Original Research Article

Study of Rotator Cuff Disorders by Ultrasound with Magnetic Resonance Imaging Correlation

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ABSTRACT

Introduction: Shoulder pain is one of the most common complaints encountered in orthopedic department. Rotator cuff pathologies are the cause of most common problems at the shoulder joint. Accurate diagnosis of these pathologies is essential for appropriate management. In addition to history and physical examination, evaluation of a patient with shoulder pain often involves assessment of the rotator cuff with a diagnostic test such as high resolution ultrasonography or MRI. This study aimed to assess the accuracy of high resolution ultrasonography in detecting the rotator cuff disorders by correlating with Magnetic Resonance Imaging findings.

Material and methods: The study included thirty patients who presented with shoulder joint pain, restriction of movements or clinically suspected rotator cuff disorders. Patients were subjected to both High resolution USG and MRI investigations. USG findings were then correlated with MRI findings.

Results: USG detected 18 cases of supraspinatous pathologies out of the 24 MRI detected abnormal supraspinatous tendons, with a sensitivity of 75%. Sensitivity, specificity, PPV, NPV and accuracy for supraspinatus tendon pathologies were found to be 75%, 66.7%, 90%, 40% and 73.7% respectively and that for subscapularis tendon were 66.7%, 95.8%, 80%, 92% and 90% respectively. USG had 58.3% sensitivity in identifying partial thickness tears, 100% specificity and PPV. For full thickness tear, USG had 100% sensitivity, 96.4% specificity, 75% PPV, 100% NPV and an accuracy of 100%.

Conclusion: USG is comparable to MRI in evaluation of disorders of the rotator cuff disorders, particularly more accurate in full thickness tear of rotator cuff tendons. USG can be used as the first line investigation, MRI can be used in situations where the diagnosis is equivocal on USG or in patients in whom USG examination is difficult to perform or patient is not cooperative. Ultrasonography being non-invasive, non-ionizing, combined with low cost with advantage of dynamic real time assessment, may serve as the most cost effective imaging method for screening of rotator cuff disorders.

Key words: Ultrasonography, Magnetic Resonance Imaging, Rotator Cuff Tears

INTRODUCTION

Shoulder pain is one of the most common complaints encountered in orthopedic department and often leads to considerable disability¹. Pathologies of the rotator cuff are the cause of most common problems at the shoulder joint and accurate diagnosis is essential for appropriate management². Cuff strain, impingement syndrome and rotator cuff tears make up a group of lesions that produce shoulder pain. It is clinically difficult to differentiate between these conditions and distinguish them from other conditions like glenohumeral instability. In addition to history and physical examination, evaluation of a patient with shoulder pain often involves assessment of the rotator cuff with a diagnostic test such as high resolution ultrasonography or MRI³.

High resolution ultrasound being non invasive, less expensive and non-ionizing modality with added advantage of real time assessment has good sensitivity in detecting rotator cuff disorders. It can be used as a focused examination providing rapid, real-time diagnosis in many clinical situations⁴. The reported accuracy, sensitivity and specificity of high resolution ultrasound in detecting any tear, whether partial or full thickness are all greater than 90%⁵. It serves as a complementary role to MRI in shoulder imaging.

High resolution ultrasound can also reveal the presence of other abnormalities that may mimic rotator cuff tear at clinical examination including tenosynovitis, tendinosis, calcific tendinitis, subacromial-subdeltoid bursitis, greater tuberosity fracture, etc.,

MRI has become the gold standard for detecting both subtle and obvious internal derangement assessing overall joint structure. MRI is an excellent modality because of its multiplanar capability. MRI can provide information about rotator cuff disorders such as tendinosis, calcific tendinitis, tears, muscle atrophy and involvement of adjacent structures such as rotator interval, long head of biceps brachii tendon, all of which have implications for rotator cuff treatment and prognosis⁶. Magnetic resonance arthrography is commonly used for instability⁷. Arthrography appears to be more accurate in diagnosing rotator cuff injuries than either MRI or ultrasound but that benefit must be set against the invasiveness and potential discomfort to patients. MRI and ultrasonography have replaced arthrography for evaluating the integrity of the rotator cuff.

Ultrasonography is as accurate as MRI, these combined with low cost for ultrasound suggests that ultrasound may be the most cost effective imaging method of screening for rotator cuff disorders. Sonography has the advantage of dynamic real time assessment⁸. This study aimed to assess the accuracy of high resolution ultrasonography in detecting the rotator cuff disorders by correlating with Magnetic Resonance Imaging findings.

MATERIAL AND METHODS

A structured pre-prepared case proforma was used to enter the patient details, clinical history and imaging findings who met the inclusion criteria.

Ultrasound examination of the shoulder joint was performed in gray scale mode using a high resolution, 7.5 - 12 MHz, linear array transducer. Rotator cuff tendons and muscles were studied by static and dynamic ultrasonography. Comparison with the contralateral side was also done.

By USG, tendinosis is detected by focal thickening of the tendon and altered echopattern. Partial thickness tear is detected as focal discontinuity/ hypoechogenicity at the bursal or articular surfaces of the tendon. USG shows full thickness tear as discontinuity of tendons extending from bursal to articular surface with retraction of the torn tendon ends (figure 1-6).

Magnetic Resonance Imaging of the shoulder joint was performed subsequently. Imaging was done with 1.5 Tesla MRI machine using shoulder coil. The following sequences were selected as required: Oblique coronal/oblique saggital T1W sequence, T2W and PD FSE sequences with or without fat saturation, Axial T2*W GRE sequence and Axial/oblique saggital STIR sequence. Field of view 14-16 cm, slice thickness 3 mm and matrix size and TR/TE kept according to the selected sequence.

In MRI, tendinosis presents as moderately increased signal intensity in short TE sequences such as T1 weighted and PD sequences while this increased signal intensity is not as high as fluid signal in T2 weighted sequence. These signal changes are seen along the long axis of the tendon, which may be focal or diffuse. On fat saturated sequences, the increased signal of tendinosis is as high as fluid and it should be differentiated from fluid signal seen in cases of tear. Severe tendinosis presents as diffuse thickening⁹.

In MRI, partial thickness tears presents as focal tendon fiber discontinuity with focal areas of hyperintensity on both short and long TE sequences on the articular or bursal surfaces. The hyperintensity does not extend through the entire thickness of the tendon.

In MRI, full thickness tears are seen as high signal intensity traversing the whole thickness of tendon, extending from articular surface to bursal surface on at least one image. The high signal intensity is due to the presence of fluid. Full thickness tears are common in supraspinatus tendon. Fluid in the subacromial-subdeltoid bursa is a non-specific sign of full thickness tear in cases of tendon fiber discontinuity¹⁰. The high resolution USG findings were correlated with the MRI findings (Figure 7-11).

STATISTICAL ANALYSIS

Both descriptive and inferential statistics were employed for data analysis. Diagnostic statistics such as sensitivity, specificity, positive predictive value, negative predictive value and accuracy were computed to assess the correlation of USG findings with MRI findings.

RESULTS

Of the supraspinatous tendon pathologies, 9 patients (30%) found to have tendinosis in USG had tendinosis in MRI, 3 (10%) of the patients who were found to have tendinosis in USG were found to have partial tear in MRI. 4 (13.3%) patients who had normal sonographic appearance of supraspinatous tendon had tendinosis in MRI. All four partial thickness tears diagnosed by ultrasound had partial thickness tears in MRI also. One full thickness tear detected by USG was found to be a partial thickness tear in MRI. 6 patients (20%) had both normal sonographic and MRI appearances.

Of the infraspinatous tendon pathologies, 28 patients (93.3%) were found to have normal tendon in both USG and MRI. One patient (3.3%) who had partial thickness tear in USG was confirmed by MRI. One patient (3.3%) found to

Affected Tendon	USG/MRI	Tears				
		Tendinosis	Partial thickness tear	Full thickness tear	Normal	
Supraspinatus	USG	12 (40.0%)	4 (13.3%)	4 (13.3%)	10 (30.0%)	
	MRI	13 (43.3%)	8 (26.7%)	3 (10.0%)	6 (20.0%)	
Infraspinatus	USG	0 (0.0%)	1 (3.3%)	0 (0.0%)	29 (96.7%)	
	MRI	1 (3.3%)	1 (3.3%)	0 (0.0%)	28 (93.3%)	
Teres Minor	USG	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	
	MRI	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	
Subscapularis	USG	3 (10.0%)	2 (6.7%)	0 (0.0%)	25 (83.3%)	
	MRI	3 (10.0%)	3 (10.0%)	0 (0.0%)	24 (80.0%)	
Biceps Tendon	USG	1 (3.3%)	0 (0.0%)	0 (0.0%)	29 (96.7%)	
	MRI	0 (13.3%)	0 (13.3%)	0 (13.3%)	30 (13.3%)	
Table-1: Pathological correlation of USG and MRI Findings.						

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have tendinosis in MRI had normal sonographic appearance. Out of the 30 subscapularis tendons, 23 patients (76.7%) had



Figure-1: USG images showing focal hypoechogenicity and thickening of the supraspinatous tendon suggestive of tendinosis.



Figure-2: USG images of two patients showing partial thickness tear of the supraspinatous tendon on the articular surface.

normal appearance in both USG and MRI. Of the 3 patients found to have tendinosis by USG, one was tendinosis, one



Figure-3: USG image showing partial thickness tear of the supraspinatous tendon on the bursal surface.



Figure-4: USG images of the supraspinatous tendon showing full thickness tear with retraction of tendon ends.

Findings	ТР	FP	FN	TN	Total
Supraspinatus	18	2	6	4	30
Infraspinatus	1	0	1	28	30
Teres Minor	0	0	0	30	30
Subscapularis	4	1	2	23	30
Biceps Tendon	0	1	0	29	30
(TP – True positive; FP – False positive; FN – False negative; TN – True Negative)					

Table-2: Observation of US	G and MRI Findings.
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Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
Supraspinatus	75.0	66.7	90.0	40.0	73.3	< 0.01
Infraspinatus	50.0	100	100	96.6	96.7	< 0.01
Teres Minor	-	100	-	100	100	-
Subscapularis	66.7	95.8	80.0	92.0	90.0	< 0.01
Biceps Tendon	-	96.7	0.0	100	96.7	-
PPV – Positive Predictive Value; NPV – Negative Predictive Value						
Table 2: Evolution of USC and MDI Findings						

 Table-3:
 Evaluation of USG and MRI Findings.

Tears	ТР	FP	FN	TN	Total	
Partial thickness	7	0	5	18	30	
Full thickness	3	1	0	27	30	
TP – True positive; FP – False positive; FN – False negative; TN – True Negative						
Table-4: Observation of USG and MRI Findings with respect to tears.						

Findings	Sensitivity	Specificity	PPV	NPV	Accuarcy	
Partial thickness	58.3	100	100	78.2	83.3	
Full thickness	100	96.4	75.0	100	100	
PPV – Positive Predictive Value; NPV – Negative Predictive Value						
Table-5: Evaluation of USG and MRI Findings with respect to tears.						



Figure-5: USG images showing partial tear of the subscapularis tendon.



Figure-6: USG image showing partial tear of the infraspinatous tendon.



Figure-7: MRI images of two patients showing focal hyperintensity and thickening of the supraspinatous tendon suggestive of tendinosis.



Figure-8: MRI coronal (A) and saggital (B) images showing partial thickness tear of the supraspinatous tendon on the articular surface.

was partial thickness tear and one was normal by MRI. The two cases diagnosed as partial tears by USG were confirmed to have partial tears in MRI. Of the three cases found to have tendinosis in MRI, 2 cases (66.7%) had normal sonographic appearance.

For supraspinatous tendon pathologies USG had sensitivity of 75%, specificity of 66.7%, PPV of 90%, NPV of 40% and accuracy of 73.3% with a p-value of <0.01. For subscapularis tendon pathologies, sensitivity of 66.7%, specificity of 95.8%, PPV of 80%, NPV of 92% and accuracy of 90% were



Figure-9: MRI saggital image showing partial thickness tear of the supraspinatous tendon extending to the bursal surface.



Figure-10: MRI axial images showing partial tear of the subscapularis tendon.



Figure-11: MRI images showing full thickness tear of the supraspinatous tendon with retraction of tendon ends.

obtained with a p-value of <0.01. Infraspinatous tendon pathologies had a sensitivity of 50%, specificity and PPV 100%, NPV of 96.6% and accuracy of 96.7% with a p-value of <0.01. p-value was not obtained for teres minor tendon evaluation as no abnormality was found by USG and MRI in all 30 patients. Biceps tendon had a specificity of 96.7% and NPV of 100%, p-value not obtained as MRI showed no abnormality in all 30 patients (table- 1-3).

In detecting partial tears of all rotator cuff tendons, USG had a sensitivity of 58.3%, specificity of 100%, PPV of 100%, NPV of 78.2& and accuracy of 83.3%. For full thickness tear detection, USG had a sensitivity of 100%, specificity of 96.4%, PPV of 75%, NPV of 100% and accuracy of 100% (table- 4,5).

DISCUSSION

Shoulder pain is one of the common presenting complaints in orthopaedic department. Rotator cuff disorders are the most common cause of shoulder pain. MRI is the investigative modality of choice used to assess the rotator cuff tendons and is sensitive and specific, but it cannot be used as a first line of investigation due to cost factor and availability. Ultrasonography being relatively inexpensive and non-invasive can be used as a first line imaging modality to assess rotator cuff pathologies.

This is a prospective study of 30 patients who presented with shoulder pain or restricted movements. The patients were subjected to USG examination of the shoulder joint and then MRI examination of the affected shoulder joint was performed. Findings of USG were compared with MRI findings.

Various rotator cuff pathologies were studied. The pathologies include tendinosis, partial thickness tear and full thickness tear of the rotator cuff tendons. Supraspinatus is the commonest tendon to be affected in this study group, followed by the subscapularis tendon.

Only two patients (6.7%) in our study had pathologies in infraspinatous tendon. Teres minor tendon was not affected (0%) in any of the patients. USG detected 18 cases of supraspinatous pathologies out of the 24 MRI detected abnormal supraspinatous tendons, with a sensitivity of 75%. Supraspinatus tendon pathologies showed 75% sensitivity, 66.7% specificity, 90% PPV, 40% NPV and an accuracy of 73.7% and significance of P value <0.01. Subscapularis tendon pathologies showed 66.7% sensitivity, 95.8% specificity, 80% PPV, 92% NPV and an accuracy of 90% and significance of P value <0.01. Infraspinatous tendon pathologies showed 50% sensitivity, 100% specificity, 100% PPV, 96.6% NPV and an accuracy of 96.7%. Biceps tendon and teres minor tendons findings showed a 100% NPV.^{4,6}

USG had a sensitivity of 58.3% in identifying partial thickness tears of the rotator cuff tendons. It had a specificity and PPV of 100%, NPV of 78.2% and an accuracy of 83.3%. For full thickness tear, USG had 100% sensitivity, 96.4% specificity, 75% PPV, 100% NPV and an accuracy of 100%.7-9 USG has many advantages, it is non-invasive, non-ionizing, widely available, inexpensive and has high spatial resolution. USG can be done in out-patient department without need for any patient preparation. Limitations of USG are high operator dependency with a long learning curve and it has high inter-observer variation. Not all pathologies of shoulder joint can be assessed by USG, evaluation is limited to assessment of rotator cuff pathologies and associated fluid collections. Labral and ligamentous pathologies, bony abnormalities and muscle atrophy changes are not well appreciated by USG. One important pitfall of USG is anisotropy, tendons appear echogenic when the ultrasound beam is perpendicular to the long axis of the tendon resulting in an erroneous hypoechogenicity which may be mistaken for tendinosis or partial tears.¹⁰

MRI is non-invasive, non-ionizing, it has multiplanar capability and high soft tissue contrast. Labro-ligamentous pathologies, subtle bony changes like edema or contusion and muscular atrophic changes are best appreciated by MRI. Limitations of MRI include high cost and availability. Other limitations are claustrophobia, metallic implants and pacemakers. Magic angle artefact is a common pitfall in MRI shoulder examinations. Increased signal intensity is seen in normal cuff tendons in short TE sequences such as T1W and PD due to the orientation of tendon fibers at an angle of 55 degrees to the main magnetic field, which is commonly mistaken for tendinosis. This artefact is not seen in long TE sequences such as T2.

CONCLUSION

USG is comparable to MRI in evaluation of disorders of the rotator cuff disorders, particularly partial or full thickness tears. MRI is the most sensitive and specific investigative modality and has high accuracy for assessment of soft tissue structures, but the cost factor and availability are its disadvantages. MRI can be used in situations where the diagnosis is equivocal on USG or in patients in whom USG examination is difficult to perform or patient is not cooperative and in problematic cases.

Cost effectiveness and ready availability are the biggest advantages of ultrasonography. The real time capability of ultrasound in conducting dynamic studies in areas like the shoulder is a very big asset. It helps to do quick comparison with the contralateral side, which is of great help in many difficult situation.

USG can be used as the first line of investigation in suspected rotator cuff disorders. It can be the most cost effective screening modality for rotator cuff disorders.

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