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Original Article

Diagnostic accuracy of ultrasound in rotator cuff and associated non-rotator cuff pathologies of shoulder joint compared to magnetic resonance imaging

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Abstract

Objectives: The present study was carried out to evaluate diagnostic accuracy of ultrasound (US) in delineating various rotator cuff and associated non rotator cuff pathologies (RCPs) of shoulder joint compared to Magnetic Resonance Imaging (MRI). **Methods**: Fifty consecutive symptomatic subjects in age-group 18-75 years (mean ±SD: 56.0±13.6 years; 39-male, 11-female) were evaluated. US performer and MRI reporting radiologists were blinded to results of each-other. The sensitivity, specificity, and accuracy of US was measured for diagnosing various musculo-tendinous pathologies of shoulder against MRI gold standard. **Results**: MRI detected RCPs in all subjects while US was abnormal in 46(92%) cases. Supraspinatus was the most frequently affected tendon. Remarkably, 28% patient had polytendon abnormalities. US showed sensitivity of 84% and specificity of 87.5% for tendinosis; sensitivity of 78.1% and specificity of 94.4% for partial thickness tear (PTT) and 100% sensitivity and specificity for diagnosing full thickness tear. However, sensitivity of US for diagnosing PTT of infraspinatus tendon, subscapularis tendinosis and teres-minor atrophy was low. US had high specificity for diagnosing non-RCPs but sensitivity was low. **Conclusions**: A normal shoulder US may not rule out with certainty some rotator cuff and associated non-rotator cuff abnormalities. It is suggested to search for polytendon abnormalities which may be missed.

Keywords: Imaging studies, Polytendon abnormalities, Rotator cuff tears, Shoulder MRI, Shoulder ultrasound

Introduction

Rotator cuff pathology (RCP) is the most common cause of shoulder pain and disability[1]. Accurate characterization of rotator cuff tears (RCTs) is essential for decision regarding conservative or surgical management. Magnetic Resonance Imaging (MRI) is a valuable, non-invasive, radiation free diagnostic imaging modality[2-7]. Hence, over the years it has gained popularity for evaluating rotator cuff abnormalities. But its high-cost, long waiting-time, lengthy procedure, and lack of dynamic assessment of shoulder call for an alternative imaging modality. Ultrasound (US) is analogous to MRI for imaging soft tissues and diagnose rotator cuff pathologies, however, different studies yielded varied results[8-18]. The present study was carried out to evaluate the diagnostic accuracy of US compared to MRI in delineating various rotator cuff and associated non rotator cuff pathologies of shoulder joint.

Material and methods

Study Subjects

Fifty consecutive patients aged 18-75 years (mean±SD: 56.0±13.6 years; 39 male and 11 female) referred by Orthopaedics Surgeons to Department of Radiodiagnosis

The authors have no conflict of interest.

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between November 2020 to September 2021 for shoulder MRI for suspected rotator-cuff pathology were prospectively included in the study after informed consent upon fulfilling one or more of the following inclusion criteria:-

- Shoulder pain, both acute and chronic
- Stiffness of shoulder
- Restriction in activities of daily living
- Trauma to shoulder

Patients with metallic implants, prosthesis or pacemaker, claustrophobia, prior history of shoulder surgery, fracture/ dislocation of shoulder, suspected tumor/malignancy, and those who refused to consent, were excluded.

Of the study subjects, 17 (34%) were ≤40 years of age while 9 (18%) were aged ≥61 years. There were 8 (16%) patients in 41-50 and 16 (32%) in the 51-60 years age-groups. All cases, except 3 young patients with h/o trauma, had shoulder pain for >1-month duration. Thirty-four (68%) patients had restriction of movements of affected shoulder. History of trauma was elicitable in 12 (24%) patients, mostly in patients below 45 years of age. All patients had unilateral affection of the shoulder. The right shoulder was affected in 34 (68%) patients while left shoulder was involved in 16 (32%) cases.

Shoulder MRI

MRI was done by a Senior Radiologist having 20 years' experience using GE optima MR 360 (1.5 Tesla) machine. All scans were acquired by standard technique.The following sequences were followed:

- Coronal oblique T1W/ proton density (PD) W fast-spin echo (FSE) sequence.
- Coronal oblique fat-suppressed (FS) Proton density (PD) W FSE / T2 W FSE sequence.
- Sagittal oblique T2 W FSE sequence (with/without fat suppression)
- Axial T2W gradient-echo (GE) sequence
- Axial PDW fast spin-echo FSE (with/ without fat suppression)

MRI findings were classified into intact cuff, partial-thickness tear (PTT) and full-thickness tear (FTT), and tendinopathy. In addition, non-rotator cuff findings of the shoulder, if any, were recorded. MRI findings were taken as gold standard for this study.

MRI criteria for rotator cuff pathology [2-3]

Tendinopathy was defined as increased signal intensity on Proton Density (PD) Weighted images but not as bright as fluid signal on T2 Weighted sequence. PTT was defined as focal increased signal intensity or discontinuity of fibres on T1 Weighted, PD Weighted and T2 Weighted sequences that was as bright as fluid signal on T2 Weighted sequence which either involved bursal or articular surface or mid substance of the tendon. The tear was considered complete when the focal discontinuity involved full thickness of the tendon from bursal surface to articular surface with retraction of the torn ends and the gap was either filled with fluid signal intensity or altered signal intensity of granulation tissue.

Shoulder Ultrasound

Shoulder US was performed by a Radiology Resident under supervision of a Senior Radiologist of the Department on GE VOLUSON E6 or Samsung HS70A Ultrasound (US) machine using high frequency (8-15 MHz) linear transducer. The US performer and MRI reporting Radiologists were blinded to findings of each-other.

Standard scanning protocol as defined previously[4,5,19] was used for evaluating long head of biceps tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, and teres minor. During sonography it was ensured that US beam is perpendicular to the tendon to reduce anisotropy. Dynamic abduction was done to assess for impingement. Throughout examination of the rotator cuff, the cuff was compressed to detect non-retracted tears. In evaluation of rotator cuff pathologies, comparison with the contralateral side was done. While examining rotator cuff, evaluation of acromioclavicular joint (ACJ) abnormalities, subacromial subdeltoid (SASD) bursal effusion, glenohumeral joint (GHJ) effusion, subcoracoid (SCB) bursal effusion, biceps tendon sheath (BTS) effusion, tendon calcification, muscle atrophy and labral abnormalities was done.

<u>Ultrasound criteria for rotator cuff pathology</u>[4,5,19]

- Tendinosis/Tendinopathy: Characterized by a tendon that appear thickened with loss of normal hyperechoic fibrillar pattern. There may be a heterogeneous, ill defined, hypoechoic area in the tendon with variable change in the caliber (enlarged / thinned) without a tendon defect.
- Rotator Cuff Tear:
  - PTT: A well-defined focal hypoechoic or anechoic abnormality that disrupt the tendon fibers which is limited to either articular surface or the bursal surface of the tendon, or intra muscle substance, but without communication of the tear to the opposing tendon surface. PTT was classified into "articular side" tear or "bursal side" tear and "high-grade" (greater than 50% thickness) or "low-grade" (less than 50% thickness) tear.
  - FTT: Characterized by a defect, a hypoechoic zone, that disrupts the hyperechoic tendon fibers and extend through the entire substance of the rotator cuff muscle (s) from the articular to bursal surface of the tendon. There may non -visualization of the tendon, hypoechoic discontinuity of the tendon, or retracted edge of the torn tendon. The full thickness tears were classified into small (<1 cm), medium (1-3 cm), large (3-5 cm) and massive (>5 cm), measured in its longest dimension.

<u>Indirect Signs of RCTs:</u>

- Presence of fluid in the SASD bursa and the GHJ.
- Cartilage interface sign- In FTTs of rotator cuff the presence of fluid in the torn area of the tendon accentuate the underlying cartilage and produce two hyperechoic lines

Pathology	MRI (Reference Standard)	US	Remarks
Any pathology in Rotator Cuff Tendons	50	46 (92%)	US missed 4 (8%) rotator cuff pathologies
Rotator cuff Tendinosis	25	24 (96%)	US missed 1 (4%) rotator cuff tendinosis
Rotator cuff Tear (RCT)	38	32 (84.2%)	US missed 6 (15.7%) RCTs
(i) Partial Tear	32	26 (81.3%)	US missed 6 (18.7%) partial thickness tears
(ii) Full Thickness Tear	06	06 (100%)	US diagnosed all Full Thickness tears
Muscle atrophy	02	01 (2%)	US missed 1 case of muscle atrophy

Table 1. Rotator Cuff Abnormalities Detected by MRI and US.

Findings	TP	FP	TN	FN	Sn	Sp	PPV	NPV	Accuracy	Kappa Coefficient
Tendinosis	21	3	22	4	84%	87.5%	87.5%	84%	86%	0.72
Partial Thickness Tear	25	1	17	7	78.1%	94.4%	96.2%	70.8%	84%	0.67
Full Thickness Tear	6	0	44	0	100%	100%	100%	100%	100%	1.0
Any pathology	52	4	83	11	82.5%	95.4%	92.8%	88.3%	90%	0.79

FN false negative, FP false positive, NPV negative predictive value, PPV positive predictive value, Sn sensitivity, Sp specificity, TN true negative, TP true positive.

Table 2. Sensitivity, Specificity, NPV, PPV, and Accuracy of Ultrasound in Detecting Various Rotator Cuff Pathologies Compared to MRI.

Rotator Cuff Tendon	MRI (Reference Standard)	US
Supraspinatus		
Tendinosis	14 (28%)	17 (34%)
Partial Thickness Tear	25 (50%)	19 (38%)
Full Thickness Tear	05 (10%)	05 (10%)
Total	**44 (88%)**	**41 (82%)**
Subscapularis		
Tendinosis	10 (20%)	6 (12%)
Partial Thickness Tear	05 (10%)	6 (12%)
Full Thickness Tear	0 (0%)	0 (0%)
Total	**15 (30%)**	**12 (24%)**
Infraspinatus		
Tendinosis	1 (2%)	1 (2%)
Partial Thickness Tear	2 (4%)	1 (2%)
Full Thickness Tear	1 (2%)	1 (2%)
Total	**4 (8%)**	**3 (6%)**
Teres Minor		
Muscle atrophy	1 (2%)	0 (0%)

Table 3. Tendon Wise Abnormalities of Rotator Cuff Detected by MRI and US.

representing the cartilage and the cortex.
- Sagging or depression of the overlying hyperechoic peri-bursal fat into the tendon gap.
- Atrophy of the muscle- Increased echogenicity and decreased bulk of the muscle.
- Fatty infiltration of muscle- (i) mild: effaced pennate pattern and mild increased echogenicity (ii) moderate- severe: absence of pennate pattern and marked hyper echogenicity.
- Fatty atrophy of muscle- poor definition and heterogeneous echotexture of the muscle belly.

Secondary signs of RCTs:
- Cortical irregularity of the greater tuberosity and shoulder joint effusion, which manifests as anechoic fluid in the axillary pouch, posterior recess, and sheath of the long head of the biceps tendon.

Statistical Analysis

Mean (±SD) were calculated. Chi-square test was used to examine significance of difference between 2-variables. P value <0.05 was taken as significant. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of the US was measured against MRI for diagnosing various musculo-tendinous pathologies. Strength of Agreement (SoA) between US and MRI was evaluated using Cohen kappa coefficient (k)[20]. Kappa values ≤0 indicated no agreement, 0.01–0.2 suggested none to slight agreement, 0.21–0.4 indicated fair agreement, 0.41–0.6 depicted moderate agreement, 0.61–0.8 as substantial agreement, and 0.81–1.0 as almost perfect agreement.

Results

Rotator Cuff Abnormalities Detected by MRI & US

All patients were detected to have one or more rotator cuff abnormalities in MRI evaluation whereas US identified RCP in 46 (92%) subjects. As evident from Table 1, US diagnosed all patients of FTTs, 81.3.% cases of PTTs and 96% subjects with tendinosis of rotator cuff but missed a case of teres minor (TM) muscle atrophy. In US examination, except 2 cases of full thickness RCTs, which measured 3.5 cm & 4 cm in length, all FTTs were moderate (2-3 cm) in size. Similarly, except 1 case of PTT which involved greater than 50% thickness of tendon, all PTTs were classified as low grade. The sensitivity, specificity, and accuracy of US compared to MRI for detecting tendinosis, PTT and FTT of the rotator cuff is presented in Table 2. The SoA between US and MRI was perfect (k=1.0) for detecting FTTs and substantial for identifying PTTs (k=0.67) and tendinosis (k=0.7).

Rotator Cuff Tendon Wise Abnormalities Detected by MRI & US

As evident from Table 3, MRI identified abnormalities in supraspinatus tendon (SST) in 44 (88%) patients. Subscapularis tendon (SubT) pathologies were noted in 15 (30%) patients. In 4 (8%) patients, infraspinatus tendons (IST) were abnormal while 1 (2%) patient had pathology of TM. In US evaluation, however, 41 (82%) patients were detected to have one or more SST pathologies while SubT and IST abnormalities were identified in 12 (24%) and 3 (6%) patients, respectively. US missed 1 patient of TM abnormality.

All patients of SST tendinosis [Figures 1 A, B] and FTTs [Figures 2 A, B, C; Figures 3 A, B] identified by MRI were correctly diagnosed by US. However, only 76% (19 out of 25 patients) of MRI confirmed PTTs of SST were correctly diagnosed by US. Of 6 (24%) cases of PTTs of SST missed by US, 3 were falsely diagnosed as tendinosis. Further, in MRI evaluation, 16 (64%) PTTs of SST were articular side [Figures 4 A, B] while 9 (36%) were bursal side tears [Figures 5 A, B]. Regarding SubT, US correctly diagnosed all cases of PTTs diagnosed by MRI, but falsely diagnosed 1 normal SubT as PTT. US correctly diagnosed 60% cases of subscapularis tendinosis. As regards, infraspinatus tendon, US correctly identified one case each of tendinosis and full thickness tear diagnosed by MRI but missed PTT in one of the two confirmed cases. US correctly diagnosed fatty generation in distal belly of supraspinatus muscle [Figure 6] but missed atrophy of TM muscle.

Further, as presented in Table 4, MRI identified 14 (28%) patients with polytendon (>1 rotator-cuff tendon) abnormalities while US detected abnormalities in greater than 1 rotator cuff tendons in 10 (20%) patients. Amongst patients with polytendon abnormalities, the most common association was that of an abnormality in SST with a pathology in the SubT.

Accuracy of US for Detecting Abnormalities in Supraspinatus Tendon

The sensitivity, specificity, and accuracy of US for diagnosing tendinosis, partial thickness and full thickness tears of SST compared to MRI is presented in Table 5. The SoA between US and MRI was perfect for detection of FTT (k=1.0), almost perfect for diagnosis of tendinosis (k=0.86) and substantial for diagnosis of PTT (k=0.76).

Accuracy of US for detecting abnormalities in subscapularis tendon

The sensitivity, specificity, and accuracy of US for diagnosing tendinosis and PTTs of SubT are depicted in Table 6. The SoA between US and MRI was perfect (k=0.89) for evaluation of PTT and substantial for tendinosis (k=0.7). However, US had low sensitivity (≈60%) for detecting tendinosis of SubT.

Accuracy of US for Detecting Abnormalities in Infraspinatus Tendon

The sensitivity, specificity, and accuracy of US for diagnosing tendinosis, partial and full thickness tears of IST are shown in Table 7. The SoA between US & MRI was perfect (k=1.0) for evaluation of FTT and tendinosis whereas

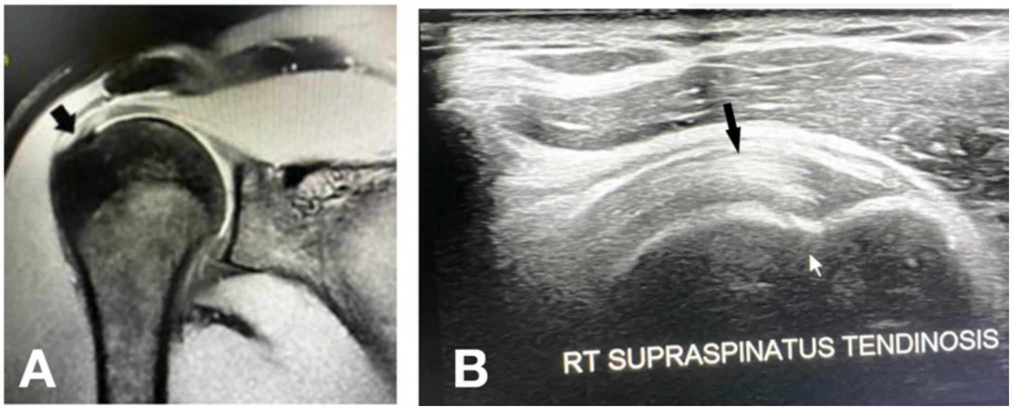

Figure 1. A: Coronal Oblique PD FS MR Image shows Right Supraspinatus Tendinosis (Arrow) in a 37-year-old man; B: Corresponding US Image Shows Right Supraspinatus Tendinosis (Arrow).

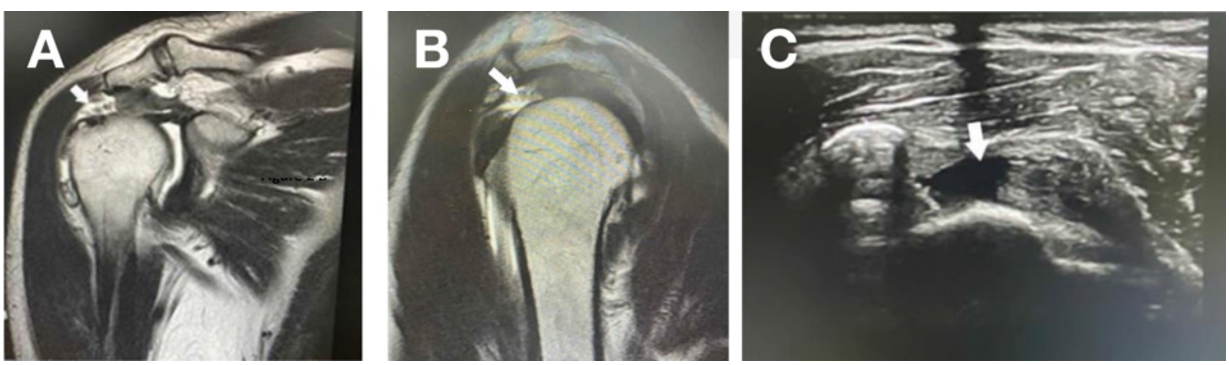

Figure 2. A: Coronal Oblique STIR MR Image Shows Full Thickness Tear (Arrow) involving critical zone of anterior part of Right Supraspinatus Tendon in a 60-year-old man; B: Sagittal T2 Weighted MR Image Shows Full Thickness Tear (Arrow) involving critical zone of anterior part of Right Supraspinatus Tendon; C: Corresponding US Image Shows Right Supraspinatus Full Thickness Tear (arrow) with retracted edge of muscle tendon.

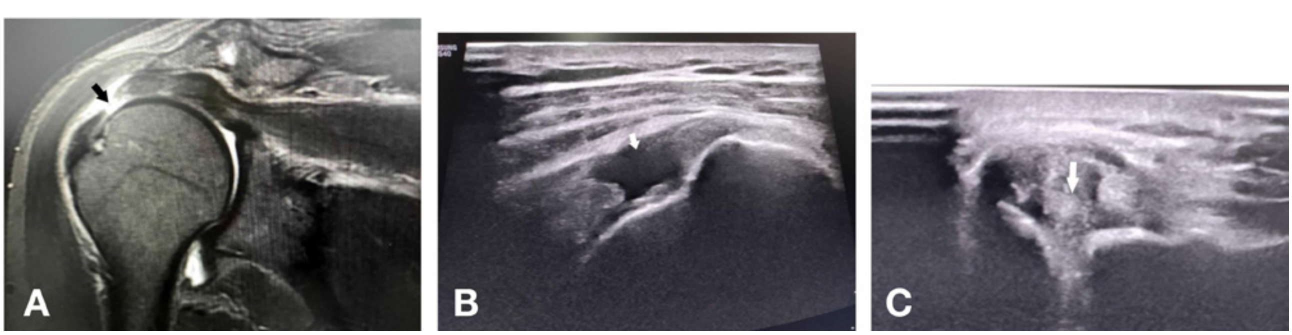

Figure 3. A: Coronal Oblique T2W MR image shows Full Thickness Tear of Right Supraspinatus Tendon in a 74-year-old male; B: Corresponding US image shows full thickness tear of right supraspinatus tendon (Arrow) with retracted edge of muscle tendon; C: US image shows Acromioclavicular Joint arthritis (arrow) in the same patient.

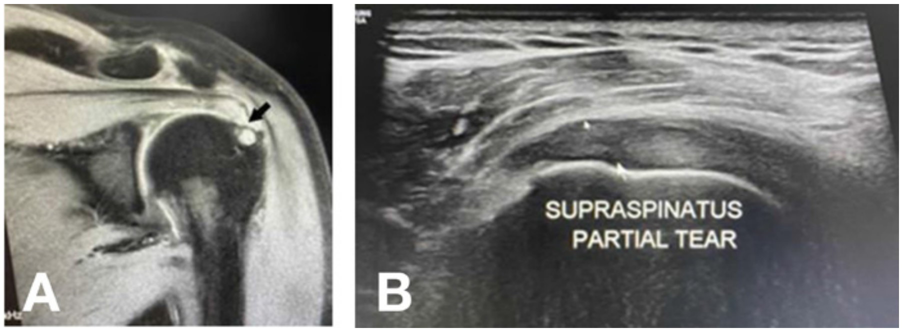

Figure 4. A: Coronal Oblique PD weighted FS MR Image Shows Left Supraspinatus Tendinosis with Partial Thickness Articular Surface Tear (Arrow) with Subchondral Cyst in Head of Humerus adjacent to site of insertion of Supraspinatus Tendon in a 59-year-old man; B: Corresponding US Image shows Partial Thickness Articular Surface Tear (Arrow) of Left Supraspinatus Tendon.

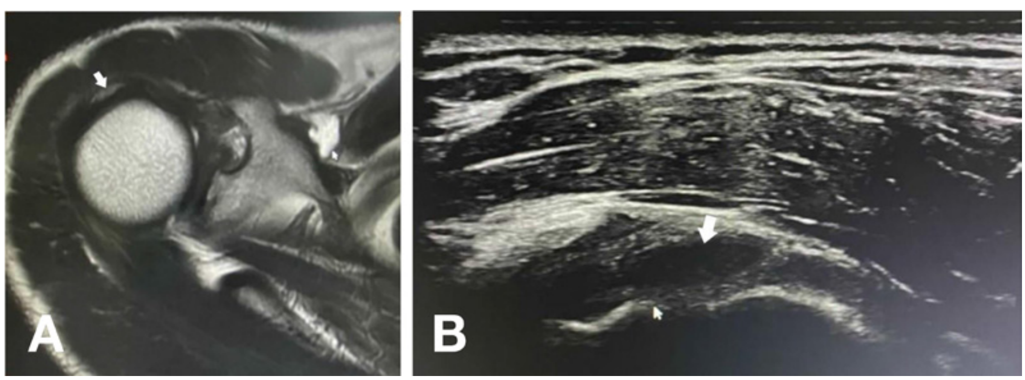

Figure 5. A: Axial T2 weighted MR image shows partial thickness tear on bursal surface of right supraspinatus tendon (Arrow) in a 50-year-old man; B: Corresponding US image shows partial thickness tear of right supraspinatus on bursal side (Arrow).

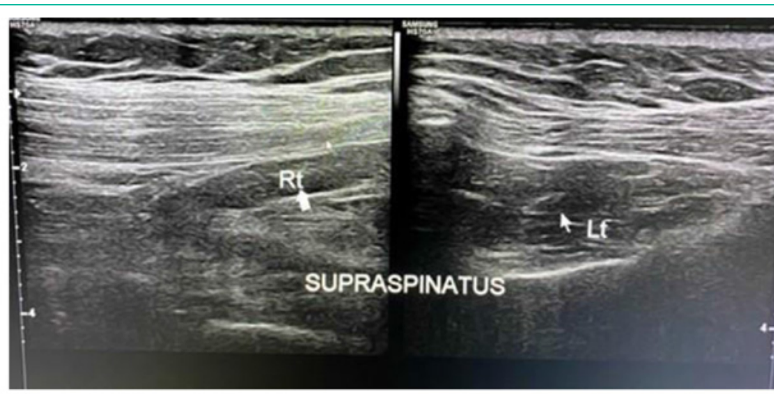

Figure 6. US Shows Fatty Degeneration of Distal belly of Right Supraspinatus Muscle with relative thinning of tendon (Arrow) compared to Normal Left Supraspinatus Tendon in a 57-year-old woman.

Pathology	MRI (n=50)	US (n=50)
Abnormality of Supraspinatus Tendon alone	31 (62%)	31 (62%)
Abnormality of Subscapularis Tendon alone	2 (4%)	2 (4%)
Abnormality of Infraspinatus Tendon alone	3 (6%)	3 (6%)
Pathology of more than 1 rotator cuff tendons	14 (28%)	10 (20%)
• FTT of SST with Subscapularis Tendinosis	04	Missed Subscapularis Tendinosis
• PTT of SST with Subscapularis Tendinosis	05	05 (Diagnosed correctly)
• PTT of SST with Tendinosis of Infraspinatus & Subscapularis and fatty muscle atrophy teres minor	01	Missed fatty muscle atrophy of Teres Minor
• PTT of SubT with SST Tendinosis	03	04 (3 correctly diagnosed and 1 PTT of SubT wrongly diagnosed)
• Fatty degeneration of distal belly of supraspinatus and thinning out of tendon	01	01 (correctly diagnosed)
Normal Rotator Cuff Tendons	0 (0%)	4 (8%)

FTT full thickness tear, PTT partial thickness tear, SST supraspinatus tendon, SubT subscapularis tendon

Table 4. Distribution of Abnormalities by Number of Rotator Cuff Tendons Involved.

Findings	TP	FP	TN	FN	Sn	Sp	PPV	NPV	Accuracy	Kappa Coefficient
Tendinosis	14	3	33	0	100%	91.6%	82.3%	100%	94%	0.86
Partial Thickness Tear	19	0	25	6	76%	100%	100%	80.6%	88%	0.76
Full Thickness Tear	5	0	45	0	100%	100%	100%	100%	100%	1.0

FN false negative, FP false positive, NPV negative predictive value, PPV positive predictive value, Sn sensitivity, Sp specificity, TN true negative, TP true positive.

Table 5. Evaluation of Supraspinatus Tendon Abnormalities by US Compared to MRI.

Findings	TP	FP	TN	FN	Sn	Sp	PPV	NPV	Accuracy	Kappa Coefficient
Tendinosis	6	0	40	4	60%	100%	100%	90.9%	92%	0.70
Partial Thickness Tear	5	1	44	0	100%	97.8%	83.3%	100%	98%	0.89
Full Thickness Tear	0	0	50	0	N.C.	100%	N.C.	100%	100%	NC

FN false negative, FP false positive, NC not computable, NPV negative predictive value, PPV positive predictive value, Sn sensitivity, Sp specificity, TN true negative, TP true positive.

Table 6. Evaluation of Subscapularis Tendon Abnormalities by US Compared to MRI.

Findings	TP	FP	TN	FN	Sn	Sp	PPV	NPV	Accuracy	Kappa Coefficient
Tendinosis	1	0	49	0	100%	100%	100%	100%	100%	1.0
Partial Thickness Tear	1	0	48	1	50%	100%	100%	97.9%	98%	0.65
Full Thickness Tear	1	0	49	0	100%	100%	100%	100%	100%	1.0

FN false negative, FP false positive, NPV negative predictive value, PPV positive predictive value, Sn sensitivity, Sp specificity, TN true negative, TP true positive.

Table 7. Evaluation of Infraspinatus Tendon Abnormalities by US Compared to MRI.

Non-Rotator Cuff Abnormalities of Shoulder Joint	No. of cases Detected by MRI	No. of cases Detected by US
Acromioclavicular Joint arthritis	18 (36%)	7 (14%)
Subacromial subdeltoid effusion	15 (30%)	12 (24%)
Bicipital tendon sheath effusion	5 (10%)	3 (6%)
Sub coracoid bursal effusion	2 (4%)	0
Tear of Glenoid labrum with avulsion of Inferior Glenohumeral ligament	3 (6%)	0
Total	**43 (86%)**	**22 (44%)**

Table 8. Comparison of MRI and US for Detecting Non-rotator cuff Abnormalities.

Non-Rotator Cuff Abnormalities	TP	TN	FP	FN	Sn	Sp	PPV	NPV	Accuracy	Kappa Coeff. (k)
Acromioclavicular Joint arthritis	7	32	0	11	38.8%	100%	100%	74.4%	78%	0.44
Subacromial subdeltoid effusion	12	35	0	3	80%	100%	100%	92.2%	94%	0.84
Bicipital tendon sheath effusion	3	45	0	2	60%	100%	100%	96.7%	96%	0.73
Sub coracoid bursal effusion	0	48	0	2	NC	100%	NC	96%	96%	NC
Tear of Glenoid Labrum & avulsion of IGH ligament	0	47	0	3	NC	100%	NA	94%	94%	NC

FN false negative, FP false positive, IGH inferior gleno humeral, NC not computable, NPV negative predictive value, PPV positive predictive value, Sn sensitivity, Sp specificity, TN true negative, TP true positive.

Table 9. Sensitivity, Specificity, PPV, NPV & Accuracy of US for Detecting Non-rotator cuff Abnormalities of Shoulder Joint Compared to MRI.

that for PTT was substantial (k=0.65). However, US had low (≈50%) sensitivity for detection of PTTs.

Distribution of Non-Rotator Cuff Abnormalities Detected by MRI & US

As evident from Table 8, MRI detected various non-rotator cuff abnormalities of shoulder joint in 43 (86%) subjects. US, however, diagnosed non-rotator cuff pathologies (non-RCPs) in 22 (44%) cases including ACJ arthritis [Figure 3C] in 7 (14%) subjects, SASD effusion in 12 (24%) cases, BTS effusion in 3 (6%) patients. US, however, failed to detect SCB effusion & labro-ligamentous tears of shoulder joint. As presented in Table 9, US had specificity of 100% for diagnosis of SASD effusion, ACJ arthritis, BTS effusion and SCB effusion. However, sensitivity of US was low for diagnosis of ACJ arthritis (≈38.8%) and BTS effusion (≈60%).

Discussion

The tears of the rotator cuff tendons may occur because of age-related tendon degeneration or trauma as observed in the present study and reported previously[21-29]. The most affected rotator cuff tendon in this study was supraspinatus followed by subscapularis, infraspinatus, and TM tendon. Except few studies[30-31], most of the previous researchers[21-22,27-28] have reported distribution pattern like present study. A noteworthy finding in the present study is detection of polytendon abnormalities in rotator cuff observed in about a quarter of patients evaluated for underlying RCPs. Most of such cases comprised of combination of pathology in SST associated with SubT abnormality in the same patient, mostly PTT of the SST and tendinosis of SubT or vice- a -versa. One patient diagnosed with PTT of SST had abnormalities of all other rotator cuff tendons with tendinosis of IST and SubT and fatty muscle atrophy of TM. Only few studies have previously reported involvement of multiple rotator cuff tendons[32-33].

Supraspinatus Tendon Abnormalities

In this study, US correctly diagnosed all full thickness tears of rotator cuff. The literature[33-42], however, is heterogenous on the sensitivity of US in detecting full thickness RCTs. Some authors[39-40] have found US to be highly specific (≈100%) in diagnosing full-thickness RCTs but not as sensitive (≈46.2% to 57.7%). These studies suggested that US can be used to rule out a full thickness RCT if not present on US imaging, but US may not capture all tears[41]. However, we observed 100% sensitivity and 100% specificity of US for diagnosis of full thickness RCTs. In this study, US correctly diagnosed 81.2% cases of PTT of rotator cuff with sensitivity, specificity, and accuracy of 78.1%, 94.4% and 84%, respectively, compared to MRI. Previous studies[9,15,22,26,28,31,33,40,42-46] with MRI as reference standard have found sensitivity, specificity, and accuracy of US ranging from 12.5-94.7%, 67.9-100%, and 78-97.3%, respectively for diagnosing a partial thickness RCT. Further, in this study 96% cases of rotator cuff tendinosis were correctly diagnosed by US with sensitivity, specificity, and accuracy of 84%, 87.5%, and 86%, respectively. Previous studies[9,15,43-44,46] have also found acceptable accuracy of US for detection of rotator cuff tendinosis. Hence, it will be less likely for an individual with normal rotator cuff US to have a rotator cuff pathology. However, US had low diagnostic accuracy compared to MRI for detection of muscle atrophy.

In the present study, supraspinatus tendinosis was diagnosed in about 1/4th cases, PTTs in half of the subjects and FTTs in 1/10th cases evaluated. Previous studies[15,21-23,25,27-28,31,34,39,42,47] have identified supraspinatus tendinosis in 3.3-43.3% subjects, PTTs in 26.7-63.3% patients, and FTTs in 3.2-24.3% patients evaluated for RCT. However, since articular side SST tears in our cases were 1.8 times more frequent compared to bursal side tears, it is possible that internal impingement may be more frequent cause of SST tear than external impingement. Further, it is known that subacromial external impingement may cause supraspinatus tendinosis[48], however, dynamic assessment did not identify any external impingement in our cases. The associated SASD bursitis present in about a-third of patients of RCTs in this study per se does not rule out the possibility of underlying chronic external impingement in pathogenesis of RCTs. Compared to MRI, US was 100% accurate for detecting FTTs, 88% accurate for diagnosing PTTs and 94% accurate for identifying tendinosis of supraspinatus tendon. The findings of the present study correlates to previous studies[28,31,46].

Subscapularis Tendon Abnormalities

Subscapularis tendinosis was diagnosed in about one-fifth and PTTs in one-tenth of subjects evaluated. Previous studies[22,27-28,33,42,47] have reported subscapularis tendinosis in 3-45% patients, PTTs in 2.6-29% patients and FTTs in 0-6% patients evaluated by MRI and US for RCTs. It was observed that a large number (≈86.6%) of patients identified with abnormality in SubT in present study also had an underlying pathology of SST in the form of PTT or FTT or tendinosis of SST. The explanation for coexistence of SST and SubT abnormalities have been provided by Lazaro[48] that it may be due to underlying subacromial impingement, resulting in SST abnormality and coexistent sub-coracoid impingement leading to pathology of SubT. US was comparable to MRI for detection of PTT and tendinosis of SubT. The accuracy of US of 98% for detection of PTT in the present study was higher compared to previous studies[16,28,31,46]. However, US may be less sensitive (≈60%) compared to MRI for diagnosis of subscapularis tendinosis. Eventually, a normal shoulder US may not rule out subscapularis tendinosis with certainty.

Infraspinatus Tendon Abnormalities

IST abnormalities were diagnosed in 8% patients Previous studies[22,27-28,33,42,47] have reported infraspinatus tendinosis in 0-20% patients, PTT in 0-29% patients and FTT in 0-6% patients evaluated for RCT. Remarkably in present study a-quarter of patients with abnormality in IST also had coexistent SST pathology. A study by Chauhan et al[47] observed that SST tears greater than 2.5 cm in anteroposterior dimension often extend into the infraspinatus or the subscapularis tendon. However, none of the SST tears extended to IST or the SubT in the present study. The sensitivity, specificity, and accuracy of US for detection of FTT of IST was 100%. For PTTs of IST, the specificity, and accuracy of US was comparable to MRI, however, the sensitivity was observed to be low. However, small sample size of patients was the limitation of the study and may have underestimated the true sensitivity of US in identifying partial thickness tears of IST.

Associated Non-Rotator Cuff Abnormalities

The most common non-rotator cuff pathology of shoulder joint noted in this study was ACJ arthritis followed by SASD bursal effusion, BTS effusion, SCB effusion and labro-ligamentous tears. Previous studies[15,22-23,25,27-28,30-31,33,47] have reported ACJ arthritis in 18-93.5% patients, SASD effusion in 4.0-86.9% cases, BTS effusion in 0-78.4% patients, and SCB effusion in 4.0-47% subjects evaluated for suspected RCTs. It is hypothesized that the RCTs results in an increased load on AC Joint causing its degeneration[49]. Further, the finding of fluid in the SASD bursa, especially when combined with a GHJ effusion, is highly specific and should prompt a careful evaluation of underlying SST tear[50]. In this study, US failed to detect 61% cases of ACJ arthritis, 20% patients of SASD effusion and 40% cases of BTS effusion, and all cases of SCB effusion and labro-ligamentous tears. US had low sensitivity for detecting ACJ arthritis and BTS effusion, hence a normal US may not rule out these abnormalities with certainty. Also, the diagnostic utility of US compared to MRI for identifying SCB effusion and labro-ligamentous tears of shoulder joint was noted to be poor as reported previously[22].

Limitations of the Study

First, in this study MRI has been taken as gold standard even when MR arthrography (MRA) is superior to it[51]. MRI has been preferred over MRA in the present and many recent studies[15,22-27,30-31,46] being a non-invasive modality. Second, in the present study accuracy and precision of US for assessing the size of the tears was not undertaken.

Conclusions

US is comparable to MRI in delineating various rotator cuff and non-rotator cuff pathologies of shoulder joint. However, US may have limitation in accurately diagnosing subscapularis tendinosis, atrophy of TM, ACJ arthritis, BTS and SCB effusion, and labro-ligamentous tears of shoulder joint. Hence a normal shoulder US may not rule out these abnormalities with certainty. It is suggested to identify polytendon abnormalities in rotator cuff which may be common but under reported.

Authors' contribution

AG conceptualized and designed the study; collected, analysed, and interpreted the patient data; reviewed the literature; and drafted the publication. SRN interpreted and validated the data, reviewed the literature. PB helped with conceptualization of the work, overall guidance and supervision, coordination, and final editing.

Ethics approval

This study was approved by the Institutional Ethics Committee- Institute of Medical Sciences (IMS) and SUM Hospital, Siksha 'O' Anusandhan (Deemed to be University) [Approval Number: ECR/627/Inst/OR/2014/RR-20, date: 8 November 2020].

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