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Original Research Article

Accuracy of Ultrasonography in Comparison with Magnetic Resonance Imaging to Detect Meniscal Tears in Knee Injuries

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Abstract: *Meniscal tears are common in active adults, and timely imaging guides triage to conservative care or arthroscopy. While MRI is the reference standard, ultrasonography (US) offers a low-cost, accessible alternative.* ***Objective:*** *To determine the diagnostic accuracy of high-resolution US for detecting meniscal tears using MRI as the reference standard.* ***Methods:*** *We conducted a cross-sectional diagnostic-accuracy study of 304 participants (mean age 29.9 ± 7.57 years; 61% male). At radiology department of JPMC karachi from 1st August 2024 till 31st January 2025.All underwent standardized knee US followed by MRI. Meniscal tear status on US was compared with MRI using 2×2 tables to compute sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Discrimination was assessed with receiver operating characteristic (ROC) analysis.* ***Results:*** *US identified tears in 207/304 (68.1%), while MRI showed tears in 222/304 (73.0%). Cross-tabulation yielded 193 true positives, 14 false positives, 68 true negatives, and 29 false negatives. Using MRI as reference, US achieved sensitivity 86.9%, specificity 82.9%, PPV 93.2%, NPV 70.1%, and accuracy 85.9%. ROC analysis demonstrated AUC 0.847 with p < 0.0001, indicating good overall discrimination.* ***Conclusion:*** *High-resolution ultrasonography showed good diagnostic performance versus MRI, with particularly strong rule-in value given its high PPV. In resource-constrained or high-throughput settings, US can function as an effective first-line triage tool, reserving MRI for equivocal cases or when clinical suspicion persists after a negative US.*

Keywords: Ultrasonography; Meniscal Tear; Knee Injury; Magnetic Resonance Imaging; Diagnostic Accuracy; Sensitivity; Specificity; ROC Curve

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Introduction

Meniscal tears are among the most common knee lesions in active adults and athletes, and rapid, accurate imaging streamlines triage to conservative care or arthroscopy. MRI is widely regarded as the non-invasive reference test. Contemporary meta-analyses show excellent overall accuracy, with summary AUCs ≈0.97 (medial) and 0.96 (lateral) and consistently strong diagnostic performance across tear locations (1). A complementary synthesis reported pooled sensitivity/specificity ≈89%/88% for medial and 78%/95% for lateral meniscal tears, underscoring particularly high rule-in ability laterally (2).

Ultrasonography (US) has gained traction as a cost-effective, portable, and dynamic alternative. Meta-analyses focusing on prospective designs indicate pooled US sensitivity around 0.88 and specificity around 0.90, while broader reviews emphasize consistently high specificity with more variable sensitivity (3,4). Technique and expertise are pivotal: high-frequency linear probes and standardized evaluation of the anterior horn/body improve conspicuity—particularly for the medial meniscus (5).

Head-to-head and real-world studies reinforce US's potential. In an emergency-department cohort, point-of-care ultrasound (POCUS) achieved 88.8% sensitivity, 89.7% specificity, and 89.2% accuracy for medial meniscal tears, while MRI in the same cohort reached ~93% accuracy (6). In community practice, US vs MRI yielded sensitivity/specificity of ~79%/97.3% (medial) and ~63%/99.5% (lateral) with accuracies around 90–94%, highlighting excellent rule-in performance (7). Earlier work in acute knees found US two times more likely than MRI to correctly classify arthroscopy findings overall (MRI Sn 91.7%, Sp 66.7%) (8). Classic clinical data likewise reported US ~86% sensitivity/85% specificity against MRI, supporting its use as a rapid triage test when performed by trained operators (9,10).

Collectively, the literature suggests MRI retains the best overall balance of sensitivity and specificity across tear types especially laterally—while modern B-mode US offers high specificity at far lower cost with dynamic assessment of associated structures (e.g., meniscal extrusion, parameniscal cysts) (1,2,4,5). Implementation depends on operator skill, probe quality, and standardized protocols; thus, local validation is advisable to guide pragmatic imaging pathways and reduce unnecessary MRI without compromising diagnostic certainty (4,6,7).

To determine the diagnostic accuracy of high-resolution ultrasonography for detecting meniscal tears, using MRI as the reference standard.

Methodology

We conducted a cross-sectional diagnostic-accuracy study in the Department of Diagnostic Radiology, JPMC Hospital, Karachi, in collaboration with Orthopedics and the Emergency Department. Recruitment spanned six months from 1st August 2024 till 31st January 2025. A consecutive non-probability sample of 304 patients referred for knee MRI was enrolled. Eligible participants were 15–50 years old with ≤1-month history of suspected meniscal injury (e.g., pain, swelling, locking/catching). We excluded postoperative cases; patients presenting for follow-up with established meniscal injury; those with conditions mimicking meniscal tears (bone contusion, popliteus tendinitis, osteochondritis dissecans, traumatic chondral damage, loose bodies, inflammatory arthritis, fracture, synovial lesions, meniscotibial ligament sprain, discoid meniscus); patients whose history/clinical picture did not favor meniscal injury; and those with open knee wounds. After written informed consent, demographics were recorded.

All participants first underwent standardized ultrasonography on a GRE ultrasound unit with a 12-MHz linear probe. With the patient supine, the knee and hip were slightly flexed; the hip was externally rotated for medial scanning and internally rotated (or lateral decubitus) for lateral scanning. The medial joint line (including MCL, pes anserine tendons/bursa, and medial retinaculum) and the anterior horn/body of the medial meniscus were evaluated in orthogonal planes. For lateral

assessment, we scanned the popliteus tendon, biceps femoris tendon, fibular collateral ligament, iliotibial band/bursa, lateral retinaculum, and joint line from posterior to anterior. Sonographic criteria for a meniscal tear included echogenic/linear clefts reaching an articular surface, abrupt contour change, or blunting of the meniscal surface. After US, all patients underwent MRI, which was interpreted by a senior radiologist blinded to US findings. MRI criteria for meniscal tears comprised linear or nodular signal changes that extended to the articular surface (or as per standard institutional criteria). Ultrasound and MRI outcomes were categorized as positive/negative for meniscal tear; operational definitions for true/false positives/negatives followed standard 2×2 classification. Data were entered in SPSS v18; we calculated sensitivity, specificity, positive/negative predictive values, and overall accuracy from a 2×2 table. Age (continuous) was summarized as mean±SD; categorical variables (gender, US finding, MRI finding) were reported as frequencies and percentages.

Results

A total of 304 participants were included (mean age 29.9 ± 7.57 years); 186 (61%) were male and 118 (39%) were female. On imaging, ultrasonography (US) identified meniscal tears in 207/304 (68.1%) and "no tear" in 97/304 (31.9%), while MRI demonstrated meniscal tears in 222/304 (73.0%) and "no tear" in 82/304 (27.0%). Cross-tabulation of US against MRI showed 193 true positives, 14 false positives, 68 true negatives, and 29 false negatives. Using MRI as the reference standard, US achieved a sensitivity of 86.9%, specificity of 82.9%, positive predictive value (PPV) of 93.2%, negative predictive value (NPV) of 70.1%, and an overall accuracy of 85.9%. Discrimination on receiver operating characteristic analysis was good, with an AUC of 0.847 and $p < 0.0001$ (Figure 1), indicating that US provided strong rule-in performance and acceptable overall diagnostic accuracy for detecting meniscal tears relative to MRI in this cohort.

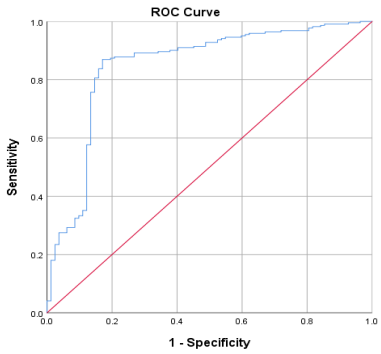

Figure 1: ROC CURVE with an AUC of 0.847 and p value <0.0001

Table 1: Demographic variable

Variable	Mean and Frequency
Age (years)	29.9±7.57
Gender	
Female	118 (39%)
Male	186 (61%)

Table 2: Tear Variables

Variable	Category	Frequency	Percent
Ultrasound meniscal tear	Tear	207	68.1%
	No tear	97	31.9%
MRI meniscal tear	Tear	222	73.0%
	No tear	82	27.0%

Table 3: 2x2 accuracy variables

	MRI: Tear	MRI: No tear
US: Tear	193	14
US: No tear	29	68
Sensitivity	86.9%	
Specificity	82.9%	
PPV	93.2%	
NPV	70.1%	
Accuracy	85.9%	

Discussion

Our findings show that ultrasonography (US) achieved sensitivity 86.9%, specificity 82.9%, PPV 93.2%, NPV 70.1%, accuracy 85.9%, and AUC 0.847 against MRI. This performance closely mirrors recent real-world studies in which US, performed with high-frequency linear probes by trained operators, has delivered accuracy ≈84–85% with sensitivities around 88–89% and specificities ≈72–77% when benchmarked to MRI—figures nearly identical to ours and reinforcing US as a pragmatic triage test in busy services (11,12). In a broader evidence summary for acute meniscal tears, ranges of US sensitivity 85–100% and specificity 69–97% have been reported, placing our point estimates comfortably within prior bounds and supporting US's strong "rule-in" utility when positive (13). A meta-analytic synthesis focused on B-mode US similarly emphasized high specificity with moderate sensitivity, consistent with our high PPV (reflecting the relatively high MRI-positive prevalence, 73%) and more modest NPV (14). Comparative MRI literature helps contextualize our results. Classic 1.5-T vs 3-T work demonstrated lateral meniscus sensitivity ≈68–69% with specificity ≈92–95%, and similar performance across field strengths, highlighting that even the reference test has blind spots—particularly laterally and in certain tear configurations (15). Prospective head-to-head data likewise found no overall diagnostic superiority of 3-T over 1.5-T for meniscal pathology, with nuances by tear type and location; importantly, lateral meniscal assessment may be more sensitive on 1.5-T in some series (16). Our cohort's good but not perfect NPV (70.1%) aligns with that landscape: when the target condition is common and the reference itself is imperfect by location, a negative US cannot fully exclude disease and should be integrated with clinical suspicion and, where indicated, MRI (15,16). Several observational MRI–arthroscopy correlation studies also caution that discordance—both false positives and false negatives—occurs with MRI, driven by tear size, location (e.g., posterior horns), and concomitant injuries. Such reports argue for a pathway approach that combines clinical examination, point-of-care imaging, and confirmatory MRI or arthroscopy only when incremental value is expected (17). Complementary MRI series using arthroscopy as the gold standard report overall MRI accuracy ≈89–91% and no consistent advantage of 3-T over 1.5-T, again underscoring that adding a high-quality US step may reduce unnecessary MRI without compromising diagnostic certainty—particularly when the US is positive (18). Collectively, our results—AUC 0.847 with balanced sensitivity/specificity—fit well within contemporary evidence that US can rapidly "rule in" meniscal tears at low cost, while MRI retains value to "rule out" in equivocal or complex presentations and to map tear morphology before surgery. Pragmatically, our high PPV suggests that US-positive cases can be advanced confidently to definitive management, whereas US-negative or indeterminate scans should be triaged to MRI when clinical suspicion persists. Operator training, standardized scanning of anterior horn/body, and equipment quality remain key levers to sustain performance gains reported across prospective cohorts and reviews (11–14,16).

Conclusion

Ultrasonography demonstrated good diagnostic performance against MRI in detecting meniscal tears (AUC 0.847; accuracy 85.9%), with especially strong rule-in value given its high PPV (93.2%). In resource-constrained

or high-throughput settings, US can serve as an effective first-line triage tool, reserving MRI for equivocal cases or when clinical suspicion remains despite a negative US (NPV 70.1%). Standardized scanning protocols and operator training are essential to sustain accuracy. Future work should stratify by meniscus/tear pattern and assess cost-effectiveness and patient pathways.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-23)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

AR, ST, SK

Review of Literature, Data entry, Data analysis, and drafting article. Manuscript drafting, Study Design,

MR, SM, KA

Study Design, manuscript review, critical input.

Conception of Study, Development of Research Methodology Design

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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