

Comparative Evaluation of Ultrasound Versus Magnetic Resonance Imaging to Diagnosis of Triangular Fibro-Cartilaginous Complex: Systematic Review

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ABSTRACT

Background: The triangular fibrocartilage complex (TFCC) is a key stabilizer of the distal radioulnar and ulnocarpal joints, and is commonly implicated in ulnar-sided wrist pain following trauma. While arthroscopy remains the diagnostic gold standard, non-invasive imaging modalities such as ultrasound and magnetic resonance imaging (MRI) are widely used for TFCC evaluation. This systematic review aims to compare the diagnostic accuracy of ultrasound and MRI in detecting TFCC injuries.

Methods: This review followed PRISMA guidelines. A comprehensive search was conducted across PubMed, Scopus, and Embase using MeSH terms and keywords related to TFCC, ultrasound, MRI, and diagnosis. Inclusion criteria encompassed studies comparing both imaging modalities with reported sensitivity, specificity, or diagnostic accuracy. Data were extracted on study design, imaging modalities, and outcomes. Risk of bias was assessed using the ROBINS-I tool.

Results: Four studies with sample sizes ranging from 30 to 72 patients were included. All studies evaluated ultrasound

and MRI performance in detecting TFCC injuries; one also included MR arthrography (MRA). Ultrasound showed high diagnostic performance, with sensitivity up to 99.1% and specificity up to 97.3% in experienced hands. However, MRI demonstrated superior accuracy in detecting deep intra-articular lesions, and MRA was most effective in evaluating subtle or equivocal findings. Operator dependency was a major limitation of ultrasound. The ROBINS-I assessment indicated an overall low risk of bias across all studies.

Conclusion: Ultrasound is an accessible, cost-effective, and efficient first-line modality for TFCC evaluation, particularly in acute or resource-limited settings. Nonetheless, MRI remains the gold standard for comprehensive assessment, and MRA is recommended for complex or inconclusive cases. Standardized ultrasound training is essential to optimize diagnostic reliability.

Keywords: Ultrasound, MRI, diagnostic imaging, triangular fibrocartilage complex

INTRODUCTION

The triangular fibrocartilage complex (TFCC) plays a pivotal role in stabilizing the distal radioulnar joint (DRUJ) and

ulnocarpal joint, and is frequently implicated in ulnar-sided wrist pain, particularly following trauma or repetitive strain. Accurate diagnosis of TFCC injuries is essential to guide appropriate management and prevent chronic wrist dysfunction. While arthroscopy remains the gold standard for definitive diagnosis, its invasive nature underscores the importance of reliable non-invasive imaging modalities (Daun et al., 2020)

Ultrasound and magnetic resonance imaging (MRI) are the two most commonly employed imaging techniques for TFCC evaluation. MRI, particularly with high-resolution 3-Tesla systems and dedicated wrist coils, has been widely validated for its capacity to detect central and peripheral TFCC tears (Magee, 2009). In contrast, ultrasound offers a dynamic, cost-effective, and radiation-free alternative that is increasingly utilized due to its real-time assessment capabilities, particularly for superficial components of the TFCC (Lee et al., 2016).

However, comparative evidence regarding the diagnostic performance of ultrasound versus MRI for TFCC injuries remains inconsistent across studies, with variability in sensitivity, specificity, operator dependency, and accessibility. This systematic review aims to critically evaluate and synthesize the current literature comparing the diagnostic accuracy of ultrasound and MRI for detecting TFCC injuries, highlighting their respective strengths, limitations, and clinical implications

MATERIALS & METHODS

Aim

This systematic review aims to compare the diagnostic accuracy of ultrasound compared to MRI in cases of TFCC injuries.

Study Design

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Haddaway et al., 2022). A

systematic approach will be performed to ensure reproducibility and transparency.

Search Strategy

A comprehensive and systematic search of electronic databases—including PubMed, Scopus, and Embase—will be conducted to identify relevant studies evaluating the diagnostic accuracy of ultrasound and MRI for TFCC injuries. The search will include studies published up to the present date and will be restricted to articles published in English.

A combination of Medical Subject Headings (MeSH) terms and relevant free-text keywords will be employed to ensure a thorough search. The MeSH terms will include: “Triangular Fibrocartilage Complex,” “Wrist Injuries,” “Ultrasonography,” “Magnetic Resonance Imaging,” and “Diagnosis.” Keywords will include “TFCC tear,” “triangular fibrocartilage,” “ultrasound,” “MRI,” “diagnostic imaging,” “wrist pain,” and “non-invasive imaging.”

These terms will be combined using Boolean operators “AND” and “OR” to refine the search strategy and capture all relevant literature. An example search string may include: ("Triangular Fibrocartilage Complex" OR "TFCC") AND ("ultrasound" OR "ultrasonography") AND ("magnetic resonance imaging" OR "MRI") AND ("diagnosis" OR "detection").

In addition to database searching, the reference lists of included studies and previously published systematic reviews will be manually screened to identify further eligible studies.

Study Selection

The following inclusion criteria filters the studies that will be included: (1) Randomized Controlled Trials (RCTs) or observational studies discussing both ultrasound and MRI for diagnosis of the TFCC, (2) Studies reporting at least one of the following: sensitivity, specificity, accuracy, or statistical significance in accuracy, (3) Full-text articles published in

English. Exclusion criteria will include: (1) Case reports, review articles, and expert opinions, (2) Studies involving non-human subjects.

Table 1. PICO Structure

Population	Intervention	Control	Outcome
Patients with ulnar-sided wrist pain undergoing ultrasound, MRI, and MRA	Imaging with ultrasound, and MRI	MRA	TFCC lesion detection and classification agreement
Trauma patients (aged 18-40) with ulnar-sided wrist pain and DRUJ instability	Ultrasound	3T MRI	Diagnostic accuracy (sensitivity, specificity, ICC)
Patients with wrist pain	Ultrasound evaluation	MRI	Sensitivity, specificity, accuracy for various pathologies

Data Extraction

Two reviewers will independently assess the titles and abstracts of identified studies to determine their relevance. Articles deemed potentially eligible will undergo full-text review. Any disagreements during the selection process will be resolved through discussion or, if necessary, by involving a third reviewer. Data will be extracted using a standardized form to capture key information, including study design, participant numbers, imaging modalities, comparison methods, and reported outcomes.

Quality Assessment

The methodological quality and risk of bias of included non-randomized studies were assessed using the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool, as recommended by the Cochrane Collaboration. This tool evaluates bias across seven domains: (1) bias due to confounding, (2) bias in selection of participants, (3) bias in classification of interventions, (4) bias due to deviations from intended interventions, (5) bias due to

missing data, (6) bias in measurement of outcomes, and (7) bias in selection of the reported result.

Two independent reviewers conducted the assessments. Each domain was rated as low, moderate, serious, or critical risk of bias, with discrepancies resolved by consensus or consultation with a third reviewer. This evaluation was used to inform the interpretation of findings and the overall strength of evidence across the included studies.

RESULT

Study Characteristics

The literature search yielded initial total of 29 articles (Figure 1). Removal of duplicates for titles, abstracts, and full texts further filters out the included study to 25 articles. Amongst these 25 articles, 19 were excluded for irrelevance to the study, resulting 6 articles to be sought. However, one studies had their full-text not in English and were excluded, and one study was excluded as the full-text was not made available, resulting in 3 articles to be included in this review.

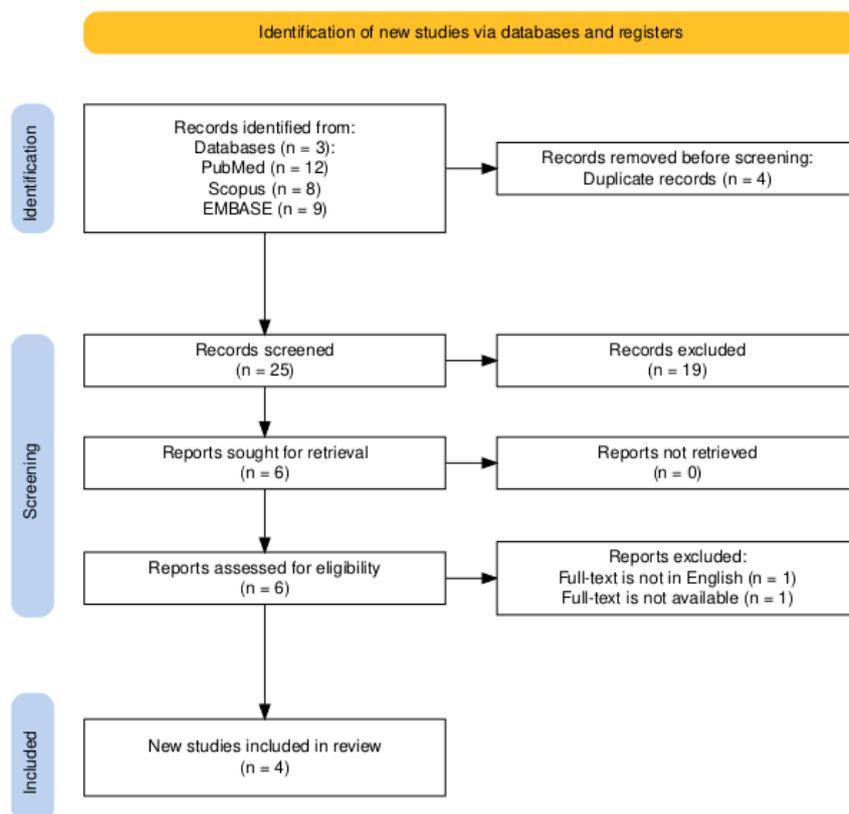


Figure 1. PRISMA Flowchart

Quality Assessment

The risk of bias of the included non-randomized studies was evaluated using the ROBINS-I tool. Overall, all four studies were judged to have a low risk of bias, with some domains rated as moderate in specific studies.

Bias due to confounding was rated as moderate in three studies (Pavić et al., 2022; El-Deek et al., 2019; Ibrahim et al., 2021), primarily due to lack of adjustment for potential confounders such as injury chronicity, trauma mechanism, or demographic factors. Lee and Yun (2018) was the only study rated low in this domain, likely due to its controlled study setting and uniform patient inclusion criteria.

All studies were rated low risk in the domains of participant selection, classification of interventions, deviations from intended interventions, and missing

data, indicating consistent study execution and complete data handling across cohorts.

Bias in outcome measurement was moderate in three studies (Pavić et al., 2022; El-Deek et al., 2019; Ibrahim et al., 2021), largely due to operator dependence of ultrasound and lack of blinding during imaging interpretation. Only Lee and Yun (2018) achieved a low rating in this domain, supported by independent, blinded assessment and high inter-observer agreement.

All studies were judged as low risk in terms of selective reporting, with clearly stated outcomes and consistent reporting across study objectives.

Collectively, the methodological quality of the included studies is acceptable, with low overall risk of bias, supporting the reliability of the synthesized findings.

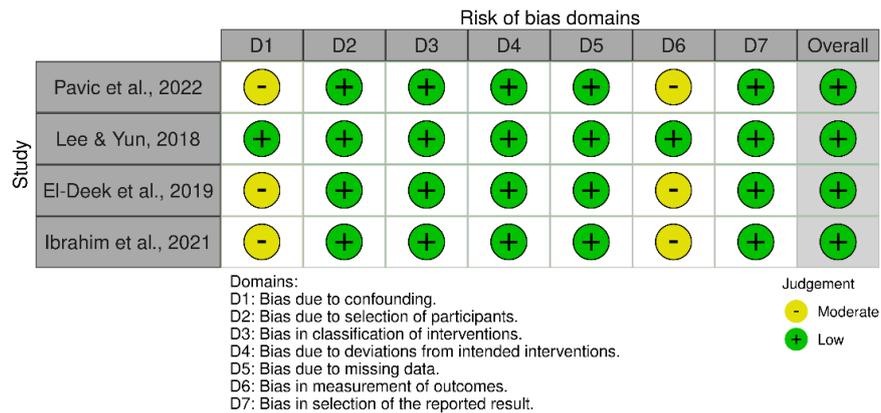


Figure 2. Risk of Bias

Baseline Characteristics

The four studies included in this review comprised sample sizes ranging from 30 to 72 participants, encompassing both prospective and retrospective designs. Pavić et al. (2022) conducted a retrospective comparative study with 72 patients (mean age 37 years), while Lee and Yun (2018) employed a prospective cross-sectional design involving 65 trauma patients (mean age 30.8 ± 5.7 years). El-Deek et al. (2019) performed a prospective observational study with 50 participants (mean age 31.7 years), and Ibrahim et al. (2021) conducted a case-control study with 30 subjects, reporting mean ages of 39.1 ± 11.1 years for cases and 29.9 ± 11.7 years for controls.

Across studies, female participants predominated, particularly in the cohorts of Pavić (46 males and 72 females) and El-Deek (35 males and 50 females). All studies evaluated the diagnostic performance of ultrasound and MRI in detecting TFCC pathology, with Pavić additionally incorporating MR arthrography (MRA). Outcome measures included sensitivity, specificity, predictive values, inter-rater reliability (ICC), and classification of TFCC lesions.

These studies provide a heterogeneous but complementary dataset for assessing the diagnostic accuracy of ultrasound versus MRI-based modalities in TFCC evaluation.

Diagnostic Accuracy

The included studies consistently evaluated the diagnostic accuracy of ultrasound in comparison to MRI for detecting TFCC injuries and associated wrist pathologies.

Pavić et al. (2022) found a statistically significant difference in detection rates between ultrasound and both MRI and MRA ($p < 0.001$), while no significant difference was observed between MRI and MRA ($p = 0.33$). The authors concluded that ultrasound is suitable for initial screening, MRI offers improved diagnostic detail, and MRA remains the most accurate modality, particularly in cases with inconclusive MRI findings.

Lee and Yun (2018) reported high diagnostic performance of ultrasound, with sensitivity ranging from 97.2% to 99.1%, specificity from 96.8% to 97.3%, and accuracy between 96.9% and 97.9%. No significant inter-observer variability was observed ($p = 0.58-0.98$), suggesting strong reproducibility. Ultrasound was found to be comparable to MRI for TFCC evaluation and suitable for prompt diagnosis in acute settings.

El-Deek et al. (2019) demonstrated that MRI outperformed ultrasound across all diagnostic metrics, including sensitivity (89.8% vs. 79.2%), specificity (98.0% vs. 96.1%), and accuracy (94.0% vs. 88.0%). Ultrasound was recommended as a first-line modality for non-ligamentous wrist conditions, whereas MRI was preferred for

ligamentous pathologies such as TFCC injuries.

Ibrahim et al. (2021) reported good agreement between ultrasound and MRI in detecting TFCC tears (sensitivity 75%, specificity 90.9%) and degeneration (sensitivity 80%, specificity 95%).

However, ultrasound showed limited sensitivity for tenosynovitis (50%). The authors emphasized that while ultrasound is accessible and cost-effective, MRI remains superior for detecting subtle or complex pathology due to the operator-dependent nature of ultrasound.

Table 2. Study Demographics

Study	Research Method	Sample Size	Gender (M/F)	Age (Range)	Mean Age	Tested Variables	Outcomes
Pavic et al., 2022	Retrospective Comparative Study	72	26/46	22-61 yo	37	Ultrasound, MRI, MRA	Detection rate and classification of TFCC lesions
Lee & Yun, 2018	Prospective Cross-sectional Study	65	56/9	18-40 yo	30.8 ± 5.7	Ultrasound (Inter-user agreement)	Diagnostic accuracy of TFCC injury detection (sensitivity, specificity, ICC)
El-Deek et al., 2019	Prospective Observational Study	50	35/15	12-62 yo	31.7	Ultrasound, MRI	Diagnostic accuracy (sensitivity, specificity, PPV, NPV) for wrist pathologies
Ibrahim et al., 2021	Case-control Study	30	9/21	18-50yo	Cases: 39.1 ± 11.1 Control: 29.9 ± 11.7	Ultrasound, MRI	Detection accuracy of TFCC abnormalities (tear, degeneration, tenosynovitis)

Table 3. Summary of Outcomes

Study	Outcomes	Results	Conclusion
Pavic et al., 2022	Detection rate and classification of TFCC lesions	There is significant difference between ultrasound and MRI and ultrasound and MRA (p<0.001), with no statistically significant difference between MRI and MRA. (p = 0.33)	- Ultrasound is a viable screening method for early ligamentous lesions - MRI is a better diagnostic modality for definitive evaluation - MRA is still the best diagnostic method, best performed in questionable MRI result
Lee & Yun, 2018	Diagnostic accuracy of TFCC injury detection (sensitivity, specificity, ICC)	Diagnostic Performance Ultrasound (Sensitivity, Specificity, Accuracy): - Sensitivity: 97.2%–99.1% - Specificity: 96.8%–97.3% - Accuracy: 96.9%–97.9% No significant difference in diagnostic values between reviewers (p = 0.58–0.98)	- Wrist ultrasonography is as precise as MRI for detected of TFCC injuries - Ultrasound can be used for immediate diagnosis and further preoperative imaging in patients with wrist sprains and DRUJ instability
El-Deek et al., 2019	Diagnostic accuracy (sensitivity, specificity, PPV, NPV) for wrist pathologies	Ultrasound vs MRI - Sensitivity (79.2% vs 89.8%) - Specificity (96.1% vs 98.0%) - PPV (95.0% vs 97.8%) - NPV (83.3% vs 90.9%) - Accuracy (88.0% vs 94.0%)	- Ultrasound should be the first choice of investigation in cystic, tendinous, vascular, and fibrotic pathologies of the wrist, but less promising results for ligamentous pathologies - Ultrasound is superior in detecting CTS and foreign bodies, otherwise, MRI is superior
Ibrahim et al., 2021	Detection accuracy of TFCC abnormalities (tear, degeneration, tenosynovitis)	- TFCC tear: Sensitivity 75%, Specificity 90.9%, Accuracy 86.6% - Degeneration: Sensitivity 80%, Specificity 95%, Accuracy 90% - Tenosynovitis: Sensitivity 50%, Specificity 82.1%, Accuracy 95.8% Overall agreement with MRI: 80%	- Ultrasound is a cost-effective, accessible modality with good agreement to MRI in detecting TFCC tears and degeneration - Ultrasound has lower sensitivity for tenosynovitis and is highly operator-dependent, making MRI preferable for subtle or inconclusive cases

DISCUSSION

This systematic review highlights the comparative diagnostic performance of ultrasound and MRI in evaluating TFCC injuries. The findings consistently support the role of ultrasound as a viable screening tool, particularly in cases of suspected

TFCC tears. Several studies, including those by Lee and Yun (2018) and Ibrahim et al. (2021), demonstrated that the sensitivity and specificity of ultrasound approach those of MRI, particularly when performed by experienced operators using high-frequency transducers. Lee and Yun (2018) reported a

sensitivity of up to 99.1% and specificity of 97.3%, with minimal interobserver variability, supporting its reproducibility.

Despite these promising results, a key limitation of ultrasound is its operator dependency. As demonstrated in the studies by El-Deek et al. (2019) and Ibrahim et al. (2021), diagnostic performance may vary based on the examiner's experience, familiarity with wrist anatomy, and imaging technique. Ibrahim et al. (2021) reported reduced sensitivity for detecting tenosynovitis (50%) compared to TFCC tears (75%) and degeneration (80%), which likely reflects the complexity of intra-articular assessment. This limitation has been echoed in earlier work, where Peetrons (2001) and Yablon et al. (2013) emphasized the need for standardized training protocols to enhance reliability and accuracy.

Another notable advantage of ultrasound is its practicality in emergency and acute care settings. With its portability, absence of ionizing radiation, and real-time dynamic imaging, ultrasound is well-suited for bedside assessments. Lee and Yun (2018) highlighted the effectiveness of point-of-care ultrasound (POCUS) in emergency departments, facilitating early triage and reducing reliance on MRI, especially in patients with distal radioulnar joint (DRUJ) instability or acute wrist trauma.

In terms of cost-effectiveness, ultrasound offers significant advantages over MRI and magnetic resonance arthrography (MRA). It is more accessible, affordable, and efficient in outpatient or resource-limited environments. Nwawka et al. (2023) noted that ultrasound can significantly reduce healthcare costs while maintaining diagnostic value in appropriate clinical scenarios.

Nevertheless, MRI remains the gold standard for comprehensive TFCC evaluation due to its superior spatial resolution and soft tissue contrast. When MRI findings are equivocal, MRA is the preferred modality for delineating subtle or peripheral TFCC lesions. Pavić et al. (2022) found significant differences in diagnostic

performance between ultrasound and both MRI and MRA ($p < 0.001$), with MRA proving superior for lesion classification. These findings are consistent with previous studies by Magee (2009) and Yao (2012), which demonstrated that MRA is more accurate than conventional MRI in detecting small or complex TFCC tears.

CONCLUSION

While MRI and MRA remain the definitive modalities for comprehensive evaluation and surgical planning, ultrasound represents a cost-effective, accessible, and efficient first-line imaging tool in the diagnostic algorithm for TFCC injuries. Its utility is especially evident in acute care, outpatient settings, and environments where MRI availability is limited. However, its diagnostic accuracy is highly dependent on operator expertise, highlighting the need for standardized training to ensure consistency.

Declaration by Authors

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