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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 Ultra Sonography (USG) with Magnetic Resonance Image (MRI) in 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 shoulder was done using a linear high-frequency probe (7.5-15 MHz) on Siemens machine and MRI evaluation was performed on 3T Siemens Skyra machine. Data was analyzed using standard statistical methods and results were compared with Arthroscopy where possible.
According inclusion criteria the patients of all age groups presenting with symptoms of shoulder pain or restricted movement referred from department of orthopaedics 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% and 100%, 66.6% and 100%, 60% and 100%, 80% and 100% respectively. 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) bursitis, which were similar to as in other studies in literature.
Conclusion: This study revealed that USG has a good sensitivity, specificity and diagnostic accuracy in diagnosing rotator cuff tendon tears and tendinosis as well as for diagnosis of Acromioclavicular (AC) joint arthroplasty. Moreover, it is a non-invasive technique, readily available and cost effective. MRI is best modality for diagnosing labro-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 which allows a wide range of movements. The size of the glenoid fossa of scapula is smaller than the size of the humeral head, with the head being four times larger than the glenoid fossa. This permits significant range of motion but also results in an increased susceptibility to instability (1).

The shoulder joint is primarily stabilized by the glenoid labarum and the rotator cuff muscles. Cartilaginous glenoid labarum increases the depth of the glenoid cavity thereby providing more contact area and more stability to glenohumeral joint (1). The Rotator cuff includes subscapularis (anteriorly), Terse minor muscle (posteriorly), infraspinatus (postero-superiorly)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 evaluation of lesions causing impairment of mobility of the shoulder joint.Moreover, very few studies in Indian population have found a statistically

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significant association between USG and MRI in diagnosing Pathologies of rotator cuff. Therefore this study aimed to compare USG with MRI in evaluation of lesions causing impairment of mobility of the shoulder joint.

Method and Materials

This study was a cross-sectional observational study conducted in department of Radio-diagnosis at ABVIMS & Dr. RML Hospital, New Delhi, for 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 prior to study. The permission for consent from the institutional ethical committee before progressing with this study. In present study patients of all age groups presenting with symptoms of shoulder pain or restricted movement referred from department of orthopedics were entered into study. However, the patients with general contraindications to MRI, pregnant patients, patients who refused to give consent, and post-operative patients of shoulder pathology were excluded from the study.

Sonographic examination of shoulder was done using a linear high-frequency probe (7.5-15 MHz) on Siemens machine and MRI evaluation was performed on 3T Siemens Skyra machine. 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.

Number of cases that underwent surgery and arthroscopy during the COVID pandemic was less, 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 total 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. Sensitivity, specificity, positive predictive value, negative predictive value of USG and MRI were also calculated. Inter rater kappa agreement was used to find out strength of agreement between USG and MRI. 'P' value less than 0.05 was taken to consider statistically significant. The statistics were tabulated and calculated in consultation with a bio-statistician (Table1).

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

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

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

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

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

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

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

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

Accuracy of measurement system is degree

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of closeness of measurements of a quantity to thatquantity's actual (true) value

Findings

The current study was a cross-sectional observational study of 50 patients of all ages and gender who presented with shoulder pain or restricted joint movement. The patients were subjected to USG examination of the affected shoulder joint, followed by MRI examination of the affected shoulder. During the time of COVID pandemic, there was restriction in number of procedures performed (Arthroscopy, surgeries). Therefore MRI was used as main reference against which sensitivity, specificity, positive predictive valve, negative predictive value, and diagnostic accuracy of USG was 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. Mean age of our population was 42 years. Maximum number of patients (32%) in our study population were in the fifth decade. Age and gender distribution of 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 measurement system is 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.

Patology	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 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 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 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 – Sub acromial Sub deltoid bursitis, AC joint – Acromioclavicular joint.

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

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

Patology	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 bicep 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 tendon [2].

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

USG provides 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 which allows instant comparison with the contralateral side and is valuable follow up modality for patients of rotator cuff injury. It may be the only imaging option for patients with severe claustrophobia or dye allergy, or for those with metallic implants or pacemakers [2].

The normal tendon appears as 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.

Tear is defined as 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 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 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, articular surfaces as well as the substance of the tendon is continuity, extending from bursal to articular surface. 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 humorous. In full thickness tear with retraction, the normal fibrillary appearance of the tendon and its foot print 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 is needed to identify these findings. Further USG has a limited role in evaluation of labarum, cartilage and bones around the shoulder joint [2].

MRI provides good spatial resolution and visualizes the tendons, bones, 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 multiplanes delineation of the shoulder joint. MRI also provides information about cartilage. It can diagnose muscle atrophy, assess muscle cross-sectional area. Fatty degeneration of the muscle which has important clinical implications can be detected as T1 hyper intensity within the muscle. MRI is able to assess the length of tear extent and the location of tendon tears more accurately [1] .

On MRI, normal tendon appears as hypo intense 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 tear. The increased signal intensity of tendinosis is not same as bright signal of fluid on T2 and PD sequences. Tears on the other hand demonstrate a hyper intense signal which 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, normal hypo intense signal of the tendon is replaced with focal hyper intensity on both PD and T2 weighted sequences in partial tear. This may be seen involving the articular or bursal surfaces, or the interstitial fibres of the tendon. Fluid from subjacent sub deltoid/sub acromial 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 articular surface to 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 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 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 present study, sensitivity, specificity and diagnostic accuracy of USG for detecting

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subscapularis tendon pathologies were 66.6%, 100% and 86% respectively. For diagnosis of pathologies of infraspinatus tendon, the sensitivity, specificity and diagnostic accuracy of USG in comparison to MRI were found to be 60%, 100%, and 96% respectively. 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 as found in other studies in literature on 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 which can cause shoulder pain. Out of 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 of shoulder pain. 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 more than as compared to the sensitivity (13%) and diagnostic accuracy (39%) found in other studies in literature (8).

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

Detection of labro-ligament pathologies

Labral pathologies commonly associated with shoulder joint immobility are labral tears. These can involve superior labrum, antero-inferior labrum with or without involvement of articular cartilage. Normal labrum appears as T2/PD hypo intense triangular shaped in cross-section. Labral tear appears on MRI as hyper intensity bisecting the labrum through its attachment at 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 antero inferior 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 labro-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 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 paucity of studies in literature regarding role of USG in diagnosis of ligament pathologies of the shoulder joint in patients of shoulder instability.

The sample size of this study could be considered as 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 with the global pandemic and we could not include more patients in our study. Number of cases that underwent surgery and arthroscopy during the COVID pandemic was less. 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 total 50 patients underwent surgical repair, so it was considered MRI as the non-invasive gold standard investigation of choice and compared our ultrasound findings with MRI.

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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 diagnosis of AC joint arthroplasty. MRI is best modality for diagnosing labro-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

Conflict of Interests

Ethical Permission

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