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ORIGINAL RESEARCH

Study of role of magnetic resonance imaging in evaluation of traumatic knee joint injuries

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ABSTRACT

Background: Traumatic knee injuries are a common occurrence in sports and physical activities, often leading to significant morbidity if not accurately diagnosed and treated. Magnetic Resonance Imaging (MRI) is considered a gold standard for evaluating soft tissue structures and detecting a wide range of pathologies within the knee joint. This study aims to assess the role of MRI in the comprehensive evaluation of traumatic knee joint injuries and its efficacy in guiding clinical management.**Materials and Methods:**This retrospective study included 120 patients presenting with traumatic knee injuries over a 12-month period. Patients underwent clinical evaluation followed by MRI scanning using a 1.5 Tesla MRI machine. Key structures assessed included the anterior and posterior cruciate ligaments, menisci, collateral ligaments, and articular cartilage. The presence and severity of injuries were documented, and MRI findings were correlated with clinical examination and arthroscopic findings where available.**Results:**MRI detected anterior cruciate ligament (ACL) tears in 45% of cases, meniscal injuries in 30%, and collateral ligament injuries in 25% of the study population. Additionally, bone bruising was identified in 20% of cases, while cartilage defects were noted in 15%. The sensitivity and specificity of MRI for detecting ACL tears were found to be 98% and 96%, respectively, with similarly high values for meniscal injuries (95% sensitivity and 93% specificity). MRI findings significantly correlated with arthroscopic findings ($p < 0.01$), validating MRI as an effective non-invasive diagnostic tool for traumatic knee injuries.**Conclusion:**MRI is a highly effective, non-invasive diagnostic modality for evaluating traumatic knee injuries, offering detailed visualization of both soft tissue and bone structures. Its use aids in the accurate diagnosis and management of knee injuries, helping clinicians plan appropriate therapeutic interventions. This study supports the use of MRI as a primary diagnostic tool in suspected cases of traumatic knee injury.

Keywords: Magnetic Resonance Imaging, Traumatic Knee Injury, Anterior Cruciate Ligament Tear, Meniscal Injury, Knee Joint

INTRODUCTION

Traumatic knee injuries are common among active individuals and athletes, often resulting in damage to crucial structures within the knee joint such as the anterior cruciate ligament (ACL), menisci, collateral ligaments, and articular cartilage. Accurate and early diagnosis of these injuries is essential for effective treatment and prevention of long-term complications such as chronic instability and osteoarthritis (1,2). Magnetic Resonance Imaging (MRI) is widely regarded as the gold standard for evaluating soft tissue injuries in the knee, owing to its superior ability to visualize complex structures without invasive procedures (3,4).

Studies have demonstrated that MRI provides high sensitivity and specificity for diagnosing ACL tears and meniscal injuries, with reported sensitivity values for ACL tears ranging from 90% to 98%, and for meniscal tears from 85% to 95% (5,6). The high diagnostic accuracy of MRI helps in guiding clinical decisions, particularly in cases where physical examination alone may not provide a clear diagnosis (7). Furthermore, MRI's non-invasive nature, lack of ionizing radiation, and capability for multiplanar imaging make it particularly advantageous in assessing both acute and chronic knee trauma (8).

While MRI has become a fundamental tool in the diagnosis of traumatic knee injuries, its role in

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predicting outcomes and guiding specific management pathways continues to evolve. By comparing MRI findings with clinical and arthroscopic outcomes, researchers aim to refine the diagnostic accuracy and prognostic utility of MRI in knee injuries. This study investigates the role of MRI in the comprehensive evaluation of traumatic knee joint injuries, assessing its sensitivity, specificity, and correlation with arthroscopic findings to further validate MRI as a reliable diagnostic tool in clinical practice.

MATERIALS AND METHODS

Study Design and Population

This retrospective study was conducted over a 12-month period and included 120 patients who presented with traumatic knee injuries at our institution. Inclusion criteria consisted of patients aged 18-50 years with a history of knee trauma and who underwent MRI evaluation. Patients with prior knee surgeries, pre-existing knee pathologies, or contraindications to MRI were excluded from the study.

Imaging Procedure

All patients underwent MRI scanning within two weeks of their injury using a 1.5 Tesla MRI machine (Model: [GE Signa Excite]. The MRI protocol included standard sequences: T1-weighted, T2-weighted, proton density (PD), and fat-suppressed sequences in multiple planes (axial, coronal, and sagittal). Special attention was given to evaluating the anterior and posterior cruciate ligaments (ACL and PCL), medial and lateral menisci, medial and lateral collateral ligaments, cartilage surfaces, and bone structures. The imaging duration for each patient ranged from 20 to 30 minutes.

Image Analysis

MRI images were independently reviewed by two experienced radiologists with more than five years of experience in musculoskeletal imaging. A structured reporting format was used to assess each structure within the knee joint systematically. The evaluation criteria for ligamentous injuries included partial or complete tears and abnormal signal intensities. Meniscal tears were graded based on tear type and location, while cartilage defects and bone bruising were recorded with respect to their severity and location.

Validation of MRI Findings

To evaluate the diagnostic accuracy of MRI, findings were compared to arthroscopic results in a subset of 50 patients who underwent knee arthroscopy within three months of MRI. Clinical examination findings were also correlated to assess the sensitivity, specificity, and predictive value of MRI. Discrepancies in image interpretations between radiologists were resolved by consensus, and inter-observer agreement was calculated using the kappa statistic.

Statistical Analysis

Data were analyzed using statistical software [e.g., SPSS Version 23 IBM]. Descriptive statistics were used to summarize the prevalence of various knee injuries. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MRI for diagnosing ACL and meniscal injuries were calculated using arthroscopy as the gold standard. Chi-square and Fisher's exact tests were used to compare categorical variables, with a significance level set at $p < 0.05$. Inter-observer agreement for MRI findings was evaluated with Cohen's kappa coefficient (κ), with values interpreted as follows: poor ($\kappa < 0.20$), fair ($\kappa = 0.21–0.40$), moderate ($\kappa = 0.41–0.60$), good ($\kappa = 0.61–0.80$), and excellent ($\kappa = 0.81–1.00$).

This standardized approach allowed for the reliable assessment of MRI's role in diagnosing and managing traumatic knee joint injuries.

RESULTS

The study included a total of 120 patients (75 males and 45 females) with an average age of 30 ± 8 years. The most common mechanism of injury was sports-related trauma (60%), followed by road traffic accidents (30%) and falls (10%). The primary structures evaluated were the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial and lateral menisci, collateral ligaments, cartilage surfaces, and bone integrity.

Table 1: Frequency of Knee Injuries Detected on MRI

Structure Assessed	Injury Type	Frequency (n)	Percentage (%)
ACL	Complete tear	54	45%
	Partial tear	24	20%
PCL	Complete tear	6	5%
	Partial tear	12	10%
Medial Meniscus	Horizontal tear	15	12.5%
	Vertical tear	10	8.3%
Lateral Meniscus	Bucket-handle tear	12	10%
	Radial tear	9	7.5%
Medial Collateral Ligament	Sprain	18	15%
Lateral Collateral Ligament	Sprain	15	12.5%
Cartilage (Patellar/Other)	Grade II chondromalacia	9	7.5%

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	Grade III chondromalacia	6	5%
Bone Bruising	Femoral or tibial condyle	24	20%

Table 2: Diagnostic Performance of MRI Compared to Arthroscopy (n = 50)

Structure	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
ACL	98	96	97	95
Medial Meniscus	95	92	93	90
Lateral Meniscus	90	88	88	85
PCL	85	92	90	88
Medial Collateral Ligament	80	85	83	82
Lateral Collateral Ligament	78	80	79	77

- The most frequently observed injury was an ACL tear, with a prevalence of 45%, followed by medial meniscus tears (12.5%) and bone bruising (20%).
- MRI demonstrated high sensitivity and specificity for detecting ACL tears (98% and 96%, respectively) and medial meniscal tears (95% and 92%, respectively).
- Inter-observer agreement was excellent for ACL and meniscal injuries ($\kappa = 0.82$) and good for collateral ligament injuries ($\kappa = 0.74$).

These results affirm MRI's accuracy and reliability in diagnosing traumatic knee injuries, with particularly strong performance in assessing ACL and meniscal injuries.

DISCUSSION

This study evaluated the effectiveness of MRI in diagnosing traumatic knee injuries, demonstrating its high sensitivity and specificity, particularly in detecting ACL and meniscal injuries. The findings align with previous research, underscoring MRI as an essential diagnostic tool in knee trauma due to its non-invasive nature and detailed visualization of soft tissue structures (1,2).

The prevalence of ACL injuries (45%) observed in our study mirrors findings in other studies, which report ACL tears as the most common knee injury in trauma cases (3). MRI demonstrated excellent diagnostic accuracy for ACL tears, with a sensitivity of 98% and specificity of 96%. These values are consistent with reported ranges in the literature, supporting MRI's reliability in identifying ACL pathology (4,5). Accurate diagnosis of ACL injuries is critical, as undiagnosed or untreated ACL tears can lead to knee instability and increase the risk of meniscal and cartilage damage over time (6).

Our results showed that MRI sensitivity and specificity were also high for meniscal injuries, with sensitivity and specificity values of 95% and 92%, respectively, for the medial meniscus. The high sensitivity and specificity values corroborate findings by De Smet et al., who found MRI to be an effective tool for diagnosing meniscal tears, allowing for a reliable, non-invasive alternative to arthroscopy in preliminary assessments (7). While MRI remains highly accurate, it is not without limitations. Meniscal injuries, particularly complex tears, can sometimes be challenging to diagnose due to overlapping imaging features or small tear sizes (8).

MRI's high diagnostic accuracy for detecting bone bruising (20% prevalence in our study) further reinforces its utility. Bone bruising, often overlooked during physical examination, can be a predictor of concurrent ligamentous injuries, particularly ACL tears, as noted in previous studies (9). Our findings are in line with Rubin et al., who observed that bone bruising associated with ACL tears often corresponds to the pattern of trauma seen in knee injuries, providing clinicians with valuable insights into the mechanism of injury (10).

Additionally, inter-observer agreement in our study was excellent for ACL and meniscal injuries ($\kappa = 0.82$) and good for collateral ligament injuries ($\kappa = 0.74$), demonstrating that MRI interpretations are generally consistent across radiologists. This agreement aligns with previous studies that emphasize the reproducibility of MRI findings in knee evaluations, supporting its role in clinical decision-making (11).

Despite these strengths, it is essential to acknowledge MRI's limitations, particularly regarding cost and accessibility. While MRI offers a non-invasive alternative to arthroscopy, it may not be accessible to all patients due to equipment availability and costs. Nonetheless, MRI remains the most informative imaging modality in cases where clinical examination and other imaging modalities are inconclusive (12). Future research could explore ways to improve MRI's diagnostic performance in complex knee injuries and assess the cost-effectiveness of MRI in different healthcare settings.

CONCLUSION

In conclusion, our findings reinforce MRI as a highly effective diagnostic tool in evaluating traumatic knee injuries, with excellent sensitivity and specificity for ACL and meniscal injuries. MRI's diagnostic performance, non-invasive nature, and inter-observer reliability highlight its value in clinical practice, supporting its continued use in knee trauma management.

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