Role Of Ultrasonography In Rotator Cuff Pathologies And Its Correlation With Magnetic Resonance Imaging Findings

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Abstract-
BACKGROUND:
Pathologies of the rotator cuff are a common affliction affecting patients presenting with shoulder pain. Imaging modalities like USG and MRI play an essential part of the modern approach towards their effective diagnosis and management. MRI is currently accepted as the reference standard imaging modality for nearly all clinical indications concerning the shoulder and the diagnostic accuracy of USG in such patients needs constant revalidation.
MATERIALS & METHODS:
The hospital based prospective study included a population of 30 patients with clinically suspected rotator cuff pathologies who underwent USG and MR imaging of the shoulder in the department of Radiodiagnosis in Rajarajeswari Medical College & Hospital, Bengaluru from October 2022 to November 2023.
RESULTS:
Taking MRI as reference standard, ultrasound showed an accuracy of 97.5% for detection of partial thickness tears (PTT), 99.17% for full thickness (FTT) and intrasubstance tears (IST) and 98% for tendinosis. The specificity of partial thickness tears was 98.13%, full thickness and intrasubstance tears was 100% and tendinosis was 98.47%. The sensitivity, specificity, positive predictive value, negative predictive value & accuracy of USG in diagnosing the overall rotator cuff pathologies of the shoulder over MRI was 90%, 99.15%, 90%, 99.15% and 98.43% respectively which was found to be strongly significant with a p value of < 0.001.
CONCLUSION:
USG shows a good correlation to MRI in diagnosing rotator cuff tendon pathologies. Hence it can be used as the initial imaging modality in these patients, provided the radiologist has undergone adequate training in image interpretation.

Keywords: **Full thickness tear, Impingement, Intrasubstance tear, Magnetic resonance imaging Partial thickness tear, Rotator cuff tendon tears, Tendinosis, Ultrasonography.**

INTRODUCTION:

The shoulder complex comprises of three joints namely the sternoclavicular, acromioclavicular, and glenohumeral joints. The first two joints link the two bones of the pectoral girdle to each other and to the trunk. The combined movements at these two joints enable the scapula to be positioned over the thoracic wall with a wide range of movement of the upper limb.[1]

Joint stability is provided by surrounding muscle tendons forming the rotator cuff, the long head of the biceps brachii muscle, a skeletal arch formed superiorly by the coracoid process and acromion and the extracapsular ligaments' Tendons of the rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) blend with the joint capsule and form a musculotendinous collar that surrounds the posterior, superior, and anterior aspects of the glenohumeral joint. This cuff of muscles stabilizes and holds the head of the humerus in the glenoid cavity of the scapula without compromising the arm's flexibility and range of motion.[1]

The common disorders involving the rotator cuff tendons include impingement and tendinopathy. There is an emerging consensus that the rotator cuff pathologies are multifactorial — Extrinsic & Intrinsic mechanisms. Microtrauma causing stress on the tendon is the basis of extrinsic mechanisms, degeneration of the tendon and zones of critical vascularity predisposing to tear in the tendon even on low energy mechanism is the basis for intrinsic mechanism.[2]

Number of entities may result in shoulder pain from tendinitis to partial or full thickness tear. They may present as pain or difficulty in elevating the arm. The prevalence of rotator cuff pathologies is 5% to 39% in the general population. It increases with age and is even more common in elderly. The causes for these rotator cuff pathologies are multifactorial and are mostly a combination of factors like trauma, daily wear and tear and age related degeneration.[3]

Ultrasound and magnetic resonance can diagnose tendinopathy and are 100% accurate in diagnosing full thickness rotator cuff tears. Partial thickness tear is less reliably demonstrated by both MRI and USG.[4]

Ultrasound is non-invasive, real time, dynamic, non-ionising, high resolution diagnostic tool. It is fast and well tolerated by patients. Its main disadvantage is operator dependent and has a steep learning curve.[5]

The advent of MRI revolutionised the imaging of musculoskeletal structures, since it provides additional relevant information such as labral tears, fatty degeneration of the muscles of the rotator cuff, abnormalities of the biceps tendon, and others.[6] The main disadvantages of MRI are availability and it is less cost effectiveness.[7-12] However, MRI is now considered as the reference standard imaging modality for almost all clinical indications concerned with the shoulder and the diagnostic accuracy of USG in such patients needs need: constant revalidation.

OBJECTIVES:

1. To study the USG and MRI appearances of various pathologies of the rotator cuff and to compare the findings.
2. To assess the sensitivity and specificity of USG in various rotator-cuff pathologies.
3. To assess if USG can be the primary mode of imaging

MATERIAL AND METHODS:

A cross sectional study was conducted among 30 patients with clinically suspected rotator cuff pathologies who underwent USG and MR imaging of the shoulder in department of Radiodiagnosis, Rajarajeswari Medical College and Hospital for a period of 24 months between October 2022 to November 2023.

Inclusion criteria:

1. Patients referred to department of radiology, both genders with clinical history or examination findings suggestive of Rotator cuff pathologies.
2. Those who give informed consent

Exclusion criteria:

1. Patients who have already undergone treatment or surgery.
2. Patients with ferromagnetic implants/ pacemakers
3. Patients unwilling to undergo investigation.
4. Patients having history of claustrophobia.

Sample size: 30

On the basis of statistics obtained from the department, an average of 16 cases of suspected rotator cuff injuries, per year fitting the criteria of the study, with study duration of 24 months, we can expect to have N=32. Based on this population size, using YAMANE equation,[13] for a known population size, sample size (n) equal to n=N/1+N(e)*
Where, n=sample size N=population size e= margin of error (for 95% of confidence level, margin error =0.05)
Hence, sample size, n=32/1+32*0.05*0.05, n=32/1.08, n=29.62 rounded off to 30

Method of data collection:

After Ethical committee approval and after obtaining informed consent form patients, they were briefed about the procedure. All the USG scans of the shoulder was performed in SAMSUNG RS80A USG machine using a high density, multi frequency (16-3 MHz) linear array transducer. Protocol for USG shoulder: Images of the Supraspinatus, Infraspinatus, Subscapularis, Long head of biceps tendons and teres minor insertion were acquired. Additional image acquisition was tailored to the patient. Dynamic evaluation for impingement was carried out.

MRI scans of the shoulder in this study were performed using — MAGNETOM AVANTO 1.5 tesla MRI system. Protocol for MRI shoulder: Axial TIW, T2W, PD Oblique coronal TIW, T2W, PD Oblique sagittal TIW, T2W, PD STIR, T2* and additional imaging sequences, planes were acquired when required.

Statistical analysis:

Data was analysed using SPSS (Statistical Package for Social Sciences) version 20. (IBM SPASS statistics [IBM corp. released 2011] Descriptive variables were calculated by mean, standard deviation. For quantitative variables, frequency and proportions and for qualitative variables. Inferential statistics like Chi-square test was applied. Diagnostic accuracy tests like Sensitivity, specificity, PPV, NPV, Accuracy were calculated between USG and MRI for various pathologies. The level of significance was set at 5%.

USG AND MRI IMAGES OF FEW CASES IN THE STUDY:

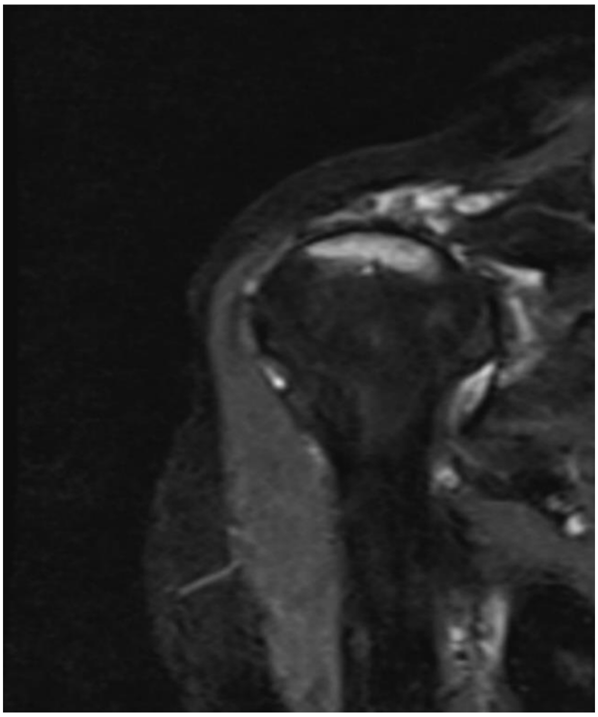


Figure 1: STIR Coronal showing contusions in humeral head with complete tear of supraspinatus tendon and superior subluxation od humeral head

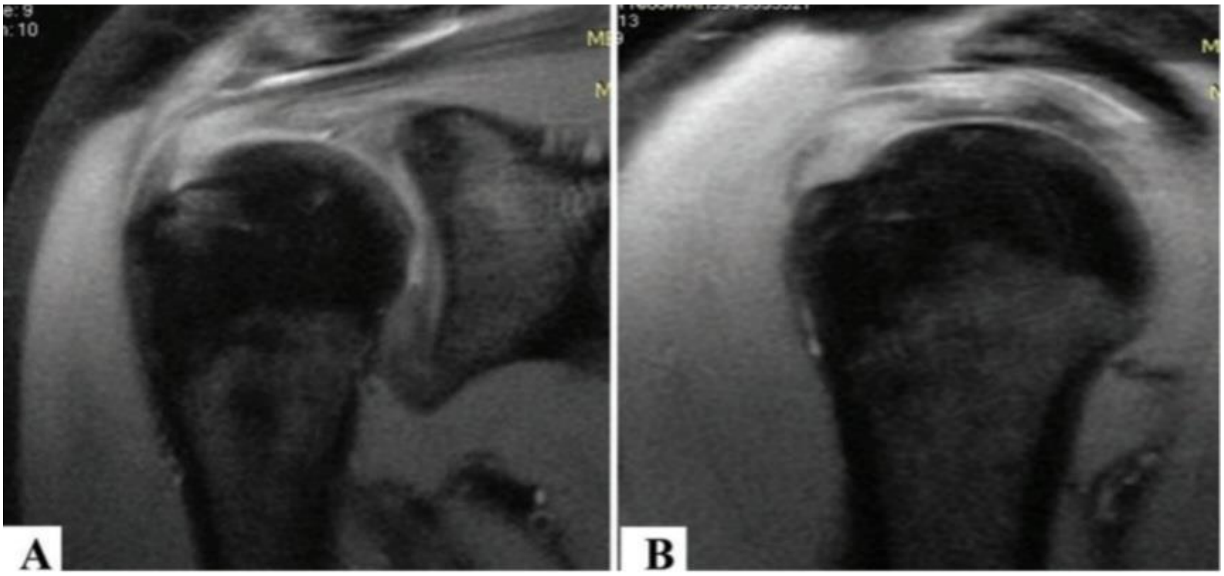


Figure 2: MRI coronal (A) and sagittal (B)images showing partial thickness tear of supraspinatus tendon on the articular surface

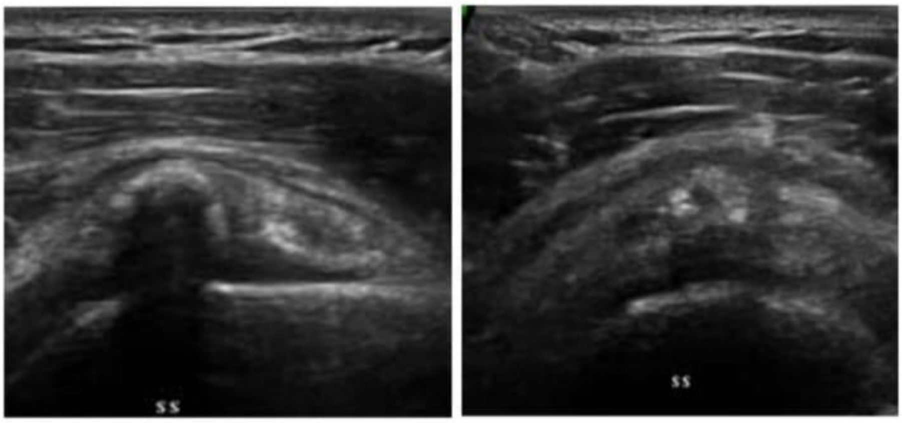


Figure 3: Supraspinatus calcific tendinitis on USG

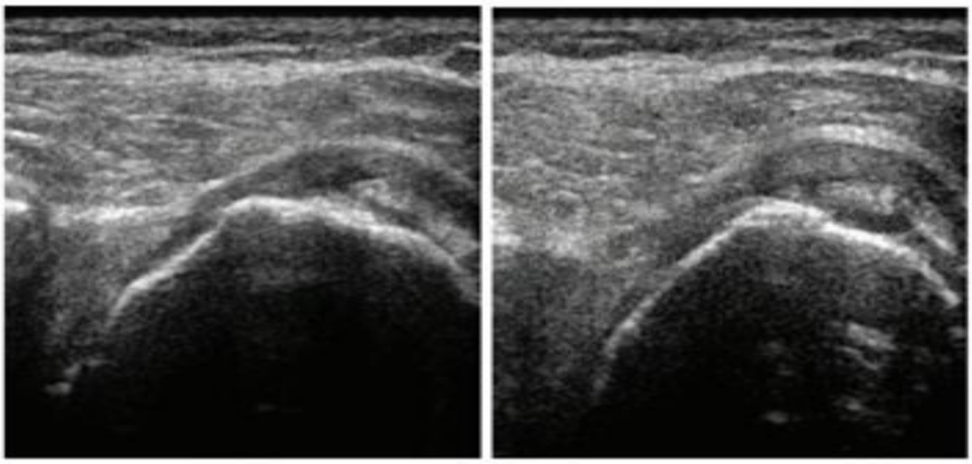


Figure 4: USG images of supraspinatus tendon showing full thickness tear with retraction of tendon ends

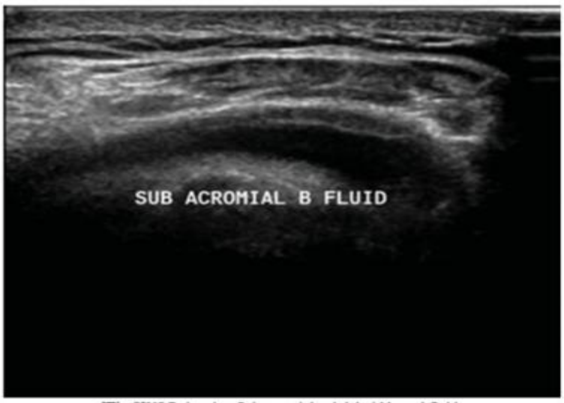


Figure 5: USG showing subacromial-sub deltoid bursal fluid

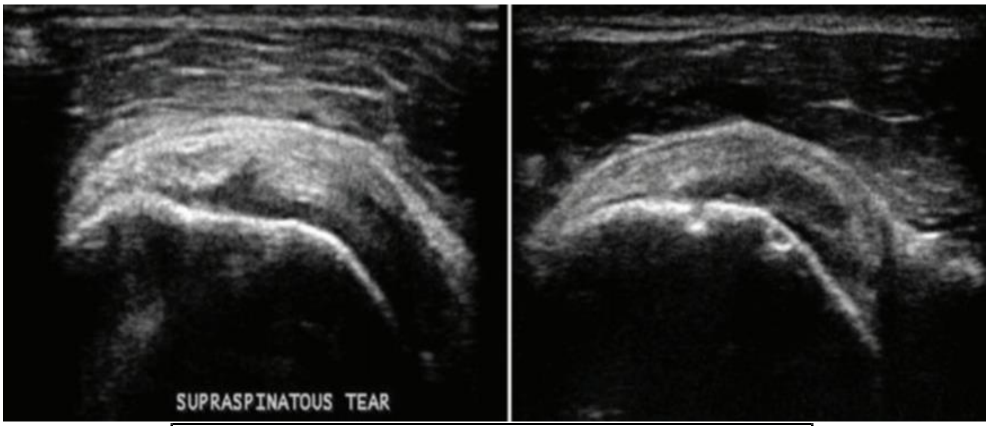


Figure 6: USG showing partial thickness tear of supraspinatus tendon on the articular surface

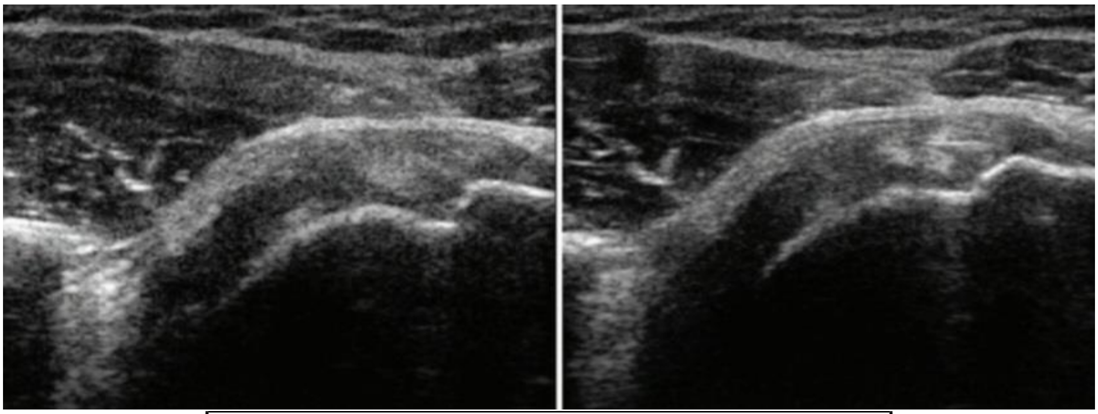


Figure 7: USG showing partial thickness tear of subscapularis tendon

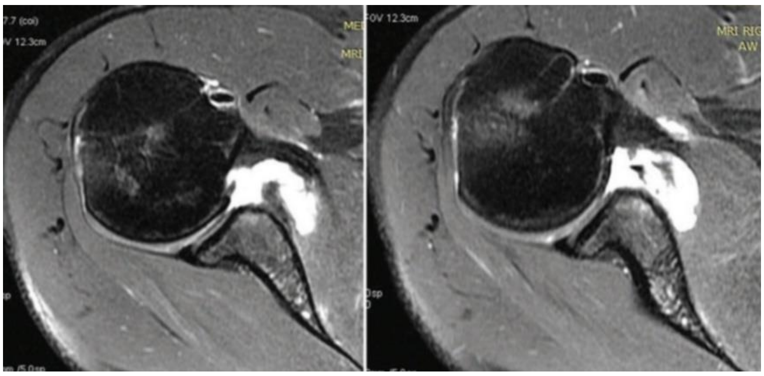
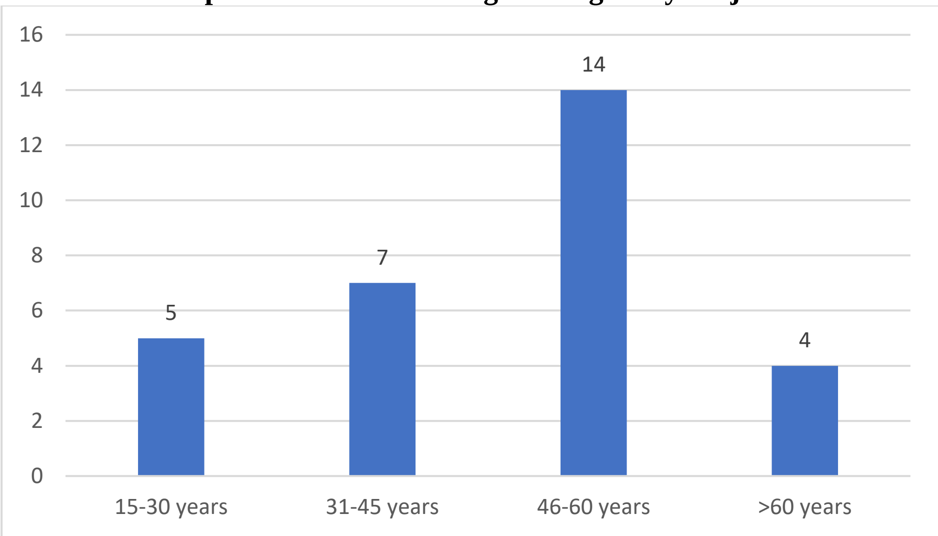


Figure 8: MRI axial images showing partial tear of subscapularis tendon

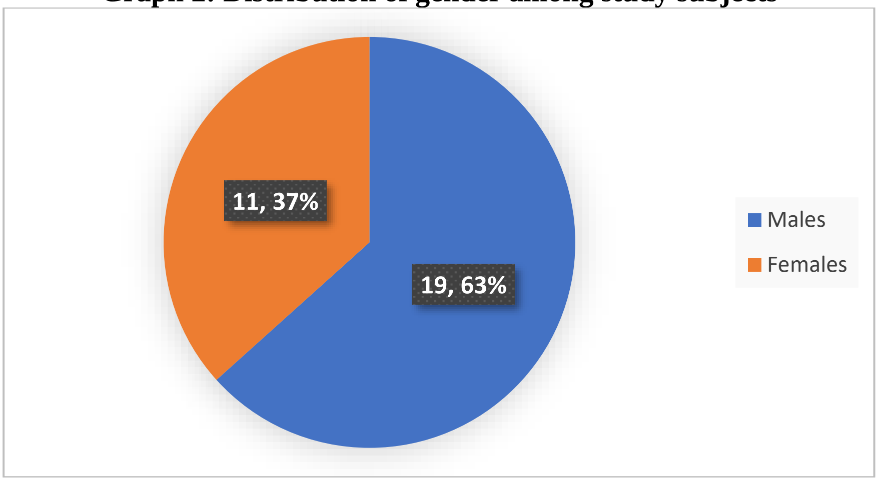
RESULTS:

Graph 1: Distribution of age among study subjects



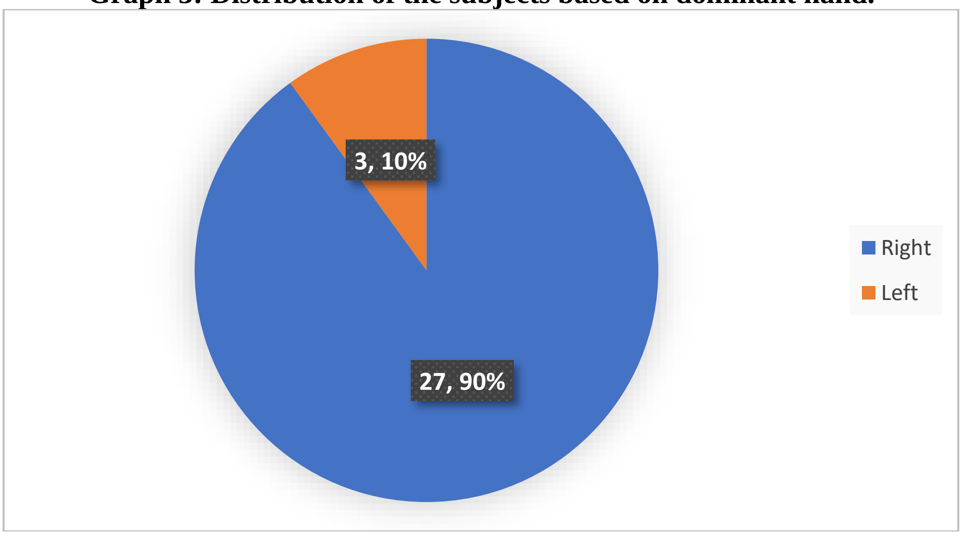
In this study, which comprised of a total number of 30 patients, the age at presentation ranged from 15 to 70 years. The mean age was 45.27 years and the maximum numbers of patients affected belong to the age group of 46 to 60 years (Graph 1).

Graph 2: Distribution of gender among study subjects



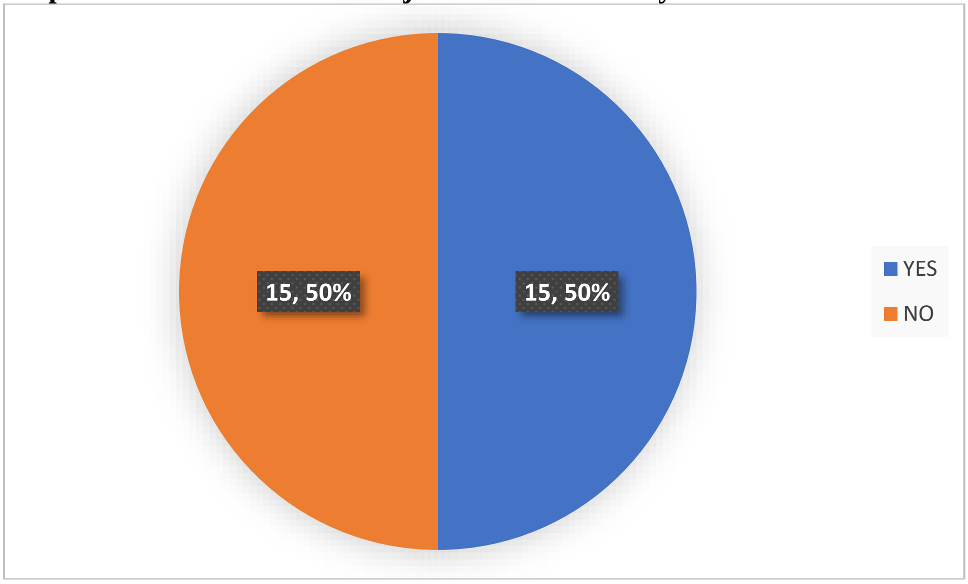
Majority in the study were males (19, 63%). (Graph 2).

Graph 3: Distribution of the subjects based on dominant hand.



In majority, right hand was the dominant hand (27, 90%) (Graph 3).

Graph 4: Distribution of the subjects based on history of trauma / dislocation.



Among the study population, 15 patients had history of prior shoulder dislocation/ trauma to the affected shoulder not associated with dislocation (Graph 4).

Table 1: Distribution of the subjects based on range of motion.

Range of motion		Frequency	%
Restricted	<30 degrees	1	3.3
	30 degrees	4	13.3
	30-90 degrees	15	50.0
Normal		10	33.3
Total		**30**	**100.0**

Of the 30 patients evaluated in this study, 20 patients had restriction of the range of motion in the shoulder involved. The patient was considered to have restricted motion if the range of motion was not more than 90°. Of these patients, 1 (3.3%) patient had severe restriction, defined as a range of motion less than 30°. 10 (33.3%) patients in the study population had normal range of motion.

Table 2: Diagnostic accuracy of USG compared to MRI findings in tendon tears and tendinosis

USG/MRI			OBSERVATIONS					SE	SP	PPV	NPV	ACC	P
			TP	FP	FN	TN	N						
TENDON TEARS	SS	PTT	10	1	1	18	30	90.91	94.74	90.91	94.74	93.33	<0.001*
		IST	0	0	0	30	30	-	100	-	100	-	-
		FTT	3	0	1	26	30	75	100	100	96.3	96.6	<0.001*
	IS	PTT	0	0	0	30	30	-	100	-	100	-	-
		IST	0	0	0	30	30	-	100	-	100	-	-
		FTT	1	0	0	29	30	100	100	100	100	100	<0.001*
	SB	PTT	0	1	0	29	30	-	96.6	0	100	-	-
		IST	0	0	1	29	30	0	100	-	96.6	96.6	-
		FTT	2	0	0	28	30	100	100	100	100	100	<0.001*
	TM	PTT	2	0	0	28	30	100	100	100	100	100	<0.001*
		IST	0	0	0	30	30	-	100	100	100	100	<0.001*
		FTT	0	0	0	30	30	-	100		100		-

TENDINOSIS	SS	8	0	1	21	30	88.89	100	100	95.5	96.6	<0.001*
	IS	2	0	0	28	30	100	100	100	100	100	<0.001*
	SB	6	2	0	22	30	100	91.67	75	100	93.3	<0.001*
	TM	0	0	0	30	30	-	100	-	100	-	-
	LHB	2	0	0	28	30	100	100	100	100	100	<0.001*

N-Total, SE-sensitivity, SE- specificity, PPV-positive predictive value, NPV-negative predictive value, ACC-accuracy, SS-supraspinatus, IS-infraspinatus, SB-subscapularis, TM-teres minor, LHB-Long head of biceps, PTT-partial thickness tear, IST-intra substance tear FTT-full thickness tear, *-significant

Table 2 showed accuracy of USG compared to MRI in diagnosis of tendon tears and tendinosis. MRI was the reference standard for tendon pathologies. USG showed a highly significant association with MRI for the detection of all tendon pathologies (p<0.001)

Table 3: Diagnostic accuracy of USG compared to MRI findings in Impingement and others

USG/MRI		OBSERVATIONS					SE	SP	PPV	NPV	ACC	P
		TP	FP	FN	TN	N						
Impingement	Subcoracoid	0	0	0	30	30	-	100		100		-
	Subacromial	3	0	0	27	30	100	100	100	100	100	<0.001*
SC		3	0	1	26	30	75	100	100	96.3	96.6	<0.001*
SASD		11	0	0	19	30	100	100	100	100	100	0.025*
Joint effusions		16	0	0	14	30	100	100	100	100	100	<0.001*
Calcifications		1	0	0	29	30	100	100	100	100	100	<0.001*

N-Total, SE-sensitivity, SE- specificity, PPV-positive predictive value, NPV-negative predictive value, ACC-accuracy, SC-Subcoracoid bursitis, SASD- subacromion-subdeltoid bursitis, *-significant

MRI was the reference standard for joint effusion, bursal collections and acromio-clavicular joint pathologies. USG was the reference standard for detection of features of tendon impingement. USG showed a highly significant association with MRI for detection of all cases with joint effusion and acromioclavicular joint pathologies. MRI showed a highly significant association with USG for detection of all cases with subacromial impingement (which was seen in dynamic ultrasound examination) (p<0.05).

DISCUSSION:

Rotator cuff pathologies are a common clinical problem. USG provides extensive information in patients with clinically suspected rotator cuff and long head of biceps tendon pathologies but MRI adds an additional information which guides management of the patient.[7] This study aims to assess correlation of ultrasonography with MRI findings and to assess whether it can be the primary mode of imaging.

Study included patients aged 15-70 years with a mean of 45.27 years and majority belonged to 46-60 years, which was similar to K Singisetti et al.[14] (mean age was 42 years). Male preponderance (63.3%) in this study was consistent with a study by WD Middleton et al.[15] (70.75%).

The study found that the right shoulder was affected in 66.7% of cases with dominant side involvement in 90% of cases. This was comparable to Yamamoto et al.[16] in which dominant side(right) was involved in 52%.20% had a history of prior dislocation of the affected shoulder in this study.

On clinical examination, 33.3% had normal range of motion, while 66.6% had restricted range of motion among which 1 patient (3.3 %) had severe restriction of motion (<30 degrees).

MRI detected Rotator cuff and long head of biceps tendon pathologies in 40 tendons. This was comparable to a study by Zlatkin et al.[17] which reported supraspinatus tendon involvement in around 80% of their cases. USG showed supraspinatus tendon as most commonly involved i.e., in 22 of the pathologies (11 partial thickness tears, 3 full

thickness tears and 8 tendinosis) in comparison to MRI which detected pathologies in 24 Supraspinatus tendons (11 partial thickness tears, 4 full thickness tears 9 tendinosis). One full thickness tear and 1 tendinosis case was false negative on USG.
One case with FTT of supraspinatus tendon, showed an avulsion fracture of the greater tuberosity. In two cases of PTT additional findings like subchondral cysts in the glenoid and bone edema were detected in the greater tuberosity.
In this study, USG showed a specificity of 100% for the detection of full thickness tears and tendinosis of the supraspinatus tendon which was similar to a study by M Ferri et al.[18] in which USG showed a specificity of 100% and a study by CH Kang et al.[19] which sensitivity of 87.5% and specificity of 90% for assessing supraspinatus tears.
In this study, USG also identified subscapularis tendon pathology in 11 patients (1 PTT, 2 FTT and 8 cases of tendinosis), with 88.89% sensitivity, 85.71% specificity, PPV of 72.73%, 94.74% NPV, and an accuracy of 86.67%. MRI identified pathologies in 9 subscapularis tendons (6 tendinosis, 1 IST and 2 FTT). One PTT was FP on USG. This was comparable to a study by K Singisetti et al.[14] in which USG showed sensitivity of 30%, specificity of 100%, PPV of 100% and NPV of 78% in the detection of subscapularis tendon tears.
On USG, Infraspinatus tendon evaluation identified 1 FTT and 2 tendinosis, with a USG specificity and accuracy of 100%. On Teres Minor tendon evaluation, USG and MRI confirmed 2 PTT, with none showing tendinosis. This comes to a USG specificity and accuracy of 100% in the detection of Teres Minor tendon pathologies.
The study evaluated the long head of biceps tendons using ultrasound (USG) and found tendinosis in two patients, which was confirmed on MRI. This resulted in a USG specificity and accuracy of 100%. Tenosynovitis of this tendon was noted as an additional finding in 3 patients.
When all tendons were grouped, USG detected 14 PTT, 6 FTT, and 20 tendinosis. MRI examination identified 13 PTT, 7 FTT, and 19 tendinosis. 1 FTT, 1 IST and 1 tendinosis were false positive on USG. USG showed a 92.31% sensitivity, 98.13% specificity, a PPV of 85.71%, a 99.06% NPV, and an accuracy of 97.5% for partial PTT of all tendons. Comparable findings were reported by Van Holsbeck et al.[20] (93% sensitivity, 94% specificity, a PPV of 82%, a 98% NPV). Vlychou et al.[21] (95.6% sensitivity, 70% specificity, a PPV of 93.6% and an accuracy of 91%),
USG showed 85.71% sensitivity, 100% specificity, a PPV of 100%, a 99.12% NPV and accuracy of 99.17% for full thickness tears which was comparable to Al-Shawi A et al.[22] (sensitivity of 96.2%, specificity of 95.4%, PPV of 96.2% and a NPV of 95.4%), Naqui et al.[23] (PPV of 88%, a NPV of 89% and an accuracy of 88.89%). Specificity of 100% with an accuracy of 99.17% was observed with IST on USG in this study.
USG showed 94.74% sensitivity, 98.47% specificity, a PPV of 90%, a 99.23% NPV, with an accuracy of 98% for detection of tendinitis comparable to Strobel et al.[24] (100% sensitivity, 68% specificity and 72% accuracy).
Overall USG showed 90% sensitivity, 99.15% specificity, a PPV of 90%, a NPV of 99.15%, with an accuracy of 98.43% for the detection of rotator cuff pathologies comparable to WD Middleton et al.[15] (91% sensitivity, 91% specificity, PPV of 84% and a NPV of 95%) and G Edelstein et al.[25] (93% sensitivity, 91% specificity and a NPV of 95%).
The study found that USG identified 3 patients with subacromial impingement, which was confirmed on MRI with 100% specificity and accuracy. Similar results were observed by Farin PU et al.[26] in which USG showed a sensitivity of 81% and specificity of 95% for tendon impingement. However, no subcoracoid impingement was found in any patient in the study population. The study also found that joint effusion was detected in 16 (53.3%) patients, with 100% specificity and accuracy. This was similar to the findings of ME Schweitzer et al.[27] who identified glenohumeral joint effusion in 40% of their patients. Tendon calcifications were identified on USG in 1 patient in supraspinatus This was similar to a study by Farin PU et al.[26]
The most common associated finding in cases with rotator cuff pathology was collection in the subacromion-subdeltoid bursa, with all cases confirmed on MRI. Similar findings were reported by TE Farley et al. (29/31) and MS Hollister et al.[28]
Subcoracoid bursitis was identified in 3 patients, with a USG sensitivity of 75%, specificity of 100%, PPV of 100%, and NPV of 96.30%. The acromioclavicular joint pathology was identified in 6 patients, with acromioclavicular joint arthropathy in 3 patients and subluxation in 3 patients. MRI identified a glenoid labrum tear in 4 patients, with 2 having a bankart lesion and an associated hillsach's lesion. No tendon pathology was identified in 2 patients, but other findings were identified to explain their clinical presentation.

CONCLUSION:
Clinical evaluation does not provide adequate insight into the patients' problem, can mimics other pathologies in the shoulder and hence is a poor guide to management protocols. Imaging evaluation is mandatory for the diagnosis and management of the patients. Ultrasound evaluation provides extensive information in patients with clinically suspected rotator cuff and long head of biceps tendon pathologies. This study revealed a high significant correlation between USG and MRI in detecting tendon pathologies, joint effusion, bursal collections and acromioclavicular joint pathologies ($p<0.001$). MRI could detect all the cases of subacromial impingement.

MRI evaluation in patients with clinically suspected rotator cuff tendon pathologies provides a more complete evaluation of all components of the shoulder joint. In this study MRI added additional information to the ultrasound findings. Hence, we conclude that USG can be used as a primary modality for accurate diagnosis of rotator cuff pathologies but when followed by MRI additional information can be attained which guides management of the patient in a better way.

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