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Original Article

Role of MRI in Evaluation of Knee Joint Trauma

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ABSTRACT

Background: Knee trauma is a significant cause of morbidity and is frequently associated with injuries to ligaments, menisci, articular cartilage, and periarticular soft tissues. Early and accurate diagnosis of these injuries is crucial for appropriate management, improved clinical outcomes, and prevention of long-term disability. Although conventional radiography is effective for identifying osseous abnormalities, its utility in assessing soft-tissue injuries is limited. Magnetic Resonance Imaging (MRI), owing to its superior soft-tissue contrast resolution and multi-planar imaging capabilities, has become the imaging modality of choice for comprehensive evaluation of traumatic knee injuries.

Aim and Objectives: To evaluate and characterize the spectrum of bony and soft-tissue injuries of the knee joint detected on MRI in patients presenting with knee trauma and to assess the diagnostic utility of MRI in their evaluation.

Materials and Methods: This hospital-based observational study included 50 patients with a documented history of knee joint trauma. All patients underwent MRI examination of the affected knee. MRI findings were systematically analyzed for ligamentous injuries, meniscal tears, bone contusions, fractures, cartilage defects, joint effusion, and associated soft-tissue abnormalities. Data were recorded and analyzed using descriptive statistical methods.

Results: Anterior cruciate ligament (ACL) injury was the most frequently observed ligamentous abnormality, with Grade II tears constituting the predominant pattern. Medial meniscal tears, particularly involving the posterior horn, were more common than lateral meniscal injuries. Injuries involving the posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) were less frequent and were predominantly low-grade in severity. Joint effusion was identified in the majority of patients. MRI also demonstrated associated findings such as Hoffa's fat pad edema and Baker's cysts, highlighting its ability to detect concomitant soft-tissue abnormalities.

Conclusion: MRI is a highly sensitive, non-invasive, and comprehensive imaging modality for the evaluation of traumatic knee injuries. It enables accurate assessment of ligamentous, meniscal, osseous, cartilaginous, and soft-tissue abnormalities, thereby facilitating early diagnosis, guiding treatment planning, and reducing the need for unnecessary invasive diagnostic procedures.

Keywords: *Knee trauma; Magnetic Resonance Imaging (MRI); Anterior cruciate ligament injury; Meniscal tear; Ligamentous injury; Internal derangement of knee; Soft-tissue injury; Joint effusion.*

INTRODUCTION

The knee is the largest synovial and weight-bearing joint in the human body, comprising the tibio-femoral and patella-femoral articulations. Its stability is maintained by the anterior cruciate ligament (ACL), posterior cruciate ligament

(PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL), menisci, surrounding musculature, and other soft-tissue structures. Owing to its complex anatomy and exposure to substantial mechanical stress, the knee is particularly susceptible to traumatic injuries involving ligaments, menisci, cartilage, and osseous structures. [1]

Knee injuries are among the most common musculoskeletal injuries encountered in clinical practice, especially in athletes and physically active individuals. They account for approximately 6% of all acute injuries presenting to emergency departments, with a significant proportion related to sports activities.[2] Such injuries may result from direct trauma, twisting mechanisms, falls, or high-energy accidents and can lead to considerable morbidity, pain, instability, and functional impairment if not diagnosed and treated appropriately.

Accurate and timely diagnosis is essential for optimal management and prevention of long-term complications. Clinical examination alone may be insufficient, particularly in the acute setting due to pain, swelling, and restricted joint movement. Conventional radiography remains the initial imaging modality for evaluating osseous injuries; however, its ability to detect soft-tissue abnormalities is limited. Ultrasonography provides assessment of superficial structures and joint effusions but is operator-dependent and has limited evaluation of intra-articular pathology. Computed tomography (CT) is valuable in characterizing fractures but offers limited soft-tissue assessment.[3-4]

Magnetic Resonance Imaging (MRI) has emerged as the imaging modality of choice for evaluating traumatic knee injuries due to its excellent soft-tissue contrast, multiplanar imaging capability, and non-invasive nature. MRI allows comprehensive assessment of ligaments, menisci, cartilage, bone marrow, tendons, and surrounding soft tissues in a single examination. It has largely replaced diagnostic arthroscopy as the primary investigation for internal derangement of the knee and plays a pivotal role in treatment planning by accurately identifying the extent and pattern of injury. [5]

The present study was undertaken to evaluate the spectrum of MRI findings in patients presenting with knee trauma and to assess the role of MRI in detecting and characterizing various osseous and soft-tissue injuries of the knee joint.

AIM AND OBJECTIVES

Aim

To evaluate the spectrum of traumatic knee joint injuries using Magnetic Resonance Imaging (MRI) and to characterize their imaging features.

Objectives

- To identify and describe the various osseous and soft-tissue lesions associated with knee joint trauma on MRI.
- To assess the diagnostic efficacy of MRI in detecting and characterizing different traumatic lesions of the knee joint.

Material and methods

Study Design and Setting

This hospital-based observational study was conducted in the Department of Radiodiagnosis and Imaging, Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh, India.

Study Population and Sample Size

The study included 50 consecutive patients presenting with a history of knee joint trauma who were referred for MRI evaluation from the outpatient and inpatient departments. The sample size was determined based on the average number of eligible patients presenting during the study period.

Study Duration

The study was conducted over 18 months, including 12 months of data collection and 6 months of data compilation and analysis.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- History of knee joint trauma.
- Referral for MRI evaluation of the knee joint.
- Availability of complete clinical information.
- Provision of written informed consent.

Exclusion Criteria

Patients were excluded if they had:

- Previous knee surgery or intervention.
- Known chronic knee pathology.

- Contraindications to MRI (e.g., pacemakers, metallic implants).
- Claustrophobia.
- Refusal to provide informed consent.

Study Procedure
After obtaining informed consent, demographic and clinical data including age, sex, mechanism of injury, duration of symptoms, affected side, and presenting complaints were recorded. All patients underwent plain radiography of the affected knee prior to MRI examination.

MRI was performed using a 1.5-Tesla scanner (Siemens MAGNETOM Essenza). Images were evaluated for ligamentous injuries, meniscal tears, cartilage defects, bone marrow contusions, fractures, tendon injuries, joint effusion, and associated soft-tissue abnormalities. MRI findings were documented using a standardized proforma. Wherever available, MRI findings were correlated with operative or arthroscopic findings.

MRI Protocol
Patients were examined in the supine position with the knee in slight external rotation. Routine MRI sequences included T1-weighted, T2-weighted, STIR, Proton Density Fat-Suppressed (PD-FS), and MEDIC sequences acquired in sagittal, coronal, and axial planes as appropriate.

Statistical Analysis
Data were entered and analyzed using SPSS version 30. Descriptive statistics were used to summarize the findings. Categorical variables were expressed as frequencies and percentages, and results were presented in tables and charts.

Ethical Considerations
The study was approved by the Institutional Ethics Committee of Muzaffarnagar Medical College. Written informed consent was obtained from all participants, and confidentiality of patient information was maintained throughout the study.

Results
Table 1: **Distribution of participants according to ACL grade involvement:(N=50)**
In the present study, Grade II ACL injury was the most frequently observed pattern, accounting for 48% (n=24) of cases. Grade III and Grade I injuries were identified in 26% (n=13) and 18% (n=9) of patients, respectively. More complex injury patterns, including Grade II/III tears, Grade II tears with anterior tibial translation, and Grade III tears with anterior tibial translation, were less common and collectively represented 8% of cases. These findings suggest that moderate-grade ACL injuries were the predominant form of ACL involvement, whereas severe and complex injuries associated with anterior tibial translation occurred relatively infrequently.

Table 1: Distribution of participants according to ACL grade involvement: (N=50):

ACL Grade involvement	No. of cases	Percentage (%)
I	09	18%
II	24	48%
III	13	26%
II/III	01	2%
II with Ant. Tib Trans	01	2%
III with Ant. Tib Trans	02	4%
Total	**50**	**100%**

Table 2: Distribution of Participants According to PCL Grade Involvement (N = 50)
In the present study, Grade I PCL injury was the most common pattern, observed in 44% (n=22) of patients. Grade I PCL injury associated with ligament buckling was noted in 14% (n=7) of cases, while isolated PCL buckling was seen in 4% (n=2). Higher-grade injuries were uncommon, with Grade II and Grade III involvement identified in 2% (n=1) and 4% (n=2) of patients, respectively. No evidence of PCL injury was found in 32% (n=16) of participants. Overall, the findings indicate that mild PCL injuries predominated, whereas advanced PCL tears were relatively infrequent in the study population.

Table 2: Distribution of Participants According to PCL Grade Involvement (N = 50):

PCL Grade involvement	No. of cases	Percentage (%)
I	22	44%
II	01	2%
III	02	4%
I with buckling	07	14%

Buckling	02	4%
None	16	32%
Total	**50**	**100%**

Table 3: Distribution of Participants According to MCL Grade Involvement (N = 50)
In the present study, no medial collateral ligament (MCL) injury was detected in 70% (n=35) of participants. Among patients with MCL involvement, Grade I injury was the most common finding, accounting for 24% (n=12) of cases. Grade II and Grade III injuries were observed in 2% (n=1) and 4% (n=2) of participants, respectively. These results indicate that MCL injuries were relatively uncommon and were predominantly low-grade, while severe MCL injuries occurred infrequently in the study population.

Table 3: Distribution of Participants According to MCL Grade Involvement (N = 50):

MCL Grade involvement	No. of cases	Percentage (%)
I	12	24%
II	01	2%
III	02	4%
No involvement	35	70%
Total	**50**	**100%**

Table 4: Distribution of Participants According to LCL Grade Involvement (N = 50)
In the present study, 68% (n=34) of participants showed no evidence of lateral collateral ligament (LCL) injury. Among those with LCL involvement, Grade I injury was the most common finding, occurring in 20% (n=10) of cases, followed by Grade II injury in 10% (n=5). Grade III LCL injury was rare, being identified in only 2% (n=1) of participants. These findings indicate that LCL injuries were relatively infrequent and predominantly low-grade, while severe LCL involvement was uncommon in the study population.

Table 4: Distribution of Participants According to LCL Grade Involvement (N = 50):

LCL Grade involvement	No. of cases	Percentage (%)
I	10	20%
II	05	10%
III	01	2%
No involvement	34	68%
Total	**50**	**100%**

Table 5: Distribution of Participants According to Joint Effusion (N = 50)
In the present study, joint effusion was detected in 88% (n=44) of participants. Mild effusion was the most prevalent finding, occurring in 40% (n=20) of cases, followed by moderate effusion in 26% (n=13) and minimal effusion in 20% (n=10). Gross effusion was uncommon and was observed in only 2% (n=1) of participants. Absence of joint effusion was noted in 12% (n=6) of cases. These findings suggest that joint effusion was a common feature of knee trauma, predominantly presenting as mild to moderate effusion, indicative of underlying intra-articular injury.

Table 5: Distribution of Participants According to Joint Effusion (N = 50)

Joint effusion	No. of cases	Percentage (%)
Mild	20	40%
Moderate	13	26%
Minimal	10	20%
Gross	01	2%
No involvement	06	12%
Total	**50**	**100%**

DISCUSSION

Magnetic Resonance Imaging (MRI) has become the imaging modality of choice for the evaluation of traumatic knee injuries owing to its superior soft-tissue contrast and ability to comprehensively assess ligamentous, meniscal, cartilaginous, osseous, and peri-articular structures. The present study evaluated the spectrum of MRI findings in patients presenting with knee trauma and demonstrated that ligamentous injuries, particularly involving the anterior cruciate ligament (ACL), and joint effusion were the most common abnormalities encountered.

ACL injury was the predominant ligamentous abnormality in the present study, with Grade II tears constituting the majority of cases. This finding suggests that partial or moderate ligament disruption is more frequently encountered than complete rupture in routine clinical practice. The predominance of Grade II injuries may be attributed to the mechanism

of injury, where rotational stress and non-contact trauma often produce partial tearing before complete ligament failure occurs. Similar observations have been reported by **Sharma D et al.** who found ACL tears in 50% of patients, with partial tears occurring more frequently than complete tears. **Medhat M. Refaat et al.** also reported a high prevalence of ACL injuries, with partial tears accounting for the majority of cases. Likewise, **Elhaj M et al.** identified the ACL as the most commonly injured ligament in traumatic knee injuries. The concordance of these findings with the present study reinforces the role of MRI in accurately detecting and grading ACL injuries, which is essential for determining appropriate treatment strategies and predicting functional outcomes.[6-8]

Posterior cruciate ligament (PCL) injuries were considerably less common than ACL injuries and were predominantly low-grade. Most cases demonstrated Grade I involvement or associated ligament buckling, whereas complete tears were uncommon. This observation is consistent with the known biomechanical characteristics of the PCL, which is thicker and stronger than the ACL and therefore less susceptible to injury during routine trauma. Comparable findings were reported by **Sharma D et al.** who observed PCL injuries in 19% of patients, predominantly of low severity. Similarly, **Thapa M et al.** reported PCL tears in only 12.3% of cases, while **Nasa A et al.** demonstrated that most MRI-detected PCL injuries were partial rather than complete tears. These findings collectively indicate that MRI is particularly valuable in identifying subtle PCL abnormalities, including partial tears and buckling, which may otherwise be clinically overlooked. [6] [9-10]

Collateral ligament injuries were relatively uncommon in the present study. MCL involvement was identified in a minority of patients, with Grade I sprains accounting for most cases, whereas higher-grade injuries were infrequent. Similar findings were reported by **Medhat M. Refaat et al.,** who documented MCL injuries in only 4.61% of patients, most of which were low-grade sprains. **Sharma D et al.** also observed that MCL injuries occurred less frequently than cruciate ligament injuries and were predominantly partial tears. [6-7]

Although studies by **Yeli R et al., Chavda V et al. and Elhaj M et al.** reported relatively higher frequencies of MCL involvement, these variations may be explained by differences in study populations, injury mechanisms, and inclusion of high-energy sports-related trauma. The predominance of low-grade MCL injuries in the present study highlights the sensitivity of MRI in detecting subtle ligamentous sprains that may not be apparent on clinical examination alone.[8] [11-12] Similarly, LCL injuries were infrequent and predominantly mild in severity. The majority of patients demonstrated no LCL involvement, while most injuries were limited to Grade I sprains. These findings are consistent with previous reports indicating that isolated LCL injuries are relatively uncommon due to the lower incidence of significant varus stress injuries. **Medhat M. Refaat et al.** reported LCL tears in only 1.53% of patients, while **Thapa M et al.** observed LCL involvement in 7.7% of cases, primarily low-grade injuries. The findings of the present study therefore support the existing literature that LCL injuries are generally uncommon and often indicate more complex patterns of knee trauma when present.[7][9]

Joint effusion was among the most frequent MRI findings observed in this study. Most cases demonstrated mild-to-moderate effusion, reflecting the inflammatory response associated with acute intra-articular injury. The high prevalence of joint effusion observed in the present study is comparable to findings reported by **Thapa M et al.**, who identified joint effusion as the most common MRI abnormality in traumatic knee injuries. Similarly**, Chavda V et al.** and **Elhaj M et al.** reported joint effusion in 81% and 74.4% of patients, respectively. The slightly higher frequency observed in the present study may be attributable to earlier imaging following trauma or inclusion of predominantly symptomatic patients. These findings emphasize that joint effusion remains an important indirect marker of internal derangement and should prompt careful evaluation for associated ligamentous, meniscal, or osteochondral injuries.[9][11-12]

In addition to primary traumatic lesions, MRI demonstrated several associated abnormalities, including Hoffa's fat pad edema, Baker's cysts, quadriceps tendinosis, infrapatellar tendinosis, and other peri-articular soft-tissue changes. Hoffa's fat pad edema was the most common ancillary finding.**Nasa A et al.** also emphasized the ability of MRI to detect peri-articular and tendinous abnormalities that may contribute significantly to patient symptoms and management. The identification of these associated findings further underscores the comprehensive diagnostic capability of MRI beyond the assessment of major ligamentous and meniscal injuries.[10]

Overall, the findings of the present study are in close agreement with previously published literature and reaffirm that ACL injury is the most common ligamentous abnormality encountered following knee trauma, whereas PCL, MCL, and LCL injuries occur less frequently and are predominantly low-grade. The high prevalence of joint effusion and associated soft-tissue abnormalities further highlights the multifaceted nature of traumatic knee pathology. MRI provides a comprehensive, non-invasive assessment of these injuries and remains indispensable for accurate diagnosis, injury grading, treatment planning, and prognostication in patients with traumatic knee disorders.

CONCLUSION

The present study highlights the pivotal role of Magnetic Resonance Imaging (MRI) in the evaluation of traumatic knee injuries. MRI provided a comprehensive assessment of ligamentous, osseous, and associated soft-tissue abnormalities, enabling accurate characterization of the extent and severity of injury.

Anterior cruciate ligament (ACL) injury emerged as the most common ligamentous abnormality, with Grade II tears representing the predominant pattern, while posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) injuries were less frequent and were largely low-grade in nature. Joint effusion was the most prevalent associated finding and served as an important indicator of underlying intra-articular pathology. In addition to primary traumatic lesions, MRI effectively identified ancillary abnormalities such as Hoffa's fat pad edema, Baker's cysts, tendinous changes, and other peri-articular soft-tissue injuries, demonstrating its ability to provide a holistic evaluation of the injured knee.

The findings of the present study are consistent with previously published literature and reaffirm that MRI is highly sensitive for detecting both primary and secondary manifestations of knee trauma. Its superior soft-tissue contrast, multiplanar imaging capability, and non-invasive nature make it the investigation of choice for assessing internal derangement of the knee. Accurate MRI diagnosis facilitates appropriate treatment planning, assists in differentiating patients requiring surgical intervention from those suitable for conservative management, and helps prevent long-term complications related to missed or underestimated injuries.

Clinical Implications

Early MRI evaluation in patients with suspected traumatic knee injury allows precise identification and grading of ligamentous injuries, detection of associated intra-articular and peri-articular abnormalities, and comprehensive assessment of injury patterns that may not be apparent on clinical examination or conventional radiography. Consequently, MRI plays a crucial role in guiding clinical decision-making, optimizing patient management, improving functional outcomes, and reducing the need for unnecessary invasive diagnostic procedures such as arthroscopy.

Limitations of the Study

- The relatively small sample size (n = 50) may limit the generalizability of the findings to the wider population.
- The study was conducted at a single tertiary care center, which may introduce selection bias and limit the external validity of the results.
- Arthroscopic or surgical correlation was not available for all patients; therefore, the diagnostic accuracy of MRI could not be assessed for every lesion detected.
- The study primarily utilized descriptive statistical analysis and did not evaluate associations between MRI findings and clinical or demographic variables such as age, sex, mechanism of injury, or duration of symptoms.
- The cross-sectional design precluded assessment of long-term clinical outcomes and the prognostic significance of the observed MRI findings.
- Follow-up MRI examinations were not performed, preventing evaluation of the progression, healing, or resolution of injuries over time.
- Meniscal, cartilage, and osseous injuries were not correlated separately with arthroscopic findings, which could have provided additional validation of MRI findings.
- Being a hospital-based study, the findings may not fully represent the spectrum of knee injuries encountered in the general community.

Despite these limitations, the study provides valuable information regarding the MRI spectrum of traumatic knee injuries and reinforces the role of MRI as a comprehensive, non-invasive modality for the evaluation of internal derangements of the knee.

Relevance of the Study

- Knee trauma is a common cause of morbidity and can result in significant functional impairment if not diagnosed and managed appropriately.
- Accurate assessment of ligamentous, meniscal, cartilaginous, osseous, and soft-tissue injuries is essential for timely treatment planning and prevention of long-term complications.
- Clinical examination and conventional radiography may be insufficient for detecting internal derangements of the knee, particularly soft-tissue injuries.
- This study highlights the role of MRI as a comprehensive, non-invasive imaging modality capable of evaluating both osseous and soft-tissue structures in a single examination.
- The study provides valuable data regarding the spectrum and distribution of MRI findings in patients with traumatic knee injuries in the local population.
- Identification of the most common injury patterns, particularly ACL injuries and associated joint effusion, can assist radiologists and clinicians in improving diagnostic accuracy and clinical decision-making.

- The findings reinforce the utility of MRI in grading ligament injuries, detecting associated abnormalities, and guiding the selection of appropriate conservative or surgical management strategies.
- The study contributes to the growing body of evidence supporting MRI as the imaging modality of choice for evaluating internal derangement of the knee.
- Early and accurate MRI diagnosis may reduce unnecessary invasive diagnostic procedures, such as diagnostic arthroscopy, thereby improving patient safety and reducing healthcare costs.
- The results may serve as a useful reference for future research and aid in developing standardized imaging and management protocols for patients presenting with knee trauma.

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