

# Clinical Tests and MRI in the Evaluation of Anterior Cruciate Ligament Injuries: A Comparative Study with Arthroscopic Findings

Sushant Kumar Khadka<sup>1</sup>, MS; Ram Lal Chaudhary<sup>2</sup>, MS; Ashkal Basi<sup>3</sup>, MS; Manasil Malla<sup>4</sup>, MS; Dipak Shrestha<sup>3</sup>, MS

<sup>1</sup>Department of Orthopaedics, Sindhuli Hospital, Sindhuli

<sup>2</sup>Department of Orthopaedics, Shreeaga Hospital, Kohalpur, Banke

<sup>3</sup>Department of Orthopaedics, Dhulikhel Hospital, Kathmandu University, Dhulikhel

<sup>4</sup>Department of Orthopaedics, Kathmandu Medical College, Kathmandu

## ABSTRACT

### Background:

Accurate diagnosis of Anterior Cruciate Ligament (ACL) injuries is essential for optimal management. While clinical examination and Magnetic Resonance Imaging (MRI) are standard, their diagnostic reliability varies. This study aimed to evaluate the diagnostic accuracy of clinical tests and MRI compared to the gold standard of arthroscopy.

### Methods:

A prospective analytical study was conducted at Dhulikhel Hospital (June 2018–March 2020) involving 108 adult patients with suspected ACL or meniscal injuries. Patients underwent clinical evaluation (Anterior Drawer, Lachman, and Pivot Shift tests) and a 1.5-T MRI before undergoing diagnostic arthroscopy. Sensitivity, specificity, and diagnostic accuracy (DA) were calculated.

### Results:

The mean age of patients was 35.41±13.12 years. Arthroscopy confirmed the diagnosis in all cases. Among individual clinical tests, the Lachman test was the most sensitive (78.79%, DA: 84.26%), while the Pivot Shift test was the most specific (97.62%, DA: 79.63%). MRI demonstrated a sensitivity of 86.36% and a specificity of 88.10% (DA: 87.04%). Notably, the combination of any one of the three clinical tests being positive yielded the highest sensitivity (89.39%) and a diagnostic accuracy (87.96%) that surpassed MRI alone.

### Conclusion:

Clinical examination remains a highly reliable tool for diagnosing ACL injuries. The Lachman test is the best “rule-out” screening tool, while the Pivot Shift test is a superior “rule-in” confirmatory test. MRI should be used as a complementary tool for assessing associated pathologies rather than a replacement for thorough clinical evaluation.

**Keywords:** Anterior cruciate ligament injury, Arthroscopy, Sensitivity, Specificity

## Introduction:

Ligamentous injuries are among the most common causes of knee dysfunction, particularly following sports-related trauma and twisting injuries.<sup>1</sup> The anterior cruciate ligament (ACL) plays a critical role in maintaining anteroposterior and rotational stability of the knee, essential for functional and athletic activities.<sup>2</sup> Early and accurate diagnosis of these internal derangements is therefore crucial for optimal management and prevention of further joint damage.

Although numerous clinical tests have been described for diagnosing ACL injuries, their diagnostic accuracy varies considerably. Meta-analyses and clinical studies report inconsistent sensitivities and specificities for commonly used tests, as their reliability is frequently compromised

## Correspondence:

**Ashkal Basi, MS**

Email: ashkal052@gmail.com

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by acute muscle guarding and the varying clinical experience of the examiner.<sup>3</sup> Similarly, magnetic resonance imaging (MRI) has become an important non-invasive modality for evaluating internal derangements of the knee, yet its diagnostic accuracy is not uniformly consistent across studies.<sup>1</sup>

In developing healthcare settings like Nepal, this diagnostic challenge is further compounded by delayed patient presentation, limited access to high-magnetic-field MRI modalities, and the financial constraints that routine imaging imposes on patients. Consequently, a significant knowledge gap remains regarding the most dependable and cost-effective diagnostic pathway when combining physical examination and imaging before proceeding to surgery. Therefore, this study aims to evaluate and correlate clinical tests and MRI findings with arthroscopic findings for ACL injuries in our setting. By determining sensitivity, specificity, predictive values, and overall diagnostic accuracy, this study seeks to identify the most reliable and practical diagnostic approach for our population.

### Methods and Materials:

This hospital-based prospective analytical study was conducted in the Department of Orthopedics and Traumatology at Dhulikhel Hospital, Kathmandu University Hospital, from June 2018 to March 2020, after approval from the Kathmandu University School of Medical Sciences–Institutional Review Committee (KUSMS-IRC: 111/18). Adult patients ( $\geq 16$  years) presenting to orthopedics department with symptoms suggestive of knee instability, pain, or mechanical symptoms attributable to suspected anterior cruciate ligament (ACL) and/or meniscal injuries and were willingness to undergo MRI as a part of further management, and subsequent arthroscopy of the same knee were included in the study. Patients with inflammatory or degenerative arthritis, previous ligament reconstruction, knee dislocations with multi-ligament involvement, absence of MRI, or arthroscopies performed for other indications were excluded. Acute knee injuries, defined as those presenting within six weeks of the initial trauma resulting in the ACL tear, were also excluded to minimize the impact of acute inflammatory changes on the study results. Written informed consent was obtained after detailed explanation of the study.

Sample size was determined following an extensive literature review to identify expected sensitivity/

specificity and minimal acceptable lower confidence limits for each parameter. The method described by Flahault et al.<sup>4</sup> was applied to calculate the minimum required sample for each diagnostic test. The largest calculated value (62 cases) was adopted as the minimum sample size to satisfy assumptions across all evaluated parameters.

All enrolled patients underwent a detailed history taking and physical examination. For ACL assessment, anterior drawer, Lachman, and pivot shift tests were conducted following the standardized techniques described in Clinical Orthopaedic Examination by McRae.<sup>5</sup> To ensure diagnostic consistency, a “positive” result for the Lachman and Anterior Drawer tests was defined as increased anterior tibial translation with a soft end point compared to the contralateral limb. The Pivot Shift was recorded as positive upon a palpable reduction jerk during knee flexion under valgus stress and internal rotation. Any ambiguity in clinical findings was resolved by consensus among two senior orthopedic surgeons.

MRI evaluation was performed using a 1.5-Tesla system (Philips Ingenia) with sagittal, coronal, and axial sequences, including T1, T2, and fat-suppressed proton density images. External MRI films (done at other centers) were accepted if reported by a qualified radiologist. Diagnostic data were derived solely from official reports generated by qualified radiologists to ensure standardized data collection. While surgeons reviewed all MRI films for surgical planning, these interpretations were not included in the statistical analysis to maintain a clear distinction between radiological diagnosis and intraoperative findings. The clinical and MRI findings were documented in a predesigned proforma and subsequently in Microsoft Excel.

A single surgeon, with more than five years experience in arthroscopic knee surgeries, performed diagnostic arthroscopy and therapeutic procedure for the patient care as necessary. The arthroscopic findings served as the gold standard against clinical tests and MRI findings to evaluate the necessary study parameters.

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy (DA) were computed using standard definitions based on true positive, true negative, false positive, and false negative results. Descriptive and analytical statistics were performed

using SPSS version 25. A value of P as 0.05 was considered for statistical significant.

### Results:

One hundred and eight patients were included in this study. The mean age of patients was  $35.41 \pm 13.12$  years and there were 57 (52.80%) males and 51 (47.20%) females (Table 1). Right knee involvement was seen in 62 (57.4%) and the left knee in 46 (42.6%). The mean duration between the clinical and MRI evaluation, and subsequent arthroscopy and the initial index injury was  $11.16 \pm 19.75$  months with a range of one to 120 months. The findings of knee arthroscopy, considering the ultimate gold standard, were summarized as in the figure 1.

**Table 1. Clinico-demographic profile of the patients**

| Age Group (in Years) | Male              | Female            | Total               |
|----------------------|-------------------|-------------------|---------------------|
| 11-20                | 14 (13.0%)        | 6 (5.5%)          | 20 (18.5%)          |
| 21-30                | 20 (18.5%)        | 5 (4.6%)          | 25 (23.1%)          |
| 31-40                | 10 (9.3%)         | 15 (13.9%)        | 25 (23.1%)          |
| 41-50                | 6 (5.5%)          | 15 (13.9%)        | 21 (19.4%)          |
| 51-60                | 4 (3.7%)          | 10 (9.3%)         | 14 (13.0%)          |
| 61-70                | 3 (2.8%)          | 0 (0.0%)          | 3 (2.8%)            |
| <b>Total</b>         | <b>57 (52.8%)</b> | <b>51 (47.2%)</b> | <b>108 (100.0%)</b> |

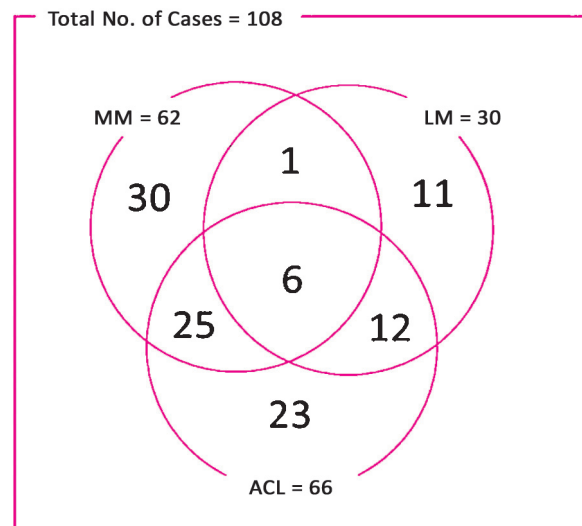


**Figure 1. Descriptive profile of the Arthroscopic finding in the study population**

**Table 2. Mode of Injury of the patients**

| Mode of Injury             | Frequency (Percentage) |
|----------------------------|------------------------|
| Fall from Height           | 7 (6.5%)               |
| Road Traffic Accident      | 8 (7.4%)               |
| Sports Injury              | 28 (25.9%)             |
| Trivial Injury             | 46 (42.6%)             |
| Does Not Recall H/O Trauma | 19 (17.6%)             |
| <b>Total</b>               | <b>108 (100.0%)</b>    |

**Table 3. Summary of study parameters for ACL examined with Anterior drawer test (ADT), Lachman test and Pivot shift test**

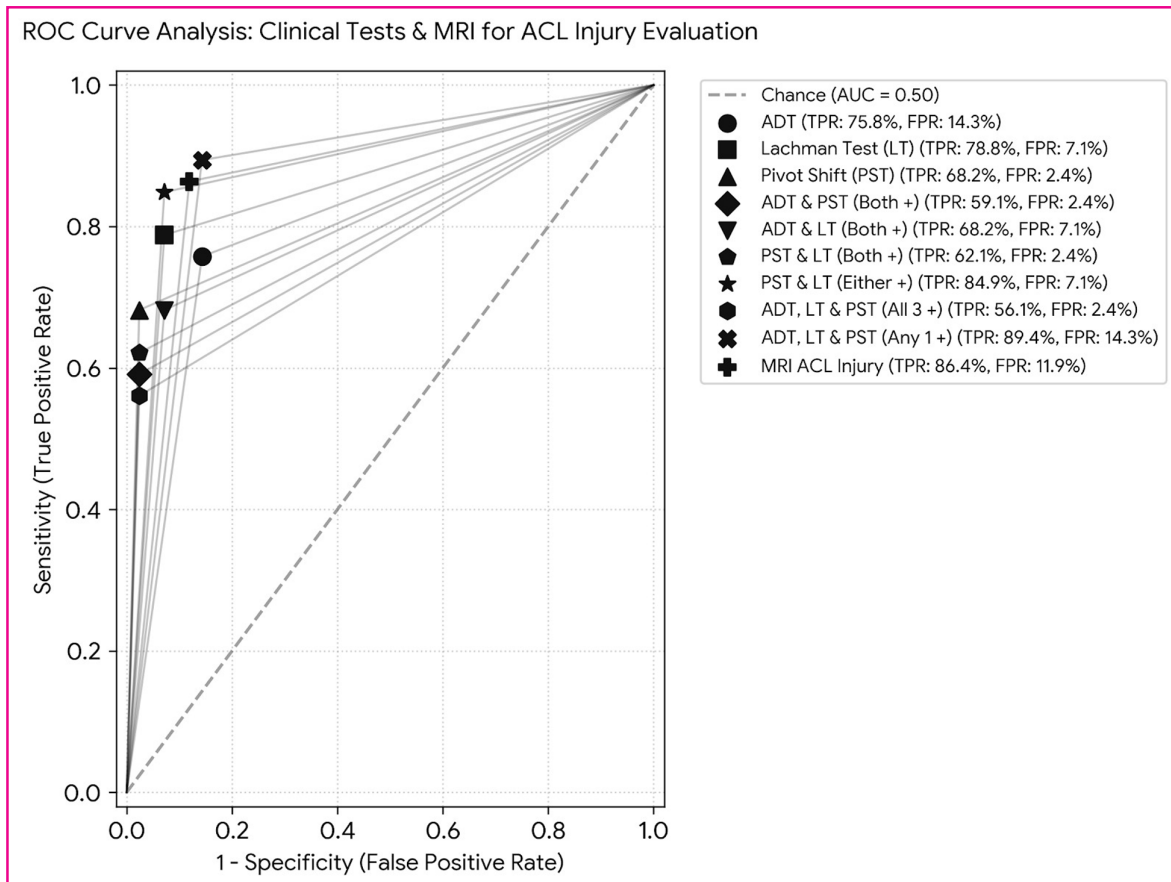
| Test Parameters                  | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Diagnostic Accuracy (%) |
|----------------------------------|-----------------|-----------------|---------|---------|-------------------------|
| ADT                              | 75.76           | 85.71           | 89.29   | 69.23   | 79.63                   |
| LT                               | 78.79           | 92.86           | 94.55   | 73.58   | 84.26                   |
| PST                              | 68.18           | 97.62           | 97.83   | 66.13   | 79.63                   |
| ADT and PST positive             | 59.09           | 97.62           | 97.50   | 60.29   | 74.07                   |
| ADT and LT positive              | 68.18           | 92.86           | 93.75   | 65.00   | 77.78                   |
| PST and LT positive              | 62.12           | 97.62           | 97.62   | 62.12   | 75.93                   |
| ADT and PST either one positive  | 84.85           | 85.71           | 90.32   | 78.26   | 85.19                   |
| ADT and LT either one positive   | 86.36           | 85.71           | 90.48   | 80.00   | 86.11                   |
| PST and LT either one positive   | 84.85           | 92.86           | 94.92   | 79.59   | 87.96                   |
| ADT, LT and PST all positive     | 56.06           | 97.62           | 97.37   | 58.57   | 72.22                   |
| ADT, LT and PST any one positive | 89.39           | 85.71           | 90.77   | 83.72   | 87.96                   |
| MRI ACL injury                   | 86.36           | 88.10           | 91.94   | 80.43   | 87.04                   |

ADT: Anterior Drawer Test, PST: Pivot Shift Test, LT: Lachman Test. PPV: Positive Predictive Value, NPV: Negative Predictive Value.

Considering a single clinical test at a time among the three clinical tests under study, Lachman test was found to be more sensitive (78.79%) and Pivot shift test was found to be more specific (97.62%). Considering two or more tests together, the ability of combined clinical tests to diagnose the ACL injury or to rule it out correctly improved significantly. (Table 3) The above findings were illustrated in Receiving Operating Characteristic (ROC) curves comparing different clinical tests done individually or in combinations for ACL injuries along with that for MRI. (Figure 2)

younger age group (21–30 years), consistent with both regional and international literature.<sup>7–9</sup> This likely reflects greater participation of young males in sports, outdoor activities, and high-risk occupations. Right knee involvement was more common, similar to findings reported by Gopal et al. and Munk et al., possibly related to limb dominance and activity patterns.<sup>7,8</sup>

A notable finding was the delay in presentation, with a mean interval of nearly one year between injury and surgical intervention. Comparable delays have been reported in previous studies;



## Discussion:

Anterior cruciate ligament (ACL) injuries are commonly diagnosed through careful physical examination, often complemented by magnetic resonance imaging (MRI), with arthroscopy regarded as the gold standard for confirmation.<sup>6</sup> The present paper represents a study on heterogeneous Nepalese population presenting to a tertiary care hospital comparing clinical examination and MRI with arthroscopic findings in ACL injuries.

The demographic pattern observed demonstrated a clear male predominance, particularly in the

Tandogan et al. documented a mean delay of 19.8 months, while Collins et al. observed that most patients underwent reconstruction within one year.<sup>10,11</sup> Such delays may be attributed to patient-related factors such as symptom tolerance and limited awareness, as well as physician-related factors such as misdiagnosis or underestimation of instability. Although delayed reconstruction has been associated with secondary intra-articular injuries, the present study focused specifically on diagnostic performance rather than associated pathology.<sup>12–15</sup>

MRI remains the primary non-invasive imaging modality for suspected ACL tears. Previous comparative studies have demonstrated high diagnostic performance of MRI when correlated with arthroscopy.<sup>7-9</sup> In the current study, MRI demonstrated sensitivity of 86.36% for detecting ACL rupture, which aligns with previously reported values generally exceeding sensitivity above 75%.<sup>16,17</sup> The high sensitivity observed in our series may be attributed to the use of high-quality imaging protocols and the diagnostic expertise of a dedicated, experienced senior radiologist who evaluated the vast majority of the scans. Although a few external reports were included, this centralized interpretation minimized observer bias. Nevertheless, observer bias remains an important consideration, especially when reports are generated by multiple radiologists, as occurred with our external cases. Moving forward, standardization of reporting by a dedicated musculoskeletal radiologist could further improve consistency in future investigations.

Clinical examination remains a cornerstone in diagnosis of ACL injuries. Among individual tests evaluated, the Lachman test demonstrated the highest sensitivity in this study, consistent with the meta-analysis by Benjaminse et al., which reported sensitivity of 85% and specificity of 94%.<sup>3</sup> The Lachman test is widely regarded as the most reliable single clinical test for ACL insufficiency, particularly in chronic cases where guarding and pain are minimal. However, lower sensitivities have been reported in acute settings, where hemarthrosis and muscle spasm may obscure accurate assessment.<sup>16</sup> The high sensitivity observed in this study may be related to the involvement of surgeons with over ten years of experience in sports and arthroscopic practice. Utilizing a consensus-based approach to resolve any ambiguous findings likely helped maintain a consistent and accurate diagnostic threshold across our patient cohort.

The pivot shift test, designed to detect rotational instability, demonstrated the highest specificity among individual clinical tests in this study, even surpassing MRI specificity in our study. This aligns with established understanding that pivot shift is highly specific for functional ACL deficiency.<sup>16</sup> Rotational instability is often the most disturbing symptom for patients with ACL rupture, and the pivot shift test directly reproduces this phenomenon. However, its sensitivity is often

limited in awake patients due to apprehension and difficulty in performing the maneuver. Performing the pivot shift test under anesthesia, with its high specificity (97.62%) and positive predictive value, serves as a strong confirmatory (rule-in) test for ACL injury. In contrast, combined clinical testing, with higher sensitivity and negative predictive value, is more useful in excluding ACL injury (rule-out).

Receiver operating characteristic (ROC) curve analysis further supported these findings. MRI demonstrated high overall diagnostic accuracy for ACL injuries, reflected by a large area under the curve (AUC). However, when multiple clinical tests were combined, their discriminatory capacity for ACL injury surpassed that of MRI alone. This finding underscores the continued relevance of comprehensive clinical evaluation in the diagnosis of ACL injuries.

This study has several limitations. First, the pivot shift test findings were not stratified based on whether the examination was performed in the outpatient setting or under anesthesia, which may have affected its diagnostic accuracy. Second, subgroup analysis comparing isolated ACL injuries with combined ligamentous or meniscal injuries was not performed. Such analysis could provide more precise estimates of diagnostic performance.

### Conclusions:

This study demonstrates that clinical examination remains highly effective in the diagnosis of ACL injuries. Among individual tests, the Lachman test showed the highest sensitivity, while the pivot shift test demonstrated the highest specificity, even comparable to or slightly exceeding that of MRI in this study. The diagnostic accuracy was further enhanced when multiple clinical tests were used in combination, reinforcing the principle that no single test is sufficient in isolation.

Although MRI is a valuable non-invasive tool, its role should be considered complementary primarily for delineating associated intra-articular pathology and preoperative planning rather than for routine confirmation of ACL injury, which can be reliably established through thorough clinical evaluation.

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