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**Original Research Article**

# Analysis of Meniscus Tear Using MRI Imaging: A Study on Tear Patterns, Causes, and Degeneration Trends

Chetna Bhardwaj[1], Kripanand Yadav[2]*

[1]M.Sc in Medical Radiography and Imaging Technology Final Year, Maharishi Markandeshwar (deemed to be) university, Mullana Ambala Haryana
[2]Assistant Professor in Radiography & Imaging Technology, Maharishi Markandeshwar (deemed to be) University Mullana Ambala Haryana

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**Abstract:** This observational study evaluates the diagnostic accuracy of Magnetic Resonance Imaging (MRI) in detecting meniscal injuries of the knee joint. A total of 40 patients presenting with knee-related symptoms—such as pain, swelling, stiffness, or mechanical locking—were included. Both inpatients (IPD) and outpatients (OPD) were examined between March and June 2025 at a tertiary care radiology center. MRI scans were performed using a dedicated knee coil, incorporating standard sequences such as T1-weighted, T2-weighted, Proton Density (PD) with fat saturation, STIR (Short Tau Inversion Recovery), and Gradient Echo (GRE). These imaging protocols enabled detailed evaluation of meniscal morphology, detection of degenerative signal changes, and precise localization of anterior and posterior horn tears in both the medial and lateral menisci. Findings confirm that MRI offers superior soft tissue contrast, enabling the early and accurate diagnosis of meniscal tears. Its non-invasive nature and diagnostic precision make MRI a crucial tool in clinical decision-making and treatment planning, particularly in cases of sports injuries or trauma.

**Keywords:** Meniscus Tear, MRI Knee, Degeneration, Sports Injury, Trauma, Anterior Horn, Posterior Horn, Medial Meniscus, Lateral Meniscus, Complex Tear.



## INTRODUCTION

Knee pain is one of the most frequent and distressing musculoskeletal complaints encountered in clinical practice, affecting individuals across all age groups, especially adults and the elderly. The increasing prevalence of this condition can be attributed to multiple contributing factors including a sedentary lifestyle, physical inactivity, occupational strain, and sports-related injuries. Additionally, as the population ages, degenerative conditions involving the knee joint are becoming more common, further contributing to the burden of knee-related ailments [1, 2].

The knee joint, being one of the most complex and weight-bearing joints in the human body, is susceptible to both traumatic and non-traumatic pathologies, making early diagnosis essential for effective treatment and functional recovery. Among the various anatomical components of the knee, the menisci, ligaments, cartilage, and synovial structures are particularly vulnerable to injury and degeneration. Meniscal tears, ligament sprains, and osteoarthritic changes are common causes of knee dysfunction and pain, often resulting in limited mobility, joint instability, and reduced quality of life [2, 3]. In such cases, clinical examination alone may not be sufficient to identify the precise cause of symptoms, especially in early stages when physical signs are subtle. This underlines the importance of advanced imaging techniques that offer detailed visualization of intra-articular structures [4].

Magnetic Resonance Imaging (MRI) has emerged as the preferred non-invasive imaging modality for evaluating internal derangements of the knee joint. It offers superior soft tissue contrast and multiplanar imaging capabilities, making it an ideal tool for detecting meniscal injuries, ligament tears, cartilage defects, bone marrow lesions, and synovial abnormalities [5–7]. MRI does not involve ionizing radiation, making it safer for repeated use, and its high-resolution images allow clinicians to visualize even minute structural alterations that might otherwise be missed on conventional radiographs or ultrasound. Given its comprehensive

***Corresponding Author:** Kripanand Yadav
Assistant Professor in Radiography & Imaging Technology, Maharishi Markandeshwar (deemed to be) University Mullana Ambala Haryana

diagnostic capabilities, MRI plays a central role in the assessment and management of knee joint disorders [6-8].

The clinical relevance of MRI lies not only in detecting abnormalities but also in ruling out significant pathology. For patients presenting with nonspecific knee pain or symptoms that do not correlate well with clinical findings, MRI serves as a decisive tool that either confirms the suspected diagnosis or reveals incidental findings that may require attention [9, 10]. Meniscal tears, especially those involving the posterior horn of the medial meniscus, are frequently encountered in both traumatic and degenerative settings [5]. Complex tears, involving both horns or both menisci, and cases of degeneration without frank tearing, are also commonly reported, further complicating the clinical picture. Early detection of such changes is vital to prevent progression to osteoarthritis and permanent joint damage [1].

In this observational study, MRI scans were conducted on 40 patients presenting with varying degrees of knee pain and related symptoms. The patients included a wide range of age groups and both genders, and the dataset captured essential clinical information such as age, sex, laterality of symptoms, trauma history, and symptomatic features. MRI findings were carefully analyzed and categorized into distinct groups: patients with normal menisci, those with meniscal tears (medial, lateral, or complex), and patients showing degenerative changes without a definite tear. The study also examined the specific anatomical location of tears (anterior or posterior horn), as well as other relevant soft tissue changes.

A notable proportion of the patients demonstrated pathological findings suggestive of meniscal injury or degeneration, reinforcing the diagnostic importance of MRI in such clinical scenarios. The high prevalence of medial meniscus involvement, particularly affecting the posterior horn, aligns with prior clinical observations and supports the need for focused evaluation in this region [5]. Similarly, lateral meniscus tears and complex multiplanar injuries were also documented, some of which presented with minimal clinical symptoms but significant imaging abnormalities. Degenerative changes, characterized by altered signal intensity and morphological distortion without definite tearing, were particularly common in older individuals, suggesting the silent progression of wear-and-tear phenomena [1-3].

This study aims to achieve several objectives. Firstly, it seeks to analyze the distribution and frequency of different types of meniscal and degenerative abnormalities in patients undergoing MRI for knee pain. Secondly, it aims to evaluate the relationship between clinical symptoms and imaging findings, to better understand how MRI can guide more accurate diagnosis and tailored treatment. Lastly, the study attempts to highlight the patterns of knee pathology in a local population, with emphasis on the role of age, gender, and trauma history in influencing the type and extent of knee damage observed.

By thoroughly examining MRI findings in a diverse group of symptomatic patients, this research contributes valuable insights into the evolving understanding of knee joint disorders. It also emphasizes the crucial role of MRI in orthopedic and sports medicine, particularly in early detection, appropriate classification of injuries, and pre-surgical planning. As knee pain continues to rise due to changing lifestyles and increasing physical demands, the utility of MRI as a diagnostic cornerstone is only expected to grow, supporting clinicians in delivering more effective and individualized patient care.

The following MRI images highlight typical appearances of frequently observed meniscal abnormalities in this study. Figure 1 illustrates a tear involving the posterior horn of the medial meniscus, which was the most commonly affected site. Figure 2 shows a lateral meniscus tear, reflecting the diversity of tear patterns seen in traumatic cases.

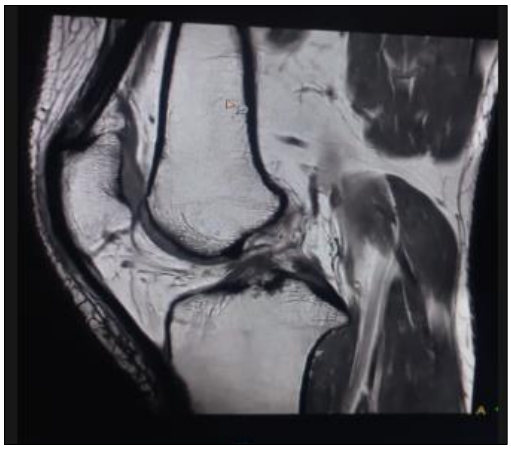


**Fig. 1: Posterior horn of medial meniscus**

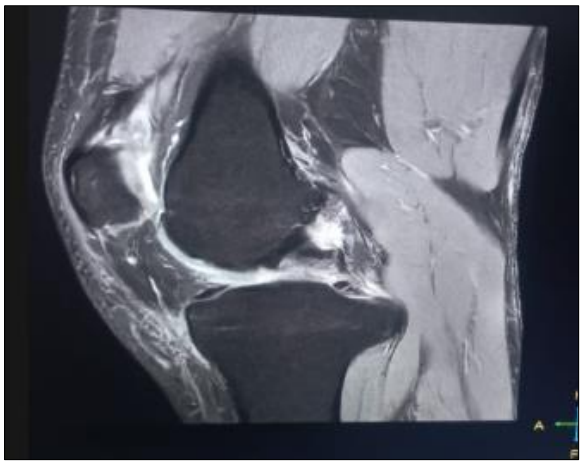


**Fig. 2: Lateral Meniscus Tear**

**Aim:** To determine the type and extent of meniscal tears and degeneration in the knee joint using MRI imaging, and to assess the effectiveness of MRI in accurate diagnosis of knee pathologies.

**Objectives**

1. To evaluate how MRI helps in identifying the type of meniscal tear (medial/lateral, anterior/posterior horn).
2. To assess the severity of meniscus degeneration and tears visible on MRI.
3. To observe the intensity changes in MRI scans that indicate the stage of degeneration or tear.
4. To demonstrate how MRI provides better clarity and detail compared to clinical symptoms alone**.**

# REVIEW OF LITERATURE

**1. MRI vs Arthroscopy in Diagnosing Meniscal Tears – An Indian Study**

In a prospective study, Akshay Tegginamath and Channabasava Patil (2019) evaluated the correlation between clinical assessment, MRI, and arthroscopic findings in diagnosing meniscal tears. The study was conducted in Bangalore and included 90 patients aged 18–60 years who presented with knee injuries. The results showed that medial meniscus tears were more common (54 cases) compared to lateral meniscus tears (36 cases). MRI demonstrated high concordance with clinical findings, and the authors concluded that MRI is a reliable non-invasive modality for identifying meniscal pathology. It significantly reduces the need for diagnostic arthroscopy in many cases.

**2. Diagnostic Accuracy of MRI in Meniscal Injuries – A Comparative Study**

Rajana Bhagawan and Sivakesav Gandham (2019) conducted a meta-analysis based in West Bengal to evaluate the diagnostic accuracy of MRI in comparison with arthroscopy for detecting meniscal injuries. Their study involved data from 60 patients with suspected internal derangement of the knee. The analysis revealed MRI sensitivity of 85–90% and specificity of 70–85%, depending on the type and location of the tear. The authors emphasized that MRI remains a highly effective tool in detecting meniscal tears, especially when used alongside clinical findings, though arthroscopy remains the gold standard for definitive diagnosis.

**3. Diagnostic Performance of 1.5T vs 3T MRI in Meniscal Tear Detection**

In a comparative study, Beldi M and colleagues (2019) analyzed the diagnostic performance of 1.5 Tesla and 3 Tesla MRI scanners in identifying meniscal tears. The study involved patients with suspected meniscal injuries who underwent both MRI and arthroscopic evaluation. Although the exact number of patients was not specified, the results indicated that 3T MRI provided clearer images and higher diagnostic accuracy, particularly for complex tears and posterior horn lesions, when compared to 1.5T MRI. The authors concluded that 3T MRI is more effective in detecting subtle or complex meniscal tears and can assist in better preoperative planning.

# METHOD AND MATERIAL

**Study Design and Setting**

This observational study was conducted on a group of 40 patients who presented with symptoms related to knee discomfort and dysfunction. Data were collected from the Department of Radiology, Maharishi Markandeshwar Super Specialty Hospital, Mullana, over a period of four months, from March to June 2025. The primary objective was to analyze MRI findings in patients with knee pain, restricted movement, or joint-related abnormalities, and to determine the nature and extent of meniscal injuries or degenerative changes.

**Inclusion Criteria**

- Patients aged between 18 and 70 years.
- Patients presenting with unilateral or bilateral knee pain.
- Patients who consented to undergo MRI.

- Both outpatient (OPD) and inpatient (IPD) cases were included.

**Exclusion Criteria**

- Patients with a history of previous knee surgery.
- Patients with metallic implants or pacemakers (contraindications for MRI).
- Patients diagnosed with congenital or neoplastic knee abnormalities.
- Pregnant women were excluded due to MRI contraindications.

**Clinical Presentation**

Patients reported a range of symptoms suggestive of internal joint injury, primarily involving the meniscus.

**The Clinical Distribution was as follows:**

- 35 patients (87.5%) had a history of accidental trauma (e.g., falls or road traffic accidents).
- 4 patients (10%) presented with sports-related injuries, often involving rotational or hyperextension forces.
- 1 patient (2.5%) sustained a dance-related injury, representing a non-conventional but valid mechanical stressor.

**Symptoms Included:**

- Pain and localized swelling
- Difficulty walking or performing daily activities
- Limited range of motion and joint instability

**Imaging Modality and MRI Protocol**

All patients underwent Magnetic Resonance Imaging (MRI) of the symptomatic knee. Scans were performed using either a 1.5 Tesla or 3 Tesla MRI scanner, depending on machine availability and clinical condition. The use of both systems ensured diagnostic flexibility without compromising image quality or clinical accuracy [4-7].

A dedicated knee coil was employed in all cases to enhance spatial resolution and signal-to-noise ratio. Multiplanar imaging was performed in axial, sagittal, and coronal planes using standard knee protocols.

**The Following Sequences Were Included:**

- T1-weighted images: For high anatomical detail and meniscal shape assessment
- T2-weighted images: To detect joint effusion, inflammation, and hyperintense meniscal changes
- Proton Density (PD) with Fat Saturation: Highly sensitive for meniscal tears, degeneration, and subtle cartilage abnormalities

**Imaging Planes:**

- Sagittal plane: Optimal for visualizing anterior and posterior horns of the menisci
- Coronal plane: Useful for assessing the body of the meniscus and collateral ligaments
- Axial plane: Enables evaluation of cruciate ligaments, patellofemoral joint, and meniscal tear extension

This multiplanar and multi-sequence protocol allowed for precise identification of the location, extent, and type of meniscal pathology. Differentiation was made between traumatic tears, complex/multiplanar tears, and degenerative signal changes.

**Ethical Considerations**

All patients gave informed consent prior to MRI scanning and data inclusion. Patient confidentiality was maintained throughout the study, in accordance with institutional ethical guidelines.

## RESULT

The study included a total of 40 patients who underwent MRI evaluation for suspected meniscal injuries. Patient ages ranged from 17 to 70 years, with the majority (55%) falling in the 31–50-year age group. A male predominance was observed, with 31 males (77.5%) and 9 females (22.5%).

In terms of knee laterality, the right knee was involved in 24 cases (60%), while the left knee was involved in 16 cases (40%).

MRI successfully detected meniscal pathology in 30 out of 40 patients (75%), while 10 patients (25%) demonstrated no significant abnormality.

**Meniscal Findings Breakdown:**

**Table 1: Anatomical Distribution of Meniscal Pathology**

| Type of Tear | No. of Patients | Notes |
|---|---|---|
| Medial meniscus tear | 12 | Most involved the posterior horn |
| Lateral meniscus tear | 8 | Some involved anterior horn |
| Complex tears (both horns or both menisci) | 4 | Multiplanar displacement visible |
| Degeneration without tear | 6 | High PD signal, altered morphology |

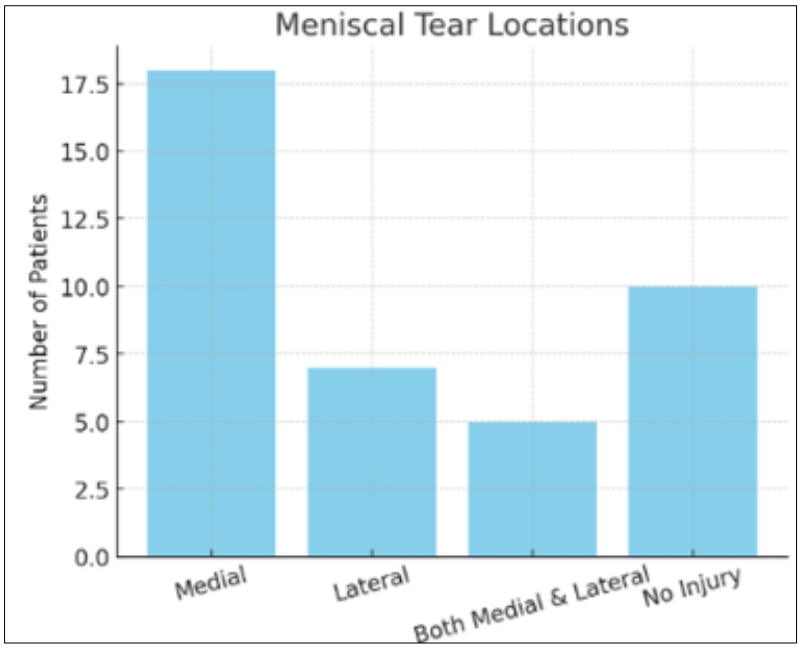



**Table 2: Distribution of Meniscal Tear Types in 40 Patients**

| Tear Type | Percentage (%) | Approx. Number of Patients (out of 40) |
|---|---|---|
| No Tear | 25.0% | 10 |
| Degenerative | 15.0% | 6 |
| Complex | 25.0% | 10 |
| Radial | 7.5% | 3 |
| Longitudinal | 12.5% | 5 |
| Horizontal | 15.0% | 6 |

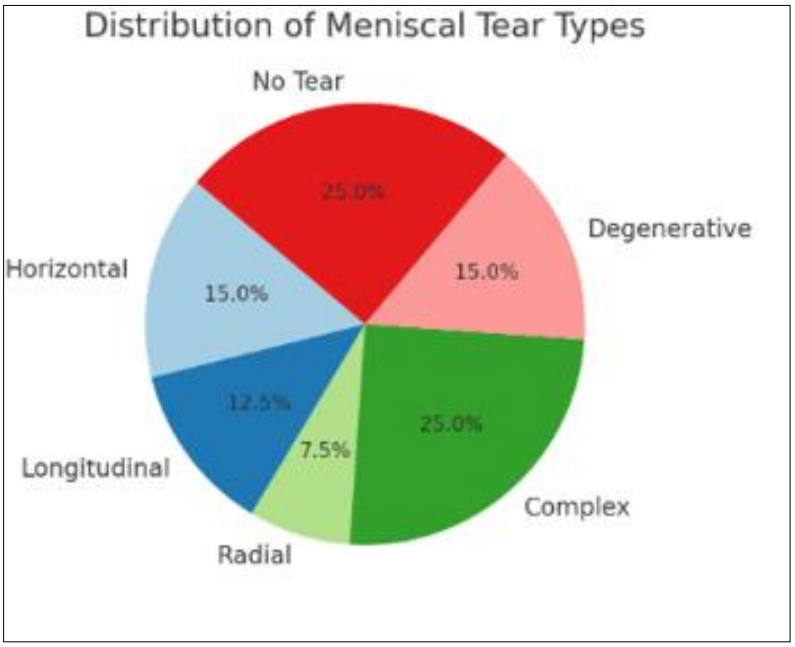



**Table 3: Gender Distribution of Patients**

| Gender | Percentage (%) | Number of Patients |
|---|---|---|
| Male | 77.5% | 31 |
| Female | 22.5% | 9 |

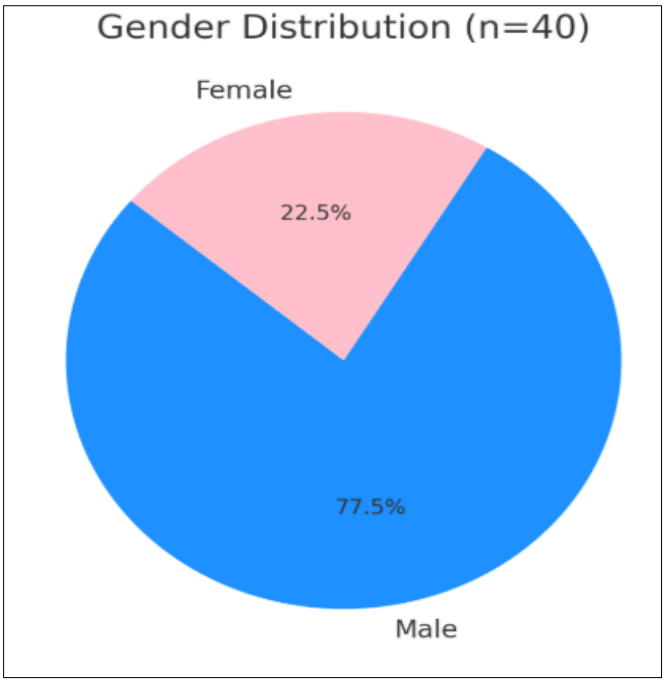
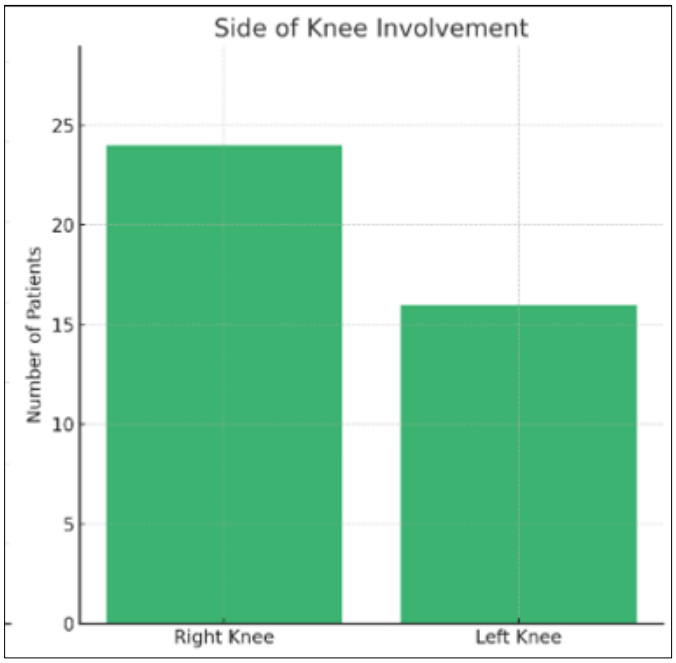



**Table 4: Side of Knee Involvement in Meniscal Pathology**

| Side of Knee | Number of Patients | Percentage (%) |
|---|---|---|
| Right Knee | 24 | 60% |
| Left Knee | 16 | 40% |




## DISCUSSION

This study underscores the critical role of Magnetic Resonance Imaging (MRI) in the accurate diagnosis of meniscal injuries in patients presenting with knee pain. MRI enabled detailed evaluation of intra-articular structures, allowing precise identification of tear type, location, and degenerative changes — findings that might be missed on physical examination alone [3-6].

In our cohort, 75% of patients demonstrated meniscal pathology, with the medial meniscus being more commonly involved than the lateral. The posterior horn of the medial meniscus was the most frequently affected region, which is consistent with prior studies highlighting its reduced mobility and stronger tibial attachment [1-5].

Among tear types, complex tears (25%) were most prevalent, followed by degenerative (15%) and horizontal (15%) tears. Complex tears, often associated with chronic repetitive stress, were predominantly found in older individuals, aligning with age-related degenerative trends [1-4].

MRI sequences such as proton density fat-suppressed (PD-FS) and T2-weighted images were particularly useful in detecting high-signal abnormalities and subtle tears. The use of both 1.5T and 3T MRI systems enhanced diagnostic reliability, with 3T scans offering improved resolution, as supported by existing literature [4-7].

The male predominance (77.5%) observed in this study may reflect greater exposure to strenuous activities and physical labor. Although right knee involvement (60%) was more frequent, there was no statistically significant correlation between knee side and tear type.

These results reinforce the clinical value of MRI in planning early intervention — whether conservative or surgical — thereby preventing further joint degeneration and improving functional outcomes. Especially in cases with inconclusive clinical findings, MRI serves as a non-invasive and definitive diagnostic tool [8, 9].

## CONCLUSION

This study highlights the diagnostic value of Magnetic Resonance Imaging (MRI) in evaluating meniscal pathology in patients with knee pain. MRI demonstrated a high detection rate of 75%, with complex tears and posterior horn of the medial meniscus being the most frequently observed patterns. Due to its non-invasive nature, superior soft tissue resolution, and multiplanar imaging capabilities, MRI remains a crucial modality in cases where clinical findings are ambiguous or non-specific. Accurate tear characterization further aids in individualized treatment planning and may reduce the need for unnecessary surgical intervention.

Timely identification of meniscal injuries via MRI can lead to improved patient outcomes, enabling early orthopedic management and rehabilitation.

**Abbreviations**

- MRI: Magnetic Resonance Imaging
- ACL: Anterior Cruciate Ligament
- OA: Osteoarthritis
- OPD: Outside Patient Department
- IPD: Inpatient Department

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