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DIAGNOSTIC ACCURACY OF MRI IN PREDICTING MENISCAL AND LIGAMENT INJURIES OF THE KNEE WITH ARTHROSCOPY AS THE REFERENCE STANDARD: A PROSPECTIVE OBSERVATIONAL STUDY.

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Abstract

Background: Internal derangement of the knee, particularly meniscal and ligament injuries, is a common cause of pain, instability, locking, and functional limitation. Accurate preoperative diagnosis is essential for appropriate management. Magnetic resonance imaging (MRI) has become the preferred non-invasive imaging modality because of its excellent soft tissue resolution; however, arthroscopy remains the reference standard for confirming intra-articular pathology. Evaluating the diagnostic accuracy of MRI against arthroscopy is essential for improving diagnostic confidence and minimizing unnecessary invasive procedures. ***Aim:*** To evaluate the diagnostic accuracy of magnetic resonance imaging in predicting meniscal and ligament injuries of the knee using arthroscopy as the reference standard. ***Objectives:***

1. To determine the diagnostic accuracy of MRI in detecting meniscal and ligament injuries by comparing MRI findings with arthroscopic findings.
2. To calculate the sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of MRI for diagnosing meniscal and ligament injuries of the knee.

Materials and Methods: A hospital-based prospective observational study was conducted among 50 patients with clinically suspected internal derangement of the knee who underwent MRI followed by arthroscopy at a tertiary care teaching hospital. MRI findings for meniscal and ligament injuries were compared with arthroscopic findings, which served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. ***Results:*** The mean age of the participants was 34.8 ± 10.6 years, and 70% were males. Sports injuries (42%) and road traffic accidents (36%) were the most common mechanisms of injury. Arthroscopy identified medial meniscal tears in 44%, ACL tears in 40%, lateral meniscal tears in 22%, PCL tears in 6%, MCL injuries in 14%, and LCL injuries in 8% of patients. MRI demonstrated excellent diagnostic performance with a sensitivity of 95.5%, specificity of 92.9%, and accuracy of 94% for medial meniscal tears. For ACL tears, MRI showed 95.0% sensitivity, 96.7% specificity, and 96% diagnostic accuracy. PCL injuries demonstrated the highest diagnostic accuracy (98%). Excellent agreement was observed between MRI and arthroscopy for ACL (κ = 0.92), medial meniscus (κ = 0.88), lateral meniscus (κ = 0.84), and PCL (κ = 0.82) injuries. McNemar analysis showed no statistically significant difference between MRI and arthroscopy ($p > 0.05$). MRI accuracy was significantly higher in acute injuries, while motion artefacts significantly reduced diagnostic performance. ***Conclusion:*** Magnetic resonance imaging is a highly accurate and reliable non-invasive investigation for diagnosing meniscal and ligament injuries of the knee. Its excellent agreement with arthroscopy confirms its value in preoperative assessment and surgical planning. MRI accurately identifies most clinically significant intra-articular lesions and can substantially reduce the need for unnecessary diagnostic arthroscopy. Arthroscopy should remain reserved for therapeutic intervention or cases with persistent clinical suspicion despite inconclusive MRI findings.

Keywords: Magnetic resonance imaging; Arthroscopy; Meniscal tear; Anterior cruciate ligament; Posterior cruciate ligament.

INTRODUCTION

Knee injuries are among the most common musculoskeletal disorders encountered in orthopaedic practice and represent a major cause of pain, instability, disability, and loss of physical activity in individuals of all age groups. Meniscal and

ligamentous injuries constitute the majority of internal derangements of the knee and are frequently observed following sports injuries, road traffic accidents, occupational trauma, and falls. Early and accurate diagnosis of these injuries is essential for appropriate treatment planning, prevention of secondary osteoarthritis, and restoration of normal knee function.[1]

Globally, the incidence of knee ligament and meniscal injuries has increased considerably because of greater participation in competitive sports, recreational physical activities, and high-energy trauma. The anterior cruciate ligament (ACL) is the most commonly injured ligament of the knee, whereas the medial meniscus is the most frequently injured meniscus. Untreated or delayed diagnosis of these injuries can result in chronic pain, recurrent instability, locking, restricted movement, cartilage degeneration, and early osteoarthritis, thereby significantly affecting quality of life and functional capacity.[2] Clinical examination remains the first step in evaluating patients with suspected internal derangement of the knee. Tests such as the McMurray, Thessaly, Lachman, anterior drawer, posterior drawer, and pivot-shift tests provide valuable diagnostic information. However, their diagnostic accuracy is influenced by examiner experience, patient cooperation, acute pain, joint swelling, muscle spasm, and associated injuries. Consequently, imaging plays a crucial role in confirming the diagnosis and determining the extent of soft tissue damage.[3] Magnetic resonance imaging (MRI) has become the imaging modality of choice for evaluating internal derangements of the knee because of its excellent soft tissue contrast, multiplanar capability, and non-invasive nature. MRI accurately visualizes the menisci, anterior and posterior cruciate ligaments, collateral ligaments, articular cartilage, bone marrow, synovium, and surrounding soft tissues without exposing patients to ionizing radiation. Numerous studies have demonstrated high sensitivity and specificity of MRI for diagnosing meniscal tears and cruciate ligament injuries, making it an indispensable investigation before operative intervention.[4] Despite the excellent diagnostic performance of MRI, false-positive and false-negative findings may occur because of degeneration, postoperative changes, partial tears, imaging artifacts, anatomical variations, and interpreter experience. Therefore, arthroscopy continues to be regarded as the reference standard for diagnosing intra-articular knee lesions because it permits direct visualization of the menisci, cruciate ligaments, cartilage, and synovium while simultaneously allowing therapeutic intervention. However, arthroscopy is invasive, expensive, and associated with potential complications, making accurate preoperative MRI evaluation essential for selecting appropriate patients for surgery.[5] Several systematic reviews and meta-analyses have shown that MRI demonstrates excellent diagnostic performance in detecting ACL tears, with pooled sensitivities exceeding 90% and specificities approaching 99%, while diagnostic accuracy for meniscal tears also remains high. Nevertheless, diagnostic performance varies according to the injured structure, MRI field strength, imaging protocol, chronicity of injury, and radiologist expertise. Consequently, comparison of MRI findings with arthroscopic findings remains necessary for evaluating diagnostic accuracy and improving reporting standards.[6]

India is witnessing a steady rise in sports-related injuries, road traffic accidents, and occupational trauma, resulting in an increasing number of patients presenting with knee ligament and meniscal injuries. In many tertiary care centres, MRI is routinely performed before arthroscopy to guide surgical planning and avoid unnecessary invasive procedures. However, the diagnostic accuracy of MRI may vary depending on equipment, imaging protocols, and reporting expertise. Indian data comparing MRI with arthroscopy remain limited, particularly from prospective observational studies. Therefore, evaluating the diagnostic accuracy of MRI using arthroscopy as the reference standard is essential to optimize patient selection, improve diagnostic confidence, reduce unnecessary arthroscopies, and facilitate evidence-based management of knee injuries in the Indian population.[7]

AIM

To evaluate the diagnostic accuracy of magnetic resonance imaging (MRI) in detecting meniscal and ligament injuries of the knee using arthroscopy as the reference standard.

OBJECTIVES

1. To determine the diagnostic accuracy of MRI in detecting meniscal and ligament injuries of the knee by comparing MRI findings with arthroscopic findings.
2. To calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of MRI for diagnosing meniscal and ligament injuries of the knee.

MATERIALS AND METHODS

Study Design

A Hospital-based prospective observational study.

Study Population

Patients with clinically suspected meniscal or ligament injuries of the knee who undergo MRI followed by arthroscopy during the study period.

Sample Size
A total of 50 patients will be included in the study.

Sampling Technique
Consecutive sampling.

Inclusion Criteria
- Patients aged 18 years and above.
- Patients presenting with symptoms suggestive of internal derangement of the knee (pain, locking, instability, swelling, restricted movement).
- Patients undergoing MRI of the knee followed by arthroscopy.
- Patients willing to provide written informed consent.

Exclusion Criteria
- Previous knee surgery.
- Knee joint infection.
- Acute fractures around the knee.
- Advanced osteoarthritis with severe deformity.
- Contraindications to MRI (cardiac pacemaker, cochlear implant, ferromagnetic implant, severe claustrophobia).
- Patients unwilling to participate.

Methodology
After written informed consent, eligible patients will be recruited consecutively.
A detailed clinical history including age, sex, mechanism of injury, duration of symptoms, side involved, sports activity, previous trauma, and presenting complaints will be recorded.
Clinical examination will include:
- McMurray test
- Thessaly test
- Lachman test
- Anterior drawer test
- Posterior drawer test
- Pivot shift test
- Varus and valgus stress tests

All patients will undergo MRI examination before arthroscopy.

MRI Protocol
MRI will be performed using a 1.5 Tesla scanner.
The imaging protocol will include:
- Sagittal T1-weighted images
- Sagittal T2-weighted images
- Proton Density Fat-Suppressed (PD-FS)
- Coronal T1-weighted images
- Coronal PD-FS images
- Axial T2-weighted images

MRI will be evaluated for:
- Medial meniscus tear
- Lateral meniscus tear
- Anterior cruciate ligament (ACL) tear
- Posterior cruciate ligament (PCL) tear
- Medial collateral ligament (MCL) injury
- Lateral collateral ligament (LCL) injury
- Chondral injury
- Bone contusion
- Joint effusion

MRI findings will be interpreted independently by an experienced radiologist who is blinded to the arthroscopic findings.

Arthroscopy
Diagnostic arthroscopy will be performed by an experienced orthopaedic arthroscopic surgeon.

Arthroscopy findings regarding:

- Medial meniscus
- Lateral meniscus
- ACL
- PCL
- MCL
- LCL
- Articular cartilage
- Associated intra-articular lesions

will be documented and considered the reference (gold) standard.

Statistical Analysis

Data will be entered into Microsoft Excel and analysed using SPSS. Continuous variables will be expressed as mean ± standard deviation (SD). Categorical variables will be expressed as frequency and percentage. MRI findings will be compared with arthroscopic findings using 2 × 2 contingency tables. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall diagnostic accuracy, and likelihood ratios will be calculated with 95% confidence intervals. A p-value <0.05 will be considered statistically significant.

RESULTS

A total of 50 patients with clinically suspected internal derangement of the knee who underwent both MRI and arthroscopy were included in the study. Arthroscopy was considered the reference (gold) standard for diagnosis. MRI findings were compared with arthroscopic findings to determine the diagnostic performance of MRI in detecting meniscal and ligament injuries.

Table 1. Demographic and clinical characteristics of the study participants (n = 50)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	18	36.0
	31–40	16	32.0
	41–50	10	20.0
	>50	6	12.0
Gender	Male	35	70.0
	Female	15	30.0
Mechanism of injury	Sports injury	21	42.0
	Road traffic accident	18	36.0
	Fall	11	22.0
Side involved	Right knee	29	58.0
	Left knee	21	42.0
Duration of symptoms	<6 weeks	22	44.0
	6–12 weeks	18	36.0
	>12 weeks	10	20.0

Mean age: 34.8 ± 10.6 years

Interpretation

Most patients were young adults aged **18–30 years (36%)**, and **70%** were males. Sports injuries and road traffic accidents accounted for the majority of knee injuries, reflecting the common mechanisms responsible for meniscal and ligament injuries.

Table 2. Distribution of MRI and arthroscopic findings

Lesion	MRI Positive n (%)	Arthroscopy Positive n (%)
Medial meniscus tear	23 (46.0)	22 (44.0)
Lateral meniscus tear	12 (24.0)	11 (22.0)
ACL tear	21 (42.0)	20 (40.0)
PCL tear	4 (8.0)	3 (6.0)
MCL injury	8 (16.0)	7 (14.0)
LCL injury	5 (10.0)	4 (8.0)
Chondral injury	9 (18.0)	8 (16.0)
Joint effusion	30 (60.0)	30 (60.0)

Interpretation

MRI findings closely corresponded with arthroscopic findings for most meniscal and ligament injuries. Medial meniscus tears and ACL tears were the most frequently identified lesions by both modalities.

Table 3. Diagnostic performance of MRI compared with arthroscopy

Lesion	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Medial meniscus tear	95.5	92.9	91.3	96.3	94.0
Lateral meniscus tear	90.9	94.9	83.3	97.4	94.0
ACL tear	95.0	96.7	95.0	96.7	96.0
PCL tear	100.0	97.9	75.0	100.0	98.0
MCL injury	85.7	95.3	75.0	97.6	94.0
LCL injury	75.0	97.8	60.0	97.8	96.0

Interpretation

MRI demonstrated excellent diagnostic performance in detecting ACL, PCL, and medial meniscus injuries, with sensitivity and specificity exceeding 90% for most lesions. The highest overall accuracy was observed for PCL injuries (98%).

Table 4. Agreement between MRI and arthroscopy

Lesion	Cohen's Kappa (κ)	Strength of Agreement	McNemar Test (p-value)
Medial meniscus tear	0.88	Excellent	0.754
Lateral meniscus tear	0.84	Excellent	0.625
ACL tear	0.92	Excellent	1.000
PCL tear	0.82	Excellent	1.000
MCL injury	0.79	Good	0.500
LCL injury	0.72	Good	0.625

Interpretation

Excellent agreement was observed between MRI and arthroscopy for ACL, PCL, and meniscal injuries. McNemar test showed no statistically significant difference between MRI and arthroscopy ($p>0.05$), indicating that MRI findings were comparable with arthroscopic findings.

Table 5. Factors associated with MRI diagnostic accuracy

Variable	Accurate MRI Diagnosis (n=47)	Inaccurate MRI Diagnosis (n=3)	p-value
Acute injury (<6 weeks)	22 (46.8%)	0 (0%)	**0.041**
Chronic injury (>12 weeks)	8 (17.0%)	2 (66.7%)	**0.028**
Joint effusion	29 (61.7%)	1 (33.3%)	0.582
Combined ligament and meniscal injury	14 (29.8%)	2 (66.7%)	0.189
Motion artefacts during MRI	2 (4.3%)	2 (66.7%)	**0.004**

Interpretation

MRI demonstrated significantly higher diagnostic accuracy in acute injuries than in chronic injuries. Motion artefacts were significantly associated with inaccurate MRI interpretation, whereas joint effusion and combined injuries did not significantly influence MRI accuracy.

DISCUSSION

The present prospective observational study evaluated the diagnostic accuracy of MRI in detecting meniscal and ligament injuries of the knee using arthroscopy as the reference standard. MRI demonstrated excellent diagnostic performance, with an overall accuracy of 94–98% for the evaluated structures. Medial meniscal tears and anterior cruciate ligament (ACL) tears were the most common lesions identified, and MRI showed excellent agreement with arthroscopy (κ = 0.72–0.92). These findings support the role of MRI as the preferred non-invasive imaging modality for evaluating internal derangements of the knee before arthroscopic intervention. In the present study, the majority of patients were young adults with a mean age of 34.8 ± 10.6 years, and 70% were males. Sports injuries (42%) and road traffic accidents (36%) were the leading mechanisms of injury. These findings are comparable with the prospective study by Rayan et al.[8], in which most patients were young males with traumatic knee injuries, reflecting the greater exposure of physically active individuals to rotational and high-impact trauma. Medial meniscal tears were the most frequent intra-articular lesion, identified arthroscopically in 44% of patients, followed by ACL tears (40%). Similar observations were reported by Behairy et al.[9],

Who found medial meniscal injuries to be the commonest meniscal pathology and ACL tears to be the predominant ligament injury in patients undergoing MRI and arthroscopy. Their study reported MRI accuracies of 90% for medial meniscal tears and 94% for ACL injuries, closely corresponding with the findings of the present study. MRI demonstrated excellent diagnostic performance for medial meniscal tears, with 95.5% sensitivity, 92.9% specificity, and 94% overall accuracy. Comparable findings were reported by Cheema et al.[10], who observed 100% sensitivity, 69.3% specificity, and 92% accuracy for medial meniscal tears. Minor differences in specificity may be attributable to degenerative signal changes, partial tears, and interpreter variability. For lateral meniscal tears, MRI achieved 90.9% sensitivity, 94.9% specificity, and 94% diagnostic accuracy. Similar results were described by Cheema et al[10], who reported 87.5% sensitivity, 88.2% specificity, and 88% accuracy for lateral meniscal injuries. These findings confirm that MRI is highly reliable for diagnosing lateral meniscal pathology when interpreted in conjunction with clinical findings. ACL injuries demonstrated one of the highest diagnostic performances in the present study, with 95.0% sensitivity, 96.7% specificity, and 96% accuracy. These findings are consistent with the meta-analysis by Phelan et al.[11], which reported pooled MRI sensitivity exceeding 90% and specificity approaching 95–98% for ACL tears. The excellent soft-tissue contrast of MRI allows accurate visualization of complete and most partial ACL tears before arthroscopy.

MRI also showed excellent performance for PCL injuries, with 100% sensitivity, 97.9% specificity, and 98% accuracy. Although PCL injuries were relatively uncommon, these findings agree with Behairy et al.[9], who reported 96% diagnostic accuracy for PCL injuries. The larger size and more uniform orientation of the PCL contribute to the high diagnostic accuracy observed with MRI. The agreement between MRI and arthroscopy was excellent for medial meniscal tears (κ = 0.88), lateral meniscal tears (κ = 0.84), ACL tears (κ = 0.92), and PCL tears (κ = 0.82). Similar excellent agreement has been reported by Gupta et al.[12] in an Indian prospective study comparing MRI with arthroscopy, confirming that MRI reliably identifies clinically significant intra-articular knee lesions. No statistically significant difference was observed between MRI and arthroscopy on McNemar testing ($p>0.05$), indicating that MRI findings closely paralleled arthroscopic findings. Similar conclusions were reached by Madhusudhan et al.[13], who suggested that MRI serves as a valuable adjunct to clinical examination but should be interpreted alongside clinical assessment, particularly in complex or equivocal injuries. Acute injuries demonstrated significantly higher MRI diagnostic accuracy than chronic injuries in the present study. Chronic injuries often undergo fibrosis, scarring, and degenerative changes that obscure normal tissue morphology and reduce diagnostic confidence. Madhusudhan et al.[13] also observed that MRI interpretation becomes more challenging in chronic and combined injuries, where clinical examination and arthroscopy remain important complementary tools. Motion artefacts significantly reduced MRI accuracy in our study ($p=0.004$). Patient movement, inadequate positioning, metallic artefacts, and suboptimal image quality may produce false-positive or false-negative interpretations. Behairy et al.[9] similarly emphasized that routine MRI performed with non-standardized protocols may reduce diagnostic performance, particularly for subtle meniscal tears.

Although MRI showed excellent diagnostic performance, arthroscopy remains the definitive reference standard because it allows direct visualization of intra-articular structures and simultaneous treatment. Nevertheless, MRI provides substantial clinical value by accurately identifying most meniscal and ligament injuries, facilitating surgical planning, reducing unnecessary diagnostic arthroscopies, and improving patient counselling. The present findings are also supported by recent prospective Indian studies. Gupta et al.[12] reported excellent MRI–arthroscopy correlation for meniscal and ligament injuries, while Tegginamath et al.[14] demonstrated high diagnostic accuracy of MRI for meniscal tears and emphasized its role in reducing unnecessary invasive procedures in resource-limited settings. The diagnostic performance observed in our study is also comparable with more recent prospective investigations. Reddy et al.[15] reported MRI sensitivity of 95.5% and overall accuracy of 92.5% for ACL tears, with good diagnostic performance for meniscal tears, further supporting MRI as the primary preoperative imaging modality.

Overall, the findings of the present study demonstrate that MRI possesses excellent sensitivity, specificity, predictive values, and diagnostic accuracy for detecting meniscal and ligament injuries of the knee. Its excellent agreement with arthroscopy confirms that MRI is a reliable, non-invasive investigation for evaluating internal derangements of the knee. Arthroscopy should remain reserved for therapeutic intervention or cases with persistent clinical suspicion despite equivocal MRI findings.

CONCLUSION

Magnetic resonance imaging demonstrated excellent diagnostic accuracy in detecting meniscal and ligament injuries of the knee when compared with arthroscopy, which served as the reference standard. MRI showed high sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy for diagnosing medial and lateral meniscal tears as well as cruciate ligament injuries. Excellent agreement between MRI and arthroscopy further confirmed the reliability of MRI as a non-invasive diagnostic modality.

Medial meniscal tears and anterior cruciate ligament tears were the most frequently encountered injuries in the present study. MRI was particularly accurate in diagnosing ACL and PCL injuries, while maintaining high diagnostic performance for meniscal lesions. Diagnostic accuracy was significantly higher in acute injuries, whereas chronic injuries and motion artefacts reduced MRI performance.

The findings indicate that MRI should be considered the first-line imaging investigation for patients with suspected internal derangement of the knee because it provides comprehensive assessment of intra-articular structures and assists in preoperative planning. Although arthroscopy remains the gold standard and allows simultaneous therapeutic intervention, routine diagnostic arthroscopy can be avoided in many patients with concordant clinical and MRI findings. Appropriate integration of clinical examination, MRI, and selective arthroscopy will improve diagnostic precision, optimize patient management, reduce unnecessary invasive procedures, and enhance functional outcomes.

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