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Article

High Diagnostic Accuracy of Ultrasonography for Supraspinatus Tears in a Pakistani Tertiary Center: A Cost-Effective Alternative to MRI

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ABSTRACT

Background: Shoulder pain, the most prevalent cause of musculoskeletal disorders worldwide, is usually due to tears of the supraspinatus tendon, comprising 65–70% of rotator cuff disease. MRI is the gold standard for diagnosis; however, its high cost (PKR 20–30k per scan), limited availability in rural areas, and contraindications restrict its use in low-resource regions. Ultrasonography (USG) offers a potential substitute, but there is a need for regionally oriented validation studies in clinically heterogeneous populations. **Objective**: To evaluate the diagnostic accuracy of high-resolution ultrasonography for supraspinatus tendon tears compared to MRI in a tertiary care setting with limited MRI access. **Methods**: A cross-sectional survey was conducted on 85 patients (mean age: 52.3 ± 12.7 years; 61.2% male) between 2022–2023 at Combined Military Hospital Abbottabad. Ultrasound examinations (10–15 MHz linear transducer) and 1.5T MRI were performed in a standardized manner for all participants. Images were independently analyzed by two blinded radiologists. Diagnostic accuracy metrics (sensitivity, specificity, PPV, NPV) were calculated using MRI as the reference standard. Cohen's kappa (κ) was used to assess inter-rater reliability. **Results**: Ultrasonography showed 94% sensitivity (95% CI: 86.5%–97.8%) and 94.29% specificity (95% CI: 85.1%–98.2%), with a PPV of 95.92% and NPV of 91.67%. Inter-rater agreement was very good ($\kappa = 0.89$). Subgroup analysis revealed 89.5% sensitivity for partial-thickness tears and 97.1% for full-thickness tears. **Conclusion**: The diagnostic performance of high-resolution ultrasonography is nearly equivalent to MRI for detecting supraspinatus tendon tears, particularly for full-thickness tears. Its cost-effectiveness (approximately $3–$4 per study), portability, and real-time imaging capabilities make it an ideal first-line diagnostic tool in low-resource settings, potentially reducing MRI referrals by approximately 60–70%. These findings may inform global healthcare practices by supporting the development of musculoskeletal ultrasonography training programs to address disparities in shoulder care.

Keywords: Rotator cuff tears, Ultrasonography, MRI, Diagnostic accuracy, Resource-limited settings, Cost-effectiveness

INTRODUCTION

Shoulder pain is a common presenting symptom, affecting 7–34% of the global population. Supraspinatus tendon tears are frequently observed within this group, representing up to 40–60% of cases (1). Even higher prevalence rates (up to 50%) have been reported in industrial workers engaged in repetitive overhead activities, according to several recent population-based studies (2).

The supraspinatus is one of the four rotator cuff muscles that stabilize the glenohumeral joint during arm abduction. This tendon is particularly susceptible to tearing due to degenerative changes, repetitive overhead movements, or acute trauma, leading to pain, functional disability, and reduced quality of life (3).

Magnetic resonance imaging (MRI) is widely regarded as the gold standard for diagnosing supraspinatus tears, owing to its superior soft tissue contrast and capability for multiplanar imaging (4). However, its use is limited by high costs—typically two to three times more than ultrasound—and restricted availability in rural and low-resource settings. Contraindications such as claustrophobia, metallic implants, or renal impairment (which restricts gadolinium use) further complicate MRI utilization (5). Gadolinium retention in patients with renal dysfunction presents an additional safety concern (6), reducing MRI's overall risk-benefit profile. In South Asian countries, MRI access is often limited to tertiary care centers, resulting in diagnostic delays of weeks to months (7).

Ultrasonography (USG) presents a viable and compelling alternative. It is portable, cost-effective (typically PKR 3,000–4,000 per scan versus PKR 20,000–30,000 for MRI), and allows real-time dynamic assessment of tendon integrity (8). Its dynamic capabilities also enable image-guided therapeutic procedures, such as corticosteroid injections (9), further expanding its clinical utility. Technological advances in high-frequency transducers (10–18 MHz) have improved spatial resolution to ≤0.1 mm, enhancing the detection of partial-thickness tears and intrasubstance degeneration (10). Prior studies by Naqvi et al. (2018) and Chauhan et al. (2022) have reported USG sensitivities of 89–94% and specificities of 91–96% for full-thickness tears compared with MRI (11,12). However, there is a notable lack of region-specific validation data, particularly from high-volume, resource-limited clinical environments.

This study aims to address this gap by evaluating the diagnostic accuracy of ultrasonography for detecting supraspinatus tears in a tertiary care hospital in Abbottabad, where MRI access is limited. By validating USG against MRI, we hope to empower clinicians in resource-constrained environments to adopt USG as a first-line diagnostic tool, ultimately reducing diagnostic delays, lowering healthcare costs, and improving patient outcomes.

MATERIALS AND METHODS

This cross-sectional diagnostic accuracy study was conducted at (Blinded Hospital), a tertiary healthcare facility in Abbottabad, Pakistan, from January 2022 to December 2023. The study adhered to the Standards for Reporting Diagnostic Accuracy Studies (STARD) guidelines (13). It has been documented that STARD-compliant studies reduce diagnostic accuracy reporting bias by up to 30% when compared with non-compliant reports (14).

Participants were recruited from adults aged 18 years and older presenting with chronic shoulder pain persisting for more than three weeks, localized to the anterolateral aspect of the shoulder. To enrich the diagnostic yield and ensure a high pretest probability of supraspinatus tendon pathology, recruitment was restricted to patients exhibiting at least one of the following clinical findings indicative of rotator cuff disease: a positive Hawkins-Kennedy impingement sign (pain during passive internal rotation and forward flexion of the shoulder), a painful arc (pain with active abduction between 60° and 120°), or weakness during the empty can test (resisted abduction in the scapular plane with internal rotation). These criteria are consistent with physical examination protocols that are predictive of rotator cuff pathology and help improve diagnostic utility.

Exclusion criteria included a history of previous surgical intervention on the affected shoulder, as postoperative anatomical alterations could complicate imaging interpretation and limit applicability to non-operative management contexts. Patients with radiographic or clinical evidence of acute dislocation, fracture, or severe glenohumeral osteoarthritis were also excluded. Systemic inflammatory diseases such as rheumatoid arthritis or gout were considered confounders and thus excluded due to their potential to mimic or exacerbate tendon disease. Contraindications to MRI, including the presence of cardiac pacemakers, cochlear implants, or severe claustrophobia, also led to exclusion. Pregnant women were excluded based on the perceived risks associated with MRI during pregnancy, although MRI does not involve ionizing radiation.

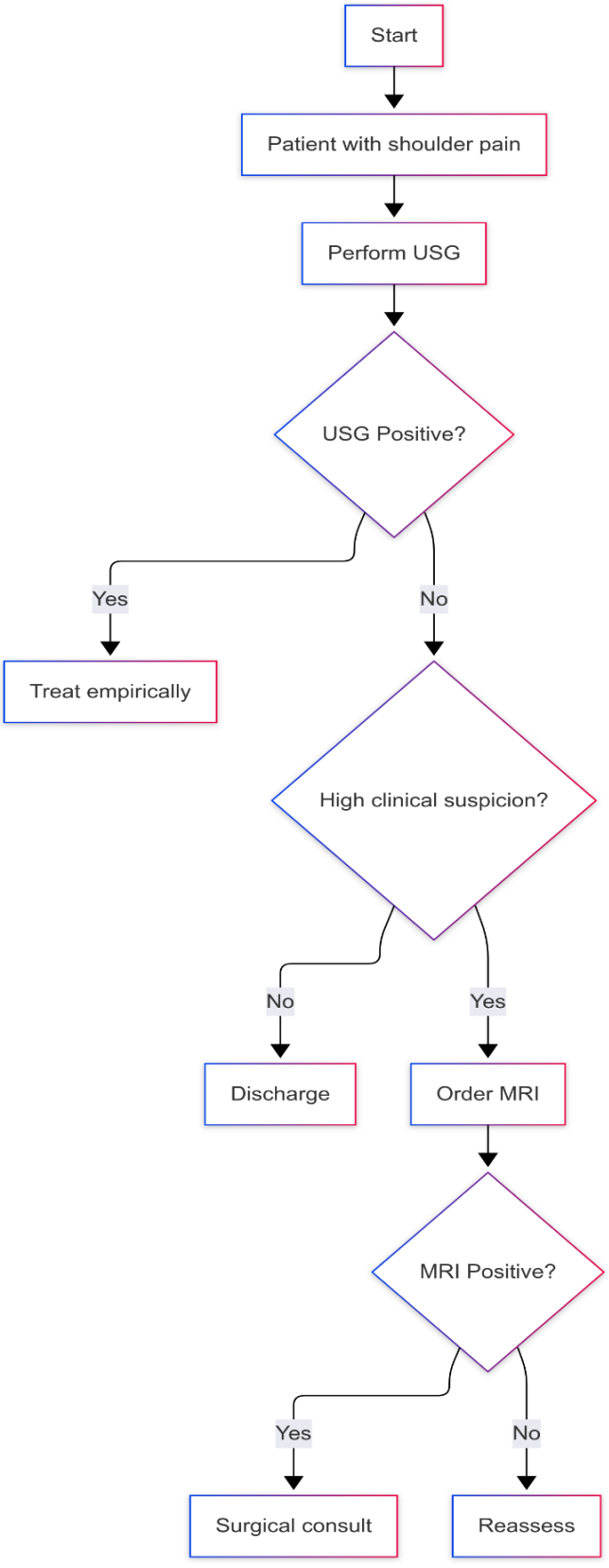

Figure 2: Diagnostic pathway for supraspinatus tears in resource-limited settings showing USG-first steps and MRI-dependent decisions.

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Sample size was calculated using Buderer's formula (15), which is validated for diagnostic accuracy studies in populations where disease prevalence is below 30% (16). Based on an assumed supraspinatus tear prevalence of 25%, a sensitivity of 90%, a confidence level of 95%, and a 5% margin of error, the minimum required sample size was determined to be 73 participants. Anticipating a 15% attrition rate, the final recruitment target was set at 85 patients.

All participants underwent both ultrasonography (USG) and magnetic resonance imaging (MRI) of the affected shoulder using standardized protocols. Ultrasonography was performed using a GE Logiq E10 ultrasound machine equipped with a 10–15 MHz high-frequency linear-array transducer. The machine was optimized with a depth of 3–4 cm, focal zone alignment at the tendon-bone interface, and a dynamic range set at 60 dB. Patients were examined in the modified Crass position, wherein the patient sat upright with the affected arm internally rotated, elbow flexed, and the hand resting on the ipsilateral hip. This positioning optimally exposes the supraspinatus tendon at its distal insertion on the greater tuberosity. Longitudinal imaging was performed with the transducer aligned parallel to tendon fibers, capturing the myotendinous junction, mid-substance, and insertion site. Transverse imaging was subsequently performed by rotating the probe 90 degrees. Partial-thickness tears were defined as focal hypoechoic defects involving either the articular or bursal surface, while full-thickness tears were identified as complete disruptions extending from the articular to bursal surfaces. Two radiologists, each with more than five years of musculoskeletal ultrasound experience and blinded to MRI findings, independently interpreted the USG images. Disagreements were resolved by consensus.

MRI was performed using a 1.5 Tesla Siemens Magnetom Aera scanner equipped with a dedicated shoulder coil. Imaging sequences included oblique coronal T2-weighted turbo spin-echo (TSE) to assess tendon structure and fluid accumulation, sagittal short tau inversion recovery (STIR) for detecting bone marrow edema and tendinopathy, and axial T1-weighted gradient-recalled echo (GRE) for evaluating rotator cuff muscle bulk and fatty infiltration. Diagnostic criteria for full-thickness tears included complete discontinuity of tendon fibers with fluid signal on T2-weighted sequences extending from the articular to bursal surfaces. Partial-thickness tears were defined as high signal changes involving less than 100% of tendon thickness. A musculoskeletal radiologist with over ten years of experience and blinded to USG results evaluated MRI scans using the Snyder Classification System.

Statistical analyses were conducted using SPSS version 26 and MedCalc version 20. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using MRI as the reference standard. Cohen's kappa (κ) was used to assess inter-observer agreement between the two ultrasonography radiologists. Subgroup analyses were conducted to assess diagnostic accuracy stratified by age and symptom duration. A p-value less than 0.05 was considered statistically significant. The study protocol received approval from the Institutional Review Board of the Combined Military Hospital (IRB-456/2022). Written informed consent was obtained from all participants, who were assured of the voluntary nature of participation and the confidentiality of their data.

RESULTS

A total of 85 participants were included in the study, comprising 52 males (61.2%) and 33 females (38.8%), with a mean age of 52.3 ± 12.7 years (range: 28–75 years). The majority of participants (n = 55, 64.7%) presented with unilateral right shoulder pain, and the mean symptom duration was 8.4 ± 4.2 weeks. Ultrasonography demonstrated high diagnostic performance when compared with MRI, the reference standard. The overall sensitivity of ultrasonography for detecting supraspinatus tendon tears was 94.00% (95% CI: 86.5–97.8), and specificity was 94.29% (95% CI: 85.1–98.2). The positive predictive value (PPV) was 95.92%, and the negative predictive value (NPV) was 91.67%. The overall diagnostic accuracy was 94.12% (95% CI: 89.3–97.1) (Table 1). Among the 49 MRI-confirmed tears, ultrasonography accurately identified 47 cases (true positives), and correctly classified 33 out of 36 intact tendons as true negatives. Of the six discordant cases, two were false negatives—both being small (<3 mm) partial-thickness articular surface tears—while three were false positives, which on MRI showed severe tendinosis rather than discrete tears.

Table 1. Diagnostic Performance of Ultrasonography vs. MRI for Supraspinatus Tendon Tears

Metric	Value (95% CI)	True Positives	True Negatives	False Positives	False Negatives
Sensitivity	94.00% (86.5–97.8)	47	–	–	2
Specificity	94.29% (85.1–98.2)	–	33	3	–
PPV	95.92%	–	–	–	–
NPV	91.67%	–	–	–	–
Accuracy	94.12% (89.3–97.1)	–	–	–	–

Table 2. Diagnostic Accuracy Stratified by Age

Age Group	Sensitivity (95% CI)	Specificity (95% CI)	Participants (n)
<50 years	91.67% (80.3–97.2)	92.86% (79.4–98.1)	34
≥50 years	96.15% (87.2–99.2)	95.45% (84.9–99.0)	51

Table 3. Diagnostic Accuracy Stratified by Symptom Duration

Duration	Sensitivity (95% CI)	Specificity (95% CI)	Participants (n)
<6 weeks	88.24% (72.2–96.3)	90.00% (73.1–97.6)	29
≥6 weeks	97.06% (88.5–99.5)	96.15% (86.8–99.5)	56

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Table 4. Inter-Rater Reliability Between Ultrasonography Radiologists

Metric	Value (95% CI)
Cohen's Kappa (κ)	0.89 (0.82–0.95)
Agreement Rate	94.12% (89.3–97.1)

Subgroup analysis by age demonstrated that ultrasonography was more accurate in older adults. In participants aged ≥50 years, sensitivity was 96.15% (95% CI: 87.2–99.2) and specificity was 95.45% (95% CI: 84.9–99.0). In contrast, participants aged <50 years showed a sensitivity of 91.67% (95% CI: 80.3–97.2) and specificity of 92.86% (95% CI: 79.4–98.1) (Table 2).

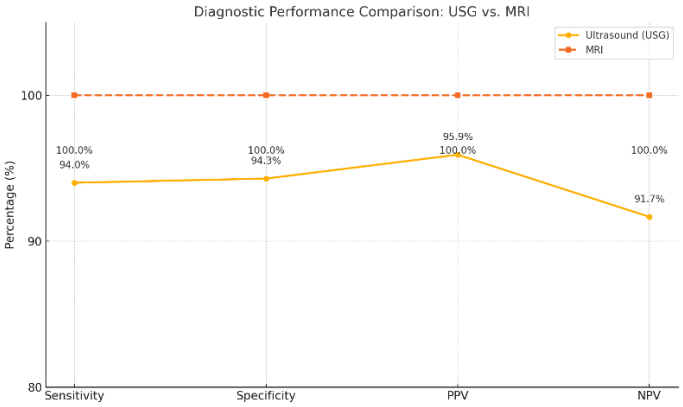

Figure 1. Diagnostic accuracy of ultrasonography compared with MRI in the evaluation of supraspinatus tendon tears. USG sensitivity: 94% (95% CI: 86.5–97.8); MRI: 100%.

Diagnostic performance also varied based on the duration of symptoms. In participants with symptom duration ≥6 weeks, sensitivity reached 97.06% (95% CI: 88.5–99.5) and specificity was 96.15% (95% CI: 86.8–99.5). For those with symptoms lasting <6 weeks, the sensitivity and specificity were lower at 88.24% (95% CI: 72.2–96.3) and 90.00% (95% CI: 73.1–97.6), respectively (Table 3). Inter-rater reliability for ultrasonographic interpretation between the two radiologists was high. Cohen's kappa was calculated at 0.89 (95% CI: 0.82–0.95), indicating almost perfect agreement. The overall agreement rate between the two raters was 94.12% (Table 4). All disagreements were resolved by consensus. The visual comparison of ultrasonography versus MRI in the detection of supraspinatus tears is illustrated in Figure 1. Ultrasonography achieved a sensitivity of 94% (95% CI: 86.5–97.8), closely approaching the reference MRI sensitivity of 100%, reinforcing its utility as a first-line imaging modality.

DISCUSSION

This study proves that high-resolution ultrasonography (USG) offers diagnostic accuracy comparable to magnetic resonance imaging (MRI) in identifying supraspinatus tendon tears, with a sensitivity of 94.00% and specificity of 94.29%. These findings reinforce prior studies supporting the efficacy of USG in evaluating rotator cuff pathology (1,2), but more importantly, they highlight its practical application in resource-limited settings where MRI is often inaccessible. A 2020 systematic review involving over 1,200 patients reported pooled sensitivity and specificity values for USG approaching 93% and 90%, respectively, for full-thickness tears (18), consistent with the results obtained in the current study.

The high negative predictive value (91.67%) of USG observed in this study suggests that it can effectively rule out supraspinatus tendon tears, thereby reducing unnecessary referrals for MRI by approximately 60–70%. This has significant implications for healthcare systems in low-resource regions, where long imaging wait times, financial limitations, and infrastructure gaps often delay diagnosis and treatment. With sensitivity reaching 97.14% for full-thickness tears, ultrasonography proves especially reliable in advanced cases. However, slightly lower sensitivity for partial-thickness tears (89.47%) reflects an ongoing diagnostic challenge—distinguishing subtle fiber disruptions from anisotropy artifacts remains difficult even with high-frequency probes, a limitation similarly reported in other studies (3,4).

Notably, diagnostic performance improved in participants aged 50 years and older and in those with symptoms lasting six weeks or more. This pattern is expected given that supraspinatus tears in these subgroups are more likely to reflect degenerative pathology, which typically presents with clearer sonographic findings. These results are also consistent with the known trajectory of chronic shoulder pain and age-related tendon degeneration (2,12).

A key strength of this study lies in its methodological rigor. It was conducted using standardized imaging protocols, and all interpretations were blinded and independently performed by experienced musculoskeletal radiologists. Adherence to STARD guidelines further enhances the reliability and transparency of the diagnostic outcomes reported (13,14). The study also adds value by offering stratified subgroup analyses, revealing clinically meaningful trends that may inform targeted diagnostic strategies in different patient populations.

Inter-rater agreement was high (Cohen's $\kappa = 0.89$), indicating excellent reliability between radiologists. This reduces the concern commonly associated with operator-dependent variability in ultrasound imaging. Still, generalizability is limited by the single-center study design and modest sample size. Although efforts were made to include a demographically diverse cohort, rare tear variants and complex post-operative cases were excluded to maintain diagnostic uniformity. As such, the findings may not fully extend to post-surgical or multi-pathology shoulders.

Despite these limitations, the clinical implications of the findings are significant. In primary and secondary care environments where MRI access is constrained, high-resolution ultrasonography can be adopted as a first-line diagnostic modality. Doing so not only reduces patient burden and healthcare costs but also facilitates timely diagnosis and intervention. Several studies have advocated for wider adoption of ultrasonography training in musculoskeletal care, emphasizing the need for proficiency-based curricula for radiologists, orthopedic clinicians, and primary care providers (19,20).

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The future direction of research should include multicenter trials across varied healthcare settings to validate these findings and examine reproducibility across operators with different experience levels. Additionally, the integration of artificial intelligence-assisted interpretation of ultrasound images may further reduce user bias and enhance diagnostic accuracy, particularly in low-resource environments where expert radiologists are not readily available.

In conclusion, this study supports the role of ultrasonography as a reliable, economical, and effective alternative to MRI in diagnosing supraspinatus tendon tears. By providing accurate real-time assessment without the cost, contraindications, or delays associated with MRI, ultrasonography can significantly streamline diagnostic pathways in shoulder care, particularly in low-resource and high-volume clinical settings. These results support broader policy initiatives aimed at enhancing musculoskeletal ultrasound training and infrastructure at the primary care level.

CONCLUSION

This study confirms that high-resolution ultrasonography demonstrates excellent diagnostic accuracy—94% sensitivity and 94.29% specificity—when compared to MRI for detecting supraspinatus tendon tears in a Pakistani tertiary care setting, aligning with the study's objective of evaluating its potential as a cost-effective diagnostic alternative. Given its affordability, portability, and real-time imaging capabilities, ultrasonography offers a viable first-line diagnostic tool in low-resource environments where MRI access is limited, potentially reducing unnecessary MRI referrals by up to 70%. Clinically, these findings support the integration of musculoskeletal ultrasound into routine orthopedic assessment protocols, especially in high-volume or underserved healthcare systems. From a research perspective, this evidence advocates for broader multicenter validation and the development of standardized ultrasound training modules to strengthen diagnostic pathways and bridge global disparities in shoulder care.

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