ROLE AND CORRELATION OF ULTRASONOGRAPHY AND MAGNETIC RESONANCE IMAGING IN EVALUATION OF ROTATOR CUFF IN PATIENTS WITH SHOULDER PAIN

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Abstract

Background: Shoulder pain is one of the most common musculoskeletal complain encountered in general practice with an estimated point prevalence of 6.9 to 26% in the general population. The aim of the study was to determine the accuracy of ultrasonography in detecting rotator cuff tears taking MRI findings as the standard. Available literature related to the present study was reviewed and salient features of each pathology discussed.

Methods: This observational, prospective study was carried out in the Department of Radiodiagnosis, National Institute Of Medical Sciences & Research, Jaipur, Rajasthan. A total of 80 patients from all age groups with symptomatology related to rotator cuff of the shoulder joint, on the basis of inclusion criteria, were examined by USG and MRI from a period of January 2019 to June 2020.

Results: USG had good sensitivity (82 to 93%), specificity (92 to 97%), PPV (85 to 87%), NPV (91 to 98%) and accuracy (90 to 96%) as compared MRI for diagnosing supraspinatus lesions. The sensitivity and accuracy of USG for detecting full thickness tears was better than the same for partial thickness tears and tendinosis.

Conclusion: In our study, USG examination had excellent sensitivity, specificity and accuracy as compared MRI for diagnosing full thickness rotator cuff tears. It was also fairly accurate in detecting partial thickness tears and tendinosis. It was comparable to MRI in diagnosing and quantifying joint effusion and acromioclavicular degenerative changes. USG scored over MRI in diagnosing calcific tendinosis while some findings, such as labral tears, were only detected by MRI.

Keywords: MRI, USG, Shoulder pain.

Introduction

Shoulder pain is one of the most common musculoskeletal complain encountered in general practice with an estimated point prevalence of 6.9 to 26% in the general population¹. Compromised shoulder movement due to pain, stiffness or weakness can lead to substantial disability and might affect a person's ability to carry out daily activities and work. There are several conditions that can generate shoulder pain. These conditions may be intrinsic or extrinsic to the shoulder. The extrinsic conditions include disorders of the cervical spine, thoracic outlet and abnormal posture². The intrinsic conditions include rotator cuff ruptures, impingement, tendonitis, and degenerative and post-traumatic disorders. Rotator cuff pathologies, particularly rotator cuff tears, account for more the half of the shoulder abnormalities. The incidence of rotator cuff tears tends to increase in frequency with age². Clinical examination alone has low sensitivity and specificity in identifying the underlying etiology of shoulder pain³. Accurate diagnosis of the etiology is essential as each of them have a different treatment and clinical outcome and hence imaging becomes necessary⁴⁻⁷.

Magnetic resonance imaging (MRI) is an excellent modality because of its multiplanar capability and is reliable technique for the evaluation of rotator cuff tendon, however, because of low availability and considering cost factor ultrasonography (USG) can be used as screening modality. It has gained its place in literature along with MRI. Cost effectiveness and ready availability are its biggest advantages in several clinical settings. The real-time capability of ultrasound in conducting dynamic studies in areas like shoulder is a very big asset. It helps to do quick comparison with the contralateral side, which is of great help in many difficult situations.

Material and Methods

Study Design:

This is an observational, prospective study to assess rotator cuff pathologies of the shoulder joint by Ultrasonography and Magnetic Resonance Imaging.

Study Settings:

The present study "Role And Correlation Of Ultrasonography And Magnetic Resonance Imaging In

Evaluation Of Rotator Cuff In Patients With Shoulder Pain” was conducted in the Department of Radiodiagnosis, National Institute of Medical Sciences & Research & Hospital, Jaipur, Rajasthan.

Sample Size:

Eighty (80) subjects.

Sampling Method:

Non-probability convenience sampling

Period Of Study:

The present study was conducted from January 2019 to June 2020 for a period of one and half year after taking approval from the ethical committee.

Source of Data:

The main source of data for this study were the patients referred for USG and MRI of shoulder joint at department of Radiodiagnosis, National Institute of Medical Sciences & Research & Hospital, Jaipur, Rajasthan having shoulder pain clinically suspected to arise from musculotendinous tissues around glenohumeral joint or with features suggestive of rotator cuff tear.

Inclusion Criteria:

Patients with history of shoulder pain clinically suspected to arise from musculotendinous tissues around shoulder joint or with features suggestive of rotator cuff tear.

Exclusion Criteria:

1. Patients with known or diagnosed fracture/dislocation involving the shoulder on plain radiography
2. Diagnosed cases of any tumor, arthritis, periartthritis of shoulder/frozen shoulder.
3. Patients with h/o shoulder surgery
4. Patients with contraindications to MRI

Study Tools:

- Ultrasonography machine: VOLUSON S6 with 3-12 MHz linear probe.
- MRI machine: Phillips Ingenia CX 1.5 tesla MRI, manufactured by Philips.
- A predesigned and pretested proforma for recording patient particulars, clinical and radiological findings.

Data Analysis:

Data analysis was done using the statistical package for social science (SPSS) for windows. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of ultrasound findings was calculated using MRI findings as

gold standard. A correlation coefficient was calculated for the results of both the imaging techniques.

Results

The present study was carried out to describe role of USG and magnetic resonance imaging of rotator cuff pathologies. Eighty patients who were found to have rotator cuff disease during the study period fulfilling the inclusion and the exclusion criteria were included in study.

The uninvolved shoulder joints were used as controls for comparison with the involved shoulder joints.

The results of this study have been presented in tabular and pictorial representations under different headings and observations are summarized accordingly.

In the present study, age range of patients was between 18 to 75 yrs. with a mean age of 46.24yrs. The mean age among females was 47.4 years and the mean age among males was 45.6 years. The maximum number of cases were in the age group of 41-50 years, constituting 26.25% (21/80) of total cases. 26 were female (32.5%) and 54 were male (67.5%). Male to female ratio was 2.07:1. 56 had symptoms on right shoulder (70%) while 24 had symptoms on left shoulder (30%). 81.25% (65/80) of the patients had right hand as their dominant hand while 18.75% (15/80) of the patients were left-handed.

Table 1: Various findings on Ultrasound

USG Findings	No. of patients	Percentage
Supraspinatus lesions	65	81.25%
Infraspinatus lesions	6	7.5%
Subscapularis lesions	9	11.25%
Biceps tendon lesions	12	15%
Bicipital tendon sheath fluid	58	72.5%
Subacromial-Subdeltoid bursal fluid	37	46.25%
Acromioclavicular arthropathy	18	22.5%
Normal	12	15%

Among all the suspected cases of rotator cuff lesions, USG was unable to detect any pathology in 12 patients. In the remaining 68 patients, supraspinatus lesions were the commonest finding, seen in 65 (81.25% of total) patients, followed by biceps tendon lesions in 12 (15% of total) patients. Bicipital tendon sheath fluid and subacromial-subdeltoid bursal fluid were fairly common findings. They were detected in nearly 72.5% and 46.25% of patients, respectively. Degenerative changes of acromioclavicular joint were picked up in 18 cases.

Out of the 65 supraspinatus tendon lesions detected on USG, 28 were partial thickness tears, 16 were full thickness tears and 21 were tendinopathies. Of the 28 partial thickness tears - 16 were articular surface tears, 9 were bursal surface tears and 3 were intrasubstance tears. Out of the 6 infraspinatus tendon lesions, 3 were partial thickness tears, 1 was a full

thickness tear and 2 were tendinopathies. Out of the 9 subscapularis lesions 5 were partial thickness tears, 1 was a full thickness tears and 3 were tendinopathies. All the cases with infraspinatus and subscapularis lesions had coexisting supraspinatus lesions. No lesion was found in the teres minor tendon in any of the patients. In total nine patients with supraspinatus tendinosis demonstrated intratendinous echogenic foci with posterior acoustic shadowing which was suggestive of calcific tendinitis.

Table 2: Various findings on MRI

MRI Findings	No. of patients	Percentage
Supraspinatus lesions	66	82.5%
Infraspinatus lesions	7	8.75%
Subscapularis lesions	10	12.5%
Biceps tendon lesions	14	17.5%
Bicipital tendon sheath fluid	63	78.75%
Subacromial-Subdeltoid bursal fluid	41	51.25%
Acromioclavicular arthropathy	26	32.5%
Normal	9	11.25%

In comparison with USG, only 9 patients were found to have no lesion on MRI. As in case of USG, the most common pathology detected on MRI was that of supraspinatus tendon seen in 66 (82.5% of total) patients. BTS fluid and SADB fluid were also detected in larger number of patients (78.75% and 51.25% respectively) in comparison to USG. Degenerative changes of acromioclavicular joint were detected in 26 cases.

Out of the 66 supraspinatus tendon lesions detected on MRI, 28 were partial thickness tears, 15 were full thickness tears and 23 were tendinopathies. Of the 28 partial thickness tears - 16 were articular surface tears, 8 were bursal surface tears and 4 were intrasubstance tears. 3 case of partial thickness tears, 2 cases of full thickness tears and 2 cases of tendinopathies was identified in infraspinatus tendon. Out of the 10 subscapularis lesions 6 were partial thickness tears, 2 were full thickness tears and 2 were tendinopathies. All the cases with infraspinatus and subscapularis lesions had coexisting supraspinatus lesions on MRI too.

Comparison between USG and MRI taking MRI findings as gold standard

Supraspinatus lesions:

- Out of the 80 cases, MRI detected supraspinatus tendon lesions in 66 patients, while USG detected it in 65 patients.
- Out of the 66 supraspinatus tendon lesions detected on MRI, 28 were partial thickness tears. USG correctly identified 24 of these lesions. It overdiagnosed these lesions in 4 cases and underdiagnosed these lesions in 4 cases.
- 15 full thickness tears were identified on MRI of which USG correctly identified 14 cases. USG missed 1 of these lesions and overdiagnosed 2 such lesions.

- 23 cases of supraspinatus tendinosis were identified on MRI. Of these, USG correctly identified 18 cases, overdiagnosed 5 cases and underdiagnosed 3 cases.

- These findings as well as the sensitivity, specificity, PPV, NPV, and accuracy of USG compared to MRI are tabulated below along with their Kappa correlation coefficient.

Table 3: Evaluation of supraspinatus lesions by USG taking MRI findings as standard

Findings	True Positive	False Positive	True Negative	False Negative
Partial thickness tear	24	4	48	4
Full thickness tear	14	2	63	1
Tendinosis	18	3	54	5

Table 4: Diagnostic Parameters of USG for the diagnosis of supraspinatus lesions

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	Kappa coefficient
Partial thickness tear	85.7%	92.3%	85.7%	92.3%	90%	0.8
Full thickness tear	93.3%	96.9%	87.5%	98.4%	96.2%	0.87
Tendinosis	82.6%	96.5%	85.7%	91.5%	90%	0.75

Infraspinatus lesions:

- Out of the 80 cases, MRI detected infraspinatus tendon lesions in 7 patients, while USG detected it in 6 patients.
- Out of the 7 infraspinatus tendon lesions detected on MRI, 3 were partial thickness tears. USG correctly identified 2 of these lesions. It overdiagnosed this lesion in 1 case and underdiagnosed it in 1 case.
- 2 full thickness tears were identified on MRI of which USG correctly identified 1 case. USG missed 1 of these lesions.
- 2 cases of infraspinatus tendinosis were identified on MRI. Of these, USG correctly identified 1 case, overdiagnosed 1 case and underdiagnosed 1 case.
- These findings as well as the sensitivity, specificity, PPV, NPV, and accuracy of USG compared to MRI are tabulated below along with their Kappa correlation coefficient.

Table 5: Evaluation of infraspinatus lesions by USG taking MRI findings as standard

Findings	True Positive	False Positive	True Negative	False Negative
Partial thickness tear	2	1	76	1
Full thickness tear	1	0	78	1
Tendinosis	1	1	77	1

Table 6: Diagnostic Parameters of USG for the diagnosis of infraspinatus lesions

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	Kappa coefficient
Partial thickness tear	66.6%	98.7%	66.6%	98.7%	97.5%	0.64
Full thickness tear	50%	100%	100%	98.7%	98.75%	0.5
Tendinosis	50%	98.7%	50%	98.7%	98.7%	0.43

Subscapularis lesions:

- Out of the 80 cases, MRI detected subscapularis tendon lesions in 10 patients, while USG detected it in 9 patients.
- Out of the 10 subscapularis tendon lesions detected on MRI, 6 were partial thickness tears. USG correctly identified 3 of these lesions. It overdiagnosed these lesions in 2 cases and underdiagnosed these lesions in 3 cases.
- 2 full thickness tears were identified on MRI of which USG correctly identified 1 case. USG missed 1 of these lesions.
- 2 cases of subscapularis tendinosis were identified on MRI. USG correctly identified the 2 cases, and overdiagnosed 1 case.
- These findings as well as the sensitivity, specificity, PPV, NPV, and accuracy of USG compared to MRI are tabulated below along with their Kappa correlation coefficient.

Table 7: Evaluation of subscapularis lesions by USG taking MRI findings as standard

Findings	True Positive	False Positive	True Negative	False Negative
Partial thickness tear	3	2	72	3
Full thickness tear	1	0	78	1
Tendinosis	2	1	77	0

Table 8: Diagnostic Parameters of USG for the diagnosis of subscapularis lesions

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	Kappa coefficient
Partial thickness tear	50%	97.3%	60%	98.6%	93.75%	0.5
Full thickness tear	50%	100%	100%	98.7%	98.75%	0.62
Tendinosis	66.6%	100%	100%	98.7%	98.75%	0.8

Discussion

Sensitivity and specificity of USG in diagnosing abnormality in rotator cuff pathologies:

The Rotator cuff pathology of all 4 muscles were classified with increasing severity into tendinosis, partial thickness tears and full thickness tears. Among all the suspected cases of rotator cuff lesions, the most common pathology detected on both MRI and USG was that of supraspinatus tendon

seen in 66 and 65 patients respectively. This was followed by subscapularis and infraspinatus tendon lesions. No lesion of teres minor tendon could be detected by either modality. This is comparable to the studies done by Zlatkin et al.⁸ and Bhatnagar et al.⁹, wherein they found supraspinatus tendon involvement in around 80% and 74.6% of their cases respectively. The characteristic anatomic location of the supraspinatus tendon is the likely cause. It is located between the greater tuberosity and the acromion process leading to repeated friction during overhead abduction of the shoulder. Partial thickness tears were more common than full thickness tears, in the present study.

Supraspinatus tendon lesions –

Out of the 66 supraspinatus tendon lesions detected on MRI, 28 were partial thickness tears. USG correctly identified 24 of these lesions. It overdiagnosed these lesions in 4 cases and underdiagnosed these lesions in 4 cases. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting partial thickness tears of supraspinatus tendon was 85.7%, 92.3%, 85.7%, 92.3% and 90% respectively. Kappa agreement between USG and MRI was 0.8, indicating substantial agreement.

15 full thickness tears were identified on MRI of which USG correctly identified 14 cases. USG missed 1 of these lesions and overdiagnosed 2 such lesions. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting full thickness tears of supraspinatus tendon was 93.3%, 96.9%, 87.5%, 98.4% and 96.2% respectively. Kappa agreement between USG and MRI was 0.87, indicating almost perfect agreement.

23 cases of supraspinatus tendinopathy were identified on MRI. Of these, USG correctly identified 18 cases, overdiagnosed 5 cases and underdiagnosed 3 cases. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting tendinosis of supraspinatus was 82.6%, 96.5%, 85.7%, 91.5% and 90% respectively. Kappa agreement between USG and MRI was 0.75, indicating substantial agreement.

Infraspinatus tendon lesions –

Out of the 80 cases, MRI detected infraspinatus tendon lesions in 7 patients, while USG detected it in 6 patients.

Out of the 7 infraspinatus tendon lesions detected on MRI, 3 were partial thickness tears. USG correctly identified 2 of these lesions. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting partial thickness tears of infraspinatus tendon was 66.6%, 98.7%, 66.6%, 98.7% and 97.5% respectively. Kappa agreement between USG and MRI was 0.64, indicating substantial agreement.

2 full thickness tears were identified on MRI of which USG correctly identified 1 case. USG missed 1 of these lesions. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting full thickness tears of infraspinatus tendon was

50%, 100%, 100%, 98.7% and 98.75% respectively. Kappa agreement between USG and MRI was 0.5, indicating moderate agreement.

2 cases of infraspinatus tendinosis were identified on MRI. Of these, USG correctly identified 1 case, overdiagnosed 1 case and underdiagnosed 1 case. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting tendinosis of infraspinatus tendon was 50%, 98.7%, 50%, 98.7% and 98.7% respectively. Kappa agreement between USG and MRI was 0.43, indicating moderate agreement.

The relatively low sensitivity and kappa agreement for these lesions can be explained by the small number of these lesions which skewed the data analysis.

Subscapularis tendon lesions -

Out of the 80 cases, MRI detected subscapularis tendon lesions in 10 patients, while USG detected it in 9 patients.

Out of the 10 subscapularis tendon lesions detected on MRI, 6 were partial thickness tears. USG correctly identified 3 of these lesions. It overdiagnosed these lesions in 2 cases and underdiagnosed these lesions in 3 cases. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting partial thickness tears of subscapularis tendon was 50%, 97.3%, 60%, 98.6% and 93.75% respectively. Kappa agreement between USG and MRI was 0.5, indicating moderate agreement.

2 full thickness tears were identified on MRI of which USG correctly identified 1 case. USG missed 1 of these lesions. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting full thickness tears of subscapularis tendon was 50%, 100%, 100%, 98.7% and 98.75% respectively. Kappa agreement between USG and MRI was 0.62, indicating substantial agreement.

2 cases of subscapularis tendinosis were identified on MRI. USG correctly identified the 2 cases, and overdiagnosed 1 case. The sensitivity, specificity, PPV, NPV and accuracy of USG in detecting tendinosis of subscapularis was 66.6%, 100%, 100%, 98.7% and 98.75% respectively. Kappa agreement between USG and MRI was 0.8, indicating substantial agreement.

The relatively low sensitivity and kappa agreement for these lesions can be explained by the small number of these lesions which skewed the data analysis.

The findings of our study are in line with many others in reporting a high level of sensitivity and specificity for full-thickness tears. These results are equivalent to studies conducted by Read et al. (1998)¹⁰ and Teefey et al. (2000)¹¹ both of which reported a 100% sensitivity of USG for detecting full thickness rotator cuff tears.

Crass et al. (1988)¹² and later Zehetgruber et al. (2002)¹³ reported the accuracy, sensitivity, and specificity of USG in

the detection of any tear, whether partial or full-thickness, to be greater than 90%. These results are in accordance to our study, which shows an overall accuracy of 95%.

Joseph et al. (2009)¹⁴ compared the diagnostic accuracy of MRI, MR arthrography, and USG for detecting rotator cuff tears through a meta-analysis of the 65 studies in the literature. They found no statistically significant difference between the sensitivities and specificities of USG and MRI in diagnosing either full- or partial-thickness tears.

Bicipital Tendon abnormality and rotator cuff diseases:

In our study, pathologies involving the long head of biceps tendon included tendon tear, tendinosis and medial dislocation of biceps tendon.

The most common of these was tendinosis seen in 11 patients on MRI and 9 patients on USG, followed by tears in 2 patients and dislocation in 1 patient seen on both MRI and USG. All of these lesions had associated rotator cuff tears. USG and MRI showed high agreement for detection of biceps tendon pathologies.

In a study conducted by Ahovuo et al. (1989)¹⁵ 17.05% (15 out of 88) cases showed bicipital tendinosis, which correlates with the present study.

Erickson et al. (1992)¹⁶ in their study showed bicipital tendinitis/ tenosynovitis was frequently accompanied rotator cuff disease. In 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 biceps tendon, tendinitis, partial tears and overt rupture.

Beall et al. (2003)¹⁷ in a study done in 111 patients with shoulder pain who underwent both MR and surgery, found 23 patients with bicipital tendon abnormality. They concluded tears of long head of biceps tendon had a statistically significant association with tears of the supraspinatus and subscapularis tendons. They also found relationship between acromio-humeral impingement and the adverse effects on both the biceps tendon and superior rotator cuff.

Joint effusion and SADB fluid in rotator cuff diseases:

USG and MRI detected biceps tendon sheath (BTS) fluid in 58 (72.5%) and 63 (78.75%) cases respectively. Since the BTS communicates with the joint space, fluid in BTS can be considered as joint effusion. Fluid in SADB was seen in 41 (51.25%) and 37 (46.25%) cases on MRI and USG respectively. USG and MRI showed a high agreement for detection of BTS fluid and SADB fluid. The association of rotator cuff tears with joint effusion, BTS fluid, and SADB fluid was very high in our study.

In a study conducted by Netam SB et al. (2017)¹⁸ 38 out of 51 (74.5%) and 40 out of 51 (78.4%) cases had fluid in BTS

on USG and MRI respectively. In the same study, 23 out of 51(45%) cases and 24 out of 51 (47%) cases was detected to have fluid in SADB on USG and MRI respectively. This correlates with the present study.

Additional findings:

Acromioclavicular Joint arthritis is also a common associated finding in patients with rotator cuff tear. USG showed ACJ arthritis in 18 patients (22.5%) in comparison to 26 patients (32.5%) on MRI.

Some associated findings were picked up only on MRI and could not be demonstrated on USG. Those included findings like subchondral cysts at greater tuberosity, bone contusions, Hill-Sachs lesion, Bankart lesion, labral tears and thickened coracohumeral ligament.

Despite being considered as a reference modality, MRI was unable to detect calcific tendinitis on its own. Calcific deposits were only appreciated retrospectively after USG findings were correlated.

Conclusion

In our study, USG examination had excellent sensitivity, specificity and accuracy as compared MRI for diagnosing full thickness rotator cuff tears. It was also fairly accurate in detecting partial thickness tears and tendinosis. It was comparable to MRI in diagnosing and quantifying joint effusion and acromioclavicular degenerative changes. USG scored over MRI in diagnosing calcific tendinosis while some findings, such as labral tears, were only detected by MRI.

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