

Accuracy of Ultrasound Compared to MRI in Evaluation of Rotator Cuff Tears

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A B S T R A C T

Introduction: Rotator cuff pathologies consist of a significant proportion of shoulder pathologies. Multiple imaging modalities are available for evaluation of shoulder. However, ultrasound and Magnetic Resonance Imaging (MRI) are the most commonly used. MRI has the advantage of providing excellent soft tissue resolution and multi-planar imaging. Ultrasound however, is much cheaper, but has a long learning curve. Aim of the study is to evaluate the accuracy of Ultrasound findings in relation to Magnetic Resonance Imaging in the patients with shoulder pain for pretreatment evaluation.

Material and Methods: 100 patients of suspected shoulder pathology were studied. Sonography was performed using high frequency linear transducer 6-12MHz in GE Voluson S6 Scanner, followed by Magnetic Resonance Imaging with GE Signa HDxT1.5 Tesla MRI using surface coil.

Results: The most common rotator cuff tendon involved was supraspinatus. On comparison with Magnetic Resonance Imaging, sonographic detection of tendinosis had a sensitivity of 77.27% and specificity of 89.45%. Partial thickness tears showed a sensitivity of 59.68% and specificity of 99% and full thickness tears showed a sensitivity of 100% and specificity of 99.63%. Also comparable accuracy amongst the two modalities was seen for evaluation of long head of biceps tendon pathologies, retraction of muscle fibers and fatty atrophy of supraspinatus muscle.

Conclusion: Pretreatment evaluation of suspected rotator cuff pathologies could include Ultrasound as first line imaging modality. However, MRI should be used as a complementary modality for further assessment of cause or identifying source of symptoms in patient presenting with shoulder pain.

Keywords: Ultrasound, Magnetic Resonance Imaging, Rotator Cuff Tear, Shoulder Pain

INTRODUCTION

Shoulder pain with or without trauma is a common complaint in day to day life. The shoulder is anatomically complex with numerous structures contributing to both the mobility and stability of the joint. Variations of normal anatomy can lead to confusion during arthroscopic diagnosis and treatment¹ Pathologically the three most important entities affecting the shoulder are the rotator cuff pathologies, impingement, and instability. Commonly used imaging modalities are plain radiograph, Ultrasound (US), Computed tomography (CT) and Magnetic Resonance Imaging (MRI). Plain radiographs form the first line of investigation but soft tissue injuries are missed. Disadvantages of CT include ionizing radiation and poor soft tissue delineation.

Ultrasound has its advantage being dynamic examination, easy availability, quick scan time, and often allows therapeutic interventions with better patient compliance.^{2,3} MRI

provides excellent soft tissue delineation and evaluation of both intra-articular and extra-articular anatomy.¹ Moreover MRI is the modality that can assess the composition of bone marrow or edema related to trauma and other conditions.⁴ In this study we compare the role of high resolution Ultrasonography with MRI for various rotator cuff pathologies presenting with shoulder pain.

MATERIAL AND METHODS

An observational, prospective study at our tertiary care hospital, in consecutive 100 patients presenting with shoulder trauma/pain and suspected of having rotator cuff pathology was done after clearance from institutional ethical committee.

Patients who had undergone either MRI or only US, post-operative patients and patients with associated referred pain were excluded from the study. First US was performed in each and then followed by MRI

Ultrasonography was done using high frequency linear transducer 6-12MHz with GE Voluson S6. The examination was done in sitting position. The standard protocol was followed for systematic examination of all rotator cuff tendons and long head of biceps tendon using various dynamic maneuvers. Modified crass position was used for supraspinatus evaluation. Also subacromial subdeltoid bursa and acromioclavicular joint were examined simultaneously. MRI was done in all patients on GE Signa HDxT 1.5 Tesla MRI using surface coil. Magnetic resonance imaging studies was performed in three orthogonal planes for all patients. The coronal oblique sequence was oriented parallel to the long axis of the body of the scapula and the supraspinatus tendon (not the muscle) and perpendicular to the tangent line passing from glenoid fossa. The routine coronal, axial and sagittal T2 w and Proton Density Fat Saturated sequence was taken. Axial Gradient Echo and Sagittal T1 W sequences were also performed whenever indicated. Slice thickness was 3-5mm (average 4mm) and FOV: 16 - 20 cm with Matrix Size: 256 * 224.

For pretreatment evaluation the following were reported in US and MRI on standard format-

Muscle(s) involved [supraspinatus (SS), Subscapularis

(SCP), Infraspinatus (IFS), Long Head of Biceps Tendon (LHBT)]

Tendinosis/Partial thickness (PT) /Full thickness (FT)tear Surface of the tendon involved in tear (articular; bursal; intrasubstance)

Extent of retraction of the torn muscle

Atrophy of the muscle involved

Associated bony changes, joint fluid and peribicipital fluid collection, subacromial-subdeltoid fluid collection, labral pathologies and impingement.

STATISTICAL ANALYSIS

Descriptive statistics for clinical parameters were reported as frequency [in %] for qualitative variable & mean+/- SD for quantitative parameter. The diagnostic measures such as sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy was calculated. All the analysis was carried out with the help of standard statistical analysis methods.

RESULTS

Demographic Data: In our study most of the patients belonged to the >40-60years age group. Mean age was 45.2

S. No	Muscle	Findings	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
1	Supraspinatus	Tendinosis	88.46	82.43	63.89	95.31	84
		Partial Thickness tear	60.00	98.57	94.74	85.19	87
		Full Thickness tear	100.0	100.0	100.0	100.0	100.0
2	Subscapularis	Tendinosis	64.17	87.95	52.38	92.41	84.00
		Partial Thickness tear	54.17	98.68	92.86	87.21	88.00
		Full Thickness tear	100.00	98.95	83.33	100.00	99.00
3	Infraspinatus	Tendinosis	NC	95.96	NC	98.96	95.00
		Partial Thickness tear	75.00	100.00	100.00	97.87	98.00
		Full Thickness	100.00	100.00	100.00	100.00	100.00
4	LHBT	Tendinosis	73.68	98.77	93.33	94.12	94.00
		Partial Thickness tear	87.50	100.00	100.00	98.62	99.00
		Full Thickness	100.00	100.00	100.00	100.00	100.00

*NC: Not calculable LHBT- Long head of Biceps tendon

Table-1: Derived table for Ultrasound in detection of individual tendon pathologies

MRI findings		Positive	Negative	Total
USG	Positive	23	0	23
	Negative	3	74	77
	Total	26	74	
Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
88.46	100	100	96.1	97

Table-2: USG findings in reference to MRI for Retraction of supraspinatus muscle fibers

MRI Findings		Positive	Negative	Total
USG	Positive	13	0	13
	Negative	4	83	87
	Total	17	83	
Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
74.47	100	100	95.4	96

Table-3: USG findings in reference to MRI for fatty atrophy of supraspinatus muscle fibers

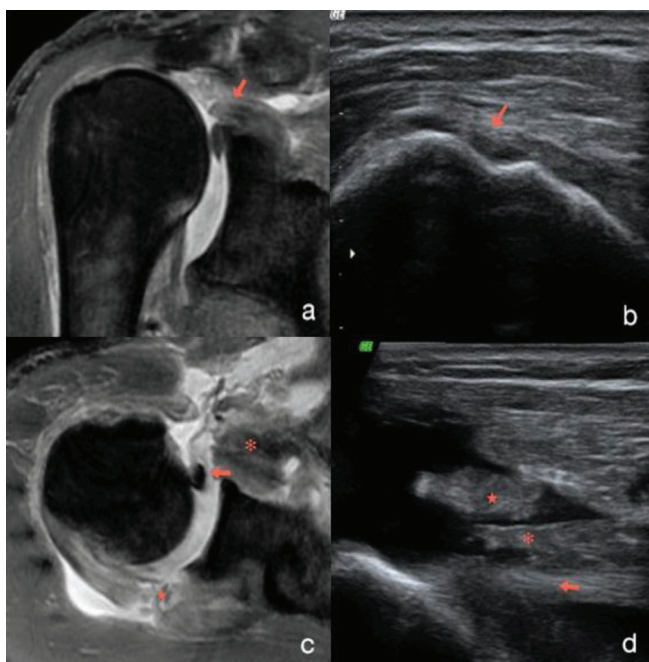
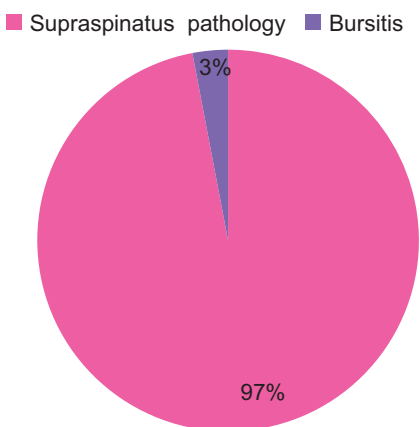


Figure-1: MRI Coronal PDFS shows superior translation of humeral head (HH) with complete full thickness tear of supraspinatus (arrow)with retraction of fibers beyond glenoid labrum (a). Moderate joint effusion also seen. Transverse USG scan shows non visualisations of the supraspinatus fibers (arrow), suggestive of full thickness tear (b). MRI Axial PDFS shows full thickness tear of subscapularis tendon (asterisk) with retraction of fibers upto the glenoid. Also note the full thickness tear of infraspinatus muscle (star). Biceps tendon is dislocated (arrow) from the groove with hyper intensity within suggestive of tendinosis(c). Transverse scan shows retraction of supraspinatus (star) and subscapularis fibers (asterisk) with moderate joint effusion. The deeper muscle fibers correspond to the biceps tendon (arrow) which appears taut and intact (d).



Graph-1: Associated pathologies with subacromial subdeltoid bursa fluid collection

years and SD 15.5 years. A clear male gender predilection, with a male to female ratio of 4.5:1 was observed in this study.

Clinical Presentation: Amongst patients aged >40years, 62.2% of patients had traumatic rotator cuff tear rest had degenerative rotator cuff tear. About 26% patients had

restriction of movements amongst the study population. This posed a diagnostic challenge during performance of dynamic maneuvers in ultrasound.

The most common rotator cuff tendon involved was supraspinatus and the most common pathology associated being partial thickness tears. All the 22 FT tears detected on MRI were confidently diagnosed on US. However, approximately half of partial thickness tears were either missed or misdiagnosed as tendinosis on US. Only one case reported as normal on MRI was misdiagnosed as tendinosis on US. (Figure 1)

Most common pathology in Subscapularis was partial thickness tears. Amongst 5 FT tears, all were correctly identified on US also. However, 5 tendinosis were not identified on ultrasound and 1 was misdiagnosed as PT tear. 10 PT tears were misdiagnosed as tendinosis and 1 was missed on US. (Figure 1)

Most common pathology we found in infraspinatus was Partial thickness tears. Amongst 4 Full Thickness tears of Subscapularis, all were correctly identified on US also. Two Partial Thickness tears were misdiagnosed, one as Tendinosis and 1 was missed on USG. (Figure 1)

The diagnostic accuracy of ultrasound in detection of SS tendinosis, partial and full thickness tears is 84%, 87% and 100% respectively. Full thickness tears had 100% sensitivity, specificity, NP V, PPV, diagnostic accuracy. For ultrasound detection of partial thickness tears we found the specificity (98.57%) to be more than sensitivity (60%), whereas for tendinosis higher sensitivity (88.46%) was found. (Table 1)

The diagnostic accuracy of ultrasound in detection of SCP tendinosis, partial and full thickness tears is 84%, 88% and 99% respectively. Full thickness tears had 100% sensitivity, 98.95% specificity, 100% NPV, 83.33% PPV, 99% diagnostic accuracy. For ultrasound detection of partial thickness tears, we found the specificity (98.68%) to be more than sensitivity (54.17%), whereas for tendinosis also we had a higher specificity (87.95%) than sensitivity (64.71%). (Table 1)

The diagnostic accuracy of US in detection of IFS tendinosis, PT and FT is 95%, 98% and 100% respectively. FT tears had 100% sensitivity, specificity, NPV, PPV, diagnostic accuracy. For US detection of PT tears, we found the specificity (100%) to be more than sensitivity (75%), similarly for tendinosis higher sensitivity (95.96%) was found. (Table 1)

Only 4 cases each of subluxation and dislocation of LHBT were identified in our study and all were correctly diagnosed, providing 100% accuracy. However, for LHBT tendinopathy 14 cases were correctly identified on ultrasound and 5 were misdiagnosed giving a total accuracy of 94%. Only 1 case of FT tear of LHBT was seen and correctly identified on US. For PT tears an accuracy of 99% was found in our study. (Table 1) (Figure 1)

The combined accuracy for diagnosis of tendinosis of any rotator cuff muscle is 87.67%, while for partial thickness tears it is 91% and full thickness tears it is 99.67%. The specificity for all the afore mentioned pathologies is more than the sensitivity in our study.

In our study 97% of subacromial subdeltoid bursal fluid collections were associated with supraspinatus pathologies (predominantly tears) and only 3% of isolated subacromial

subdeltoid bursitis was found. (Graph1)

Most cases of biceps effusion (79%) were associated with rotator cuff tears in our study.

A total of 26 patients with SS tear had retraction of muscle fibers. Amongst these 23 were correctly identified in our study. Ultrasound had a near equal accuracy (97%) as compared to MRI for diagnosis of retraction of SS fibers in rotator cuff tears especially beyond glenoid. (Table 2)

A total of 17 patients with SS tear had fatty atrophy of supraspinatus muscle. Amongst these 13 were correctly identified in our study. Thereby, USG provided a near equal diagnostic accuracy of 96% for diagnosis of fatty atrophy in patients with rotator cuff tears. (Table 3)

Ultrasound showed good detection rate of bony changes as MRI, especially avulsion injuries associated with greater tuberosity fractures.

DISCUSSION

About 60% of patients with >40yrs of age and rotator cuff tear had history of trauma. Rest 40% had a degenerative tear correlating with the previous studies by Neer et al describing most of tears in old patients as degenerative tears.⁵ About 26 patients amongst 100 study population had restriction of movements. This led to decreased efficacy of ultrasound in our study, especially during the dynamic maneuvers.

In our study the most common rotator cuff tendon involved in pathology was supraspinatus tendon (78%) followed by subscapularis tendon and infraspinatus tendon. Most common supraspinatus pathology found was partial thickness tears amongst which articular surface tears were the more common ones. For supraspinatus muscle on comparison to MRI we found that ultrasound could detect all the full thickness tears with 100% accuracy, sensitivity and specificity. We speculate that this was mainly because most of the full thickness tears had moderate effusion providing us good acoustic window for visualization of muscle pathologies.

Most of these tears were associated with retraction of fibers giving us a diagnostic clue. Amongst 30 partial thickness tears of supraspinatus, 16 were detected on ultrasound, 13 were misdiagnosed as tendinosis and 1 low grade tear was not detected. This could be due to chronic nature of tears due to which they appear more heterochoic than anechoic leading to an inaccurate interpretation. Chronic tears are also associated with minimal to no effusion providing poor window for visualization on Ultrasound.

Partial thickness tears of higher grade and the ones with associated signs (most commonly subacromial subdeltoid bursal fluid collection, bony irregularities or associated fractures) could be detected on Ultrasound. Overall we found 94% accuracy for detection of partial thickness supraspinatus tears.

For subscapularis tears we found 5 full thickness tears with 100% sensitivity, 98.5% specificity and 99% accuracy of detection on US. For 24 partial thickness tears of subscapularis, on Ultrasound 13 were correctly diagnosed. This could be due to the limitation of external rotation in these patients usually associated with subscapularis tears. Most of these subscapularis tears were located near musculotendinous junction (where the muscle fibers go deep

to the coracoid process) in our study and the visualization of the same on ultrasound is usually inaccurate due to anisotropy on transverse scan.

For infraspinatus tendon most common pathology was partial thickness tears, all of which were articular surface tears. We found a good accuracy rate of 94% for detection of these tears. Four full thickness tears were found on MRI and all were detected accurately on Ultrasound.

All over for detection of rotator cuff pathologies on US we found tendinosis to have a sensitivity of 77.27% and specificity of 89.45%. Partial thickness tears showed a sensitivity of 59.68% and specificity of 99% and for full thickness tears we found a sensitivity of 100% and specificity of 99.63%.

These results were similar to the metaanalysis of Jesus et al. They found sensitivity of 66.7% and specificity of 93.5% in partial thickness and 92.3% sensitivity and 94.4% specificity in full thickness tears.⁶

Similar results were seen in the meta analysis of Roy et al who found 91% sensitivity, 93% specificity for full thickness tears. 68% sensitivity, 94% specificity for partial thickness tears and 79% sensitivity and 94% specificity for tendinosis.⁷ However, in our study we found 100% sensitivity and 99.63% specificity and diagnostic accuracy of 99.67% for full thickness tears similar to the study by Anastasia et al⁸ who found an accuracy of 98% for full thickness tears. This discrepancy could be due to the selection bias since most cases had positive findings in our study and presented with trauma and extensive joint effusion.

For long head of biceps tendon pathology Skendzel et al⁹ described an accuracy of 88% and 97% for detection of partial and full thickness tears respectively.

In our study we found a diagnostic accuracy of 99% and 100% for partial and full thickness tears. We speculate the discrepancies of aforementioned findings could be due to decreased sample size in our study (no of cases of partial thickness (four) and full thickness tear (one)).

For pretreatment evaluation of patient and prognostic implication, orthopedic surgeons also require particulars about atrophy and fatty degeneration of ruptured muscle, retraction of fibers in tears and associated bony changes. Retraction of supraspinatus fibers beyond glenoid carry bad prognosis.¹⁰ For the assessment of retraction of fibers in supraspinatus tears we found 88.4% sensitivity and 100% specificity similar to the findings of Alagappan et al.¹¹

Fatty Degeneration and atrophy of muscle correlates with the level muscle function that could be revived following surgery, helping in deciding surgical treatment or medical management for many patients.¹⁰ Fatty degeneration evaluation was done for supraspinatus muscle only in our study by Goutallier staging.¹² We found a sensitivity of USG of 74.4% and diagnostic accuracy of 96%. These findings correlate with Lindley B. Wall et al who found a similar sensitivity of 84.6%.¹³

Limitations: MR arthrography was not performed in any of the cases, which could have helped us delineate the very small partial thickness tears. Inter observer variability was not been assessed in our study since all images were evaluated by a single radiologist.

CONCLUSION

Other than being a cost effective, readily available modality USG has an added advantage of providing superior resolution by high frequency transducers. It also has the ability to perform real time evaluation and dynamic maneuvers, especially to confirm cases of subacromial or sub coracoid impingement and subluxation of biceps. Another benefit was convenient comparison with the contralateral normal shoulder which is generally not undertaken in MR Imaging since it will not be cost effective.

In our study we also evaluated accuracy of ultrasound compared to MRI for pretreatment and prognostic information required (retraction of muscle fibers in supraspinatus tears up to glenoid bone and fatty atrophy of supraspinatus muscle) in a rotator cuff tear. Comparable accuracy was found between both modalities.

Other than being used in rotator cuff and long head of biceps tendon pathology, role of US in assessment of bony abnormalities (e.g. Acromioclavicular joint arthropathy, greater tuberosity fractures, cortical irregularities at supraspinatus footprint and large hill sacks lesions) were well evaluated with good accuracy in our study.

Ultrasound however has certain limitations, most important being operator dependence, a long learning curve, artefacts like anisotropy and difficulty in diagnosis of chronic tears. Also the cause for tears in patients other than acute traumatic presentation could not always be assessed for which further MRI Imaging is advisable.

Role of ultrasound in bursal fluid collection and joint effusion is already well established. However, we also found that very small subacromial collection could not be detected in ultrasound due to posterior acoustic shadowing from acromion process. This being an indicator of degenerative bursal surface tear, especially in elderly age group, MR imaging is suggested in such cases.

In the end we conclude that ultrasound could safely be considered as first line imaging modality in patients presenting with shoulder pain with suspected rotator cuff pathology for complete pretreatment evaluation. However, MRI should be used as a complementary modality for assessment of cause or identifying source of symptoms in patient presenting with shoulder pain.

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