

Original research article

## A Prospective Study Of Clinical, MRI And Arthroscopic Correlation In Meniscal And Cruciate Ligament Injuries Of Knee Joint

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### Abstract

**Background:** Injuries to the meniscus and cruciate ligaments of the knee are common and debilitating, leading to significant pain, dysfunction, and long-term complications such as osteoarthritis. Accurate diagnosis is critical for effective management and improved patient outcomes. This study aims to evaluate the diagnostic accuracy of clinical examination, MRI, and arthroscopy in identifying meniscal and cruciate ligament injuries.

**Methods:** This prospective study was conducted over eight months among a total of 36 patients aged 18-60 years with suspected meniscal or cruciate ligament injuries were included. Each patient underwent a thorough clinical examination, MRI, and arthroscopy. MRI scans were performed using a 1.5T MRI scanner and interpreted by a blinded radiologist. Arthroscopy served as the gold standard for diagnosis. Sensitivity, specificity, PPV, NPV, and accuracy of MRI were calculated and compared with arthroscopic findings.

**Results:** The study included 31 males (86.1%) and 5 females (13.89%), with a mean age of 28.6 years. MRI demonstrated a sensitivity of 92.0% and specificity of 81.8% for ACL tears, with an accuracy of 88.9%. For PCL tears, MRI showed 100.0% sensitivity and specificity. MRI sensitivity and specificity for medial meniscus tears were 81.8% and 64.0%, respectively, with an accuracy of 69.4%. For lateral meniscus tears, MRI sensitivity was 66.7%, specificity was 86.7%, and accuracy was 83.3%.

**Conclusion:** MRI is a highly sensitive and specific tool for diagnosing ACL and PCL tears but shows moderate sensitivity and lower specificity for medial and lateral meniscus tears. While MRI is valuable for non-invasive diagnosis, it should complement clinical assessment and be interpreted cautiously to avoid misdiagnosis.

**Keywords:** Knee injuries, MRI, arthroscopy, meniscal tears, cruciate ligament injuries, diagnostic accuracy

### Introduction

Injuries to the meniscus and cruciate ligament of the knee joint are among the most common and debilitating conditions encountered in orthopedic practice. These injuries not only cause significant pain and dysfunction but also predispose individuals to long-term complications such as osteoarthritis, impaired mobility, and reduced quality of life. The accurate diagnosis and effective management of meniscal and cruciate ligament injuries are therefore critical to improving patient outcomes and preventing chronic disability.

Magnetic Resonance Imaging (MRI) has become the cornerstone of non-invasive diagnostic modalities for knee injuries, offering detailed visualization of soft tissue structures, including the meniscus, ACL and PCL. Despite its widespread use, the reliability of MRI in accurately diagnosing these injuries has been subject to debate, with discrepancies often noted between MRI findings and intraoperative

observations during arthroscopy. Arthroscopy considered the gold standard for diagnosing knee joint pathologies, provides direct visualization and the ability to simultaneously treat identified lesions. However, it is an invasive procedure with associated risks and costs.

Given the variability in diagnostic accuracy, there is a compelling need for comprehensive studies that evaluate the correlation between clinical findings, MRI results, and arthroscopic observations in the diagnosis of meniscal and cruciate ligament injuries. Such studies are essential to validate the diagnostic accuracy of MRI, refine clinical assessment protocols, and enhance the decision-making process for surgical intervention.

This prospective study aims to systematically compare clinical examination findings with MRI results and arthroscopic findings in patients presenting with suspected meniscal and cruciate ligament injuries. By analyzing the concordance between these diagnostic methods, we seek to identify the strengths and limitations of MRI and establish more robust diagnostic criteria that can improve the precision of preoperative assessments. Additionally, this study will explore the factors contributing to any diagnostic discrepancies, thereby providing valuable insights into optimizing patient management strategies and improving overall treatment outcomes for knee joint injuries.

### **Methodology**

This prospective study was conducted at in the Department of Orthopedics, SMS Hospital, Jaipur over a period of 8 months, involving patients who presented with knee pain and were suspected to have meniscal and/or anterior/Posterior cruciate ligament (cruciate ligament) injuries. Ethical approval was obtained from the institutional review board, and informed consent was secured from all participants.

A convenience sampling method of the non-probable sampling technique was used for patient selection based on inclusion and exclusion criteria. Patients aged 18 to 60 years with clinical signs suggestive of meniscal or cruciate ligament injuries were included in the study. Patients with previous knee surgeries, other concurrent knee pathologies (such as fractures or significant osteoarthritis, Ankylosis, acute injury less than 2 weeks and infection or cellulitis over portal sites), and those who declined to participate were excluded from the study.

Each participant underwent a thorough clinical examination conducted by experienced orthopedic surgeons. The examination included specific tests for meniscal injuries (McMurray's test, Apley's test) and ACL injuries (Lachman test, Anterior Drawer test, Pivot Shift test). Clinical findings were recorded and scored based on predefined criteria.

Following the clinical examination, participants underwent MRI of the affected knee using a 1.5T MRI scanner. Standard MRI protocols were employed, capturing images in multiple planes (axial, coronal, sagittal) with sequences optimized for soft tissue visualization (T1-weighted, T2-weighted, proton density, and fat-suppressed sequences). MRI scans were interpreted by a radiologist blinded to clinical and arthroscopic findings. The presence and extent of meniscal and cruciate ligament injuries were documented.

Arthroscopy was performed on all participants as the definitive diagnostic and therapeutic procedure. The arthroscopic examination was conducted by experienced orthopedic surgeons who were blinded to MRI results. During the procedure, detailed observations of the meniscus and cruciate ligament were made. Arthroscopic findings were recorded and used as the reference standard for diagnosis.

Clinical, MRI, and arthroscopic data were systematically collected and entered into a secure database. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MRI were calculated using arthroscopic findings as the gold standard. Statistical analysis was performed using [appropriate statistical software, e.g., SPSS, version 25]. Descriptive statistics were used to summarize patient demographics and the prevalence of meniscal and cruciate ligament injuries.

### **Result**

Overall, a total of 36 patients were included in the study among them 31 (86.1%) were males and 5 (13.89%) were female. The overall mean age of patients was  $28.6 \pm 8.1$  years. The majority were between age 25-29 years. Right-side knee injury was more commonly seen in 22 (61.11%). There were no cases of bilateral knee injury in our study. Sports injury (18) was the most common mode of injury, followed by road traffic accidents (10), Slips and falls (5) and giddiness (3).

**Table 1:** Diagnostic Accuracy of Clinical Examination, MRI, and Arthroscopy in Detecting Knee Injuries

Structures Injured	Clinical Exam. (%)	MRI (%)	Arthroscopy (%)
ACL	24 (66.7%)	25 (69.4%)	25 (69.4%)
PCL	0 (0.0%)	1 (2.8%)	1 (2.8%)
Medial Meniscus	9 (25.0%)	18 (50.0%)	11 (30.6%)
Lateral Meniscus	4 (11.1%)	8 (22.2%)	6 (16.7%)
Osteochondral defect	0 (0.0%)	1 (2.8%)	1 (2.8%)

The detection rates of knee injuries, specifically ACL tears, PCL tears, medial meniscus tears, lateral meniscus tears, and osteochondral defects, were compared using clinical examination, MRI, and arthroscopy. For ACL tears, clinical examination identified 24 cases (66.7%), while MRI and arthroscopy both detected 25 cases (69.4%). In the case of PCL tears, the clinical examination found no cases (0.0%), whereas MRI and arthroscopy each identified 1 case (2.8%). For medial meniscus tears, clinical examination detected 9 cases (25.0%), MRI detected 18 cases (50.0%), and arthroscopy confirmed 11 cases (30.6%). Lateral meniscus tears were identified in 4 cases (11.1%) by clinical examination, 8 cases (22.2%) by MRI, and 6 cases (16.7%) by arthroscopy. Osteochondral defects were not detected by clinical examination (0.0%), but MRI and arthroscopy each identified 1 case (2.8%).

The data indicates that MRI generally has a higher detection rate compared to clinical examination, particularly for medial and lateral meniscus tears. However, arthroscopy, as the gold standard, confirms all cases detected by MRI and clinical examination. This comparison underscores the importance of MRI as a non-invasive diagnostic tool closely aligning with arthroscopic findings, while also highlighting the critical role of arthroscopy in accurately diagnosing knee injuries.

**Table 2:** Comparison of MRI and Arthroscopy for Knee Injury Diagnosis

Tear	MRI	Arthroscopy	
		Positive	Negative
ACL Tear	Positive	23 (92.0%)	2 (18.2%)
	Negative	2 (8.0%)	9 (81.8%)
PCL	Positive	1 (100%)	0 (0%)
	Negative	0 (0%)	35 (100%)
Medial Meniscus tear	Positive	9 (81.8%)	9 (36.0%)
	Negative	2 (18.2%)	16 (64.0%)
Lateral Meniscus tear	Positive	4 (66.7%)	4 (13.3%)
	Negative	2 (33.3%)	26 (86.7%)

For ACL tear, MRI showed a sensitivity of 92.0% (23 out of 25 positive cases correctly identified) and a specificity of 81.8% (9 out of 11 negative cases correctly identified).

PCL tear was perfectly detected by both MRI and arthroscopy, with 100.0% sensitivity and specificity, indicating accurate diagnosis by both methods.

In diagnosing medial meniscus tears, MRI correctly diagnose 9 out of 11 cases positive and a 16 out of 25 cases negative.

For lateral meniscus tears, MRI exhibited 4 cases positive out of 6 confirmed by arthroscopy. while 26 found negative from total 30 cases.

**Table 3:** Diagnostic Performance of MRI Compared to Arthroscopy for Knee Injuries

Diagnostic Performance	ACL Tear	PCL Tear	Medial Meniscus tear	Lateral Meniscus tear
Sensitivity	92.0%	100.0%	81.8%	66.7%
Specificity	81.8%	100.0%	64.0%	86.7%
PPV	92.0%	100.0%	50.0%	50.0%
NPV	81.8%	100.0%	88.9%	92.9%
Accuracy	88.9%	100.0%	69.4%	83.3%

The tables present the diagnostic performance of MRI compared to arthroscopy for detecting ACL tear, PCL tear, medial meniscus tear, and lateral meniscus tear in knee injuries.

**ACL Tear:** MRI demonstrates a sensitivity of 92.0%, correctly identifying 23 out of 25 cases of ACL tear confirmed by arthroscopy. It shows a specificity of 81.8%, accurately ruling out ACL tear in 9 out of 11 cases where arthroscopy confirms no tear. The positive predictive value (PPV) for MRI indicating an ACL tear is 92.0%, meaning it correctly predicts the presence of tear in 92.0% of cases. The negative predictive value (NPV) is 81.8%, indicating that when MRI indicates no ACL tear, it correctly predicts the absence of tear in 81.8% of cases. The accuracy for ACL tear diagnosis is 88.9%.

**PCL Tear:** For PCL tear detection, MRI shows 100.0% sensitivity and specificity. It correctly identifies the single case of PCL tear confirmed by arthroscopy (sensitivity). Additionally, MRI correctly rules out PCL tear in all 35 cases where arthroscopy confirms no tear (specificity). Both the PPV and NPV for PCL tear are 100.0%, indicating perfect prediction for presence and absence of tear based on MRI results. The accuracy for PCL tear diagnosis is 100.0%.

**Medial Meniscus Tear:** MRI exhibits 81.8% sensitivity for medial meniscus tear, accurately identifying 9 out of 11 cases confirmed by arthroscopy. Its specificity is 64.0%, correctly ruling out tear in 16 out of 25 cases where arthroscopy shows no tear. The PPV for MRI indicating a medial meniscus tear is 50.0%, meaning it correctly predicts the presence of tear in half of the cases where it indicates tear. The NPV is 88.9%, indicating it correctly predicts the absence of tear in 88.9% of cases where it indicates no tear. The accuracy for medial meniscus tear diagnosis is 69.4%.

**Lateral Meniscus Tear:** MRI shows 66.7% sensitivity for lateral meniscus tear, correctly identifying 4 out of 6 cases confirmed by arthroscopy. Its specificity is 86.7%, accurately ruling out tear in 26 out of 30 cases where arthroscopy confirms no tear. The PPV for MRI indicating a lateral meniscus tear is 50.0%, correctly predicting the presence of tear in half of the cases where it indicates tear. The NPV is 92.9%, indicating it correctly predicts the absence of tear in 92.9% of cases where it indicates no tear. The accuracy for lateral meniscus tear diagnosis is 83.3%.

In summary, while MRI demonstrates high sensitivity and specificity for ACL and PCL tears, its performance for medial and lateral meniscus tears shows lower specificity but moderate sensitivity. These metrics emphasize role of MRI as a valuable non-invasive tool in diagnosing knee injuries, complementing clinical assessment but requiring careful interpretation in clinical practice.

## Discussion

The present study involving 36 patients was done to compare the accuracy of MRI in diagnosing knee injury and was compared with gold standard arthroscopy findings.

In our study, males and young age groups were more likely to suffer knee injuries. Which is in a corddance with the study done by Sultana *et al.* <sup>[1]</sup> and a study by Ahmed *et al.* <sup>[2]</sup> The overall mean age of patients was 28.6±8.1 years. Sports injury was the most common mode of injury reported. Males re more commonly reported might be due to they were more commonly involved in sports activity and wise a verse.

Similar to our study finding, A study done by Almmawi *et al.*, reported that the knee injury was more common in the age group of (18-21) accounting for 53.73% of their study population. And the majority were injured due to sports activity <sup>[3]</sup>. This finding is consistent with what was observed by John *et al.* (64.4%) of their sample <sup>[4]</sup>.

Arthroscopy allows direct observation of the internal structure of the joint and is currently considered the "gold standard" for diagnosing ACL injuries, boasting an accuracy rate of 100% <sup>[5]</sup>. However, due to its invasive nature and associated risks, many patients are reluctant to undergo this procedure. In contrast, MRI offers a non-invasive alternative with high resolution, sensitivity, and specificity for diagnosing ACL injuries.

**ACL Tear:** In our study, MRI demonstrated a sensitivity of 92.0%, correctly identifying 23 out of 25 cases of ACL tear confirmed by arthroscopy, and a specificity of 81.8%, accurately ruling out ACL tear in 9 out of 11 cases where arthroscopy confirmed no tear. The positive predictive value (PPV) for MRI indicating an ACL tear was 92.0%, meaning it correctly predicted the presence of a tear in 92.0% of cases. The negative predictive value (NPV) was 81.8%, indicating that when MRI indicated no ACL tear, it correctly predicted the absence of a tear in 81.8% of cases. The overall accuracy for ACL tear

diagnosis was 88.9%. However, some misdiagnoses were present in our study, potentially due to hemorrhage and fluid accumulation around the ligaments following acute trauma, as well as varying scanning angles.

When compared to the study by Zhao *et al.*, where MRI detected ACL injuries with a sensitivity of 95.45%, specificity of 91.67%, and an overall accuracy of 94.87%, our study's sensitivity and accuracy are slightly lower, while specificity is comparably high. Zhao *et al.* reported that MRI confirmed 95.45% of the 66 ACL injury cases identified by arthroscopy, with an accuracy of 92.86% for complete tears and 94.74% for partial tears <sup>[6]</sup>.

Sultana *et al.* found that MRI diagnosed ACL tears with a sensitivity of 97.4%, specificity of 75.0%, accuracy of 92.0%, PPV of 92.5%, and NPV of 90.0%. These results indicate higher sensitivity and accuracy compared to our findings but lower specificity. Their study also highlighted the presence of other injuries, such as medial and lateral meniscus injuries, which were significant among the patients <sup>[11]</sup>.

Ahmed *et al.* reported that MRI had an accuracy of 91.89% in diagnosing ACL tears, with a sensitivity of 93.33%, specificity of 85.71%, PPV of 96.55%, and NPV of 75%. These findings demonstrate higher sensitivity and PPV but slightly lower specificity and NPV compared to our study <sup>[2]</sup>.

Clinical examinations, as reported in the study by Shantanu *et al.*, showed a sensitivity of 90.4%, specificity of 75.0%, PPV of 95.9%, NPV of 54.5%, and accuracy of 83.3%. These results suggest that clinical examinations are slightly less sensitive and specific than MRI, but they remain valuable for initial assessments <sup>[7]</sup>.

Panigrahi *et al.* found that clinical tests had a sensitivity of 94.7%, specificity of 71.4%, PPV of 90.0%, NPV of 83.3%, and accuracy of 88.5%. These findings reinforce the high sensitivity of clinical examinations, although their specificity and accuracy are generally lower than those of MRI <sup>[8]</sup>.

Previous studies have reported a range of sensitivity, specificity, PPV, NPV, and accuracy for MRI in diagnosing ACL tears. Sensitivity values range from 66% to 100% <sup>[9-13]</sup>, indicating that MRI can detect ACL tears with varying degrees of effectiveness across different studies. Specificity values range from 67% to 98% <sup>[9, 10, 14]</sup>, showing the ability of MRI to correctly identify patients without an ACL tear. The PPV, which reflects the proportion of positive MRI results that are true positives, ranges from 75% to 93% <sup>[9, 10]</sup>. The NPV, indicating the proportion of negative MRI results that are true negatives, ranges from 79% to 100% <sup>[9, 10, 13]</sup>. Finally, accuracy values, representing the overall correctness of MRI in diagnosing ACL tears, range from 78% to 98% <sup>[9, 10, 15]</sup>.

Overall, while our study's MRI results for diagnosing ACL tears align closely with those of previous studies, minor variations in sensitivity, specificity, and accuracy exist. These discrepancies may be attributed to differences in patient populations, imaging techniques, and diagnostic criteria. Despite these differences, the general consensus across studies reinforces the utility of MRI as a reliable, non-invasive diagnostic tool for ACL injuries, albeit with some limitations compared to the gold standard of arthroscopy.

**PCL Tear:** In our study, MRI demonstrated perfect diagnostic performance for detecting PCL tears, with 100.0% sensitivity and specificity. It correctly identified the single case of PCL tear confirmed by arthroscopy and accurately ruled out PCL tears in all 35 cases where arthroscopy confirmed no tear. The PPV and NPV for PCL tears were also 100.0%, indicating that MRI perfectly predicted both the presence and absence of PCL tears based on our results. This led to an overall accuracy of 100.0% for PCL tear diagnosis.

Gimhavanekar *et al.* found that MRI had 100% sensitivity, specificity, PPV, and NPV for PCL tears, mirroring our results. Our study aligns with the findings of Gimhavanekar *et al.*, confirming that MRI is highly effective in diagnosing PCL tears with perfect sensitivity, specificity, PPV, NPV, and accuracy. This suggests that MRI can be relied upon as a non-invasive and accurate diagnostic tool for PCL tears <sup>[9]</sup>.

Shantanu *et al.* reported an accuracy of 100% for clinical examinations in diagnosing PCL tears. This indicates that clinical examinations alone can be highly reliable for diagnosing PCL tears, matching the performance of MRI in our study <sup>[7]</sup>.

Panigrahi *et al.* observed 100% sensitivity, specificity, PPV, NPV and accuracy for clinical examinations of PCL tears. However, their findings showed that MRI did not achieve these perfect scores, indicating some variability in MRI performance across different studies and patient populations <sup>[8]</sup>.

The results from Shantanu *et al.* and Panigrahi *et al.* underscore that clinical examinations also provide

high accuracy, which can be particularly useful in settings where MRI is not readily available. However, the slight discrepancies in MRI performance reported by Panigrahi *et al.* highlight that while MRI is generally reliable, its diagnostic accuracy can vary, potentially due to factors like the quality of imaging equipment, technician expertise, and patient differences.

Overall, our study reinforces the notion that MRI is an excellent screening tool for ligamentous injuries of the knee joint, providing high diagnostic accuracy comparable to clinical examinations. This consistency across multiple studies strengthens the evidence for MRI as a preferred method for non-invasive diagnosis of PCL tears.

**Medial Meniscus Tear:** For medial meniscus injuries, our study utilized MRI and the McMurray test for comparison against arthroscopy. The MRI demonstrated an 81.8% sensitivity, accurately identifying 9 out of 11 cases confirmed by arthroscopy. The specificity of MRI was 64.0%, correctly ruling out a tear in 16 out of 25 cases where arthroscopy showed no tear. The positive predictive value (PPV) for MRI in indicating a medial meniscus tear was 50.0%, meaning it correctly predicted the presence of a tear in half of the cases where it indicated a tear. The negative predictive value (NPV) was 88.9%, indicating it correctly predicted the absence of a tear in 88.9% of cases where it indicated no tear. The overall accuracy for medial meniscus tear diagnosis was 69.4%.

Shantanu *et al.* found the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of the McMurray test to be 47.4%, 97.6%, 90.0%, 80.0%, and 81.7%, respectively. This suggests a lower sensitivity but higher specificity and PPV compared to our MRI results, indicating that while the McMurray test may be more specific, it is less sensitive than MRI <sup>[7]</sup>.

Panigrahi *et al.* reported sensitivity, specificity, PPV, NPV, and diagnostic accuracy of clinical tests for medial meniscus tears as 76.5%, 68.6%, 54.2%, 85.7%, and 71.2%, respectively. These results are relatively comparable to our MRI findings, though slightly lower in sensitivity and specificity <sup>[8]</sup>.

Chandru *et al.* studied the clinical and arthroscopic correlation of medial meniscal injuries of the knee and found sensitivity and specificity of 83.33% and 77.78%, respectively. Their sensitivity is slightly higher, and specificity is notably higher compared to our MRI results, suggesting that clinical assessment can also be quite effective <sup>[13]</sup>.

Sharma *et al.* conducted a study on 41 patients to correlate clinical and MRI findings with arthroscopy and found that the sensitivity, specificity, and diagnostic accuracy of clinical examination for medial meniscus injury were 96.1%, 33.3%, and 73.1%, respectively. This indicates very high sensitivity but low specificity for clinical examinations, suggesting that while clinical examinations can detect most tears, they may also have a higher rate of false positives compared to MRI <sup>[12]</sup>.

Overall, our study confirms that MRI remains a valuable diagnostic tool for medial meniscus injuries, offering a balanced sensitivity and specificity. However, clinical exams like the McMurray test can serve as effective initial screening tools, particularly in settings where MRI is not readily available. The variability in diagnostic performance across different studies suggests that combining clinical and imaging assessments might provide the most comprehensive diagnostic approach for medial meniscus injuries.

**Lateral Meniscus Tear:** In our study, MRI shows a 66.7% sensitivity for lateral meniscus tear, correctly identifying 4 out of 6 cases confirmed by arthroscopy. Its specificity is 86.7%, accurately ruling out tears in 26 out of 30 cases where arthroscopy confirms no tear. The PPV for MRI indicating a lateral meniscus tear is 50.0%, correctly predicting the presence of a tear in half of the cases where it indicates a tear. The NPV is 92.9%, indicating it correctly predicts the absence of a tear in 92.9% of cases where it indicates no tear. The accuracy for lateral meniscus tear diagnosis is 83.3%.

In Shantanu *et al.*'s study, the sensitivity, specificity, PPV, NPV and accuracy of MRI for lateral meniscus tears were 87.5%, 94.2%, 70.0%, 98.0%, and 93.33%, respectively <sup>[7]</sup>.

Panigrahi *et al.* reported these values as 46.7%, 89.2%, 63.6%, 80.5% and 76.9%, respectively <sup>[8]</sup>.

Chandru *et al.* found the sensitivity and specificity of MRI for the lateral meniscus to be 62.5% and 72.73%, respectively <sup>[13]</sup>. Sharma *et al.* reported the sensitivity, specificity, and accuracy of MRI for lateral meniscus injuries to be 86.6%, 96.4%, and 92.6%, respectively <sup>[12]</sup>. Previous studies have shown a wide range of values for MRI diagnostics: sensitivity between 41-100% <sup>[8, 9, 12, 16, 17]</sup>, specificity between 72-100% <sup>[8, 12, 13, 16, 17]</sup>, PPV between 34-100% <sup>[8, 17]</sup>, NPV between 90-100% <sup>[8, 17]</sup>, and accuracy between 68-100% <sup>[8, 9, 12, 17]</sup>.

### Conclusion

In summary, while MRI demonstrates high sensitivity and specificity for ACL and PCL tears, its performance for medial and lateral meniscus tears shows lower specificity but moderate sensitivity. These metrics emphasize role of MRI as a valuable non-invasive tool in diagnosing knee injuries, complementing clinical assessment but requiring careful interpretation in clinical practice.

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