

Research Article

ROLE OF MRI IN THE EVALUATION OF PAINFUL KNEE JOINT AND CORRELATION WITH CLINICOPATHOLOGICAL, ARTHROSCOPIC AND HISTOPATHOLOGICAL FINDINGS

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Abstract: **Introduction:** Painful knee joint is a common clinical condition with diverse etiologies, including traumatic, degenerative, inflammatory, and infective causes. Accurate imaging is essential for identifying internal derangements and guiding management. **Objectives:** To evaluate the role of magnetic resonance imaging (MRI) in the assessment of painful knee joint and to determine its diagnostic accuracy by correlating MRI findings with clinical, arthroscopic, and histopathological outcomes. **Methods:** This hospital-based cross-sectional study included 111 patients presenting with knee pain. All patients underwent MRI using a 3 Tesla scanner with standard multiplanar sequences. MRI findings were analyzed for meniscal, ligamentous, cartilaginous, bone marrow, and synovial abnormalities. Arthroscopic and histopathological correlations were performed in selected cases. **Results:** The majority of patients were aged 31–40 years, with male predominance (64.9%). Trauma was present in 61.3% of cases. MRI revealed medial meniscus tears (75.7%) as the most common finding, followed by ACL injuries (52.3%) and joint effusion (73.9%). Cartilage abnormalities and bone marrow edema were observed in 44.1% and 30.6% of cases, respectively. MRI showed high sensitivity and accuracy for meniscal and ACL injuries, with strong correlation with arthroscopy and histopathology. **Conclusion:** MRI is a highly sensitive, reliable, and non-invasive modality for comprehensive evaluation of painful knee joint.

Keywords: Painful knee joint, Magnetic resonance imaging, Meniscal tear, ACL injury, Arthroscopy, Diagnostic accuracy

INTRODUCTION

The knee joint is one of the largest and most complex synovial joints in the human body, playing a pivotal role in locomotion, weight-bearing, and stability. Owing to its intricate anatomy and constant exposure to mechanical stress, it is highly susceptible to a wide spectrum of traumatic, degenerative, inflammatory, and infective pathologies that commonly present with pain, swelling, and functional limitation^{1,2}. Painful knee joint is a frequent clinical complaint encountered across all age groups and constitutes a significant proportion of musculoskeletal consultations worldwide³.

Globally, knee disorders represent a major cause of disability and reduced quality of life, particularly in active young individuals and the aging population⁴. Traumatic injuries such as meniscal tears and ligamentous disruptions predominate in younger populations, especially among athletes, whereas degenerative conditions such as osteoarthritis are more

common in older individuals^{5,6}. Osteoarthritis alone affects hundreds of millions of individuals globally and is a leading cause of chronic knee pain and disability⁷. In addition, inflammatory arthropathies, infections, and synovial disorders contribute significantly to the burden of knee morbidity⁸.

Accurate diagnosis of the underlying etiology of knee pain is essential for appropriate management and prevention of long-term complications. Clinical examination, although fundamental, is often insufficient to precisely localize intra-articular pathology due to overlapping clinical features⁹. Conventional radiography remains the initial imaging modality but is limited in its ability to assess soft tissue structures such as menisci, ligaments, cartilage, and synovium¹⁰. While ultrasonography provides dynamic evaluation of superficial structures, it is operator-dependent and inadequate for comprehensive intra-articular assessment¹¹. Computed tomography offers excellent

visualization of osseous anatomy but has limited utility in soft tissue evaluation and involves ionizing radiation¹². Magnetic resonance imaging (MRI) has emerged as the imaging modality of choice for evaluating painful knee joint due to its superior soft tissue contrast, multiplanar capability, and absence of ionizing radiation^{13,14}. MRI enables detailed visualization of intra-articular structures, including menisci, cruciate and collateral ligaments, articular cartilage, synovium, and bone marrow, thereby allowing comprehensive assessment of both traumatic and non-traumatic pathologies¹⁵. High-resolution sequences such as proton density-weighted and fat-suppressed imaging further enhance the detection of subtle lesions, including bone marrow edema and early cartilage degeneration¹⁶.

Extensive literature has validated the diagnostic accuracy of MRI in knee pathologies, particularly when correlated with arthroscopy, which remains the gold standard for intra-articular evaluation¹⁷. Studies have reported MRI sensitivity and specificity exceeding 90% for medial meniscal tears and anterior cruciate ligament (ACL) injuries^{18,19}. MRI also plays a crucial role in identifying associated findings such as bone contusions, synovial abnormalities, and cartilage defects, thereby influencing clinical decision-making and surgical planning²⁰. Moreover, advanced MRI techniques such as T2 mapping and delayed gadolinium-enhanced imaging of cartilage (dGEMRIC) have further improved the ability to detect early biochemical changes in cartilage before morphological alterations become apparent²¹.

Despite its high diagnostic accuracy, MRI is not devoid of limitations. False-positive findings may occur due to degenerative signal changes, while small peripheral tears and partial ligament injuries may be missed²². Additionally, asymptomatic individuals may demonstrate MRI abnormalities, emphasizing the importance of clinical correlation²³. Therefore, integration of MRI findings with clinical examination and confirmatory modalities such as arthroscopy and histopathology remains essential for accurate diagnosis and optimal patient management²⁴.

Arthroscopy continues to be regarded as the definitive diagnostic and therapeutic modality for internal derangements of the knee, allowing direct visualization and intervention²⁵. Histopathological examination is particularly important in cases involving synovial proliferative disorders, infections, and neoplastic conditions, where it provides definitive diagnosis²⁶. Correlation of MRI findings with arthroscopic and histopathological results enhances diagnostic confidence and helps refine imaging criteria²⁷.

In the Indian context, knee joint pathologies show distinct demographic and etiological patterns influenced by occupational activities, trauma prevalence, and healthcare access²⁸. Although several studies have evaluated MRI in knee disorders, there remains a relative

paucity of comprehensive studies integrating clinicopathological, arthroscopic, and histopathological correlations within a single cohort²⁹. Such correlation is crucial to establish the true diagnostic accuracy of MRI and to optimize its role as a non-invasive diagnostic tool. Given these considerations, the present study was undertaken to evaluate the role of MRI in the assessment of painful knee joint and to determine its diagnostic accuracy through correlation with clinical findings, arthroscopy, and histopathology wherever applicable. This integrated approach aims to enhance diagnostic precision, guide appropriate management strategies, and potentially reduce the need for unnecessary invasive procedures.

MATERIALS AND METHODS

Study Design and Setting: This hospital-based cross-sectional observational study was conducted in the Department of Radio-diagnosis at a tertiary care teaching hospital in Jaipur, Rajasthan, over a period of 18 months (April 2024 to September 2025). The study aimed to evaluate the role of magnetic resonance imaging (MRI) in patients presenting with painful knee joint and to correlate imaging findings with clinical, arthroscopic, and histopathological outcomes wherever available.

Study Population and Sampling: A total of 111 patients presenting with clinically suspected painful knee joint and referred for MRI evaluation were included in the study. The sample size was calculated using G*Power software with a confidence level of 95% ($\alpha = 0.05$) and power of 80%. A consecutive sampling technique was employed, enrolling all eligible patients during the study period until the desired sample size was achieved.

Inclusion and Exclusion Criteria: Adult patients (≥ 18 years) of either sex presenting with knee pain and undergoing MRI evaluation were included. Patients who refused consent, had prior knee surgery or intervention, or had contraindications to MRI such as cardiac pacemakers, cochlear implants, or severe claustrophobia were excluded from the study.

MRI Technique and Image Acquisition: MRI examinations were performed using a 3 Tesla scanner (Siemens Vida) with a dedicated knee coil. Standard imaging protocol included multiplanar sequences such as T1-weighted, T2-weighted, proton density fat-saturated (PD-FS), and short tau inversion recovery (STIR) images in sagittal, coronal, and axial planes to comprehensively evaluate osseous, ligamentous, meniscal, cartilaginous, and synovial structures.

Image Analysis and Data Collection: MRI images were systematically analyzed on dedicated workstations for the presence of bone marrow lesions, meniscal tears, ligament injuries, cartilage abnormalities, and synovial pathologies. Clinical data were recorded, and wherever

feasible, MRI findings were correlated with arthroscopic and histopathological findings to assess diagnostic accuracy.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using appropriate statistical methods. Descriptive statistics were used to summarize demographic and clinical characteristics. Diagnostic accuracy parameters such as sensitivity and specificity were calculated wherever applicable, and relevant

statistical tests were applied with a significance level set at $p < 0.05$.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants, and confidentiality of patient information was strictly maintained throughout the study.

RESULTS

A total of 111 patients presenting with painful knee joint were included in the study. The age distribution revealed that the 31–40 years age group constituted the largest proportion (25.2%), followed by the 21–30 years group (21.6%), indicating that knee pathologies were most prevalent among young to middle-aged adults. This distribution reflects increased physical activity and susceptibility to trauma in this population. A clear male predominance (64.9%) was observed, suggesting a higher incidence of knee-related injuries among males, possibly due to occupational and activity-related exposure.

Table 1: Demographic Profile of Study Participants (n = 111)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–20	8	7.2
	21–30	24	21.6
	31–40	28	25.2
	41–50	22	19.8
	51–60	17	15.3
	>60	12	10.8
Gender	Male	72	64.9
	Female	39	35.1

Analysis of laterality demonstrated that the right knee was more commonly involved (56.8%) compared to the left knee (43.2%). Furthermore, a significant proportion of patients (61.3%) had a history of trauma, indicating that trauma was the predominant etiological factor in the study population. These findings highlight the role of mechanical stress and injury in the development of knee pathologies.

Table 2: Clinical Profile of Knee Involvement

Parameter	Category	Frequency (n)	Percentage (%)
Side Involved	Right	63	56.8
	Left knee	48	43.2
History of Trauma	Present	68	61.3
	Absent	43	38.7

Arthroscopic correlation was available in 34 patients (30.6%), while histopathological evaluation was performed in 12 patients (10.8%). This limited availability reflects real-world clinical practice, where invasive procedures are selectively performed based on clinical indication and severity of disease.

Table 3: Availability of Arthroscopy and Histopathology

Parameter	Yes (n)	No (n)	Percentage Yes (%)
Arthroscopy	34	77	30.6
Histopathology	12	99	10.8

A total of 111 patients were evaluated. Pain was the universal presenting complaint (100%), followed by pain during walking (74.8%), pain during flexion/extension (68.5%), and pain during upslope/downslope walking (64.0%). Swelling (62.2%) and stiffness (48.6%) were also common, while deformity was least frequent (8.1%). These findings indicate that the majority of patients had active intra-articular pathology affecting movement and function.

Table 4: Distribution of Presenting Clinical Features

Clinical Feature	Frequency (n)	Percentage (%)
Pain	111	100

Pain during walking	83	74.8
Pain during flexion/extension	76	68.5
Pain during upslope/downslope	71	64.0
Swelling	69	62.2
Stiffness	54	48.6
Restricted movement	47	42.3
Limp	41	36.9
Loss of function	38	34.2
Deformity	9	8.1

MRI FINDINGS

Meniscal abnormalities were the most common MRI findings, with medial meniscus involvement (75.7%) significantly higher than lateral meniscus (44.1%). According to Stoller grading, Grade II and III lesions constituted the majority of clinically significant abnormalities. Tear morphology showed predominance of longitudinal and complex tears.

Table 5: Meniscal Findings (Combined Table)

Parameter	Category	Frequency (n)	Percentage (%)
Medial Meniscus	Grade 0	39	35.1
	Grade I	21	18.9
	Grade II	28	25.2
	Grade III (tear)	23	20.7
Lateral Meniscus	Grade 0	62	55.9
	Grade I	18	16.2
	Grade II	17	15.3
	Grade III (tear)	14	12.6

Table 6: Types and Location of Meniscal Tears

Parameter	Category	Frequency (n)	Percentage (%)
Tear Type (n=14)	Longitudinal	4	28.6
	Horizontal	3	21.4
	Complex	2	14.3
	Bucket handle	2	14.3
	Radial	2	14.3
	Root tear	1	7.1
Tear Location (Lateral)	Posterior horn	8	57.1
	Body	4	28.6
	Anterior horn	2	14.3

ACL injuries were the most common ligamentous abnormality (52.3%), with partial tears (32.4%) more frequent than complete tears (18%). PCL injuries were relatively rare (9%). Among collateral ligaments, MCL injuries (25.2%) were more common than LCL injuries (13.5%), indicating predominance of valgus stress-related trauma.

Table 7: Ligament Injury Pattern (Combined Table)

Ligament	Status	Frequency (n)	Percentage (%)
ACL	Intact	55	49.5
	Partial tear	36	32.4
	Complete tear	20	18.0
PCL	Intact	101	91.0
	Injury	10	9.0
MCL	Normal	83	74.8
	Injury	28	25.2
LCL	Normal	96	86.5
	Injury	15	13.5

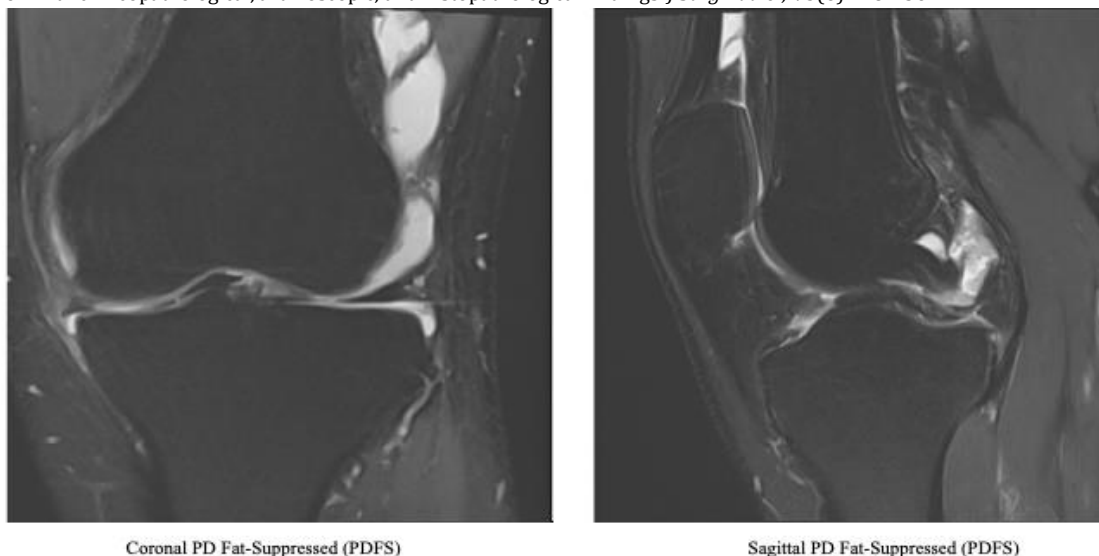


Figure 1: MRI knee demonstrates a displaced handle tear of medial meniscus with fragment in the intercondylar notch and features suggestive of a ramp lesion.

Bone marrow edema was observed in 30.6% of cases, commonly associated with ligamentous injuries, especially ACL tears. Cartilage abnormalities were present in 44.1% of patients, indicating a significant contribution of degenerative pathology to knee pain. Joint effusion was the most common MRI finding (73.9%), reflecting active inflammatory or traumatic processes. Baker's cyst was seen in 8.1% of patients, typically associated with underlying intra-articular pathology.

No statistically significant association was observed between history of trauma and ACL injury ($p = 0.968$) or medial meniscus injury ($p = 1.000$), suggesting that these pathologies also occur in non-traumatic or degenerative conditions. However, a significant association was found between ACL injury and bone marrow edema ($p = 0.033$), supporting the presence of associated bone contusions in ligament injuries.

MRI demonstrated: High sensitivity for meniscal tears (93.5%), High diagnostic accuracy for ACL injuries (85.3%), Excellent correlation with histopathology in synovial lesions. The present study demonstrates that painful knee joint is a multifactorial condition involving multiple intra-articular structures, with meniscal tears and ACL injuries being the most common abnormalities. The predominance of medial meniscus pathology, high frequency of joint effusion, and significant presence of cartilage degeneration highlight the combined role of trauma and degenerative processes.

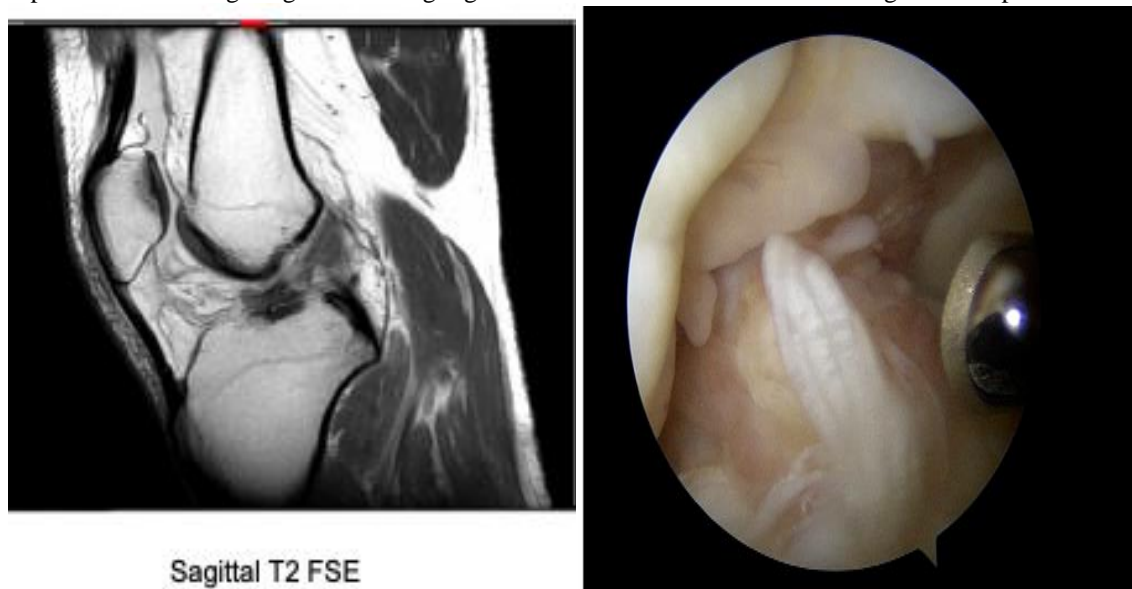
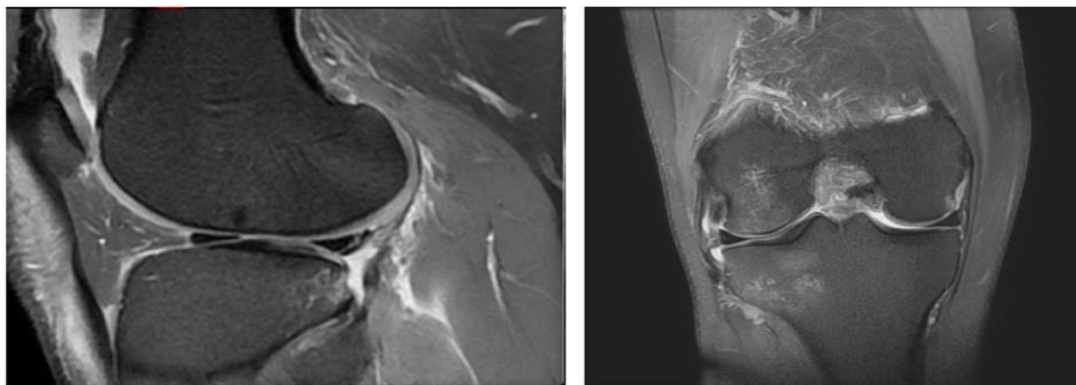


Figure 2: MRI knee demonstrating discontinuity of mid ACL fibres & Figure 3: Arthroscopic image showing complete tear of the anterior cruciate ligament with disrupted fibres and ligaments discontinuity

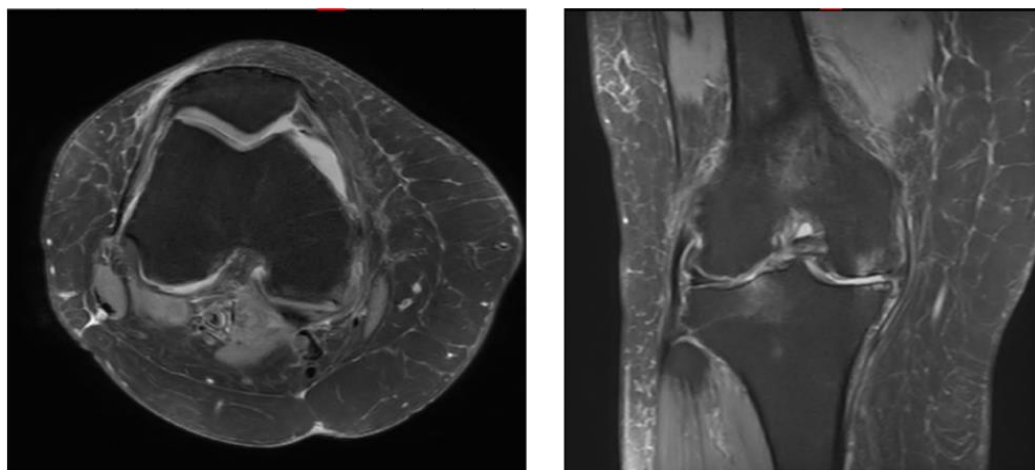
MRI proved to be a highly sensitive and reliable diagnostic modality, showing excellent correlation with arthroscopy and histopathology. Its ability to detect combined pathologies in a single examination reinforces its role as the primary non-invasive imaging tool in the evaluation of knee joint disorders.



Sagittal PD FSE FS

Coronal PD fat-suppressed

Figure 3: MRI knee image demonstrating a peripheral tear of the lateral meniscus at the posterolateral aspect (wrisburg rip) with associated bone marrow contusions in the femoral condyles and tibia plateau



Axial PDW TSE SPAR

Coronal PDW TSE SPAR

Figure 4: MRI Knee demonstrating articular cartilage thinning and loss involving the medial tibiofemoral and patellofemoral compartments with associated osteoarthritis changes.

DISCUSSION

Painful knee joint represents one of the most common musculoskeletal complaints encountered in clinical practice, with a wide spectrum of underlying etiologies ranging from traumatic injuries to degenerative and inflammatory disorders. The present study was undertaken to evaluate the role of MRI in identifying these pathologies and correlating them with clinicopathological, arthroscopic, and histopathological findings. The results demonstrate that MRI provides a comprehensive assessment of intra-articular structures and plays a pivotal role in the diagnostic workup of knee pain.

In the present study, the majority of patients belonged to the 31–40 years age group (25.2%), followed by the 21–30 years group (21.6%), indicating a predominance of knee pathology among young and middle-aged adults. This finding is consistent with the observations of

Maffulli et al.⁵, who reported that knee injuries are most common in physically active individuals, particularly in the third and fourth decades of life. Similarly, Peat et al.³ highlighted that knee pain is highly prevalent in adults engaged in occupational and physical activities.

The higher prevalence in this age group may be attributed to increased exposure to trauma, sports-related injuries, and occupational stress, which predispose individuals to meniscal and ligamentous injuries. These findings are further supported by Hunter and Bierma-Zeinstra⁷, who emphasized the role of mechanical stress and early degenerative changes in this age group.

The present study demonstrated a male predominance (64.9%), which aligns with findings reported by Sharma et al.²⁸ and Kaur et al.²⁹ in Indian populations. This trend is also supported by Vos et al.⁴, who reported a higher burden of musculoskeletal injuries among males due to increased participation in physically demanding

activities. The observed gender difference may be explained by occupational exposure, higher involvement in sports, and greater susceptibility to traumatic injuries among males. However, degenerative conditions such as osteoarthritis tend to show a higher prevalence in females in older age groups, as noted by Hunter and Bierma-Zeinstra⁷.

Pain was the universal presenting complaint (100%), followed by pain during walking (74.8%) and swelling (62.2%). These findings are consistent with the clinical spectrum described by Solomon et al.⁹, who emphasized that knee pain, swelling, and restricted movement are the most common manifestations of intra-articular pathology. The high prevalence of pain during movement reflects active involvement of joint structures, including cartilage, menisci, and synovium. Draghi et al.¹¹ also reported similar findings, highlighting that functional pain is strongly associated with internal derangements of the knee.

In the present study, 61.3% of patients had a history of trauma, indicating that trauma is the predominant cause of knee pain. This observation is consistent with findings reported by Maffulli et al.⁵, who identified trauma as the leading cause of knee injuries in young adults. However, no statistically significant association was observed between trauma and meniscal or ACL injuries ($p > 0.05$). This suggests that non-traumatic and degenerative causes also play a significant role. Similar observations were reported by Englund et al.²³, who demonstrated that meniscal abnormalities may be present even in asymptomatic individuals, indicating a degenerative component.

Meniscal injuries were the most common MRI findings in the present study, with medial meniscus involvement (75.7%) significantly higher than lateral meniscus (44.1%). These findings are in agreement with studies by Englund et al.⁶ and Crawford et al.¹⁹, who reported a higher prevalence of medial meniscus tears due to its relative immobility and greater load-bearing function. The predominance of posterior horn involvement observed in this study is also consistent with findings reported by De Smet¹⁴, who highlighted the posterior horn of the medial meniscus as the most vulnerable site for injury.

The distribution of tear types, including longitudinal, horizontal, and complex tears, aligns with the observations of Fox et al.²⁰, who described similar patterns based on injury mechanisms and degenerative changes. Among ligamentous injuries, ACL tears were the most common (52.3%), followed by MCL and LCL injuries. This finding is consistent with the observations of Phelan et al.¹⁸ and Nikolaou et al.²⁴, who reported ACL injury as the most frequent cause of knee instability. The higher prevalence of partial ACL tears (32.4%) compared to complete tears (18%) suggests that many patients present in the subacute or chronic phase. Mink

and Deutsch²⁰ also described similar findings, emphasizing the importance of MRI in detecting partial tears and associated secondary signs. PCL injuries were relatively uncommon (9%), which is consistent with the findings of Anderson et al. and Rubin¹⁵, who reported that PCL is less frequently injured due to its stronger anatomical structure.

Bone marrow edema was observed in 30.6% of cases and showed a statistically significant association with ACL injury ($p = 0.033$). This finding is consistent with the study by Mink and Deutsch²⁰, who described the characteristic "kissing contusion" pattern associated with ACL injuries. Additionally, Hunter et al.²⁰ demonstrated that bone marrow lesions are strongly associated with pain severity and disease progression, highlighting their clinical significance.

Cartilage abnormalities were present in 44.1% of patients, indicating a substantial contribution of degenerative changes. These findings are in agreement with Mosher et al.¹⁶, who reported that MRI is highly sensitive in detecting cartilage degeneration. Furthermore, Hunter and Bierma-Zeinstra⁷ emphasized that osteoarthritis is a whole-joint disease involving cartilage, subchondral bone, and synovium, which is consistent with the findings of the present study. Joint effusion was the most common MRI finding (73.9%), followed by synovial abnormalities and Baker's cyst. These findings are consistent with Murphey et al.²⁶, who reported that MRI is highly effective in detecting synovial pathologies and cystic lesions. The high prevalence of joint effusion reflects active inflammatory or traumatic processes within the joint. Similar findings were reported by McQueen et al.²⁷, who demonstrated a strong correlation between MRI-detected synovitis and histopathological findings.

The present study found no significant association between trauma and meniscal or ACL injuries, suggesting that degenerative changes also contribute significantly to knee pathology. This observation is supported by Englund et al.²³, who demonstrated that meniscal degeneration is common in aging populations. However, a significant association between ACL injury and bone marrow edema was observed ($p < 0.05$), indicating a strong relationship between ligament injury and osseous trauma. This finding is consistent with Mink and Deutsch²⁰ and Hunter et al.²⁰. MRI demonstrated high sensitivity (93.5%) and accuracy (85.3%) for meniscal tears, which is comparable to findings reported by Oei et al.¹⁷ and Crawford et al.¹⁹, who reported sensitivities exceeding 90%. For ACL injuries, MRI showed sensitivity of 87.5% and accuracy of 85.3%, which is in agreement with Nikolaou et al.²⁴ and Phelan et al.¹⁸.

MRI also showed excellent correlation with histopathology in synovial lesions, consistent with findings reported by Murphey et al.²⁶ and McQueen et

al.²⁷, confirming its reliability in evaluating inflammatory and neoplastic conditions.

The present study has certain limitations that should be considered while interpreting the results. First, it was a single-center study with a relatively modest sample size (n = 111), which may limit the generalizability of the findings to broader populations. Second, arthroscopic and histopathological correlation was available only in a subset of patients, introducing potential selection bias and limiting comprehensive validation of MRI findings across all cases. Third, the study design was cross-sectional, precluding assessment of disease progression and long-term outcomes. Additionally, inter-observer variability in MRI interpretation and the possibility of false-positive or false-negative findings, particularly in degenerative meniscal changes and partial ligament injuries, cannot be entirely excluded. Finally, advanced quantitative MRI techniques were not employed, which may have further improved early detection of cartilage and soft tissue abnormalities.

The findings of the present study reinforce that painful knee joint is a multifactorial condition involving multiple joint components, including menisci, ligaments, cartilage, and synovium. MRI provides a comprehensive evaluation of these structures and demonstrates high diagnostic accuracy when correlated with gold standard modalities. These results are in agreement with the conclusions of Recht et al.¹³, Oei et al.¹⁷, and Hunter et al.²⁰, who established MRI as the imaging modality of choice for knee joint evaluation.

CONCLUSION

The present study demonstrates that magnetic resonance imaging (MRI) is a highly sensitive, reliable, and non-invasive modality for the evaluation of painful knee joint, capable of accurately identifying a wide spectrum of traumatic and non-traumatic pathologies. Meniscal tears, particularly involving the medial meniscus, and anterior cruciate ligament injuries were the most common findings, often associated with bone marrow edema, cartilage degeneration, and synovial abnormalities. MRI showed excellent correlation with arthroscopic and histopathological findings, reinforcing its diagnostic accuracy and clinical utility. The ability of MRI to detect multiple coexisting intra-articular abnormalities in a single examination highlights its role as the primary imaging modality and a crucial decision-making tool in the management of knee joint disorders.

Recommendations

Based on the findings of the present study, it is recommended that MRI should be routinely utilized as the first-line imaging modality in patients presenting with persistent or unexplained knee pain, particularly when internal derangement is suspected. Early use of MRI can facilitate prompt and accurate diagnosis, reduce unnecessary invasive procedures such as diagnostic

arthroscopy, and aid in appropriate treatment planning. A multidisciplinary approach integrating clinical evaluation, MRI findings, and selective arthroscopic or histopathological correlation is essential for optimal patient care. Future studies with larger sample sizes, multicentric design, and incorporation of advanced MRI techniques are recommended to further validate these findings and enhance diagnostic precision, especially in early degenerative and inflammatory conditions.

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