tendon, tendinosis was seen in 13 patients (32.5%) partial tear in 19 (47.5%) and a complete tear in 3 (7.5%). Thus partial tear and tendino pathies are the most commonly encountered abnormality in the supraspinatus tendons in this study population accounting for 47.5% and 32.5% respectively.

There were 19 patients with a partial tear of the supraspinatus, of these common type was the articular surface tear in 8 (42.5%),followed by the intra substance tear in 6 (33.3%) the least common was the bursal surface tear in 5 (26.31%).

Among the abnormalities of subscapularis, tendinosis with no evidence of tear was noted in 10 (25%), tear noted in 6 (15 %), with partial tear in 4 (10%) and complete in 2(5%) and fluid around the joint with no signal abnormality in the tendon was noted in 4 (10%). Normal subscapularis tendon noted in 50%.Tendinosis or tendinopathy is the frequently encountered pathology in the subscapularis tendons.

Among the abnormalities of infraspinatus, fluid around tendon in 1(2.5%), partial tear in 5 (12.5%), complete tear in 1 (2.5%), rest of the tendons 33 were normal. Thus the frequent abnormality in the infraspinatus in this study was partial tear.

Associated abnormalities in bicipital tendons were noted in 15(37.5%). The abnormalities seen in the tendon included dislocation of the tendon in 2 (5%), tendinosis in 4(10%), fluid around the tendon with no signal abnormality in the tendon in9 (22.5%).

Other Related/ Predisposing Findings: Of the 40 patients, type I acromion was seen in 22(55%), type II in 7 (17.5%), type III in 11 (27.5%) patients. In this study, the common type of acromion is the type I or flat acromion.

The orientation and the sloping of the acromion are described as horizontal, posterior up sloping, anterior downs loping, inferolateral tilt or low placed. The most frequent being anterior downs loping in this study, in 17 (42.5%), next being horizontal in 10(25%) inferolateral tilt in 8(20%) and low placed in 3 (7.5%) and posterior upsloping in 2(5%)

Of 17patients with down sloping acromion, 1(2.5%) had normal tendon, tendinosis in 5(12.5%) and 11(27.5%) had tears. Of the 8 patients with inferolateral tilt, 1(2.5%) normal tendon, 4 (10%) had a tear,3 (7.5%) had tendinosis. Of 12 patients with horizontal or upward acromion 5(12.5%) had tendinosis and 6 had a tear (15%) and 1(2.5%) is normal. Of the 3 patients with low placed acromion, one had normal tendon (2.5%), 2(5%) had a tear.

Acromioclavicular joint was assessed in terms of being normal, degenerative while showing osteophytosis or hypertrophic when there is hypertrophy and callus formation which appears as rounded mass of medium signal intensity surrounding the joint. In our study, AC joint was found to be normal in 26 (65%), hypertrophy in11(27.5%)patients and degenerative in 3 (7.5%). Of these 14 patients with acromioclavicular arthropathy, 8(20%) had a tear,5 (12.5%) had tendinosis, and 1 (2.5%) had normal tendon.

Of the 40 patients with rotator cuff pathologies, labral tear noted in 5 patients (12.5%) and one (2.5%) had degenerative changes. Rest of the patient showed no labral abnormality.

In 13 out of 40 patients (32.5%) in the study sample showed changes in the adjacent bones like oedema, contusion, geodes or subchondral cysts and erosion, osteophytes depending upon the mechanism causing rotator cuff disease or as changes secondary to the rotator cuff disease itself. Joint effusion was noted in 14 patients (35%) out of 40 patients. No effusion was noted in 25 cases. Joint effusion was mild or minimal in 11 patients (27.5%) and moderate in 4 patients(10%).

Bursal fluid/bursitis can be seen in patients with rotator cuff disorders. In our study, bursae around the shoulder joint were normal in 28 (70%). Isolated subacromial,

subdeltoid and subcoracoid bursitis was noted in 2(5%), 1(2.5%) and 2(5%) respectively.

Combination of subacromial and subdeltoid bursitis was seen in 5 (12.5 %), being the most frequent in our study population. All the three were involved in 2 patients. Of the 12 patients with bursitis,9(22.5%) had tears and 3(7.5%) had tendinosis.

The acromiohumeral distance (AHD) is measured between the superior articular surface of the humeral head and the under-surface of the acromion. The patients were grouped as more than 10mm, 8-10mm and less than 7 mm. 22 patients (55%) had AHD less than 7mm and all 22 (i.e. 100%) patients had abnormal supraspinatus tendon, no patient had normal supraspinatus tendon in this group. There were 8 patients (20%) in the 8-10mm group of this 1 (2.5%) had normal tendon and 8 (20%) had abnormal tendons. Ten patients (25%) had AHD more than 10mm, of this 7 (17.5%) had abnormal tendons and 3(7.5%) had normal supraspinatus tendon

The coracohumeral distance is measured between the tip of the coracoid process and lesser tuberosity. Normally it is more than 11mm. In our study patients were 8mm, 8-++10mm and more than 10 mm. Twenty patients (50%) had coracohumeral distance more than 10mm, of these 15(37.5%) had normal tendon and 5(12.5%) had abnormal tendons. Four (10%) had a coracohumeral distance <6 mm, of these all had abnormal subscapularis tendon. 11 (27.5%) had coracohumeral distance between 6 and 8 mm, of these 4(10%) had normal tendons, and 7(17.5%) has abnormal tendons. In the coracohumeral distance between 8 -10 mm group, there were 5 (12.5%) of the 1(2.5%) was normal and 2 each has tendinosis and 2 had tear.

Rotator cuff diseases are multifactorial where both extrinsic and intrinsic factors have been implicated. Intrinsic factors like poor vascularity, alteration in the material composition and properties with ageing have been studied[4], Ozaki *et al* and Uhthoff believed that the pathogenesis of rotator cuff disorders is an intrinsic process[5] and the risk of rotator cuff disorder increases with ageing corroborating with our study as well. Microvascular studies have shown diminished vascularity in the cuff tissue with increased age which appears consistent with the pattern of degeneration observed in age-related degenerative tendinopathies[6].

In a study conducted by Needell[7] in 100 asymptomatic shoulders, a higher incidence of tendinosis was found among younger population against more tears in the older age group in the fifth and sixth decade of life.

Among 90 patients by Milgrom *et al.* which showed no statistically significant differences in the incidence of rotator-cuff lesions related to gender[8].

Pain is the most frequently associated complaint with rotator cuff pathology. It is usually located over the anterior, superior and lateral aspects of the shoulder[9]. Pain usually is minimal at rest in a neutral and supported position of the arm. The pain is typically exacerbated with overhead raising or abduction of the arm as in combing hair, especially when lifting against resistance[10].

Rotator Cuff Diseases: Jerosch *et al.* in their study conducted on the dissected specimen of shoulder joints of 122 patients. It was found that isolated supraspinatus involvement occurred in 78% cases11. It was also noted no tear occurred without the involvement of supraspinatus tendon. DePalma *et al.* examined[11] cadaver shoulder and showed similar finding of supraspinatus as the commonly affected

tendon and the incidence and degree of tear increased with age[12] as noted in our present study.

Partial tears of tendon can be intratendinous/ intra substance without the involvement of the surface either on the bursal or the articular surface of the tendon. On MRI, partial tears appear as focal areas of hyper intensity on both short and long TE sequences[13].

Fluid in the subdeltoid bursa may commonly be identified in bursal-side partial thicknesstears and may make it easier to assess the size and depth of bursal-side partial tears[14]. Articular surface tear is found more common than the bursal surface tears15. Jacobson et al. in a study conducted in 50 patients with surgical correlation found among the partial tears., articular surface tears occurred in 70%. In our study 19 patients(47.5%) had a partial tear of the supraspinatus tendon of these partial tears most common was articular surface tears in 20% followed by intrasubstance tears in 15% and bursal tears in 12.5%, which was found to be least common. The articular surface of the cuff is hypovascular compared to the bursal surface, resulting in a higher incidence of partial-thickness rotator cuff tears on the articular surface of the cuff[9].

Full thickness tears are once in which the signal abnormalities appear to traverse through the whole thickness, extending through from surface to surface on at least one image[13]. This bright signal intensity is related to the presence of fluid secondary to tear. Presence of fluid in the subacromial-subdeltoid bursa is a common finding. Complete or full thickness tear is more frequent in supraspinatus.

Teres minor is an important external rotator of the shoulder, contributing up to 45% of the power of external rotation. An intact or even hypertrophied teres minor can provide enough power to external rotation and can maintain the ability to perform the activities of daily living, such as eating and drinking and reduce the symptoms of the other rotator cuff tendon tear. In a study conducted on 2,436 shoulder MRI examinations for a period of 67-months period from September 1996 to April 2002. MRI findings of teres minor abnormality were seen in 0.8% 16 whereas none were seen in our study.

No statistically significant correlation between type IV and impingement is available in the literature currently. Type II and III are commonly associated with shoulder impingement[9].

Ellman in other studied found association of rotator cuff tears with type II and III acromions[17]. Variation in acromion configuration and slope drastically affect the space available for supraspinatus tendon especially during abduction and rotational movements. The slope of the acromion is best appreciated on sagittal and coronal oblique images.

Bony sclerosis and an abnormal contour of the inferior surface of the acromion have been associated with shoulder impingement1[16]. The bony sclerosis is manifest as a decreased signal in the subchondral bone marrow on MR sequences. Humeral side hypertrophic changes or flattening and sclerosis can be seen in the region of the greater tuberosity in patients with impingement[18]. This is likely due to trauma to the greater tuberosity on the undersurface of the acromion during the abduction. On MR exam these changes can be seen as areas of cortical thickening or prominent low signal in the region of the greater tuberosity[19]

Bicipital Tendon Abnormality and Rotator Cuff Diseases: Erickson *et al.* in their study showed bicipital tendinitis/tenosynovitis was frequently accompanied rotator cuff diseases[20]. Rotator cuff disorders, especially in complete tears, the long bicipital tendon can get impinged between the humeral head and the coracoacromial arch. This can result in flattening of the biceps tendon, tendinitis, partial tears and overt rupture.

Labrum and Rotator Cuff Diseases: Overlap of symptoms exists among patients with a glenoid labral lesion and those with a rotator cuff disorder or glenohumeral instability[21]. A labral tear can result as a result of trauma like in patients who engage in overhead throwing athletic sports activities, or secondary to degenerative changes in the labrum leading on to tear. Rotator cuff tears and long head of the biceps tendinopathy may accompany a superior labral tear.

In our study out of the 40 patients, 6 patients showed abnormal glenoid labrum. This a smaller number may be because of the limitation of magnetic resonance imaging without comparable arthrogram in detecting labral tears[22].

Joint Effusion, Bursal Fluid and Rotator Cuff Disease: In a study by Hollister *et al.* done on 97 patients with surgery proven rotator cuff tear 52% had fluid in the joint, bursa or both. It was concluded in this study that fluid in the bursa (subacromial/subdeltoid), joint effusion had a strong association with rotator cuff tears. The specificity and PPV for rotator cuff tears increased when both bursal and joint fluid was present, and careful evaluation of cuff tendons is a warranted to rule out tears in the presence of joint effusion or bursal effusion[23]. Similar results were also found in the study by Grainger *et al.* who reviewed 1831 MRI over 2 years.

Acromio-Humeral Distance and Supraspinatus Tendon: The acromiohumeral distance is measured between the superior articular surface of the humeral head and the under-surface of the acromion. This is occupied only by the rotator cuff and easily compressible subacromial bursa. Saupe *et al.* in a study showed that reduced acromiohumeral distance was associated with rotator cuff tears and rotator cuff muscle degeneration. In that study 63 patients were divided into three groups according to the acromiohumeral distance with age and gender matched controls-group I <7 mm, group II 8-10mm and group III more than 10mm. It was shown that the incidence of supraspinatus pathology was less in group III, AHD > 10mm and AHD < 7mm is almost always seen with complete tear[24].

Coracohumeral Distance and Subscapularis Tendon: The coracohumeral distance assesses the space between the tip of the coracoid process and the lesser tuberosity and ideally is measured with the humerus in maximal internal rotation, which may not be possible in the presence of a subscapularis tendon tear. The average CHD is 11mm[25].

In a study by D.P. Richards *et al.* done on 36 shoulders with corresponding controls, showed coracohumeral distance in the patients with subscapularis impingement or tear was 5mm as compared to 10mm in the control group. He concluded there is a significant relationship between tears of the subscapularis and a decreased coracohumeral distance. The narrowed coracohumeral distance may be one of the possible causes of torn subscapularis26.

CONCLUSION

Magnetic Resonance Imaging is very useful in depicting rotator cuff disease for prompt diagnosis along with the predisposing factors like the acromion type and orientation, reduction in coracohumeral distance, reduced acromioclavicular distance and other associated features like effusion, bursitis and bone changes. The advantage of MRI over arthrography is that it is a non-invasive technique but also that it allows visualisation of osseous and periarticular soft tissue of the shoulder in the coronal, sagittal, axial and oblique planes. MRI provides the surgeon with critical information regarding tear location, the specific tendons involved, the degree of muscular atrophy and tendon retraction and the quality of torn edges, such information is invaluable for assessing the feasibility of surgery and type of necessary repair

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