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DIAGNOSTIC EFFICACY OF HIGH-RESOLUTION ULTRASOUND IN CLINICALLY SUSPECTED PATIENTS OF ROTATOR CUFF TEAR AND ITS CORRELATION WITH MAGNETIC RESONANCE IMAGING

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Abstract

Background: Rotator cuff tears (RCTs) are among the most common causes of shoulder pain and disability, particularly in middle-aged and elderly individuals. Accurate diagnosis is essential for appropriate management and prevention of long-term functional impairment. Magnetic resonance imaging (MRI) is considered the reference standard for non-invasive evaluation of rotator cuff pathology; however, high-resolution ultrasonography (USG) offers a cost-effective, readily available, and dynamic alternative. This study aimed to evaluate the diagnostic efficacy of high-resolution USG in clinically suspected patients with rotator cuff tears and correlate its findings with MRI.

Materials and Methods: This hospital-based cross-sectional observational study was conducted in the Department of Radio-diagnosis, Geetanjali Medical College & Hospital, Udaipur, over a period of 18 months. A total of 58 adult patients with clinically suspected rotator cuff tears were enrolled using consecutive sampling. All participants underwent both high-resolution ultrasonography and 3-Tesla MRI of the affected shoulder. MRI was used as the reference standard. Diagnostic performance of USG was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and Cohen's kappa coefficient.

Results: The mean age of the study population was 53.4 ± 13.6 years, with a male predominance (63.8%). The supraspinatus tendon was the most commonly affected tendon on both USG (79.3%) and MRI (84.5%). Partial-thickness tears were the most frequent pathology identified on MRI (48.3%), followed by full-thickness tears (24.1%). Using MRI as the reference standard, USG demonstrated an overall sensitivity of 90.5%, specificity of 93.8%, PPV of 97.4%, NPV of 78.9%, and diagnostic accuracy of 91.4%, with excellent agreement ($\kappa = 0.80$). For full-thickness tears, USG achieved sensitivity, specificity, and accuracy of 92.9%, 97.7%, and 96.6%, respectively ($\kappa = 0.91$). For partial-thickness tears, sensitivity, specificity, and accuracy were 82.1%, 90.0%, and 86.2%, respectively ($\kappa = 0.72$). MRI was superior in detecting muscle atrophy, fatty infiltration, joint effusion, and labral pathology.

Conclusion: MulHigh-resolution ultrasonography demonstrated excellent diagnostic accuracy and strong agreement with MRI in the detection of rotator cuff tears, particularly full-thickness tears. Given its accessibility, lower cost, and ability to provide dynamic real-time assessment, USG can be considered an effective first-line imaging modality for patients with suspected rotator cuff pathology, while MRI remains valuable for equivocal cases, preoperative planning, and evaluation of associated intra-articular abnormalities.

Keywords: Rotator cuff tear; Ultrasonography; Magnetic resonance imaging; Shoulder pain; Diagnostic accuracy; Supraspinatus tendon.

Introduction: The shoulder joint is the most mobile joint in the human body, allowing a wide range of movements necessary for daily activities and occupational tasks. This remarkable mobility is achieved at the expense of inherent bony stability and is largely dependent on the integrity of the rotator cuff musculotendinous unit for dynamic stabilization[1]. The rotator cuff comprises four muscles—supraspinatus, infraspinatus, teres minor, and subscapularis—whose tendons surround the humeral head and maintain its central position within the glenoid cavity during shoulder movements. Any disruption of this complex can lead to pain, weakness, restricted range of motion, and functional impairment. [2]Rotator cuff tears (RCTs) represent one of the most common causes of shoulder pain and disability, accounting for a substantial proportion of musculoskeletal consultations worldwide. The prevalence of rotator cuff tears increases with advancing age, ranging from approximately 20% in the general population to more than 50% among elderly individuals[3]. Degenerative tendon changes, repetitive microtrauma, subacromial impingement, vascular compromise, and acute traumatic injuries have all been implicated in the pathogenesis of these tears. Important risk factors include increasing age, male gender, smoking, diabetes mellitus, and dominant arm involvement. [4,5]Rotator cuff tears may be classified as partial-thickness or full-thickness tears and further categorized according to their size and extent. Accurate characterization of the tear is essential because management decisions, prognosis, and surgical planning depend largely on the location, size, and severity of tendon involvement[6]. Clinical examination tests such as the Jobe test, drop arm test, and lift-off test provide useful clues regarding rotator cuff pathology; however, their diagnostic accuracy is variable, particularly in partial-thickness tears and in patients with coexisting shoulder disorders. Consequently, imaging plays an important role in confirming the diagnosis and guiding treatment. [7]High-resolution ultrasonography (USG) has emerged as a valuable imaging modality for evaluating rotator cuff pathology. The use of high-frequency linear transducers enables detailed visualization of tendon morphology and detection of tendon defects[8]. Ultrasonography offers several advantages, including wide availability, low cost, absence of ionizing radiation, dynamic real-time assessment, comparison with the contralateral shoulder, and the ability to guide therapeutic interventions. Full-thickness tears typically appear as focal hypoechoic or anechoic defects traversing the entire tendon thickness, whereas partial-thickness tears manifest as localized tendon abnormalities without complete discontinuity. Despite these advantages, ultrasonography remains operator dependent and may be limited in assessing deeper intra-articular structures. [9,10]Magnetic resonance imaging (MRI) is considered the reference standard for non-invasive assessment of rotator cuff disorders because of its excellent soft tissue contrast and multiplanar imaging capability. MRI not only detects rotator cuff tears with high accuracy but also provides information regarding tendon retraction, muscle atrophy, fatty degeneration, and associated intra-articular abnormalities. However, MRI is relatively expensive, less readily available, time-consuming, and contraindicated in certain patients with metallic implants or device-related restrictions. [11,12]Several studies have compared the diagnostic performance of ultrasonography and MRI in the evaluation of rotator cuff tears. A comprehensive meta-analysis by de Jesus et al. reported comparable sensitivity and specificity between ultrasonography and MRI for detecting both full-thickness and partial-thickness rotator cuff tears. Similarly, Farooqi et al. demonstrated excellent diagnostic accuracy of ultrasonography for full-thickness tears with findings comparable to MRI. Indian studies have also reported high sensitivity and specificity of high-resolution ultrasonography when MRI is used as the reference standard. [13–15]Despite growing evidence supporting the use of ultrasonography, data from the Indian population remain limited. Variations in patient demographics, occupational exposure, healthcare accessibility, and imaging expertise may influence the diagnostic performance of ultrasonography in routine clinical practice. Establishing the accuracy of high-resolution ultrasonography in comparison with MRI could help optimize imaging strategies, reduce healthcare costs, and facilitate early diagnosis in resourceconstrained settings. Therefore, the present study was undertaken to evaluate the diagnostic efficacy of high-resolution ultrasonography in clinically suspected patients with rotator cuff tears and to correlate its findings with magnetic resonance imaging.

Materials and Methods: This hospital-based cross-sectional observational study was conducted in the Department of Radio-diagnosis, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India, over a period of 18 months after obtaining approval from the Institutional Ethics Committee. The study was designed to evaluate the diagnostic efficacy of high-resolution ultrasonography (USG) in clinically suspected cases of rotator cuff tear and to correlate its findings with magnetic resonance imaging (MRI).

Study Population: Adult patients (>18 years) presenting with clinical suspicion of rotator cuff injury based on history, physical examination, and provocative shoulder tests were screened for inclusion. Patients with contraindications to MRI, previous shoulder surgery, shoulder fractures or dislocations detected on radiography, and those unwilling to provide informed consent were excluded from the study.

Imaging Protocol

High-Resolution Ultrasonography

All participants underwent high-resolution ultrasonography of the affected shoulder using GE Voluson E10 and Samsung V8 ultrasound systems equipped with high-frequency linear transducers (7–11 MHz). Examination was performed with the patient seated, following a standardized protocol evaluating the long head of the biceps tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, teres minor tendon, and acromioclavicular joint. Dynamic assessment during shoulder movements and contralateral comparison were performed when required.Ultrasonographic parameters assessed included tendon echotexture, presence and type of rotator cuff tear (partial-thickness or full-thickness), tendon involved, tear location and size, subacromial-subdeltoid bursal fluid, joint effusion, biceps tendon abnormalities, and cortical irregularities of the greater tuberosity.

Magnetic Resonance Imaging

MRI examinations were performed using a 3-Tesla MRI scanner (GE SIGNA Architect, GE Healthcare) with a dedicated phased-array shoulder coil. Patients were scanned in the supine position with the affected shoulder placed in slight external rotation.The MRI protocol included coronal oblique T2-weighted and fat-suppressed proton-density (FS-PD) sequences, sagittal oblique T1-weighted and FS-PD sequences, and axial FS-PD and 3D MERGE sequences. MRI evaluation included assessment of the type and extent of rotator cuff tear, tendon involvement, tear dimensions, tendon retraction, muscle atrophy, fatty infiltration, bursal fluid, joint effusion, biceps tendon abnormalities, labral pathology, and acromioclavicular joint changes.

Data Collection

Clinical and imaging findings were recorded using a predesigned structured proforma. Demographic details, clinical history, presenting symptoms, and imaging findings from both USG and MRI were documented. MRI findings were considered the reference standard for comparison with ultrasonography.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 21. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages.

The diagnostic performance of ultrasonography was evaluated using MRI as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated. Agreement between USG and MRI findings was assessed using Cohen's kappa coefficient. The Chi-square test was used to compare categorical variables. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and the Indian Council of Medical Research (ICMR) ethical guidelines. Approval was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent was obtained from all participants before enrolment, and confidentiality of patient information was maintained throughout the study.

Results

A total of 58 patients with clinically suspected rotator cuff tear were included in the study. The mean age of the study population was 53.4 ± 13.6 years (range: 22–78 years). Most patients belonged to the 51–60 years age group (29.3%), and males constituted 63.8% of the study population. The right shoulder was affected in 67.2% of cases, while 96.6% of patients were right-hand dominant (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n=58)

Variable	Value
Age (years), Mean ± SD	53.4 ± 13.6
Male, n (%)	37 (63.8)
Female, n (%)	21 (36.2)
Right shoulder involvement, n (%)	39 (67.2)
Right-hand dominance, n (%)	56 (96.6)
Pain, n (%)	52 (89.7)
Restricted ROM, n (%)	34 (58.6)
Overhead abduction difficulty, n (%)	28 (48.3)
Night pain, n (%)	26 (44.8)
History of trauma, n (%)	21 (36.2)

Pain was the most common presenting complaint (89.7%), followed by restricted range of motion (58.6%) and inability to perform overhead abduction (48.3%). Diabetes mellitus and hypertension were present in 25.9% and 27.6% of patients, respectively, while 48.3% were overweight or obese. Patients with full-thickness tears had the highest mean BMI and longest duration of symptoms (Table 2).

Table 2. Relationship of BMI and Duration of Symptoms with MRI Diagnosis

MRI Diagnosis	Mean BMI (kg/m²)	Mean Duration of Symptoms (months)
Normal	23.1 ± 2.8	1.9
Tendinopathy	25.1 ± 3.0	2.8
Partial-thickness tear	24.9 ± 3.2	4.3
Full-thickness tear	27.3 ± 3.5	10.2

Assessment of tendon involvement revealed that the supraspinatus tendon was the most frequently affected tendon on both ultrasonography and MRI. MRI detected a slightly greater number of abnormalities compared to ultrasonography, particularly partial-thickness tears (Table 3).

Table 3. Tendon-wise Findings on Ultrasonography and MRI

Tendon	Abnormal on USG n (%)	Abnormal on MRI n (%)
Supraspinatus	46 (79.3)	49 (84.5)
Infraspinatus	16 (27.6)	19 (32.8)
Subscapularis	12 (20.7)	15 (25.9)
Teres Minor	3 (5.2)	3 (5.2)

Partial-thickness tears were the most common rotator cuff pathology identified on both imaging modalities, accounting for 43.1% of cases on ultrasonography and 48.3% on MRI. Full-thickness tears were detected in 22.4% and 24.1% of patients on ultrasonography and MRI, respectively (Table 4)

Table 4. Comparison of Rotator Cuff Pathology on USG and MRI

Diagnosis	USG n (%)	MRI n (%)
Normal	15 (25.9)	10 (17.2)
Tendinopathy	5 (8.6)	6 (10.3)
Partial-thickness tear	25 (43.1)	28 (48.3)
Full-thickness tear	13 (22.4)	14 (24.1)

MRI demonstrated additional information regarding acromial morphology and associated shoulder abnormalities. Type II acromion was the most common morphology (48.3%), whereas Type III acromion showed the strongest association with rotator cuff tears. MRI also detected a greater number of associated findings such as subacromial-subdeltoid bursitis, joint effusion, biceps tendon pathology, and muscle atrophy compared with ultrasonography (Table 5).

Table 5. Associated Findings Detected on Ultrasonography and MRI

Associated Finding	USG n (%)	MRI n (%)
SASD bursal fluid	26 (44.8)	30 (51.7)
Joint effusion	18 (31.0)	24 (41.4)
Biceps tendon pathology	8 (13.8)	12 (20.7)
AC joint changes	20 (34.5)	24 (41.4)
Cortical irregularity	22 (37.9)	18 (31.0)
Muscle atrophy/fatty infiltration	4 (6.9)	14 (24.1)
Labral tear	0 (0.0)	3 (5.2)

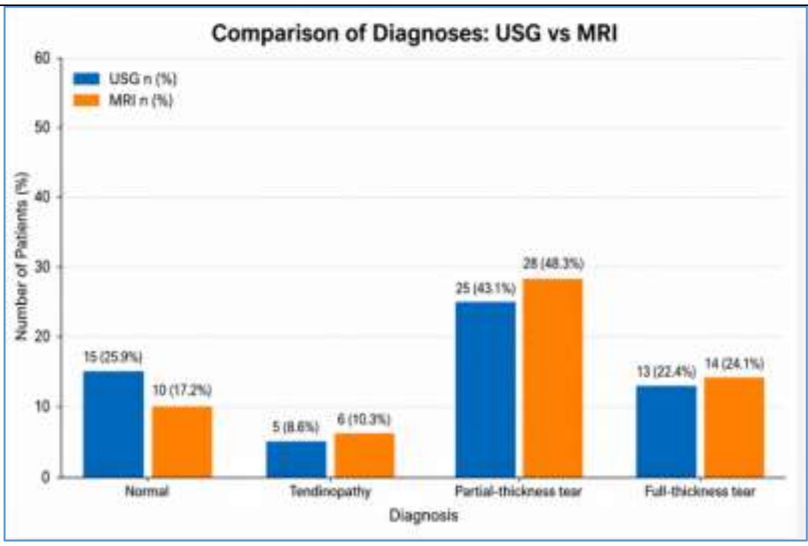

Figure 1. Associated Findings Detected on Ultrasonography and MRI

Using MRI as the reference standard, high-resolution ultrasonography demonstrated excellent diagnostic performance for detection of rotator cuff tears. Overall sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were 90.5%, 93.8%, 97.4%, 78.9%, and 91.4%, respectively, with excellent agreement between modalities (κ = 0.80). Diagnostic performance was highest for full-thickness tears (Table 6).

Table 6. Diagnostic Performance of Ultrasonography Using MRI as Reference Standard

Parameter	Overall Tear (%)	Full-thickness Tear (%)	Partial-thickness Tear (%)
Sensitivity	90.5	92.9	82.1
Specificity	93.8	97.7	90.0
PPV	97.4	92.9	88.5
NPV	78.9	97.7	84.4
Accuracy	91.4	96.6	86.2
Kappa (κ)	0.80	0.91	0.72

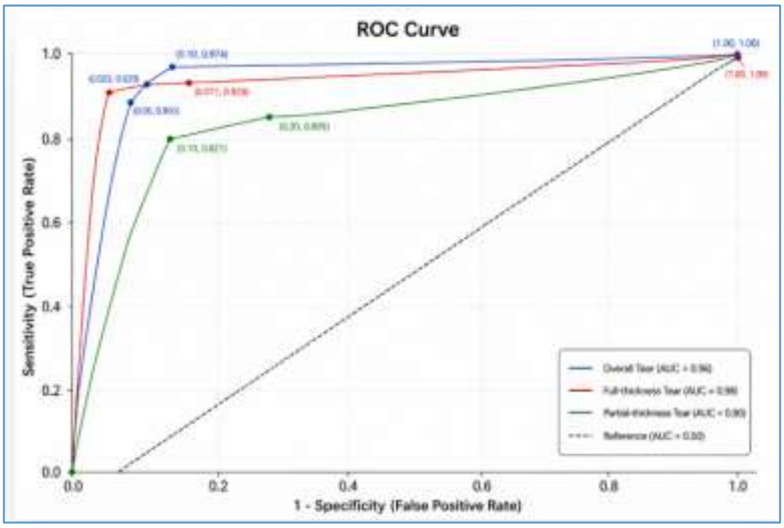

Figure 2: Diagnostic Performance of Ultrasonography Using MRI as Reference Standard

Discussion

The present study evaluated the diagnostic efficacy of high-resolution ultrasonography (USG) in clinically suspected rotator cuff tears and correlated the findings with magnetic resonance imaging (MRI), which served as the reference standard. Among the 58 patients studied, the mean age was 53.4 ± 13.6 years, with the highest frequency of rotator cuff pathology occurring in the fifth and sixth decades of life. This age distribution is consistent with previous reports demonstrating an increasing prevalence of rotator cuff tears with advancing age due to progressive tendon degeneration, reduced vascularity, and cumulative mechanical stress [4,16,17]. A male predominance (63.8%) was observed, similar to findings reported in earlier studies, possibly reflecting greater occupational and recreational exposure to repetitive overhead activities and shoulder strain [16,18,19].Diabetes mellitus, hypertension, and elevated body mass index (BMI) were common risk factors in our cohort. These findings support existing evidence linking metabolic disorders and obesity with tendon degeneration and increased risk of rotator cuff pathology [19–21]. Clinically, pain was the most frequent presenting symptom, followed by restricted shoulder movements and difficulty with overhead abduction, which are recognized hallmark manifestations of rotator cuff disease [22,23].The supraspinatus tendon was the most commonly involved tendon on both USG and MRI, corroborating previous anatomical and imaging studies that identify the supraspinatus as the most vulnerable component of the rotator cuff due to its hypovascular critical zone and subacromial location [24–28]. MRI detected slightly more abnormalities than USG, particularly partial-thickness tears and subscapularis tendon lesions, reflecting its superior soft-tissue contrast and multiplanar imaging capability [29,30]. The lower sonographic sensitivity for subscapularis pathology remains a recognized limitation because of the tendon's deep location and complex anatomy.Acromial morphology showed a significant relationship with rotator cuff pathology. Type III (hooked) acromion demonstrated the highest prevalence of tears, whereas Type I acromion exhibited the lowest association, supporting the concept of mechanical impingement in rotator cuff degeneration [29]. A progressive reduction in acromiohumeral distance with increasing tear severity was also observed, consistent with superior humeral migration seen in chronic full-thickness tears [30].A major finding of the present study was the excellent diagnostic performance of high-resolution ultrasonography. Using MRI as the reference standard, USG demonstrated an overall sensitivity of 90.5%, specificity of 93.8%, and diagnostic accuracy of 91.4%, with excellent agreement ($\kappa = 0.80$). These results are comparable to previous systematic reviews and comparative studies that reported no significant difference between USG and MRI for the detection of rotator cuff tears [31]. For full-thickness tears, USG achieved a sensitivity of 92.9%, specificity of 97.7%, and accuracy of 96.6%, highlighting its excellent capability in identifying complete tendon disruptions through characteristic sonographic findings such as tendon discontinuity, focal defects, tendon retraction, and the naked tuberosity sign [31].Although the diagnostic performance for partial-thickness tears was relatively lower, USG still demonstrated good sensitivity (82.1%) and accuracy (86.2%), exceeding values reported in several earlier studies [32]. The improved performance may be attributed to the use of high-frequency transducers and a standardized scanning protocol. Consistent with previous literature, bursal-sided tears were detected more accurately than articular-sided and intratendinous tears because of their more accessible sonographic location [33]. Tendon-wise analysis further demonstrated substantial agreement between USG and MRI for supraspinatus, infraspinatus, and subscapularis tendons, although sensitivity remained comparatively lower for subscapularis lesions [34].MRI retained superiority in the assessment of associated findings such as muscle atrophy, fatty infiltration, labral abnormalities, and joint effusion, all of which are important for prognostication and surgical planning [34]. Nevertheless, ultrasonography provided excellent visualization of cortical irregularities and bursal abnormalities while offering additional advantages of dynamic evaluation, portability, low cost, and real-time assessment.

Conclusion

High-resolution ultrasonography demonstrated excellent diagnostic performance in the evaluation of clinically suspected rotator cuff tears, showing strong agreement with MRI findings. The modality was particularly accurate for detecting full-thickness tears, with slightly lower but clinically acceptable accuracy for partial-thickness tears. The supraspinatus tendon was the most commonly involved tendon, and increasing age, male gender, higher BMI, and Type III acromial morphology were important associated factors. Although MRI remained superior for assessment of muscle atrophy, fatty infiltration, and associated intra-articular abnormalities, ultrasonography provided reliable detection of rotator cuff pathology with the advantages of lower cost, wider availability, and dynamic real-time assessment. Therefore, high-resolution ultrasonography can be recommended as an effective first-line imaging modality for patients with suspected rotator cuff tears, with MRI reserved for equivocal cases and preoperative evaluation.

Limitations of the Study

This was a single-centre study with a relatively small sample size, which may limit the generalizability of the findings. MRI was used as the reference standard instead of arthroscopy, the true gold standard for rotator cuff tear diagnosis. Additionally, both USG and MRI were interpreted by a single investigator, and inter-observer variability was not assessed.

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