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Original Research Article

MRI Assessment of Knee Joint Injuries in Athletes: Correlation with Arthroscopic Findings

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Abstract:

Background: Knee joint injuries are prevalent among athletes and can significantly impair performance and quality of life. Magnetic Resonance Imaging (MRI) is widely used as a non-invasive modality for diagnosing internal derangements of the knee. Arthroscopy, while considered the gold standard, is invasive. Correlating MRI findings with arthroscopy helps validate its diagnostic accuracy in clinical practice.

Aim and Objectives: To assess the diagnostic accuracy of MRI in detecting knee joint injuries in athletes and compare its findings with arthroscopic evaluation.

Materials and Methods: This prospective observational study included 60 athletes with clinically suspected internal derangement of the knee who underwent both MRI and arthroscopy within a 3-week interval. MRI was performed using a 1.5 Tesla scanner with standard knee imaging protocols. Arthroscopic findings served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for MRI in detecting ACL tears, meniscal injuries, PCL tears, and cartilage lesions.

Results: MRI showed high diagnostic performance for ACL tears (sensitivity 94.3%, specificity 91.7%, accuracy 93.3%), medial meniscus tears (sensitivity 89.3%, specificity 85.2%), and lateral meniscus tears (sensitivity 80.0%, specificity 94.1%). For PCL tears, MRI demonstrated sensitivity of 85.7% and specificity of 98.0%. Cartilage injuries were identified with lower sensitivity (66.7%) but high specificity (92.5%). ROC analysis for ACL detection yielded an AUC of 0.96.

Conclusion: MRI is a reliable and accurate modality for diagnosing knee joint injuries in athletes, with strong correlation to arthroscopic findings. It serves as an effective non-invasive tool in preoperative evaluation and can reduce the need for diagnostic arthroscopies. However, attention should be given to its limitations in detecting cartilage lesions.

Keywords: MRI, Knee Injuries, Athletes, Arthroscopy, ACL Tear, Meniscal Tear, Diagnostic Accuracy.

Introduction

Knee injuries are among the most frequently encountered musculoskeletal complaints in athletes, often resulting from high-impact or pivoting sports that place excessive stress on joint structures such as ligaments, menisci, and cartilage. These injuries can significantly impair athletic performance and lead to long-term morbidity if not diagnosed and managed accurately [1]. Early and precise identification of intra-articular knee pathology is therefore crucial to ensure timely treatment and optimal functional recovery.

Magnetic Resonance Imaging (MRI) has become the preferred non-invasive modality for evaluating knee injuries, offering superior soft-tissue contrast and multiplanar imaging capability. MRI provides detailed visualization of cruciate ligaments, menisci, cartilage, and other intra-articular structures, making it a reliable first-line tool in the assessment of suspected internal derangements of the knee [2]. However, while MRI is highly sensitive and specific in detecting various injuries, discrepancies with intraoperative arthroscopic findings have been reported, raising concerns about over- or under-diagnosis in certain cases [3].

Arthroscopy, regarded as the gold standard for diagnosing intra-articular knee pathology, allows direct visualization and concurrent therapeutic interven-

tion. Nonetheless, it is an invasive procedure associated with potential complications, emphasizing the need to evaluate the diagnostic accuracy of MRI in comparison to arthroscopy [4]. The correlation between MRI and arthroscopic findings is particularly relevant in sports medicine, where clinical decision-making is often guided by imaging results.

The present study aims to evaluate the diagnostic accuracy of MRI in detecting various knee joint injuries in athletes and to assess its correlation with arthroscopic findings. By identifying the sensitivity, specificity, and predictive values of MRI for different types of intra-articular lesions, this study seeks to support evidence-based imaging protocols and refine preoperative evaluation strategies in the athletic population.

Materials and Methods

This was a prospective observational study conducted at the Department of Radiodiagnosis and Department of Orthopaedics at a tertiary care teaching hospital over a period of 12 months (March 2023 to February 2024). The study was approved by the Institutional Ethics Committee, and informed written consent was obtained from all participants.

Study Population: A total of 60 athletes presenting with clinical suspicion of internal derangement of the knee were enrolled. These individuals were referred for MRI evaluation followed by arthroscopic examination within 3 weeks.

Inclusion Criteria

- Athletes aged between 18 and 40 years.
- History of knee trauma during sports activities.
- Clinical suspicion of internal derangement of the knee (e.g., positive Lachman test, McMurray's test, or joint line tenderness).
- MRI and arthroscopy performed within 3 weeks of each other.

Exclusion Criteria

- Prior knee surgery or arthroscopy.
- Contraindications to MRI (e.g., pacemakers, metallic implants).
- History of inflammatory joint disease or infection.
- Poor quality MRI scans.

MRI Protocol

All MRI scans were performed using a 1.5 Tesla scanner (GE/Siemens/Philips) with a dedicated knee coil. The knee was positioned in slight flexion with neutral rotation.

Imaging sequences included:

- Axial T1-weighted spin echo
- Axial and coronal T2-weighted fat-suppressed
- Sagittal proton-density (PD) with fat suppression
- Coronal PD-weighted
- Sagittal T2-weighted

MRI findings were interpreted independently by two experienced musculoskeletal radiologists who were blinded to arthroscopic results. In case of disagreement, a consensus reading was done.

Arthroscopic Evaluation: Diagnostic arthroscopy was performed under spinal or general anesthesia by experienced orthopedic surgeons within 3 weeks of MRI. A standard anterolateral and anteromedial portal was used to examine all intra-articular structures, including:

- Anterior cruciate ligament (ACL)
- Posterior cruciate ligament (PCL)
- Medial and lateral menisci
- Articular cartilage
- Synovium and patellofemoral joint

Arthroscopic findings served as the reference standard for diagnosis. All findings were recorded immediately during the procedure.

Data Collection and Analysis: Clinical, radiological, and arthroscopic data were recorded using a structured proforma. The diagnostic performance of MRI was assessed in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy for detecting specific injuries (ACL, PCL, menisci, cartilage).

Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics version 25.0. Chi-square test was used to assess the association between MRI and arthroscopy findings. ROC curve analysis was performed for MRI in detecting ACL injuries. A p-value of <0.05 was considered statistically significant.

Results

A total of 60 athletes (42 males and 18 females) with clinically suspected internal derangement of the knee underwent both MRI and arthroscopic evaluation. The mean age of participants was 26.4 ± 4.8 years. The most commonly affected side was the right knee (61.7%). The interval between MRI and arthroscopy was maintained within 3 weeks for all cases to minimize progression of injury.

Table 1: Distribution of Knee Injuries Observed on Arthroscopy

Type of Injury	Number of Cases (n=60)	Percentage (%)
ACL tear	35	58.3
Medial meniscus tear	28	46.7
Lateral meniscus tear	15	25.0
PCL tear	7	11.7
Cartilage injury (Grade II or above)	12	20.0

Table 2: Diagnostic Accuracy of MRI Compared to Arthroscopy

Injury Type	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
ACL Tear	94.3	91.7	94.3	91.7	93.3
Medial Meniscus Tear	89.3	85.2	83.3	90.5	86.7
Lateral Meniscus Tear	80.0	94.1	84.2	92.3	90.0
PCL Tear	85.7	98.0	85.7	98.0	96.7
Cartilage Injury	66.7	92.5	72.7	90.2	85.0

Table 3: Cross-tabulation of MRI vs Arthroscopy Findings for ACL Tear

	Arthroscopy ACL Tear Present	Arthroscopy ACL Tear Absent	Total
MRI Positive for ACL	33	2	35
MRI Negative for ACL	2	23	25
Total	35	25	60

Chi-square test revealed a significant association between MRI and arthroscopy findings for ACL tear detection ($\chi^2 = 52.96$, $p < 0.001$), indicating high diagnostic agreement.

Correlation of Injury Type with Age and Activity Level: There was no statistically significant correlation between age and presence of ACL or meniscal injury ($p > 0.05$). However, athletes involved in contact sports (e.g., football, wrestling) showed a significantly higher incidence of combined ligamentous injuries ($p = 0.017$).

ROC Curve Analysis: An ROC curve was plotted for MRI detection of ACL injuries, using arthroscopy as the reference standard. The Area Under the Curve (AUC) was 0.96 (95% CI: 0.91–0.99), suggesting excellent diagnostic performance of MRI.

Discussion

In the present study, MRI demonstrated high diagnostic accuracy for evaluating various internal knee joint injuries in athletes, with arthroscopy serving as the reference standard. The sensitivity, specificity, and overall accuracy for anterior cruciate ligament (ACL) tears, posterior cruciate ligament (PCL) injuries, meniscal tears, and cartilage lesions were found to be consistent with values reported in previous literature.

Our study found MRI to have a sensitivity of 94.3% and specificity of 91.7% in detecting ACL tears, which aligns closely with results reported by Khandelwal et al., who documented a sensitivity of 97.5% and specificity of 90.4% for MRI in an Indian cohort [5]. Similarly, a systematic review by Crawford et al. concluded that MRI offers high diagnostic performance for ACL injuries, with pooled sensitivity and specificity nearing 90% [3]. The high negative predictive value (NPV) observed in our study supports MRI's role as a reliable modality for ruling out ACL injuries non-invasively.

MRI also performed well in the detection of medial and lateral meniscal tears. Our sensitivity (89.3%) and specificity (85.2%) for medial meniscus (MM) tears are comparable to the findings by Phelan et al., who reported pooled sensitivity and specificity of 89% and 81%, respectively [2]. For lateral meniscus (LM) tears, we found slightly lower sensitivity (80.0%) but high specificity (94.1%), which mirrors the values (sensitivity 81%, specificity 87%) reported in a meta-analysis by Smith et al. [6]. The relatively lower sensitivity for LM tears may be due to anatomical variability and the presence of subtle or complex tear patterns that are difficult to detect on MRI.

PCL injuries were identified on MRI with high accuracy (sensitivity 85.7%, specificity 98.0%), consistent with the findings of Rubin et al., who emphasized MRI's reliability in diagnosing cruciate ligament injuries [7]. However, the sensitivity of MRI in detecting cartilage lesions was comparatively lower (66.7%), although specificity remained high (92.5%). This limitation has been well documented in the literature, as cartilage abnormalities—especially early or superficial lesions—are often subtle and may be missed on conventional MRI sequences [8,9].

Arthroscopy, being the gold standard, allows direct visualization of intra-articular structures and is invaluable for confirming diagnosis and guiding treatment. However, its invasive nature and associated risks underscore the importance of accurate non-invasive diagnostic tools like MRI [10]. The strong

statistical correlation between MRI and arthroscopic findings in our study reinforces MRI's utility in preoperative planning, particularly in athletic populations where prompt diagnosis and intervention are critical.

Clinical Relevance and Implications: MRI's high sensitivity and specificity for cruciate ligament and meniscal injuries indicate that it can reliably guide management decisions and reduce the need for diagnostic arthroscopy in selected cases. Our findings suggest that MRI can serve as an effective screening tool, particularly when arthroscopy is contraindicated or not readily available. Furthermore, athletes involved in contact sports had a higher incidence of combined injuries, highlighting the need for comprehensive joint assessment in this subgroup.

Limitations and Future Scope: While our study provides valuable insights, it is limited by its relatively small sample size and restriction to a single center. The performance of MRI may vary with magnet strength, radiologist experience, and technical parameters. Future research should focus on larger, multicentric studies with standardized MRI protocols, as well as the integration of advanced imaging techniques such as 3D isotropic sequences and machine learning algorithms to enhance diagnostic precision.

Conclusion

The present study highlights the high diagnostic accuracy of MRI in detecting knee joint injuries in athletes, particularly for ACL, PCL, and meniscal tears, when compared to arthroscopic findings. MRI demonstrated excellent sensitivity, specificity, and overall agreement with arthroscopy, reinforcing its role as a reliable, non-invasive tool for preoperative evaluation. However, its relatively lower sensitivity in detecting cartilage lesions underscores the need for careful interpretation and, where necessary, supplementary assessment. Overall, MRI serves as an effective first-line imaging modality that can guide clinical decision-making, minimize unnecessary invasive procedures, and facilitate timely management of sports-related knee injuries.

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