The Role of Ultrasound and Magnetic Resonance Imaging in the Evaluation of Musculotendinous Pathologies of the Shoulder Joint

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ABSTRACT

Aim: To evaluate and characterize the musculotendinous pathologies of shoulder joint using ultrasound (USG) and magnetic resonance imaging (MRI). **Background and Objectives:** The glenohumeral joint, being the most mobile and unstable of all the joints, is often prone to injuries. To compensate for its unstable bony anatomy, the shoulder is protected anteriorly, posteriorly, and superiorly by a capsule and tendons that form the rotator cuff. Sonography is often considered the first-line imaging modality in the assessment of cuff as well as in nonrotator cuff disorders. MRI is of value in cases of extensive abnormality that is often incompletely characterized by the initial sonographic examination, as in case of sonographically inaccessible areas. However, musculoskeletal imaging is truly a multimodality approach and in order to identify and characterize the lesion, a combination of modalities should be used. **Materials and Methods:** A prospective study was carried out on 75 patients in the Department of Radiodiagnosis, Padmashree Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pimpri, Pune over a period of 2 years from July 2011 to September 2013. Patients from all age groups including both men and women with shoulder pain, suspected to be arising from the musculotendinous tissues of the shoulder joint, were taken up for study. **Results:** In our study, USG showed a sensitivity of 95.2%, specificity of 88.8%, and positive predictive value of 80% for demonstrating full-thickness tears. In case of partial-thickness tears, USG showed overall sensitivity of 94.7%, specificity of 85.7%, and positive predictive value of 90%. Overall accuracy of USG in detecting full-thickness as well as partial-thickness tears was 91%. **Conclusion:** In patients with shoulder complaints, USG is a reliable dynamic diagnostic tool. It reveals high diagnostic accuracy in detecting rotator cuff pathologies including cuff tears and tendinopathy. However, MRI has always been successful in overall assessment of joint structure. Its ability to evaluate labrum and various glenohumeral ligaments cannot be superseded by USG.

Key words: Magnetic resonance imaging; rotator cuff; ultrasound

Introduction

The glenohumeral joint is a synovial joint of the ball and socket variety. It is formed by articulation of the scapula and the head of the humerus. Being the most mobile and unstable of all the joints, it is often prone to injuries. To compensate for its unstable bony anatomy, the shoulder is protected anteriorly, posteriorly, and superiorly by a capsule and tendons that form the rotator cuff.[1]

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The point prevalence of shoulder pain in the general population is 6.9-26%.[2] Various causes of shoulder pain include tendon injuries, adhesive capsulitis, cervical nerve root compression, and acute joint inflammation. More than half of the shoulder abnormalities have been attributed to rotator cuff lesions. They are the most common cause of shoulder pain and dysfunction in patients above the age of 40.[3]

Ultrasound (USG) has been shown to be a successful imaging modality for diagnosing both rotator cuff and nonrotator cuff disorders.[4] It is affordable but also allows dynamic examination of the patient in multiple scanning planes and in specific arm positions. In addition to this, it allows examiner to focus on the region of maximum discomfort. It plays a major role in diagnosing calcific deposits, impingement, acromioclavicular joint pathologies, and guided therapy.[5]

Magnetic resonance imaging (MRI) is currently considered the reference standard for imaging of shoulder disorders. The strength of MRI lies in its ability to assess sonographically inaccessible areas such as labrum, deep parts of various ligaments, capsule, and areas obscured by bone.[6] Currently, it is being used as the primary form of investigation for recurrent dislocations, labral lesions, articular cartilage, synovial disease, tumors, and infection. It also accurately depicts associated muscle abnormalities, and thus, helps in recognizing surgically amenable pathologies. In addition, it can reveal other causes of painful shoulder that clinically mimics rotator cuff disease.

These days, USG serves as a complementary role to MRI, and there are potential benefits from the combined use of these two modalities. Sonography is often considered the first-line imaging modality in the assessment of cuff as well as in nonrotator cuff disorders. It is suitable for examination of localized and predominantly superficial disorders. MRI is of value in cases of extensive abnormality that is often incompletely characterized by the initial sonographic examination, as in case of sonographically inaccessible areas. However, musculoskeletal imaging is truly a multimodality approach and in order to identify and characterize the lesion, a combination of modalities should be used.[6]

Materials and Methods

A prospective study was carried out on 75 patients in the Department of Radiodiagnosis, Padmashree Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pimpri, Pune over a period of 2 years from July 2011 to September 2013. Ethics committee clearance was obtained before the start of the study.

Patients from all age groups including both men and women with shoulder pain, suspected to be arising from the musculotendinous tissues of the shoulder joint, were taken up for study. Diagnosed cases of any tumor, arthritis, periarthritis of shoulder/frozen shoulder, or those who had already undergone shoulder surgery were excluded from the study. Any patient with fracture involving the shoulder joint was excluded on basis of radiographic examination. Those with contraindication to MRI evaluation, that is, patients with pacemaker, metallic implants, or claustrophobic patients were also excluded.

Detailed clinical history was taken and relevant clinical examination was performed. All patients were subjected to radiograph shoulder–anteroposterior (AP) and axial views. The study was carried with either Acuson X300 PE (Premium Edition) or Acuson Antares (Siemens co. Ltd. Munich, Germany) or Sonosite. A high frequency linear transducer (7.5-12 MHz) was used to image the shoulder joint. MRI was performed with Siemens 1.5 Tesla Magnetom Avanto machine.

Usg examination

Ultrasonography examination of shoulder was performed with patient sitting on a stool or the bed. Sonographic examination was performed in a sequential order. Biceps and subscapularis tendons were examined first, followed by supraspinatus tendon, and finally the posterior structures were examined, which included infraspinatus and posterior glenohumeral joint.

MRI examination

Patient was positioned in supine position with shoulder and the arm placed alongside and parallel to the body, positioned in the neutral to mild external rotation. The shoulder was kept as close as possible to the center of the magnet. We found that it was useful to tuck the patient's hand under the hip to help keep the shoulder motionless. A four-channel flex coil was used for examination. Abduction-external rotation technique (ABER) was used in cases of marked suspicion of labral pathology as well as articular surface rotator cuff tears, which were not clearly depicted using conventional technique [Figures 1-6].

Results

The study was carried out in 75 patients. Out of which 54 were males and 21 were females. Age ranged from 15 to 77 years with mean age of 46 years. Majority of the patients were in the age group of 41-50 years [Table 1].

On the basis of history and clinical examination, the patients were categorized into three categories [Figure 7]:
- Rotator cuff tears
- Impingement
- Recurrent dislocation or instability.

Overall rotator cuff pathology including tear and impingement were found to be leading cause of shoulder pain. Rotator cuff pathology was suspected in 66 out of 75 patients.

Among all the suspected cases of rotator cuff lesions, USG was unable to detect any pathology in nine patients. In the remaining 66 patients, supraspinatus lesions (75%) were the commonest finding, followed by biceps tendon pathologies.

Table 1: Age and sex distribution of patients

Age (years)	Male	Female	Total
<20	3	2	5
21-30	9	1	10
31-40	7	3	10
41-50	12	5	17
51-60	9	6	15
61-70	8	2	10
> 70	6	2	8
Total	54	21	75

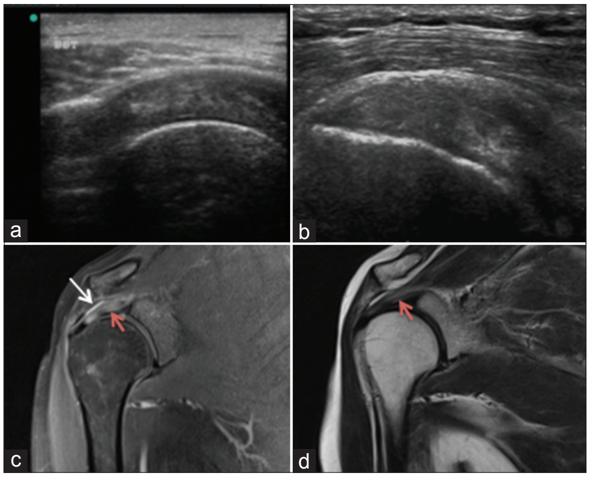

Figure 1: A 50-year-old female patient presented with right shoulder pain since 2 months. On clinical examination, resisted abduction produced pain suggestive of supraspinatus lesion. (a) Transverse; and (b) Longitudinal sonogram of right supraspinatus tendon demonstrated a thickened and heterogeneous tendon with loss of normal fibrillar pattern. No focal defect was noted within the tendon. (c) Coronal oblique proton density (PD) fat sat. (d) T2-weighted images (T2WI) revealed hyperintense signal within the supraspinatus tendon (red arrow) which was not as bright as fluid. There was associated subacromial-subdeltoid bursitis (white arrow)

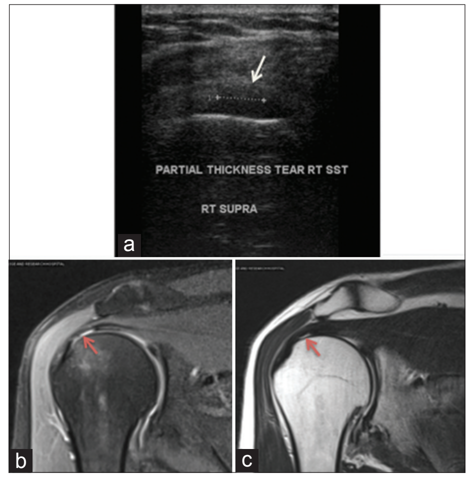

Figure 2: A 57-year-old female patient presented with history of fall on the right shoulder following which she was unable to abduct her arm. On clinical examination, involvement of supraspinatus tendon was suspected. (a) Transverse sonogram demonstrated a hypoechoic defect at the articular surface of the supraspinatus tendon. Overlying bursal surface fibers (white arrow) remained intact; and (b) Coronal oblique PD fat sat. (c) T2W images revealed an articular surface partial-thickness tear involving less than 50% of the tendon thickness (red arrow)

Figure 3: A 66-year-old male presented with complaints of gradual restriction of movements of the right shoulder. There was history of fall on the right shoulder 1 year back. (a) Transverse sonogram of the right supraspinatus revealed full-thickness hypoechoic defect at the normal location of the supraspinatus tendon (white arrows). Fluid was seen within the defect and extended from the articular to bursal surface. The torn edge of the retracted supraspinatus tendon could be seen (S); and (b) Transverse sonogram of the right subscapularis tendon demonstrated full-thickness tear of the tendon

Figure 4: Multitendinous rotator cuff tears. (a) Coronal oblique PD fat sat image of the right shoulder revealed full-thickness tear of the supraspinatus tendon (double arrow shows greatest dimensions) with medial retraction of the tendon margin. Minimal joint effusion was noted. Altered signal intensity with bulk loss was noted in the deltoid muscle; and (b) Axial PD fat sat image showed U-shaped tear of the supraspinatus tendon. (c) Sagittal oblique T2WI image demonstrated extension of the tear into the rotator interval and subscapularis tendon anteriorly (large white arrow)

Joint effusion and subacromial-subdeltoid bursitis were fairly common findings. They were detected in nearly 77 and 73% of patients, respectively. Bicipital tenosynovitis was the most common pathology involving the biceps tendon. Involvement of the supraspinatus tendon was more frequently observed than that of infraspinatus or subscapularis tendons [Table 2].

We found that the partial-thickness tear was the most common lesion of the supraspinatus and infraspinatus tendons followed by tendinopathy. Tears of subscapularis tendon were found in only three patients. Out of these, one of the cases was associated with biceps tendon dislocation and another case had associated biceps tendon rupture [Figure 8].

In total nine patients demonstrated intratendinous echogenic foci with posterior acoustic shadowing which was suggestive of calcific tendinitis. Tendon calcification was well-delineated on USG than on conventional radiographs, especially in cases

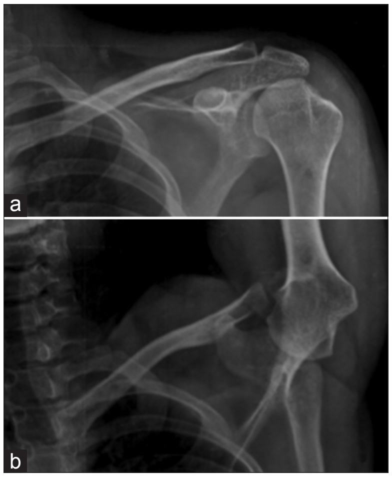

Figure 5: A 19-year-old male patient came with history of recurrent anterior dislocation of the left shoulder since 5 months. Radiograph anteroposterior view (a) and, (b) Stryker's notch view of the left shoulder demonstrated wedge-shaped defect at the posterosuperior aspect of the humeral head

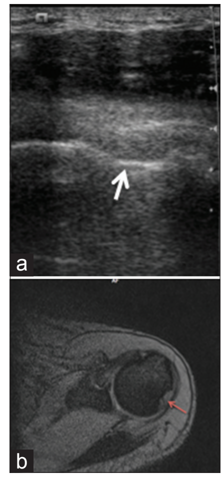

Figure 6: (a) Longitudinal sonogram at the level of the infraspinatus muscle demonstrated a step defect at the posterosuperior aspect of the humeral head (white arrow); and (b) Axial Gradient image showed a wedge-shaped defect at the posterolateral portion of humeral head (red arrow) above the level of coracoid process

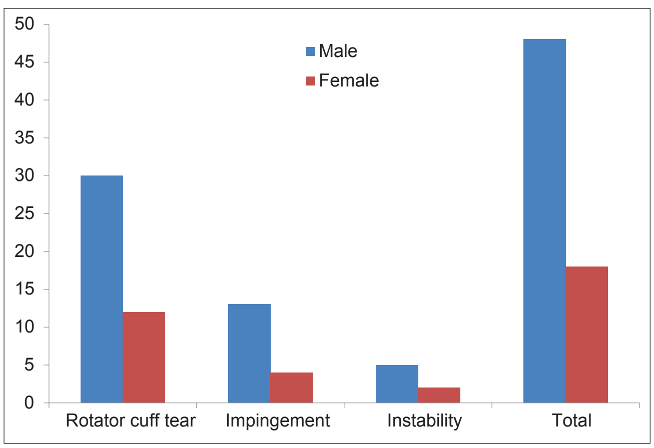

Figure 7: Distribution of patients according to clinical diagnosis

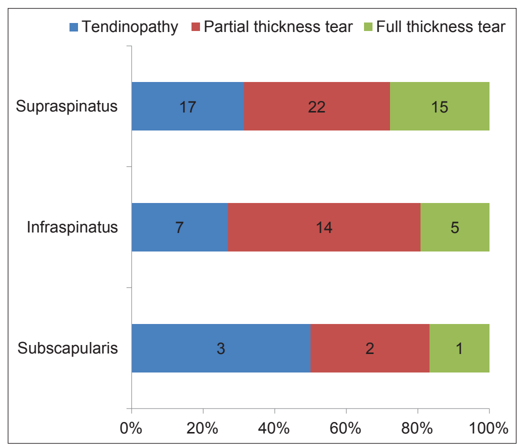

Figure 8: Various rotator cuff lesions on ultrasound (USG)

of subscapularis calcific tendinitis where the calcific foci were often obscured by the underlying bones. USG successfully identified Hill–Sachs lesion in five out of seven patients with recurrent dislocation of shoulder. However, no labral tears were identified on USG. These were subsequently identified on MRI examination.

MRI was done in all patients and the findings were assessed independent of USG findings. Later, both USG and MRI results were compared and additional findings were noted [Table 3].

In comparison with USG, only six patients were found to have no lesion. USG missed supraspinatus pathology in two patients. The third patient had minimal joint effusion without rotator cuff pathology. As in case of USG, the most common pathology detected on MRI was that of supraspinatus tendon. Equal numbers of biceps tendon pathologies including bicipital tenosynovitis were diagnosed on both the modalities. Joint effusion was found in a larger number of patients on

Table 2: Various findings on ultrasound

USG findings	Number of patients	Percentage
Supraspinatus lesions	54	75
Infraspinatus lesions	26	34.6
Subscapularis lesions	6	8
Biceps tendon pathologies	36	48
Joint effusion	58	77.3
Subacromial-subdeltoid bursitis	55	73.3
Acromioclavicular arthropathy	27	36
Normal	9	12

USG – Ultrasound

MRI (86%) compared to USG (77%). Bone changes detected on MRI included acromioclavicular joint arthropathy, Hill–Sachs lesion, and bony Bankart lesion. Involvement of labrum and the glenohumeral ligaments was detected on MRI in 15 and 4% of patients, respectively. Thickening of glenohumeral ligament especially of inferior glenohumeral ligament was found in three cases.

Partial-thickness tear was the most common pathology in the rotator cuff group. Among supraspinatus pathologies, two new cases of partial-thickness tear were diagnosed on MRI. Table 4 Another patient was found to have a full-thickness tear instead of massive partial-thickness tear on MRI. USG also missed three full-thickness tears and one partial-thickness tear of infraspinatus. Subscapularis pathologies were well delineated on USG as well as on MRI [Figure 9].

In case of partial-thickness tears, USG showed overall sensitivity of 94.7%, specificity of 85.7%, and positive predictive value of 90%. Overall accuracy of USG in detecting full-thickness as well as partial-thickness tears was 91%.

Discussion

Overall rotator cuff pathology including rotator cuff tear and impingement was the most common cause for radiology referral, comprising almost 88% of our cases. This is in accordance with the study done by Hawkins *et al*., who found that more than 60% of shoulder abnormalities were due to rotator cuff disease.[7]

Of all the lesions detected on USG as well as on MRI, supraspinatus tendon was more commonly involved than infraspinatus or subscapularis tendon. This is comparable to the study done by Zlatkin *et al*.,[8] wherein they found supraspinatus tendon involvement in around 80% of their cases. 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.[8]

Table 3: Various findings on magnetic resonance imaging

MRI findings	Number of patients	Percentage
Supraspinatus lesions	56	74.6
Infraspinatus lesions	27	36
Subscapularis lesions	6	8
Biceps tendon pathologies	36	48
Joint effusion	65	86.7
Bony changes	36	48
Labral pathologies	15	20
Glenohumeral ligaments	3	4
Normal	6	8

MRI – Magnetic resonance imaging

Table 4: Accuracy of USG in detecting tears with MRI as reference standard

USG	MRI		
	Positive	Negative	Total
(a) Full-thickness tears			
Positive	20	1	21
Negative	5	40	45
Total	25	41	66
(b) Partial-thickness tears			
Positive	36	2	38
Negative	4	24	28
Total	40	26	66

USG – Ultrasound; MRI – Magnetic resonance imaging. In this study, USG showed a sensitivity of 95.2%, specificity of 88.8%, and positive predictive value of 80% for full-thickness tears

Tears of the subscapularis tendon have always been considered uncommon. We found only three patients (4%) with subscapularis tendon tear. All the patients had coexistent supraspinatus and/or infraspinatus tear. One out of three patients had a dislocated biceps tendon. These findings are consistent with that of Codman who reported involvement of subscapularis tendon in less than 3.5% patients in a series of 200 rotator cuff tears.[9] More recent studies have shown significant association of subscapularis tears with lesions of other rotator cuff components.[10]

The association of rotator cuff tears with effusion of the joint space, biceps tendon sheath, and subacromial bursa is very high in our study. The high specificity of effusion with cuff tears was also observed by Van Holsbeeck and his coworkers[11] who found it to be 90% specific. 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.

In cases of recurrent dislocation of shoulder and instability, USG was only able to identify Hill–Sachs defect. No labral tears or pathology involving the glenoid could be identified. MRI successfully demonstrated labral involvement in all the cases with recurrent dislocation. Hill–Sachs defect, cartilaginous, and bony Bankart lesions were also diagnosed in six out of seven patients.

On comparison with MRI, USG showed a sensitivity of 95.2% and specificity of 88.8% for full-thickness tears, and a sensitivity of 94.7% and specificity of 85.7% for partial-thickness tears. Overall accuracy of USG in detecting tears was 91%. 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 and Parker[12] in 1998 and later by Goldberg *et al*., in 2003.[13] The level of sensitivity and specificity in the diagnosis of partial-thickness tears are also similar to those of Van Holsbeeck *et al*.,[14] (sensitivity 93%) and Wiener and Seitz[15] (sensitivity 94%), but are in contrast to the findings of Teefey (sensitivity 67%).[16]

Naredoe and his team conducted a comparative study of USG and MRI in 36 patients with painful shoulder.[17] The MRI results were considered the gold standard. USG showed high sensitivity, specificity, and positive and negative predictive values (range: 85.7-100%) in the diagnosis of tendinitis and partial-thickness and full-thickness tear of the rotator cuff. These results correlate well with our results.

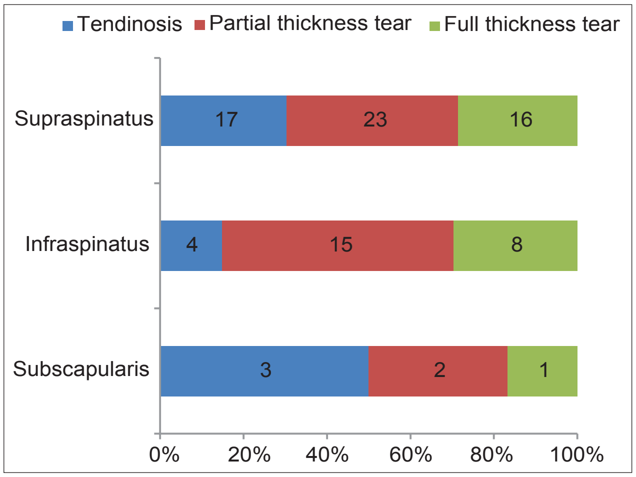

Figure 9: Various rotator cuff lesions on magnetic resonance imaging

Crass *et al.*,[18] and later Zehetgruber *et al.*,[19] in the year 2002 reported the accuracy, sensitivity, and specificity of USG in the detection of any tear, whether partial or full-thickness, to be greater than 90%. Similar study done by Teefey *et al.*,[20] in 2004 revealed overall accuracy of USG to be 87% in correct identification of partial as well as full-thickness tears. These results are in accordance to our study, which shows an overall accuracy 91%.

Joseph and his team in the year 2009 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.[21] They found no statistically significant difference between the sensitivities and specificities of USG and MRI in diagnosing either full- or partial-thickness tears. In 2010, a similar study was conducted by Matthieu and his associates to evaluate the need for additional MRI examination following USG in patients with shoulder pain and/or disability.[22] The results of the imaging modalities were compared with surgical findings. The accuracy of USG in diagnosing full- and partial-thickness tears was 94 and 81%, respectively.

Conclusion

In patients with shoulder complaints, USG is a reliable, dynamic diagnostic tool. It reveals high diagnostic accuracy in detecting rotator cuff pathologies including cuff tears and tendinopathy. Given the fact that more than half of the complaints are attributed to these lesions, USG obviates the need for further imaging in most cases. However, MRI has always been successful in overall assessment of joint structure. Its ability to evaluate labrum and various glenohumeral ligaments cannot be superseded by USG.

Even though our study showed compatible results with recently published medical literature, it has several limitations. Operator dependency and limited study population are among the few. The major drawback of our study was absence of correlation with surgical findings. Although MRI has been widely accepted as the modality of choice for detection of shoulder disorders, it is not 100% accurate as a reference standard. Our study would have greatly benefited if surgery was considered as a reference point. Including other modalities like MR arthrography would have led to more accurate detection of labral pathologies.

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