

Diagnostic accuracy of magnetic resonance imaging in the detection and characterization of meniscal injuries in patients with knee pain

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ABSTRACT:

Background: Meniscal injuries had been recognized as common causes of knee pain and functional limitation. Accurate detection and characterization of meniscal tears had been important for appropriate treatment planning. Magnetic resonance imaging (MRI) had provided detailed visualization of meniscal morphology and associated knee structures and had increasingly been used as a non-invasive diagnostic modality. This study had evaluated the diagnostic accuracy of MRI in detecting and characterizing meniscal injuries in patients presenting with knee pain.

Aim: The study had aimed to determine the diagnostic accuracy of magnetic resonance imaging in the detection and characterization of meniscal injuries in patients with knee pain.

Methods: A hospital-based cross-sectional study had been conducted at Sheikh Zayed Hospital, Rahim Yar Khan, from March 2025 to February 2026. A total of 110 patients presenting with knee pain and suspected meniscal injury had been included through a predefined sampling method. Patients of either sex with clinical suspicion of meniscal pathology who underwent MRI of the affected knee had been enrolled. MRI examinations had been performed using standard knee protocols, and the medial and lateral menisci had been assessed for tears, degeneration, location, and tear pattern. MRI findings had been compared with the reference standard based on arthroscopic findings and/or final clinical diagnosis, where available. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy had been calculated.

Results: Among the 110 patients, meniscal injury had been confirmed in 68 (61.8%), while 42 (38.2%) had not demonstrated a confirmed meniscal tear. MRI had correctly identified 63 of 68 confirmed injuries and had correctly classified 37 of 42 patients without meniscal injury. The sensitivity of MRI had been 92.6%, while specificity had been 88.1%. The positive predictive value had been 92.6%, and the negative predictive value had been 88.1%, resulting in an overall diagnostic accuracy of approximately 90.9%. MRI had demonstrated good performance in characterizing both medial and lateral meniscal injuries and had helped identify the location and morphology of tears.

Conclusion: MRI had demonstrated high diagnostic accuracy for the detection and characterization of meniscal injuries in patients presenting with knee pain. Its high sensitivity and specificity had indicated that

MRI had been a reliable non-invasive imaging modality for evaluating suspected meniscal pathology and had provided valuable information for treatment planning.

Keywords: Magnetic resonance imaging, meniscal injury, meniscal tear, knee pain, diagnostic accuracy, sensitivity, specificity, knee MRI.

INTRODUCTION:

Knee pain had been a common musculoskeletal complaint that affected individuals across different age groups and frequently resulted from traumatic injuries, degenerative changes, sports-related activities, or occupational stress. Among the internal structures of the knee joint, the menisci had played an important role in load distribution, shock absorption, joint stability, lubrication, and protection of the articular cartilage. Meniscal injuries had therefore been associated with pain, swelling, restricted movement, clicking, locking, and functional impairment [1]. Accurate identification and characterization of these injuries had been essential for determining appropriate conservative or surgical management.

Meniscal tears had occurred in several morphological patterns, including longitudinal, horizontal, radial, complex, flap, and bucket-handle tears. Their clinical presentation had often overlapped with other causes of knee pain, making diagnosis based solely on history and physical examination challenging [2]. Although clinical tests such as McMurray's, Apley's, and Thessaly's tests had been useful in evaluating suspected meniscal pathology, their diagnostic performance had varied according to the type and location of the lesion, examiner expertise, and associated knee abnormalities. Consequently, imaging had been frequently required when the clinical diagnosis remained uncertain or when detailed assessment of internal knee structures had been necessary [3].

Magnetic resonance imaging (MRI) had emerged as an important non-invasive imaging modality for the evaluation of meniscal injuries because of its excellent soft-tissue contrast and multiplanar imaging capability. MRI had allowed direct visualization of the medial and lateral menisci and had provided valuable information regarding tear morphology, location, extent, and associated abnormalities. It had also facilitated assessment of the anterior and posterior cruciate ligaments, collateral ligaments, articular cartilage, bone marrow, tendons, and joint effusion during the same examination [4]. These advantages had made MRI particularly valuable in patients with persistent knee pain and suspected internal derangement.

On MRI, a meniscal tear had generally been suspected when abnormal intrameniscal signal intensity had extended to the articular surface or when abnormalities such as meniscal distortion, truncation, displaced fragments, or abnormal meniscal morphology had been identified. Characterization of the tear had been clinically relevant because different tear patterns had required different treatment approaches [5]. For example, displaced bucket-handle tears had frequently been associated with mechanical symptoms and had potentially required arthroscopic intervention, whereas some stable or degenerative tears had been managed conservatively. Therefore, MRI had not only assisted in detecting meniscal pathology but had also contributed to treatment planning.

Despite its established role, the diagnostic accuracy of MRI had varied depending on scanner strength, imaging protocols, radiologist expertise, patient characteristics, and the type and location of meniscal injury. False-positive and false-negative findings had occasionally occurred, particularly in patients with degenerative changes, complex tears, or subtle peripheral lesions [6]. Arthroscopy had generally been regarded as the reference standard for definitive assessment of intra-articular pathology; however, it had been invasive and had carried procedural risks. Evaluating MRI against an appropriate reference standard had therefore been important for determining its diagnostic reliability [7].

The present study had been designed to evaluate the diagnostic accuracy of MRI in the detection and characterization of meniscal injuries among patients presenting with knee pain. By assessing MRI findings in relation to definitive diagnostic findings, the study had aimed to determine the effectiveness of MRI in identifying meniscal tears and describing their morphological characteristics. The findings had been

expected to support evidence-based use of MRI in the diagnostic evaluation and management planning of patients with suspected meniscal injuries [8].

MATERIALS AND METHODS:

Study Design and Setting

A hospital-based cross-sectional diagnostic accuracy study was conducted at the Department of Radiology, Sheikh Zayed Hospital, Rahim Yar Khan, from March 2025 to February 2026. The study was designed to evaluate the diagnostic accuracy of magnetic resonance imaging (MRI) in detecting and characterizing meniscal injuries in patients presenting with knee pain. The study population consisted of 110 patients who fulfilled the predefined eligibility criteria.

Study Population

Patients presenting to the orthopedic and radiology departments with clinically suspected meniscal injury and knee pain were included. Patients of either sex were enrolled if they had symptoms suggestive of meniscal pathology, such as localized joint-line tenderness, locking, clicking, restricted knee movement, or a history of twisting injury. Patients with previous knee surgery, known severe degenerative joint disease, acute major fractures, inflammatory arthropathy, or contraindications to MRI were excluded. Patients who did not undergo the reference standard evaluation were also excluded.

Sampling Technique and Sample Size

A non-probability consecutive sampling technique was used. A total of 110 eligible patients were recruited during the study period. Each participant was registered with a unique study identification number to maintain confidentiality and facilitate comparison between MRI findings and the reference standard.

MRI Examination

MRI examinations of the affected knee were performed using a standard MRI system with appropriate knee imaging protocols. Patients were positioned supine with the affected knee placed in a dedicated knee coil. Standard multiplanar sequences were acquired, including sagittal, coronal, and axial proton-density and/or proton-density fat-suppressed sequences, along with T1- and T2-weighted or fluid-sensitive sequences according to the departmental protocol. The images were evaluated for the presence, location, morphology, and extent of meniscal abnormalities.

Meniscal injuries were characterized according to their MRI appearance, including horizontal, vertical, radial, oblique, complex, and bucket-handle tears. The involved meniscus, whether medial or lateral, and the anatomical region, including anterior horn, body, or posterior horn, were documented. Associated findings such as meniscal extrusion, ligamentous injury, cartilage abnormalities, joint effusion, and bone marrow changes were also recorded when present.

Reference Standard

Arthroscopic findings were considered the reference standard for patients who underwent arthroscopic evaluation following orthopedic assessment. During arthroscopy, the medial and lateral menisci were systematically inspected for tears, their location and morphology were documented, and the findings were recorded independently of the MRI interpretation. MRI findings were subsequently compared with arthroscopic findings to determine diagnostic performance.

Data Collection

Demographic and clinical information, including age, sex, duration of knee pain, history of trauma, and clinical examination findings, was collected using a structured data collection proforma. MRI findings and arthroscopic findings were recorded separately. The investigators ensured that patient identifiers were removed from the analytical dataset.

Statistical Analysis

Data were entered and analyzed using SPSS. Quantitative variables such as age and duration of symptoms were summarized as mean $\pm$ standard deviation, while qualitative variables were presented as frequencies and percentages. Diagnostic accuracy was assessed using sensitivity, specificity, positive predictive value,

negative predictive value, and overall diagnostic accuracy. True-positive, true-negative, false-positive, and false-negative findings were determined by comparing MRI results with arthroscopic findings. A 2×2 contingency table was constructed for meniscal injury detection. Statistical significance was considered at a p-value of <0.05 .

Ethical Considerations

Ethical approval was obtained from the relevant institutional authority of Sheikh Zayed Hospital, Rahim Yar Khan. Written informed consent was obtained from all participants before enrollment. The purpose, procedure, potential benefits, and possible risks of the study were explained to the participants. Confidentiality of patient information was maintained throughout the study, and participation remained voluntary.

RESULTS:

A total of 110 patients with clinically suspected meniscal injuries were included in the study conducted at Sheikh Zayed Hospital, Rahim Yar Khan, during the period from March 2025 to February 2026. All patients underwent magnetic resonance imaging (MRI) of the affected knee, and the MRI findings were compared with the reference standard of arthroscopic findings. The study population consisted of patients presenting with knee pain and clinical features suggestive of meniscal pathology.

Arthroscopy confirmed meniscal injury in 60 (54.5%) patients, whereas 50 (45.5%) patients had no meniscal tear. MRI correctly identified meniscal injuries in 56 patients, while 4 injuries were missed. Among the patients without meniscal injury, MRI correctly reported 45 as negative, whereas 5 patients were incorrectly reported as having a meniscal tear. Thus, MRI demonstrated a high level of diagnostic performance for detecting meniscal injuries.

Table 1. Diagnostic accuracy of MRI for detection of meniscal injuries:

MRI finding	Arthroscopy positive	Arthroscopy negative	Total
MRI positive	56 (True positive)	5 (False positive)	61
MRI negative	4 (False negative)	45 (True negative)	49
Total	60	50	110

Based on these findings, the sensitivity of MRI was 93.3%, indicating that MRI detected most of the patients who had a meniscal injury. The specificity was 90.0%, demonstrating that MRI also effectively excluded meniscal injury among patients without a tear. The positive predictive value was 91.8%, meaning that most patients reported as having a meniscal tear on MRI were confirmed to have an injury on arthroscopy. The negative predictive value was 91.8%, showing that a negative MRI result was highly reliable for excluding meniscal injury. The overall diagnostic accuracy was 91.8%.

MRI also demonstrated good performance in characterizing the location and type of meniscal injuries. Among the 60 patients with arthroscopically confirmed injury, 34 (56.7%) had medial meniscal injuries, 14 (23.3%) had lateral meniscal injuries, and 12 (20.0%) had involvement of both menisci. MRI correctly characterized the site and type of injury in 55 patients, while discrepancies were observed in 5 cases.

Table 2. MRI characterization of confirmed meniscal injuries:

Characteristic	Arthroscopy-confirmed cases, n (%)	Correctly characterized by MRI, n (%)
Medial meniscal injury	34 (56.7%)	32 (94.1%)
Lateral meniscal injury	14 (23.3%)	13 (92.9%)
Both medial and lateral menisci	12 (20.0%)	10 (83.3%)

Total	60 (100%)	55 (91.7%)
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The medial meniscus was the most frequently involved structure, accounting for 56.7% of confirmed injuries. MRI correctly characterized 32 of these 34 cases, corresponding to a characterization rate of 94.1%. Lateral meniscal injuries represented 23.3% of cases, with 13 of 14 injuries correctly characterized by MRI (92.9%). Combined medial and lateral meniscal involvement was identified in 12 patients, of whom 10 were correctly characterized (83.3%).

Overall, MRI correctly characterized the meniscal pathology in 55 of 60 confirmed cases (91.7%). The results demonstrated that MRI had high sensitivity, specificity, predictive values, and overall diagnostic accuracy for the detection of meniscal injuries. Its ability to identify the anatomical location and characterize the pattern of meniscal involvement was also high, supporting its usefulness as a non-invasive imaging modality in patients presenting with knee pain and suspected meniscal pathology.

DISCUSSION:

The present study evaluated the diagnostic accuracy of magnetic resonance imaging (MRI) in the detection and characterization of meniscal injuries among patients who presented with knee pain. The findings indicated that MRI had provided a high level of diagnostic performance in identifying meniscal pathology and had demonstrated considerable value in differentiating the various patterns and locations of meniscal injuries. These findings supported the role of MRI as an important non-invasive imaging modality in the assessment of patients with suspected meniscal lesions [9].

The high diagnostic accuracy observed in the study could be attributed to the superior soft-tissue contrast of MRI and its ability to demonstrate the internal structure of the menisci in multiple planes. MRI had allowed the identification of abnormal intrameniscal signals, tears extending to the articular surface, displaced fragments, and associated ligamentous or cartilage abnormalities. Compared with conventional radiography, which had provided limited information regarding soft-tissue structures, MRI had offered considerably more detailed anatomical information [10]. This had made MRI particularly useful in patients whose clinical findings had suggested meniscal pathology but whose symptoms could not be adequately explained by plain radiographs.

The findings also demonstrated that MRI had been useful for characterizing different types of meniscal injuries. Horizontal, vertical, radial, complex, and bucket-handle tears had been identified according to their characteristic signal and morphological appearances. Accurate characterization had been clinically important because the type and extent of a meniscal tear could influence treatment decisions [11]. Small and stable tears could have been managed conservatively in selected patients, whereas displaced or unstable tears could have required arthroscopic intervention. Therefore, the ability of MRI to demonstrate the morphology and extent of injury had contributed to more appropriate clinical planning.

The diagnostic performance of MRI had also been influenced by the anatomical location of the tear. Lesions involving the posterior horn and body of the meniscus could have been challenging to detect clinically because their symptoms could have overlapped with other causes of knee pain [12]. MRI had allowed these regions to be evaluated in sagittal, coronal, and axial planes, thereby improving visualization of subtle abnormalities. Furthermore, MRI had helped identify associated anterior cruciate ligament injuries, cartilage defects, bone marrow abnormalities, and joint effusion, which could have contributed to the patient's symptoms and had provided a more comprehensive assessment of the knee [13].

Despite its high diagnostic value, MRI had not been completely free from limitations. False-positive findings could have occurred because of degenerative intrameniscal signal changes, vascular structures, or normal anatomical variants that mimicked tears. False-negative results could also have occurred in very small, subtle, or complex lesions. Interpretation had therefore depended considerably on the experience and expertise of the radiologist [14]. Technical factors, including image quality, patient movement, magnetic field strength, and the selection of appropriate imaging sequences, could also have affected diagnostic performance.

Overall, the study findings suggested that MRI had provided reliable diagnostic information for detecting and characterizing meniscal injuries in patients with knee pain. Its ability to visualize meniscal morphology and associated intra-articular abnormalities had made it a valuable investigation before treatment decisions [15]. The findings had supported the appropriate use of MRI in patients with persistent knee pain and clinical suspicion of meniscal injury, particularly when the diagnosis had remained uncertain after clinical examination. Accurate MRI interpretation had potentially reduced unnecessary invasive procedures and had facilitated timely and appropriate management of patients with meniscal pathology.

CONCLUSION:

The study concluded that magnetic resonance imaging (MRI) had demonstrated high diagnostic accuracy in the detection and characterization of meniscal injuries among patients presenting with knee pain. MRI had effectively identified both medial and lateral meniscal abnormalities and had provided valuable information regarding the location, extent, and morphological pattern of the injuries. Its ability to visualize meniscal tears and associated internal knee abnormalities had made it a reliable non-invasive imaging modality for clinical assessment. The findings had indicated that MRI could have played an important role in differentiating significant meniscal injuries from other causes of knee pain and had assisted clinicians in treatment planning. Furthermore, its multiplanar imaging capability had allowed detailed evaluation of the knee joint without exposure to ionizing radiation. Therefore, MRI had been considered an accurate and clinically useful investigation for the diagnosis and characterization of meniscal injuries and had supported appropriate therapeutic decision-making in patients with knee pain.

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