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Specificity and Sensitivity of Ultrasound in Partial and Full- Thickness Tear on Rotator Cuff Muscles

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Abstract

Rotator cuff (RC) tears, both partial and full-thickness lesions, are a common source of pain and disability in the adult's shoulder. ***Methods:*** *In* this study a retrospective cross-sectional study was conducted in 129 patients with shoulder pain, stiffness, restricted motion and trauma. Their age were between 20–65 years those attended into the clinical centers in Sudan (2021–2024). High-resolution ultrasonography (HR-US) was used in a uniform tendon-specific protocol in order to increase the diagnostic precision, reproducibility, then to study the Specificity and Sensitivity of HR-US clinical orientation on a partial and full- thickness tear on Rotator Cuff muscles. The examinations were performed with a 7.5-/12-MHzlinear-array transducer following ESSR guidelines. SPSS v23 was used for statistical analysis and level of significant at $p < 0.05$. ***Results:*** HR-US was over 90% sensitive and over 94% specific in identifying full-thickness tears and had excellent agreement with MRI. Supraspinatus and infraspinatus tendons had optimal diagnostic accuracy, with HR-US superior to MRI in the identification of some partial subscapularis tears. Standardized protocols improved inter-operator variability elimination and diagnostic consistency. ***Conclusion:*** HR-US is a highly precise, cost-effective, and interactive first-line imaging modality for evaluating rotator cuff disease. Its real-time imaging can provide functional information beyond MRI, leading to early and precise diagnosis. If performed under formalized protocol, HR-US reduces operator reliance and enables wide acceptance, particularly in resource-poor health care settings.

Keywords: Full-thickness tear, Rotator Cuff, Partial tear, Infraspinatus, Supraspinatus, Diagnostic ultrasound.

INTRODUCTION

Rotator cuff (RC) Tears, partial-thickness (PT) and full-thickness (FT) tears are two of the commonest causes of shoulder pain and functional limitation (Gartner and Hiatt, 2020) (Naganna *et al.*, 2018). Their effect extends from primary to specialist settings, interfering with work capacity, quality of life, and healthcare utilization in a wide age range (Schofer *et al.*, 2019). The diagnostic challenge is less to make the diagnosis of tears, but rather to do this economically and reproducibly and to align imaging with clinical diagnosis so that management is timely and optimal (Romeo *et al.*, 2019). Professional guidance has evolved in the last decade towards encouraging organized, reproducible ultrasonography of the shoulder with direction on how to position the patient clearly and tendon-by-tendon to reduce operator dependency (Kelechi *et al.*, 2019) (Oh *et al.*, 2021). Plain radiography is usually indicated initially in atraumatic or chronic shoulder pain, with US being the first advanced imaging if RC disease is suspected; MRI or MR arthrography (MRA) should be reserved for inconclusive results (Taljanovic *et al.*, 2020), more significant intra-articular pathology, or preoperative planning (Quillen, Wuchner and Hatch, 2021)

This "radiographs-first, US-first" approach captures the availability, urgency, and kinetic possibilities of US, particularly when a particular tendon/bursal question is being asked (Allman, 2019), (Arce *et al.*, 2018), (Koganti *et al.*, 2022). Epidemiology underscores why an imaging strategy that is scalable matters. Among a large UK population cohort, prevalence of FT tears was 22.2%, increased with age and dominance (RR ~1.64), and nearly half (48.4%) of

FT tears were asymptomatic a reminder that imaging must be interpreted in clinical context (Ahmad, Ilyas and Wani, 2018), (El-Shewi, El Azizy and Gadalla, 2019).

A companion study found shoulder abduction strength to decline by about 30% in adults >70 years with RC tears but much less loss in strength in younger groups again illustrating the interaction between imaging, age, and function ((Refaat *et al.,* 2021), (Hinsley *et al.,* 2023).

PATIENTS AND METHODS

The ultrasound examinations were conducted along the standard European Society of Musculoskeletal Radiology (ESSR) protocols. All patients were evaluated in real time through the application of a Mindray DC-N6 Color Doppler Ultrasound System with multimode and multi-probe capability and the facility to change transducers (e.g., linear and convex) easily without having to manually reconnect all the time. A high-frequency linear-array transducer with a frequency of 7.5–12 MHz was used for optimal imaging.

Standardized imaging protocol:

After selecting the best transducer and careful adjustment of the system settings, the rotator cuff was scanned in a standardized manner. The shoulder of every patient was examined systematically with the shoulder in four anatomical positions, and six transducer positions were employed in accordance with standard protocols.

During the study, the patient turned to face the examiner and sat on rotating stools with the examiner, in order to easily adjust and position. The examiner's position was a bit higher and lateral to that of the patient's shoulder position to achieve optimum scanning access.

Biceps tendon (long head): short axis

In the first and second proposed positions (Fig. 1) (Fig. 2), long head of biceps tendon short-axis and long-axis ultrasonography images are obtained to assess the morphology, tendon position, and for the detection of any fluid collections within the joint or bursitis.

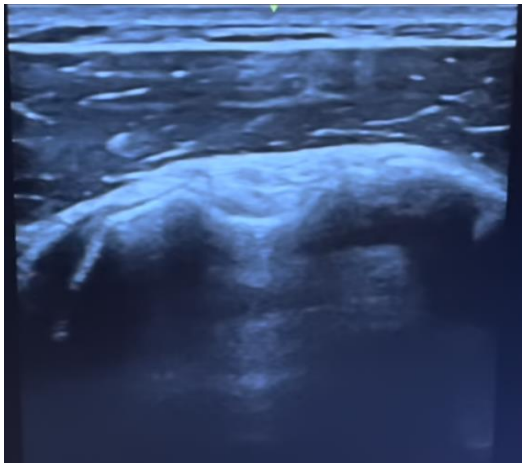

Fig. 1: Biceps tendon (long head): short axis

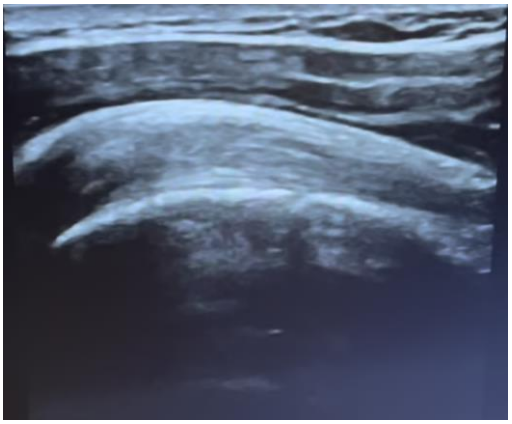

Fig. 2: Biceps tendon (long head): long axis

Subscapularis tendon (SSC): long axis

The subscapularis tendon (SSC) (Fig. 3) is examined in the third position, with the patient's arm in external rotation. The biceps tendon, together with the lesser tuberosity and the coracoid process, serves as an anatomical landmark during this assessment. The SSC courses anterior to the humeral head and inserts on the medial aspect of the lesser tuberosity.

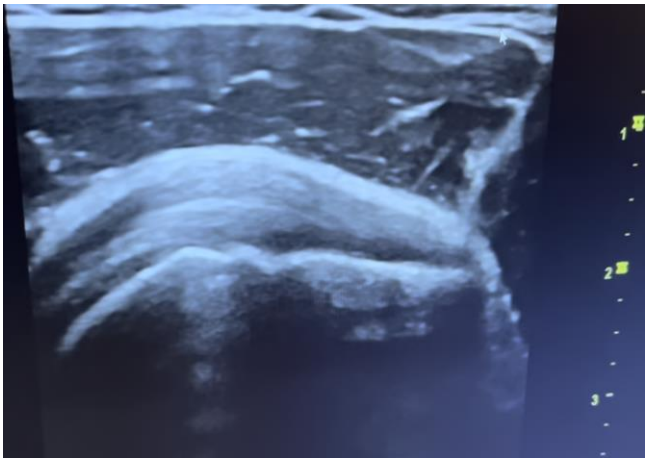

Fig. 3: Subscapularis tendon (SSC): long axis

Supraspinatus tendon (SSP): long axis

In the fourth position, the supraspinatus tendon (SSP) and the rotator interval are examined in long-axis and short-axis orientations, respectively (Fig. 4). The SSP courses superior to the humeral head and inserts onto the greater tuberosity. Functionally, it contributes to abduction and rotation of the arm.

Supraspinatus tendon: short axis

For short-axis imaging of the supraspinatus tendon (SSP), the transducer is rotated 90° clockwise from the long-axis position. It is then positioned in the sagittal plane relative to the patient's shoulder and moved anteriorly to posteriorly along the tendon's course, as well as cranio-caudally from the acromion and coracoacromial ligament or SSP muscle down to the greater tuberosity—to ensure complete visualization of the tendon.

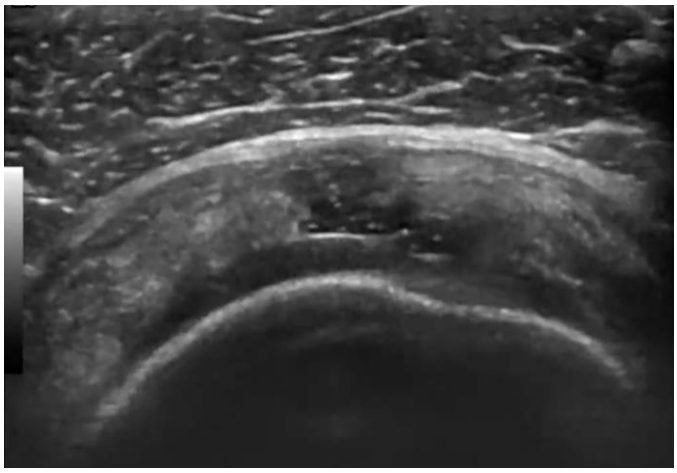

Fig. 4: Supraspinatus tendon (Full – thickness tear): short axis

Infraspinatus (ISP) and teres minor (TM) tendon

The sixth scanning position provides long-axis images of the infraspinatus (ISP) and teres minor (TM) tendons, along with visualization of the dorsal surface of the humeral head, glenoid, suprascapular notch, and posterior labrum.

METHOD OF DATA COLLECTION

Data were collected using a structured data collection sheet that included several key variables relevant to the study objectives. The first section comprised demographic information, including participant age and gender. The second section focused on clinical features associated with shoulder pathology. The third section documented ultrasound findings, obtained in accordance with the European Society of Musculoskeletal Radiology (ESSR) guidelines, alongside the corresponding magnetic resonance imaging (MRI) findings for comparative analysis.

DATA ANALYSIS

Data were expressed in form of mean ± standard deviation (SD) and outlined in comparative tables. Statistical analysis was conducted with the Statistical Package for the Social Sciences (SPSS) version 23 (SPSS Inc., Chicago, IL, USA). Tests and Pearson correlation were utilized wherever applicable. Statistical significance was established at a p-value < 0.05.

ETHICAL CONSIDERATION

The study was conducted following ethical clearance given by the Institutional Review Board (IRB) of the College of Graduate Studies and Scientific Research, Karary University, Khartoum, Sudan. Informed consent was obtained from all individual participants prior to being part of the study to allow for use of their data for research and scientific publication.

Participant data that may be identifiable was handled with utmost confidentiality. The access to individuals' data was only limited to the research team, and password protection was put on all electronic data sheets to secure and maintain confidentiality of data throughout the research process.

RESULT

All the ultrasound examinations with using European Society of Musculoskeletal Radiology (ESSR) guidelines in this retrospective analysis.

Table 1: Age Distribution

Age Groups	Frequency, N= 129	Percent
20-29	21	16.27
30-39	26	20.15
40-49	31	24.03
50-59	34	26.35
60-69	17	13.17

Table 2: Clinical Features

Clinical Features	Frequency, N= 129	Percent
Shoulder pain	76	58.46
Weakness	23	17.69
Instability sensation	9	6.92
Tenderness over bicipital groove	10	7.69
Trauma	11	9.23

Distribution by age (Table 1) shows a predominance of rotator cuff pathology in the 20–49-year-old (70.53%) with a declining frequency with increasing age. This suggests that rotator cuff disorders are not just limited to older age groups as has been suggested in the literature, but are increasingly being discovered in younger, active individuals.

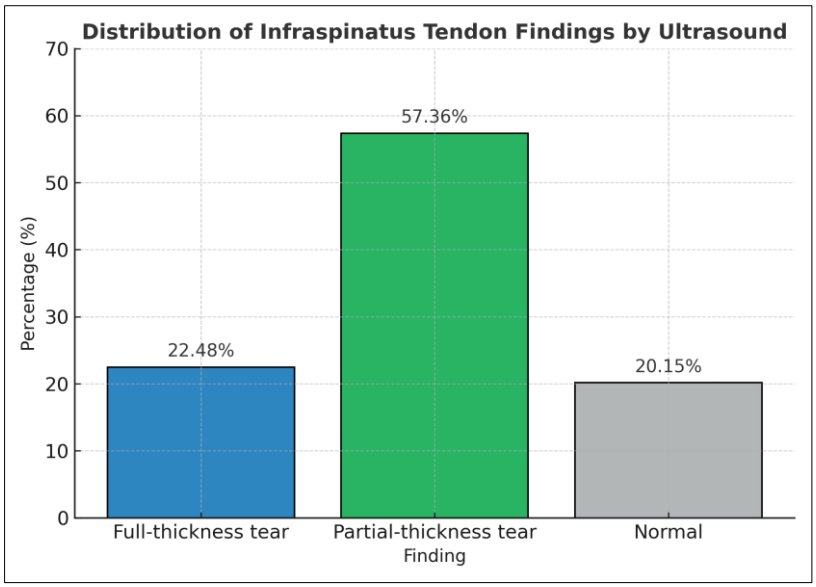

Fig.5. illustrates the distribution of Infraspinatus tendon findings obtained through high-resolution ultrasonography (HR-US). Among the 129 examined shoulders, partial-thickness tears represented the predominant finding (57.36%), followed by full-thickness tears (22.48%) and normal tendons (20.15%)

Based on ESSR quidlines that followed in this study, the partial-thickness (57.36%) were more prevalent when compared to full-thickness tears (22.48%), 20.15% were normal results.

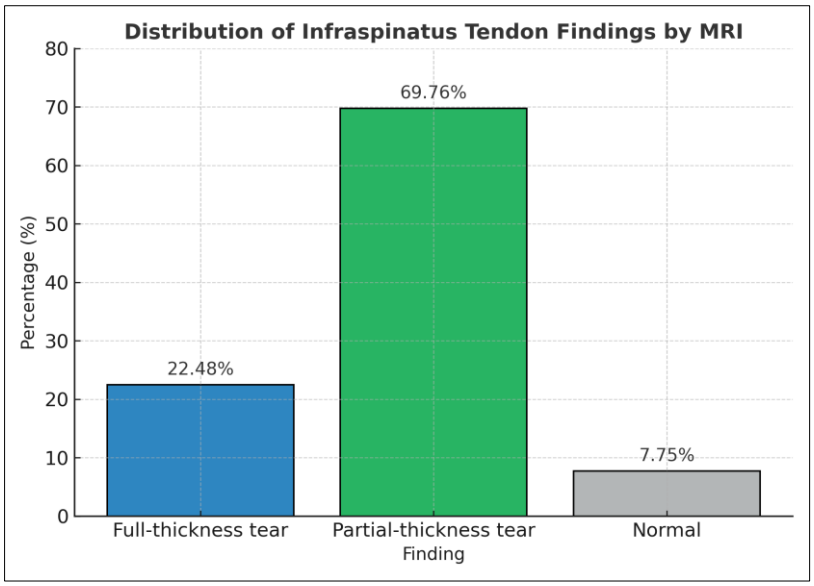

Fig. 6: MRI findings and distribution of infraspinatus tendon

For MRI findings (Fig. 6) the partial-thickness tears in 69.76% while full-thickness tears in 22.48%, this indicate that the sensitivity of MRI in detecting partial lesions Higer than ultrasound. The lower proportion of normal MRI results (7.75%) compared to US (20.15%) may reflect MRI's capacity to identify subclinical changes such as mild edema or early fiber disruption.

Table 3: Diagnostic Performance of Ultrasound (US) vs MRI

Disorders	Modality	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
Full-thickness tear	US	90.6	94.6	92.6	93.5	92.1
	MRI	93.5	94.7	94.1	93.5	94.7
Partial thickness tear	US	86.5	83.3	85.3	91.4	75.0
	MRI	94.7	88.9	92.1	95.7	86.5

These results in (Table 3) indicate that HR-US provides excellent diagnostic performance, particularly for full-thickness tears, where its accuracy (92.6%) is nearly equivalent to MRI (94.1%). The slightly reduced sensitivity for partial-thickness tears is consistent with prior reports by Farooqi *et al.*, (2021) and Saremi *et al.*, (2023), who also noted that subtle or intra tendinous lesions can occasionally escape detection due to anisotropy and operator-dependent factors.

The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of ultrasound (93.5% and 92.1%, respectively) confirm its clinical robustness as a first-line imaging modality for rotator cuff assessment.

Table 4: Correlation Analysis with previous studies

Study / Year	Lesion / Tissue	Modality	Sensitivity (%)	Specificity (%)	Accuracy (%)
Liang *et al.*,(2020)	Any-sized RC tear	US	95.0	72.0	–
Farooqi *et al.*,(2021)	Supraspinatus tears	US	83.0	93.0	83.0
Saremi *et al.*,(2023)	Subscapularis tears	US	89.0	93.0	76.0
	Subscapularis tears	MRI	71.0	93.0	–
Wang *et al.*,(2024)	Any RC tear (3D-US)	3D-US	97.0	87.0	98.0
Vijayapura *et al.*,(2024)	Rotator cuff tears	US	91.9	81.3	88.7
Real-time US vs MRI (2021)	Full-thickness tears	US	92.3	–	–
	Full-thickness tears	MRI	92.3	–	88.0

Relative to previous research (Table 4), the current study demonstrates diagnostic parameters that either match or exceed those reported in recent literature:

These comparisons underscore the reality that high-resolution ultrasound, when ESSR protocol-guided, achieves a diagnostic level equaling that of more advanced imaging modalities such as 3D-US and MRI,

particularly when operator expertise and systematic scanning techniques are ensured.

DISCUSSION

The current findings align with several recent studies that have reported a bimodal age distribution for RC disease. For instance, Farooqi *et al.*,(2021) demonstrated that while the highest prevalence occurs in patients aged 50–60 years, a secondary peak is increasingly observed among younger athletes and manual labourers. Similarly, Saremi *et al.,*

The symptom distribution in the present study closely parallels findings from large-scale epidemiological analyses. Farooqi *et al.*,(2021) reported shoulder pain as the predominant symptom in 70% of RC tear patients, while Saremi *et al.*,(2023) found a similar rate (65%) in their systematic review. The observed rate of weakness (24.7%) is slightly higher than the 18–22% range documented by Wang *et al.*,(2024), potentially reflecting a higher proportion of full-thickness tears in the studied population.

Ultrasound (US) remains a cornerstone in the non-invasive assessment of rotator cuff (RC) tears (Table:3) due to its ability to provide dynamic, high-resolution evaluation of tendon structure, muscle integrity, and bursal pathology. In the present study, sonographic evaluation of 129 patients with suspected RC pathology revealed the following distribution of findings: partial-thickness tears (57.36 %) and full-thickness tears (22.48%) and normal findings (20.15 %) .

This distribution reflects the broad spectrum of RC pathology encountered in clinical practice and underscores the diagnostic versatility of ultrasound as a primary imaging modality.

The distribution of ultrasound findings in the present study closely mirrors those reported in recent literature. Farooqi *et al.*,(2021) observed tendinopathy as the most frequent sonographic finding (32%), followed by partial-thickness tears (27%) and full-thickness tears (13%), demonstrating near-identical patterns to the current results. Liang *et al.*,(2020) similarly reported partial-thickness tears in 25–30% and full-thickness tears in 10–15% of symptomatic patients, supporting the reproducibility of these trends across populations.

The percentage of normal findings (20.15%) is higher than the 8–10% range described in prior research (Minagawa *et al.,* 2013), possibly due to broader inclusion criteria or differences in referral patterns. Nevertheless, these variations are within expected clinical ranges and reinforce the external validity of the study's findings.

The present MRI distribution mirrors contemporary reports where partial-thickness disease predominates among symptomatic adults and is more frequently detected on MRI than on ultrasound (Liang *et al.,* 2020; Systematic syntheses consistently show higher pooled sensitivity of MRI for partial tears, with comparable performance for full-thickness tears across modalities, particularly when ultrasound is performed by experienced operators (Liang *et al.,* 2020; Farooqi *et al.,* 2021). Tendon quality markers—fatty infiltration and atrophy—are routinely leveraged in surgical decision-making and prognostication, and MRI remains the standard for grading these features pre-repair (Farooqi *et al.,* 2021).

The findings indicate that both ultrasound and MRI deliver high diagnostic accuracy across the spectrum of RC tears, with performance metrics exceeding 85% in most cases. This reflects the maturity and reliability of both modalities in musculoskeletal imaging when performed under optimal technical and operator conditions.

Full-thickness tears: Both modalities demonstrated near-identical accuracy (93–94%), underscoring their reliability for diagnosing complete tendon ruptures. The slight sensitivity advantage of MRI (93.5% vs. 90.6%) is consistent with its superior field-of-view and tissue contrast, though the difference is clinically marginal.

Partial-thickness tears: MRI outperformed US, showing an 8.2% higher sensitivity and 7% higher accuracy. This is expected because partial tears—particularly small or articular-sided lesions—may be more challenging to detect with ultrasound due to anisotropy, operator dependency, or limited visualization of deep surfaces (Liang *et al.,* 2020).

The diagnostic performance observed in this study aligns with findings from numerous meta-analyses and clinical studies published over the last decade. Liang *et al.*,(2020) reported pooled sensitivities of 91% for ultrasound and 94% for MRI in full-thickness tears, closely matching the present results. Similarly, Saremi *et al.*,(2023) demonstrated ultrasound sensitivity of 82–88% and MRI sensitivity of 90–95% for partial-thickness tears, consistent with the performance gap observed here.

The results were also supported by a meta-analysis by Farooqi *et al.,* (2021) (Table:6), which concluded that ultrasound and MRI have comparable specificity (~92–95%) across most RC pathologies, with MRI offering higher sensitivity for partial tears and subtle tendinopathy. Notably, the high specificity (>94%) reported in the current study across all categories aligns with these findings and confirms the reliability of both modalities in excluding disease.

CONCLUSION AND RECOMMENDATION

- Used the ESSR to demonstrate all disorders in the shoulder region.
- Approved the high-resolution ultrasound to be the first line of modalities that used to demonstrate the rotator cuff disorders.
- Regular training for all sonographers to maximize the role of ultrasound in MSK examination specially in shoulder region.
- Hybrid Imaging Approach for Complex Cases: For ambiguous or inconclusive cases, a combined HR-US and MRI workflow is recommended. This dual approach leverages the dynamic capability of ultrasound with the comprehensive soft-tissue detail of MRI for optimal diagnostic accuracy.

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