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Original Research Article

ECHOES AND MAGNETS: A COMPARATIVE ANALYSIS OF USG AND MRI IN ROTATOR CUFF PATHOLOGY

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Abstract

Background: Shoulder pain is the third most prevalent cause of musculoskeletal pain, following lower back pain and knee pain. Rotator cuff pathology is the leading cause of shoulder pain, affecting approximately 65% to 70% of patients. Timely identification of rotator cuff tears is crucial (1,2). Magnetic Resonance Imaging (MRI) has become the gold standard for evaluating rotator cuff injuries due to its multiplanar imaging capability, offering high sensitivity (80-97%) and specificity (93-94%). In current clinical practice, ultrasonography complements MRI, often serving as the initial imaging modality for assessing both rotator cuff and non-rotator cuff disorders. Comparative studies of ultrasound and MRI have demonstrated ultrasound's effectiveness as a cost-efficient preliminary tool in diagnosing rotator cuff injuries. **Materials and Methods:** This is a retrospective study including 78 patients who had presented with symptoms of rotator cuff injuries and were referred to the Department of Radiodiagnosis, PES Institute of Medical Sciences and Research, kuppam, during the period June 2023 to December 2024 for Ultrasound and MRI of the shoulder. **Result:** Diagnostic accuracy of USG in correlation to MRI showed higher agreement for supraspinatus full-thickness tears(κ=0.94) and tendinosis(κ=1.00), moderate agreement for infraspinatus tears (κ=0.56, p=0.0002), and lower for subscapularis partial tears(k=0.68), indicating detection of supraspinatus was comparatively easier than subscapularis in ultrasound. **Conclusion:** This study compared ultrasonography (USG) and magnetic resonance imaging (MRI) in diagnosing rotator cuff pathologies. The agreement (Kappa value) between USG and MRI was highest for supraspinatus full-thickness tears and tendinosis, indicating near-perfect correlation. However, USG had lower sensitivity for partial-thickness tears, particularly in the infraspinatus and subscapularis, a combined approach using USG for initial screening and MRI for detailed evaluation ensures optimal diagnostic accuracy and effective clinical decision-making in rotator cuff pathologies.

INTRODUCTION

Shoulder pain is the third most prevalent cause of musculoskeletal pain, following lower back pain and knee pain. The glenohumeral joint, characterized by its exceptional mobility and inherent instability, is highly susceptible to injuries. The protective capsule and tendons forming the rotator cuff compensate for its structural vulnerability. Rotator cuff pathology is the leading cause of shoulder pain, affecting approximately 65% to 70% of patients. Timely identification of rotator cuff tears is crucial, as a significant proportion of asymptomatic cases progress to symptomatic stages, often resulting in irreversible fatty degeneration of shoulder musculature.[1,2]

Magnetic Resonance Imaging (MRI) has become the gold standard for evaluating rotator cuff injuries due to its multiplanar imaging capability, offering high sensitivity (80-97%) and specificity (93-94%).[3-5] MRI not only aids in identifying tear characteristics—such as size, depth, thickness, and involvement of adjacent structures—but also

provides detailed visualization of associated muscle atrophy and implications for treatment planning.[6] Its limitations, however, include cost, limited accessibility, and contraindications such as claustrophobia and the presence of metallic implants or electronic devices.[7] In specific cases, arthrography remains valuable for confirming complete rotator cuff tears, particularly in individuals unable to undergo MRI.[8]

In current clinical practice, ultrasonography complements MRI, often serving as the initial imaging modality for assessing both rotator cuff and non-rotator cuff disorders. Comparative studies of ultrasound and MRI have demonstrated ultrasound's effectiveness as a cost-efficient preliminary tool in diagnosing rotator cuff injuries.[1,7]

However, there is ongoing debate regarding the reliability of USG compared to MRI. This study aims to analyze the agreement and accuracy of USG against MRI in diagnosing rotator cuff pathologies using statistical measures, including kappa values and p-values.[9,10]

Objectives of the study: To evaluate the diagnostic accuracy of high-resolution ultrasound (USG) in identifying rotator cuff pathologies and determine its effectiveness as a diagnostic tool compared to MRI.

MATERIALS AND METHODS

With approval from the hospital ethics committee, this is a retrospective study conducted in the Department of Radiodiagnosis at P.E.S. Institute of Medical Sciences and Research, a tertiary care center, over 14 months (October 2023 to January 2025). A total of seventy-eight patients of all age groups and genders, presenting with clinical suspicion of rotator cuff injuries of either traumatic or degenerative origin, were included in this cross-sectional study.

Inclusion Criteria

All patients referred to the radiology department with a clinical suspicion of rotator cuff injury, a history of shoulder pain, and restricted movement, aged between 18 and 70 years, were included.

Exclusion Criteria

Patients with claustrophobia, those unwilling to undergo MRI, and individuals with metallic implants, cardiac pacemakers, aneurysmal clips, dentures, cochlear implants, otologic devices, or other ear implants were excluded.

Imaging Methods: The sonographic evaluation of the shoulder was done on SAMSUNG HS70A, GE voluson S8, and SAMSUNG HS40 Ultrasound machines using its linear high-frequency probe. The MRI examination was performed on the SIGNA explorer 1.5 Tesla MRI machine using a shoulder (Peripheral) coil.

Statistical Analysis: Statistical analysis, performed using SPSS version 22.0, compared ultrasound (USG) and MRI diagnoses. This comparison involved calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Agreement between USG and MRI for rotator cuff findings was assessed using Cohen's kappa, where $p \leq 0.005$ indicated statistical significance. Kappa values were interpreted as follows: poor (≤ 0.20), fair (0.20-0.40), moderate (0.40-0.60), good (0.60-0.80), and very good (0.80-1.00).

RESULTS

A total of 78 patients were included in the study, with an age range of 18 to 70 years. The mean age was 43.7 years, with a standard deviation of 12.4 years. The most affected age group was 31-40 years (25.6%), followed by 51-60 years (24.3%). The participants comprised 56 males (71.8%) and 22 females (28.2%), indicating a male predominance [Table 1]. Among the study population, 69 cases (88.4%) were diagnosed with rotator cuff pathology, whereas 9 cases (11.6%) showed no signs of pathology. Regarding laterality, 47 cases (60.3%) had right shoulder involvement, while 31 cases (39.7%) had left shoulder involvement.

Table 1: Age and Gender Distribution among the study population.

Characteristics	Values(Yrs)	Age(Yrs)	Males	Females	Frequency	Percentage
Mean	43.7	< 30	15	3	18	23
Standard deviation(SD)	12.4	31-40	16	4	20	25.6
Median	44	41-50	7	8	15	19.2
Mode	34	51-60	14	5	19	24.3
		> 60	4	2	6	7.6
		Total	56	22	78	100

Rotator cuff pathology was present in 69 cases (88.4%), with the supraspinatus tendon being the most frequently involved (84%). Among these, combined tendon involvement was common, with supraspinatus and infraspinatus affected in 30% of cases, supraspinatus and subscapularis in 50.7%, and all three tendons involved in 20.2%. The majority of pathologies were observed on the right side (60.3%).

A comparison of USG and MRI findings demonstrated a variable degree of agreement in detecting different types of rotator cuff injuries. In cases of supraspinatus partial tears, USG correctly identified 42 cases, whereas MRI detected an additional 5 cases. For full-thickness tears, USG detected 11 cases, with MRI confirming an additional case. Tendinosis detection was highly accurate with USG, matching MRI findings in all cases. In contrast,

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infraspinatus partial tears were more frequently detected by MRI (18 cases), whereas USG missed 10 cases. A similar trend was observed for subscapularis partial tears, where MRI detected 32 cases, while USG identified only 21 [Table 2].

Statistical analysis of diagnostic accuracy showed that USG had high specificity (100%) for all tears but varied sensitivity. Supraspinatus full-thickness tears had the highest sensitivity (91.6%), while subscapularis partial tears had the lowest (65.6%). The overall diagnostic accuracy of USG ranged between 85.9% and 98.7%, depending on the pathology [Table 3].

MRI revealed additional findings, including labral tears (3 cases), adhesive capsulitis (4 cases), Bankart lesions (7 cases), Hill-Sachs lesions (3 cases), and varying degrees of joint effusion (Figure 3). MRI also characterized acromion morphology, with Type 2 acromion being the most common (79.5%).

Table 2: Frequencies of rotatory cuff pathologies.

	USG			MRI		
Prevalence of Injuries	**Partial Tear**	**Full thickness Tear**	**Tendinosis**	**Partial Tear**	**Full thickness Tear**	**Tendinosis**
Supraspinatus Tendon	42	11	8	47	12	8
Infraspinatus Tendon	8	2	0	18	2	0
Subscapularis Tendon	21	1	2	32	1	2
Infraspinatus Tendon	0	0	0	0	0	0
Biceps Tendon	0	0	4	0	0	6

Table 3: Kappa agreement, sensitivity, and specificity of rotatory cuff pathologies.

Pathology	Kappa Value	P-value	Sensitivity (%)	Specificity (%)	Accuracy (%)
Supraspinatus Partial Tear	0.88	<0.0001	89.3	100	93.6
Supraspinatus Full Thickness Tear	0.94	<0.0001	91.6	100	98.7
Supraspinatus Tendinosis	1	<0.0001	100	100	100
Infraspinatus Partial Tear	0.56	0.0002	44.4	100	87.2
Infraspinatus Full Thickness Tear	1	0.11	100	100	100
Subscapularis Partial Tear	0.68	<0.0001	65.6	100	85.9
Subscapularis Full Thickness Tear	1	1	100	100	100
Subscapularis Tendinosis	1	0.11	50	100	97.5

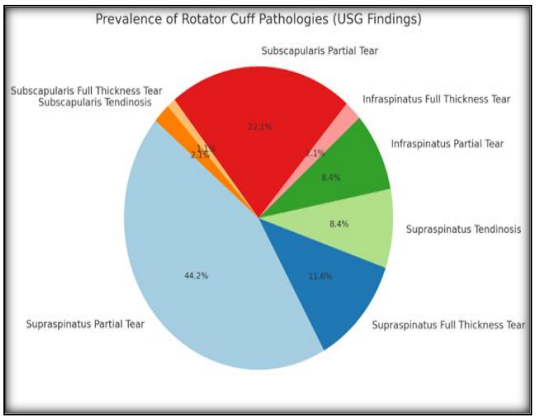

Figure 1: Prevalence of Rotator Cuff Pathologies (Pie diagram) in the present study.

Figure 2. Accuracy, specificity, sensitivity, Kappa and P value of rotatory cuff pathologies.

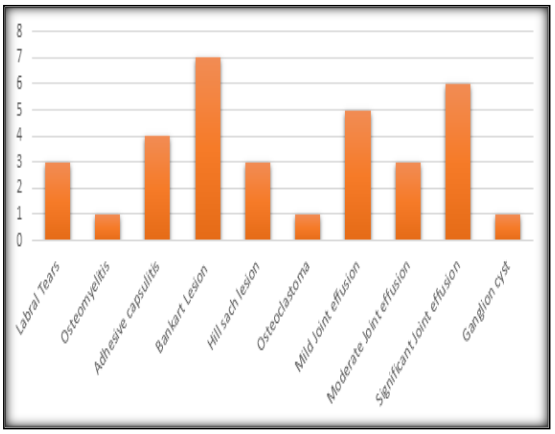

Figure 3: Additional findings on MRI in the present study

Supplementary Image gallery:

Figure 1: MRI Coronal PD FS sequence of left shoulder showing a complete tear of the supraspinatus tendon, with retracted fibres and significant fluid collection and joint effusion.

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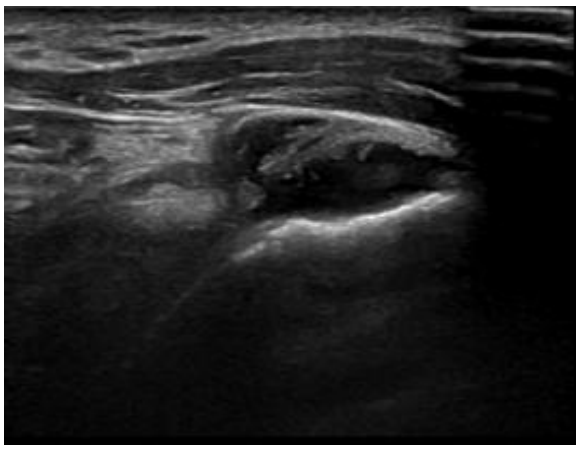

Figure 2: Longitudinal ultrasound shows full-thickness mid-fibre tear of the supraspinatus tendon with tendon discontinuity. The gap is filled with anechoic fluid with fibres retracted.

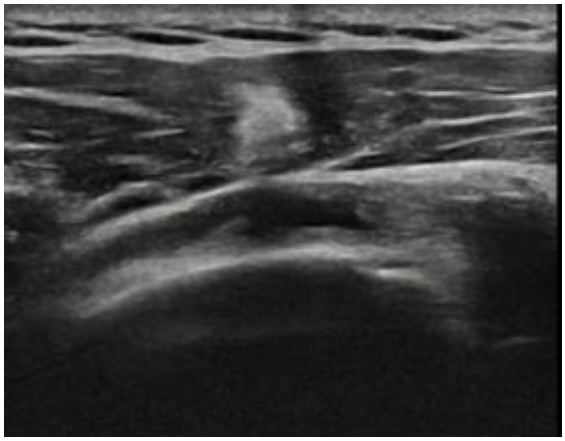

Figure 3: Longitudinal ultrasound of the supraspinatus tendon showing a discrete irregular hypoechoic focus, consistent with partial thickness tendon tear.

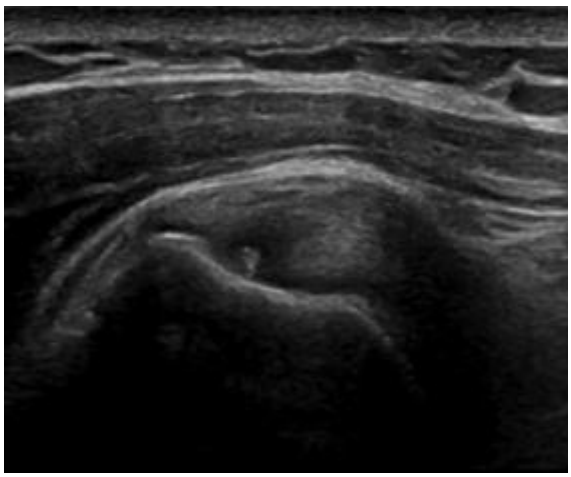

Figure 4: Longitudinal ultrasound shows a bulky supraspinatus tendon with calcification at the insertion site - Tendinopathy.

DISCUSSION

Rotator cuff injuries are among the most common causes of shoulder pain, necessitating accurate and early diagnosis for effective treatment.[1,2] While Magnetic Resonance Imaging (MRI) is widely regarded as the gold standard for evaluating rotator cuff pathologies, Ultrasonography (USG) remains a valuable first-line imaging tool due to its accessibility, real-time capabilities, and cost-effectiveness.[3,4]

This study aimed to evaluate and compare the diagnostic performance of ultrasonography (USG) and magnetic resonance imaging (MRI) in detecting rotator cuff pathologies. The findings align with multiple prior studies that have assessed the sensitivity, specificity, and accuracy of these imaging modalities.

Table 4: Comparative Diagnostic Accuracy of USG and MRI.

Study/Parameter	Supraspinatus Sensitivity (USG)	Infraspinatus Sensitivity (USG)	Subscapularis Sensitivity (USG)	MRI Superiority
Present Study	91.60%	44.40%	65.60%	Detected additional partial-thickness tears and associated pathologies
Madhavi et al	High for supraspinatus	Lower than supraspinatus	Lower than supraspinatus	Superior for deep tendon pathology
Selvaraj et al.	93%	88%	74%	Superior for infraspinatus and subscapularis

In the present study, USG demonstrated high specificity (100%) across all rotator cuff pathologies, making it a reliable modality for confirming the presence of tears. However, its sensitivity varied, with the highest for supraspinatus full-thickness tears (91.6%) and the lowest for subscapularis partial tears (65.6%). These findings are in line with previous studies, such as those by Madhavi et al., who reported lower sensitivity of USG for subscapularis and infraspinatus tears compared to MRI.[1]

Similarly, Selvaraj et al. found that USG had a sensitivity of 93% for supraspinatus tears, 88% for infraspinatus tears, and 74% for subscapularis tears, demonstrating that USG is most reliable for supraspinatus pathology, while MRI is superior for infraspinatus and subscapularis evaluation.[9] Our study showed a similar trend, with MRI detecting additional cases of partial-thickness infraspinatus and subscapularis tears that were missed by USG [Table 4].

Additionally, Toh et al. highlighted that MRI remains the gold standard for rotator cuff pathology due to its ability to assess tear depth, muscle atrophy, and involvement of adjacent structures (2). The present study supports this, as MRI detected additional findings such as labral tears, joint effusion, and Hill-Sachs lesions, which were not seen on USG.

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Table 5: Comparison of Laterality and Tendon Involvement.

Study/Parameter	Right-Sided Pathology (%)	Left-Sided Pathology (%)	Most Affected Tendon
Present Study	60.30%	39.70%	Supraspinatus (84%)
Singh et al.	Higher in dominant arm	Lower in non-dominant arm	Supraspinatus > Subscapularis > Infraspinatus
Madhavi et al.	Not specified	Not specified	Supraspinatus most affected

In our study, right-sided involvement (60.3%) was more common than left-sided involvement (39.7%), which is consistent with studies such as Singh et al., who reported that rotator cuff injuries are more frequently observed in the dominant arm,[3] [Table 5]. Additionally, supraspinatus tendon involvement was the most frequent (84%), aligning with Madhavi et al., who reported that supraspinatus is the most commonly affected tendon, followed by the subscapularis and infraspinatus.

Comparison of Additional Findings on MRI: A major advantage of MRI over USG is its ability to detect additional associated shoulder pathologies. In our study, MRI revealed Bankart lesions (7 cases), Hill-Sachs lesions (3 cases), and varying degrees of joint effusion, similar to findings reported by Anand et al., who noted that MRI detected joint effusion in 14 cases and bone marrow edema in 7 cases. Additionally, Mohtasib et al. found that MRI had higher sensitivity than USG for detecting partial-thickness tears (87.5% vs. 62.5%) and for detecting associated conditions like tendinosis and bursitis.[8] In this study MRI also characterized acromion morphology, with Type 2 acromion being the most common (79.5%). Type III acromion is a major risk factor for rotator cuff disease, while Type I is least associated with impingement. Recognizing acromion type on imaging is essential for diagnosing impingement syndrome, planning surgical interventions, and preventing rotator cuff injuries.

Agreement Between USG and MRI: High Agreement: In our study, supraspinatus full-thickness tears (κ=0.94) and supraspinatus tendinosis (κ=1.00) exhibited excellent agreement between USG and MRI. These results are consistent with the findings of McMonagle et al., who reported a kappa value of 0.79, indicating substantial agreement between the two modalities.

Moderate Agreement: Infraspinatus partial tears had a moderate kappa value (κ=0.56, p=0.0002), reflecting the limitations of USG in detecting smaller or less severe tendon injuries

Subscapularis Partial Tears: A kappa value of 0.68 was observed for subscapularis partial tears, which is lower than that of supraspinatus but still suggests a good level of agreement. Previous studies have reported sensitivity rates of 74% for subscapularis tears with USG, indicating that detection of subscapularis pathology is more challenging.

Sensitivity, Specificity and Accuracy Analysis: Supraspinatus full-thickness tears (91.6%) and partial-thickness tears (89.3%) had the highest sensitivity, meaning USG is effective at detecting these lesions. Subscapularis partial-thickness tears (65.6%) and infraspinatus partial tears (44.4%) had the lowest sensitivity, meaning USG misses a significant number of cases.

USG showed 100% specificity across all pathologies, meaning it rarely falsely diagnoses a pathology when it is not present. This makes USG highly reliable for confirming pathology, but less effective at ruling it out when negative.

Highest accuracy (98.7%-100%) was seen in full-thickness tears and tendinosis, confirming USG is an excellent tool for these cases. Lowest accuracy (85.9% for subscapularis partial tears and 87.2% for infraspinatus partial tears) suggests MRI should be preferred when USG is inconclusive.

MRI remains the modality of choice in cases requiring pre-surgical evaluation or when USG findings are inconclusive. MRI provides greater anatomical detail, particularly for infraspinatus and subscapularis pathologies, and is more effective in detecting associated abnormalities such as labral tears and bone marrow edema.

Strengths and Limitations of USG: Advantages of USG: 1) Non-invasive and cost-effective, making it accessible in primary care settings. 2)Real-time dynamic assessment, allowing for evaluation of impingement syndromes. 3)Comparable accuracy to MRI for full-thickness tears, particularly in the supraspinatus tendon.

Limitations of USG: 1) Operator Dependence: The accuracy of USG relies heavily on the skill of the sonographer, and misinterpretations may occur due to anisotropy or scanning angle errors.2) Lower Sensitivity for Partial Tears: Compared to MRI, USG may underreport partial-thickness tears, particularly in the infraspinatus and subscapularis tendons.3) Inability to Evaluate Deep Structures: Joint effusions, labral tears, and subtle intra-articular abnormalities are better visualized on MRI.

Clinical Implications and Recommendations: Given the findings of our review, a tiered diagnostic approach is recommended: 1) Use USG as a first-line imaging modality in patients with suspected rotator cuff injuries, particularly in resource-limited settings. 2)Reserve MRI for cases where USG findings are inconclusive, in suspected partial-thickness tears, or for preoperative planning. 3)Standardized imaging protocols should be implemented, including proper training for USG operators to improve diagnostic accuracy.

Economic analysis by Toh (2024) indicated that while USG is more cost-effective than MRI, its limitations may necessitate additional imaging, increasing overall healthcare costs. The study concluded that MRI should remain the preferred imaging modality when a definitive diagnosis is required, particularly for surgical candidates.

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CONCLUSION

The comparative analysis of ultrasonography (USG) and magnetic resonance imaging (MRI) in diagnosing rotator cuff pathologies highlights the strengths and limitations of each modality. USG demonstrated excellent specificity (100%) across all pathologies, making it a reliable tool for confirming rotator cuff tears. It showed high sensitivity and accuracy for detecting full-thickness supraspinatus tears (91.6% and 98.7%) and tendinosis (100%), indicating that USG can serve as an effective first-line imaging modality for these conditions.

However, USG had lower sensitivity for partial-thickness tears, particularly in the infraspinatus (44.4%) and subscapularis (65.6%), where MRI proved superior in detecting subtle tendon abnormalities and associated conditions such as labral tears, joint effusion, and bony lesions. The agreement between USG and MRI was strong for supraspinatus tears (Kappa = 0.88–0.94) but moderate for infraspinatus (Kappa = 0.56) and subscapularis (Kappa = 0.68) partial tears, suggesting that MRI should be preferred in cases where USG findings are inconclusive or negative despite clinical suspicion.

Given its cost-effectiveness, accessibility, and dynamic real-time assessment, USG remains a valuable first-line imaging modality, especially for screening and follow-up evaluations. However, MRI remains the gold standard for comprehensive assessment, particularly in preoperative planning, complex cases, and when additional pathologies are suspected. A combined approach, utilizing USG for initial assessment and MRI for confirmation in doubtful cases, ensures optimal diagnostic accuracy and clinical decision-making in rotator cuff pathologies

USG demonstrates excellent specificity and agreement with MRI for supraspinatus full-thickness tears and tendinosis. However, its lower sensitivity, particularly for infraspinatus partial tears, suggests MRI remains the preferred diagnostic tool for comprehensive evaluation and surgical planning.[3,4] Given the economic and accessibility advantages of USG, it remains an effective initial screening modality, with MRI reserved for equivocal cases or preoperative assessment.[5,6]

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