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Evaluating the Diagnostic Accuracy of McMurray, Apley, and Thessaly Tests Compared to MRI in Meniscal Injury

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Abstract: This study aimed to compare the diagnostic accuracy of standard clinical tests, specifically McMurray's test, Apley's compression test, and Thessaly test, with magnetic resonance imaging (MRI) for detecting knee meniscal injuries. A prospective analysis was conducted involving patients with clinical suspicion of meniscal injury. Each participant underwent the selected clinical tests followed by an MRI examination. Each test's sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using MRI as the reference standard. The study found that among the clinical tests, the Thessaly test at 20 degrees of knee flexion demonstrated the highest sensitivity and specificity, closely followed by McMurray's test. Apley's compression test showed lower diagnostic accuracy. The combined use of multiple clinical tests improved diagnostic confidence but did not surpass the accuracy of MRI. While MRI remains the gold standard for diagnosing meniscal injuries, specific clinical tests offer considerable diagnostic value, particularly the Thessaly test. These tests can aid the initial assessment, especially in resource-limited settings where MRI is not readily available.

Keywords: *Meniscal injury, McMurray's test, Apley's test, Thessaly test, Magnetic Resonance Imaging, Diagnostic accuracy*

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1. Introduction

Meniscal injuries are among the most frequently encountered intra-articular knee lesions in orthopaedic practice, with significant implications for joint function, mobility, and long-term musculoskeletal health (Bhan, 2008). These injuries, which commonly result from rotational forces applied to a flexed knee, such as during sports activities or accidental trauma, can lead to chronic pain, mechanical symptoms, and progressive degenerative changes if not diagnosed and managed appropriately (Fox et al., 2012). The meniscus-shaped fibrocartilaginous structures between the femoral condyles and the tibial plateau play an important role in the knee joint biomechanics. They are responsible for distributing axial loads, enhancing joint congruity, providing shock absorption, aiding proprioception, and contributing to joint stability (Fox et al., 2012; McDermott et al., 2008).

Accurate diagnosis of meniscal injuries is, therefore, critical to prevent long-term sequelae such as osteoarthritis. Traditionally, the clinical evaluation of a suspected meniscal injury begins with a thorough history and physical examination, often followed by the application of specific clinical tests designed to provoke meniscal symptoms. Among the most used are the McMurray's test, Apley's compression test, and the Thessaly test. McMurray's test involves flexing and rotating the knee to elicit a click or pain, which may suggest a tear. Apley's test applies axial compression and rotation in the prone position to differentiate between meniscal and ligamentous pathology, while the Thessaly test

assesses joint line discomfort and mechanical symptoms by having the patient perform weight-bearing knee flexion with rotation (Karachalios et al., 2005).

Although these tests have been standard components of knee examinations for decades, their diagnostic reliability has been increasingly scrutinised. Variability in reported sensitivity and specificity has raised concerns about their clinical utility as standalone diagnostic tools. For instance, some studies have reported moderate to high specificity for McMurray's test but limited sensitivity, indicating its usefulness in confirming but not necessarily excluding meniscal pathology (Malanga & Andrus, 2001). Similarly, Apley's test may be less reliable due to difficulties in distinguishing between meniscal and capsuloligamentous injuries, while the Thessaly test has demonstrated high diagnostic accuracy in some trials but requires proper patient instruction and cooperation to be effective (Karachalios et al., 2005).

However, MRI has revolutionised the diagnosis of meniscal and other intra-articular knee injuries by providing high-resolution, non-invasive visualisation of soft tissue structures. MRI allows for the detailed assessment of meniscal morphology, the detection of tears (including complex, horizontal, and radial types), and the evaluation of associated chondral or ligamentous pathology (Stoller, 2007). The diagnostic accuracy of MRI in detecting meniscal tears has been reported to range between 85% to 95% in various studies, making it the imaging modality of choice prior to surgical intervention (Kocabey et al., 2004). Its utility is particularly valuable in ambiguous clinical scenarios with inconclusive history and examination findings.

However, the availability and accessibility of MRI remain limited in many parts of the world, particularly in resource-constrained settings. The high cost of MRI, the need for specialised infrastructure, and potential scheduling delays limit its routine use, especially in primary and secondary care environments. Moreover, there is growing recognition that over-reliance on imaging may lead to incidental findings that do not correlate with clinical symptoms, thereby contributing to unnecessary interventions (Ryzewicz et al., 2007).

Despite the widespread use of clinical tests (such as McMurray's, Thessaly, and joint line tenderness) and MRI for diagnosing meniscal injuries, their comparative diagnostic accuracy remains inconsistent across studies, particularly in resource-limited settings. Existing literature reports variable sensitivity and specificity for these tests, and few studies directly compare their performance against MRI using arthroscopy as the gold standard. This study addresses this gap by systematically evaluating the diagnostic accuracy of clinical tests and MRI in a cohort of patients with suspected meniscal tears, aiming to provide evidence-based guidance for clinicians, especially where advanced imaging is inaccessible.

2. Materials and methods

A descriptive cross-sectional study was conducted in the Department of Orthopaedic Surgery, Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, over a period of one year from March 2017 to February 2018. The initial calculation yielded a sample size of 29.14, which was adjusted to 32 after accounting for a 10% non-response rate. Ultimately, 30 patients aged 15 to 60 years were included in the study.

Data collection involved a structured proforma to record demographic details, injury history, clinical findings, MRI results, and arthroscopic observations. Patients were selected based on inclusion criteria, such as a history of twisting knee injury with or without recurrent effusion, age between 15 and 60 years, and symptoms persisting for more than six weeks. Exclusion criteria included previous knee surgery, signs of osteoarthritis or rheumatoid arthritis, neuromuscular disorders, ligament injuries, contraindications to MRI, and refusal to consent for arthroscopy. Clinical assessments were performed by an orthopaedic surgeon and included joint line tenderness, McMurray test, and Thessaly test at 20 degrees of knee flexion. These findings were documented alongside preoperative symptoms before patients underwent MRI and subsequent arthroscopy.

Arthroscopy was conducted under spinal anaesthesia using standard anterolateral and anteromedial portals, with a systematic examination of the knee joint structures. The diagnostic accuracy of clinical tests and MRI was compared against arthroscopic findings, with results categorised as true positive, true negative, false positive, or false negative. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated. Statistical analysis was performed using SPSS 20, with Fisher's exact test applied to determine significance ($p < 0.05$). Additionally, Kappa statistics were used to assess agreement levels between diagnostic methods. Ethical approval was obtained from the institutional review committee, and informed consent was secured from all participants, ensuring confidentiality and transparency regarding study objectives, risks, and benefits.

3. Results and discussion

Age and Gender Distribution

The study observed a wide age range of participants, from 15 to 60, with a mean age of 36.10. Most patients (60%) fell within the 20-40 age group, indicating that meniscal injuries are more prevalent among young adults. The study showed a male predominance (66.7%) in the patient population, with a male-to-female ratio of 2:1.

Mode and Side of Injury
Most patients (53%) experienced meniscal injuries due to trivial trauma to the knee, followed by road traffic accidents (27%) and sports injuries (20%), as shown in Table 1. In terms of the side of injury, the left knee was more commonly affected, accounting for 53% of cases, while the right knee was affected in 47% of cases. This near-equal distribution indicates no significant bias toward either side, suggesting that factors other than handedness or dominant leg may influence injury occurrence.

Table 1: Key demographic information such as age, gender, and injury side

Parameter	Category	Number of Patients	Percentage (%)
Age Group	10-20 years	1	3.3%
	20-40 years	18	60%
	41-60 years	11	36.7%
Gender	Male	20	66.7%
	Female	10	33.3%
Side of Injury	Left	16	53%
	Right	14	47%

Presenting Complaints
Knee pain was the most frequent presenting complaint (66.67%), followed by a combination of pain and locking (23.33%). This finding underscores the significant role of knee pain in identifying meniscal injuries, while locking and giving-way symptoms were reported in smaller proportions. This suggests that the clinical presentation of meniscal injuries may vary, with pain being the most common symptom.

Joint Line Tenderness (JLT)
Joint line tenderness demonstrated good sensitivity (85%) for MMT and 80% for LMT, with relatively lower specificity (50% for MMT and 75% for LMT). The negative predictive value (NPV) was higher for LMT (88.24%) compared to MMT (62.5%), indicating that JLT can be a useful negative test for ruling out lateral meniscus tears. However, the moderate correlation between JLT and arthroscopy findings for both MMT and LMT, and the fair-to-moderate Kappa coefficients, suggest that JLT alone may not be definitive in diagnosing meniscal tears.

McMurray Test
The McMurray test demonstrated a sensitivity of 75% for MMT and 60% for LMT, with lower specificity (60% for MMT and 70% for LMT). The positive predictive value (PPV) was higher for MMT (78.95%) than for LMT (50%). While McMurray's test showed moderate agreement with arthroscopy findings, it did not achieve statistical significance. This suggests that although McMurray's test is a relatively good diagnostic tool, it should be used with other tests for a more accurate diagnosis.

Thessaly Test
The Thessaly test exhibited the lowest sensitivity and specificity among the three clinical tests, with a sensitivity of 55% for MMT and 40% for LMT. Its low PPV and NPV for both MMT and LMT, and its low accuracy, suggest that the Thessaly test may be less reliable in detecting meniscal tears than other clinical tests. The slight Kappa coefficients indicate poor agreement with arthroscopic findings.

Combined Clinical Tests
Combining all three clinical tests (Joint Line Tenderness, McMurray's test, and Thessaly test) significantly improved the diagnostic sensitivity, rising to 95% for MMT and 90% for LMT. The negative predictive values also increased, indicating that a combination of tests can be highly effective for ruling out meniscal tears. However, the moderate-to-low Kappa coefficients and non-statistically significant correlation suggest that while this combined approach improves sensitivity, it still requires confirmation with more definitive diagnostic tools.

MRI Findings
MRI showed a sensitivity of 80% for MMT and 70% for LMT, with higher specificity for LMT (90%) than MMT (60%). The negative predictive value (NPV) was high for LMT (85.77%) but lower for MMT (60%). MRI had a higher overall accuracy for LMT (83.33%) than MMT (73%), suggesting that MRI is more reliable for detecting lateral meniscal tears. The moderate-to-substantial agreement (Kappa coefficients of 0.400 for MMT and 0.615 for LMT) indicates that MRI is a useful diagnostic tool for meniscal injuries, particularly for LMT.

Table 2: Sensitivity, Specificity, PPV, NPV, and Accuracy for Each Test (MMT and LMT)

Test	Sensitivity	Specificity	PPV	NPV	Accuracy
Joint Line Tenderness (JLT)	MMT: 85%	MMT: 50%	MMT: 77.27%	MMT: 62.5%	MMT: 73.33%
	LMT: 80%	LMT: 75%	LMT: 61%	LMT: 88.24%	LMT: 76.67%
McMurray Test	MMT: 75%	MMT: 60%	MMT: 78.95%	MMT: 54.55%	MMT: 70%
	LMT: 60%	LMT: 70%	LMT: 50%	LMT: 77.78%	LMT: 66.67%
Thessaly Test	MMT: 55%	MMT: 60%	MMT: 73.33%	MMT: 40%	MMT: 56.67%
	LMT: 40%	LMT: 60%	LMT: 33.33%	LMT: 66.67%	LMT: 53.33%

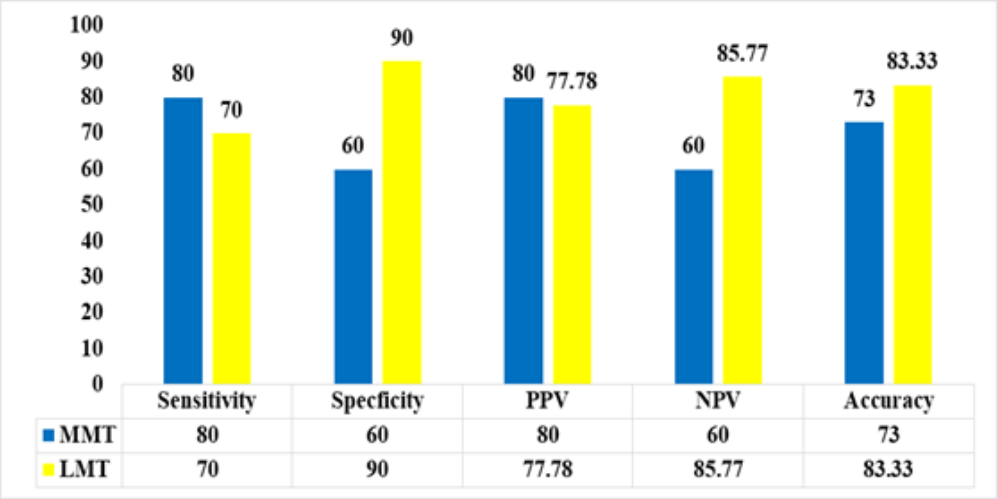

Figure 1: Diagnostic accuracy of MRI to detect meniscal tear

Comparison of Various Diagnostic Accuracy of Clinical Tests and MRI for Detecting MMT

When comparing the combined results of the three clinical tests (Joint Line Tenderness, McMurray Test, and Thessaly Test) with MRI for the diagnosis of MMT, the study revealed that the combined clinical tests demonstrated higher sensitivity and NPV as shown in Figure 2. This suggests that the combined tests were more effective in correctly identifying patients without a meniscal tear (i.e., true negatives) and detecting MMT.

However, MRI showed superior specificity and PPV, meaning it was more reliable in confirming the presence of a meniscal tear (i.e., true positives). The overall diagnostic accuracy of the combined clinical tests and MRI was quite similar, indicating that while both approaches have their strengths, neither outperformed the other in terms of accuracy.

The combined clinical tests' higher sensitivity and NPV may be advantageous in a clinical setting where ruling out MMT (false positives) is a critical factor. On the other hand, MRI's higher specificity and PPV suggest its role in confirming diagnoses where a meniscal tear is suspected.

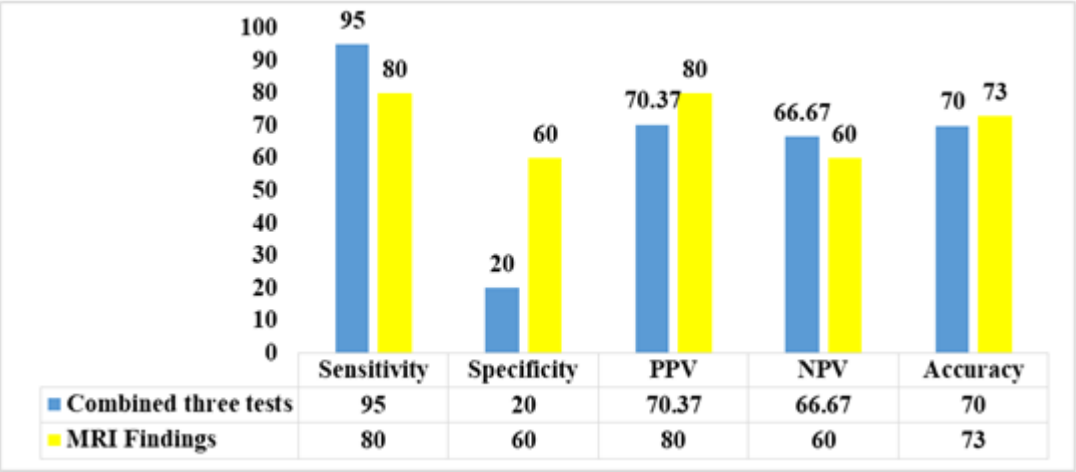

Figure 2: Bar chart showing comparison of diagnostic accuracy of combine clinical test vs MRI for MMT in the study

Comparison of Various Diagnostic Accuracy of Clinical Tests and MRI for Detecting LMT

In contrast, when comparing the diagnostic accuracy of the combined clinical tests with MRI for the detection of LMT, it was found that the combined tests had a significantly higher sensitivity, as shown in Figure 3. This indicates that the

combined clinical tests were better at identifying patients with an LMT. However, MRI outperformed the combined tests regarding specificity, PPV, and overall accuracy. This means that MRI was more reliable in confirming the presence of a lateral meniscus tear and distinguishing between torn and non-torn menisci.

The NPV was almost identical for the combined clinical tests and MRI, suggesting that both methods were equally good at identifying patients without a meniscal tear (true negatives). However, MRI's superior specificity, PPV, and accuracy make it a better choice for confirming a diagnosis of LMT.

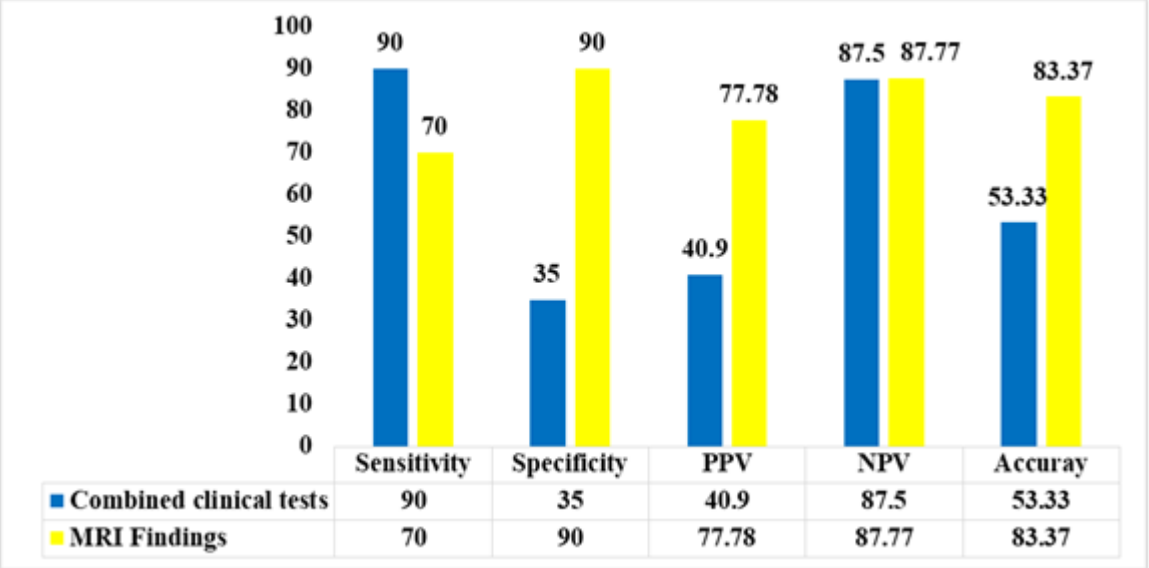

Figure 3: Bar chart showing comparison of diagnostic accuracy of combine clinical test vs MRI for LMT in the study

4. Discussion

Regarding demographics, the mean age of participants in the study was 36.1 years, with the highest incidence of meniscal injuries occurring in individuals aged 20 to 40 years. This is consistent with findings from other studies, which also report a higher prevalence in younger, physically active individuals (Kocabey et al., 2008). The involvement of younger individuals in sports and outdoor activities likely contributes to the higher rate of meniscal injuries in this age group (Muthuuri et al., 2020). Gender distribution in the study showed a male-to-female ratio of 2:1, which agrees with other studies. Men are more likely to sustain meniscal tears due to their greater participation in high-risk physical activities (Greis et al., 2002). Studies showing that males are at a higher risk for knee injuries, particularly in sports (Avcu et al., 2015), further support this finding.

Regarding the side of injury, the study found a slight predominance of left knee injuries (53%) over right knee injuries (47%). This result aligns with other studies, although some have reported a higher incidence of right knee injuries, likely due to the dominance of the right leg in most individuals (Nikolaou et al., 2009; Sharma et al., 2015).

Medial meniscal tears (MMTs) were more common than LMTs , with a ratio of 66.66% to 33.33%, respectively. This pattern is consistent with existing literature, which suggests that the medial meniscus is more prone to injury due to its limited mobility and its role in absorbing a significant portion of the knee's shock (Mohan et al., 2002). The medial meniscus is less mobile compared to the lateral meniscus, making it more susceptible to injury under abnormal stresses (Christoforakis et al., 2007).

The predominant mode of injury in the study was trivial trauma (57%), followed by road traffic accidents (27%) and sports injuries (20%). This distribution is like other studies where non-sport-related trauma is more common than sports-related injuries (Sharma et al., 2015). Pain was the most common presenting symptom (66.67%) in the study, which differs from findings by Yogendra et al. (2008), who reported a higher prevalence of mechanical symptoms such as instability and locking.

For the medial meniscus, the study showed a sensitivity of 85%, specificity of 50%, and accuracy of 73.33%, comparable to those reported by Rose et al. (2001). The lateral joint line tenderness test demonstrated sensitivity of 80%, specificity of 75%, and accuracy of 76.67%, like findings by Eren et al. (2002). However, some studies, such as Shelbourne et al. (2004), report lower specificity, particularly for medial meniscus tears. The specificity of joint line tenderness for lateral meniscus tears was higher than sensitivity, aligning with other studies' findings (Karachalios et al., 2003).

The study showed moderate sensitivity and specificity for both medial and lateral meniscus tears, with sensitivity of 75% and specificity of 60% for MMT, and sensitivity of 75% and specificity of 60% for LMT. While prior studies report varying diagnostic accuracies for clinical tests—e.g., Karachalios et al. (2005) found the Thessaly test highly sensitive

(89%), our results showed lower sensitivity (55% for MMT), potentially due to differences in patient populations (e.g., inclusion of acute/chronic injuries) or methodological heterogeneity, such as stricter arthroscopic confirmation criteria. Similarly, McMurray's test in our study demonstrated moderate sensitivity (75% for MMT), aligning with Evans et al. (2004) (72%) but contrasting with higher values (92%) in Shelbourne et al. (2004), possibly attributable to examiner experience or inconsistent interpretation of "pain vs. click" as positive findings. For MRI, our sensitivity (80% for MMT) was lower than Kocabey et al. (2004) (95%), likely due to differences in MRI resolution or radiologist expertise, underscoring the context-dependent nature of these diagnostic tools. These discrepancies highlight the need for standardised protocols and tailored test selection based on clinical settings..

The sensitivity, specificity, and accuracy for Thessaly's test at 20° knee flexion in the study were lower than in other studies (Karachalios et al., 2003; Konan et al., 2005). This could be due to the heterogeneity of the study population, which included individuals with a range of knee pathologies, leading to increased false positives. Despite this, the results were consistent with other studies reporting lower sensitivity for the lateral meniscus compared to the medial meniscus.

MRI has long been considered the gold standard for diagnosing meniscal tears. In the study, MRI demonstrated higher sensitivity for medial meniscal tears (80%) and lateral meniscal tears (70%) than the clinical tests. However, the specificity of MRI was lower than that of clinical tests, particularly for the lateral meniscus. This result aligns with previous studies by Rayan et al. (2008) and Schurz et al. (2012), who found that MRI is highly sensitive but not as specific as clinical tests.

The comparison of diagnostic accuracy between clinical tests and MRI showed that while MRI had higher sensitivity, the combined clinical tests performed better in detecting medial meniscus tears (95% sensitivity) than MRI (80%). MRI's specificity and negative predictive value were lower than those of clinical tests, suggesting that clinical examination might be better at ruling out meniscal tears.

The kappa coefficient for the agreement between clinical tests and arthroscopy in the study was moderate for medial meniscus tears (0.294) and slight for lateral meniscus tears (0.157), indicating that the clinical tests, while helpful, did not always correspond well with arthroscopic findings. This is consistent with findings from previous studies that report varying levels of agreement between clinical tests and arthroscopic results (Sharma et al., 2015).

Several limitations should be considered when interpreting our findings. First, the relatively small sample size may limit the statistical power and generalizability of the results. Second, as a single-centre study conducted at a tertiary hospital, the patient population may not fully represent broader or primary care settings. Third, the performance of clinical tests such as McMurray's and Thessaly tests could be subject to operator bias, as inter-examiner variability in technique and interpretation was not assessed. Additionally, while arthroscopy served as the gold standard, its invasive nature may have introduced selection bias, as only patients with strong clinical indications underwent the procedure. Finally, the study did not account for potential confounding factors such as concurrent ligamentous injuries or degenerative changes, which could influence diagnostic accuracy. These limitations highlight the need for larger, multicenter studies with standardised protocols to validate our findings further.

5. Conclusion

This study aimed to evaluate the diagnostic accuracy of clinical tests, MRI, and arthroscopy in detecting meniscal tears in the knee. The findings show that while clinical tests, including joint line tenderness, McMurray's test, and Thessaly test, exhibit varying degrees of sensitivity, specificity, and accuracy, MRI remains a valuable diagnostic tool, particularly in cases where clinical tests may be inconclusive or difficult to perform, such as in acute injuries.

Regarding patient demographics, this study supports the established understanding that meniscal injuries are more common in younger, physically active individuals, particularly those involved in sports and outdoor activities. The study found that the left knee was slightly more affected than the right. However, this finding was in line with some studies while differing from others, which may be due to differences in study populations or methods.

Regarding the type of meniscal tears, the study found that medial meniscal tears were more prevalent than lateral tears, which attributes this to the medial meniscus being less mobile and more susceptible to injury. The most common mode of injury in the study was trivial trauma, followed by road traffic accidents and sports injuries, highlighting the varied nature of knee injuries that lead to meniscal damage.

The diagnostic accuracy of clinical tests, particularly joint line tenderness and McMurray's test, demonstrated moderate sensitivity but relatively low specificity. The sensitivity of the combined clinical tests was high, especially for medial meniscus tears, although the specificity was lower. MRI offers better sensitivity and specificity than clinical tests, but it is more expensive and may not be feasible for routine screening in all patients.

The study shows the importance of using a combination of clinical tests and MRI to accurately diagnose meniscal tears, particularly in the context of varying patient presentations and injury mechanisms. While arthroscopy remains the gold standard for diagnosis, the non-invasive nature of MRI and the ease of clinical examination make them valuable complementary tools in assessing knee injuries. Further studies with larger sample sizes and standardized diagnostic criteria are needed to refine the diagnostic value of clinical tests and enhance the understanding of their role in the early detection of meniscal injuries.

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