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Systematic Review

Ultrasound vs. MRI Assessment of Rotator Cuff Tear Severity: A Systematic Review and Meta-Analysis of Supraspinatus Tears

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Abstract

Rotator cuff tears involving the supraspinatus tendon are a common cause of shoulder pain. Ultrasound (US) is accessible, dynamic, and less costly than MRI, but its diagnostic performance may vary with tear severity and operator expertise. This systematic review and meta-analysis evaluated the diagnostic performance of US for supraspinatus tears using MRI as the non-invasive reference imaging standard. MEDLINE, Embase, Scopus, and CINAHL Plus were searched for studies published from January 2015 to June 2026, and study quality was assessed using QUADAS-2. A total of 23 studies involving 1452 participants were included. Mean sensitivity, specificity, and accuracy were 89.7%, 97.3%, and 95.4%, respectively, for full-thickness tears, compared with 71.6%, 93.1%, and 80.2% for partial-thickness tears. HSROC analysis excluding studies with high overall risk of bias showed pooled sensitivity and specificity of 83% and 88% for any tear, 67% and 91% for partial-thickness tears, and 72% and 97% for full-thickness tears. Agreement was generally more consistent for full-thickness tears, while operator expertise and study quality varied. Overall, US demonstrated stronger diagnostic performance for full-thickness than partial-thickness supraspinatus tears and may be considered an accessible initial imaging option in appropriate clinical settings, with MRI remaining complementary for equivocal or subtle partial-thickness tears and preoperative assessment.

Keywords: ultrasound; magnetic resonance imaging; supraspinatus tendon tear; rotator cuff; partial-thickness tear; full-thickness tear

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1. Introduction

The shoulder is a highly mobile and complex joint whose function depends largely on the rotator cuff, comprising the supraspinatus, infraspinatus, teres minor, and subscapularis muscles and tendons [1,2]. Rotator cuff tears (RCTs) are a common cause of shoulder pain and dysfunction in adults, accounting for 30–70% of cases [3]. The supraspinatus is most frequently affected because of its anatomical position and repetitive mechanical loading [3–5]. Tears may result from acute trauma or, more commonly, age-related degeneration, overuse, or impingement [1].

Athletes involved in overhead sports such as baseball, tennis, and swimming are particularly at risk of partial- and full-thickness tears [6,7], which can impair performance and delay return to sport [6,7]. Common symptoms include pain, weakness, limited

motion, and functional impairment [8]. Although physical examination maneuvers such as the empty can test [9], drop arm test [10], and Neer sign [11] may suggest rotator cuff pathology, imaging is often required to confirm the diagnosis, determine tear severity, and guide management [12].

Distinguishing partial- from full-thickness tears is clinically important because tear severity influences management. Partial-thickness tears are often managed conservatively, whereas full-thickness tears may require surgical repair depending on symptoms and tear characteristics [13]. Although arthroscopy is considered the definitive reference standard for confirming rotator cuff tears, it is invasive and generally reserved for operative management. MRI therefore serves as the principal non-invasive reference imaging modality for preoperative assessment, providing detailed visualization of tear extent, tendon retraction, muscle atrophy, and associated pathology [14,15]. Earlier reviews used arthroscopy as the definitive reference, supporting MRI as a suitable non-invasive comparator for US [16]. However, MRI is costly, may involve long waiting times, and may be unsuitable or less accessible for some patients [15,17,18].

Ultrasound (US) provides accessible, low-cost, real-time musculoskeletal (MSK) imaging [19], but remains operator-dependent and may be limited by obesity and reduced visualization of intra-articular structures [20,21]. Despite these limitations, ultrasound remains more affordable and accessible than MRI, particularly with the increasing availability of handheld and point-of-care systems [22–24]. POCUS may further expand access to rapid bedside MSK assessment, although evidence for rotator cuff evaluation remains limited [25,26]. Together, these advantages support ultrasound as a practical first-line imaging option for suspected rotator cuff pathology, especially where timely MRI access is limited.

For orthopedic practice, a reliable and accessible first-line imaging strategy may support earlier tear detection, referral, and treatment planning, while reserving MRI for equivocal or complex cases [27]. Advances in portable and high-resolution ultrasound further support its growing first-line role, while emerging AI-assisted approaches may improve diagnostic accuracy and reduce interobserver variability [28].

Rationale for this review:

This review focuses specifically on the supraspinatus tendon, the most commonly affected rotator cuff tendon and one that is readily assessed using ultrasound. Studies published from 2015 onward were included to reflect contemporary ultrasound technology and clinical practice. Earlier systematic reviews often incorporated older imaging technologies or evaluated the rotator cuff collectively, limiting tendon- and tear-specific interpretation [13,16,29]. More recent work has largely provided qualitative comparisons of US and MRI [30], leaving an important gap in contemporary quantitative evidence. Therefore, the objective of this systematic review and meta-analysis was to evaluate the diagnostic performance of ultrasound relative to MRI for supraspinatus tendon tears, with separate assessment of any, partial-thickness, and full-thickness tears.

The key contribution of the present review is a supraspinatus-specific, tear-stratified quantitative assessment of ultrasound performance. Rather than combining rotator cuff tears into a single diagnostic category, we separately evaluate any, partial-thickness, and full-thickness supraspinatus tears, allowing performance to be interpreted according to tear severity. This distinction is clinically important because partial- and full-thickness tears differ in diagnostic difficulty and may influence management. By integrating pooled diagnostic estimates with agreement, study quality, operator expertise, and equipment-related variability, this review provides a clinically informative assessment of where ultrasound performs reliably and where MRI remains complementary, while also identifying gaps in handheld and POCUS-based shoulder imaging.

2. Materials and Methods

2.1. Information Sources and Search Strategy

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines [31]. The completed PRISMA 2020 checklist is provided in the Supplementary Materials. The review was not prospectively registered, and no separate review protocol was published. A comprehensive literature search was conducted in MEDLINE, Embase, Scopus, and CINAHL Plus for English-language studies published between 1 January 2015 and 1 June 2026. The search strategy combined keywords, subject headings, and Boolean operators related to *ultrasound, magnetic resonance imaging, rotator cuff tears, supraspinatus, diagnostic accuracy*. Database-specific search strategies were adapted to the indexing and syntax requirements of each database and are provided in Table 1. Covidence was used for duplicate removal and study screening (Veritas Health Innovation, Melbourne, Australia).

Table 1. Information sources and search strategies applied across the included databases.

Database	Search Strategy
CINAHL Plus with Full Text	1: (MH "Ultrasonography") OR (Ultrasound OR ultrasonograph*) 2: (MH "Magnetic Resonance Imaging") OR ("Gold standard" OR MRI) 3: (MH "Rotator Cuff") OR ((supraspinatus OR subscapularis OR infraspinatus OR "teres minor") N6 (tear* OR retear* OR torn OR rupture* OR lesion* OR injury*)) 4: (MH "Sensitivity and Specificity") OR (sensitivity OR specificity OR "diagnostic accuracy" OR "reference standard" OR "predictive value*" OR PPV OR NPV OR "false positive*" OR "false negative*" OR "true positive*" OR "true negative*" OR "likelihood ratio*" OR "receiver operating characteristic*" OR "ROC curve*") 5: S1 AND S2 AND S3 AND S4
Embase and MEDLINE	1: ultrasound/ 263,072; 2: (Ultrasound OR ultrasonograph*).tw,kf. 727,131; 3: 1 OR 2 799,195; 4: nuclear magnetic resonance imaging/ 1,152,064 5: ("Gold standard" OR MRI OR "magnetic resonance imaging").tw,kf. 1,035,630; 6: 4 OR 5 1,514,139; 7: rotator cuff injury OR rotator cuff rupture/ 15,751 8: (("rotator cuff" OR supraspinatus OR subscapularis OR infraspinatus OR "teres minor") (tear* OR retear* OR torn OR rupture* OR injury*)).mp. 20,675; 9: 7 OR 8 20,675; 10: accuracy 346,741; 11: "sensitivity and specificity"/ 554,449 12: (sensitivity OR specificity OR "diagnostic accuracy" OR "reference standard" OR "predictive value*" OR PPV OR NPV OR "false positive*" OR "false negative*" OR "true positive*" OR "true negative" OR "likelihood ratio*" OR "receiver operating characteristic*" OR "ROC curve*").mp. 3,146,780 13: 10 OR 11 OR 12 3,146,780; 14: 3 AND 6 AND 9 AND 13 295 15: limit 14 to (conference abstracts OR "preprints (unpublished, non-peer reviewed)") 29; 16: 14 NOT 15 266; 17: limit to yr = "2015–Current" 189
Scopus	TITLE-ABS (Ultrasound OR ultrasonograph*) AND TITLE-ABS-KEY ("Gold standard" OR MRI OR "magnetic resonance imaging") AND TITLE-ABS-KEY (("rotator cuff" OR supraspinatus OR subscapularis OR infraspinatus OR "teres minor") W/6 (tear* OR retear* OR torn OR rupture* OR lesion* OR avulsion* OR injury*)) AND TITLE-ABS-KEY (sensitivity OR specificity OR "diagnostic accuracy" OR "reference standard" OR "predictive value*" OR PPV OR NPV OR "false positive*" OR "false negative*" OR "true positive*" OR "true negative" OR "likelihood ratio*" OR "receiver operating characteristic*" OR "ROC curve*") AND PUBYEAR >= 2015 AND PUBYEAR <= 2026

Note: The asterisk (*) denotes a truncation wildcard used to retrieve variations of a search term.

2.2. Study Selection and Eligibility Criteria

Eligibility criteria were defined using the PICO framework [32]. The population included subjects with shoulder pain or suspected rotator cuff pathology, with a specific focus on supraspinatus tendon tears. Ultrasound was the index test, and MRI served as the non-invasive reference imaging standard. Although MRI is not a definitive gold standard, particularly for partial-thickness tears, it was selected as a widely accepted non-invasive comparator. Therefore, the reported diagnostic performance measures reflect ultrasound findings relative to MRI rather than absolute diagnostic accuracy against arthroscopy. Outcomes of interest included sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) for detecting supraspinatus tears.

Original, full-text clinical studies were eligible if they directly compared ultrasound with MRI and reported supraspinatus-specific quantitative diagnostic outcomes. Animal and cadaveric studies, conference abstracts, systematic reviews, meta-analyses, case reports, non-English publications and studies without quantitative diagnostic data were excluded. Studies with fewer than 20 participants were excluded to minimize unstable diagnostic estimates, particularly in tear-specific analyses. For the meta-analysis, studies with a high overall risk of bias under QUADAS-2 or insufficient 2×2 diagnostic data were excluded.

2.3. Data Collection Process and Extraction

Two authors (K.K. and S.G.) independently screened titles, abstracts, and full texts, with disagreements resolved through discussion and consensus or, when necessary, by a third author (A.H.). Data from included studies were extracted into a standardized Microsoft Excel template. K.K. performed the initial extraction, and S.G. independently verified the data for accuracy. Extracted variables included study design, sample size, population characteristics, ultrasound system, operator experience, tear type, reference standard, and diagnostic outcomes. These included sensitivity, specificity, agreement statistics (κ values and p-values), and study-level results for normal, partial-thickness, and full-thickness supraspinatus tears.

To enable formal meta-analysis, 2×2 diagnostic data comprising TP, FP, FN, and TN were extracted separately for any supraspinatus tear, partial-thickness supraspinatus tears, and full-thickness supraspinatus tears wherever available. Exact Clopper-Pearson 95% confidence intervals for sensitivity and specificity were also calculated for each tear category. Notes on study limitations and other relevant methodological considerations were recorded during data extraction.

2.4. Quality and Risk of Bias Assessment

The risk of bias and applicability of the included studies were evaluated using the Quality Assessment of Diagnostic Accuracy Studies–2 (QUADAS-2) tool [33]. Two authors (K.K. and S.G.) independently assessed each study across four domains for risk of bias: patient selection, index test, reference standard, and flow and timing, and across three domains for applicability: patient selection, index test, and reference standard. Each domain was rated as low, high, or unclear (some concerns). For visualization purposes, the term "some concerns" was used to represent unclear judgments, primarily reflecting insufficient reporting of methodological details. In this review, ultrasound was considered the index test and MRI the reference imaging standard. Any disagreements between reviewers were resolved through discussion and consensus.

2.5. Diagnostic Meta-Analysis Methodology

Due to variability in study design and reporting, complete 2×2 diagnostic data were available for only a subset of studies. Where available or derivable, TP, FP, FN, and TN were

used to assess ultrasound diagnostic performance relative to MRI. Studies lacking sufficient 2 × 2 diagnostic data or classified as having a high overall risk of bias under QUADAS-2 were excluded from the quantitative meta-analysis but retained in the qualitative synthesis.

Hierarchical Summary Receiver Operating Characteristic (HSROC) analyses and forest plots [34] were generated using the *metafor* package in R version 4.4.1 [35]. These analyses were used to obtain pooled estimates of sensitivity and specificity with corresponding 95% confidence intervals and to visualize variability in diagnostic performance across studies. Separate meta-analyses were conducted for any supraspinatus tear, partial-thickness supraspinatus tears, and full-thickness supraspinatus tears, allowing diagnostic performance to be evaluated according to tear severity.

3. Results

3.1. Study Selection

A total of 615 records were identified through database searches, including Embase (n = 229), Scopus (n = 198), MEDLINE (n = 140), and CINAHL (n = 48), and imported into Covidence. After removal of 331 duplicates, 284 records remained for title and abstract screening within the prespecified publication period of 1 January 2015, to 1 June 2026. Following screening against the predefined eligibility criteria, 86 full-text articles were sought for retrieval, of which one could not be retrieved. The remaining 85 articles were assessed for eligibility. Of these, 62 were excluded because of a wrong comparator (n = 27), wrong study design (n = 14), wrong patient population (n = 8), or irrelevant outcomes (n = 13). **Finally, 23 studies met the inclusion criteria and were included in the systematic review.** The study selection process is illustrated in the PRISMA flow diagram (Figure 1). All 23 studies were included in the qualitative synthesis. After excluding studies with a high overall risk of bias under QUADAS-2 or insufficient diagnostic data, 7 studies contributed to the meta-analysis of any supraspinatus tear, 7 to partial-thickness tears, and 8 to full-thickness tears.

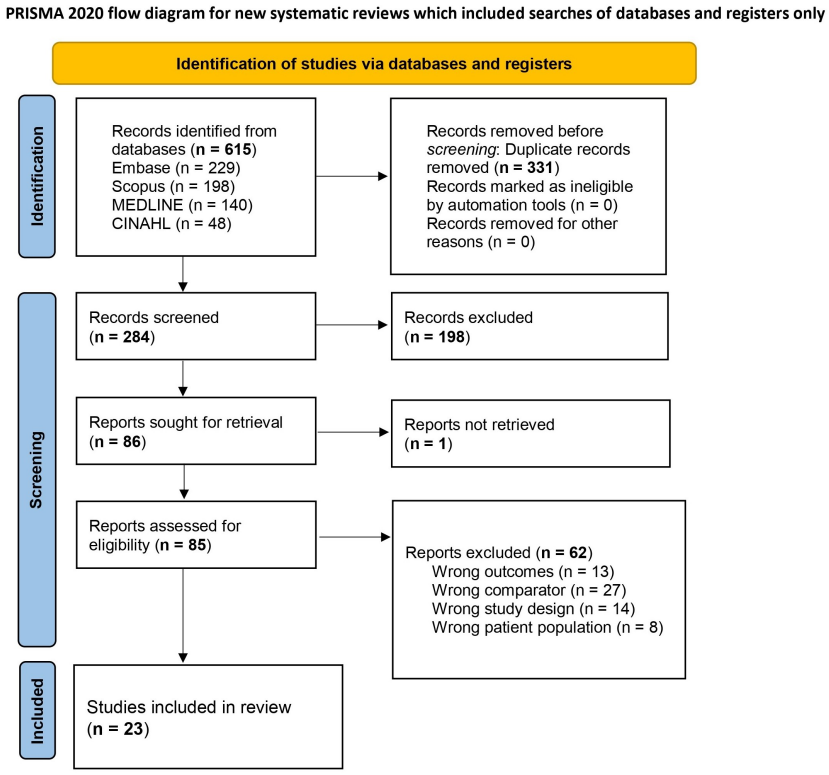


Figure 1. PRISMA flow diagram illustrating the identification, screening, eligibility assessment, and inclusion of studies in the systematic review.

3.2. Study Characteristics

The 23 included studies were published between 2015 and 2026 and reflected contemporary ultrasound technology and clinical practice. Of these, 17 were prospective, four retrospective, and two cross-sectional studies. Sample sizes ranged from 25 to 138 participants, comprising a total of 1452 participants. Where reported, mean participant age ranged from 38.8 to 68.3 years. Most studies evaluated both partial- and full-thickness supraspinatus tears, while two studies focused on partial-thickness tears only. Most studies used conventional ultrasound systems with high-frequency linear-array transducers, with reported frequencies ranging from approximately 3 to 18 MHz. One study specifically evaluated a handheld ultrasound system. Operators included radiologists, musculoskeletal radiologists, orthopedic surgeons, sonographers, and a radiology trainee under specialist supervision, although operator experience was not reported in several studies. The characteristics of the included studies are summarized in Table 2.

Table 2. Characteristics of the included studies comparing supraspinatus US with MRI ($n = 23$).

Author (Year)	Study Design	Sample Size and Mean Age	Tear	US Scanner	US Operator
Banerjee (2025) [36]	Prospective	SS = 50; MA = NS	Partial and Full	GE Voluson S6 Pro (7–12 MHz)	Radiologist
Barad (2022) [37]	Prospective	SS = 50; MA = 51.2	Partial	NS	NS
Elgamal (2026) [38]	Prospective	SS = 25; MA = 46.4	Partial and Full	Toshiba Ultrasound Aplio 500	Two radiologists (14 and 7 years of MSK experience)
Fischer (2015) [39]	Prospective	SS = 45; MA = 68.3	Partial and Full	GE Logiq P5 (10 MHz)	Orthopedic surgeon with over ten years of experience in shoulder US
Furtado (2024) [40]	Prospective	SS = 112; MA = NS	Partial	Siemens ACUSON S2000 (7.5–14 MHz)	Radiologist
Ganesh (2024) [41]	Prospective	SS = 53; MA = 48.6	Partial and Full	GE Voluson S8 (9 MHz)	Radiologist specializing in MSK imaging with eight years of experience
Ghosh (2025) [42]	Retrospective	SS = 138; MA = 51.5	Partial and Full	GE Logiq E9 with ML6-15-D linear-array transducers	NS
Gupta (2022) [43]	Prospective	SS = 50; MA = 56	Partial and Full	GE Voluson E6/Samsung HS70A (8–15 MHz)	Radiology resident under supervision of a senior radiologist
Khan (2024) [44]	Prospective	SS = 40; MA = NS	Partial and Full	Samsung HS70A	Radiologist
Kraats (2023) [45]	Retrospective	SS = 61; MA = 64	Partial and Full	Philips Lumify L12-4 linear-array transducer	Orthopedic surgeon and MSK radiologist
Mandloi (2024) [46]	Prospective	SS = 50; MA = NS	Partial and Full	NS	NS
Mohtasib (2019) [47]	Retrospective	SS = 86; MA = 53.7	Partial and Full	Philips IU22, EPIQ 7 (3–12 MHz)	MSK radiologist and radiology fellow
Murugan (2023) [48]	Prospective	SS = 90; MA = 40.5	Partial and Full	Philips Affiniti 70G (12–3 MHz)	Radiologist
Nunna (2024) [49]	Prospective	SS = 80; MA = NS	Partial and Full	Aloka Hitachi (12–18 MHz)	NS

Table 2. *Cont.*

Author (Year)	Study Design	Sample Size and Mean Age	Tear	US Scanner	US Operator
Padhy (2023) [50]	Prospective	SS = 30; MA = 52	Partial and Full	NS	NS
Pandya (2025) [51]	Prospective	SS = 84; MA = NS	Partial and Full	Conventional USG	NS
Paul (2026) [52]	Cross-sectional	SS = 70; MA = 39.7	Partial and Full	NS	NS
Rajkumar (2025) [53]	Prospective	SS = 45; MA = 38.8	Partial and Full	Philips HD 11 XE (12–3 MHz)	Radiologist
Roshini (2024) [54]	Prospective	SS = 40; MA = 43	Partial and Full	Mindray DC8 (7–12 MHz)	NS
Stephen (2026) [55]	Cross-sectional	SS = 60; MA = 67.6	Partial and Full	Mindray DC 80 (6–12 MHz)	NS
Varma (2024) [56]	Prospective	SS = 35; MA = NS	Partial and Full	Philips Affiniti 70 (5–12 MHz)	MSK sonographer
Venkatesh (2025) [57]	Retrospective	SS = 78; MA = 43.7	Partial and Full	Samsung HS70A, GE Voluson S8, Samsung HS40	NS
Yazigi (2018) [58]	Prospective	SS = 80; MA = 48.9	Partial and Full	NR (10 MHz)	Two radiologists

Note: SS = Sample Size; MA = Mean Age; US = Ultrasound; MSK = Musculoskeletal; NS = Not Specified; NR = Not Reported.

3.3. Risk of Bias Assessment Results

In Figure 2, the term "some concerns" represents unclear risk-of-bias judgments under the QUADAS-2 framework, primarily reflecting insufficient reporting of methodological details. Overall, most studies demonstrated a low risk of bias in the patient-selection domain, although Kraats et al. [45], Mohtasib et al. [47], Varma et al. [56], and Venkatesh et al. [57] were judged to be at high risk. In the index-test and reference-standard domains, several studies were rated as having an unclear risk of bias, largely because of insufficient reporting of methodological safeguards such as blinding. Elgamal et al. [38] was the only study judged to be at high risk in the index-test domain, while Mohtasib et al. [47] was the only study rated at high risk in the reference-standard domain. Flow and timing also frequently received unclear judgments, with Kraats et al. [45] and Mohtasib et al. [47] being the only two studies judged to be at high risk in this domain (see Figure 2 for details).

Overall, unclear risk-of-bias judgments predominated. Five studies were judged to have an overall high risk of bias: Elgamal et al. [38], Kraats et al. [45], Mohtasib et al. [47], Varma et al. [56], and Venkatesh et al. [57]. Four studies—Gupta et al. [43], Pandya et al. [51], Rajkumar et al. [53], and Roshini et al. [54]—were judged to have an overall low risk of bias, while the remaining 14 studies received unclear judgments. These judgments were most commonly associated with insufficient methodological reporting involving the index test, reference standard, and flow-and-timing domains.

3.4. Diagnostic Performance of Ultrasound for Supraspinatus Tears

3.4.1. Overall Diagnostic Performance

Diagnostic performance was assessed against MRI, with tear-specific sensitivity, specificity, PPV, NPV, and accuracy summarized in Table 3. Studies reporting combined tear outcomes were summarized separately in Table 4A. Where complete 2 × 2 data were available, studies were also included in the meta-analysis of any supraspinatus tear.

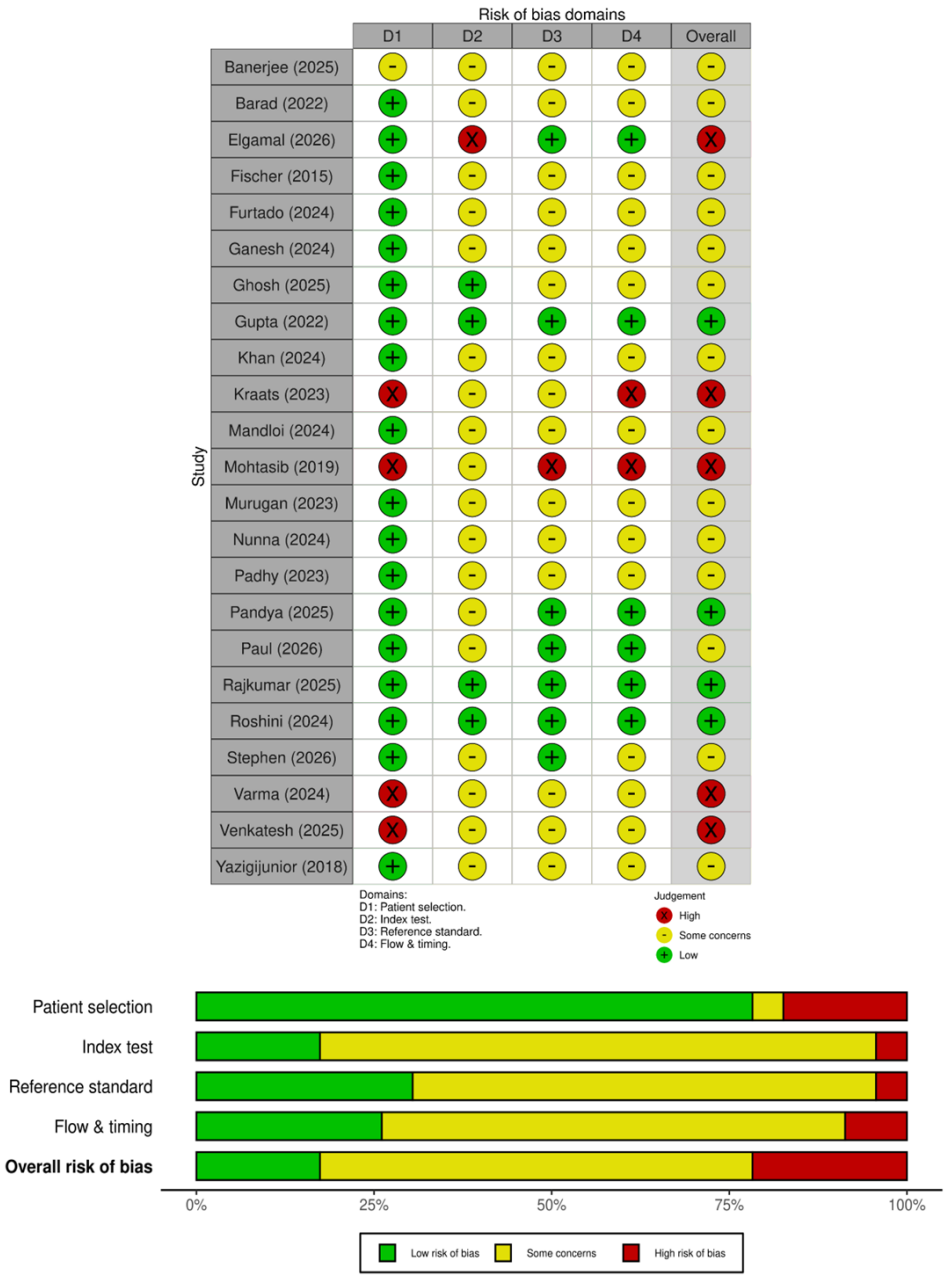


Figure 2. QUADAS-2 risk-of-bias assessment of the included diagnostic accuracy studies [36–58]. The upper panel shows study-level risk-of-bias judgments across the four QUADAS-2 domains and the overall assessment, while the lower panel summarizes the proportion of studies rated as low (green), some concerns (yellow), or high (red) risk of bias.

Across studies with tear-specific data, ultrasound demonstrated stronger and more consistent diagnostic performance for full-thickness than for partial-thickness supraspinatus tears. For partial-thickness tears, mean sensitivity, specificity, and accuracy were 71.6% ± 23.3%, 93.1% ± 8.0%, and 80.2% ± 12.7%, respectively. For full-thickness tears, the corresponding values were 89.7% ± 16.3%, 97.3% ± 4.9%, and 95.4% ± 5.8%, respectively. These study-level averages indicate higher diagnostic performance and lower variability for full-thickness supraspinatus tears, particularly for sensitivity and overall accuracy.

3.4.2. Partial-Thickness Supraspinatus Tears

Across the 17 studies reporting separate diagnostic performance for partial-thickness supraspinatus tears, sensitivity ranged from 25.8% to 98.0%. 11 studies (64.7%) reported sensitivity $\geq$ 70%, while 6 (35.3%) reported sensitivity $<$ 70%. Specificity ranged from 70.0% to 100%, with 11 of 17 studies (64.7%) reporting specificity $\geq$ 90%. Overall accuracy, where reported, ranged from 58.0% to 94.4%.

3.4.3. Full-Thickness Supraspinatus Tears

Across the 15 studies reporting separate diagnostic performance for full-thickness supraspinatus tears, sensitivity ranged from 46.2% to 100%, with 10 studies (66.7%) reporting sensitivity $\geq$ 90%. Specificity ranged from 82.0% to 100%, with 14 of 15 studies (93.3%) reporting specificity $\geq$ 90%. Where reported, PPV ranged from 30.0% to 100% and NPV from 85.3% to 100%. Overall accuracy ranged from 83.0% to 100%, with 10 of 12 studies (83.3%) reporting accuracy $\geq$ 90%. Overall, diagnostic performance was higher and more consistent for full-thickness than for partial-thickness supraspinatus tears. Study-level variation in sensitivity, specificity, and diagnostic accuracy for partial- and full-thickness tears is illustrated in Figure 3.

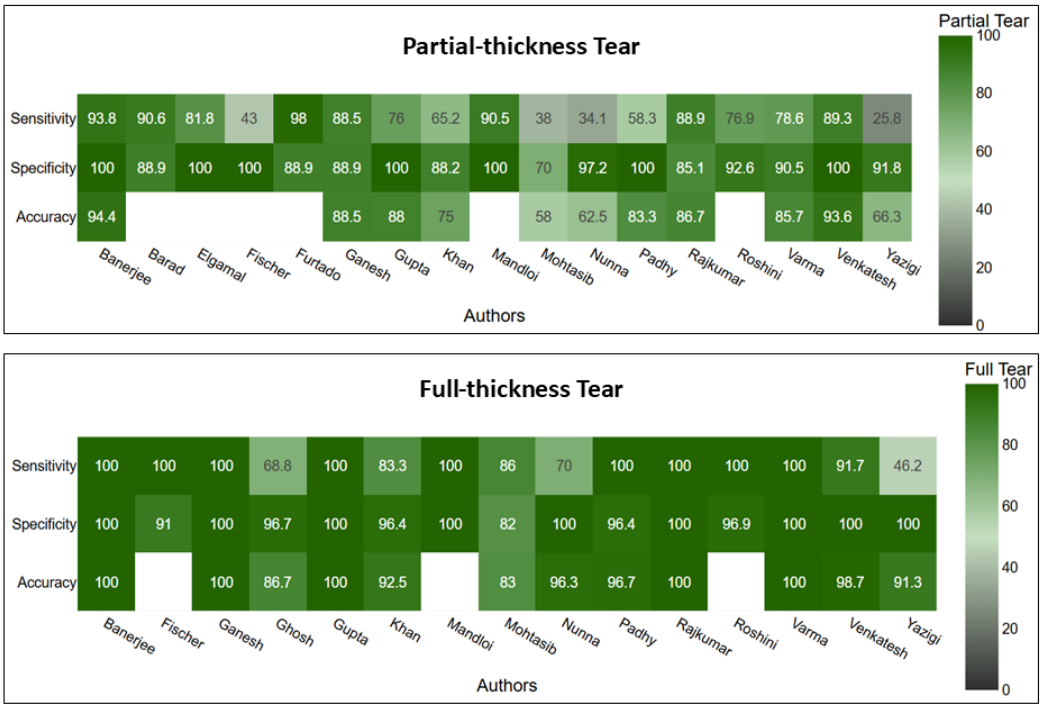


Figure 3. Heat maps showing sensitivity, specificity, and diagnostic accuracy for partial-thickness supraspinatus tears (**top**) and full-thickness supraspinatus tears (**bottom**). Blank cells indicate studies that did not report the corresponding diagnostic metric.

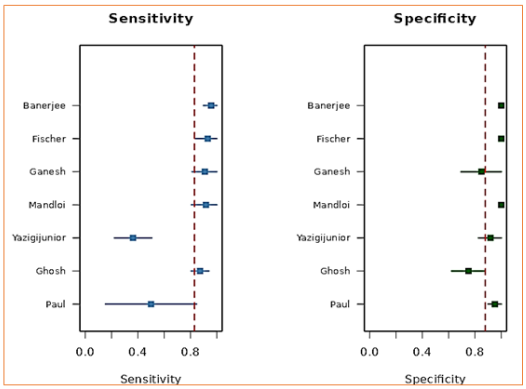
3.5. Diagnostic Meta-Analysis Results

Formal diagnostic meta-analysis was performed for studies with sufficient 2 $\times$ 2 contingency data, excluding those rated high risk of bias, using MRI as the reference imaging standard. Separate analyses were conducted for any supraspinatus tear, partial-thickness supraspinatus tears, and full-thickness supraspinatus tears. HSROC analyses and forest plots were used to summarize pooled sensitivity and specificity and their corresponding 95% confidence intervals.

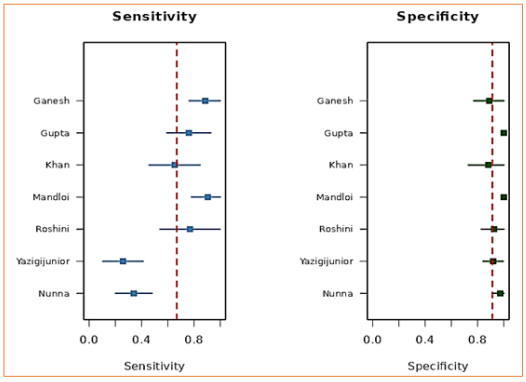
3.5.1. Any Supraspinatus Tear

Of the eight studies with available 2 × 2 diagnostic data and without a high overall risk of bias, Stephen et al. [55] were excluded because all participants had partial- or full-thickness supraspinatus tears, preventing estimation of specificity. HSROC analysis of the remaining 7 studies yielded a pooled sensitivity of 83% (95% CI: 63–93%) and specificity of 88% (95% CI: 78–94%) (Figure 4A). Substantial between-study heterogeneity remained, particularly for sensitivity, with estimated between-study variances (τ^2) of 1.69 for sensitivity and 0.37 for specificity on the logit scale.

(A) Forest plots of sensitivity and specificity for **Any Supraspinatus Tear** relative to MRI (**n = 7 studies** with complete 2 × 2 data and low or unclear risk of bias).



(B) Forest plots of sensitivity and specificity for **Partial-thickness Supraspinatus Tears** relative to MRI (**n = 7 studies** with complete 2 × 2 data and low or unclear risk of bias).



(C) Forest plots of sensitivity and specificity for **Full-thickness Supraspinatus Tears** relative to MRI (**n = 8 studies** with complete 2 × 2 data and low or unclear risk of bias).

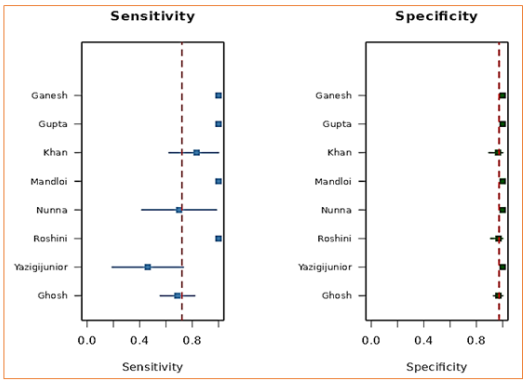


Figure 4. Forest plots of sensitivity and specificity for ultrasound detection of supraspinatus tears using MRI as the reference imaging standard: (**A**) any supraspinatus tear (n = 7 studies), (**B**) partial-thickness tears (n = 7 studies), and (**C**) full-thickness tears (n = 8 studies). The red dashed lines indicate the pooled estimates of sensitivity and specificity.

3.5.2. Partial-Thickness Supraspinatus Tear

7 studies provided complete 2 × 2 diagnostic data for partial-thickness supraspinatus tears after excluding studies with a high overall risk of bias. HSROC analysis yielded a pooled sensitivity of 67% (95% CI: 44–84%) and specificity of 91% (95% CI: 86–95%) (Figure 4B). Between-study variance was greater for sensitivity ($\tau^2 = 1.33$) than for specificity ($\tau^2 = 0.01$) on the logit scale, consistent with the greater variability in sensitivity observed in the descriptive analysis.

3.5.3. Full-Thickness Supraspinatus Tear

8 studies provided complete 2 × 2 diagnostic data for full-thickness supraspinatus tears after excluding studies with a high overall risk of bias. HSROC analysis yielded a pooled sensitivity of 72% (95% CI: 58–83%) and specificity of 97% (95% CI: 95–99%) (Figure 4C). Between-study variance was lower than that observed for any and partial-thickness tears, with $\tau^2 = 0.21$ for sensitivity and $\tau^2 = 0.03$ for specificity on the logit scale.

3.6. Kappa Values and Statistical Significance

Agreement was reported using kappa (κ) statistics in several studies. Five studies (Fischer, Ghosh, Gupta, Khan, and Venkatesh) [39,42–44,57] reported κ values for both partial- and full-thickness supraspinatus tears. Among these, Fischer, Ghosh, and Venkatesh also reported associated p-values. Across seven studies reporting κ values for partial-thickness tears, values ranged from 0.51 to 0.88. For full-thickness tears, five studies reported κ values ranging from 0.53 to 1.00. Overall, agreement tended to be higher and more consistent for full-thickness tears, although the type of agreement assessed and reporting methods varied across studies. Several additional studies reported p-values without corresponding κ estimates, limiting direct comparison of agreement across the full evidence base. Reported κ values and associated p-values are summarized in Table 4B.

Table 3. Comparison of ultrasound diagnostic performance for partial- and full-thickness supraspinatus tears assessed separately, using MRI as the reference standard (sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy).

Author	Sample and Age	Tear	Sens. (%)	Spec. (%)	Acc. (%)	PPV (%)	NPV (%)
Banerjee [36]	50; NS	Partial Full	93.8 100.0	100.0 100.0	94.4 100.0	– 100.0	– 100.0
Barad [37]	50; 51.2	Partial	90.6	88.9	–	93.5	84.2
Elgamal [38]	25; 46.4	Partial	81.8	100.0	–	100.0	87.5
Fischer [39]	45; 68.3	Partial Full	43.0 100.0	100.0 91.0	– –	– –	– –
Furtado [40]	112; NS	Partial	98.0	88.9	–	92.7	96.9
Ganesh [41]	53; 48.6	Partial	88.5 (70.0–97.6)	88.9 (70.8–97.7)	88.5 –	88.9 –	– –
		Full	100.0 (66.4–100.0)	100.0 (91.8–100.0)	100.0 –	– –	– –
Ghosh [42]	138; 51.5	Full	68.8 (53.7–81.3)	96.7 (90.6–99.3)	86.7 (81.1–92.3)	91.7 (78.1–97.1)	85.3 (79.2–89.8)
Gupta [43]	50; 56	Partial	76.0 (54.9–90.6)	100.0 (83.4–100.0)	88.0 –	100.0 –	80.6 –
		Full	100.0 (47.8–100.0)	100.0 (92.1–100.0)	100.0 –	100.0 –	100.0 –

Table 3. *Cont.*

Author	Sample and Age	Tear	Sens. (%)	Spec. (%)	Acc. (%)	PPV (%)	NPV (%)
Khan [44]	40; NS	Partial	65.2 (42.7–83.6)	88.2 (63.6–98.5)	75.0 –	88.2 –	65.2 –
		Full	83.3 (51.6–97.9)	96.4 (81.7–99.9)	92.5 –	90.9 –	93.1 –
Mandloi [46]	50; NS	Partial	90.5 (69.6–98.8)	100.0 (88.1–100.0)	– –	– –	– –
		Full	100.0 (29.2–100.0)	100.0 (92.5–100.0)	– –	– –	– –
Mohtasib [47]	86; 53.7	Partial	38.0	70.0	58.0	43.0	66.0
		Full	86.0	82.0	83.0	30.0	99.0
Nunna [49]	80; NS	Partial	34.1 (20.5–49.9)	97.2 (85.5–99.9)	62.5 –	93.8 –	54.7 –
		Full	70.0 (34.8–93.3)	100.0 (94.9–100.0)	96.3 –	100.0 –	95.9 –
Padhy [50]	30; 52	Partial	58.3	100.0	83.3	100.0	78.2
		Full	100.0	96.4	96.7	75.0	100.0
Rajkumar [53]	45; 38.8	Partial	88.9	85.1	86.7	80.0	92.0
		Full	100.0	100.0	100.0	100.0	100.0
Roshini [54]	40; 43	Partial	76.9 (46.2–95.0)	92.6 (75.3–98.7)	– –	83.3 –	89.3 –
		Full	100.0 (63.1–100.0)	96.9 (83.8–99.9)	– –	88.9 –	100.0 –
Varma [56]	35; NS	Partial	78.6	90.5	85.7	84.6	86.4
		Full	100.0	100.0	100.0	100.0	100.0
Venkatesh [57]	78; 43.7	Partial	89.3 (76.9–96.5)	100.0 (88.8–100.0)	93.6 –	– –	– –
		Full	91.7 (61.5–99.8)	100.0 (94.6–100.0)	98.7 –	– –	– –
Yazigi [58]	80; 48.9	Partial	25.8 (11.9–44.6)	91.8 (80.4–97.7)	66.3 –	66.7 –	66.2 –
		Full	46.2 (19.2–74.9)	100.0 (93.2–100.0)	91.3 –	100.0 –	90.5 –

Note: NS = Not Specified; NR = Not Reported. Values in parentheses represent reported 95% confidence intervals.

Table 4. Diagnostic performance and agreement statistics for ultrasound assessment of supraspinatus tears using MRI as the reference standard.

A. Combined partial- and full-thickness diagnostic outcomes							
Author	**Sample and Age**	**Tear**	**Sens. (%)**	**Spec. (%)**	**Acc. (%)**	**PPV (%)**	**NPV (%)**
Kraats [45]	61; 64	Combined	81.1	62.5	–	–	–
Murugan [48]	90; 40.5	Combined	69.7	64.3	68.9	91.4	28.1
Pandya [51]	84; NS	Combined	83.9	52.1	79.9	91.4	26.4
Paul [52]	70; 39.7	Combined	84.0	78.8	–	–	–
Stephen [55]	60; 67.6	Combined	88.3	–	–	100.0	–

Table 4. *Cont.*

B. Reported kappa (κ) statistics and *p*-values				
Author	**Sample and Age**	**Tear**	**κ**	***p*-value**
Barad [37]	50; 51.2	Partial Full	0.75 –	– –
Fischer [39]	45; 68.3	Partial Full	0.85 0.85	0.68 0.26
Furtado [40]	112; NS	Partial Full	0.88 –	<0.0001 –
Ganesh [41]	53; 48.6	Partial Full	– –	0.0012 0.0021
Ghosh [42]	138; 51.5	Partial	0.59 (0.46–0.72)	<0.0001
		Full	0.53 (0.34–0.70)	<0.0001
Gupta [43]	50; 56	Partial Full	0.76 1.0	– –
Khan [44]	40; NS	Partial Full	0.51 0.82	– –
Padhy [50]	30; 52	Partial Full	– –	0.5 0.4
Varma [56]	35; NS	Partial Full	– –	<0.001 –
Venkatesh [57]	78; 43.7	Partial Full	0.88 0.94	<0.0001 <0.0001
Yazigi [58]	80; 48.9	Partial Full	– –	0.031 <0.001

Note: NS = Not Specified; Sens. = Sensitivity; Spec. = Specificity; Acc. = Accuracy; PPV = Positive Predictive Value; NPV = Negative Predictive Value. Values in parentheses represent 95% confidence intervals for κ.

4. Discussion

This systematic review and meta-analysis provides a contemporary evaluation of ultrasound for supraspinatus tendon tears using MRI as the non-invasive reference imaging standard. Across 23 studies involving 1452 participants, ultrasound demonstrated stronger and more consistent performance for full-thickness than for partial-thickness tears. Mean sensitivity, specificity, and accuracy were higher for full-thickness tears (89.7%, 97.3%, and 95.4%) than for partial-thickness tears (71.6%, 93.1%, and 80.2%), respectively. This tear-specific difference is clinically important and highlights the need to interpret ultrasound performance according to tear severity.

Full-thickness tears produce complete structural disruption, whereas partial-thickness tears may be small, articular- or bursal-sided, and difficult to distinguish from tendinosis or imaging artefacts. Ultrasound is also susceptible to anisotropy, whereby subtle changes in probe orientation alter tendon echogenicity and may obscure small defects [59]. These factors likely explain the lower and more variable sensitivity observed for partial-thickness tears despite generally high specificity. This pattern suggests that ultrasound is more consistent for confirming obvious structural abnormalities than for excluding subtle partial-thickness pathology. Clinically, a negative or equivocal ultrasound examination should therefore be interpreted cautiously when suspicion for a partial-thickness tear remains high, supporting a complementary role for MRI in such cases.

The present findings are consistent with earlier evidence showing stronger ultrasound performance for full-thickness than partial-thickness tears. De Jesus et al. [13] found no significant difference between US and MRI, although their analysis included older imaging technologies and a broader rotator cuff population. Smith et al. [29] reported higher pooled sensitivity and specificity for full-thickness than partial-thickness tears, and Farooqi et al. [16] similarly found lower ultrasound performance for partial-thickness supraspinatus tears. Together, these studies support the consistent observation that full-thickness tears are detected more reliably. Our review extends this evidence by focusing specifically on the supraspinatus tendon and contemporary studies from 2015 onward. Compared with the recent 2026 review [30], which included 13 studies and was primarily qualitative, our review includes 23 studies and provides separate quantitative analyses for any, partial-thickness, and full-thickness tears. This tear-stratified approach reveals clinically important differences in diagnostic performance that may be obscured when tear categories are combined and provides a more clinically informative assessment of the role of ultrasound across tear severity.

Operator expertise and ultrasound equipment varied considerably across studies. Some involved experienced MSK radiologists or orthopedic surgeons with more than eight years of shoulder ultrasound experience [39,41], whereas others used radiologists, supervised trainees, or sonographers [36,40,43,44,48,56,58]; several studies did not report operator experience [37,46,49,50,54,57]. Most studies used conventional high-frequency systems, while only van der Kraats et al. [45] evaluated a handheld device. That study reported 81.1% sensitivity and 62.5% specificity, with high intrarater but lower interrater agreement, highlighting persistent operator dependence. Overall, these findings emphasize the importance of operator training, standardized scanning protocols, and further validation of handheld and POCUS systems, particularly for partial-thickness tears.

Five studies reported diagnostic performance for partial- and full-thickness supraspinatus tears as a combined group. Van der Kraats et al. [45], Murugan et al. [48], Pandya et al. [51], and Paul et al. [52] demonstrated sensitivities of 81.1%, 69.7%, 83.9%, and 50.0%, respectively, with specificity ranging from 52.1% to 95.2%. Stephen et al. [55] reported a sensitivity of 88.3%, but specificity could not be estimated. Notably, Paul et al. [52] reported sensitivity and specificity of 84.0% and 78.8% in the article text; however, recalculation from their supraspinatus-specific 2×2 diagnostic data yielded 50.0% and 95.2%, respectively, which were used in the quantitative analysis. These combined estimates should be interpreted cautiously, as combining partial- and full-thickness tears may obscure clinically important differences in diagnostic performance. This highlights the importance of tear-stratified analyses whenever sufficient data are available.

Across studies reporting kappa (κ) statistics, agreement values ranged from 0.51 to 0.88 for partial-thickness tears and from 0.53 to 1.00 for full-thickness tears. High agreement for full-thickness tears was reported by Gupta et al. [43] ($\kappa = 1.00$) and Venkatesh et al. [57] ($\kappa = 0.94$), while agreement for partial-thickness tears was more variable. However, the type of agreement assessed and reporting methods differed across studies, limiting direct comparison of κ values. Several studies also reported p-values without corresponding κ estimates. Overall, the available evidence suggests more consistent agreement for full-thickness tears, although agreement reporting remained limited and heterogeneous.

The QUADAS-2 assessment showed mixed study quality, with four studies at low overall risk of bias, five at high risk, and the remaining 14 classified as unclear. High overall risk was identified in Elgamal et al. [38], van der Kraats et al. [45], Mohtasib et al. [47], Varma et al. [56], and Venkatesh et al. [57]. High-risk judgments were primarily associated with patient selection, while unclear judgments in the index-test, reference-standard, and flow-and-timing domains often reflected insufficient methodological reporting, including

blinding procedures. Differences in the timing of ultrasound and MRI examinations may also have affected diagnostic agreement. These methodological limitations may partly explain the variability in diagnostic estimates and should be considered when interpreting the pooled findings.

From an orthopedic perspective, ultrasound and MRI have complementary roles in rotator cuff assessment. Ultrasound is an accessible, dynamic, and lower-cost first-line option, particularly for suspected full-thickness supraspinatus tears and in settings with limited MRI access [22,27]. Its greater variability for partial-thickness tears supports continued use of MRI for subtle or equivocal lesions and for detailed assessment of tear extent, retraction, muscle changes, associated pathology, and preoperative planning [14,15,27]. However, as the included studies primarily evaluated diagnostic performance rather than clinical outcomes or comparative diagnostic pathways, these findings should not be interpreted as establishing ultrasound as the preferred first-line imaging modality. Further prospective studies are needed to evaluate its role in clinical decision-making and diagnostic pathways.

A major strength of this review is the tear-stratified diagnostic meta-analysis, which assessed ultrasound performance separately for any, partial-thickness, and full-thickness supraspinatus tears. Due to variability in diagnostic reporting, only studies with sufficient reported or derivable 2×2 diagnostic data and without a high overall risk of bias under QUADAS-2 were included in the quantitative analyses. Accordingly, 7, 7, and 8 studies contributed to the analyses of any, partial-thickness, and full-thickness tears, respectively. Stephen et al. [55] were excluded from the any-tear analysis because the absence of MRI-negative cases prevented estimation of specificity. Pooled sensitivity and specificity were 83% and 88% for any tear, 67% and 91% for partial-thickness tears, and 72% and 97% for full-thickness tears, respectively. Full-thickness tears demonstrated higher pooled specificity and slightly higher sensitivity than partial-thickness tears, consistent with the direction of the descriptive findings. The pooled estimates were generally comparable to the descriptive results, particularly for specificity. However, the lower pooled sensitivity for full-thickness tears relative to the descriptive mean may reflect differences in study inclusion, statistical weighting, and between-study heterogeneity. Overall, these findings highlight the clinical relevance of tear-stratified analysis while emphasizing the need for cautious interpretation given the limited number of studies contributing to the meta-analysis.

Several limitations should be considered. Complete 2×2 data were available only for subsets of studies, limiting each meta-analysis. Additionally, the exclusion of studies with fewer than 20 participants, although intended to reduce the influence of very small samples, may have introduced selection bias and limited the comprehensiveness of the evidence synthesis. Heterogeneity in patient populations, ultrasound systems, operator expertise, scanning protocols, and reporting methods may also have influenced diagnostic estimates. Several studies had modest sample sizes, evidence for handheld ultrasound was limited to one study, and none evaluated a dedicated POCUS shoulder pathway. These factors may limit the generalizability of the pooled findings.

An additional limitation relates to the use of MRI as the reference imaging standard. Although MRI is widely accepted as a non-invasive modality for assessing rotator cuff pathology, its diagnostic performance is not perfect, particularly for subtle partial-thickness supraspinatus tears. Consequently, the sensitivity and specificity estimates reported in this review represent ultrasound performance relative to MRI rather than diagnostic accuracy established against a definitive reference standard such as arthroscopy. Potential misclassification by MRI may influence these estimates and should therefore be considered when interpreting the findings, particularly for partial-thickness tears.

Limitations of the review process should also be acknowledged. The review was restricted to English-language studies published from 2015 to 2026, focused specifically

on supraspinatus tendon tears, which improved the specificity of the analysis but limited generalizability to other rotator cuff tendons and tear patterns. MRI was used as the non-invasive reference standard, and studies using arthroscopy as the reference were not included, limiting comparison with definitive surgical findings. In addition, the search was limited to the selected databases and studies without sufficient or derivable 2×2 diagnostic data could not contribute to the quantitative meta-analysis.

The findings have implications for clinical practice, healthcare delivery, and future research. Ultrasound may serve as an accessible first-line imaging modality for suspected supraspinatus tears, particularly full-thickness tears, while MRI remains important for equivocal findings, subtle partial-thickness pathology, associated abnormalities, and preoperative planning. Wider use of appropriately performed ultrasound may also improve access to musculoskeletal imaging and reduce unnecessary MRI use, particularly in resource-limited settings. However, none of the included studies evaluated a dedicated POCUS shoulder pathway. Future research should therefore focus on standardized scanning protocols, defined operator training, handheld and POCUS-based approaches, and prospective multicenter evaluation of diagnostic performance, clinical outcomes, cost-effectiveness, downstream MRI use, and AI-assisted methods to reduce operator dependence [25,26,28].

5. Conclusions

Ultrasound demonstrated high specificity but moderate sensitivity for full-thickness supraspinatus tears, while partial-thickness tears remained more variable and challenging to detect. Tear-stratified analysis highlighted clinically important differences in diagnostic performance that may be obscured when tear categories are combined. Ultrasound may be considered an accessible initial imaging option in appropriate clinical settings, with MRI remaining complementary for equivocal or subtle partial-thickness tears, associated pathology, and preoperative planning. Standardized protocols, operator training, and further prospective clinical validation, including evaluation of handheld and POCUS-based approaches, may help strengthen the role of ultrasound in orthopedic practice.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jimaging12110586/s1, PRISMA 2020 Checklist.

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Abbreviations

The following abbreviations are used in this manuscript:

US	Ultrasound
MRI	Magnetic resonance imaging
RCT	Rotator cuff tear
MSK	Musculoskeletal
POCUS	Point-of-care ultrasound
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QUADAS-2	Quality Assessment of Diagnostic Accuracy Studies 2
HSROC	Hierarchical summary receiver operating characteristic
PPV	Positive predictive value
NPV	Negative predictive value
CI	Confidence interval

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