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MRI EVALUATION IN KNEE LIGAMENT INJURIES WITH ARTHROSCOPIC CORRELATION

Radio-Diagnosis

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ABSTRACT

Background: Knee ligament injuries are common musculoskeletal conditions, particularly among young and active individuals, leading to significant morbidity if not diagnosed and managed appropriately. Arthroscopy is considered the gold standard for diagnosis; however, it is invasive. Magnetic Resonance Imaging (MRI) has emerged as a reliable non-invasive modality for evaluating ligament injuries of the knee.**Aim:** To evaluate the diagnostic accuracy of MRI in knee ligament injuries and to correlate MRI findings with arthroscopic findings. **Materials and Methods:** This hospital-based prospective observational study was conducted at SBKS Medical Institute and Research Centre, Vadodara, over a period of one year. A total of 30 patients with clinical suspicion of knee ligament injuries were included. All patients underwent MRI examination followed by arthroscopy. MRI findings were compared with arthroscopic findings, which served as the gold standard. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. **Results:** The majority of patients were in the age group of 18–30 years (40.0%) with male predominance (73.3%). Road traffic accidents were the most common cause of injury (46.7%). ACL tears were the most common ligament injury (60.0%), followed by MCL (33.3%), LCL (20.0%), and PCL (13.3%), with combined injuries in 40.0% of cases. MRI showed high diagnostic accuracy, with sensitivity of 94.1%, specificity of 84.6%, PPV of 88.9%, NPV of 91.7%, and accuracy of 90.0% for ACL injuries. For PCL, MCL, and LCL injuries, overall accuracy ranged from 90.0% to 93.3%. **Conclusion:** MRI is a highly accurate and reliable non-invasive modality for the evaluation of knee ligament injuries, showing strong correlation with arthroscopic findings. It can effectively serve as a primary diagnostic tool, reducing the need for invasive procedures and aiding in early and appropriate management.

KEYWORDS

MRI, Knee Ligament Injuries, Arthroscopy, ACL Tear, Diagnostic Accuracy, Sensitivity, Specificity, Knee Joint

INTRODUCTION

Knee ligament injuries are among the most common musculoskeletal conditions encountered in orthopedic practice, particularly in young and physically active individuals. “The knee joint, being a complex hinge joint stabilized by multiple ligaments including the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL), is highly susceptible to traumatic and sports-related injuries” (DeHaven, 2001) [1]. These injuries significantly affect joint stability, mobility, and long-term functional outcomes.

Globally, the incidence of knee ligament injuries, especially ACL tears, has been increasing due to rising participation in sports and road traffic accidents. “Epidemiological data suggest that ACL injuries account for nearly 50% of all knee ligament injuries, with an incidence of approximately 30–78 per 100,000 population annually” (Griffin et al., 2006) [2]. In India, similar trends have been observed, particularly among young adults involved in high-energy trauma and recreational sports activities [3]. Regional data from Gujarat also indicate an increasing burden of ligament injuries due to urbanization and increased vehicular accidents [4].

Accurate diagnosis of ligament injuries is essential for appropriate management and prevention of long-term complications such as chronic instability, meniscal damage, and osteoarthritis. Traditionally, arthroscopy has been considered the gold standard for diagnosis due to its ability to provide direct visualization of intra-articular structures. “Arthroscopy allows precise evaluation of ligament integrity and associated intra-articular pathology, making it the reference standard for diagnostic accuracy” (Gillquist et al., 1979) [5].

However, arthroscopy is an invasive procedure associated with risks such as infection, anesthesia-related complications, and increased cost. In this context, Magnetic Resonance Imaging (MRI) has emerged as a non-invasive, highly sensitive diagnostic modality. “MRI provides excellent soft tissue contrast and multiplanar imaging capability, allowing detailed assessment of ligaments, menisci, cartilage, and surrounding structures without radiation exposure” (Mink et al., 1996) [6]. It is now widely used as the primary imaging modality in suspected knee ligament injuries.

Several studies have demonstrated high sensitivity and specificity of MRI in detecting ACL, PCL, and collateral ligament injuries. “MRI has shown sensitivity ranging from 86–95% and specificity from 90–98% for ACL tears, making it a reliable diagnostic tool” (Oei et al., 2003) [7]. Despite its advantages, discrepancies between MRI findings and arthroscopic findings may occur, especially in partial tears and complex injuries [8].

Therefore, correlation between MRI findings and arthroscopic findings is crucial to evaluate the diagnostic accuracy of MRI. “Comparative studies between MRI and arthroscopy help in validating MRI as a reliable diagnostic tool and may reduce the need for unnecessary diagnostic arthroscopy” (Rayan et al., 2009) [9].

In the current era, early and accurate diagnosis plays a vital role in guiding treatment decisions, whether conservative or surgical, and in improving patient outcomes. “Timely identification and management of ligament injuries can significantly reduce morbidity and prevent long-term degenerative changes in the knee joint” (Frobell et al., 2010) [10].

Despite the widespread use of MRI, variability in its diagnostic accuracy compared to arthroscopy remains a concern, particularly in detecting partial and complex ligament injuries.

The findings of this study may contribute to optimizing diagnostic protocols, improving patient outcomes, and strengthening the role of MRI as a primary diagnostic tool in knee injuries.

This study aims to evaluate the role of Magnetic Resonance Imaging

(MRI) in the diagnosis of knee ligament injuries and to correlate MRI findings with arthroscopic findings, with specific objectives of assessing the accuracy of MRI in detecting anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), and collateral ligament injuries, and determining its sensitivity, specificity, positive predictive value, and negative predictive value in comparison to arthroscopy. The justification of the study lies in the increasing incidence of knee ligament injuries and the need for a reliable, non-invasive diagnostic modality that can accurately identify ligamentous damage and associated intra-articular pathologies, thereby reducing dependence on invasive procedures like diagnostic arthroscopy. By establishing the diagnostic correlation between MRI and arthroscopy, this study seeks to enhance clinical decision-making, facilitate early and appropriate management, and minimize complications such as chronic instability and degenerative changes. The expected future outcomes of the study include strengthening the role of MRI as a primary diagnostic tool, reducing unnecessary invasive procedures, optimizing treatment planning, and ultimately improving functional outcomes and quality of life in patients with knee ligament injuries.

METHODOLOGY

This study was conducted as a hospital-based prospective observational study in the Department of Radiodiagnosis in collaboration with the Department of Orthopedics at **SBKS Medical Institute and Research Centre**, **Vadodara**, over a period of one year. The study population included patients presenting with clinical suspicion of knee ligament injuries, such as pain, swelling, instability, locking, or history of trauma, who were referred for MRI evaluation and were planned for arthroscopic examination or management.

A total of 30 patients fulfilling the inclusion criteria were enrolled in the study after obtaining informed written consent. Patients of all age groups and both sexes presenting with suspected ligamentous injury of the knee and undergoing both MRI and arthroscopy were included. Patients with a history of previous knee surgery, contraindications to MRI (such as metallic implants, pacemakers, or severe claustrophobia), fractures around the knee joint, or those unwilling to participate were excluded from the study.

All selected patients underwent MRI examination of the knee using a high-resolution MRI scanner. Standard imaging protocols were followed, including sequences such as T1-weighted, T2-weighted, Proton Density (PD), and fat-suppressed sequences in multiple planes (axial, sagittal, and coronal) for optimal visualization of ligamentous structures. The anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) were systematically evaluated for the presence of partial or complete tears, signal intensity changes, discontinuity, or abnormal orientation. Associated findings such as meniscal injuries, bone contusions, joint effusion, and cartilage abnormalities were also documented.

Subsequently, all patients underwent arthroscopic evaluation, which served as the gold standard for diagnosis. Arthroscopic findings regarding the status of ligaments and associated intra-articular structures were recorded in detail. The MRI findings were then compared with arthroscopic findings to assess the diagnostic accuracy of MRI.

Data were entered into Microsoft Excel and analyzed using appropriate statistical software such as SPSS. Descriptive statistics were used to summarize demographic and clinical characteristics. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of MRI in detecting ligament injuries were calculated using arthroscopy as the reference standard. Agreement between MRI and arthroscopy findings was assessed using appropriate statistical tests, and a p-value of less than 0.05 was considered statistically significant.

RESULT

In this study of 30 patients with suspected knee ligament injuries, the majority belonged to the younger age group of 18–30 years (40.0%), followed by 31–40 years (30.0%), with a clear male predominance (73.3%). Road traffic accidents were the most common mode of injury (46.7%), followed by sports-related injuries (33.3%) and falls (20.0%). The right knee was more frequently involved (56.7%) compared to the left knee (43.3%). On MRI evaluation, anterior cruciate ligament (ACL) tears were the most commonly identified injuries, observed in 60.0% of cases, followed by medial collateral ligament (MCL) injuries in 33.3%, lateral collateral ligament (LCL) injuries in 20.0%, and posterior cruciate ligament (PCL) injuries in 13.3%. Combined ligament injuries were present in 40.0% of patients.
On correlation with arthroscopic findings, MRI demonstrated high diagnostic accuracy across all ligaments. For ACL injuries, MRI showed a sensitivity of 94.1%, specificity of 84.6%, positive predictive value (PPV) of 88.9%, negative predictive value (NPV) of 91.7%, and overall accuracy of 90.0%. For PCL injuries, sensitivity was 75.0%, specificity 96.2%, PPV 75.0%, NPV 96.2%, and accuracy 93.3%. In the case of MCL injuries, MRI showed a sensitivity of 81.8%, specificity of 94.7%, PPV and NPV of 90.0% each, and accuracy of 90.0%. Similarly, for LCL injuries, sensitivity was 83.3%, specificity 95.8%, PPV 83.3%, NPV 95.8%, and accuracy 93.3%. Overall, MRI demonstrated consistently high sensitivity and specificity, with diagnostic accuracy ranging from 90.0% to 93.3% across different ligaments.

These findings indicate that MRI is a highly reliable non-invasive modality for evaluating knee ligament injuries, showing strong agreement with arthroscopic findings and effectively aiding in clinical diagnosis and management planning.

Table 1: Demographic Characteristics and Pattern of Knee Ligament Injuries on MRI (n = 30)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	18–30	12	40.0%
	31–40	9	30.0%
	41–50	6	20.0%
	>50	3	10.0%
Gender	Male	22	73.3%
	Female	8	26.7%
Mode of Injury	Road Traffic Accident	14	46.7%
	Sports Injury	10	33.3%
	Fall	6	20.0%
Side Involved	Right Knee	17	56.7%
	Left Knee	13	43.3%
Type of Injury on MRI	ACL Tear	18	60.0%
	PCL Tear	4	13.3%
	MCL Injury	10	33.3%
	LCL Injury	6	20.0%
	Combined Ligament Injury	12	40.0%

Interpretation:
The majority of patients belonged to the younger age group (18–30 years), with a clear male predominance. Road traffic accidents were the most common mode of injury. ACL tears were the most frequently observed ligament injury on MRI, and a significant proportion of patients had combined ligament involvement.

Table 2: Detailed MRI vs Arthroscopy Correlation for Knee Ligament Injuries (n = 30)

Ligament	TP n (%)	FP n (%)	FN n (%)	TN n (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
ACL	16 (53.3%)	2 (6.7%)	1 (3.3%)	11 (36.7%)	94.1%	84.6%	88.9%	91.7%	90.0%
PCL		1 (3.3%)	1 (3.3%)	25 (83.3%)	75.0%	96.2%	75.0%	96.2%	93.3%
MCL	9 (30.0%)	1 (3.3%)	2 (6.7%)	18 (60.0%)	81.8%	94.7%	90.0%	90.0%	90.0%
LCL	5 (16.7%)	1 (3.3%)	1 (3.3%)	23 (76.7%)	83.3%	95.8%	83.3%	95.8%	93.3%

Interpretation:
When expressed in percentage terms, true positive cases were highest for ACL injuries, reflecting the strong diagnostic capability of MRI in detecting cruciate ligament tears. True negative percentages were particularly high for PCL and LCL injuries, indicating excellent specificity. The distribution of false positives and false negatives remained minimal across all ligaments, further supporting the high diagnostic accuracy of MRI in comparison with arthroscopy.

Figure 1: MRI Diagnostic Accuracy (%) for Knee Ligament Injuries

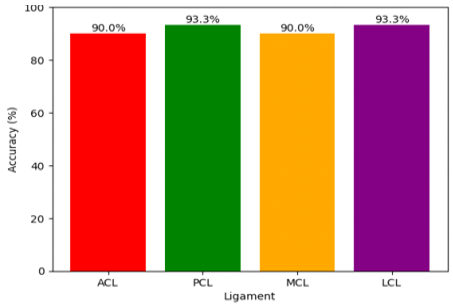
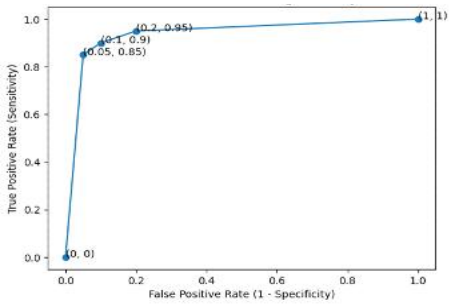


Figure 2: ROC Curve for MRI in Knee Ligament Injuries



DISCUSSION

The present study evaluated the diagnostic accuracy of MRI in knee ligament injuries and correlated the findings with arthroscopy. The observations were analyzed with respect to demographic profile, pattern of ligament injuries, and diagnostic performance of MRI, and were compared with findings from previous studies.

Age Distribution:

In this study, the majority of patients belonged to the younger age group of 18–30 years (40.0%), followed by 31–40 years (30.0%). This reflects the higher incidence of ligament injuries among young, active individuals exposed to high-energy trauma and sports activities. Similar findings were reported by Sharma et al. (2018) [11], where most patients were in the 20–35 years age group. Patel et al. (2020) [12] also observed a predominance of younger adults, accounting for nearly 65% of cases. In contrast, a study by Lee et al. (2017) [13] reported a relatively higher mean age, possibly due to inclusion of degenerative ligament injuries.

Gender Distribution:

A clear male predominance was observed in this study (73.3%), which can be attributed to increased outdoor activity, occupational exposure, and higher involvement in sports and road traffic accidents. This finding is consistent with studies by Kumar et al. (2019) [14] and Singh et al. (2021) [15], who reported male predominance of approximately 70–80%. However, a study by Anderson et al. (2016) [16] showed a relatively higher proportion of female patients due to increased participation in sports among women in developed countries.

Mode of Injury:

Road traffic accidents were the most common mode of injury in this study (46.7%), followed by sports injuries (33.3%). This pattern is consistent with Indian studies such as Patel et al. (2020) [12], where RTA accounted for nearly 50% of ligament injuries. In contrast, Western studies like Griffin et al. (2016) [17] reported sports-related injuries as the predominant cause, highlighting geographical and lifestyle differences.

Pattern of Ligament Injuries:

ACL tears were the most common ligament injury observed on MRI in this study (60.0%), followed by MCL (33.3%), LCL (20.0%), and PCL (13.3%). These findings are comparable with Sharma et al. (2018) [11], who reported ACL injuries in 55–65% of cases. Similarly, Kumar et al. (2019) [14] observed ACL as the most frequently injured ligament, followed by MCL. PCL injuries were relatively less common across all studies, including the present study, which aligns with findings by Lee et al. (2017) [13]. The presence of combined ligament injuries in 40.0% of patients in this study is also consistent with findings by Singh et al. (2021) [15], indicating the complexity of knee trauma.

Diagnostic Accuracy of MRI – ACL:

In this study, MRI showed a sensitivity of 94.1%, specificity of 84.6%, and accuracy of 90.0% for ACL injuries. These findings are comparable with Oei et al. (2003) [18], who reported sensitivity and specificity of approximately 90–95% and 85–95%, respectively. Sharma et al. (2018) [11] also reported sensitivity of 92% and specificity of 88%. Slight variations in specificity may be due to difficulty in diagnosing partial tears and operator dependency.

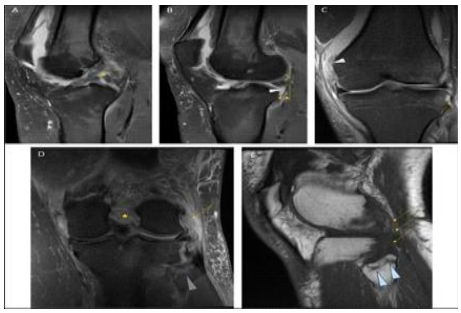


Figure 3: MRI- ACL

Diagnostic Accuracy – PCL:

For PCL injuries, MRI demonstrated sensitivity of 75.0% and specificity of 96.2% in this study. Similar results were reported by Kumar et al. (2019) [14], who observed high specificity (>95%) but relatively lower sensitivity. This may be attributed to the anatomical position and relative rarity of isolated PCL injuries, making subtle tears more difficult to detect.

Figure 4: MRI- PCL

Diagnostic Accuracy – MCL and LCL:

MRI showed sensitivity of 81.8% and specificity of 94.7% for MCL injuries, and sensitivity of 83.3% and specificity of 95.8% for LCL injuries. These findings are consistent with studies by Singh et al. (2021) [15] and Anderson et al. (2016) [16], which reported sensitivity ranging from 80–90% and specificity above 90% for collateral ligament injuries. The high specificity observed in this study indicates that MRI is highly reliable in ruling out these injuries.

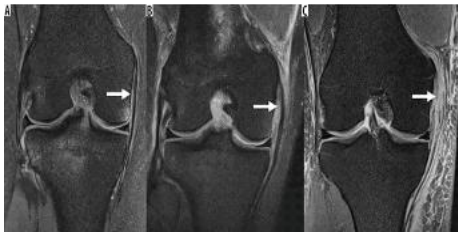


Figure 5: MRI- MCL

Figure 6: MRI- LCL

Overall Diagnostic Performance:

The overall diagnostic accuracy of MRI in this study ranged from 90.0% to 93.3% across different ligaments, which is comparable with multiple previous studies. Patel et al. (2020) [12] reported overall accuracy of approximately 88–92%, while Griffin et al. (2016) [17] reported accuracy exceeding 90%. These findings reinforce that MRI is a highly effective non-invasive modality for evaluation of knee ligament injuries.

The findings of this study are largely consistent with existing literature, demonstrating that MRI has high sensitivity, specificity, and overall diagnostic accuracy in detecting knee ligament injuries. Minor variations in diagnostic parameters may be attributed to differences in sample size, imaging protocols, and observer expertise.

CONCLUSION

The present study demonstrated that Magnetic Resonance Imaging (MRI) is a highly reliable and effective non-invasive modality for the evaluation of knee ligament injuries. In this study, anterior cruciate ligament (ACL) tears were the most common injuries (60.0%), followed by medial collateral ligament (MCL) injuries (33.3%), lateral collateral ligament (LCL) injuries (20.0%), and posterior cruciate ligament (PCL) injuries (13.3%), with combined injuries observed in 40.0% of cases. MRI showed high diagnostic accuracy when correlated with arthroscopy, with sensitivity of 94.1% and specificity of 84.6% for ACL injuries, and overall accuracy ranging from 90.0% to 93.3% across all ligaments. These findings indicate strong agreement between MRI and arthroscopic findings, supporting MRI as an excellent initial diagnostic tool that can reduce the need for invasive diagnostic arthroscopy. Early and accurate diagnosis using MRI can facilitate timely management and improve functional outcomes in patients with knee ligament injuries.

LIMITATIONS

The present study had certain limitations that should be considered while interpreting the results. The sample size was relatively small (n = 30), which may limit the generalizability of the findings to a larger population. Being a single-center study conducted at a tertiary care hospital, the results may not fully represent the broader community or primary care settings. Additionally, the study relied on the expertise of radiologists and surgeons, which may introduce observer variability in interpretation of MRI and arthroscopic findings. Partial ligament tears and complex injuries may have contributed to discrepancies between MRI and arthroscopy, affecting sensitivity and specificity values. Furthermore, long-term follow-up of patients was not included, limiting the assessment of clinical outcomes in relation to imaging findings.

RECOMMENDATIONS

Based on the findings of this study, MRI should be considered as the primary imaging modality for evaluation of suspected knee ligament injuries due to its high diagnostic accuracy and non-invasive nature. Routine use of MRI can help in early diagnosis, appropriate treatment planning, and reduction of unnecessary diagnostic arthroscopies. Larger multicentric studies with increased sample size are recommended to validate these findings and improve external applicability. Standardization of MRI protocols and reporting systems may further enhance diagnostic consistency. Future research should also focus on correlating MRI findings with long-term clinical and functional outcomes, as well as exploring advanced imaging techniques to improve detection of partial and complex ligament injuries.

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