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Comparison of Ultra Sonography With Magnetic Resonance Image in Evaluation of Lesions Causing Impairment of Mobility of the Shoulder Joint

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ABSTRACT

Aims: To compare Ultrasonography (USG) with Magnetic Resonance Imaging (MRI) in the evaluation of lesions causing impairment of mobility of the shoulder joint.
Method and Materials: This study was a cross-sectional observational study. Sonographic examination of the shoulder was done using a linear high-frequency probe (7.5-15 MHz) on a Siemens machine, and MRI evaluation was performed on a 3T Siemens Skyra machine. Data was analyzed using standard statistical methods, and results were compared with Arthroscopy where possible.According to the inclusion criteria, the patients of all age groups presenting with symptoms of shoulder pain or restricted movement referred from the department of orthopedics were studied.
Findings: Fifty patients were included in the study. Sensitivity and specificity of USG in comparison with MRI for diagnosing supraspinatus, subscapularis, infraspinatus, and long head of biceps tendon pathologies in our study were 95.4%, 100%, 66.6%, and 100%, 60% and 100%, 80%, and 100%, respectively. The sensitivity and specificity of USG for detecting AC joint arthropathy were 88.2% and 100%, respectively, in our study. The Sensitivity and specificity of USG were 82.7% and 100%, respectively, in detecting Subacromial Subdeltoid bursitis (SASD), which was similar to other studies in the literature.
Conclusion: This study revealed that USG has good sensitivity, specificity, and diagnostic accuracy in diagnosing rotator cuff tendon tears and tendinosis, as well as for the diagnosis of Acromioclavicular (AC) joint arthroplasty. Moreover, it is a non-invasive technique, readily available, and cost-effective. MRI is the best modality for diagnosing labor-ligamentous pathologies at the shoulder.

Keywords: : Rotator cuff, Shoulder Joint, Ultra Sonography (USG) ,Magnetic Resonance Image Subacromial Subdeltoid bursitis (SASD)

Introduction

The glenohumeral, commonly called the shoulder joint, is a multiaxial ball-and-socket joint that allows a wide range of movements. The size of the glenoid fossa of the scapula is smaller than the size of the humeral head, with the head being four times larger than the glenoid fossa. This permits a significant range of motion but also results in an increased susceptibility to instability (1).

The shoulder joint is primarily stabilized by the glenoid labrum and the rotator cuff muscles. The cartilaginous glenoid labrum increases the depth of the glenoid cavity, thereby providing more contact area and more stability to the glenohumeral joint (1). The Rotator cuff includes the subscapularis (anteriorly), the teres minor muscle (posteriorly), and supraspinatus muscle (superiorly). These 4 rotator cuff muscles and their tendons envelop the glenohumeral joint and hold the humeral head firmly in the glenoid fossa (2).

Both USG and MRI are commonly used for the evaluation of pathologies of the shoulder joint and can obviate the need for an invasive conventional arthrography. It is argued that USG can reliably be used as the primary imaging modality for the identification of partial-thickness tears.

Very few studies have been done in the Indian population to compare the role of USG and MRI in the evaluation of lesions causing impairment of mobility of the shoulder joint. Moreover, very few studies on the Indian population have found a significant association between USG and MRI in diagnosing the Pathologies of the rotator cuff. Therefore, this study aimed to compare USG with MRI in the evaluation of lesions causing impairment of mobility of the shoulder joint.

Method and Materials

This study was a cross-sectional observational study conducted in the Department of Radio-diagnosis at ABVIMS & Dr. RML Hospital, New Delhi, for a time duration of 2 years from November 2019 to August 2021. Fifty patients suspected to have shoulder pathology based on clinical assessment, referred from the department of orthopedics, were evaluated with USG and MRI to look for the cause of impairment of shoulder mobility. Proper written consent was taken from each participant before the study. The permission for consent from the institutional ethical committee is required before progressing with this study. In the present study, patients of all age groups presenting with symptoms of shoulder pain or restricted movement referred from the department of orthopedics were entered into the study. However, the patients with general contraindications to MRI, pregnant patients, patients who refused to give consent, and post-operative patients with shoulder pathology were excluded from the study.

Sonographic examination of the shoulder was done using a linear high-frequency probe (7.5-15 MHz) on a Siemens machine, and MRI evaluation was performed on a 3T Siemens Skyra machine. A single person interpreted the USG and MRI findings. The following MR sequences were used-

Oblique coronal: PD TSE FS , T2 TSE FS, T1 TSE FS, T2 DE 3D

Oblique sagittal: PD TSE FS , T1 TSE F

Axial: PD TSE FS axial.

The number of cases that underwent surgery and arthroscopy during the COVID pandemic was lower, therefore, all MR findings could not be compared with surgical/arthroscopic findings. In our study, only 6 patients (who had full-thickness rotator cuff tears) out of a total of 50 patients underwent surgical repair, so we considered MRI as the non-invasive gold standard investigation of choice and compared our ultrasound findings with MRI Statistical analysis and results were calculated using chi-square test and bar charts and tables were obtained using the SPSS software. The sensitivity, specificity, positive predictive value, and negative predictive value of USG and MRI were also calculated. Inter-rater kappa agreement was used to find out the strength of the agreement between USG and MRI. A 'P' value less than 0.05 was taken to be considered statistically significant. The statistics were tabulated and calculated in consultation with a biostatistician (Table 1).

Table 1) Statistical 2 x 2 contingency

	Positive	Negative	
Positive	TP	FP	TP+FP
Negative	FN	TN	FN+TN
	TP+FN	FP+TN	TP+FP+FN+TN

Definitions:

- True Positive = Correctly Identified
- False Positive = Incorrectly Identified
- True Negative = Correctly missed
- False Negative = Incorrectly missed

$$\text{Sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false negatives}}$$

Sensitivity relates to the test's ability to identify positive results.

$$\text{Sensitivity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false positives}}$$

Specificity relates to the test's ability to identify negative results.

$$\text{Positive Predictive Value (PPV)} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false positives}}$$

$$\text{Negative Predictive Value (NPV)} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false negatives}}$$

$$\text{Accuracy} = \frac{\text{number of true positives} + \text{number of true negatives}}{\text{true positives} + \text{false positives} + \text{true negatives} + \text{false negatives}}$$

Accuracy of the measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) value.

Findings

The current study was a cross-sectional observational study of 50 patients of all ages and genders who presented with shoulder pain or restricted joint movement. The patients were subjected to a USG examination of the affected shoulder joint, followed by an MRI examination of the affected shoulder. During the time of the COVID pandemic, there was a restriction on several procedures performed (Arthroscopy, surgeries). Therefore, MRI was used as the main reference against which sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of USG were calculated for diagnosing shoulder joint pathologies.

Out of 50 patients studied, 36 were males and 14 were females, with ages ranging from 19 to 72 years. The mean age of our population was 42 years. A maximum number of patients (32%) in our study population were in the fifth decade. The age and gender distribution of the study population is shown in Table 2.

Table 2) Distribution of the study population in terms of age and gender

AGE	GENDER		Total
	Male N(%)	Female N (%)	
<30 years	9 (18)	1 (2)	10 (20%)
31-40 years	9 (18)	4 (8)	13 (26%)
41-50 years	12 (24)	4 (8)	16 (32%)
51-60 years	4 (8)	4 (80	8 (16%)
>60 years	2 (4)	1 (2)	3 (6%)
TOTAL	36 (72)	14 (28)	50 (100%)

Accuracy of the measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) value.

TABLE 3) Spectrum of shoulder pathologies encountered in our study.

Pathology	Frequency	
	USG N(50) N(%)	MRI N(50) N(%)
Rotator cuff Tendon tear/ Tendinosis	42 (84%)	45 (90%)
SASD Bursitis	24 (48%)	29 (58%)
AC joint arthropathy	30 (60%)	34 (68%)
Ligament pathologies	-	21 (42%)
Glenoid Labrum tear	-	16 (32%)
Adhesive capsulitis	-	7 (14%)

Rotator cuff pathologies were found to be the leading cause of shoulder pain in our study population. Other causes of shoulder immobility detected in our study were - AC joint arthroplasty, SASD bursitis, glenoid labrum tear, ligamentous pathologies, and adhesive capsulitis, as shown in Table 3. USG of the shoulder diagnosed rotator cuff pathologies in 42 patients, while MRI detected rotator cuff pathologies in 45 patients.

TABLE 4) USG AND MRI Comparison of Rotator Cuff Tendon Pathology Detection

Tendon pathology		USG N(%)	MRI
Supraspinatus	Partial thickness tear	25 (50)	29 (58)
	Full-thickness tear	4(8)	5 (10)
	Tendinosis	17(34)	18 (36)
Subscapularis	Partial thickness tear	7(14)	10(20)

	Full-thickness tear	0 (0)	0(0)
	Tendinosis	8 (16)	13(26)
Infraspinatus	Partial thickness tear	2(4)	3(6)
	Full-thickness tear	0(0)	0(0)
	Tendinosis	1(2)	2(4)
Long head of the Biceps	Partial thickness tear	1(2)	2(4)
	Full-thickness tear	1(2)	1(2)
	Tendinosis	6 (12)	7

USG – Ultrasound, MRI – Magnetic resonance imaging, SASD – Subacromial Subdeltoid bursitis, AC joint – Acromioclavicular joint.

According to the results, rotator cuff lesions and supraspinatus tendon pathologies were the commonest findings (88%) resulting in shoulder pain in our study, followed by subscapularis tendon pathologies. A comparison of USG and MRI findings and statistical analysis of rotator cuff pathologies in our study is shown in Tables 4 and 5, respectively.

TABLE 5) Sensitivity, Specificity, PPV and NPV, and Diagnostic accuracy of USG in comparison with MRI in the diagnosis of Rotator cuff tendon pathologies

Pathology	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy	Cohen's kappa	
						k value	p-value
Supraspinatus tendon	95.4	100	100	75	96	0.834	<0.001
Subscapularis tendon	66.6	100	100	80.5	86	0.698	<0.001
Infraspinatus tendon	60	100	100	95.7	96	0.729	<0.001
Long head of the biceps tendon	80	100	100	95.2	96	0.864	<0.001

PPV – Positive predictive value, NPV – Negative predictive value

Discussion

Rotator cuff pathologies are the most common cause of shoulder immobility. Shoulder immobility and pain are the common complaints in people presenting with Rotator cuff pathologies. The rotator cuff is prone to degeneration secondary to numerous active and passive movements occurring at the joint. The common rotator cuff pathologies causing shoulder pain include tendinosis, partial thickness or full thickness tear of one or more of the 4 tendons constituting the Rotator cuff, namely supraspinatus, subscapularis, infraspinatus, and teres minor tendons [2].

USG and MRI are widely used imaging modalities in the diagnosis and evaluation of the pathologies affecting the shoulder [1].

USG provides a rapid, dynamic, real-time assessment of rotator cuff tendons, allowing detection of tendinopathy. Dynamic ultrasonography of the rotator cuff has several distinct advantages compared with other imaging modalities. USG, with recent advances, better probes, and increasing experience, has become an important tool for shoulder evaluation. It detects the specific tendon involved. USG is an accessible, cost-effective technique that allows instant comparison with the contralateral side and is a valuable follow-up modality for patients with rotator cuff injury. It may be the only imaging option for patients with severe claustrophobia or dye allergy or those with metallic implants or pacemakers [2].

The normal tendon appears as a hyperechoic fibrillary pattern on USG. The 2 features that enable diagnosis of rotator cuff tendinosis on USG are - a) zone of focal thickening of the tendon and b) altered echo pattern of the tendon.

The tear is defined as a focal or complete discontinuity in the tendon substance. These can be partial-thickness or full-thickness types depending on the extent of involvement. Partial thickness tendon tear is detected as a focal discontinuity along the course of the tendon, along with a focal area of hypo-echogenicity. This may be seen involving either the bursal or articular surfaces of the tendon. In interstitial varieties of partial thickness tear, there is no discontinuity at the articular or bursal margins of the tendon; instead, hypo-echogenicity involving the substance of the tendon is seen. A full-thickness tear of a Rotator cuff tendon is diagnosed on USG as hypo-echogenicity involving the complete thickness, i.e, the bursal and articular surfaces as well as the substance of the tendon, is continuity extending from the bursal to the articular surface. The full-thickness tear may exist with or without retraction of the tendon. Tendon retraction occurs proximal to its insertion on the lesser or greater tuberosity of the humerus. In a full-thickness tear with retraction, the normal fibrillary appearance of the tendon and its footprint cannot be identified. The muscle belly ends abruptly without visualization of the transition into the myotendinous junction. The retracted tendon is seen as a jumbled-up/clumped hypoechoic area abutting the muscle belly [3].

The location of rotator cuff tears is identified as:[4] A: At the articular surface, B: At the bursal surface, C: A complete tear, connecting A and B tears.

Diagnosis of rotator cuff pathologies by USG is therefore easy and accurate. However, the limitation of USG is that it is a user-dependent modality, and training and expertise are needed to identify these findings. Further, USG has a limited role in the evaluation of the labrum, cartilage, and bones around the shoulder joint [2].

MRI provides good spatial resolution and visualizes the tendons, bones, and adjacent ligamentous and muscular structures at the shoulder joint. Thereby providing anatomical information regarding the pathology causing shoulder joint pain. MRI has excellent contrast resolution, too, and provides good multiplane delineation of the shoulder joint. MRI also provides information about cartilage. It can diagnose muscle atrophy and assess muscle cross-sectional area. Fatty degeneration of the muscle, which has important clinical implications, can be detected as T1 hyperintensity within the muscle. MRI can assess the length of the tear extent and the location of tendon tears more accurately [1].

On MRI, the normal tendon appears as hypointense on both PD/T2-weighted images. Tendinosis can be diagnosed as an increased signal intensity within the tendon. The signal intensity helps to differentiate tendinosis from a tear. The increased signal intensity of tendinosis is not the same as the bright signal of fluid on T2 and PD sequences. Tears, on the other hand, demonstrate a hyper-intense signal that appears as bright as the hyper-intense signal of fluid, along with visualization of fluid tracking from the bursae into the disrupted tendon. We know that tendon tears can be partial or full-thickness. On MRI, a normal hypo-intense signal of the tendon is replaced with focal hyperintensity on both PD and T2-weighted sequences in a partial tear. This may be seen involving the articular or bursal surfaces, or the interstitial fibers of the tendon. Fluid from the subjacent subdeltoid/subacromial bursa may track into the partial tear. Full-thickness tears, on the other hand, are differentiated from partial-thickness tears by visualization of T2 hyper-intense signal traversing the tendon, extending across the tendon from the articular surface to the bursal surface on at least one image [4].

In our study, USG diagnosed rotator cuff pathologies in 42 patients out of total 50 patients, supraspinatus tendon pathologies were diagnosed in 42 patients, subscapularis tendon pathologies in 14 patients, Infraspinatus tendon pathologies in 3 patients and long head of biceps tendon pathologies in 8 patients. MRI detected rotator cuff pathologies in total of 45 patients out of total 50 patients, supraspinatus tendon pathologies were diagnosed in 44 patients, subscapularis tendon pathologies in 21 patients, infraspinatus tendon pathologies in 5 patients and long head of biceps tendon pathologies in 10 patients. One patient among our 50 study participants showed terse minor tendon pathology as the cause of shoulder pain. On the MRI shoulder, a partial thickness tear on the articular side of the teres minor tendon was detected. USG in the same patient was not able to detect this pathology. USG did not identify teres minor pathology in any other patient in our study. Thus, rotator cuff pathologies, especially supraspinatus tendon involvement, constituted a major proportion of lesions identified in our study.

Sensitivity, specificity, and diagnostic accuracy of USG in comparison with MRI for diagnosing supraspinatus tendon pathologies in our study were 95.4%, 100%, and 96% respectively, were more than the sensitivity (78.7%), specificity (84.6%) and diagnostic accuracy (70%) of USG in other studies in literature in detecting pathologies of supraspinatus tendon[10].

In the present study, the sensitivity, specificity, and diagnostic accuracy of USG for detecting subscapularis tendon pathologies were 66.6%, 100%, and 86%, respectively. For the diagnosis of pathologies of the infraspinatus tendon, the sensitivity, specificity, and diagnostic accuracy of USG in comparison to MRI were found to be 60%, 100%, and 96%, respectively. The sensitivity, specificity, and diagnostic accuracy of USG for diagnosing long head of biceps tendon pathologies were 80%, 100%, and 96%, respectively. Our study shows similar diagnostic accuracy to that found in other studies in the literature comparing these two modalities for diagnosing subscapularis, infraspinatus and biceps tendon pathologies was 90%, 96.7% and 96.7% respectively.[12]

AC joint arthropathies were also found in association with rotator cuff pathologies or detected as degenerative changes that can cause shoulder pain. Out of a total study population of 50 patients, USG detected AC Joint arthropathy in 30 (60%) patients, and MRI showed AC Joint arthropathy in 34 (68%) patients with shoulder pain. The sensitivity, specificity, and diagnostic accuracy of USG for detecting AC joint arthropathy were 88.2%, 100%, and 92%, respectively, in our study. For detecting AC joint arthropathy, the sensitivity and diagnostic accuracy of USG in comparison with MRI in our study were higher than as compared to the sensitivity (13%) and diagnostic accuracy 39% found in other studies in the literature [8].

A common sonographic finding associated with rotator cuff tears includes fluid in the subacromial/subdeltoid bursa. In our study, USG was able to detect SASD bursitis in 24 patients, whereas MRI detected it in 29 patients. The Sensitivity, specificity, and diagnostic accuracy of USG were 82.7%, 100%, and 90%, respectively, in detecting SASD bursitis, which was similar to the diagnostic accuracy in other studies in the literature [5,8].

Detection of labor-ligament pathologies

Labral pathologies commonly associated with shoulder joint immobility are labral tears. These can involve the superior labrum and antero-inferior labrum with or without involvement of articular cartilage. Normal labrum appears as T2/PD hypointense triangular triangular-shaped in cross-section. Labral tear appears on MRI as hyper-intensity bisecting the labrum through its attachment at the glenoid. In our study, out of 50 patients, MRI detected glenoid labrum pathologies as the cause of shoulder pain and disability in 18 patients (36%). MRI detected Buford complex in 3 patients as atrophic/absent anterior labrum with compensatory thickening of MGHL, Bankart lesions in 3 patients as detachment of anteroinferior labrum with or without an osseous fragment of the glenoid, SLAP tear in 10 patients, ALPSA lesion in 1 patient as absent anterior labrum on glenoid with medial displacement of labor-ligamentous complex and GLAD lesion in 1 patient as disruption of anterior inferior labrum with adjacent cartilage damage. Labro-ligament pathologies could not be detected on USG in our study. Similar results were also demonstrated by the study in the literature [6,14].

Out of 50 patients, MRI demonstrated SGHL tear in 6 (12%) patients, MGHL tear in 9 (18%) patients, IGHL tear in 8 (16%) patients, Coraco-acromial ligament tear in 4 (8%) patients, and Coraco-humeral ligament tear in 6 (12%) patients. Ligament abnormality could not be detected on USG in any of the patients in our study population. We found a paucity of studies in the literature regarding the role of USG in the diagnosis of ligament pathologies of the shoulder joint in patients with shoulder instability.

The sample size of this study could be considered a limiting factor in our study, and some of the perfect values might be attributed to this relatively smaller sample size. However, we were struck by the global pandemic, and we could not include more patients in our study. Several cases that underwent surgery and arthroscopy during the COVID pandemic were fewer. Therefore, all MR findings could not be compared with surgical/arthroscopic findings. In our study, only 6 patients who had full-thickness rotator cuff tears out of a total of 50 patients underwent surgical repair, so it was considered MRI as the non-invasive gold standard investigation of choice, and we compared our ultrasound findings with MRI.

Conclusion

This study revealed that USG has a good sensitivity, specificity, and diagnostic accuracy in diagnosing rotator cuff tendon pathologies, bursitis, as well as for the diagnosis of AC joint arthroplasty. MRI is the best modality for diagnosing labor-ligamentous pathologies at the shoulder. In the evaluation of rotator cuff pathologies, USG was the primary imaging modality. However, MRI remains the superior and standard in accurate localization, characterization, and assessment of rotator cuff injuries.

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Authors Contribution:

All authors contribute to design and conduct this study. They confirmed the final version of the manuscript.

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There is no confilict of interest for this study.

Ethical Permission:

All ethical principals were considered n this study. All patients confirmed and signed the consent form.

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