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Role of USG and MRI to detect the rotator cuff injury and to compare the efficacy of both

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ABSTRACT

Background: The objectives of this study were to detect the rotator cuff injury using high-resolution ultrasonography in clinically suspected patients, compute MRI findings and compare the effectiveness of ultrasound and MRI diagnostically in such patients.

Materials and Methods: 30 patients who were suspected to be suffering from rotator cuff injury were referred to the Department of Radiodiagnosis, Medical Trust Hospital, Kochi, Kerala. MRI and high-resolution ultrasonography were used to evaluate them after taking their written consent. The present study was carried out from November 2018 to October 2019.

Results: In partial thickness tears, the specificity of ultrasound was 87.5% and sensitivity was 72% whereas it was 83.3 % and 95.8% respectively for full-thickness tears. MRI was more sensitive than USG in evaluating the capsular and labral pathologies. MRI was the most sensitive and specific modality in the evaluation of shoulder pain. A specificity of 94% and a sensitivity of 92.3% was seen in relation to MRI in case of partial thickness tears; whereas in full thickness tears a specificity of 95.8% and a sensitivity of 100.0% were seen. In calcific tendinitis, picking bursal fluid and impingement, MRI was better than USG and also highly sensitive for labral tears.

Conclusions: In the evaluation of shoulder pain, MRI is the most appropriate evaluation modality and in case of labral tears it is highly sensitive. When compared to USG, MRI is better in picking bursal fluid, impingement as well as calcific tendinitis and also in evaluating labral and capsular pathologies.

1. Introduction

There axis of rotation in case of a shoulder joint is not fixed. It is an incongruous ball and socket joint but motion is in multiple planes and the range of motion is wide, due to which stability is reduced to enable higher range of mobility.

The variety of structures for stability on which the shoulder joint is dependent includes the glenohumeral ligaments, the joint capsule, osseous glenoid, the fibrous labrum, and most importantly the rotator cuff (formed by four tendons). The spectrum of aetiologies of shoulder pain includes degenerative changes, trauma, acute and chronic causes, full thickness/partial thickness defects of the cuff. Others are posterior capsular tightness, cuff tear arthropathy, degenerative cuff failure, tendinitis, subacromial abrasion impingement syndromes and tendinopathy.

For the optimal treatment planning and prognostic accuracy, the anatomy and function of the rotator cuff should be understood. Its disorders also should be understood. The most common lesion of the shoulder joint is the injury to the rotator cuff. Accurate and early and diagnosis is the key for the proper management.

"The location of the periarticular lesions is accurately determined by a large number of clinical tests used for the

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diagnosis of the painful shoulder, but these entities may be difficult to differentiate by physical examination."[1]

Evaluation of any tear partial or full-thickness became possible with the help of USG as it was introduced in musculoskeletal imaging in 1977. Subacromial-Subdeltoid bursitis, calcific tendinosis, tenosynovitis, tendinosis, greater tuberosity fracture are some of the abnormalities revealed by the high-resolution ultrasound at the time of clinical examination which resemble rotator cuff tear. "Both rotator cuff and non-rotator cuff disorders are detected by high-resolution ultrasound which is a non-invasive, less expensive, and non-ionizing modality with good sensitivity that serves a complementary role to magnetic resonance imaging of the shoulder. It is a very big advantage of the ultrasound to conduct dynamic studies in areas like the shoulder. It has limited use in the evaluation of labral, rotator cuff interval, and in demonstrating subtle bony lesions."[2] andmakes comparison with the opposite side quick, which in many difficult situations is of great help.

The beginning of imaging of the musculoskeletal system by MRI in the 1980s has revolutionized the diagnostic imaging of the shoulder. The extra- and the intra-articular structures of the shoulder have been accurately evaluated by this innovative technology with multiplanar imaging capability that allows superior soft-tissue detail which is not demonstrated with other imaging modalities. Since MRI detects both the obvious and the subtle internal derangement and assesses overall joint-structure, it is considered the "gold standard" The details on-site, the extent of the lesion and the surrounding structures and secondary changes are provided by MRI. The evaluation of the shape and the size of the tear, the extent to which tendon is retracted, the prominence atrphy of the muscle, and the quality of the remaining RC tendon besides accurately evaluating other probable causes of pain in the shoulder joint may mimic RC tears all these are done by MRI. "MRI has a diagnostic and therapeutic impact by playing an increasingly important role as a non-invasive investigation for determining which patients may benefit from surgery."[3]

2. Aims and Objectives

1. To evaluate MRI findings in these patients.
2. To determine the rotator cuff injury by the use of high-resolution ultrasonography in clinically suspected patients.
3. To differentiate the effectiveness of MRI and ultrasound diagnostically.

3. Materials and Methods

30 patients who were suspected to be suffering from rotator cuff injury were referred to the Department of Radiodiagnosis, Medical Trust Hospital, Kochi, Kerala. MRI and high-resolution ultrasonography were used to evaluate them after taking their written consent. The present study was carried out from November 2018 to October 2019.

3.1. Equipment & techniques

On a high frequency Philips IU-22 linear probe, shoulder ultrasound was performed in our study. Evaluation of both dynamic and static examination of the shoulder as well as the comparison of the opposite side was done.

MRI of the affected shoulder was done following the shoulder USG. MRI was performed on 1.5 TESLA MR Scanner (PHILIPS MR ACHIEVA).

3.2. MRI protocol

Since external rotation causes the anterior capsular structures to appear tauter and sharply defined, the patients being kept in the supine position their shoulder and arms are positioned in mild external rotation. It is important to stabilize the shoulder to reduce motion artifact.

3.3. Pulse sequences and imaging plane

A three-plane localizer is obtained for planning of the various sequences. Oblique coronal, axial and oblique sagittal planes were used to obtain the multiplanar images. Following are the sequences used T2W spin-echo, Proton density, T2W T2, *WI STIR.

3.4. Inclusion criteria

1. Patients with a history of injury (trivial).
2. Patients having pain history in either shoulder joint.
3. Patients suspected with injury of the rotator cuff (partial/full thickness tears), calcific tendinitis/ biceps tendon injury clinically.

3.5. Exclusion criteria

1. Those who are contraindicated to MRI.
2. Patients who underwent management.
3. Those who underwent surgery.

Patients were taken for the study after giving their informed written consent and a detailed history of the patient including signs and symptoms and detailed clinical examination findings were recorded and tabulated as in the proforma shown later. Ultrasound and MRI were done, and the results were recorded.

4. Results

The maximum no. of patients in our study group was in the 4^{th} decade (33%). There were 60% males & 40 % females in our study. Around 86.6 % of the patients had symptoms for less than 6 months in our study. The right shoulder was

mostly affected in most of the patients (70 %). The dominant hand involved in most of the cases was the right side in our study (93.3%). Restriction of movement was the most common symptom apart from the pain in the majority of patients (50%). The injury was associated with 10 patients (33.3%). The commonest tendon found to be involved in this study was the supraspinatus with 90 % of the cases followed by subscapularis (6%) & infraspinatus (3%), whereas the tendon that was not involved in our study was teres minor.

On USG, partial-thickness tears of subscapularis were present in 3.3% and 30% of cases had partial-thickness tears of the supraspinatus whereas 13.3% had full-thickness supraspinatus tears in our study. Peribicipital tendon fluid was present in 19 cases (63%) on USG. 16 (53.3%) of the cases had SASD on USG however subcoracoid bursitis cases were not present on USG. 12 cases (40%) had ACJ hypertrophy on USG, 2 cases (6.6%) had calcific tendinitis on USG but no labral tears on bony changes were detected on USG.

Full-thickness supraspinatus tears were in 23% of the cases and partial-thickness tears of the supraspinatus were present in 36% of cases in our study. Partial thickness tear was present in 7 % of the cases in subscapularis and 1 (3.3%) in infraspinatus on MRI. MRI detected peribicipital tendon fluid in 80% of cases, subacromial subdeltoid bursitis in 76% of cases and subcoracoid bursitis in 40% of cases. ACJ hypertrophy was detected in 60% of cases on USG and 70% of cases on MRI. The commonest type to be detected on MRI was the Type II acromion with (50%) of cases. The labral tears were present in 23.3% of cases on MRI. Calcific tendinitis was present in 10% of cases, bony changes in the humeral head like Hill-Sachs lesion were present in 13% of cases while thickened IGHL was found in 1 case.

The accuracy was 80 % for detecting rotator cuff tears with partial-thickness on USG whereas in relation to MRI it was 93.3%.

Full-thickness rotator cuff tears on USG had an accuracy of 93.3 % whereas it was 96.6% on MRI.

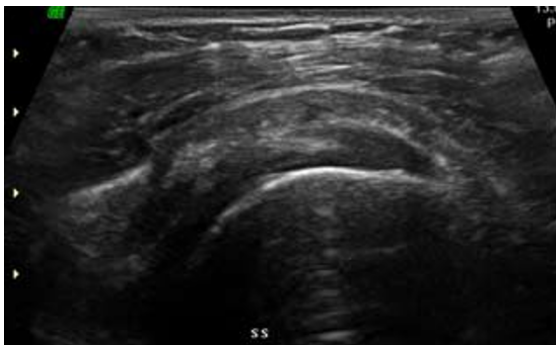

Figure 1: Partial thickness supraspinatus tear on USG

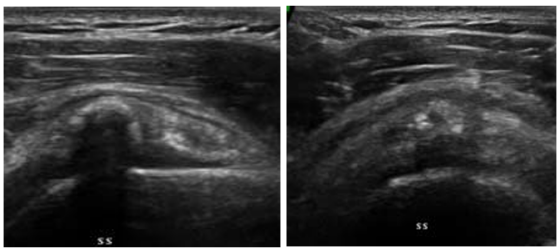

Figure 2: Supraspinatus calcific tendinitis on USG

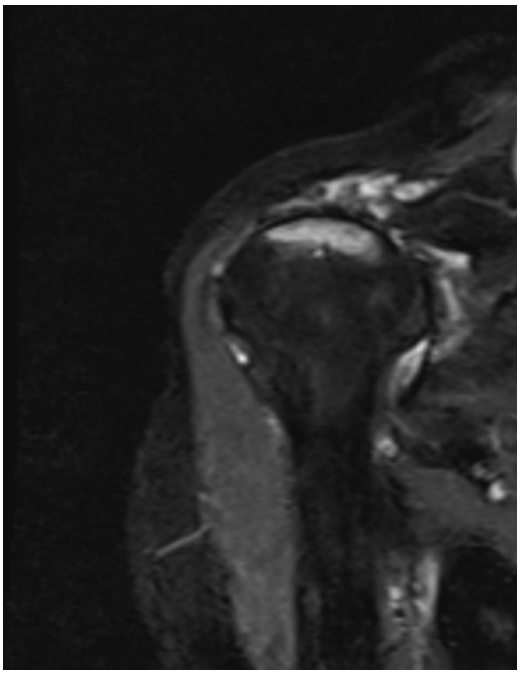

Figure 3: STIR coronal showing contusions in humeral head with complete tear of supraspinatus tendon & superior subluxation of humeral head

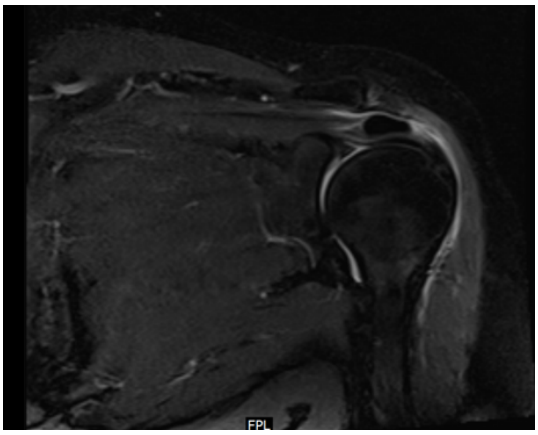

Figure 4: STIR coronal showing calcific tendinosis of supraspinatus tendon.

Table 1:

Partial Thickness Rotator Cuff Tears on USG	Follow up		Total
	Present	Absent	
Present	10	2	12
Absent	4	14	18
Total	14	16	30

Correlation of USG findings of partial thickness rotator cuff tears with surgical findings

Partial thickness rotator cuff tears on MRI	Follow up		Total
	Present	Absent	
Present	13	1	14
Absent	1	15	16
Total	14	16	30

Correlation of MRI findings of partial thickness rotator cuff tears along with surgical findings

Table 2:

S.No	Parameter	Percentage
1	Sensitivity	72%
2	Specificity	87.5%
3	PPV	83.3%
4	NPV	77.8%
5	Accuracy	80%

Accuracy of USG in p artial thickness rotator cuff tears

S.No.	Parameter	Percentage
1	Sensitivity	92.3%
2	Specificity	94.1%
3	PPV	92.3%
4	NPV	94.1%
5	Accuracy	93.3%

MRI Sensitivity in p artial thickness rotator cuff tears

Table 3:

Full-Thickness Rotator Cuff Tears on USG	Follow Up		Total
	Present	Absent	
Present	5	1	6
Absent	1	23	24
Total	6	24	30

Correlation of USG Findings of Full-Thickness Rotator Cuff Tears with Surgical Findings

Full-Thickness Rotator Cuff Tears on MRI	Follow Up		Total
	Present	Absent	
Present	6	1	7
Absent	0	23	23
Total	6	24	30

Correlation of MRI Findings of Full-Thickness Rotator Cuff Tears with Surgical Findings

Partial-thickness rotator cuff tears were detected accurately by 80 % on USG while it was 93.3% in MRI. Full-thickness rotator cuff tears in case of MRI had an accuracy of 96.6% which was slightly more than that for USG (93.3%). MRI was 100% accurate in detecting Bankart lesions in our study while it was 96% for SLAP lesions of the labrum.

MRI (100%) was slightly more accurate in detecting calcific tendinitis than USG (96.6%). MRI was 100% accurate in diagnosing subacromial subdeltoid bursitis which was better than that of USG (76%). MRI was more sensitive (83.3%) and accurate (96.6%) for diagnosis of impingement than USG which was only 66.6% sensitive and 93% accurate.

5. Discussion

The most complex joint of the body is the shoulder joint which is subjected to damage because of the inherent structural instability and wide range of motion. There is significant morbidity and disability caused as a result of the disease processes and injuries disrupting rotator

Table 4:

S.No.	Parameter	Percentage
1	Sensitivity	83.3%
2	specificity	95.8%
3	PPV	83.3%
4	NPV	95.8%
5	Accuracy	93.3%
USG sensitivity in f ull-thickness rotator cuff tears		
S.No.	**Parameter**	**Percentage**
1	Sensitivity	100%
2	Specificity	95.8%
3	PPV	85.7%
4	NPV	95.8%
5	Accuracy	96.6%
MRI sensitivity in f ull-thickness rotator cuff tears		

Table 5:

S.No.	Parameter	USG	MRI
1	Sensitivity	72%	92.3%
2	Specificity	87.5%	94.1%
3	PPV	83.3%	92.3%
4	NPV	77.8%	94.1%
5	Accuracy	80%	93.3%
Comparison of accuracy of USG and MRI in Partial Thickness Rotator Cuff Tears			
S.No.	**Parameter**	**USG**	**MRI**
1	Sensitivity	83.3%	100%
2	Specificity	95.8%	95.8%
3	PPV	83.3%	85.7%
4	NPV	95.8%	95.8%
5	accuracy	93.3%	96.6%
Comparison of accuracy of USG and MRI in full thickness rotator cuff tears			

Table 6:

S.No.	Parameter	USG	MRI
1	Sensitivity	66.6%	100%
2	Specificity	100%	100%
3	Accuracy	96.6%	100%
Comparison of USG and MRI s ensitivity in calcific supraspinatus tendinitis			
S.No.	**Parameter**	**USG**	**MRI**
1	Sensitivity	70%	100%
2	Specificity	100%	100%
3	Accuracy	76.6%	100%
Comparison of USG and MRI s ensitivity in subacromian/subdeltoid bursitis			
S.No.	**Parameter**	**USG**	**MRI**
1	Sensitivity	66.6%	83.3%
2	Specificity	100 %	100%
3	Accuracy	93.3%	96.6%
Comparison of USG and MRI sensitivity in subacromian and subcoracoid impingement			

cuff tendons, cartilaginous and bony labrum and other supporting ligamentous structures of the shoulder. To evaluate the patients with shoulder pain various techniques including clinical examination, USG, X-ray, CT scan, arthrography, and MRI are used. As the clinical tests have their limitations it is not always possible to diagnose rotator cuff pathology clinically in the setting of injury to the shoulder. Surface abnormalities are evaluated by arthroscopy which is invasive and also gives excellent visualization of the interior of the joint.

Some of the abnormalities revealed by the high-resolution ultrasound at the time of clinical examination which resemble rotator cuff tear are Subacromial-Subdeltoid bursitis, Tenosynovitis, Greater tuberosity fracture, Calcific tendinosis and Tendinosis.

The gold standard for rotator cuff injuries of the shoulder joint is the magnetic resonance imaging. It is non-invasive and has the multiplanar capability that demonstrates excellent soft tissue without the involvement of ionizing radiation. The details on-site, the extent of the lesion and the surrounding structures and secondary changes are provided by MRI. MRI is a diagnostic method accurate enough to determine which patients may benefit from surgery. It has a diagnostic and therapeutic impact by playing this role.

The role of MRI and USG for evaluating shoulder joints was determined with this background. Though MRI is a costly investigation it has emerged as the gold standard for evaluating rotator cuff pathologies. Ultrasound is considered as an initial imaging modality for evaluating rotator cuff pathologies cost-effective and easily accessible. Although ultrasound is operator dependent and may not have the accuracy of MRI it gives a fast, non-invasive, real-time, cross-sectional image of the joint.

Patients in the age group of 41-50 years having rotator cuff injury comprised 33 % of the cases and this was the most common age group of patients in the present study. The majority of them were males constituting around 60% of the cases with the mean age being 44.5 years. Right shoulder joint (63.3%) involvement was more common than left (30%) & both in 6.6% and right-hand dominance was more in the majority (93%) of patients in our study. The findings seen by Urwin M et al.[4] who proposed that "rotator cuff tears tend to persist in the dominant arm" were in concordance with our results.

96% of the patients had pain in the shoulder joint as the most common presenting complaint and in 54% of cases there was restriction of movement. Trauma was the main cause in 10 patients (33.3%), and in 4 (13.3%) patients there was a history of diabetes. Most of the patients had symptoms for less than 6 months (86.6%) in our study.

Rotator cuff pathology was the most common aetiology of painful shoulder in this study.

Supraspinatus tendon was the most common tendon to be involved in this study (90%). In Zlatkin et al.[5] they found that "supraspinatus tendon involvement was present in the majority" of their cases which was comparable with that of our study.

"There was subscapularis tear in only 1 case comprising 3.3% of the cases and in 3.5% of the cases" in a study by Codman et al.[6] and "this tear was associated with supraspinatus tear in our study" Deutsch A et al[7] concluded similar findings that isolated subscapularis tears are very rare. There was only 1 case with infraspinatus involvement and no teres minor tendon in our study.

5.1. Partial thickness rotator cuff tears

On USG, 2 cases (6.6%) had partial-thickness tears of subscapularis and partial-thickness tears of supraspinatus were present in 10 (30%) out of 30 cases in our study. Whereas partial-thickness tears of supraspinatus were present in 11 cases (36%) and 2 cases (7%) of the subscapularis and 1 case (3%) had partial thickness tear of the infraspinatus in case of MRI. During follow-up a total of 14 partial tears were noted of which 12 were supraspinatus tears, 1 was subscapularis and 1 was of the infraspinatus.

The PPV of 83.3%, NPV 77.8%, sensitivity 72%, specificity 87.5%, and accuracy 80% in relation to partial-thickness rotator cuff tears for USG were in concordance with the study of Shoubhi et al.[8]

The PPV, NPV, sensitivity, specificity and accuracy of 83.3%, 95.8%, 92.3%, 94% and 93.3% respectively in case of MRI of the partial-thickness rotator cuff tears were in agreement with the study of Shoubhi et al[8] and Vlychou M et al.[9]

In our study, probably due to anisotropy related artefacts there were 2 false-positive cases and 4 false-negative cases on USG.

Subscapularis tendon was involved in 1 false-negative MRI in this study. Intrasubstance tear of subscapularis was misdiagnosed as tendinosis since it did not involve the bursal or articular surface on retrospective analysis of MRI.

Due to the overestimation of pathology, there was 1 false-positive case on retrospective analysis of MRI.

5.2. Full-thickness rotator cuff tears

5 cases (16.7%) out of 30 on USG had full-thickness supraspinatus tears whereas they were seen in 7(23%) cases on MRI. There was a total of 6 full-thickness tears but no full-thickness tears of subscapularis were found on follow-up.

The PPV, NPV, specificity, sensitivity, and accuracy of full-thickness rotator cuff tears on USG were 83.3%, 95.8%, 95.8%, 83.3%, and 93.3% respectively that were in agreement with the study of Lenza et al.[10]

Whereas the PPV, NPV, specificity, specificity and accuracy of partial-thickness rotator cuff tears on MRI was 85.7 %, 95.8%, 95.8%, 100% and 96.6% respectively that

were corresponding to the study of Lenza et al.[10]

There was 1 false-positive case and 1 false-negative case on USG in our study probably due to anisotropy related artefacts.

Due to magic-angle artifact involving the distal most supraspinatus tendon there was 1 false-positive MRI in this study.

5.3. Labral tears

On MRI, 7 cases (23.3%) out of 30 had labral tears of which 4 were Bankart lesions and 4 were slap tears but during followup the Bankart lesions were 4 and slap tears were 3 in number. In our study, on USG, due to the inability to adequately visualize the cartilaginous labrum, we were unable to detect the labral tears.

A sensitivity of 100%, specificity of 100 % and accuracy of 100% were seen on MRI for detecting Bankart lesions and these were in concordance to the study of Joseph P Iannoti et al.[11]

A specificity of 96.4%, sensitivity of 100%, and accuracy of 96.6% were seen on MRI which was in agreement with the study of Connel et al.

Sublabral recess (a normal variant) was wrongly diagnosed as a tear on retrospective analysis of 1 false-positive SLAP tear.

5.4. Subacromial subdeltoid bursitis

There was subacromial subdeltoid bursitis on USG in 16(53%) cases while it was present in 23(76%) cases on MRI. Subcoracoid bursitis was seen in 12(80%) cases on MRI but it was not detected on USG.

The specificity, sensitivity, and accuracy were 100%, 100%, and 100% respectively for detecting SASD for MRI whereas in USG they were 100%, 70% and 76.6% respectively and this was in agreement with the study of Shrestha et al.[12] When compared to USG, MRI is a better tool for the detection of SA-SD bursitis.

5.5. Peribicipital fluid

MRI is a better modality as compared to USG in detecting for the detection of peribicipital tendon fluid as in our study, peribicipital tendon fluid was present in 19(63%) cases on USG while it was detected in 24 (80%) cases on MRI. This is in concurrence with the findings of Mary Hollister et al.

5.6. ACJ hypertrophy

MRI is a better tool compared to USG in detecting ACJ hypertrophy as it was present in 12(60%) cases on USG while it was present in 20(70%) cases on MRI.

5.7. Impingement

Subacromial impingement was seen in five patients (16.6%) on MRI, whereas it was seen in 4 cases on USG in our study. The sensitivity, specificity, and accuracy were 66.6%, 100%, and 93.3% respectively for detecting impingement for USG whereas in case of MRI, it had a sensitivity of 83.3%, specificity 100%, and accuracy 96.6% which were in concordance with the study of Farin et al.[13] and Nathalie et al.[14]

Different types of acromion were determined by MRI. The most common type to be detected on MRI was the type II acromion in 50% of cases with it being associated in most cases of impingement. In 13(43.3%) cases, type I was found and type III in 2(6.7%) cases. These findings are in concurrence with the study conducted by Biglani et al.

5.8. Calcific tendinitis

Supraspinatus calcific tendinitis was present in three patients (10%) on MRI, and 2 cases of calcification on USG in our study. A sensitivity of 66.6%, specificity 100 % and accuracy of 96.6% was present for detecting calcific tendinitis for USG while for detecting calcific tendinitis for MRI there was a sensitivity of 100 %, specificity 100 % and accuracy 100% which were corresponding to the study of Shrestha et al.[12]

IGHL thickening was seen in 1 case and bony changes in the humeral head in 4 cases (13.3%) on MRI. In this study, USG was found to be a non-invasive, useful, and dynamic modality which is highly sensitive, specific, and accurate in diagnosing rotator cuff tears. Between the findings of USG and those of MRI there was a good correlation in the assessment of partial/full-thickness rotator cuff tears. But MRI was found to be slightly superior. MRI is superior to USG for impingement, SASD and calcific tendinitis as it can delineate other structural changes like labral tears.

MRI remains the gold standard with regard to assessment, characterization and accurate localization of rotator cuff injuries.

6. Conclusion

MRI is the best modality for evaluation of shoulder pain. It is also very sensitive for labral tears. MRI is more sensitive than USG in evaluating labral and capsular pathologies since it is better in identifying impingement, bursal fluid, and calcific tendinitis.

The primary screening method of all painful shoulder joints is the USG as it is economic and fast and can serve effectively if performed well even though the operator is dependent. In the case of rotator cuff tears USG is almost equally effective as MRI but not for other pathologies. In the assessment of overall joints including capsular, labral, or ligamentous pathologies, MRI should be used. MRI should be done before planning surgery because of the

superior soft-tissue resolution with multiplanar imaging capability. Although MRI is considered the gold standard in the evaluation of rotator cuff pathologies USG remains as a first line of investigating a case of shoulder joint pain exclude rotator cuff pathologies.

7. Source of Funding

None.

8. Conflict of Interest

None.

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