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Evaluation of Traumatic Knee Pathologies Using Magnetic Resonance Imaging: A Cross-Sectional Study Conducted At a Tertiary Care Institution

Dr. Prateek Padhy[1], Dr.Sailendra Ku. Prusty[2],Dr. Punyada Padhy[3], Dr.Manas kar[4]

[1] *Post Graduate resident, Department of Radiodiagnosis, Hi-Tech medical college and hospital, Bhubaneswar, India*
[2] *Assistant rofessor, Department of Radiodiagnosis, Hi-Tech medical college and hospital, Bhubaneswar, India*
[3] *Consultant Radiologist, Department of Radiodiagnosis, Nidan diagnostic and research Centre,Bhubaneswar, India*
[4]*Associate Professor, Department of Radiodiagnosis, Hi-Tech medical college and hospital, Bhubaneswar, India*

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ABSTRACT:

Background: Traumatic knee injuries are common and constitute a major source of morbidity, particularly among young and active individuals. Clinical examination in the acute phase is often limited by pain, effusion, and guarding, and radiographs offer minimal insight into soft-tissue derangements. Magnetic Resonance Imaging (MRI), a non-invasive and radiation-free modality, enables high-resolution assessment of ligamentous, meniscal, cartilaginous, and osseous injuries. This study aimed to evaluate the diagnostic efficacy of MRI in detecting soft-tissue and bony lesions in patients presenting with acute knee trauma.

Materials and Methods: This observational cross-sectional study was conducted in the Department of Radiodiagnosis at **Hi-Tech Medical College & Hospital, Bhubaneswar**, over a 12-month period from December 2023 to December 2025. A total of 100 patients with recent (≤7 days) traumatic knee injury were enrolled. All patients underwent MRI of the affected knee performed on **1.5T Siemens Sempra and 1.5T GE SIGNA systems** using a dedicated knee coil and standard multiplanar imaging protocol. Imaging findings were analysed for ligamentous, meniscal, cartilaginous, osseous, and periarticular abnormalities.

Results: Of the 100 patients evaluated, 78% were male and 22% female (male-to-female ratio 3.6:1). The most common age group was 21–30 years. Right-sided knee trauma predominated (58%). **ACL injury was the most frequent abnormality (63%)**, followed by **meniscal tears (47%)**, **collateral ligament injuries**, and **patellar and osseous injuries**, including lateral tibial condyle fractures and bone contusional edema. **PCL injuries were less common (9%)**.

Conclusion: MRI is a highly effective, non-invasive modality for comprehensive evaluation of traumatic knee injuries. Its superior soft-tissue contrast and multiplanar capability enable accurate characterization of ligamentous, meniscal, chondral, and osseous lesions, supporting timely diagnosis, appropriate management, and reduction of unnecessary arthroscopy.

Keywords: Knee joint trauma, magnetic resonance imaging, internal derangement, meniscal tears, cruciate ligament injuries, bone contusion, cartilage lesions, diagnostic accuracy, tertiary care hospital, cross-sectional study

I. INTRODUCTION :

The knee is one of the largest and most biomechanically complex synovial joints of the human body, functioning as a modified hinge joint formed by the distal femur, proximal tibia, and patella, and permitting flexion–extension with secondary rotational movements essential for gait and load transmission [5–7]. The joint capsule, cruciate ligaments, menisci, collateral ligaments, and periarticular tendons collectively stabilize the knee and dissipate substantial mechanical forces encountered in daily and athletic activities. Because these structures are frequently exposed to high torsional and compressive stresses, soft-tissue injuries of the knee—particularly involving the menisci and cruciate ligaments—constitute a major cause of morbidity among young adults, labourers, and athletes [5].

Across diverse populations, epidemiological studies show that traumatic knee injuries are common and often severe. Among coal miners, repetitive kneeling, squatting, rotational loading, and impact forces lead to a high burden of internal derangement, with medial meniscal and

anterior cruciate ligament (ACL) injuries reported in 72% and 51% of trauma events, respectively [1]. In primary care populations, MRI demonstrates positive traumatic findings in 39% of patients aged 18–45 years with post-traumatic knee complaints—most frequently ACL ruptures (22%) and traumatic meniscal tears (15%) [2]. Similar patterns are observed in tertiary-care imaging cohorts, where MRI detects ACL injuries in 63% and meniscal injuries in 36% of symptomatic patients, with significantly higher prevalence among individuals with a history of trauma [3]. Retrospective MRI reviews from resource-limited regions also confirm the predominance of traumatic internal derangements, with cruciate ligament tears (37%) and meniscal injuries (33%) comprising the most frequent abnormalities, particularly in active males in the third and fourth decades of life [4].

Although clinical examination remains integral to evaluation, its diagnostic accuracy in the acute phase is often compromised due to pain, joint effusion, and guarding [8]. Radiographs, though useful for detecting fractures, offer limited ability to characterize meniscal, ligamentous, and chondral injuries early after trauma [9]. Arthroscopy is considered definitive but is invasive, costly, and more suitable for treatment than initial diagnosis.

Magnetic Resonance Imaging (MRI) has therefore become the preferred non-invasive modality for evaluating traumatic knee injuries. MRI provides superior soft-tissue contrast, multiplanar capability, and high diagnostic accuracy for meniscal tears, cruciate ligament rupture, bone contusion, cartilage defects, and periarticular soft-tissue injury—often comparable to arthroscopy while avoiding procedural morbidity [10–15]. Early MRI has been shown to enhance diagnostic confidence, reduce unnecessary arthroscopy, assist in triaging patients appropriately, and promote faster return to activity when guided by timely imaging findings [2].

Given the significant prevalence of traumatic knee injuries and the diagnostic advantages of MRI, the present study aims to determine the efficacy of MRI in identifying bony and soft-tissue lesions in patients presenting with acute knee trauma, thereby reinforcing its essential role in comprehensive assessment and management of internal derangements of the knee.

II. MATERIALS AND METHODS

The present **observational cross-sectional study** was conducted in the Department of Radiodiagnosis and Imaging co**nducted in the department of Radiodiagnosis at HI-TECH Medical College & Hospital, Bhubaneswar**for a period of **12 months**, from **December 2023 to December 2025**, following approval from the Institutional Ethics and Scientific Committee.

Patients presenting to the OPD or IPD with a **recent history of knee injury** were evaluated, and those fulfilling the inclusion and exclusion criteria were enrolled. A total of **100 patients** who provided informed consent were included in the study. All enrolled patients underwent **MRI of the knee joint** performed using **1.5 Siemens Sempra and 1.5T GE SIGNAMRI system** equipped with a dedicated knee coil and standard imaging protocol.

INCLUSION CRITERIA

• Patients of **any age group**, male or female.
• Patients presenting with **recent traumatic knee injury within 7 days** of the event.
• Patients referred from **OPD or IPD** for MRI evaluation of the knee joint.
• Patients **willing to participate** and provide informed consent.

EXCLUSION CRITERIA

• Patients **unwilling to provide consent** for participation.
• Patients with a **previous history of knee surgery** or any prior procedural intervention involving the knee joint.
• Patients with **chronic knee joint disorders**.
• Patients with **claustrophobia** or **other contraindications to MRI** (e.g., metallic implants, pacemakers).

III. IMAGING PROTOCOL

All patients underwent MRI using standard knee imaging sequences on the **1.5T Philips Achieva system**. Imaging protocol included multiplanar acquisitions with proton-density, T1-weighted, T2-weighted, and fat-suppressed sequences. Images were evaluated for **meniscal, ligamentous, cartilaginous, osseous, and periarticular abnormalities**.

IV. STATISTICAL ANALYSIS

Imaging findings for all patients were recorded prospectively in a master chart using **Microsoft Excel (version 16.0)**. Data were analysed using frequency distribution and percentage calculations. Results were represented through **tables, bar diagrams, pie charts, and column charts** prepared in Microsoft Word. Patients were categorized according to the pattern and frequency of MRI-detected abnormalities

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V. RESULTS

In this study, 100 patients were evaluated with MRI for knee joint injuries. Of these, 78% were male and 22% were female, yielding a male-to-female ratio of 3.6:1. The age-wise distribution of the study population is shown in Table 1. Among the 100 patients, 58 presented with trauma to the right knee and 42 with trauma to the left knee.

Table 1: Distribution of patients according to gender and age

Age	Male	Female	Total
10 or ≤10	0	0	0
11–20	12	2	14
21–30	23	8	31
31–40	24	6	30
41–50	11	6	17
51–60	6	0	6
>60	2	0	2
Total	**78**	**22**	**100**

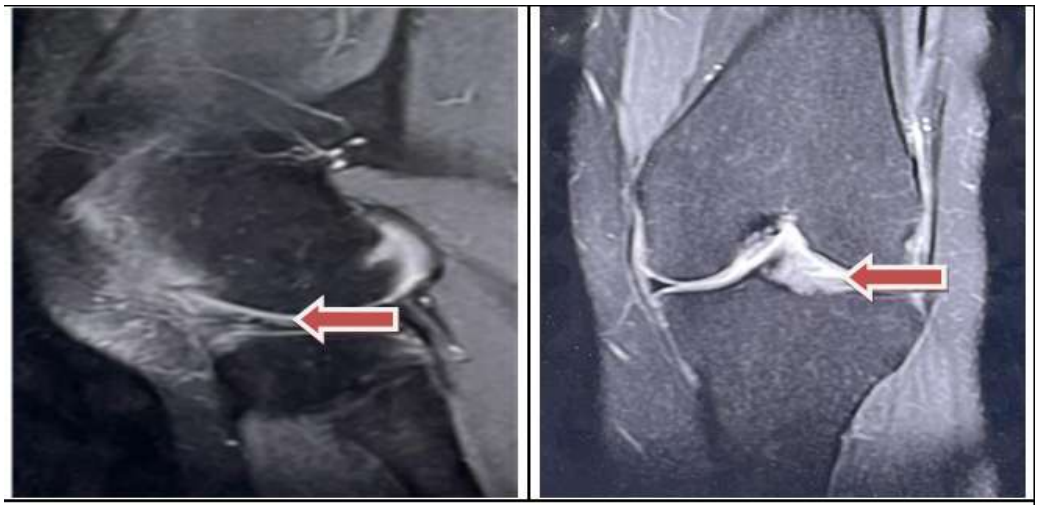

Figure 1
Sagittal PDFS and Coronal PDFS image showing tear of anterior horn of lateral meniscus adjacent to anterior root (red arrow) with minimal joint effusion.

Figure 2
Coronal PDFS and Sagittal PDFS image showing full thickness ACL tear (red arrow) and mild joint effusion.

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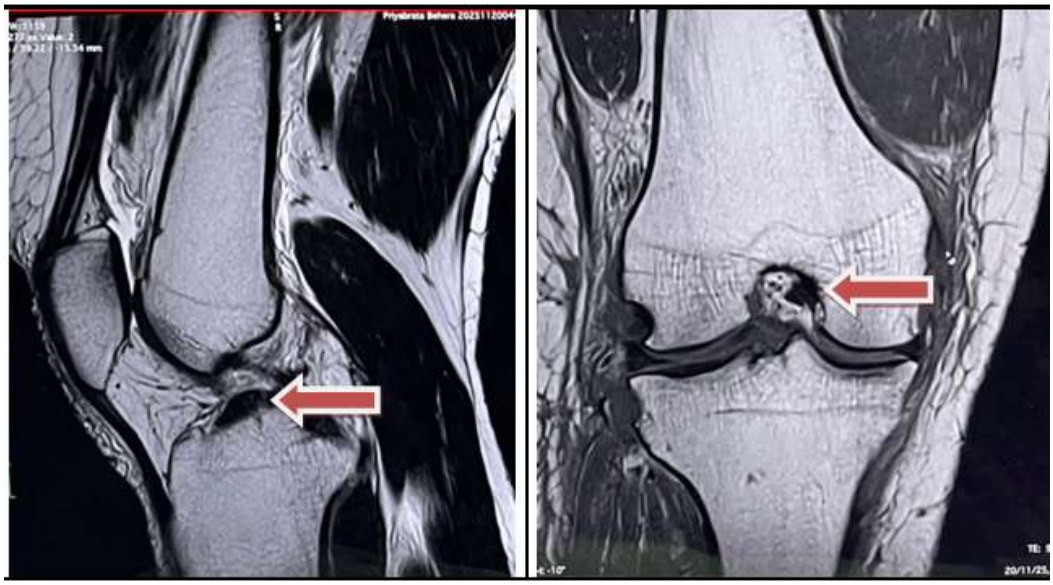

Figure 3.
Sagittal T2 and Coronal T1 image showing full thickness ACL tear (red arrow)and mild joint effusion

Among all soft-tissue components assessed (ligaments, cartilage, tendons, and menisci), ACL injury represented the most prevalent abnormality, detected in 63% of patients. Meniscal injury was the next most common soft-tissue lesion,[12] present in 47% of cases.

Table 2: Distribution of Structural Injuries on MRI

Structure	%
ACL	63
PCL	10
MCL	24
LCL	14
Medial Meniscus	32
Lateral Meniscus	15
MPR / Medial PFL	19
LPR / Lateral PFL	6
Bone fracture + contusion	27
Bone contusion only	23
Patellar injury	15
Joint effusion	76
Effusion + lipohemarthrosis	12

Among the patients with ACL injury (63%), complete or Grade III tears constituted the majority (44%). This was followed by partial or Grade II tears, while tibial-attachment avulsion fractures were present in 8% of cases, as shown in [Table 3].

ACL Injury Patterns

Table 3: ACL Injury Breakdown

ACL Injury Type	n
Grade III (complete)	44
➢ Near femoral attachment	17
➢ Mid-substance	26
➢ Near tibial attachment	0
Grade II (partial)	9
Grade I	3
Tibial attachment avulsion	8

In the patients with PCL tear, PCL avulsion fracture was found in majority amongst them as shown in **Table 4**.

Table 4: Distribution of MRI finding of PCL involvement

PCL injury type	n
Grade I/interstitial sprain	2
Grade II /partial tear	3
Grade III complete tear- proximal	2
Grade III complete tear- middle	0
Grade III complete tear- distal	0
Grade IV	0
Avulsion – tibial attachment	6
Avulsion – femoral attachment	0
Total	9

The meniscus constituted the second most frequently injured soft-tissue structure in knee trauma, with overall involvement in 47% of

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patients. The medial meniscus predominated, being torn in 33% of cases, while lateral meniscal injury was markedly less frequent, occurring in only 14%

Table 5: Distribution of various grades of Meniscal tear – observed frequency

Grading	medial meniscus	lateral meniscal	Total
Grade I	7	0	7
Grade II	5	3	8
Grade III	21	11	32
Total	**33**	**14**	**47**

In the present cohort, patellar injuries accounted for 12% of all cases. Patellar subluxation or dislocation was observed in 5% of patients [Figure 3 & Table 6], while the remaining patellar pathology consisted of articular cartilage damage, which was categorized according to the modified Outerbridge grading system for chondromalacia patellae \

Table 6: Patellar injury

Type	n
Lateral subluxation	5
Cartilage injury (Chondromalacia)	
Grade I	4
Grade II	1
Grade III	1
Grade IV	1
Total	**12**

Among the osseous injuries, fractures of the lateral tibial condyle were the most common, accounting for 16% of cases, followed by fractures of the lateral femoral condyle. The distribution of fractures in descending order was as follows: lateral tibial condyle (15%), lateral femoral condyle (8%), medial tibial condyle (5%), fibular head (3%), intercondylar tibial notch (1%), and comminuted tibial condyle fractures (1%). Bony contusional edema appeared as discrete or confluent areas of high signal intensity on T2/FS sequences, with variable involvement depending on the site of injury

Table 7: Bone fracture distributions according to bony involvement

Site	Number
Tibia – Lateral condyle	15
Tibia – Medial condyle	5
Femur – Lateral condyle	8
Femur – Medial condyle	0
Fibular head	3
Other – Notch (1), Comminuted fracture (1)	2
Total	22

VI. DISCUSSION

The present study demonstrates that magnetic resonance imaging (MRI) plays a pivotal role in the evaluation of traumatic knee injuries, with high diagnostic yield for meniscal, ligamentous, chondral, and osseous pathologies. Our findings align with multiple contemporary studies from diverse clinical environments that consistently identify the **medial meniscus** and the **anterior cruciate ligament (ACL)** as the most frequently affected structures following acute trauma [1–4]. This pattern reflects the inherent biomechanical vulnerability of these structures, which are critical stabilizers and force distributors within the knee joint.

In occupational cohorts exposed to repetitive stress—such as coal miners—MRI studies report a predominance of medial meniscal injuries (72%) and ACL injuries (51%) [1], mirroring the high incidence observed in sports-related and general trauma populations. Similarly, primary care studies of young adults with post-traumatic knee complaints report traumatic MRI abnormalities in 39% of patients, with ACL ruptures and meniscal tears comprising the majority [2]. These findings underscore that across occupational, recreational, and general populations, the **ACL–medial meniscus complex** is most susceptible to injury due to mechanisms such as pivoting, twisting, hyperextension, and rotational overload.

Our results also correlate with tertiary-care MRI analyses, where ACL injuries were identified in 63% and meniscal injuries in 36% of symptomatic patients [3]. The strong association between a clear history of trauma and the presence of ACL tears, collateral ligament injury, bone contusions, and joint effusion—as demonstrated in Shetty et al. [3]—reinforces the diagnostic value of MRI in acute presentations. Moreover, retrospective analyses from resource-limited settings similarly highlight that cruciate ligament tears (37%) and meniscal pathologies (33%) predominate among knee MRI abnormalities, particularly in young, active males [4]. These converging patterns across geographic, demographic, and socioeconomic contexts emphasize the universal diagnostic relevance of MRI in internal derangements of the knee.

The **high frequency of bone marrow edema and joint effusion** observed in our study is also consistent with findings from both primary care cohorts [2] and trauma-heavy tertiary-care

populations [3]. Bone contusions, present in up to 40% of trauma cases [3], often coexist with ligamentous injury and may serve as indirect markers of pivot-shift or valgus–external rotation mechanisms. In coal miners and other high-load occupations, similar marrow changes and effusion patterns have been reported [1], likely reflecting the combined effect of direct impact and repetitive microtrauma.

Our study aligns with prior literature asserting that **clinical assessment alone is limited** in the acute post-traumatic phase due to swelling, pain, and guarding, which reduce the accuracy of stress tests [8]. Radiographs serve an essential role in excluding fractures but offer minimal utility for evaluating soft-tissue injury [9]. Across numerous studies, MRI consistently demonstrates excellent accuracy for diagnosing meniscal tears, cruciate ligament injuries, and chondral lesions, with sensitivity and specificity often approaching arthroscopy [10–15]. The ability of MRI to delineate not only the primary lesion but also associated findings—such as synovitis, retinacular injury, Baker's cysts, and cartilage degeneration—enhances clinical decision-making and helps stratify patients for conservative versus surgical management.

In the context of health system efficiency, early MRI has been shown to shorten diagnostic pathways, reduce unnecessary arthroscopy, and promote timely return to activity [2]. In resource-limited regions, despite lower MRI availability, studies demonstrate that even low-to-mid–field MRI scanners reliably detect clinically significant knee injuries, reinforcing the modality's importance as a non-invasive diagnostic standard [4]. As MRI technology becomes more widespread, its role in trauma evaluation is expected to grow further, particularly with the increasing availability of 3T systems, which provide superior spatial resolution and cartilage imaging [3].

The pattern of injury distribution in our study—predominantly involving the ACL, followed by the medial meniscus and bone marrow changes—is consistent with the injury mechanisms described in both sports medicine literature and occupational injury studies. Medial meniscal tears typically arise from rotational trauma associated with ACL injury, whereas isolated lateral meniscal tears, though less frequent, may be associated with high-energy trauma or certain pivot-shift patterns [5,6,11]. Our findings further echo reports that horizontal and complex meniscal tears are more common in chronic or repetitive loading environments, whereas longitudinal and radial tears predominate in acute trauma [1,3,4].

Taken together, the evidence supports MRI as an indispensable tool in the diagnostic evaluation of acute knee trauma, providing comprehensive assessment of intra-articular and periarticular structures with high accuracy. The consistency of our observations with those reported across primary care [2], tertiary trauma centres [3], occupational cohorts [1], and resource-limited settings [4] underscores the robustness of MRI in clinical decision pathways.

Future studies correlating MRI findings with arthroscopic and long-term functional outcomes may help refine treatment algorithms and improve prognostication. Nonetheless, the present study reinforces that MRI remains the gold-standard non-invasive modality for diagnosing internal derangements of the knee, guiding management, and reducing unnecessary surgical intervention

VII. CONCLUSION

Knee joint injuries are frequently encountered in patients following road traffic accidents, outdoor sports participation, twisting mechanisms, and falls. In the acute setting, the diagnostic value of clinical examination, radiography, CT, and ultrasound is limited, particularly for detecting internal derangements involving ligaments, menisci, tendons, and cartilage. Although arthroscopy remains the gold standard for evaluating intra-articular knee pathology, its invasive nature, procedural risks, and cost restrict its routine use as a primary diagnostic tool.

Findings from this study affirm that **Magnetic Resonance Imaging (MRI)** is a safe, non-invasive, and radiation-free modality that offers superior characterization of soft tissue injuries associated with traumatic knee events. MRI provides excellent soft-tissue contrast and multiplanar capability, allowing accurate delineation of ligamentous tears, meniscal injuries, chondral defects, tendon abnormalities, bone contusions, and associated periarticular pathology. By enabling early and precise diagnosis, MRI reduces unnecessary arthroscopy and surgical interventions, optimizes patient triage, and improves overall cost-effectiveness in clinical care. Given its high diagnostic efficacy, MRI should be considered the **preferred imaging modality for comprehensive evaluation of traumatic knee injuries**, particularly when internal derangement is suspected and when initial clinical or radiographic findings are inconclusive.

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Additional Information

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