A comparative study of magnetic resonance imaging and arthroscopy in internal derangement of the knee: a prospective study

✉ Shrestha R[1], Shrestha N[2], Jha R[3]

1. Department of Radiodiagnosis, Nobel Medical College Teaching Hospital,Biratnagar, Nepal
2. Dhaulagiri Hospital, Baglung, Nepal
3. Department of Orthopedics, Nobel Medical College Teaching Hospital, Biratnagar, Nepal

ABSTRACT

Introduction: Internal derangement of the knee, particularly involving the cruciate ligaments and menisci, is a common cause of pain and functional limitation. Magnetic resonance imaging (MRI) is widely used as a noninvasive diagnostic modality, whereas arthroscopy remains the gold standard for confirmation. This study aims to evaluate the diagnostic accuracy of MRI for detecting internal derangement of the knee by comparing MRI findings with arthroscopic findings.

Methods: This prospective observational study included 60 patients aged 16–65 years with clinically suspected internal derangement of the knee. All patients underwent MRI using a 3 Tesla scanner, followed by diagnostic arthroscopy. MRI findings were compared with arthroscopic findings, and sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated.

Results: Arthroscopy identified 48 anterior cruciate ligament (ACL) tears, 11 posterior cruciate ligament (PCL) tears, 26 medial meniscal tears, and 19 lateral meniscal tears. MRI demonstrated a sensitivity, specificity, and accuracy of 87.5%, 83.3%, and 86.7% for ACL tears; 100%, 100%, and 100% for PCL tears; 84.6%, 88.2%, and 86.7% for medial meniscal tears; and 78.9%, 92.7%, and 88.3% for lateral meniscal tears. This study showed a statistically significant association between MRI and arthroscopic findings.

Conclusion: MRI demonstrates high diagnostic accuracy in detecting cruciate ligament and meniscal injuries and serves as an excellent first-line investigation in patients with suspected internal derangement of the knee. Arthroscopy should be reserved primarily for therapeutic intervention.

Keywords: Arthroscopy, cruciate ligament, knee, magnetic resonance imaging, meniscus tear.

INTRODUCTION

A variety of intra-articular disorders affecting the menisci, cruciate ligaments, collateral ligaments, and articular cartilage are collectively referred to as internal derangement of the knee (IDK). These injuries usually manifest as discomfort, instability, mechanical symptoms, or limited movement and are most frequently caused by trauma or sports-related activities.[1,2] The cruciate ligaments, menisci, cartilage, and musculotendinous tissue are all intricately arranged in the knee joint. Sagittal-plane images are essential for assessing meniscal architecture and the cruciate ligaments.[3] Although the degree of knee damage can be assessed clinically, advances in magnetic resonance imaging (MRI) have made it possible to diagnose soft-tissue and cartilage lesions in the knee with greater accuracy.[4] It enables a thorough assessment of osteochondral lesions, meniscal rips, ligamentous injuries, and joint effusions.[5] Clinical examination alone may be insufficient to accurately diagnose internal derangement due to overlapping symptoms and the limited specificity of physical tests. Conventional radiography and computed tomography are useful for evaluating osseous abnormalities but have limited value in assessing soft-tissue structures.[3,4]

Since it allows for simultaneous therapeutic

Corresponding author
Dr. Robinson Shrestha
Department of Radiology
Nobel Medical College Teaching Hospital
Email: iamrabba@gmail.com

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intervention and direct viewing of intra-articular structures, arthroscopy is still the gold standard for diagnosing IDK.[6] However, it is invasive, costly, and associated with potential complications, making it less suitable as a purely diagnostic tool.[6]

Although the diagnostic accuracy of MRI has been extensively evaluated in international literature, data from resource-limited settings remain limited. In Nepal, MRI is available in only a few centers, and local validation of its diagnostic performance is scarce. Establishing the reliability of high-field MRI in our clinical context is important to support appropriate utilization and potentially reduce unnecessary diagnostic arthroscopy. Therefore, this study was conducted to evaluate the diagnostic accuracy of MRI in detecting cruciate ligament and meniscal injuries by correlating MRI findings with arthroscopic findings in our institution.

METHODS

This prospective, single-center observational study was conducted in the Department of Radiodiagnosis, Nobel Medical College, Biratnagar, Nepal, between Dec 2024 and Nov 2025. Ethical approval was taken from the Institutional Review Committee (IRC No 115/2024).

The sample size for this study is calculated using McNemar's test, based on anticipated discordant proportions between MRI and arthroscopy findings. The following parameters are set for the calculation:

Alpha (α): 0.05 (5% significance level)
Power (1-β): 70% (reduced from 80% to accommodate practical limitations in sample availability)
Proportion of positive-to-negative discordance: 20%
Proportion of negative-to-positive discordance: 4%

These proportions are informed by a similar study in the literature.[7] Using these parameters in MedCalc, the minimum required sample size is estimated to be 57.

A total of 60 patients aged 16–65 years with clinical suspicion of IDK were included. All patients underwent MRI evaluation followed by diagnostic arthroscopy. Patients with open knee injuries, neoplastic, infective, or inflammatory knee conditions, and those with a prior history of knee surgery were excluded.

MRI examinations were performed using a 3 Tesla Siemens scanner with a dedicated knee coil. Imaging sequences included sagittal, coronal, and axial proton density (PD), PD with fat suppression (PDFS), T1-weighted, and T2-weighted images. Slice thickness was 3 mm with an interslice gap of 0.3 mm. During sagittal imaging, the knee was positioned in approximately 15 degrees of flexion to optimize visualization of the ACL. [9]

MRI images were interpreted by a single senior consultant radiologist with more than 5 years of experience, who was blinded to clinical and arthroscopic findings. Ligaments were classified as either torn or intact. Partial tears were not evaluated separately. Meniscal tears were diagnosed based on established MRI criteria (Stoller Grade III), defined as abnormal intrameniscal signal intensity extending to an articular surface on at least two consecutive slices.[1,10]

All patients subsequently underwent diagnostic arthroscopy performed by a single experienced orthopedic knee surgeon, who was blinded to MRI findings. Arthroscopic findings, based on direct intra-articular visualization and probing of structures, were considered the reference standard.

Convenience consecutive sampling was used. Statistical analysis was performed using SPSS version 26. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of MRI were calculated. Agreement between MRI and arthroscopic findings was assessed using Cohen's kappa (κ) statistic. Kappa values were interpreted as follows: <0.20 poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good, and 0.81–1.00 excellent agreement.[11,12]

RESULTS

A total of 60 patients were included in the study, with a mean age of 39.10 years. The most common age group was 21–30 years (43.33%). Males constituted 56.67% of the study population. The right knee (63.33%) was more commonly affected (Table 1). Sports-related injuries were the most frequent mechanism of injury.

Arthroscopy identified 48 ACL tears, of which MRI correctly detected 42 cases (Figure 1). Six ACL tears were false negatives on MRI. The sensitivity, specificity, and diagnostic accuracy

Table 1. Demographic and Clinical Characteristics of the Study Population (n = 60)

Variable	Number (n)	Percentage (%)
Age group (years)		
16-20	8	13.33
21-30	26	43.33
31-40	12	20
41-50	8	13.33
51-65	6	10
Sex		
Male	34	56.67
Female	26	43.33
Side involved		
Right knee	38	63.33
Left knee	22	36.67

Table 2. Relation Between MRI and Arthroscopic Findings

Anterior Cruciate Ligament (ACL)			
MRI finding	Arthroscopy: Tear	Arthroscopy: No tear	Total
Tear	42	2	44
No tear	6	10	16
Total	48	12	60
Posterior Cruciate Ligament (PCL)			
MRI finding	Arthroscopy: Tear	Arthroscopy: No tear	Total
Tear	11	0	11
No tear	0	49	49
Total	11	49	60
Medial Meniscus (MM)			
MRI finding	Arthroscopy: Tear	Arthroscopy: No tear	Total
Tear	22	4	26
No tear	4	30	34
Total	26	34	60
Lateral Meniscus (LM)			
MRI finding	Arthroscopy: Tear	Arthroscopy: No tear	Total
Tear	15	3	18
No tear	4	38	42
Total	19	41	60

Table 3. Diagnostic Performance of MRI Using Arthroscopy as Reference Standard

Structure	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accurcy (%)	Kappa (κ)
ACL	87.50	83.33	95.45	62.50	86.67	0.63
PCL	100	100	100	100	100	1
Medial meniscus	84.62	88.24	84.62	88.24	86.67	0.73
Lateral meniscus	78.95	92.68	83.33	90.48	88.33	0.73

of MRI for ACL tears were 87.50%, 83.33%, and 86.67%, respectively (Table 2,3).

All 11 PCL tears detected on arthroscopy were correctly identified on MRI (Figure 2), yielding 100% sensitivity, specificity, and diagnostic accuracy.

For medial meniscal tears (Figure 3,4), MRI demonstrated a sensitivity of 84.62%, specificity of 88.24%, and accuracy of 86.67%. Lateral meniscal tears showed a sensitivity of 78.95%, specificity of 92.68%, and accuracy of 88.33% (Table 2,3).

Cohen's kappa analysis demonstrated good agreement between MRI and arthroscopy for ACL tears (κ = 0.63) and meniscal tears (medial κ = 0.73; lateral κ = 0.73), while PCL tears showed perfect agreement (κ = 1.00) (Table 2,3).

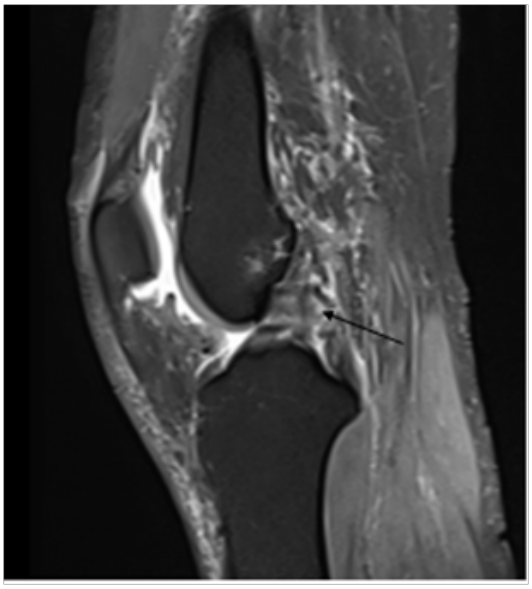

Fig 2: Sagittal PDFS image showing non visualization of PCL fibers suggesting complete PCL tear.

Fig 1: Sagittal PDFS image showing non visualization of ACL fibers suggesting complete ACL tear

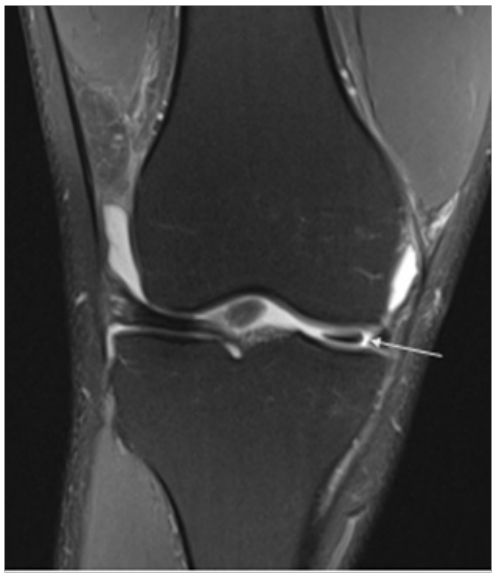

Fig 3: Coronal PDFS image showing radial tear of medial meniscus

Fig 4: Sagittal PDFS image showing bucket handle tear of medial meniscus

DISCUSSION

MRI's higher soft-tissue contrast, multiplanar capabilities, and direct visualization of intra-articular structures have made it the ideal noninvasive modality for assessing IDK. Despite being the gold standard for diagnosis, arthroscopy's use as a primary diagnostic tool is limited due to its invasive nature and related procedural hazards.[4,8–10] The present study demonstrates a strong and statistically significant correlation between MRI and arthroscopic findings, supporting MRI as a reliable first-line imaging investigation in patients with suspected internal derangement of the knee.

MRI demonstrated high diagnostic accuracy for ACL tears, with sensitivity and specificity comparable to those reported in multicenter and regional studies. The diagnostic performance observed in this study closely aligns with findings of other studies, underscoring the consistency and reproducibility of MRI in ACL evaluation across different populations and imaging settings. [4,11,12]

False-negative ACL findings in this study are likely attributable to recognized imaging limitations, including partial tears, chronic injuries with diminished secondary signs, and volume-averaging effects. Chronic ACL tears may present with subtle signal alterations without obvious fiber discontinuity, emphasizing the importance of meticulous multiplanar assessment and careful evaluation of secondary MRI signs.[13,14]

PCL injuries were detected with 100% sensitivity and specificity. This excellent diagnostic performance is consistent with prior literature and is likely related to the PCL's larger size, well-defined anatomic orientation, and lower susceptibility to degenerative signal changes. These findings further confirm MRI as a highly reliable modality for PCL assessment.[15]

Meniscal tears were more frequently identified in the medial meniscus than in the lateral meniscus, with predominant involvement of the posterior horn. This distribution pattern is well documented in imaging literature and reflects the medial meniscus's firm attachment to the joint capsule and deep fibers of the medial collateral ligament.[16] MRI demonstrated good diagnostic accuracy for both medial and lateral meniscal tears, with performance metrics within the 80–95% range.[17]

False-positive meniscal findings on MRI are most commonly related to intrameniscal degenerative signal that does not extend to an articular surface, whereas false-negative findings may occur in small radial tears, complex tear configurations, or lesions confined to the free edge of the meniscus. These limitations highlight the importance of applying strict diagnostic criteria, including the presence of an abnormal intrameniscal signal extending to an articular surface on consecutive slices, to optimize diagnostic accuracy.[18,19]

Limitations: The sample size was relatively small and derived from a single center, which may limit generalizability. Convenience sampling was employed. Interobserver variability was not assessed, as MRI interpretation was performed by a single radiologist.

CONCLUSIONS

MRI is a highly accurate and reliable modality for diagnosing internal derangement of the knee, particularly cruciate ligament and meniscal injuries. Its noninvasive nature, high diagnostic performance, and wide availability make it an ideal first-line investigation. Arthroscopy should

be reserved primarily for therapeutic intervention rather than routine diagnostic use.

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Data availability statement: The data are available from the corresponding author upon reasonable request.

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