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Rotator Cuff Pathologies- A Co-Relative Study of Imaging Features of Ultarsound Shoulder with MRI

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Abstract: *Shoulder pain is one of the most common complaint with which patients consult an orthopaedician and rotator cuff pathologies is the commonest cause of it. The imaging modalities used for evaluation of rotator cuff pathologies are USG and MRI.USG is less time consuming and cost effective modality for detection of rotator cuff pathologies. This study is done to compare the efficiency of USG in detection of shoulder pathologies when compared to MRI.*

Keywords: *Full thickness tears, Rotator cuff Pathologies, Magnetic Resonance Imaging , Ultrasonography.*

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I. Introduction

As rotator cuff pathologies are the most common cause of shoulder pain[1] this study aims at assessing the efficiency of USG in detecting rotator cuff pathologies and use of USG as the initial modality of imaging . MRI is used as the reference standard to correlate the findings and to study the pitfalls and limitations of USG.

II. Materials And Methods

A prospective study was undertaken in Department of Radiology in Dr. B R Ambedkar Medical College, Bengaluru, on 60 patients referred for MRI shoulder joint for a period of two years from June 2016 to July 2018. Symptomatic patients with painful shoulder, who were referred for shoulder MRI were considered for the study. After clinical evaluation, once a patient satisfied the inclusion and exclusion criteria for this study, he or she underwent sonographic evaluation of the shoulder joint followed by MRI of the affected shoulder. Ethical committee approval was obtained. Patient consent was taken.

Inclusion Criteria

- Pain in either or both shoulders
- Restricted movements at the shoulder joint
- Patients with clinical suspicion of rotator cuff injury, biceps tendon injury, calcific tendinitis, etc.

Exclusion Criteria

- Patients with glenoid labral pathologies.
- Patients with instability disorders.
- Patients with any electrically, magnetically or mechanically activated implants (pacemaker, biostimulators, neuro- stimulators and cochlear implants).
- Claustrophobic patients

Data Acquisition

After clinical evaluation, once a patient satisfied the inclusion and exclusion criteria for this study, he or she underwent sonographic evaluation of the shoulder joint followed by MRI of the affected shoulder.

Ultrasound: The examination on the affected shoulder was carried outwith high frequency linear array transducer (5-12MHz). Both static and dynamicexamination of the shoulder were performed and comparison to the opposite side was done.

Techniques:Ultrasound was done using musculoskeletal ultrasound technical guidelines for shoulder joint as per Europeansociety of musculoskeletal radiology.

Protocol
1Biceps brachii tendon, long head
2Subscapularis and biceps brachii tendon, subluxation/ dislocation
3Supraspinatus and rotator interval
4Acromioclavicular joint, subacromial-subdeltoid bursa, and dynamic evaluation for subacromialimpingement
5Infraspinatus, teres minor
USG – diagnostic criteria: In our study, we used major and minor criteria for diagnosing rotator cuff tears as described by Sobleet al[2] and Chauba[3].

Major criteria were non-visualisation of the cuff, focal non visualisation, discontinuity in the cuff and focal abnormal echogenicity.

Minor criteria were fluid along the biceps tendon sheath and in the subdeltoid bursa, concave subdeltoid bursal contour, irregularity of the greater tuberosity and compressibility.

Full thickness tear: It is focal or complete non visualisation of tendon which presents as an anechoic or hypoechoic defect in tendon extending from articular to bursal surface.

Partial thickness tear: It is presence of hypoechoic or heterogeneously echoic defect extending to articular surface or bursal surface but not completely involving the tendon. When intratendinous longitudinal splits are identified which appear as thin fluid-filled intratendinous line oriented from the bony insertion proximally without exiting onto either the bursal or the articular side of the tendon they are referred to as intrasubstance tears.

Criteria for non-tear related rotator cuff pathologies: Tendon calcification is presence of echogenic structure with marked posterior acoustic shadow.Tendinosis is depicted as thickened and/or hypoechoic tendon. Effacement of fibrillar pattern of tendon may also be seen in some individuals[4].
Impingement: Subacromial impingement is pooling of bursal fluid at the lateral acromion edge or snapping of bursal tissue indicated[5].Interposition of the supraspinatus tendon between the greater tuberosity and the acromion, as well as direct contact between the greater tuberosity and the acromion are the other signs of impingement[6].

Criteria for non-rotator cuff tear related pathologies: Biceps Tendinopathy is considered when there is thickening or thinning of the tendon, hypoechoic appearance and loss of fibrillar pattern on long axis. Biceps tendon dislocation is considered when tendon is not seen in bicipital groove or when tendon is seen displaced medially or laterally.
Bursa: It is considered pathological when there is fluid distension which appears predominantly anechoic. Appearance of thickened bursal wall is also a diagnostic criteria for inflammation.
Acromioclavicular joint arthropathy is considered when there is narrowing, distension of joint capsule and/or presence of marginal osteophytes[7].

Magnetic resonance imaging: The MRI examination of shoulder was performed on a 1.5 Tesla Philips Achieva. Patient was positioned supine and an approximately neutral position of the arm was obtained by asking the patient to place his hand at the side of the body, with the thumb pointing upwards.
Sense–Flex- M coil was used and centered over the affected shoulder.
Multiplanar images were obtained in the axial, oblique coronal and oblique sagittal planes.
Field of view 16 cm, slice thickness 2-3 mm and matrix 512 x 512 [Table 1].

Sequences	FOV	THK(mm)	TR(ms)	TE(ms)
T1W _TSE /Sagittal	160mm	3.0	400-700	10-20
T2W _ aTSE / Coronal / TSE	160mm	3.0	3500-6500	80-100
PDW_SPAIR/ Coronal/ TSE	160mm	3.0	3500-6500	20-40
PDW_SPAIR/ Axial / TSE	160mm	3.0	3500-6500	20-40
PDW_aTSE/Coronal	160mm	2.0	3500-6500	20-40
STIR_long TE/Sagittal	160mm	3.0	2500-5000	40-80
STIR_long TE/ Coronal/ TIR	160mm	3.0	2500-5000	40-80

[Table 1]: MRI scanning protocol.
MRI Findings: Normal tendons are hypointense on standard MR sequences[Fig-2].
Tears: Increased signal intensity within the substance of such tendons are usually considered pathologic or indicative of injury.

Focal region of fiber discontinuity that is filled with fluid signal as demonstrated on T2-weighted imaging with or without retraction of tendinous fibers from the distal insertion were considered partial tear[Fig-3,4]. Tendon defect extending from the articular surface to the bursal surface filled with fluid signal intensity was the most direct and definite sign of a complete rotator cuff tear[Fig-5,6]. Important secondary signs of cuff

tear considered were diffuse loss of the peribursal fat plane and the presence of fluid in the subdeltoid bursa. Muscle atrophy and fluid in the glenohumeral joint, decrease in the acromial humeral distance, presence of AC joint cysts, superior translation of the humeral head with associated remodeling of the under surface of the acromion were other signs[8].

Tendinosis: The typical MR appearance of tendinosis is high signal on short TE sequences, such as proton density sequences. On T2-weighted images, true defects associated with partial tears are hyperintense, contrary to tendon degeneration. Magic angle phenomenon may result in artifactually increased signal in regions where the tendon courses at a 55-degree angle in relation to the main magnetic field. Magic angle artifact usually resolves on T2 weighted (long TE) sequences, thus differentiating it from tendinopathy [8].

Statistical Analysis

The statistical analysis was performed by STATA 11.2 (College Station TX USA). Kappa statistics were used to find the agreement between the USG and MRI findings. Sensitivity, specificity, accuracy, the positive predictive value and the negative predictive value were calculated using cross tabulations. Descriptive statistics were performed. Chi square test were used to find the significance of MRI and USG findings, and it was expressed as frequency and percentage. The p-value <0.05 was considered as statistically significant.

III. Results

Study design: Total 60 patients with shoulder joint pain were studied and USG findings were correlated with MRI findings. Rotator cuff pathology was the most common outcome in our study and hence was the focus of our study.

Spectrum of pathology: Of the patients with shoulder complaints referred to our department, rotator cuff pathologies were the most common finding and were seen in 57 patients.

USG findings: Among the subjects studied for painful shoulder, on USG majority had supraspinatus tendon

[**Table 2].** This was followed by subscapularis tendon pathologies seen in 32 (53%) patients.

Tendons	USG/ MRI	Partial thickness tear	Full thickness tear	Tendinosis	Intra substance tear	Normal
Subscapularis	USG	5 (8%)	1 (2%)	25 (42%)	1 (2%)	28 (46%)
	MRI	4 (6%)	1 (2%)	27 (45%)	1 (2%)	27 (45%)
Supraspinatus	USG	31 (51%)	7 (12%)	12 (20%)	1 (2%)	9 (15%)
	MRI	38 (63%)	8 (13%)	9 (15%)	1 (2%)	4 (7%)
Infraspinatus	USG	4(7%)	0	4 (7%)	0	52 (86%)
	MRI	4 (7%)	1 (2%)	6 (10%)	0	49 (81%)
Teres Minor	USG	-	-	-	-	60 (100%)
	MRI	-	-	-	-	60 (100%)
Biceps tendon	USG	-	-	1 (2%)	-	54 (90%)
	MRI	-	-	1 (2%)	-	54 (90%)

[Table 2]: Detailed Correlation of pathological findings on USG and MRI.

Among the non rotator cuff disorders, acromio-clavicular joint arthropathy was the most common pathology detected on USG [Table-3].

Pathology	MRI	USG
ACJ arthropathy	40	33
SASD bursa effusion	18	8
SC bursa effusion	11	2
Biceps tendinosis	1	1
Biceps dislocation	5	5
Peribicipital tendon fluid	33	33

[Table-3]: Correlation of USG and MRI in detection of non rotator cuff related pathologies.

MRI findings: On MRI, 56 patients showed supraspinatus tendon pathologies. Detailed MRI spectrum of supraspinatus pathologies is represented in [Table-2]. Among the non rotator cuff disorders acromioclavicular joint arthropathy was most common pathology seen in 40(66.67%) patients on MRI other pathologies subacromial-subdeltoid bursa effusion, subcoracoid bursa effusion, acromio-clavicular joint arthropathies, biceps tendinosis and dislocation [Table-3].

Correlation of USG and MRI findings: In our study, MRI was used as reference standard and out of 60 patients, 49(81%) patients showed either partial thickness, full thickness or combined partial and full thickness rotator cuff tears whereas on ultrasonography examination out of 60 patients 42 (70%) patients showed either isolated or combined rotator cuff tears [Table-2].

Rotator cuff tears: Tear in any tendon, whether in isolation or in combination with other tendons was considered a rotator cuff tear. Overall, MRI showed rotator cuff tears in 49 patients [Table-4].

USG showed good sensitivity in diagnosing full thickness tears and correctly identified eight out of nine cases of full thickness tears [Table-4].

Findings	TP	FP	TN	FN	Sensitivity	Specificity	PPV	NPV
Partial Thickness Tear	32	2	17	9	78.04%	89.47%	94.11%	65.38%
Full Thickness Tear	8	0	51	1	88.89%	100%	100%	98.07%

[Table-4]: USG in evaluation of rotator cuff tears.

Agreement between USG and MRI in diagnosing rotator cuff tears: The agreement between the two methods was assessed using kappa coefficient (Kappa=0.63). The strength of agreement between USG and MRI for the diagnosis of any tear of rotator cuff is considered to be 'substantial' in our study [Table-5].

	MRI				
	Diagnosis	No Tear	PTT	FTT	Total
USG	No Tear	9	9	0	18
	PTT	2	31	1	34
	FTT	0	0	8	8
		11	40	9	60
Agreement	Expected Agreement	Kappa	Standard Error	Z	P-value
80.00%	45.28%	0.63	0.0945	6.73	<0.001

[Table-5]: Agreement between USG and MRI in diagnosing rotator cuff tears.

(Kappa value & agreement; 0.01–0.20: none to slight, 0.21–0.40: fair, 0.41– 0.60: moderate, 0.61–0.80: substantial, and 0.81–1.00: perfect agreement)

IV. Discussion

Rotator cuff tears have been reported the most common rotator cuff pathology with Ultrasound showing high sensitivity and specificity for full-thickness tears [Fig-6], but less for partial thickness tears[9] [Fig-3,4].

The rotator cuff is a functional-anatomic unit rather than four unrelated tendons, and injury to one component may have an influence on other regions of the rotator cuff[10].

In our study rotator cuff pathologies were the commonest cause for referral to Department of Radio-diagnosis which was found similar to study carried out by Mitchell C et al.,[11].

Various techniques are used for evaluating patients with shoulder pain including clinical examination, plain radiography, arthrography, Ultrasound, CT-scan and MRI. Arthrography traditionally used for diagnosis of rotator cuff tears is an invasive technique with many health risks[12].Hence, Ultrasonography and MRI have widely overtaken this technique. Conventional MRI is sensitive and specific, but cannot be used as a first line of investigation. USG is non-invasive, relatively inexpensive modality that can be used.However diagnosticdifficulties are attributed to limited movement of shoulderin painful conditions, long learning curve, technicalrestrictions and insufficient expertise[13-15].

In the present study we have compared the findings of ultrasound with MRI, using it as a reference standard for the detection of rotator cuff and related pathology in patients referred to our department.

Our study is a prospective observational study involving 60 patients.Among 60 patients, who complained to have painful shoulder that underwent sonography and MRI, majority of the subjects, 37(62%) patients (21 males and 16 females) were in the age group of 50 –70 years with mean age 56.67. Rotator cuff tears were seen in 31(52%) patients in age group of 50-70 years. Highest incidence of rotator cuff tears in our study was seen in sixth decade of life, similar to that observed by White et al., [16].

In our study, MRI was used as reference standard and out of 60 patients, 49(81.67%) patients showed either partial thickness, full thickness or combined partial and full thickness rotator cuff tears whereas on ultrasonography examination out of 60 patients, 42(70%) patients showed either isolated or combined rotator cuff tears.

USG detected 51 patients and MRI detected 56 patients with supraspinatus tendon pathologies which included tears, tendinosis and calcifications. Zlatkin et al., also found presence of supraspinatus tendon involvement in around 80% of cases in their study[8].

USG of supraspinatus tendon for detection of any tear showed sensitivity of 78.72%, specificity of 84.6%, PPV of 94.87%, NPV of 52.38%, an accuracy of 70 % and a significance of $p<0.001$.

USG of subscapularis tendon for detection of any tear showed sensitivity of 83.34%,specificity of 96.29 %, PPV of 71.42%, NPV of 98.11%, an accuracy of 95 % and a significance of $p<0.001$.

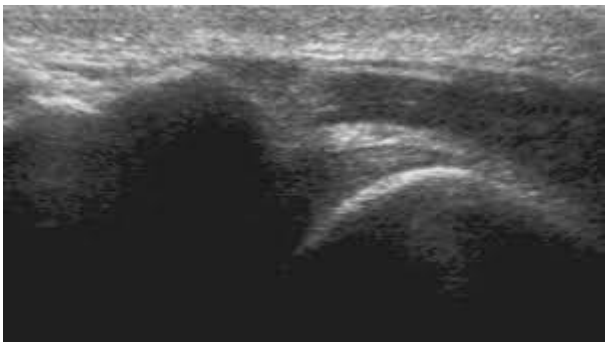
USG of infraspinatus tendon for detection of any tear showed sensitivity of 80%, specificity of 100%, PPV of 100%, NPV of 98.21%, with an accuracy of 98 % and a significance of $p<0.001$.

Overall, MRI showed rotator cuff tears in 49 patients. Partial thickness tear was present in 40(66.67%) patients which included two patients with intrasubstance tear. Nine (15%) patients had full thickness tear or combined partial and full thickness tear. Rest of the 11(18.34%) patients had intact rotator cuff without any tendon tear. Hence, partial thickness tears were the most common rotator cuff pathology seen in our study.

USG of shoulder correctly picked partial thickness tears in 31 patients which included two patients with intrasubstance tear. Nine patients with partial thickness tears of rotator cuff on MRI were falsely diagnosed on USG as intact rotator cuff, out of which five patients were misdiagnosed to have tendinosis. For full thickness tears, out of nine patients diagnosed on MRI, USG correctly diagnosed eight patients. One patient with full thickness rotator cuff tear was misdiagnosed as partial thickness tear. Five patients had associated dislocation of biceps tendon from bicipital groove all of which were correctly identified on USG.

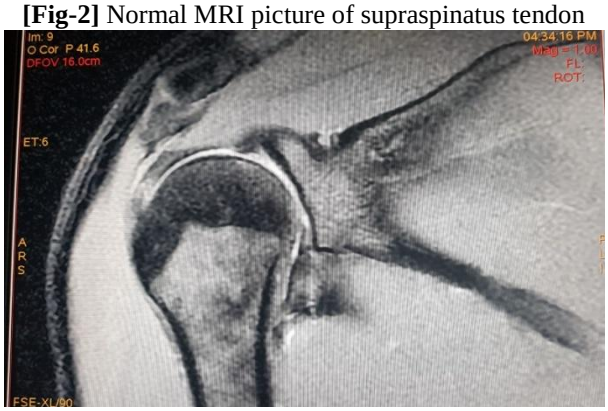
USG had a sensitivity of 78.04%, specificity of 89.47%, PPV of 94.11% and NPV of 65.38% in detection of partial thickness tears and a sensitivity of 88.89%, specificity of 100%, PPV of 100% and NPV of 98.07% in detection of full thickness tears. Overall accuracy of USG in detection of any type of tear was 82%.

The findings in our study are comparable to studies carried out by Bashir et al., [17] and Rutten et al., [18] where they found substantial agreement between USG and MRI in detection of rotator cuff tears. The level of sensitivity and specificity seen in our study closely resembles to that of Cullen et al., who reported a sensitivity of 89% and specificity of 100% in detection of full thickness tear and sensitivity of 79% and specificity of 94% in detection of partial thickness tears[19].



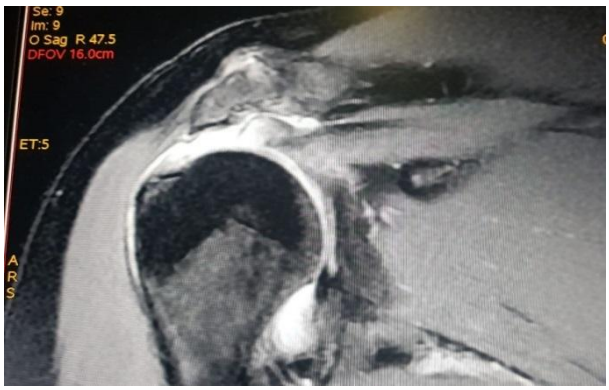
[Fig-1]Normal USG picture of supraspinatus tendon

[Fig-2] Normal MRI picture of supraspinatus tendon

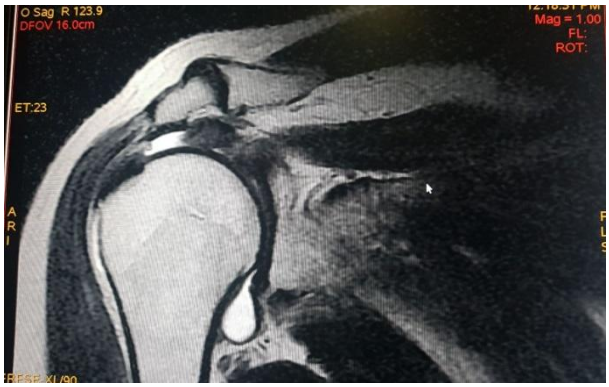


[Fig-3]Grade I Tear

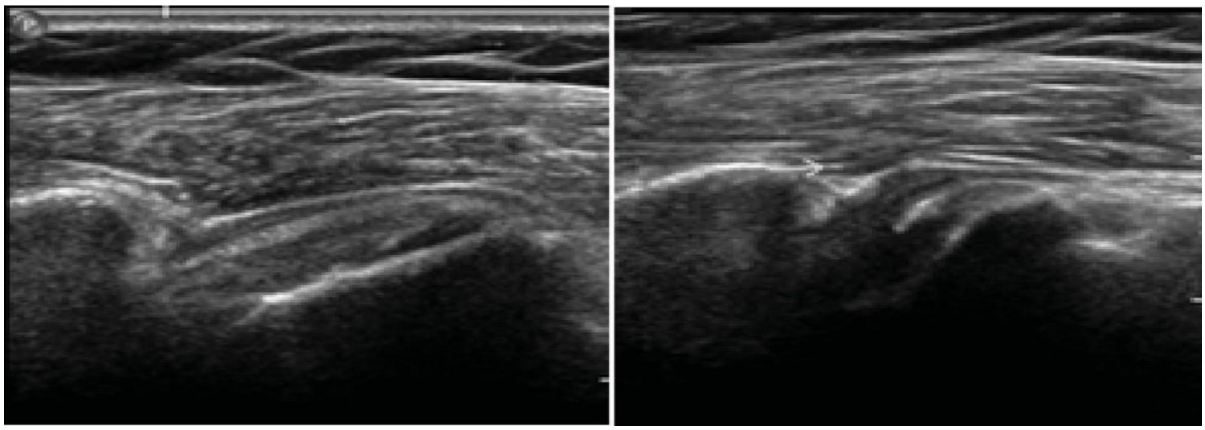
[Fig-4]Grade II Tear



[**Fig-5]**Near complete tear…Grade III

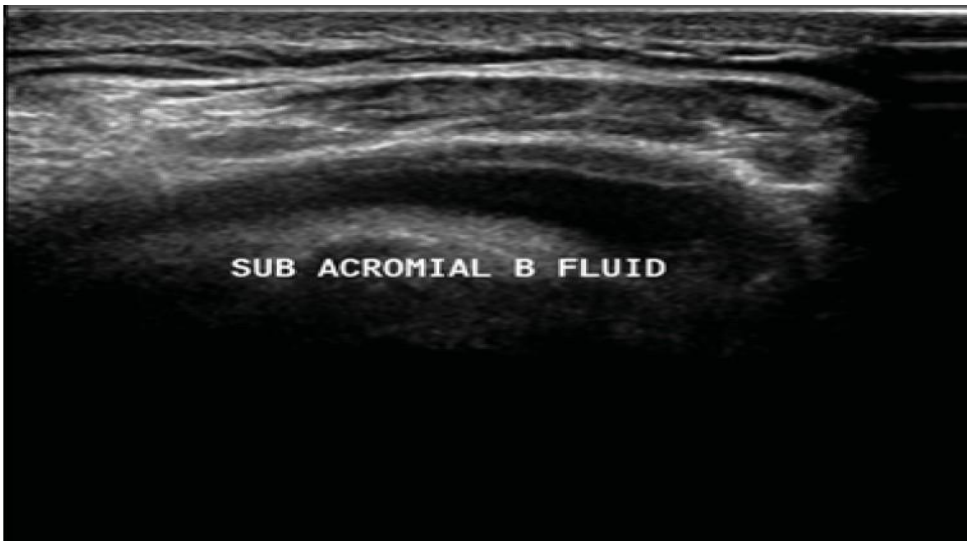


[Fig-6]High grade tear…Grade III with tendon retraction



[Fig-7]: Longitudinal USG of subscapularis tendon in

(a) external rotation and (b) Internal rotation showing signs of subcoracoid impingement.



[Fig-8]USG showing Subacromial-subdeltoid bursal fluid.

In our study we found that MRI was less accurate in detecting calcific deposits in tendon. Calcific deposits were identified only in one patient on MRI. Zubler et al., also found that detection of smaller amounts of calcification may be difficult with MRI, whereas, Hartig and Huth in a study found USG to show 100% sensitivity in detecting calcific deposits in rotator cuff tendon[20,21]. Hence, our findings were in accordance with literature and USG proved to be a better modality in detection of tendon calcification.

Dynamic examination of shoulder showed sub acromial impingement of tendon in two patients and subcoracoid impingement in one patient[Fig-7].

ACJ arthropathy was the most commonly observed non rotator cuff related pathology in our study. USG correctly identified acromio-clavicular joint arthropathy in 32(53.3%) patients with a sensitivity of 80% and specificity of 95%. Iagnocco et al., also found ACJ involvement in 51.5% patients in their study and considered it to be commonly involved in patients with painful shoulder[22].

USG showed a sensitivity of 44.4% and specificity of 100 % in detection of subacromial-subdeltoideffusion[Fig-8] and a sensitivity of 18.18% and specificity of 100% in detection of subcoracoid effusion in reference to MRI. Hence, MRI proved to be a better modality in detection of bursal effusion.

USG showed 100% sensitivity in detection of biceps tendinosis and dislocation. Thus, in our study we found USG to have good sensitivity, specificity and accuracy for detection of rotator cuff tears. USG and MRI findings showed good agreement in diagnosis of partial and full thickness tears. MRI proved to be superior in characterisation of tear with respect to location and extent. It also proved to be superior in detection of certain non rotator cuff related pathologies like subacromial-subdeltoid effusion, subcoracoid effusion and ACJ arthropathy.

However, USG has a limitation with respect to inter observer variation and needs a trained Radiologist/expertise for interpretation. High frequency probes with good resolution for the musculoskeletal ultrasound is needed.

Tissue harmonic imaging [THI] is found to be superior to conventional US in the examination of patients suspected of having rotator cuff tears as joint and tendon surfaces are better seen with use of THI as compared to conventional US[23].

Limitations

MRI was used as a reference standard which itself is not 100% accurate in detection of rotator cuff pathology. True pathology of rotator cuff was not known as follow-up of all the patients was not available. This could have lead to overestimation or underestimation of accuracy of USG in detection of rotator cuff pathology. The subjects had higher probability for rotator and non rotator cuff pathology and were not fully representative of general patients with shoulder pain. This could have lead to selection bias which caused an increase in positive predictive value and decrease in negative predictive value of USG. Also USG had limited role in evaluation of non rotator cuff related pathologies like bursal effusion, labral tears and ACJ arthropathy in our study.

V. Conclusion

Ultrasound can be used as an initial line of investigation for evaluation of all patients with painful shoulder who are clinically suspected to have rotator cuff disorders.

Rotator cuff pathologies are the most common cause of shoulder pain and Ultrasound showed comparable results to MRI in detection of rotator cuff pathology. Thus, it can be used as a cost effective first line imaging modality in assessment of shoulder pain.

Dynamic examination and ability to compare findings with contralateral shoulder are the advantages of Ultrasound over MRI. It is proved to have high sensitivity and specificity for full thickness tears with relatively less sensitivity and specificity in detection of partial thickness tear.

MRI proved to be superior to localize the site and extent of tear. It is also superior in detection of non-rotator cuff related pathologies like subacromial-subdeltoid effusion, subcoracoid effusion, ACJ arthropathies.

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