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The Correlation of Anterior Cruciate Ligament Tear on Mri With Arthroscopic Findings – A Prospective Observational Study

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ABSTRACT

Background: Anterior cruciate ligament (ACL) injuries are among the most frequent causes of knee instability in young adults. Magnetic resonance imaging (MRI) is widely used for non-invasive diagnosis, while arthroscopy remains the gold standard. **Objective:** To evaluate the diagnostic accuracy of MRI in ACL tears by comparing findings with arthroscopy. **Methods:** This prospective observational study was conducted between May 2023 and January 2025 on 40 patients (18–65 years) with clinically suspected ACL injuries. MRI was performed on a 1.5T Siemens system using standard knee protocols. Arthroscopy served as the reference standard. Diagnostic indices—sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy—were calculated. **Results:** Mean patient age was 33.9 ± 11.3 years; 82.5% were male. Slip and fall (35%), road traffic accidents (27.5%), and sports injuries (27.5%) were the commonest causes. MRI detected complete ACL tears in 57.5%, partial tears in 27.5%, and interstitial edema in 15%. Arthroscopy confirmed complete tears in 70% and partial tears in 17.5%. The femoral attachment was the most frequent tear site (65% on MRI; 72.5% on arthroscopy). MRI demonstrated a sensitivity of 94.29%, specificity of 80.00%, PPV of 97.06%, NPV of 66.67%, and overall accuracy of 92.50%. **Conclusion:** MRI is a highly sensitive and accurate modality for diagnosing ACL tears and should be considered a first-line investigation. However, arthroscopy remains the gold standard for definitive diagnosis and therapeutic intervention.

INTRODUCTION:

The knee joint is the largest and most complex synovial joint in the human body, comprising the articulation between the femur, tibia, and patella. Structurally, it consists of a sellar joint between the patella and femur, and two condylar joints between the tibial and femoral condyles.[1] Its stability depends heavily on ligamentous support; therefore, ligament injuries are frequent and range from mild sprains to complete ruptures with associated fractures.[2] The principal stabilisers are the cruciate ligaments, which prevent anterior–posterior translation and provide a pivot point for rotational

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movements of the tibia over the femur.[3]

The menisci are crescent-shaped fibrocartilaginous structures interposed between the femoral condyles and tibial plateau. They function to absorb shock, enhance stability, and distribute weight evenly across the knee joint, thereby protecting articular cartilage.[4] Injuries to the cruciate ligaments and menisci occur commonly in sports and road traffic accidents, and when left untreated, can accelerate degenerative changes leading to osteoarthritis.[5] Anterior cruciate ligament (ACL) injury is one of the most common knee injuries worldwide. It is most frequently encountered during high-impact activities such as pivoting sports, jumping, or sudden deceleration, but in the Indian context, road traffic accidents and slip-and-fall injuries are also major causes. Obesity has also been identified as a risk factor contributing to ligamentous tears.[6] These injuries compromise the stability and normal function of the knee, leading to difficulty in walking, weight-bearing, and daily activities, thereby creating a significant physical and socioeconomic burden.

Clinical diagnosis remains the first step in evaluating ACL injury. History and examination are essential, with joint line tenderness, Apley's test, McMurray's test, Lachman's test, and the anterior drawer test being commonly performed.[7] Each test has varying sensitivity and specificity, and accuracy is reduced in the acute setting due to swelling and guarding. Clinical suspicion therefore often requires confirmation by imaging.

Radiological modalities play a crucial role in knee evaluation. Conventional radiographs are useful mainly to exclude fractures, as soft tissues are poorly visualised.[8] Fluoroscopy and ultrasound may guide interventional procedures, while CT is reserved for complex bony injuries. Arthroscopy, although considered the gold standard for intra-articular diagnosis, is invasive, requires anaesthesia, and carries risks such as infection, hemarthrosis, and iatrogenic cartilage damage.[9]

Magnetic resonance imaging (MRI) has revolutionised the non-invasive assessment of ACL injuries since its introduction in the 1980s. It provides high-resolution multiplanar imaging of soft tissues without ionising radiation. MRI allows direct visualisation of the ACL, menisci, collateral ligaments, articular cartilage, and bone marrow. Reported accuracy for MRI in ACL tear detection varies between 77% and 96% across different studies, making it an ideal pre-arthroscopy screening tool.[10]
MRI features of ACL tear include primary signs such as fibre discontinuity, abnormal orientation, and increased intraligamentous signal intensity. The sagittal plane is particularly valuable for demonstrating non-parallel orientation of the ligament with Blumensaat's line. Secondary signs include bone contusions on the lateral femoral condyle and posterolateral tibial plateau, anterior tibial translation, PCL buckling, and positive posterior femoral line sign.[11] Collectively, these findings enhance diagnostic accuracy and help differentiate between complete and partial tears.

Despite the high accuracy of MRI, arthroscopy continues to serve as the reference standard because of its direct visualisation and therapeutic capability. Studies have shown that MRI and arthroscopy are highly concordant in diagnosing ACL tears, though MRI can occasionally overestimate partial tears or miss chronic/degenerative lesions.[12]

Early and accurate diagnosis of ACL injuries is crucial, especially in young active individuals. Untreated ACL deficiency predisposes to recurrent instability, secondary meniscal and chondral damage, and early osteoarthritis. Literature supports early reconstruction in such cases to prevent long-term sequelae. In this context, MRI serves as an indispensable first-line investigation, guiding clinical decisions and reducing the need for purely diagnostic arthroscopies.

However, in the Indian setting, there is still limited prospective evidence correlating MRI findings directly with arthroscopic outcomes. Most available data are from Western populations, with fewer large studies from India addressing variations in injury mechanisms and diagnostic accuracy. Thus, this study was undertaken to evaluate the correlation between MRI and arthroscopic findings in ACL tears at our institution, aiming to determine the sensitivity, specificity, and accuracy of MRI in an Indian cohort.

AIMS AND OBJECTIVES:

1. To assess the sensitivity and specificity of MRI findings with respect to Arthroscopy in diagnosing ACL tears.
2. To evaluate the diagnostic accuracy of MRI in Anterior Cruciate Ligament tears by comparing the observations with the arthroscopic findings.

MATERIALS AND METHODS:

Study Design and Setting:

Prospective observational study conducted at the Department of Radiodiagnosis, Government Medical College & Rajindra Hospital, Patiala, between May 2023 and January 2025.

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Sample:
Forty patients (33 males, 7 females; age range 18–65 years) clinically suspected to have ACL injuries.

Inclusion criteria:
- Age 18–65 years
- Clinically suspected traumatic ACL tear

Exclusion Criteria:
- Patients unfit for undergoing MRI
- Patients with major trauma and unstable vitals
- Patients with degenerative knee diseases
- Patients with intra-articular fractures, patellar dislocations, extra-articular ligament injuries
- Patients with previous injury or surgery involving the same joint Imaging Protocol

Study Procedure:
MRI was performed on a 1.5 Tesla Siemens MAGNETOM AERA system using a dedicated knee coil. Sequences included:
- Proton density fat-suppressed (sagittal, coronal, axial, coronal oblique)
- T2-weighted fat-suppressed (sagittal, axial)
- T1-weighted (sagittal, coronal, axial)

DIAGNOSTIC CRITERIA
Primary Signs:
- Swelling of ligament
- Increased signal intensity on T2 or PD fat-saturated images
- Fiber discontinuity
- Abnormal ACL orientation relative to Blumensaat's line
- Empty notch sign

Secondary Signs:
- Bone contusions in lateral femoral condyle
- Increased anterior tibial translocation
- Segond fracture
- Buckling of PCL Reference Standard

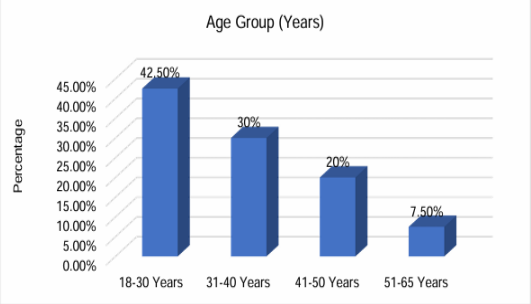
All patients underwent diagnostic and/or therapeutic arthroscopy performed by the orthopaedics team.

Statistical Analysis:
Sensitivity, specificity, PPV, NPV, and accuracy were calculated using a 2×2 contingency table with arthroscopy as the gold standard.

RESULTS

Table No. 1:- Demographics and Clinical Profile

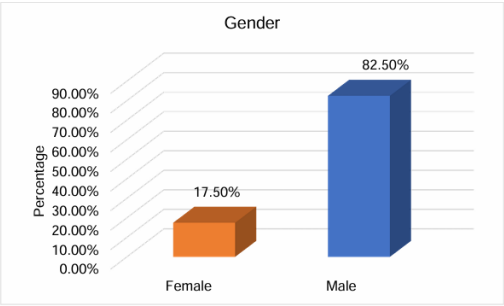
Age Group (Years)	Number of Patients	Percentage
18–30	17	42.5%
31–40	12	30.0%
41–50	8	20.0%
51–65	3	7.5%
Total	**40**	**100%**



The age distribution included in our study was from 18-65yrs. The majority of patients (42.5%) were in the 18–30 year age group, followed by 30% in 31–40 years, 20% in 41–50 years, and only 7.5% in the 51–65 year group.

Table 2: Gender Distribution Of Patients

Gender	Number of Patients	Percentage
Female	7	17.5%
Male	33	82.5%
Total	**40**	**100%**



In the present study, out of 40 patients assessed for knee injuries, 33 (82.5%) were male and 7 (17.5%) were female, indicating a clear male predominance. The difference in gender distribution was found to be significant, with a chi-square value of 16.9 (df = 1, $p < 0.001$), suggesting that the probability was significantly greater among males to present with knee injuries.

Table no. 3: Mode of Injury

Mode of Injury	Number of Patients	Percentage
Road Side Accident (RSA)	11	27.5%
Sports Injury	11	27.5%
Trivial Injury	4	10.0%
Slip/Fall	14	35.0%
Total	**40**	**100%**

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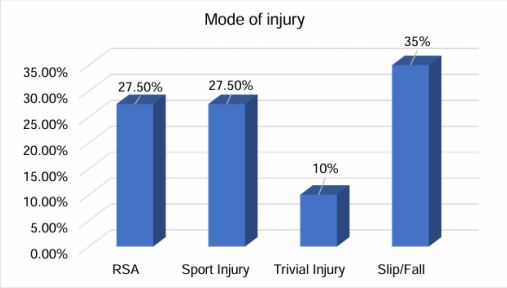
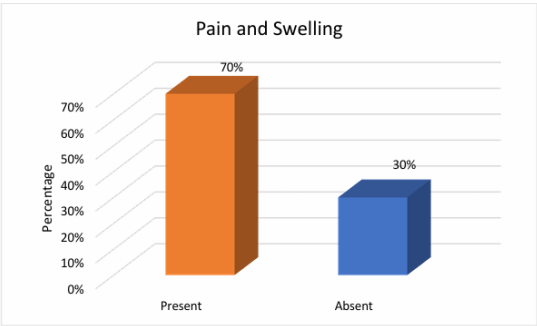


Among the 40 patients, the most common mode of injury was slip and fall, seen in 14 patients (35%), followed by road traffic accidents (RSA) and sports injuries, each accounting for 11 cases (27.5%). Trivial injuries were reported in 4 patients (10%). The chi-square value was 10.4 (df = 4, p = 0.034), indicating a statistically significant variation in the mode of injury.

Table no. 4: Associated Pain and Swelling.

Pain and Swelling	Number of Patients	Percentage
Present	28	70%
Absent	12	30%
Total	**40**	**100%**



Out of 40 patients, 28 (70%) reported pain and swelling, while 12 (30%) patients pain and swelling was absent. The chi-square value was 6.4 (df = 1, p ≈ 0.011), indicating a statistically significant difference in the presence of pain and swelling among the study population. This suggests that pain with swelling is a significantly common clinical presentation in ACL injuries

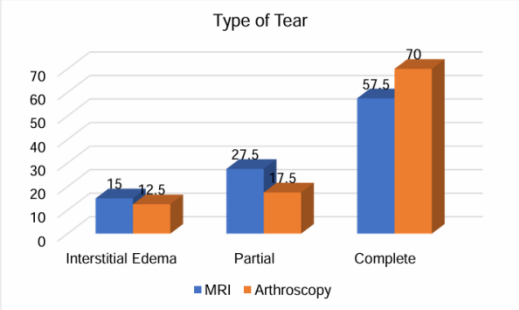
Table no. 5: Associated Injuries

Associated Injury	Number of Patients	Percentage
Complete PCL Tear	3	7.5%
Medial Meniscus Tear	10	25.0%
None	27	67.5%
Total	40	100%

The most frequently observed accompanying finding was a medial meniscus tear in 10 patients (25%), followed by complete PCL tear in 3 (7.5%). The chi-square test yielded a value of 17.3 (df = 4, p = 0.002), indicating a statistically significant variation in the distribution of associated injuries. This highlights that associated injuries, particularly medial meniscus involvement, are commonly observed alongside ACL pathology, likely due to rotational or valgus stress, which are typical mechanisms of ACL injury, as the medial meniscus gets trapped between the femur and tibia.

Table no. 6: Type of Tear

Type of ACL Injury (MRI)	Number of Patients	Percentage
Interstitial Edema	6	15.0%
Partial Tear	11	27.5%
Complete Tear	23	57.5%
Total	40	100%
Type of ACL Injury (Arthroscopy)	**Number of Patients**	**Percentage**
Interstitial Edema	5	12.5%
Partial Tear	7	17.5%
Complete Tear	28	70.0%
Total	40	100%



	Arthroscopy Present	Arthroscopy Absent	Total
MRI Present	33 (True Positive)	1 (False Positive)	34
MRI Absent	2 (False Negative)	4 (True Negative)	6
Total	35	5	40

Out of 40 patients, MRI identified tears in 34 cases, with 33 confirmed by arthroscopy (true positives) and 1 false positive. Among the 6 MRI-negative cases, 2 were false negatives and 4 were true negatives. The diagnostic performance of MRI showed a sensitivity of 94.29%, specificity of 80.00%, positive predictive value (PPV) of 97.06%, negative predictive value (NPV) of 66.67%, and an overall diagnostic accuracy of 92.50%. The chi-square value was 14.74 (df = 1, p = 0.001), indicating a statistically significant correlation between MRI and arthroscopic findings. These results confirm MRI as a highly sensitive and accurate tool for detecting intra-articular knee tears, reinforcing its role in preoperative assessment.

DISCUSSION:

Discussion:

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In our study, the majority of patients with ACL tears were **young adults**, with a mean age of 33.9 years and 42.5% between 18–30 years. This age profile aligns with Sanders et al. (2016), who reported peak incidence in the second and third decades[13], and with Madurwar et al.[14] and Kushbu et al., who similarly noted the highest frequency in younger patients.[15]

In the present study, **males constituted 82.5%** of cases, showing a clear male predominance. This finding is consistent with **Mlv et al. (2023)**, who reported 91.1% males among 124 patients with ACL injuries, and attributed this to greater involvement of men in risk-taking activities, occupational hazards, and higher exposure to road traffic accidents in developing regions.[16] Similarly, **Madurwar et al.** observed 84% males in their series, further supporting the trend.[14] Taken together, these results indicate that male predominance is a consistent feature in ACL epidemiology, reflecting both demographic and lifestyle factors.

In the present study, the **commonest mode of ACL injury was slip and fall (35%)**, followed by **sports injuries (27.5%)** and **road traffic accidents (27.5%)**, with trivial trauma accounting for 10%. This contrasts with Western literature, where sports predominate, but aligns with South Asian data. A Nepalese study reported RTAs (38.8%) as the leading cause, while **Ahmed et al.** highlighted that even low-velocity vehicle accidents can result in ACL tears.[17] These findings suggest that in developing regions, ACL injuries arise from a broader spectrum of trauma, necessitating region-specific prevention strategies.

In our study, **pain and swelling were present in 70% of patients**, confirming that these are common presenting features of ACL injuries. Swelling, often due to hemarthrosis or synovial irritation, is a well-recognized hallmark of acute ACL tears. **Kushbu et al.** reported joint effusion in 52% of patients on MRI,[15] while **Evans et al.** observed that nearly 70% of patients experience immediate swelling following ACL rupture, often accompanied by a sudden “pop” and deep knee pain.[17] These findings highlight that while pain and swelling are important early indicators, they are not universally present, reinforcing the role of MRI for definitive diagnosis.

In our study, the most common associated lesion was a medial meniscus tear (25%), followed by PCL tears (7.5%). This is lower than reported by Mander et al. (57.5% medial meniscus)[19] and Iqbal Khan et al. (2020) (92% medial meniscus), through their series involved more chronic cases.[20] These differences highlight the variability of associated injury profiles and the importance of comprehensive MRI evaluation in suspected ACL tears.

In our study, MRI demonstrated a **sensitivity of 94.29%, specificity of 80%, PPV of 97.06%, NPV of 66.67%, and overall accuracy of 92.5%**, showing partial concordance with arthroscopy. These findings are consistent with **Navali et al. (2013)**, who reported sensitivity of 98.6% and accuracy of 92.5%,[21] and **Rayan et al. (2009)**, who observed accuracy of 93%.[22] Similarly, **Mallula et al. (2020)** documented sensitivity and accuracy of 100% and 95%, respectively, further supporting the reliability of MRI as a diagnostic tool.[23] By contrast, **Mohabey et al. (2020)** reported lower sensitivity (76.9%) and accuracy (65.6%), emphasizing that MRI performance may vary with technique and interpretation.[24] Overall, our results reaffirm MRI as a highly sensitive, accurate, and non-invasive modality for evaluating ACL tears, though arthroscopy remains the gold standard.

Thus, our findings corroborate the existing literature that MRI is a highly sensitive and reliable tool for ACL tear diagnosis, with the advantage of detecting associated injuries. However, subtle differences between MRI and arthroscopy, particularly in partial tears, reinforce that arthroscopy remains the definitive gold standard for diagnosis and management.

Strengths: Prospective design, direct MRI–arthroscopy correlation.
Limitations: Small sample size, single-center study, inter-observer variability not assessed.
Clinical Implications: MRI can reduce unnecessary diagnostic arthroscopies and guide surgical planning, but arthroscopy should remain the confirmatory and therapeutic modality.

CONCLUSION:

MRI is a highly sensitive and accurate investigation for ACL tears, particularly for detecting complete disruptions and localizing tear sites. It should be considered the first-line diagnostic tool in suspected ACL injuries. Arthroscopy, however, remains indispensable as the gold standard for definitive diagnosis and management.

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