

R E V I E W

Diagnostic accuracy of ultrasound in assessing medial collateral ligament and medial meniscus injuries? A systematic review and meta-analysis.

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ABSTRACT

Background: Medial Collateral Ligament (MCL) and Medial Meniscus (MM) injuries are common medial knee pathologies. While MRI and arthroscopy are gold-standard diagnostic modalities, they are costly, invasive, and often delayed. Ultrasound is fast, inexpensive, and non-invasive, with growing use clinically, particularly point-of-care ultrasound (POCUS). This systematic review and meta-analysis aims were to evaluate ultrasound's diagnostic performance for MCL and MM injuries, both as standalone modalities and initial screening tools.

Methods: A systematic search of PubMed, Cochrane, Embase, CINAHL, and Google Scholar identified studies between 1st October 2014 and 31st October 2024. Fourteen studies (1,259 patients) met inclusion criteria. Methodological quality was assessed using validated tools.

Results: Overall risk of bias was low, with moderate certainty of evidence for MCL and low certainty for MM injuries. Nine studies (713 patients) evaluated MCL injuries. Bivariate meta-analysis showed pooled sensitivity 0.83 (95% CI: 0.76–0.88), specificity 0.96 (95% CI: 0.91–0.98), diagnostic odds ratio (DOR) 117.8, and area under the SROC curve (AUC) 0.90. Heterogeneity was minimal ($I^2 = 0\%$). Twelve studies (969 patients) evaluated MM injuries, with pooled sensitivity 0.85 (95% CI: 0.82–0.88), specificity 0.89 (95% CI: 0.81–0.94), DOR 45, and AUC 0.88. Heterogeneity was low for sensitivity but substantial for specificity ($I^2 = 70.6\%$).

Conclusions: Ultrasound demonstrated high specificity for MCL and moderate sensitivity for MM injuries. It may serve as a valuable modality for MCL injuries in POCUS settings and as an initial screening tool for MM injuries. As POCUS utilisation expands, it may support diagnostic pathways.

Key words: medial collateral ligament, medial meniscus, knee injuries, ultrasound, magnetic resonance imaging



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Background

Medial knee injuries account for over 40% of knee injuries (1), with the Medial Collateral Ligament (MCL), and Medial Meniscus (MM), amongst the most injured (1, 2). Both structures play important roles in stability, shock-absorption, and load bearing (3, 4, 5). They have similar mechanisms of injury, including valgus force, external rotation, and sudden changes in direction (4, 6, 7). Whilst the majority of MCL injuries are isolated, 78% of Grade III injuries have associated structural injury (6). However, due to MCL's healing potential (2), conservative management is normally indicated (8), unless there is significant valgus alignment, fracture avulsion, severe Grade III injury or multiple structural injuries (4, 6, 8). Grade III MCL injury specifically increases risk of MM tears to 32%, more common in older populations (9), split into horizontal, complex, flap, radial, root, and vertical (3, 11). Horizontal, complex and flap tears are typically degenerative, found in older populations, and treated conservatively. In contrast, vertical injuries are associated with younger populations, are twice as common medially, occur alongside multi-ligamentous injuries (10), and are frequently treated surgically. Therefore, the type and severity of injury guides management, with diagnosis traditionally completed with examination, followed by MRI. However, ultrasonography holds many advantages over MRI (3, 5), including being accessible, inexpensive, and allowing dynamic assessment (1, 12). Recently nearly 20% of patients in England missed recommended diagnostic waiting targets (13), and whilst demand increases, the workforce has not kept pace (14). These delays adversely affect disadvantaged groups, contributing to poor outcomes, and health inequalities (14-16). The King's Fund (14) discussed the need for innovation, advocating Point-of-care Ultrasound (POCUS), typically performed as an extension to physical examination. Moreover, POCUS' adoption reflects a shift toward more immediate, resource-conscious diagnostic strategies (17). Previous systematic reviews of diagnostic ultrasound in MM injury found diagnostic accuracy to be high (18) or good (19, 20). However, moderate to significant heterogeneity was found, with low subject numbers, and the latter reviews included pooled data on

both medial and lateral meniscus injuries. Further, to the authors' knowledge, there have been no recent systematic reviews on MM injury and regarding MCL imaging, only one, contemporary review (1). This review included only two studies on diagnostic ultrasound, which showed low sensitivity and high specificity. These gaps, alongside the growing clinical use of POCUS, and recommendations for regular updates (14, 21), highlight the need for a more current and comprehensive synthesis. Therefore, this review's aims and objectives were to evaluate the diagnostic accuracy of ultrasound for MCL and MM injuries, both as standalone modalities and initial screening tools, and to inform evidence-based guidance on its role within diagnostic pathways, with implications for improving access, efficiency, and equity of care.

Methods

Design and search strategy

This study's design was a systematic review and meta-analysis of diagnostic test accuracy (DTA), conducted according to a registered protocol (PROSPERO CRD420250656377), in line with PRISMA-DTA guidelines. PubMed, Cochrane, Embase, CINAHL and Google Scholar were systematically searched with support from an information specialist to ensure rigour (22-24). These databases were chosen for their recognised standards of precision, recall and reproducibility (22). Embase provides high sensitivity and retrieval yield, considered essential for medically oriented searches, whilst PubMed provides additional biomedical content and complementary indexing (22, 25-28). CINAHL was selected for subject-specific coverage of nursing, biomedicine, and allied health (26). Whilst Google Scholar has lower precision, recall and lacks transparency (22), it adds value when combined with highly sensitive databases, by capturing grey literature (25). Firstly, a research question was formulated, utilising PIRD (Population, Index Test, Reference Test, and Diagnosis of Interest) framework, due to the inclusion of DTA study designs (28). This allowed the formulation of key words and concepts (29). Subsequently, each databases' thesaurus was searched for matching

index terms, within Medical subject headings (MeSH) and keywords or synonym terms, to increase number of studies retrieved (29). Secondly, free-text keywords were searched within the title and abstract, in addition to their corresponding thesaurus terminology (28), and finally, truncation was used, to narrow the search results to relevant articles (28). Subsequently, search terms and strategies were saved (Supplementary File 1 – Databases' Search Strategies.docx), limited to 10 years (1st October 2014 to 31st October 2024) to stay contemporary (30), and with 82% of POCUS studies, published within this period (31). Moreover, both empirical and grey studies were included, to produce broad, objective, and comprehensive results (32, 33).

Study selection and data extraction

Titles and abstracts were screened against the study's inclusion and exclusion criteria (Supplementary File 2 – Inclusion and Exclusion Criteria.docx), to ascertain eligibility. DTA cross-sectional (cohort) and comparative studies were included, to allow direct comparison of tests. Studies with less than 20 subjects, were excluded, in keeping with previous systematic review (20). Further, studies were only included if they reported sufficient data to construct 2×2 contingency tables (true positives, false positives, false negatives, true negatives), to allow statistical analysis. All processes were performed by two independent reviewers, and where disagreements occurred, were resolved by discussion, according to the guidelines of PRISMA (23). Decisions made were recorded, including how many studies were excluded and the reasons why (Supplementary File 3 – Excluded Studies.docx), to enable the PRISMA flowchart to be completed (Figure 1) (23). Subsequently, following full-text critical review, a final list of included studies were agreed (23). All relevant information and data were extracted from those articles, including key variables, research design, participants, year of publication and results (Table 1 in Supplementary File 4 – Study Characteristics.docx).

Study quality assessment

DTA studies evaluate and compare precision of tests, however, they frequently exhibit methodological

flaws (34). Therefore, quality assessment tools to critically evaluate findings, were used. These were the updated Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool (29, 34, 35), and QUADAS-C tool, which serves as an extension of QUADAS-2, specifically developed to assess the risk of bias and the accuracy of tests, employing rigorous methodologies and thorough piloting (34). These instruments evaluated the quality of the studies included by examining risk of bias and addressing applicability concerns across four specific domains, namely, patient selection, the index test, the reference standard, and flow and timing. Whilst QUADAS tools enabled risk of bias to be assessed for individual studies, they do not offer conclusions regarding overall body of evidence (36). Therefore, the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach was used (37). The GRADE approach focuses on how certain an effect estimate, reflects the true effect, and is sufficient to support a particular recommendation (38). GRADE represents a formal, rigorous, and transparent systematic methodology (39).

Statistical analysis

A meta-analysis was undertaken to synthesise evidence on the diagnostic accuracy of ultrasound for detecting MCL and MM injury. Given the variability in reported sensitivity and specificity across individual studies, a pooled analysis was necessary to obtain a more precise estimate to explore potential heterogeneity in test performance. This approach aimed to provide clinically meaningful evidence regarding the reliability of ultrasound diagnostic capabilities across diverse study populations and settings. DTA measures deemed appropriate to denote accuracy, were sensitivity, specificity, accuracy, positive and negative predictive values (PPV and NPV), and diagnostic odds ratio (DOR), in line with previous reviews (1, 18-20). All statistical analyses were conducted using R software (version 4.5.1), following the framework described by Shim et al. (40), outlining robust workflows for DTA meta-analysis. Univariate meta-analysis was performed using the meta package to estimate pooled sensitivity, specificity, DOR accuracy, PPV and NPV, applying logit transformation to stabilise variance and using random-effects models

with DerSimonian-Laird estimators. Forest plots were generated to visualise individual study estimates alongside pooled values. For bivariate meta-analysis, the mada package was employed to fit a random-effects model via the Reitsma function (41), producing summary receiver operating characteristic (SROC) curves with confidence and prediction regions, and assessing the correlation between logit-transformed sensitivity and specificity. Heterogeneity was quantified using I^2 and τ^2 statistics, and funnel plots, Egger's tests and

Berg tests were used, to evaluate publication bias and the presence of small-study effects.

Results

Study selection

From 1,077 records, 40 studies were screened for eligibility, demonstrated in PRISMA flow diagram and decision tree (Figure 1). Following full text review,

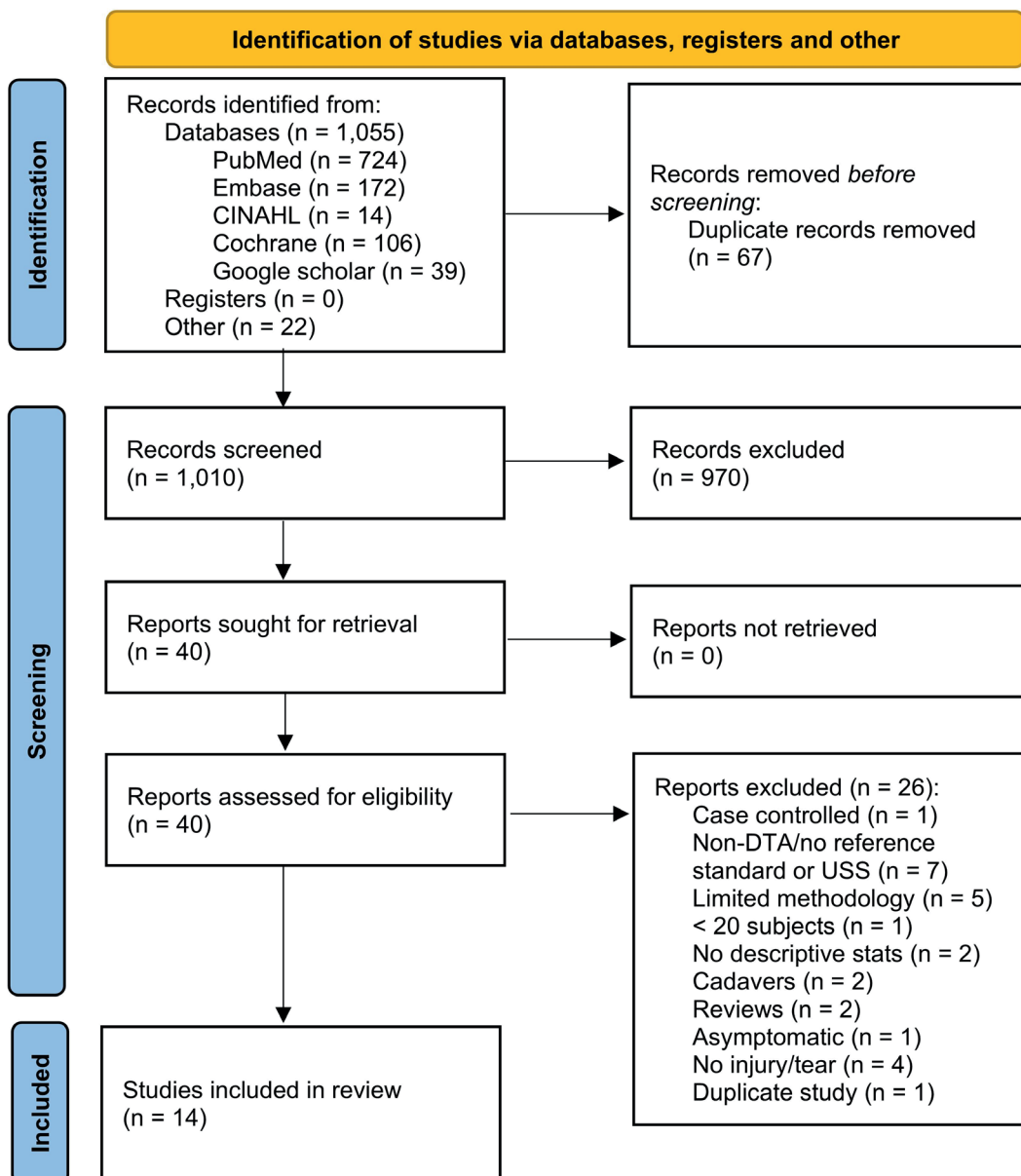


Figure 1. PRISMA Flowchart.

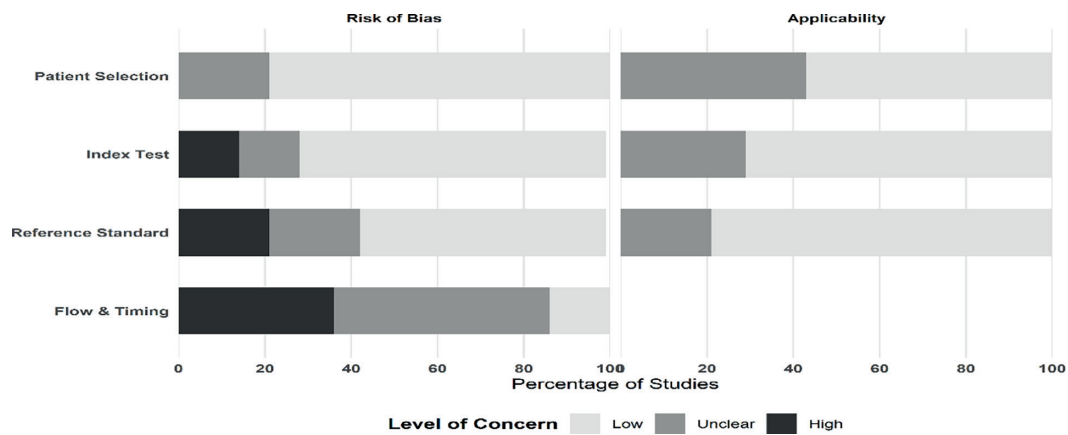


Figure 2. QUADAS-2 - Risk of bias and applicability concerns graph. Review authors' judgements about each domain presented as percentages across included studies.

26 studies were excluded (Supplementary File 3 – Excluded Studies.docx). Therefore, fourteen studies were included in the study (42-55).

Study characteristics

A total of 1,259 subjects were included, with weighted mean age 33.5 years (SD +/- 4.99), including 69% males. The studies' shared aims were to evaluate the diagnostic accuracy of ultrasound in detecting MCL (42, 45, 47, 48-52, 54) and MM (43-51, 53-55) injuries. These were measured using reference standards of arthroscopy (44, 46, 48), MRI (42, 43, 45, 47, 49, 51-55), or combination of arthroscopy/MRI (50). Most testing was completed in emergency departments (42-44) utilising POCUS, or more traditional ultrasound machines in radiology (45-54), with clinician's experience ranging from four hours to more than 5 years. Probe frequency varied, with the majority utilising linear probes of 5-12/13 MHz (42-46) or 7-12MHz (50-52). Four studies used higher frequency linear probes of 7-18MHz, 7-15MHz and 12-17MHz respectively (47, 48, 54, 55), and one, low frequency of 5-6MHz (49). Furthermore, positioning of MCL was supine, with knee flexion and hip external rotation (42, 45, 47-52, 54). Similarly, MM was done in supine positioning, (43, 44, 47, 49, 52, 54) or both prone and supine positioning (45, 46, 48, 50-53). Interestingly, only three studies used the dynamic capabilities of ultrasound (48, 50, 51).

Quality assessment

A comprehensive overview of the risk of bias and applicability concerns was completed, illustrated in Figures 2 and 3. Overall, risk of bias was considered low, with eight studies (57%) exhibiting low risk, four (29%) unclear, and two studies (14%) high risk. Regarding applicability concerns, most studies also demonstrated low risk (71%), with four studies (29%) showing unclear concerns, and none indicating high concerns. MCL injuries had moderate certainty of evidence and MM injuries, low certainty of evidence (Figure 4). Populations across the studies were similar, typically of predominant male gender and younger cohorts, therefore, this review's recommendations may be limited to these populations. Regarding MM injuries, there appeared more inconsistency and reduced precision of results across the studies, reflected in the wider 95% CIs, and presence of outliers, which was reflected in the lower certainty of evidence.

Meta analysis of MCL injuries

Nine studies (713 patients) evaluating MCL injuries were included. Study designs varied in imaging protocols, operator experience, and threshold definitions. Univariate meta-analysis was performed yielding a pooled sensitivity of 0.85 (95% CI: 0.80-0.90), specificity of 0.99 (95% CI: 0.91-1.00), and DOR of 89.97 (95% CI: 42.62-189.93) (Figures 5-7).

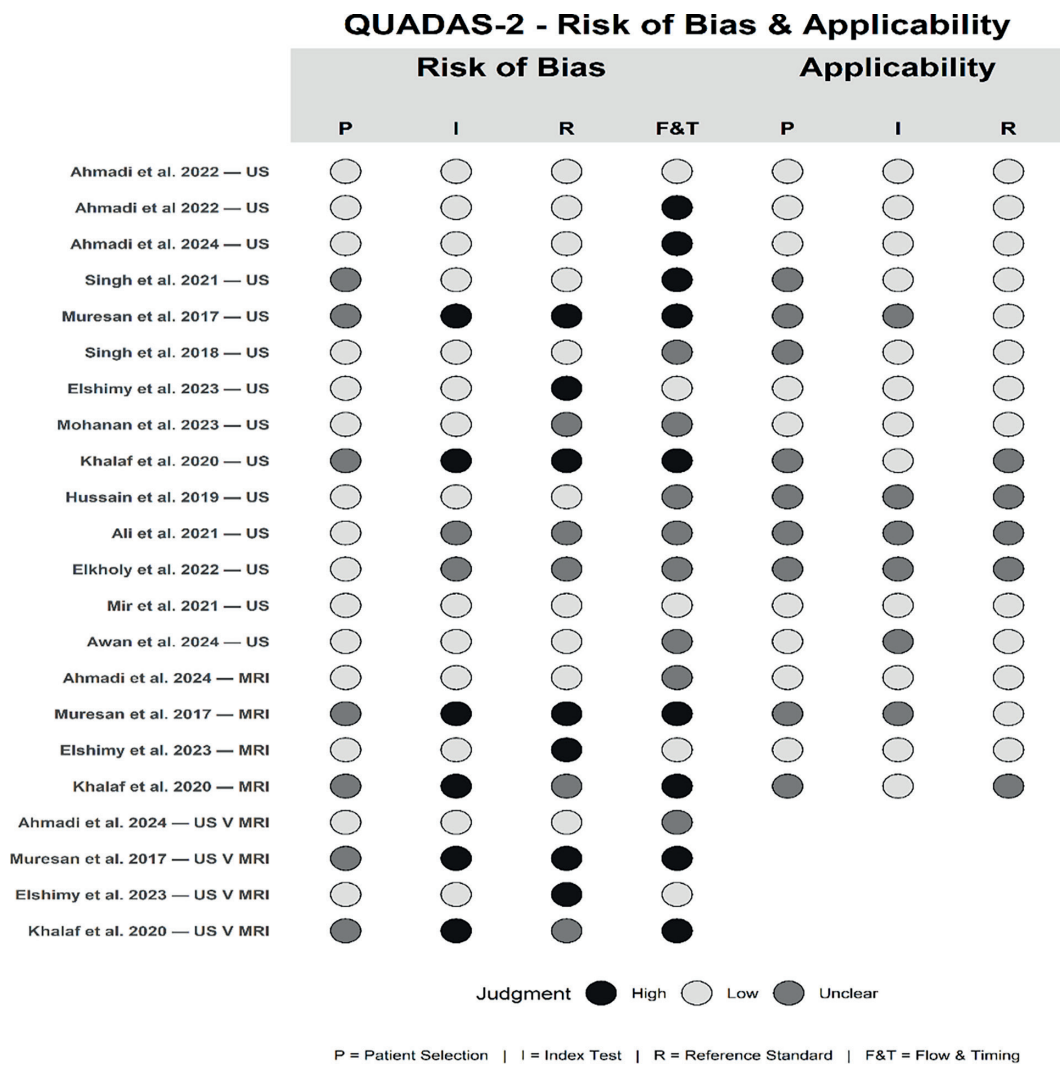


Figure 3. QUADAS-2/C - Risk of bias and applicability concerns summary. Review authors’ judgements about each domain for each included study.

Additional pooled metrics were calculated, for accuracy 0.94 (95% CI: 0.91–0.97), PPV 0.97 (95% CI: 0.77–1.00), and NPV 0.95 (95% CI: 0.90–0.98) (Supplementary File 5 – MCL Plots.docx). These univariate estimates do not account for threshold effects or the inherent correlation between sensitivity and specificity. Thus, further meta-analysis was undertaken to obtain more precise estimates, to provide clinically meaningful evidence, across diverse study populations and settings.

A bivariate random-effects meta-analysis yielded summary estimates of sensitivity 0.83 (95% CI: 0.76–0.88), specificity 0.96 (95% CI: 0.91–0.98), Diagnostic

Odds Ratio (DOR) 117.8 (95% CI: 65.44–212.04), and area under the SROC curve (AUC) 0.90 (95% CI: 0.86–0.93). The SROC curve included confidence and prediction regions that visually reflected between-study variability (Figure 8). The AUC indicated strong diagnostic performance, with broad prediction regions suggesting dispersion in sensitivity and specificity across studies. Heterogeneity was initially assessed using univariate random-effects models. For sensitivity, $\tau^2 = 0$, $\chi^2(8) = 3.64$ ($p = 0.8879$), and $I^2 = 0\%$, indicated no detectable variability. For specificity, $\tau^2 = 4.43$, $\chi^2(8) = 6.57$ ($p = 0.5839$), and $I^2 = 0\%$, suggesting minimal heterogeneity. The elevated τ^2 may reflect model sensitivity

to ceiling effects, as several studies reported perfect specificity. Notably, Khalaf et al. (50) was a significant outlier, with perfect sensitivity and specificity, lying outside the 95% region of the SROC and contributing

disproportionately to between-study variance. Overall, heterogeneity was low and visually consistent with the prediction region of the SROC curve, aside from this study. Funnel plots (Supplementary File 5 – MCL Plots.docx) showed no marked asymmetry. However, it is important to interpret these findings with caution, as Egger’s and Begg’s tests, commonly used to formally assess publication bias, were not conducted due to the limited number of studies. Consequently, the possibility of undetected publication bias cannot be entirely ruled out. Ultrasound demonstrated high accuracy for diagnosing MCL injuries. Despite some variability in study design and imaging protocols, the consistently high specificity and AUC support its utility for ruling in MCL injury in appropriate clinical settings.

GRADE	Concerns?	Outcome/Downgrade?
Risk of Bias	Not serious	●●●●
Indirectness & Applicability	Not serious	●●●●
Inconsistency	Not serious (MCL)	●●●●
	Serious concerns (MM)	●●●●
Imprecision	Serious concerns (MCL)	●●●●
	Serious concerns (MM)	●●●●
High Probability of Publication Bias	Not serious (MCL)	●●●●
	Not serious (MM)	●●●●
Overall Certainty of Evidence for MCL Injuries = Moderate		
Overall certainty of Evidence for MM Injuries = Low		

Figure 4. GRADE Results.

Meta analysis of MM injuries

Twelve studies (969 patients) evaluating MM injuries were included. Study designs varied in imaging

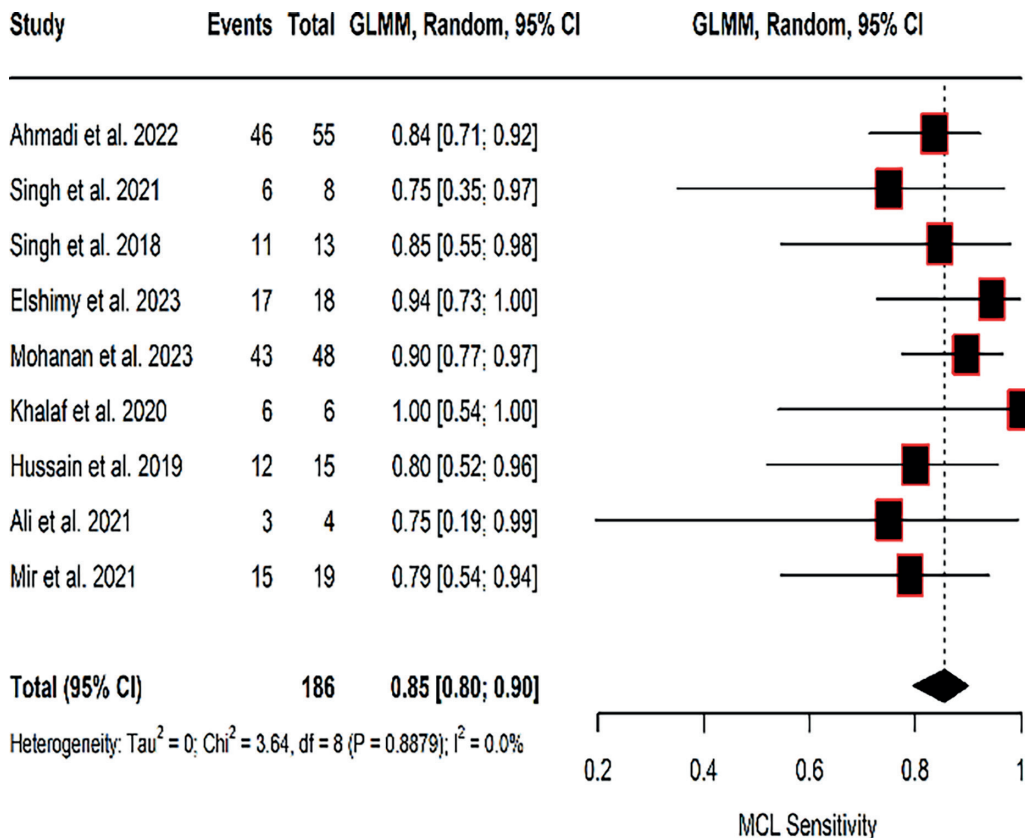


Figure 5. MCL sensitivity forest plot.

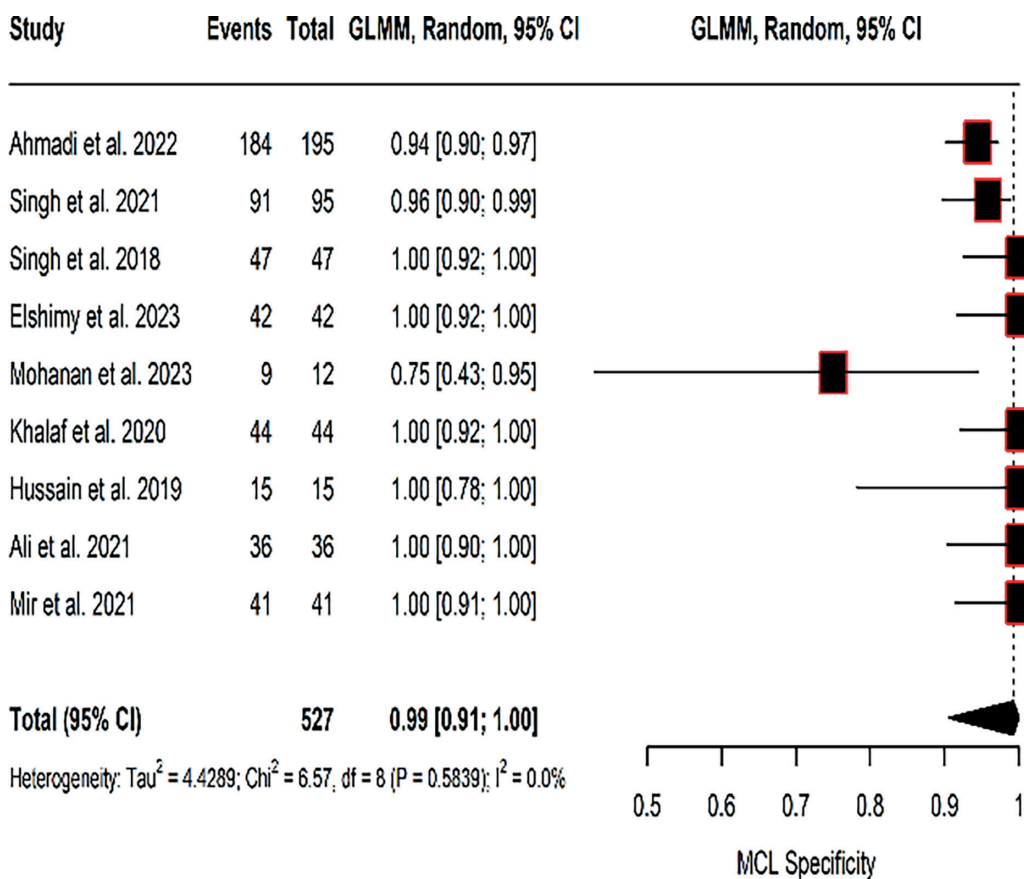


Figure 6. MCL specificity forest plot.

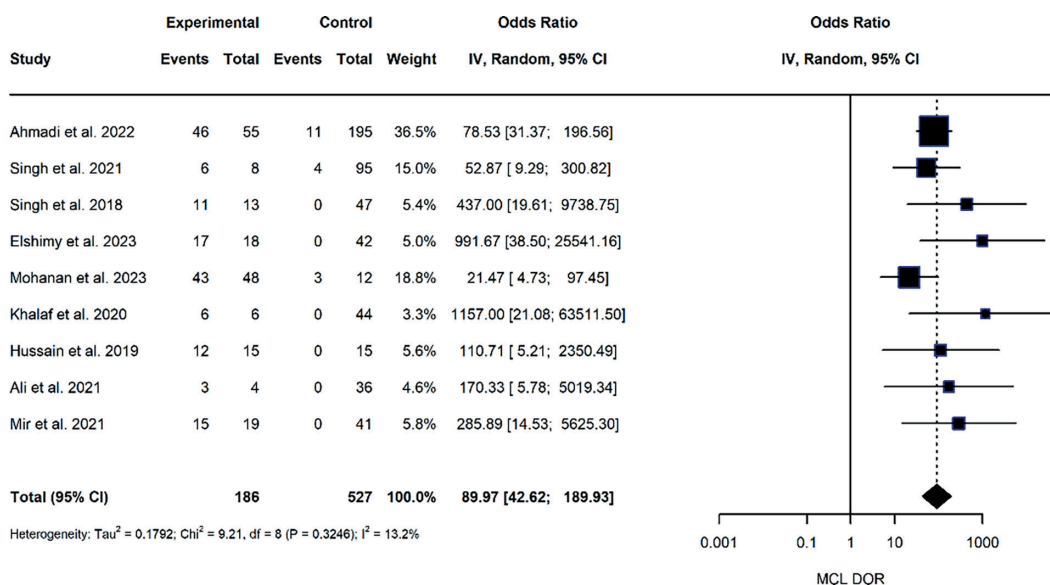


Figure 7. MCL DOR forest plot.

protocols, operator experience, and threshold definitions. Univariate meta-analysis was performed yielding pooled estimates for sensitivity 0.85 (95% CI: 0.82–0.88), specificity 0.91 (95% CI: 0.83–0.95), and

diagnostic odds ratio (DOR) 40.51 (95% CI: 21.74–75.64) (Figures 9–11). Additional pooled metrics were calculated, for accuracy 0.88 (95% CI: 0.85–0.90), PPV 0.92 (95% CI: 0.86–0.95), and NPV 0.84 (95% CI: 0.77–0.89) (Supplementary File 6 – MM Plots.docx).

Bivariate meta-analysis produced summary sensitivity 0.85 (95% CI: 0.82–0.88), specificity 0.89 (95% CI: 0.81–0.94), DOR 45.0 (95% CI: 18.5–109.6), and area under the SROC curve (AUC) 0.88 (95% CI: 0.85–0.91). The SROC curve showed a shaded confidence region and broader prediction region, reflecting moderate variability across studies (Figure 12). The AUC supports strong overall test performance across varying thresholds. Heterogeneity was initially assessed using univariate random-effects models. For sensitivity it was low ($\tau^2 = 0$; $I^2 = 0\%$) but substantial for specificity ($\tau^2 = 0.8282$; $I^2 = 70.6\%$), consistent with the dispersion seen in the SROC prediction

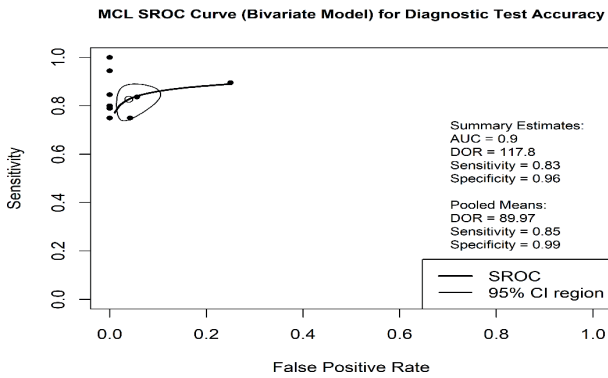


Figure 8. MCL SROC curve based on REML bivariate modelling.

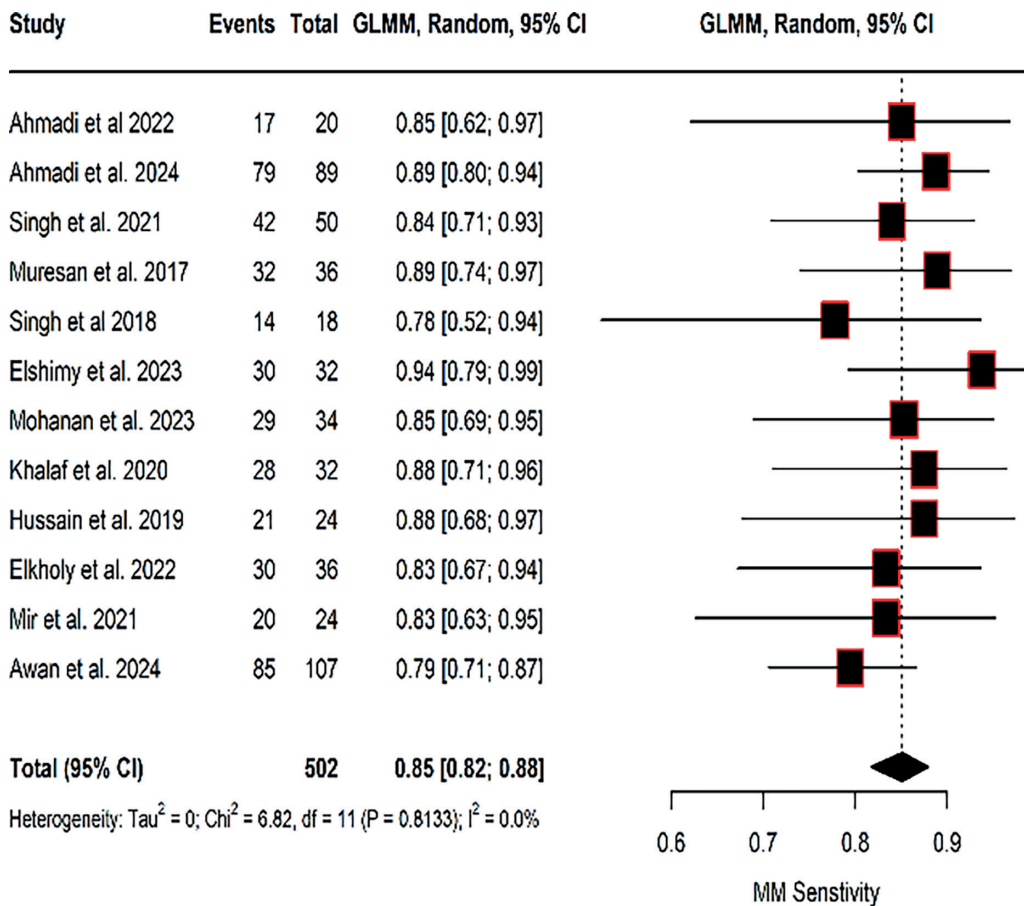


Figure 9. MM sensitivity forest plot.

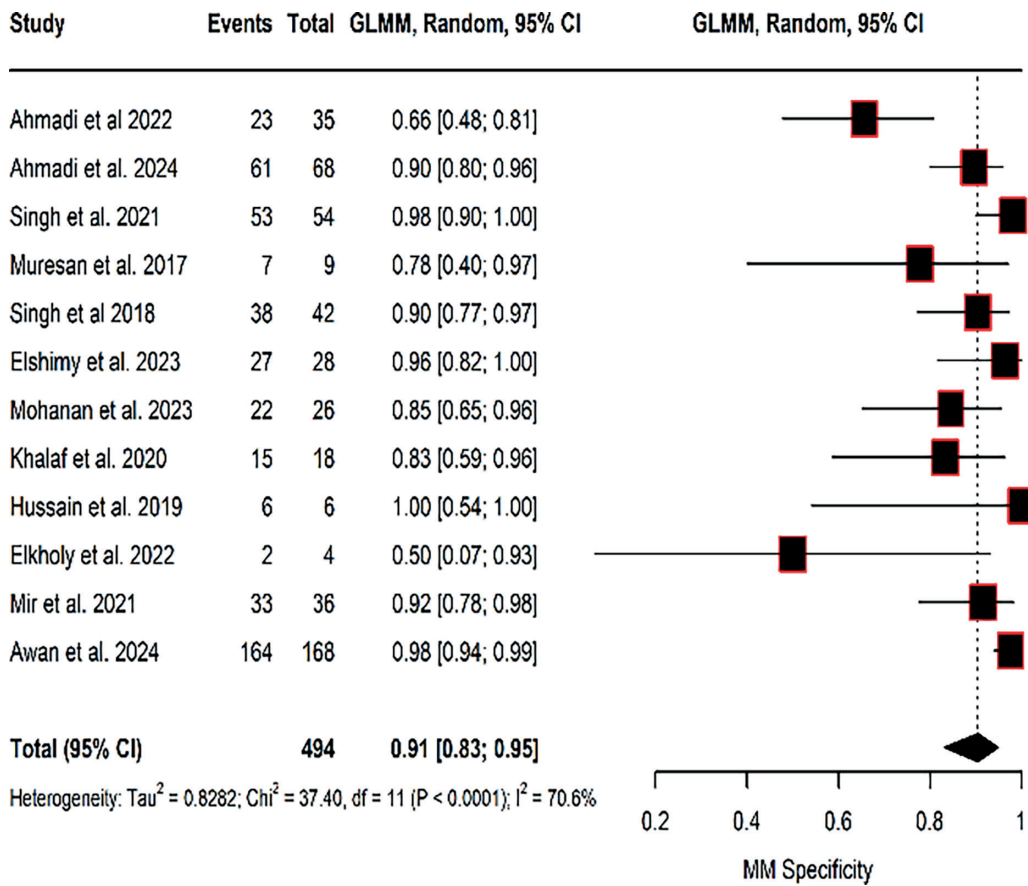


Figure 10. MM specificity forest plot.

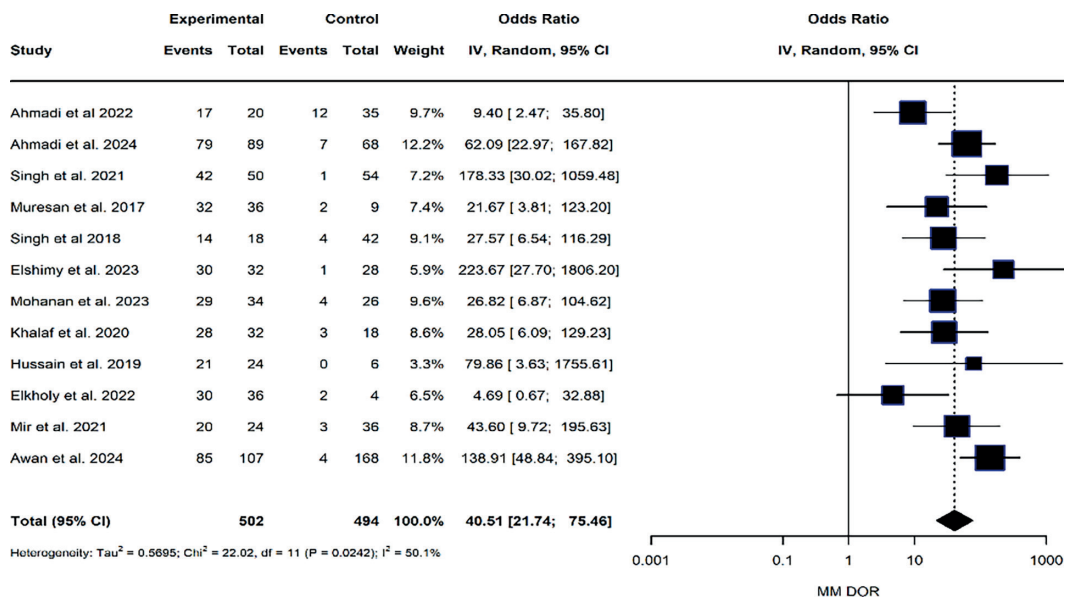


Figure 11. MM DOR forest plot.

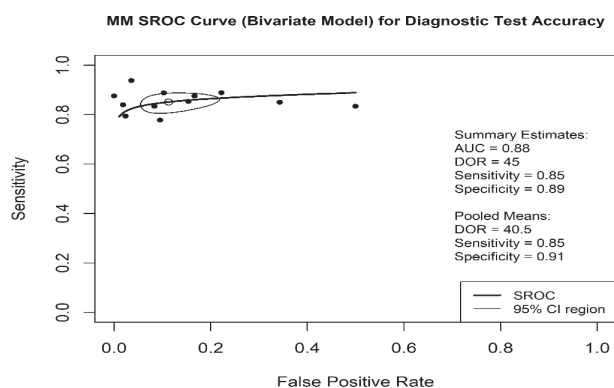


Figure 12. MM SROC curve based on REML bivariate modelling.

region. Elkholy et al. (53) and Singh et al. (47) were identified as significant outliers, driven by low specificity and low sensitivity, respectively, likely contributing disproportionately to between-study heterogeneity. Funnel plot asymmetry was assessed upon visualisation of Funnel Plots (Supplementary File 6 – MM Plots.docx) and using Egger's and Begg's tests. For sensitivity, Egger's test suggested marginal asymmetry ($t = 2.01$, $p = 0.0722$), while Begg's test was non-significant ($z = 0.82$, $p = 0.4106$). For specificity, both tests indicated no asymmetry (Egger: $t = 0.88$, $p = 0.3970$; Begg: $z = 0.00$, $p = 1.0000$). Therefore, there was no compelling evidence of publication bias. Ultrasound demonstrated high diagnostic accuracy for MM injury. Despite heterogeneity, the consistently strong sensitivity and AUC, support its clinical utility, particularly for ruling out MM injury, in appropriate clinical settings.

Additional analysis

The included studies offered limited insights into the anatomical location, grading, and classification of injuries. Mohanan et al. (49) addressed the grading of MCL injuries, indicating that diagnostic ultrasound successfully identified all Grade III MCL injuries, in comparison to MRI. Regarding anatomical location, Khalaf et al. (50) reported 71% of MM injuries were to the posterior horn and Hussein et al (51) 100%. The latter reported a sensitivity of 83.3% and specificity 100% of ultrasound compared to MRI. Regarding tear morphology, positive correlation was reported with arthroscopy, compared to ultrasound and MRI. However, bucket handle tears, often necessitating surgical

intervention, were not detected by ultrasound (50, 53). These findings were also reflected in Awan et al. (55) study, with ultrasound having difficulty detecting radial and horizontal tears, suggesting that ultrasound may lack the ability to clearly classify type of tears, and may be more useful as an initial screening tool.

Discussion

Summary of evidence

The medial collateral ligament (MCL) and medial meniscus (MM) are essential for knee stability and load transmission. While many injuries are managed conservatively, accurate diagnosis is crucial to prevent long-term dysfunction. Imaging enhances clinical evaluation, with MRI and arthroscopy considered gold standards. However, their cost, invasiveness, and wait times limit accessibility. Diagnostic ultrasound offers a dynamic, non-invasive, and cost-effective alternative, increasingly adopted in clinical practice, at first point of contact. This review found ultrasound to be highly effective for diagnosing MCL injuries, with pooled sensitivity of 83% (95% CI: 76–88) and specificity of 96% (95% CI: 91–98). The diagnostic odds ratio (DOR) of 117.8 and area under the SROC curve (AUC) of 0.90 reflect robust performance, particularly for ruling in pathology. Minimal heterogeneity ($I^2 = 0\%$) further supports robustness. To date, only one systematic review has assessed ultrasound for MCL injuries (1), reporting lower sensitivity (63–87%) and specificity (83–96%). The improved accuracy in this review reflects larger sample sizes, technological advances, and increased operator experience. For MM injuries, pooled sensitivity was 85% (95% CI: 82–88) and specificity 89% (95% CI: 81–94), with a DOR of 45 and AUC of 0.88. These findings suggest moderate diagnostic performance, particularly for ruling out pathology. Earlier reviews (18, 19, 20) reported sensitivity ranging from 77.5–88.8% and specificity from 83.3–90%, indicating this review shows slightly higher sensitivity and comparable specificity. However, substantial heterogeneity, particularly in specificity ($I^2 = 70.6\%$) and low certainty of evidence, should be considered when interpreting these findings. Although, ultrasound demonstrated strong diagnostic accuracy

for MCL injuries and moderate for MM injuries, these results should be interpreted cautiously. Ultrasound is valuable in point-of-care settings, but MRI remains essential when high-grade MCL injury or complex, surgically relevant MM pathology is suspected. Thus, ultrasound should be considered a complementary or first-line screening tool, rather than a replacement for MRI in more severe or uncertain cases.

Differences in diagnostic accuracy seen across studies, may be attributed to patient age, probe frequency, positioning, and operator experience. The two included studies (44, 46) with the youngest cohorts (20's), had consistent high scores across sensitivity, specificity, and accuracy. Previously, Alizadeh et al. (56) found ultrasound accuracy exceeded 95% in patients under 30 but dropped significantly in older groups. Anatolia et al. (57) similarly reported better performance in patients under 35. Certainly, degenerative changes in older patients, such as hypoechoic tissue, joint space narrowing, and osteophyte formation, are likely to reduce visualisation and diagnostic yield (56, 57). Furthermore, both these studies (56, 57) incorporated prone positioning to assess the posterior horn of the MM, reporting improved sensitivity. Given that over 70% of load transmission occurs in the middle and posterior zones (58), with most tears occurring posteriorly (59), prone evaluation is critical. Rodriguez-Sanz et al. (60), using cadaveric models, demonstrated near-complete visualisation of the MM with supine and prone positioning. Despite previous studies advocating both supine and prone positioning, only 50% of the included studies used this approach. Further, within this review, only two studies (50, 51), discussed specific anatomical location of MM injury, both reporting that the posterior horn had the largest number of tears, 71% (50) and 100% (51) respectively. Akatsu et al. (61) also supported prone evaluation, however, noted ultrasound's limitations in detecting tear morphology. This was in keeping with this review's findings where bucket handle tears, which often necessitate surgical intervention, were not detected by ultrasound. Further, ultrasound was noted to have difficulty detecting radial and horizontal tears. Thus, ultrasound may lack the ability to clearly classify type of tears and may be more useful as an initial screening tool. Probe frequency was another key factor, demonstrated in the

study with the lowest specificity, using the lowest frequency (49), in contrast to those using high-frequency probes, reporting specificity of 94.7–100% and accuracy above 96% (47, 48, 54). Similarly, the study with the highest MM diagnostic values, used one of the highest probe frequencies and had among the most experienced clinicians (48). Operator experience was equally important, with the lowest accuracy, correlating with clinicians receiving only four hours of training (43), highlighting the known steep learning curve novice clinicians' experience (62–64).

Strengths and limitations

This is the first systematic review and meta-analysis focused solely on ultrasound's diagnostic accuracy for MCL injuries and the most contemporary for MM injuries. It combines quantitative analysis with critical appraisal, offering clinically relevant insights. However, limitations exist, including the exclusion of non-English studies, which may introduce selection bias, and heterogeneity, which may limit generalisability. Additionally, the exclusion of Scopus and Web of Science databases may have reduced retrieval breadth, and limited citation tracking sensitivity. Finally, the strength of conclusions depends on the quality of included studies. Across both MCL and MM analyses, several studies and pooled DORs showed wide confidence intervals due to small sample sizes and limited data, meaning these estimates should be interpreted cautiously. While most included studies exhibited low risk of bias, the overall certainty of evidence warrants consideration.

Conclusions

This systematic review and meta-analysis demonstrates that diagnostic ultrasound offers high specificity for MCL injuries and moderate sensitivity for MM injuries. These findings support its use as a valuable modality for assessing MCL injuries in point of care and early assessment settings and as an effective screening tool for MM injuries. While MRI and arthroscopy remain the gold standards, ultrasound provides a non-invasive, cost-effective, and accessible

alternative, particularly relevant in healthcare systems facing diagnostic backlogs.

However, MRI remains essential with high-grade MCL injury due to potential concurrent injuries, or where complex, surgically relevant MM pathology is suspected. Variability in operator expertise, imaging technique, and study populations may also influence diagnostic performance, highlighting the need for consistent imaging standards and further research. Nevertheless, integrating ultrasound into diagnostic pathways may contribute to reduced delays, more efficient resource use, and improved accessibility.

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Consent for Publication: Not applicable.

Competing Interests: The authors declare no competing interests.

Declaration on the Use of AI: None.

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