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Original Research Article

COMPARISON OF DIAGNOSTIC ACCURACY OF HIGH-RESOLUTION ULTRASONOGRAPHY WITH MAGNETIC RESONANCE IMAGING IN DETECTING MUSCULOTENDINOUS PATHOLOGIES OF THE SHOULDER JOINT

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Abstract

Background: The shoulder joint is prone to instability and injury and often presents with pain due to rotator cuff injuries, which is the most common cause of shoulder pain in patients over 40 years of age. This study aimed to determine the diagnostic performance of high-resolution US compared to MRI for the detection and characterisation of RC tears. **Materials and Methods:** This prospective comparative study included 40 patients referred for MRI at the Mahatma Gandhi Medical College and Research Institute, Pondicherry, between November 2015 and May 2017. All patients first underwent shoulder MRI, followed by a blinded US examination. The supraspinatus, infraspinatus, and subscapularis tendons were evaluated for full-thickness, partial-thickness, tendinosis, and intact tears. Additional findings have also been documented, including bursal fluid and joint effusions. **Result:** US showed high sensitivity (100%) and specificity (96.88%) for detecting complete supraspinatus tears, with similar performance for subscapularis and infraspinatus tears. US effectively identified partial supraspinatus tears with 76.92% sensitivity and 92.59% specificity, and tendinosis with 75% sensitivity and 91.67% specificity. For associated findings, the US had high accuracy for detecting impingement (87.5% sensitivity), peribursal fluid (85.71%), joint effusion (81.82%), and bursal fluid (90%). MRI provided a slightly higher accuracy for subtle degenerative changes and labral pathologies. **Conclusion:** High-resolution ultrasound shows high accuracy and good agreement with MRI in detecting rotator cuff pathologies, especially full-thickness tears. US is preferred for dynamic assessments and guiding procedures, and in cases where MRI is contraindicated, MRI remains superior for comprehensive evaluation of deeper structures.

INTRODUCTION

The shoulder joint is a shallow ball and socket type of synovial joint formed by the articulation of the humeral head with the glenoid fossa of the scapula. It is inherently highly unstable and more prone to injuries.[1] Among the general population, the prevalence of shoulder pain is 6.9-26%. Pain around the shoulder joint, with or without a reduced range of motion, is a common musculoskeletal referral to the radiology department. Among the various causes of shoulder pain, more than 60% of cases have been attributed to rotator cuff (RC) injuries, which are the most common cause of shoulder pain and discomfort in patients above 40 years of age.[2] Early diagnosis is required for proper surgical planning and prevention of functional impairment. Clinical examination alone does not provide adequate information for managing RC injuries. Therefore, RC ultrasound (US) assessment was attempted more than two decades ago, but it did not show any favourable results.[3]

Magnetic resonance imaging (MRI) is currently considered the reference standard for the diagnosis of RC lesions. A meta-analysis showed that MRI had the best sensitivity and comparable specificity for detecting full and partial-thickness tears of the rotator cuff when correlated with surgical findings. However, this method is expensive, time-consuming, and not always available. Claustrophobic patients and patients with pacemakers and cochlear implants are not suitable for MRI examination.[3] The US has evolved using high-resolution transducers. The US is rapid, relatively inexpensive, dynamic, and capable of performing bilateral examinations in a single sitting position.[4] Hence, it may be used as a first-line investigation for patients with shoulder pain. US is also helpful in assessing the RC and biceps tendon in revision cases, where MRI quality is often reduced due to metallic implants.[5]

The advantage of MRI over the US is its ability to assess sonographically inaccessible areas, such as the labrum, deep parts of various ligaments, capsules, and areas obscured by bone, and accurately show associated muscle abnormalities.[6] It can also reveal other causes of painful shoulders that clinically simulate rotator cuff disease. Nowadays, many modalities such as US, MRI, and MR arthrography (MRA) are commonly used by clinicians to delineate the extent of damage of RC.[7]

Aim

This study aimed to determine the accuracy of high-resolution US compared with MRI for detecting musculotendinous pathologies of the shoulder joint, assess the role of US in assessing rotator cuff tears, and enumerate the associated findings.

MATERIALS AND METHODS

This prospective comparative study included 40 patients referred to MRI Scan to the Department of Radiodiagnosis with suspected musculotendinous pathology of the shoulder joint at Mahatma Gandhi Medical College and Research Institute, Pondicherry, between November 2015 and May 2017. This study was approved by the Institutional Ethics Committee (ECR/451/Inst/PY/2013) before initiation, and informed consent was obtained from all patients.

Inclusion Criteria

Patients with suspected musculotendinous pathology of the shoulder, aged > 18 years, and of both sexes were included.

Exclusion Criteria

Patients with MRI and USG reports from other hospitals, < 18 years of age, with acute bony injury, who did not provide consent, and those with claustrophobia, metal implants, metallic foreign bodies, and cardiac pacemakers were excluded.

Methods: All the patients underwent an initial MRI examination of the shoulder, followed by the US, performed by an examiner who was blinded to the MRI results. The supraspinatus, infraspinatus, and subscapularis tendons were classified as full-thickness tears (complete tears), partial-thickness tears, tendinosis, or intact tears. Associated findings, such as bursal fluid and joint effusion, were also recorded.

All US examinations used a high-resolution linear-array transducer (7–12 MHz) on Mindray DC8 or WIPRO GE S7 EXPERT machines, adhering to a standardised protocol for rotator cuff evaluation. Ultrasound gel was generously applied to the shoulder. The patients positioned their arm at the side with the elbow bent to 90°, allowing the transducer to be placed around the humeral head's curvature in the oblique transverse plane. This positioning enabled the visualisation of the biceps tendon within its osseous groove, which was then traced longitudinally. Dynamic imaging of the subscapularis tendon was performed as the patient rotated the shoulder from internal to external rotation, with the transducer oriented transversely to display the full tendon length and individual slips in transverse images. Dynamic imaging of the supraspinatus tendon was recorded with the arm in extension and internal rotation, using the scapula's spine as a reference to differentiate between the supraspinatus and infraspinatus fossae. The infraspinatus was viewed longitudinally, following its course laterally across the posterior glenohumeral joint, as it transitioned into a tendon.

Ultrasound criteria for a rotator cuff tear: A hypoechoic area persisting in two planes. A full-thickness tear is characterised by a continuous hypoechoic area from the bursal space to the articular surface, indicating complete tendon absence. A partial-thickness tear was identified by a defect on the bursal side or a hypoechoic, mixed hypoechoic, and hyperechoic area on the articular-sided cuff portions.

Ultrasound criteria for detecting tendinosis in the US: Thickened or hypoechoic or heterogeneous tendon, and effacement of the fibrillar pattern.

Ultrasound test for impingement: The patient was asked to elevate his hands. Impingement was ruled out if the supraspinatus tendon glided smoothly below the subacromial outlet.

MRI: MRI was conducted on a 1.5 Tesla PHILIPS INTERA machine with a shoulder coil. The patient lay supine, maintaining a neutral shoulder position, with sponges placed at the elbow and hand for support, and the arm was strapped to prevent movement. The rotator cuff and biceps tendons were assessed using three imaging planes: two proton density-weighted fat-saturated turbo-spin-echo (PD TSE) sequences (coronal and axial), a coronal T1-weighted spin-echo sequence, and a T2-weighted TSE sequence in sagittal, axial, and coronal planes.

MRI criteria for a rotator cuff tear: increased signal intensity with tendon discontinuity or irregularity on T2- and PD TSE-weighted images indicates a full-thickness tear, diagnosed by a continuous tendon gap linking the bursal space to the articular surface. A partial-thickness tear presents with high signal intensity within the tendon substance on T2 and fat-suppressed PD-weighted images without tendon retraction. Tendinosis is identified when a tendon shows hyperintensity on fat-suppressed PD-weighted images but not on T2-weighted images.

Statistical Analysis: Data were presented as mean, standard deviation, frequency and percentage. Cross tabulations were created to find the sensitivity and specificity. Cohen's kappa coefficient was used to measure inter-rater reliability. Significance was defined as $p < 0.05$, using a two-tailed test. Data analysis was performed using IBM-SPSS version 21.0 (IBM-SPSS Science Inc., Chicago, IL).

RESULTS

The study group consisted of 40 patients, of whom 27 (67.5%) were male and 13 (32.5%) were female. The age of the patients included in the study ranged from 17 to 70 years (mean-43 years).

For supraspinatus lesions, partial tears were seen in 12 (30%) in the US and 13 (32.5%) in MRI, while tendinosis was higher on MRI 16 (40%) compared to the US 14 (35%). Subscapularis partial tears were equally detected by both US and MRI in 3 (7.5%) patients, with tendinosis observed in 9 (22.5%) on US and 10 (25%) on MRI. Both modalities identified infraspinatus complete tears in 1 (2.5%) of cases, while peribicipital fluid and impingement were found in 14 (35%) and 20 (50%), respectively, by both US and MRI. Bursal fluid was slightly higher on MRI 20 (50%) than on US 18 (45%). Labral pathology and teres minor tendinosis were detected only by MRI [Table 1].

In the supraspinatus, a complete tear was observed in 8 patients, and the US was able to detect all cases. There was a false positive case in which US detected a complete tear instead of a high-grade partial tear. Partial tears occurred in 13 patients, and US identified a defect in 10 patients. There were three false-negative results by US, which detected tendinopathy in 1 case and a normal cuff in the second patient, rather than a partial-thickness tear. Of these, 16 patients had tendinosis, and US correctly identified the pathology in 12 patients. False-negative results were found in four patients, in whom US showed either a normal study result or a partial-thickness tear rather than tendinosis. A false-positive tendinosis result was seen in two patients, one of whom had a partial tear and the other had a normal tendon.

In the subscapularis, three patients had a partial tear, and two of the three patients had a defect. A false-negative result was found in one patient, in whom US showed a normal tendon rather than a partial tear. A false-positive result was observed in one patient. Two of the 40 patients had a complete tear that was correctly diagnosed using US. Ten out of the 40 patients had tendinosis. False-negative results were found in 3 patients in whom US confirmed a diagnosis of either a partial tear or a normal tendon. One case of partial tear was reported as tendinosis in US. In the infraspinatus, 1 of the 40 patients had a complete tear that was correctly diagnosed using US [Table 2].

In the supraspinatus, US showed a sensitivity of 100%, specificity of 96.88%, PPV of 88.89%, and NPV of 100% for the detection of a complete tear. For the detection of partial-thickness tears, US showed sensitivity, specificity, PPV, and NPV of 76.92%, 92.59%, 83.33%, and 89.29%, respectively. US showed a sensitivity of 75.0%, specificity of 91.67%, PPV of 85.71%, and NPV of 84.62% for diagnosing tendinosis.

In subscapularis, for diagnosing partial-thickness tears, US showed a sensitivity of 66.67%, specificity of 97.30%, PPV of 66.67%, and NPV of 97.30%. The sensitivity and specificity of US for detecting complete tears were 100%. US had sensitivity, specificity, PPV, and NPV of 80%, 96.67%, 88.89%, and 93.55%, respectively, for diagnosing tendinosis. In the infraspinatus, US had a sensitivity and specificity of 100% [Table 3].

Impingement included 40 patients with supraspinatus tendon injuries, and seven were correctly diagnosed using US. False-positive US results were reported in one patient. PTF had 14 patients. 12 were diagnosed using US. Eleven patients had joint effusions. US diagnosed joint effusion in nine patients. No false-positive cases were reported in the US. Twenty patients had bursal fluid loss. US identified fluid in 18 patients in whom fluid was present in the bursal. US was not able to detect bursal fluid in 2 patients. No false-positive results were obtained with US [Table 4].

US had sensitivity, specificity, PPV, and NPV of 87.5%, 96.88%, 87.50%, and 96.88%, respectively, for the detection of impingement. US had a sensitivity of 85.71%, specificity of 100%, PPV of 100%, and NPV of 92.86% for identifying PTF. US had a sensitivity of 81.82%, specificity of 100%, PPV of 100%, and NPV of 93.55% for detecting joint effusion. US had a sensitivity of 90%, specificity of 100%, PPV of 100%, and NPV of 90.91% for detecting bursal fluid [Table 5].

The accuracy of US in detecting any supraspinatus lesion when MRI was used as a reference was 80%. There was significant agreement between the US findings and MRI, with a kappa of 0.7176 ($p<0.001$). The accuracy of US in detecting any subscapularis lesions when using MRI was 92.5%. There was a significant agreement between the US and MRI findings, with kappa values of 0.8583 and $p<0.001$ [Table 6].

Table 1: Various findings in the US and MRI prevalence.

		Frequency (%)	
		US	**MRI**
Supraspinatus lesions	Partial tear	12 (30%)	13 (32.5%)
	Complete tear	9 (22.5%)	8 (20%)
	Tendinosis	14 (35%)	16 (40%)
Subscapularis lesions	Partial tear	3 (7.5%)	3 (7.5%)
	Complete tear	2 (5%)	2 (5%)
	Tendinosis	9 (22.5%)	10 (25%)
Infraspinatus lesions	Complete tear	1 (2.5%)	1 (2.5%)

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Impingement	8 (20%)	8 (20%)
Peribicipital fluid (PTF)	14 (35%)	14 (35%)
Joint effusion	9 (22.5%)	11 (27.5%)
Bursal fluid	18 (45%)	20 (50%)
Labral pathology	-	11 (27.5%)
Teres minor tendinosis	-	1 (2.5%)

Table 2: Comparison of RC tear with ultrasound and MRI

		Complete tear		Partial tear		Tendinosis	
		MRI (+)	**MRI (-)**	**MRI (+)**	**MRI (-)**	**MRI (+)**	**MRI (-)**
Supraspinatus	US (+)	8	1	10	2	12	2
	US (-)	0	31	3	25	4	22
Subscapularis	US (+)	2	0	2	1	8	1
	US (-)	0	38	1	36	2	29
Infraspinatus tendon	US (+)	1	0	-	-	-	-
	US (-)	0	39	-	-	-	-
Overall accuracy	US (+)	9	1	10	2	15	5
	US (-)	0	30	4	24	2	18

Table 3: Diagnostic performance of US in detecting RC tear compared with MRI

		Sensitivity	Specificity	PPV	NPV
Supraspinatus	Complete tear	100%	96.88%	88.89%	100%
	Partial tear	76.92%	92.59%	83.33%	89.29%
	Tendinosis	75.00%	91.67%	85.71%	84.62%
Subscapularis	Complete tear	100%	100%	100%	100%
	Partial tear	66.67%	97.30%	66.67%	97.30%
	Tendinosis	80%	96.67%	88.89%	93.55%
Infraspinatus	Complete tear	100.00%	100.00%	100.00%	100.00%

Table 4: Comparison of US and MRI findings in detecting impingement, PTF, joint effusion, bursal fluid

	Impingement		PTF		Joint effusion		Bursal fluid	
	MRI (+)	**MRI (-)**	**MRI (+)**	**MRI (-)**	**MRI (+)**	**MRI (-)**	**MRI (+)**	**MRI (-)**
US (+)	7	1	12	0	9	0	18	0
US (-)	1	31	2	26	2	29	2	20

Table 5: Sensitivity, Specificity, PPV, NPV of US for detecting impingement, PTF, joint effusion, bursal fluid

		Sensitivity	Specificity	PPV	NPV
US	Impingement	87.50%	96.88%	87.50%	96.88%
	PTF	85.71%	100%	100%	92.86%
	Joint effusion	81.82%	100%	100%	93.55%
	Bursal fluid	90%	100%	100%	90.91%

Table 6: Comparison of US findings of supraspinatus and subscapularis with MRI

	US	MRI				P value
		Normal	**Partial tear**	**Complete tear**	**Tendinosis**	
Supraspinatus	Normal	2	1	0	2	<0.001
	Partial tear	0	10	0	2	
	Complete tear	0	1	8	0	
	Tendinosis	1	1	0	12	
subscapularis	Normal	25	0	0	1	<0.001
	Partial tear	0	2	0	1	
	Complete tear	0	0	2	0	
	Tendinosis	0	1	0	8	

DISCUSSION

The ages of the patients included in the study ranged from to 17-70 years (mean-43 years). Of all the lesions detected on USG and MRI, the supraspinatus tendon was more commonly involved than the infraspinatus or subscapularis tendon. This observation is comparable to the study done by Minagawa et al. observation the results showed that the mean age (years old) was 69.5 (range, 20–87).[8] Bhatnagar et al. found that 75% of the patients included in their study had supraspinatus tendon lesions.[9]

In our study, US showed a sensitivity and specificity of 100% and 96.88%, respectively, for the detection of complete supraspinatus tears. US showed a sensitivity of 75.0% and a specificity of 91.67% for detecting supraspinatus tendinosis. This is consistent with the findings of a study conducted by Fischer et al. showed a sensitivity of 100% and specificity of 91% for the US in detecting complete tears of supraspinatus.[10] Our study results are higher when compared to the Dhirenbhaithakker et al. study which stated that the US was 82% specific in detecting tendinosis of supraspinatus, whereas sensitivity was as low as 27%.[11]

In our study, the accuracy of US in detecting supraspinatus lesions when MRI was used as the reference was 80%. There was a significant agreement between the US and MRI findings, with a kappa of 0.7176 (p<0.001). US showed a specificity of 96.67% for the detection of tendinosis of subscapularis. US is more specific than sensitive for detecting tendinosis of the subscapularis. This is in concordance with the results of Fischer et al., who showed that the accuracy of US when MRI was used as a reference was 91.1% (kappa=0.85, p=0.26).10 Dhirenbhaithakker et al. study stated that the US has a specificity of 92% in detecting tendinosis of subscapularis.[11]

In our study, the accuracy of US in detecting any subscapularis lesions when using MRI as a reference was 92.5%. There was significant agreement between the US findings and MRI, with a kappa of 0.8583 and p-value <0.001. Our value is higher when compared to the study done by Fischer et al., where the US showed an accuracy of 77.8% and a kappa value of 0.5 for subscapularis lesions when compared with an MRI.[10]

In our study, one case of complete infraspinatus tear was diagnosed using US. Therefore, the US had a sensitivity and specificity of 100%. Similar results were reported by Dhirenbhaithakker et al., who showed a sensitivity and specificity of 100% for the US in detecting complete infraspinatus tears.[11] According to Fischer et al. study, all complete infraspinatus tears detected on imaging were also seen during surgery.[10]

In our study, 8(20%) out of 40 patients had subacromial impingement of the supraspinatus tendon, of which 7 were correctly diagnosed by US. US had a sensitivity of 87.5% and a specificity of 96.88% for the detection of impingement. This was consistent with the study by Read et al., who suggested a sensitivity of 80% in diagnosing impingement.[12]

In our study, 14 of the 40 patients (35%) had PTF. Twelve of the 14 patients were diagnosed using US and had a sensitivity of 85.71%, specificity of 100%, PPV of 100%, and NPV of 92.86% for identifying PTF. All 14 patients had RC pathology (partial/complete RC tears or tendinosis). This agrees with Chaubal et al., who stated that in patients with fluid along the biceps tendon sheath, there was a 95% probability of an RC tear.[13] In our study, US had a sensitivity of 81.82% for detecting joint effusion. Similar observations were made by Bhatnagar et al., who stated that the sensitivity of the US in detecting joint effusion was 77%.[9]

In our study, US had a sensitivity of 90%, specificity of 100%, PPV of 100%, and NPV of 90.91% for the detection of bursal fluid. Similar results were obtained by Dhirenbhaithakker et al., who showed that sensitivity, specificity, PPV, and NPV of US in detecting SASD bursal fluid were 86.67%, 100%, 100%, and 83.33% respectively.[11]

In our study, US showed an overall sensitivity of 100%, a specificity of 96.77%, a PPV of 90%, an NPV of 100%, and an accuracy of 97.5% for complete tears. US showed an overall sensitivity of 71.43% and specificity of 92.31% compared to MRI for partial tears. US showed an overall sensitivity of 88.24% and specificity of 78.26% compared with MRI for tendinosis. The results are like the study conducted by Fotiadou et al., which stated that the sensitivity, specificity, and overall accuracy of the US in detecting complete tears were 98%, 100%, and 98% respectively with MRI as reference.[14] Cullen et al., stated that the sensitivity and specificity of US in detecting partial thickness tears were 79% and 94%, respectively.[15] Roy et al. suggested that for tendinopathy, the US showed a high specificity of > 90% and showed a lower sensitivity of 67-83%.[3]

CONCLUSION

MRI and US are viable options for the assessment of RC tendon pathologies and other causes of shoulder pain. These imaging modalities are complementary. This study demonstrated that high-resolution US has high accuracy and agrees well with MRI in detecting rotator cuff pathologies, particularly full-thickness RC tears. However, US is less reliable in patients with a restricted range of motion, notably in external rotation, leading to inconsistent results for partial subscapularis tears.

US excels over MRI for dynamic examinations to identify conditions, such as impingement and guiding procedures. It is also preferable for patients with pacemakers, MRI-incompatible metal implants, or claustrophobia. While MRI remains the reference standard, offering a comprehensive shoulder evaluation, it is particularly suited for imaging the labrum, articular cartilage, bone marrow, and deep soft tissues. The choice between MRI and US for rotator cuff evaluation depends on the imaging access, radiologist expertise, referring physician preference, MRI contraindications, and patient preference.

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