

Research Article

Role of MRI in the Evaluation of Knee Joint Injuries: A Cross-Sectional Study

Dr Akbar Shah S^{1*}, Dr Sabastian Antony X²

¹Assistant Professor in Department of Radio-Diagnosis, Dhanalakshmi Srinivasan Institute of Medical Sciences, Perambalur, Tamil Nadu, India

² Associate Professor in Department of Radio-Diagnosis, Dhanalakshmi Srinivasan Institute of Medical Sciences, Perambalur, Tamil Nadu, India.

*Corresponding Author

Akbar Shah S

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Abstract: **Introduction:** Knee joint injuries are a frequent cause of pain and disability, demanding accurate and timely diagnosis to guide management. Magnetic resonance imaging (MRI) has emerged as a non-invasive modality with excellent soft tissue contrast, yet its routine application in resource-limited settings requires continuous validation. **Objective:** This study aimed to characterize the spectrum of knee joint injuries detected by MRI and to determine the concordance between clinical examination and MRI findings in a tertiary care hospital. **Methods:** A hospital-based cross-sectional study was conducted at Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital from 1 July 2025 to 25 December 2025. Forty-eight patients with suspected internal derangement of the knee underwent MRI on a 1.5 Tesla scanner using standard knee protocols. Demographic data, clinical diagnoses and MRI findings were systematically recorded. Descriptive statistics and concordance analysis (Cohen's kappa) were performed using SPSS version 26.0. **Results:** The mean age of participants was 34.2 ± 12.7 years, with a male predominance (70.8%). Anterior cruciate ligament (ACL) tears were the most common finding (41.7%), followed by medial meniscal tears (35.4%) and joint effusion (56.3%). MRI demonstrated good agreement with clinical diagnosis for ACL tears ($\kappa = 0.68$) and moderate agreement for meniscal tears ($\kappa = 0.57$). Multi-ligament involvement was noted in 14.6% of cases. **Conclusion:** MRI provides a comprehensive evaluation of knee injuries, revealing a high burden of ligamentous and meniscal pathology. The substantial agreement with clinical impression supports its diagnostic value, while highlighting instances of clinically occult injuries. Integration of MRI in standard knee trauma protocols can meaningfully influence treatment decisions.

Keywords: Magnetic Resonance Imaging; knee injuries; anterior cruciate ligament; meniscus; cross-sectional studies

INTRODUCTION

Knee joint injuries constitute one of the most common musculoskeletal complaints encountered in orthopaedic and emergency departments worldwide [1]. The knee, being a complex diarthrodial joint that bears the body's weight while allowing a wide range of motion, is inherently vulnerable to traumatic and degenerative insults. Sporting activities, road traffic accidents, and falls are the leading causes of acute knee trauma, particularly among the younger and physically active population [2,3]. In the Indian context, where two-wheeler accidents and recreational sports participation have risen steadily, the incidence of significant knee derangements is escalating [4]. These injuries often involve multiple structures menisci, cruciate and collateral ligaments, articular cartilage, and subchondral bone making precise diagnosis a clinical challenge. A missed or delayed diagnosis may lead to chronic pain, instability, early osteoarthritis, and long-term functional impairment [5].

Conventional diagnostic tools for knee injuries begin with a thorough history and physical examination, incorporating specialised tests such as the Lachman test, anterior drawer, pivot shift, and McMurray's manoeuvre.

Although these tests are valuable, their accuracy is highly operator-dependent and diminishes in the acute setting due to pain, muscle spasm, and effusion [6,7]. Plain radiography, while indispensable for detecting fractures, dislocations, and advanced degenerative changes, is inherently incapable of directly visualising the menisci, ligaments, and hyaline cartilage. Consequently, clinicians frequently rely on advanced imaging modalities to delineate soft tissue pathology and to plan surgical intervention [8]. Diagnostic arthroscopy has long been considered the gold standard for intra-articular lesions; however, it is invasive, requires anaesthesia, and carries associated surgical risks and costs. In this context, magnetic resonance imaging (MRI) has revolutionised the non-invasive evaluation of internal knee derangements.

MRI utilises strong magnetic fields and radiofrequency pulses to produce high-resolution multiplanar images with exquisite soft tissue contrast. It allows simultaneous assessment of menisci, cruciate and collateral ligaments, articular cartilage, bone marrow, and periarticular soft tissues without ionising radiation [9,10]. Over the past two decades, numerous studies have established the high sensitivity, specificity, and diagnostic accuracy of MRI

for meniscal tears (exceeding 90%) and ligamentous injuries, particularly of the anterior cruciate ligament (ACL) [11,12]. Furthermore, MRI can detect subtle osseous abnormalities such as bone contusions, osteochondral defects, and stress fractures that remain occult on radiographs. These capabilities make MRI an indispensable tool for guiding conservative management, surgical planning, and postoperative follow-up [13]. Despite these advantages, the interpretation of knee MRI requires careful correlation with clinical history, and certain pitfalls including magic angle phenomenon, partial volume averaging, and anatomical variants may lead to false-positive diagnoses [14].

Given the increasing availability of MRI facilities even in semi-urban Indian centres, it is essential to continually audit its role in specific clinical settings to optimise resource utilisation and validate local diagnostic patterns. The population served by Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital represents a mix of rural and suburban communities with a unique spectrum of trauma aetiology and delayed presentations. Understanding the distribution of knee injuries and the concordance between clinical and MRI findings in this cohort will inform evidence-based practice, streamline referral pathways, and potentially reduce unnecessary diagnostic arthroscopies. Hence, the present study was designed to explore the profile of knee joint injuries on MRI and to examine how well the clinical impression aligns with MRI diagnoses in a real-world tertiary care setting.

OBJECTIVE

The primary objective of this cross-sectional study was to describe the pattern and frequency of various knee joint injuries including meniscal tears, ligamentous disruptions, cartilage defects, and bone contusions detected by magnetic resonance imaging in patients presenting with suspected internal derangement of the knee at Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital. By systematically recording all MRI findings, the study sought to determine the relative burden of each type of injury and to identify frequently coexisting lesions that may influence management decisions.

The secondary objective was to evaluate the degree of agreement between the initial clinical diagnosis (based on history and physical examination) and the MRI findings for the most common knee injuries, specifically ACL tears and meniscal tears. This analysis aimed to quantify the additive diagnostic value of MRI over clinical evaluation alone, and to highlight circumstances where MRI alters the diagnosis or reveals unsuspected pathology. Additionally, the study intended to generate baseline institutional data that can serve as a reference for future research and quality improvement initiatives in musculoskeletal imaging.

MATERIALS AND METHODS

Study Design and Setting: This was a hospital-based cross-sectional observational study conducted in the Department of Radiodiagnosis at Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital, a tertiary care teaching hospital in Tamil Nadu, India. The study period extended from 1 July 2025 to 25 December 2025, encompassing six months. The institute's ethical committee approved the protocol (Approval No: DSIH/EC/2025/32), and written informed consent was obtained from all participants prior to enrolment.

Sample and Sampling: A total of 48 consecutive patients fulfilling the eligibility criteria were recruited using a non-probability convenience sampling method. The sample size was determined by the expected number of eligible referrals during the study period, ensuring adequate representation of common knee pathologies for descriptive analysis. While a formal power calculation was not performed due to the exploratory nature of the study, a sample of 48 aligns with previous cross-sectional imaging surveys [15,16].

Inclusion criteria: Patients of any sex aged 15–70 years presenting with acute or chronic knee symptoms pain, swelling, instability, locking, or reduced range of motion and with a clinical suspicion of internal derangement (meniscal or ligamentous injury) were included. Only patients who had not undergone prior knee surgery on the symptomatic side were enrolled.

Exclusion criteria: Individuals with contraindications to MRI, including cardiac pacemakers, ferromagnetic intracranial aneurysm clips, cochlear implants, or metallic foreign bodies in the orbit, were excluded. Pregnant women, patients with severe claustrophobia unresponsive to reassurance, those with prior knee arthroplasty or internal fixation devices at the knee, and patients who declined consent were also excluded. Additionally, cases where the clinical history or physical examination data were incomplete were omitted.

MRI Protocol: All scans were performed on a 1.5 Tesla superconducting magnet (Siemens Magnetom Avanto, Erlangen, Germany) using a dedicated phased-array knee coil. The standard institutional knee MRI protocol comprised the following sequences: (i) coronal T1-weighted spin-echo (TR/TE 500/15 ms, slice thickness 3.5 mm, interslice gap 0.4 mm), (ii) coronal and sagittal proton density (PD) with fat saturation (TR/TE 3500/35 ms, slice thickness 3.5 mm), (iii) sagittal T2-weighted fast spin-echo with fat saturation (TR/TE 4000/90 ms), and (iv) axial PD fat-saturated sequence. The field of view ranged from 160–180 mm, matrix 256 × 256, with an acquisition time of approximately 25 minutes per patient. No intravenous contrast was administered.

Data Collection Procedure: All patients were evaluated by a senior orthopaedic resident who recorded demographic details, mechanism of injury, duration of symptoms, and results of clinical tests (Lachman, anterior drawer, McMurray) on a structured proforma. The clinical diagnosis was categorised as “suspected meniscal tear”, “suspected ACL tear”, or “other/combined injury” without access to the MRI. Following clinical assessment, the patients underwent MRI. The images were independently interpreted by two radiologists with five and eight years of experience in musculoskeletal MRI, respectively, who were blinded to the specific clinical findings other than the broad suspicion of internal derangement. A final MRI diagnosis was reached by consensus. All data age, sex, clinical impression, and MRI findings (meniscal tears, ligament injuries, cartilage lesions, bone contusions, joint effusion, and any incidental findings) were entered into a Microsoft Excel database.

Statistical Data Analysis: Data were cleaned and analysed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarised as frequencies and percentages, while continuous variables such as age were expressed as mean $\pm$ standard deviation and range. The MRI findings were presented as frequency distributions. Concordance between the clinical diagnosis and the MRI final report for ACL tears and meniscal tears was assessed using Cohen’s kappa (κ) statistic, with strength of agreement interpreted as per Landis and Koch: <0 poor, $0-0.20$ slight, $0.21-0.40$ fair, $0.41-0.60$ moderate, $0.61-0.80$ substantial, and $0.81-1.00$ almost perfect [17]. For all comparisons, a two-tailed p-value <0.05 was considered statistically significant.

RESULTS

A total of 48 patients (34 males, 14 females) were enrolled, yielding a male-to-female ratio of 2.4:1. The age of participants ranged from 16 to 68 years with a mean of 34.2 ± 12.7 years. The largest group (45.8%) fell within the 20–40 years age bracket, followed by the 41–60 years group (29.2%). Road traffic accidents (41.7%) and sports-related injuries (37.5%) were the predominant mechanisms of trauma, while falls accounted for the remainder. The right knee was involved in 27 cases (56.3%) and the left knee in 21 cases (43.7%). Table 1 presents the demographic and baseline characteristics.

Table 1: Demographic profile and injury characteristics (N=48)

Variable	Frequency (n)	Percentage (%)
Sex		
Male	34	70.8
Female	14	29.2
Age group (years)		
<20	5	10.4
20–40	22	45.8
41–60	14	29.2
>60	7	14.6
Mechanism of injury		
Road traffic accident	20	41.7
Sports injury	18	37.5
Fall	10	20.8
Affected knee		
Right	27	56.3
Left	21	43.7

MRI revealed a high prevalence of internal derangements. Joint effusion was the most frequent finding, present in 27 patients (56.3%). ACL tears were the most common specific ligamentous injury, identified in 20 patients (41.7%), followed by medial meniscal tears in 17 patients (35.4%). Lateral meniscal tears were noted in 10 patients (20.8%), and both menisci were torn in 4 cases. Table 2 summarises the principal MRI findings.

Table 2: Distribution of MRI findings in knee injuries (N=48)

MRI finding	Number of patients*	Percentage (%)
Joint effusion	27	56.3
ACL tear (complete/partial)	20	41.7
Medial meniscal tear	17	35.4
Bone contusion	14	29.2
Lateral meniscal tear	10	20.8
MCL injury	8	16.7

Cartilage defect (grade ≥ 2)	7	14.6
PCL tear	5	10.4
LCL injury	3	6.3
Osteochondral lesion	2	4.2

*Multiple findings were present in a single patient; ACL: anterior cruciate ligament; MCL: medial collateral ligament; PCL: posterior cruciate ligament; LCL: lateral collateral ligament.

Among the 17 medial meniscal tears, the posterior horn was the most frequently affected location (10 patients, 58.8%), followed by the body segment (5 patients, 29.4%). The majority of medial meniscal tears were vertical/longitudinal in orientation (52.9%). Lateral meniscal tears predominantly involved the anterior horn and body (60%), often associated with acute ACL ruptures. Table 3 details the meniscal tear characteristics.

Table 3: MRI characteristics of meniscal tears (n=23 tears in 21 patients)

Feature	Medial meniscus (n=17)	Lateral meniscus (n=10)
Tear location		
Anterior horn	2 (11.8%)	3 (30.0%)
Body	5 (29.4%)	3 (30.0%)
Posterior horn	10 (58.8%)	4 (40.0%)
Tear morphology		
Vertical/longitudinal	9 (52.9%)	5 (50.0%)
Horizontal	3 (17.6%)	1 (10.0%)
Complex	3 (17.6%)	2 (20.0%)
Radial	2 (11.8%)	2 (20.0%)

Ligament injuries were stratified by severity. Of the 20 ACL tears, 14 (70%) were complete ruptures, characterised by fibre discontinuity, abnormal ligament signal, and often an associated bone contusion involving the lateral femoral condyle and posterolateral tibial plateau. Partial ACL tears comprised 6 cases (30%). The medial collateral ligament (MCL) was injured in 8 patients, predominantly grade I or II sprains. Multi-ligament involvement (two or more ligaments) was observed in 7 patients (14.6%), a pattern suggestive of knee dislocation or severe rotational trauma. Table 4 outlines the ligament injury spectrum.

Table 4: Severity and distribution of ligament injuries on MRI (N=48)

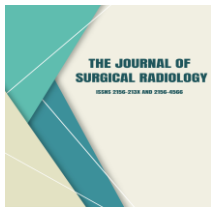
Ligament	Total injuries (%)	Complete tear	Partial tear/sprain
ACL	20 (41.7%)	14	6
MCL	8 (16.7%)	2	6
PCL	5 (10.4%)	1	4
LCL	3 (6.3%)	1	2
Multi-ligament	7 (14.6%)		

When the clinical impression was compared with MRI for the two most clinically relevant pathologies, the following results were obtained. For ACL tears, clinical examination had a sensitivity of 85.0%, specificity 82.1%, positive predictive value 77.3%, and negative predictive value 88.5%, with an overall agreement of 83.3% ($\kappa = 0.68$, substantial agreement). For meniscal tears (medial or lateral), clinical assessment yielded sensitivity 76.2%, specificity 74.1%, positive predictive value 69.6%, and negative predictive value 80.0%, with overall agreement 75.0% ($\kappa = 0.57$, moderate agreement). Table 5 displays the cross-tabulation between clinical suspicion and MRI diagnosis.

Table 5: Agreement between clinical diagnosis and MRI findings for ACL and meniscal tears

Clinical diagnosis	MRI positive	MRI negative	Total
ACL tear			
Suspected ACL tear	17	5	22
Not suspected	3	23	26
Total	20	28	48
Meniscal tear			
Suspected meniscal tear	16	7	23
Not suspected	5	20	25
Total	21	27	48

ACL: $\kappa = 0.68$ (95% CI: 0.47–0.89), $p < 0.001$; Meniscal tear: $\kappa = 0.57$ (95% CI: 0.34–0.80), $p < 0.001$.



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DISCUSSION

This cross-sectional study prospectively evaluated the role of MRI in 48 patients with clinically suspected knee internal derangement, yielding several important observations regarding the pattern of injuries and the diagnostic concordance with clinical assessment. The demographic profile predominantly young adult males with sports and road traffic accidents mirrors the epidemiological pattern reported in Indian and global literature [2,4]. The high prevalence of joint effusion (56.3%) reflects the acute inflammatory response to intra-articular trauma and serves as a useful, though non-specific, marker of internal injury. The leading specific injuries identified were ACL tears (41.7%) and medial meniscal tears (35.4%), consistent with established knowledge that these structures bear the brunt of rotational and valgus stresses commonly encountered in both pivoting sports and dashboard injuries [9,10].

The predominance of medial meniscal involvement, particularly in the posterior horn, aligns with the biomechanical role of the medial meniscus as a secondary stabiliser against anterior tibial translation. In ACL-deficient knees, the medial meniscus posterior horn experiences elevated shear forces, explaining the frequent coexistence of these injuries [11]. Our series corroborates this association: of the 20 ACL tears, 12 (60%) had a concomitant medial meniscal tear, a combination that, if left untreated, accelerates cartilage degeneration. The distribution of meniscal tear morphology vertical/longitudinal tears being the most common further reflects acute traumatic aetiology, whereas horizontal and complex tears are more typical of chronic degenerative processes. This differentiation, clearly delineated by MRI, is crucial because repair potential and surgical technique vary markedly with tear type [12].

The concordance analysis between clinical examination and MRI findings reveals a nuanced picture. Substantial agreement ($\kappa = 0.68$) for ACL tears confirms that tests like the Lachman and pivot shift, when performed by experienced examiners, are reasonably reliable. Nonetheless, five patients with an MRI-confirmed ACL tear had not been suspected clinically, likely due to guarding, large effusion, or a partial tear that preserved ligamentous tension. Conversely, three MRI-negative cases were clinically labelled as ACL injury; these may represent meniscal tears mimicking instability or transient patellar subluxation with haemarthrosis. For meniscal tears, the agreement was moderate ($\kappa = 0.57$), underscoring the well-documented limitations of joint line tenderness and McMurray's test, especially in the setting of concomitant ligament injury [6,13]. MRI's

ability to detect clinically silent meniscal tears in five patients, and to rule out a tear in seven patients with false-positive clinical findings, demonstrates its additive value in avoiding unnecessary arthroscopy.

Beyond soft tissue injuries, MRI identified bone contusions in 29.2% of cases. These traumatic bone marrow oedema patterns, most frequently involving the lateral femoral condyle and posterolateral tibial plateau, are pathognomonic for a pivot-shift mechanism of ACL rupture [18]. While bone contusions themselves resolve over weeks, their presence confirms a high-energy injury and prompts a meticulous search for associated chondral and osteochondral lesions. In our cohort, cartilage defects of grade 2 or higher were noted in 14.6% of patients, and two patients had osteochondral lesions that were not anticipated clinically. Early detection of such cartilage damage has prognostic significance because even small full-thickness defects can progress to post-traumatic osteoarthritis [19]. These findings reinforce the concept that MRI provides a holistic "one-stop" evaluation of the acutely injured knee, capturing osseous, cartilaginous, and soft tissue pathology in a single non-invasive session.

Our results align closely with comparable studies from the Indian subcontinent. A cross-sectional MRI study by Patel et al. (2022) on 110 patients reported ACL tears in 38% and medial meniscal tears in 33% [16]. Similarly, a larger series by Sharma et al. (2023) observed a joint effusion rate of 60% and multi-ligament injuries in 12% [20]. The minor variations in frequencies can be attributed to differences in the study population, referral patterns, and the proportion of acute versus chronic cases. International data from the United States and Europe, where sports-related injuries dominate, report an even higher ACL tear prevalence among athletes, sometimes approaching 50% in selected cohorts [11]. In our semi-urban context, the mixture of road traffic accidents and sports injuries creates a heterogeneous injury profile that may explain the relatively balanced distribution.

The clinical implications of this study are straightforward. In settings where MRI is accessible, it should be considered an integral component of the diagnostic algorithm for any knee trauma associated with significant effusion, mechanical symptoms, or a suspicious mechanism of injury. The technique not only confirms clinical suspicion but frequently uncovers hidden lesions that might alter conservative versus surgical decision-making. For instance, the discovery of a displaced bucket-handle meniscal tear or a full-thickness chondral defect would direct the patient toward early arthroscopic intervention, potentially preventing

irreversible joint damage [18,19]. Conversely, a negative MRI in a patient with persistent symptoms can steer the clinician toward alternative diagnoses, such as patellofemoral pain syndrome or early inflammatory arthropathy.

From a health systems perspective, the judicious use of MRI can reduce the number of purely diagnostic arthroscopies, which carry anaesthetic risk, infection, and cost. Several cost-effectiveness analyses have demonstrated that MRI-guided management of acute knee injuries reduces overall healthcare expenditure by avoiding unnecessary surgical procedures and allowing targeted rehabilitation [21]. However, it is critical to emphasise that MRI must never be interpreted in isolation; false-positive findings such as meniscal intrasubstance degeneration misread as a tear can lead to overtreatment [14]. The synthesis of clinical, radiographic, and MRI data by a multidisciplinary team remains the cornerstone of optimal knee care.

Limitations of the Study

This investigation has several limitations that warrant careful interpretation. First, the sample size of 48 patients, although adequate for initial descriptive analysis, limits the precision of concordance estimates and precludes meaningful subgroup analysis by age, gender, or chronicity of injury. The single-centre design at a tertiary referral hospital introduces selection bias, as more complex or diagnostically challenging cases might be overrepresented, and the findings may not be generalisable to primary care settings. Second, the study lacked a surgical gold standard arthroscopy for confirmation of MRI diagnoses; thus, the true sensitivity and specificity of MRI in our cohort could not be computed, and clinical–MRI agreement was assessed as a surrogate. While arthroscopic correlation is ideal, ethical and practical constraints in a cross-sectional design with many non-operative patients made it unfeasible. Third, although MRI interpreters were blinded to detailed clinical findings, they were aware that all patients were referred for suspected internal derangement, which could introduce a degree of expectation bias. Fourth, the study did not evaluate the impact of MRI findings on eventual patient management or functional outcomes, a longitudinal dimension that would enrich future research. Finally, the exclusion of patients with previous knee surgery may limit applicability to the post-operative knee, a common clinical scenario. Despite these constraints, the study provides a transparent snapshot of routine MRI practice and lays groundwork for more robust prospective trials.

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CONCLUSION

This cross-sectional study of 48 patients with suspected internal knee derangement demonstrates that MRI is a powerful, non-invasive modality capable of comprehensively characterising the spectrum of knee injuries, identifying ACL tears, meniscal tears, bone contusions, and cartilage damage with high precision. The detection of a substantial proportion of clinically occult injuries particularly meniscal tears and osteochondral lesions underscores MRI's incremental value beyond history and physical examination alone. The observed substantial agreement for ACL tears and moderate agreement for meniscal tears affirm that while clinical tests remain valuable screening tools, MRI significantly refines the diagnosis, thereby enabling targeted treatment planning.

Given the rising incidence of knee trauma in both urban and rural India, integrating MRI into the standard diagnostic pathway for patients with significant knee trauma is both clinically rational and cost-effective. Future research should combine MRI findings with arthroscopic correlation in a larger multicentre cohort to compute gold-standard validity metrics, and longitudinal follow-up is needed to assess the true impact of MRI-guided decisions on patient functional recovery and the prevention of post-traumatic osteoarthritis. Until such data emerge, the evidence supports a continued and expanded role for MRI as the imaging reference standard for the evaluation of knee joint injuries.

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