

Original Article

Diagnostic accuracy of ultrasound compared to magnetic resonance imaging for rotator cuff tears: a systematic review

Farzaneh Hekmatnia¹, Ghazaleh Jamalipour Soufi², Andrew Parviz Zarei³, Shamim Shafieioun², Ali Hekmatnia², Nazanin Sadraei⁴, Farshad Riahi²

¹Department of Radiology, St George's Hospital, London, UK; ²Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran; ³Department of Medicine, The Princes Alexandra Hospital, London, UK; ⁴Department of Radiology, Shiraz University of Medical Sciences, Shiraz, Iran

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Abstract: Objective: This systematic review aimed to conduct a comprehensive comparative analysis of the diagnostic performance of magnetic resonance imaging (MRI) and ultrasound (US) in detecting rotator cuff tears (RCTs). Methods: A systematic literature search was conducted in the PubMed, Scopus, and Embase databases from January 2021 to March 2025 for original studies on adults (≥ 18 years) with suspected RCTs undergoing both US and MRI. Thirteen studies involving 792 participants met the inclusion criteria. Results: US was better than MRI for full-thickness tears, with a sensitivity of 100% (especially for supraspinatus), a specificity of 81-100%, and a kappa of up to 1.0. For partial-thickness tears, the results varied (sensitivity 72-94%, accuracy 76-94%). Non-supraspinatus tendons were less reliable, and the results were affected by the operator's skill, the patient's sex (worse in females), and the side of the body. MRI was better for partial tears, complicated cases, and planning surgery. Conclusion: The findings demonstrate that US can serve as a valuable auxiliary imaging modality for rotator cuff evaluation, particularly excelling in detecting full-thickness tears when MRI is contraindicated, unavailable, or in resource-limited settings. While US shows excellent diagnostic performance for full-thickness supraspinatus tears, MRI remains the primary diagnostic standard in clinical practice for comprehensive rotator cuff assessment, particularly for partial tears, complex pathologies, and detailed pre-operative planning.

Keywords: Rotator cuff tears, ultrasound, magnetic resonance imaging, diagnosis

Introduction

The shoulder is the third most frequently injured joint in sports, with rotator cuff tears (RCTs) being the most common cause of shoulder pain. Approximately 30% of people over 60 years of age and 65% of patients over 70 years of age, who are asymptomatic, are affected by RCT [1]. The rotator cuff, which dynamically stabilizes the shoulder, is composed of four muscles and their tendons. When its integrity is lost the shoulder joint gradually deteriorates, becomes unstable, and is excruciatingly painful [2]. Acute tearing from an injury, chronic problems linked to structural defects, or overuse can cause loss of integrity. The etiology of RCTs is multifactorial, involving both intrinsic and extrinsic risk factors. Older age is the most sig-

nificant and consistent demographic risk factor for RCTs, with a 1.2-fold increase in odds for every 10-year increase. Meta-analytic research shows that people who are 60 years old or older are 5 to 7 times more likely to get RCTs than individuals who are younger than 40. This is because of age-related changes that make collagen less stable, lower microvascular perfusion, and lower tendon tensile strength [3]. Cigarette smoking has emerged as a major modifiable risk factor, whereby the odds are about 2 times higher among current smokers compared to those who do not smoke, attributed mainly to the effects of nicotine on vasoconstriction and the aggregation process of the synthesis of collagen [4]. Genetic traits also form part of the account in the susceptibility to RCT, since the chances are considerably higher

The diagnosis of the rotator cuff tears

among the families of patients with RCTs, even beyond those related within third-cousin marriages, including various genetic loci involved in the pathology, such as fibroblast growth factors (FGF), matrix metalloproteinases (MMP), and apoptosis-regulating proteins [5]. Early detection using imaging, physical examination, and patient history aids in determining the best course of action to prevent functional loss and enhance patient outcomes [6].

Since RCTs can be difficult to diagnose, it is critical to describe the various imaging modalities to choose the one that works best for each patient [7]. The gold standard for evaluating rotator cuff injuries, magnetic resonance imaging (MRI), uses tendon abnormalities and signal alterations on T2- and PD-weighted images to identify tears. The benefits of MRI are that it has a high soft-tissue resolution and is a noninvasive, radiation-free method [8, 9]. Although the accuracy of ultrasound (US) is more operator-dependent, numerous studies have shown that US and MRI are equally accurate in identifying RCTs before surgery [10]. US remains an adjunct imaging technique that may also yield important diagnostic insights in particular clinical settings, although its effectiveness remains operator-dependent. Several studies have confirmed that US scans conducted by trained sonographers may yield levels of diagnostic accuracy equivalent to those of MRI scans in identifying full-thickness RCTs, especially in relation to supraspinatus tendon RCTs. However, it is imperative to underscore that the effectiveness of the US is still contingent upon the quality of its apparatus, the proficiency of its operators, and the physical characteristics of its personnel. However, the US offers numerous additional advantages, such as immediate availability, cost-effectiveness, real-time surveillance, and the absence of contraindications. These advantages may prove valuable, especially when MRI scanning cannot be carried out, such as when scanning individuals who possess pacemakers or cochlear implants, are claustrophobic, possess metal fragments, or are severely obese [11-13]. Nevertheless, MRI remains superior for detecting partial-thickness tears, evaluating non-supraspinatus tendons, assessing muscle atrophy and fatty infiltration, and providing comprehensive preoperative planning informa-

tion essential for surgical decision-making [14, 15].

Presently, the gold standard for the final diagnostic work-up of injuries to the rotator cuff is MRI, while US is essentially a secondary procedure, generally used alternatively when there is a contraindication or absence of access to MRI, either as a cost-saving method in lower-resource units for the initial work-up, for dynamic impingement studies, or as a method for image-guided procedures. Clinical practice guidelines have always recommended the use of the US as a method of initial imaging following a radiograph, while the essential role of magnetic resonance imaging is noted, especially with equivocal US results or when surgery is being contemplated [16-18]. Therefore, this systematic review aimed to conduct a comprehensive comparative analysis of MRI and US in diagnosing RCTs and to clarify their respective diagnostic accuracies and clinical roles in contemporary practice.

Material and methods

Search strategy

This systematic review was written to evaluate the diagnostic accuracies of US and MRI in identifying RCTs. This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review question was structured using the population, intervention, comparison, and outcome (PICO) framework: adults (≥ 18 years) with shoulder pain and clinical suspicion of rotator cuff tears (population); diagnostic shoulder ultrasound (intervention); magnetic resonance imaging, and when available, arthroscopy or surgery as reference standards (comparison); and diagnostic performance measures of US and MRI, including sensitivity, specificity, positive and negative predictive values, and overall diagnostic accuracy for rotator cuff tears (outcomes). A thorough search of the PubMed, Scopus, and Embase databases was performed for English-language papers published between January 2021 and March 2025 (**Figure 1**). The search technique, designed in collaboration with a medical librarian, employed a combination of Medical Subject Headings (MeSH) and free-text terms such as

The diagnosis of the rotator cuff tears

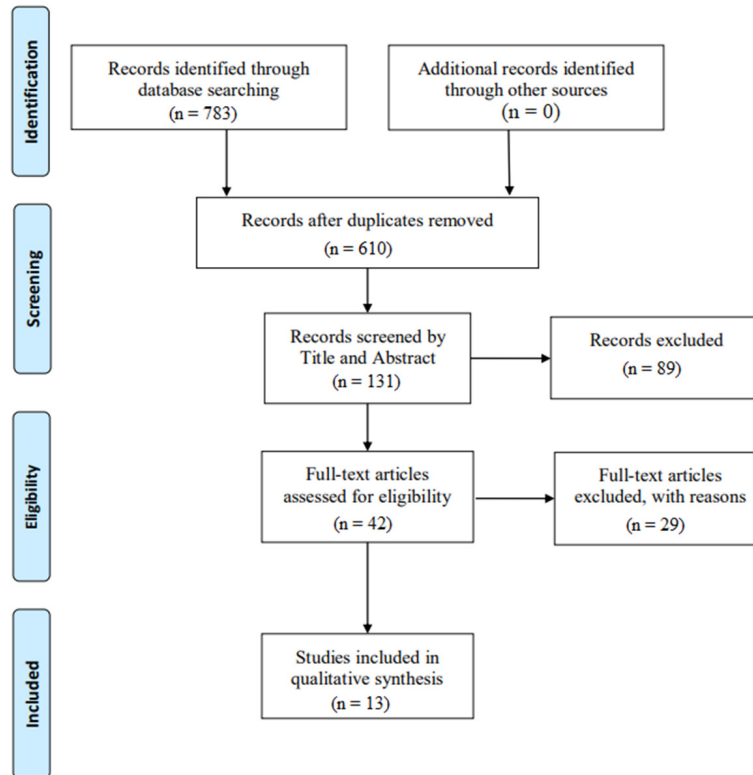


Figure 1. PRISMA flow diagram for enrollment of studies.

“Ultrasonography”, “Magnetic resonance imaging”, and “Rotator cuff injuries”.

Inclusion and exclusion criteria

Original articles that evaluated the diagnostic performance of US and MRI for rotator cuff tear detection were eligible for inclusion in the systematic review. The study population was comprised of patients aged 18 years and older who presented with shoulder pain and dysfunction, clinical symptoms suggestive of rotator cuff injuries, restricted shoulder movement, or in some cases, a history of shoulder trauma. All included patients were required to have undergone both US and MRI examinations of the affected shoulder to enable direct comparison between the two imaging modalities.

Studies were excluded if they involved patients with MRI contraindications (e.g., pacemakers, ferromagnetic clips, cochlear implants, metallic foreign bodies, claustrophobia, or unwillingness to undergo MRI) were excluded. Studies involving postoperative shoulders, prior rotator cuff surgery, structural abnormalities (e.g., fractures or dislocations visible on radiography), or

confounding conditions were omitted. Non-original works, such as case reports, series, editorials, conference abstracts, animal studies, reviews, meta-analyses, and systematic reviews without primary data, were also excluded.

Data extraction

Titles and abstracts were reviewed by F.H. and A.H. After implementing inclusion and exclusion criteria, data from studies was extracted based on the requirements of the survey.

After scanning the references in previously published review articles, any relevant studies were included. We obtained 13 eligible published research articles in their final version. For some of the articles, we chose to include only the main findings that fit the purpose of

this review. Data extraction tables based on the final articles’ data are shown in **Table 1**.

Outcomes and definitions

The primary observation indicators of diagnostic performance were sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of US and MRI for detecting rotator cuff tears, using the study-specific reference standard (MRI and/or arthroscopy or surgery).

For each included study, these indicators were extracted as reported or calculated from two-by-two contingency tables (true positives, false positives, true negatives, false negatives) where sufficient data were available.

Sensitivity was defined as the proportion of patients with a rotator cuff tear on the reference standard correctly identified as positive by the index test (US or MRI), that is, true positives divided by the sum of true positives and false negatives.

Specificity was defined as the proportion of patients without a rotator cuff tear on the refer-

The diagnosis of the rotator cuff tears

Table 1. Basic characteristics and evaluating the diagnostic value of ultrasound in the diagnosis of rotator cuff tears of the included studies

First Author	Year	Study Design	Sample Size	Mean Age	Most affected tendon	Standard reference	Gender (Male, %)	Key findings
Ganesh et al.	2024	Prospective	53	48.6	Supraspinatus	MRI	66%	A study reported 88.6% overall accuracy for US in detecting rotator cuff tears, with 91.2% sensitivity and 81.8% specificity, demonstrating strong performance comparable to MRI.
Raza et al.	2024	Cross-sectional	50	-	Supraspinatus	MRI	64%	US showed 65.71% sensitivity, 46.7% specificity, 74.2% PPV, 36.84% NPV, and 60% accuracy for supraspinatus tears, with similar results for infraspinatus and subscapularis tears, indicating effective diagnostics even with novice operators.
Naseem et al.	2025	Cross-sectional	130	47.32 ± 7.06	-	MRI	70%	US achieved 94% sensitivity, 91% specificity, 92% accuracy, 91% PPV, and 94% NPV for RCTs, positioning it as a reliable, cost-effective alternative to MRI with comparable accuracy.
Venkatesh et al.	2025	Retrospective	78	43.7 ± 12.4	Supraspinatus	MRI	71.8%	US exhibited highest agreement with MRI for supraspinatus full-thickness tears and tendinosis, but lower sensitivity for partial-thickness tears in infraspinatus (44.4%) and subscapularis (65.6%), where MRI was superior.
Prajwal et al.	2025	Prospective	70	42.14 ± 14.07	Supraspinatus	MRI	78%	For supraspinatus pathologies, US had 76% accuracy, 72.5% sensitivity, and 90% specificity versus MRI; MRI excelled for teres minor and other tendons, especially supraspinatus detection.
Madhavi et al.	2024	Prospective	70	47.5	Supraspinatus	MRI	-	US sensitivity was 59% for supraspinatus, 50% for infraspinatus, and 67% for subscapularis tears, with 100% specificity, PPV, and accuracy for calcifications; accuracy for complete tears was 100% (supraspinatus/subscapularis) and 82.3% (infraspinatus), and for partial tears 82.3% (supraspinatus), 100% (infraspinatus/subscapularis); however, US may be less reliable for tear detection than thought.
Kumar et al.	2025	Prospective	20	49.2	Supraspinatus	MRI	80%	Diagnostic accuracy of US for identifying complete supraspinatus, infraspinatus, and subscapularis tears were 100%, 82.3%, and 100%, respectively. For partial tears, the accuracy rates were 82.3%, 100%, and 100%, respectively.
Banerjee et al.	2025	Descriptive	50	-	Supraspinatus	MRI	86%	US demonstrated perfect 100% sensitivity, specificity, and accuracy for full-thickness tears, and 93.75% sensitivity, 100% specificity, and 94.4% accuracy for partial-thickness tears compared to MRI, with a strong kappa of 0.954 for supraspinatus tears.
Nunna et al.	2024	Cross-sectional	80	-	Supraspinatus	MRI	61%	MRI detected supraspinatus partial tears in 55% and complete in 12.5% of cases, while US found partial in 19.5% and complete in 8.8%; moderate to high agreement between US and MRI for shoulder pathologies, with near-perfect agreement for complete RCTs.
Refaat et al.	2021	Prospective	30	45 ± 12	Supraspinatus	MRI	60%	US achieved 100% sensitivity, specificity, PPV, NPV, and accuracy for full-thickness supraspinatus tears; for partial-thickness, 80% sensitivity, 95% specificity, 88.9% PPV, 90.5% NPV, and 90% accuracy; US is comparable to MRI for shoulder impingement and rotator cuff tears, especially full-thickness.
Kraats et al.	2023	Retrospective	61	64 ± 10	Supraspinatus	MRI	43%	Handheld US had moderate to strong intra-rater reliability but poor inter-rater agreement for rotator cuff tears; sensitivities/specificities were 81.1%/62.5% for supraspinatus, 60%/93.1% for subscapularis, and 55.6%/88.9% for infraspinatus, concluding it cannot replace MRI.
Ahmed et al.	2023	Prospective	50	36	Supraspinatus	MRI	64%	US showed 100% sensitivity, 92.68% specificity, 94% accuracy, 75% PPV, and 100% NPV for complete tears; it matches MRI in sensitivity/specificity and serves as a cost-effective screening tool with high-resolution imaging and trained experts.
Gupta et al.	2022	Prospective	50	56.0 ± 13.6	Supraspinatus	MRI	78%	US had 84% sensitivity and 87.5% specificity for tendinosis, 78.1% sensitivity and 94.4% specificity for partial-thickness tears, and 100% for full-thickness tears, with variations by tendon.

MRI: Magnetic resonance imaging, US: Ultrasound, NPV: Negative predictive value, PPV: Positive predictive value.

The diagnosis of the rotator cuff tears

ence standard correctly identified as negative by the index test, that is, true negatives divided by the sum of true negatives and false positives.

PPV was defined as the probability that a patient with a positive index test result truly had a rotator cuff tear, calculated as true positives divided by the sum of true and false positives, whereas NPV was defined as the probability that a patient with a negative index test result truly did not have a tear, calculated as true negatives divided by the sum of true and false negatives.

Overall diagnostic accuracy was defined as the proportion of correctly classified patients, calculated as the sum of true positives and true negatives divided by the total number of examined patients.

When reported, additional indicators of agreement, such as Cohen's kappa coefficients between US and MRI, were also extracted to describe concordance for full- and partial-thickness tears and for tendon-specific pathology (supraspinatus, infraspinatus, subscapularis, and teres minor).

Rotator cuff tears were categorized according to the original study definitions into full-thickness and partial-thickness tears. Full-thickness tears were generally defined as a complete discontinuity of the tendon from the bursal to the articular surface (with or without complete tendon width involvement), whereas partial-thickness tears involved only a portion of the tendon thickness, either on the bursal side, articular side, or within the tendon substance.

Where studies reported separate diagnostic indicators by tendon, data were extracted for supraspinatus, infraspinatus, subscapularis, and, when available, teres minor tendons, to allow comparison of tendon-specific performance of US and MRI.

The definitions and extraction of these observation indicators were guided by contemporary standards for reporting diagnostic accuracy research, including the STARD 2015 recommendations [19].

Quality assessment

F.H. and A.H. assessed the quality of the published interventions. A third author (G.S.) en-

sured that any disagreements were resolved. To address the quality of the intervention measures employed in the included studies, the methodological quality and risk of bias were assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool [20]. The patient selection domain evaluates the representativeness of the study population and the potential to introduce spectrum bias as a result of inappropriate exclusions, such as cases that are difficult to diagnose. The index test domain checks if ultrasonic tests were done and read without knowing the findings of the reference standard (blinding) and if the technical information are clear enough for others to do the same. The reference standard domain checks to see if MRI or surgical findings correctly identify the target condition and if the interpretation was done without knowing the index test results. Finally, the flow and timing domain examines the interval between tests to ensure clinical condition stability and verifies that all participants received the same reference standard. The tool comprises four main categories: flow and timing, reference standards, index tests, and patient selection. For each specific study, every category was evaluated as either "low", "high", or "unclear". The ratings for every domain were then shown, along with a subjective judgment of the overall quality of the studies included.

Results

Study selection

After doing a comprehensive search, we identified 783 records from database searches and 0 additional documents from other sources. We screened 610 records based on their titles and abstracts, excluded 479, and were left with 131 full-text articles to assess for eligibility. After assessing the full-text articles, we excluded 89 with reasons, leaving 42, of which 29 were further excluded. In total, 13 studies met the inclusion criteria for our qualitative synthesis. The selection process for these studies is presented in **Figure 1**. We extracted data from 13 eligible articles, and summarized the information in **Table 1**.

Quality assessment

Based on the QUADAS-2 assessment (**Figure 2**), seven of the included studies demonstrated high overall risk of bias [16-21, 23], primar-

The diagnosis of the rotator cuff tears

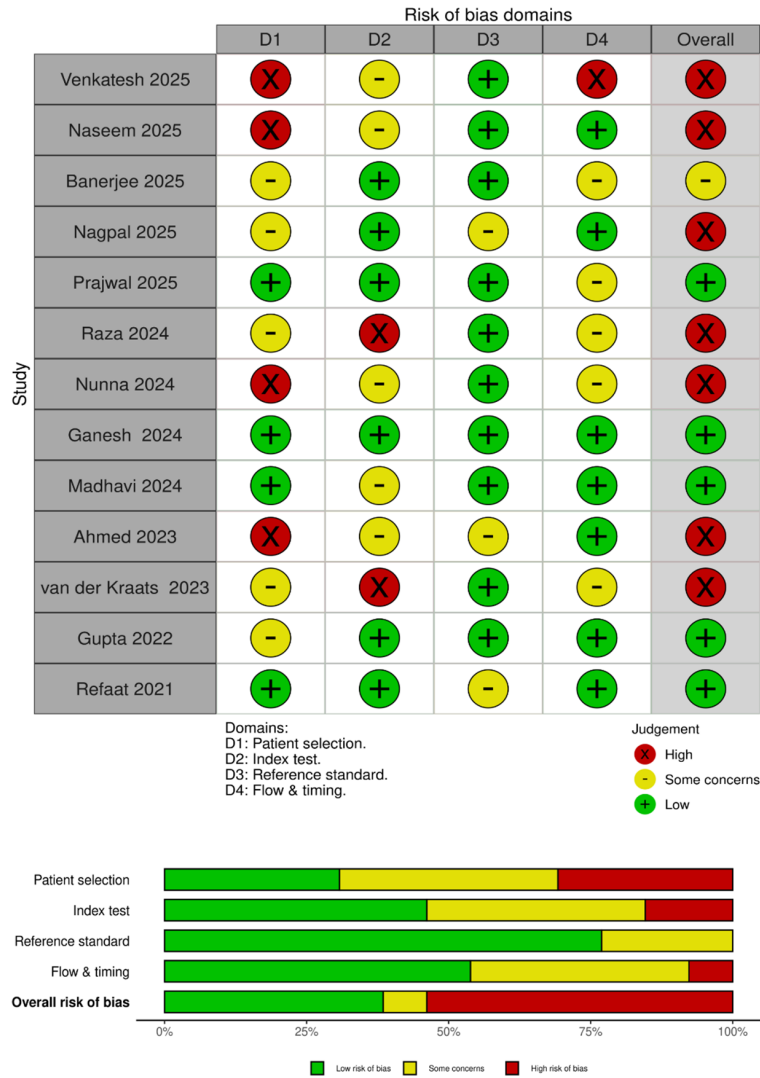


Figure 2. Quality assessment and bias risk assessment in the investigations included in this review.

ily due to concerns in patient selection and index test domains. Patient selection emerged as the most problematic area, with four studies rated as high risk [16, 17, 19, 20] and five with some concerns [18, 21, 23-25] in this domain. The index test domain also showed considerable variability, with two studies at high risk [18, 23] and six with some concerns [16, 17, 19, 20, 22, 25]. Conversely, five studies (38%) achieved low overall risk of bias [22, 24, 25, 27, 28], though only one study demonstrated low risk across all four domains [27]. Notably, the reference standard domain exhibited the most favorable performance, with the majority of studies achieving low risk of bias in this area.

Figure 2 illustrates the risk of bias across the different domains of the included studies. Four studies (Venkatesh et al. [21], Naseem et al. [22], Raza et al. [23], Nunna et al. [24], and Ahmed et al. [25]) were identified as having a high overall risk of bias. Venkatesh et al. [21] exhibited high bias in patient selection, index test, and flow and timing, while Naseem et al. [22] showed high bias in patient selection. Raza et al. [23] had high bias in the index test domain, and Nunna et al. [24] had high bias in patient selection. Ahmed et al. [25] also had a high bias in patient selection. Several other studies have raised concerns in various domains. Venkatesh et al. [21], Naseem et al. [22], Nagpal et al. [26], Raza et al. [23], Nunna et al. [24], Madhavi et al. [27], Ahmed et al. [25], van der Kraats et al. [28], Gupta et al. [29], and Refaat et al. [30] all had concerns regarding patient selection. Naseem et al. [22], Banerjee et al. [31], Nagpal et al. [26], Raza et al. [23], Nunna et al. [24], Madhavi et al. [27], Ahmed et al. [25], van der Kraats et al. [28], and Refaat et al. [30] raised concerns in the index test domain. In contrast, only one study, Ganesh et al. [32], had a low risk of bias across all four domains.

Study selection and characteristics

Thirteen studies with a total of 792 participants were included, with individual sample sizes ranging from 20 to 130 and mean ages between 36 and 66 years, reflecting an adult population at typical risk for rotator cuff pathology. Most cohorts showed a male predominance (approximately 43-86%), in line with the higher reported incidence of rotator cuff tears in men. All studies compared US to magnetic resonance imaging (MRI), which was the stan-

The diagnosis of the rotator cuff tears

standard reference in every case, and primarily evaluated supraspinatus pathology, with variable reporting for infraspinatus, subscapularis, and teres minor tendons [21-33].

Overall diagnostic performance of ultrasound

Across the 13 studies, US demonstrated consistently high diagnostic performance for rotator cuff tears, with particularly strong results for full-thickness lesions [21-33]. In multiple cohorts, sensitivity for any rotator cuff tear ranged from approximately 80% to over 90%, and specificity from the low 80% to mid-90% range, yielding overall accuracies commonly in the mid-80% to mid-90% range [21, 22, 25, 27, 29, 32, 33]. For example, studies using conventional cart-based US systems and experienced operators frequently reported accuracies above 88% and kappa values indicating substantial to near-perfect agreement with MRI, whereas studies with handheld US or less experienced operators showed lower accuracy and poorer inter-rater agreement [24, 25, 28, 29, 32]. As an illustration, Ganesh et al. [32] reported 91.2% sensitivity, 81.8% specificity, and 88.6% overall accuracy for US in detecting rotator cuff tears, whereas van der Kraats et al. [28] observed a sensitivity of 81.1%, specificity of 62.5%, and only fair concurrent validity with MRI for handheld US.

Full-thickness versus partial-thickness tears

When stratified by tear type, US performance was highest for full-thickness tears and more variable for partial-thickness tears [21-33]. Several studies reported 100% sensitivity, specificity, and accuracy of US for full-thickness supraspinatus tears, and one study found perfect agreement with MRI (κ up to 1.0) for full-thickness lesions [26, 29-31]. In contrast, partial-thickness tears showed sensitivity values mostly in the 72-94% range and accuracies around 76-94%, with some studies indicating only moderate agreement ($\kappa \approx 0.4-0.7$) and others achieving high accuracy when high-resolution probes and standardized protocols were used. For example, Banerjee et al. [31] reported 93.75% sensitivity and 94.4% accuracy for partial supraspinatus tears, whereas Nunna et al. [24] documented only moderate agreement for partial supraspinatus tears ($\kappa = 0.4$, 62.5% agreement). These patterns suggest that incomplete tendon disruption is more challenging to detect sonographically and that the diag-

nostic performance for partial-thickness tears is more susceptible to technical and operator-related factors.

Tendon-specific performance

Across studies, the supraspinatus tendon emerged as the most reliably assessed structure with US, showing the highest concordance with MRI [21-33]. Reported kappa values for supraspinatus full-thickness tears frequently fell in the substantial to almost perfect range ($\kappa \approx 0.9-1.0$), and both sensitivity and specificity for full-thickness supraspinatus tears approached or reached 100% in several cohorts [21, 25, 26, 29-32]. For infraspinatus and subscapularis tendons, US performance was more heterogeneous: some studies reported good to excellent agreement for complete tears, while others documented reduced sensitivities (down to about 44-60%) despite relatively preserved specificity, particularly for partial-thickness lesions [21, 23, 25, 27-29, 33]. Handheld US systems showed lower and more variable accuracy for non-supraspinatus tendons compared with conventional high-resolution devices, again underscoring the influence of equipment quality on tendon-specific performance.

The influence of technology, the operator, and patient factors on diagnostic performance

The US's diagnostic performance varied according to equipment type, operator expertise, and patient characteristics [21-25, 27-29, 32, 33]. Studies employing high-frequency linear probes operated by radiologists with several years of musculoskeletal US experience demonstrated higher sensitivity, specificity, and kappa values compared with studies that used handheld devices or less experienced sonographers [22, 25, 27-29, 32]. Naseem et al. [22] showed that overall US sensitivity, specificity, and accuracy reached 94%, 91%, and 92%, respectively, when examinations were performed by an experienced radiologist, yet stratified analyses revealed much poorer sensitivity in women and left-sided tears, indicating that body habitus, tear laterality, and possibly handedness may influence US visualization. Taken together, these findings indicate that US accuracy is not only modality-dependent but also highly contingent on standardized scanning techniques, operator training, and patient-related factors [21-25, 27-29, 32, 33].

The diagnosis of the rotator cuff tears

Comparison with MRI and clinical implications

Across the included studies, MRI consistently served as the reference standard and typically demonstrated equal or superior performance for partial-thickness tears and complex or multi-tendon pathology [21-33]. While US frequently matched MRI for full-thickness supraspinatus tears and showed high negative predictive value for excluding major cuff ruptures, MRI retained an advantage for small, intra-substance, or multi-tendon lesions and for comprehensive pre-operative planning [23, 25-27, 29, 30, 32, 33]. Overall, the synthesized data support the role of US as a highly accurate first-line test for suspected full-thickness rotator cuff tears, particularly of the supraspinatus, with MRI reserved for equivocal US findings, suspected partial-thickness or complex tears, and detailed surgical decision-making.

Discussion

The findings of this systematic review highlight a complementary, rather than competitive, relationship between US and MRI in the diagnostic work-up of RCTs, and they broadly align with previous meta-analyses showing high diagnostic accuracy for both modalities. In contemporary clinical practice, MRI remains the reference standard and is widely regarded as the gold standard for comprehensive assessment of rotator cuff pathology, a position that is consistent with prior network and conventional meta-analyses that have demonstrated slightly higher pooled sensitivity and specificity for MRI, particularly when all tear types are considered collectively. Within this framework, our synthesis confirms and extends earlier reports by showing that US can achieve diagnostic performance approaching that of MRI for selected indications, especially full-thickness supraspinatus tears, thereby supporting its role as a valuable auxiliary and, in appropriate contexts, first-line imaging modality rather than a universal substitute [34-36].

There is evidence of a complex diagnostic state from 13 trials involving 792 participants. Factors such as different types of tears (full-thickness and partial-thickness), the tendon involved, pathological characteristics of the tear, and patient demographics (patient age, sex, and tear location) have been known to influence the success of the procedure. The

diagnostic accuracy of US in full-thickness RCTs is a recurring finding across studies. Several investigations, including those by Refaat et al. [30], Banerjee et al. [31], Nagpal et al. [26], and Ahmed et al. [25], reported 100% sensitivity for full-thickness tears, particularly involving the supraspinatus tendon. This is corroborated by Gupta et al. [29], who observed perfect agreement between US and MRI for full-thickness tears ($\kappa = 1.0$), and Nunna et al. [24], who found near-perfect agreement for complete tears ($\kappa = 0.961$). In a prospective study of 50 patients, Ahmed et al. [25] reported 92.68% specificity, 94% accuracy, 75% PPV, and 100% NPV for complete tears. These modality-specific results are in line with earlier high-quality meta-analyses by Roy et al. [34], which showed that US, MRI, and MR arthrography all achieve sensitivities and specificities above 0.90 for full-thickness tears, and that US and MRI have statistically comparable accuracy for these lesions. Thus, our findings corroborate the existing evidence that, particularly for full-thickness tears, US can provide accuracy comparable to MRI, provided that examinations are performed with high-resolution equipment and sufficient operator expertise. However, this high accuracy is dependent on perfect technical circumstances and operator experience, which may not be consistently accessible in all clinical contexts [37].

In contrast, the detection of partial-thickness tears showed greater heterogeneity. Banerjee et al. [31] documented a high sensitivity of 93.75% and an accuracy of 94.4% for partial supraspinatus tears, and Naseem et al. [22] reported similar results, including a sensitivity of 94%, specificity of 91%, and accuracy of 92% for partial supraspinatus tears, whereas other studies have reported more moderate results. For instance, Prajwal et al. [33] reported an overall sensitivity of 72.5% for supraspinatus pathologies, Nunna et al. [24] noted only moderate agreement for partial tears ($\kappa = 0.4$), and Ahmed et al. [25] found 80.65% sensitivity, 100% specificity, 88% accuracy, 100% PPV, and 76% NPV for partial tears. This heterogeneity highlights a significant limitation of US for partial-thickness tears, likely due to minor acoustic changes associated with incomplete tendon damage, which pose inherent limitations for US visualization. In comparison, MRI consistently outperforms US for partial-thick-

The diagnosis of the rotator cuff tears

ness rips, and several studies have shown that it can identify tiny, intrasubstance, and bursal-side partial tears that US can miss. When clinical suspicion of partial-thickness rips arises, MRI is the modality of choice due to its multiplanar imaging capabilities and greater soft-tissue contrast [34, 35, 37].

The diagnostic accuracy also differs by tendon, which makes the comparison analysis even more complicated. US is the most reliable way to evaluate the supraspinatus tendon, and many studies have shown that it works well with MRI. Banerjee et al. [31] also found a good level of agreement for supraspinatus pathology ($\kappa = 0.954$), while Venkatesh et al. [21] revealed excellent agreement for tendinosis ($\kappa = 1.00$) and supraspinatus full-thickness tears ($\kappa = 0.94$). In support of this, Ahmed et al. [25] highlighted that 58-64% of cases involved the supraspinatus muscle and that there was generally a strong agreement ($\kappa = 0.807$) between the methods used to diagnose rotator cuff disorders. Farooqi et al. [37] found that US has very high sensitivity and specificity for supraspinatus tears and can attain performance similar to MRI for this tendon, especially for full-thickness abnormalities. These tendon-specific findings are in line with these findings.

The performance for other tendons was less consistent and generally worse, indicating an important clinical limitation of US. For the subscapularis tendon, findings vary from excellent concordance in certain studies to significantly diminished sensitivity in others; van der Kraats et al. [28] reported merely 60% sensitivity using handheld US, and Gupta et al. [29] observed low sensitivity for subscapularis tendinosis. Ahmed et al. [25] identified subscapularis involvement in 18-20% of cases, with good overall concordance but occasional discrepancies in tear classification. These heterogeneous results likely reflect the deeper anatomical location of the subscapularis tendon and the technical challenges of obtaining optimal sonographic windows. Comparable variability has been documented for the infraspinatus and teres minor tendons; although Nunna et al. [24] reported excellent agreement for infraspinatus partial tears ($\kappa = 0.974$), other studies have demonstrated more modest diagnostic indices. These observations align with previous imaging reviews indicating that deeper and more posteriorly situated tendons, as well as associated

muscle changes such as atrophy and fatty infiltration, are more accurately characterized by MRI than by ultrasound, particularly in the pre-operative setting [35-37]. Collectively, these findings support current recommendations that MRI should be preferred when detailed assessment of non-supraspinatus tendons and overall muscle quality is required.

Technology and the operator's expertise are the primary factors that influence US performance. Van der Kraats et al. [28] emphasized the operator-dependent character of handheld US by highlighting inter-rater variability ($\kappa = 0.465$ for supraspinatus evaluation). Ahmed et al. [25] emphasized the importance of skilled radiologists and high-resolution equipment in achieving optimal outcomes, which is consistent with the literature's recommendations for standardized procedures. Naseem et al. [22] further supported this by demonstrating overall US sensitivity of 94%, specificity of 91%, and accuracy of 92% when examinations were performed by an experienced radiologist using a 10-MHz linear probe; however, stratified analyses revealed notable variability, with superior results in men and right-sided tears contrasted by poor performance in women and left-sided tears. These findings echo earlier meta-analyses showing that, when performed by appropriately trained operators, US can achieve accuracy comparable to MRI, while also underscoring that real-world performance may be more variable because of differences in training, device quality, and scanning technique. Recent narrative reviews on imaging algorithms for RCTs have similarly highlighted that, although both US and MRI are accurate, MRI tends to show higher interobserver reliability and less dependence on local expertise, which helps explain its enduring status as the gold standard in many institutions [34-36].

MRI is currently used as the gold standard, while US is predominantly an auxiliary method—for example, in patients who are not suitable for MRI examination. The robust performance of US for full-thickness tears positions it as an effective initial screening tool, especially in settings with limited MRI availability or significant resource constraints. As noted by Ahmed et al. [25] and Naseem et al. [22], US offers advantages in terms of cost-effectiveness, rapid access, and real-time dynamic assessment, which can enhance patient triage and guide

The diagnosis of the rotator cuff tears

conservative management or injections. This is in agreement with prior imaging algorithms and cost-effectiveness analyses suggesting that US is often the most efficient first-line imaging choice for suspected full-thickness tears, whereas MRI or MR arthrography should be reserved for equivocal US examinations, suspected partial-thickness or complex tears, and pre-operative planning. The present review therefore supports, rather than contradicts, these existing recommendations by quantifying how US and MRI perform across different tear types and tendons.

Challenges and gaps

Despite technological progress, both US and MRI retain inherent limitations that shape their respective clinical roles in rotator cuff tear diagnosis. The US is constrained by operator dependency, challenges in visualizing deep or small partial-thickness tears, and variability in access to high-quality equipment and expert sonographers, particularly in low-resource regions-issues consistently highlighted across the included studies and prior meta-analyses [21-25, 27, 28, 32-34, 37]. MRI is more thorough for complex pathology, but it's pricier, harder to get, and takes longer to get results. It also has some contraindications, such as implanted devices, severe claustrophobia, and renal impairment when contrast is used. These trade-offs closely mirror those described in prior narrative reviews and health-system analyses, which conclude that MRI should remain the gold standard for definitive work-up and preoperative planning, while US is best integrated as a cost-effective adjunct and, often, as the initial imaging test after radiography [17, 18]. Our findings thus align with this evolving yet still MRI-centric diagnostic framework.

Both modalities have trouble finding small lesions, tendinosis, and subtle partial-thickness tears in tendons other than the supraspinatus. For instance, US sensitivity can drop to 44-60%, and inter-rater reliability is still low, especially with handheld devices [27, 28]. Obesity, pain that makes it hard to position the shoulder, and differences in anatomy all make US images less clear. MRI access problems also affect underserved groups more than others. Standardized diagnostic criteria and reporting remain lacking across studies, complicating meta-analyses due to heterogeneous

tear definitions, reference standards, and operator experience levels-a persistent gap noted in prior systematic reviews. Even though US is easier to get to, the fact that skilled musculoskeletal sonographers are not evenly spread around the world makes it less reliable in real life than MRI, which works better in the lab.

Future directions

Advances in US technology, including high-resolution transducers and AI integration, could elevate its role as a primary diagnostic tool, with studies reporting up to 91.2% sensitivity and 88.6% accuracy for supraspinatus tears [32]. This may narrow the gap between US and MRI for various RCTs. Better patient stratification is key, as US underperforms for partial-thickness tears in the infraspinatus and subscapularis tendons [21, 33]. Further studies need to examine customized protocols, elastography, or contrast-enhanced ultrasound for subtle lesions. AI and machine learning have the potential to standardize acquisition, reduce operator dependency, and enhance detection in intricate cases, as evidenced by the variability in operator agreement [28]. Comparative studies are vital to assessing the cost-effectiveness, success of the outcomes, and most beneficial US-MRI sequencing for patients. MRI innovations such as shorter procedures and metal removal artifacts have the potential to enhance its practice among patients with devices and claustrophobes.

Conclusion

This systematic review shows that ultrasound offers excellent accuracy for full-thickness rotator cuff tears, particularly of the supraspinatus tendon, but demonstrates greater variability for partial-thickness tears and non-supraspinatus tendons. MRI therefore remains the gold standard for comprehensive assessment, especially for partial tears, complex or multi-tendon pathology, and pre-operative planning, while US is best used as a complementary, often first-line option in patients unsuitable for MRI or in resource-limited settings, and as a cost-effective tool for dynamic evaluation and image-guided interventions.

Disclosure of conflict of interest

None.

The diagnosis of the rotator cuff tears

Address correspondence to: Farshad Riahi, Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran. Tel: +98-818-519-1953; Fax: +98-3137265007; E-mail: farshadriahi@gmail.com

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