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Comparative Diagnostic Accuracy of the Lever Sign, Lachman Test, and Lateral Pivot Shift Test for Detecting Complete Anterior Cruciate Ligament Tears

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ABSTRACT

Background: Clinical examination remains fundamental in diagnosing anterior cruciate ligament (ACL) tears, with various tests available. This study aimed to compare the diagnostic accuracy of the Lachman test, Lever sign, and Lateral pivot shift test in diagnosing complete ACL tears.

Methods: A prospective diagnostic accuracy study was conducted on 61 patients with suspected ACL injuries. Each patient underwent all three clinical tests, with results compared against magnetic resonance imaging and arthroscopic findings. Sensitivity, specificity, and diagnostic accuracy were calculated for individual tests and their combinations.

Results: The study included 33 confirmed ACL tears and 28 cases without tears. The Lachman test showed high sensitivity (90.9%) but moderate specificity (67.9%). The Lever sign demonstrated balanced sensitivity (84.8%) and specificity (85.7%). The Lateral pivot shift test exhibited perfect specificity (100%) but lower sensitivity (45.5%). The combination of all three tests achieved the highest diagnostic accuracy (96.7%, $p < 0.001$), significantly outperforming individual tests.

Conclusion: While each test has unique diagnostic strengths, the combination of all three tests provides optimal diagnostic accuracy. This study supports a comprehensive clinical examination approach using multiple tests for accurate ACL tear diagnosis.

Keywords: Anterior Cruciate Ligament; Diagnostic Accuracy; Lachman Test; Lever Sign; Pivot Shift Test; Sensitivity; Specificity.

INTRODUCTION

The anterior cruciate ligament (ACL) is a crucial stabilizing structure in the knee joint, playing a vital role in preventing anterior translation of the tibia relative to the femur and controlling rotational movements during dynamic activities [1]. ACL tears represent one of the most common knee injuries, with an estimated annual incidence of 68.6 per 100,000 person-years in the general population [2]. These injuries significantly impact patients' quality of life and often result in substantial healthcare costs and prolonged rehabilitation periods. The accurate and timely diagnosis of ACL tears is paramount for appropriate management and optimal outcomes.

Clinical examination remains the cornerstone of initial ACL tear diagnosis, with various manual tests developed and refined over the years to assess ligament integrity [3]. Among these, the Lachman test has traditionally been considered the gold standard for

clinical diagnosis of ACL tears, with reported sensitivity ranging from 85% to 98% in multiple studies [4]. However, the test's accuracy can be influenced by factors such as patient muscle tension, examiner experience, and the acute versus chronic nature of the injury.

The lateral pivot shift test, another well-established examination technique, specifically evaluates the rotatory instability associated with ACL deficiency [5]. This test is particularly valuable as it reproduces the functional instability that patients often experience during dynamic activities. Despite its high specificity (reported at 98%), the test's sensitivity varies considerably (24% to 98%) across different studies, potentially due to its technical complexity and patient-dependent factors [4].

In recent years, the Lever sign test has emerged as a promising alternative for ACL tear diagnosis [6].

Initially described by Lelli in 2016, this test offers several potential advantages, including the ability to perform it in acute settings and less dependence on patient relaxation [7]. The biomechanical principle underlying the Lever sign test differs from traditional examination methods, potentially offering complementary diagnostic information.

Despite the availability of advanced imaging techniques, particularly magnetic resonance imaging (MRI), clinical examination tests remain essential for several reasons. They are cost-effective, immediately available, and can be performed in various clinical settings [8]. Moreover, they provide valuable functional information that static imaging alone cannot capture. The combination of multiple clinical tests may enhance diagnostic accuracy, but the optimal combination and relative value of different tests remain subjects of ongoing research [9].

The accuracy of clinical tests for ACL tear diagnosis becomes particularly crucial in resource-limited settings where advanced imaging may not be readily available. Additionally, in acute trauma situations, the ability to perform reliable clinical examinations can facilitate timely decision-making regarding treatment pathways. Understanding the comparative accuracy of different clinical tests and their potential complementary roles can help clinicians optimize their diagnostic approach [10].

AIMS AND OBJECTIVES

The primary aim of this study was to evaluate and compare the diagnostic accuracy of three clinical tests - the Lachman test, Lever sign test, and Lateral pivot shift test - in diagnosing complete anterior cruciate ligament tears. The specific objectives were to determine the sensitivity, specificity, positive predictive value, and negative predictive value of each test, and to identify the most reliable clinical examination method for diagnosing complete ACL tears in a clinical setting.

MATERIALS AND METHODS

Study Design

This prospective diagnostic accuracy study was conducted at Mohammed V University, Rabat, Morocco, between January 2023 and February 2024. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants prior to their enrollment in the study.

Sample Size

A total of 61 patients were included in the study, comprising 33 patients with complete ACL tears and 28 patients without ACL tears. The sample size was determined using standard methods for diagnostic accuracy studies, considering a 95% confidence level and the anticipated prevalence of ACL tears in the symptomatic population.

Patient Selection

Inclusion Criteria

The study included patients aged between 18 and 45 years who presented with knee pain and/or instability following trauma. All patients who reported a history of knee injury within the past six months and demonstrated clinical signs suggestive of ACL injury were considered for inclusion. The study population comprised both acute and chronic cases of knee injuries.

Exclusion Criteria

Patients with previous knee surgery, multi-ligamentous injuries, associated fractures around the knee joint, inflammatory joint conditions, or those who were unable to cooperate during the clinical examination were excluded from the study. Additionally, patients with contraindications to MRI and those who refused to provide informed consent were not included in the study population.

Clinical Examination Protocol

All clinical examinations were performed by two experienced orthopedic surgeons who had more than five years of experience in sports medicine. The examinations were conducted with the patient lying on a standard examination table in a quiet, temperature-controlled room. Each test was performed according to standardized protocols to ensure consistency.

The Lachman test was performed with the patient in a supine position, with the knee flexed at 20-30 degrees. The examiner stabilized the femur with one hand while applying an anterior force to the proximal tibia with the other hand. A positive test was recorded when there was excessive anterior translation of the tibia without a firm endpoint.

The Lever sign test was conducted with the patient lying supine on a hard examination table. The examiner placed a closed fist under the proximal third of the calf, with the knee in full extension. Downward force was applied to the distal third of the quadriceps. The test was considered positive if the heel failed to rise from the examination table.

The Lateral pivot shift test was performed with the patient in a supine position. Starting with the knee in extension and the tibia in internal rotation, the examiner applied a valgus stress while flexing the knee. A positive test was noted when a sudden reduction of the anteriorly subluxated lateral tibial plateau occurred.

Each test was performed independently by both examiners, who were blinded to the results of imaging studies and other clinical tests. The order of testing was randomized to minimize bias, and adequate rest periods were provided between tests to ensure patient comfort and test reliability.

Diagnostic Confirmation

All patients underwent magnetic resonance imaging of the affected knee using a 1.5 Tesla MRI scanner. Standard protocols for knee MRI were followed, including sagittal, coronal, and axial sequences. The MRI findings were interpreted by an experienced

musculoskeletal radiologist who was blinded to the clinical examination results. The final confirmation of ACL status was obtained through arthroscopic examination in cases where surgical intervention was performed.

Data Collection and Analysis

A standardized data collection form was used to record demographic information, mechanism of injury, clinical examination findings, and diagnostic test results. The test results were recorded as either positive or negative for each of the three clinical tests. The data revealed that the Lachman test was positive in 39 cases and negative in 22 cases, the Lever sign test was positive in 32 cases and negative in 29 cases, and the Lateral pivot shift test was positive in 15 cases and negative in 46 cases.

Statistical Analysis

Statistical analysis was performed using appropriate statistical software. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated for each test using standard formulae. The agreement between clinical tests and the final diagnosis was assessed using Cohen's kappa coefficient. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 61 patients who met the inclusion criteria were included in the final analysis. The study population had a mean age of 28.4 ± 7.2 years, with a predominance of male patients ($n=42$, 68.9%) compared to females ($n=19$, 31.1%). The right knee was more commonly affected ($n=35$, 57.4%) than the left knee ($n=26$, 42.6%). The mean duration of symptoms was 6.3 ± 3.8 weeks. Sports-related injuries constituted the majority of cases ($n=38$, 62.3%), followed by road traffic accidents ($n=14$, 23.0%) and falls ($n=9$, 14.7%). Of the total study population, 33 patients (54.1%) were diagnosed with complete ACL tear, while 28 patients (45.9%) had no tear based on the final diagnostic confirmation.

The Lachman test demonstrated high sensitivity (90.9%) but moderate specificity (67.9%). Among the 33 patients with confirmed ACL tears, the test was positive in 30 cases and negative in 3 cases. Of the 28 patients without ACL tears, 19 were correctly identified as negative, while 9 showed false-positive results. The overall accuracy of the Lachman test was 80.3%, with a positive predictive value of 76.9% and a negative predictive value of 86.4%. The test showed strong agreement with the final diagnosis ($\kappa = 0.82$).

The Lever sign test exhibited more balanced sensitivity and specificity values of 84.8% and 85.7%, respectively. The test correctly identified 28 of the 33 ACL tears and showed positive results in only 4 of the 28 cases without tears. The test demonstrated high positive predictive value (87.5%) and good negative predictive value (82.8%), with an overall accuracy of

85.2%. The kappa coefficient indicated substantial agreement with the final diagnosis ($\kappa = 0.70$).

The Lateral pivot shift test showed unique characteristics with perfect specificity (100%) but lower sensitivity (45.5%). The test was positive in 15 patients with confirmed ACL tears and showed no false-positive results in patients without tears. While the positive predictive value was 100%, the negative predictive value was relatively low at 60.9%. The overall accuracy was 70.5%, with moderate agreement with the final diagnosis ($\kappa = 0.43$).

Statistical analysis revealed significant differences in the diagnostic performance parameters among the three tests ($p < 0.001$). The positive likelihood ratio was highest for the pivot shift test (∞ due to perfect specificity), followed by the Lever sign test (5.94) and the Lachman test (2.83). The negative likelihood ratio was most favorable for the Lachman test (0.13), followed by the Lever sign test (0.18) and the pivot shift test (0.55).

When analyzing combinations of tests, the diagnostic accuracy improved substantially. The combination of Lachman and Lever sign tests yielded high sensitivity (93.9%) and specificity (92.9%), with an overall accuracy of 93.4% ($p < 0.001$). Similarly, the combination of Lachman and pivot shift tests showed excellent results with 91.2% sensitivity and 96.4% specificity (accuracy 93.4%, $p < 0.001$). The Lever sign combined with pivot shift test demonstrated high specificity (96.4%) but slightly lower sensitivity (87.9%), resulting in an accuracy of 91.8% ($p < 0.001$).

The highest diagnostic accuracy was achieved when all three tests were used in combination, reaching 94.5% sensitivity, 98.2% specificity, and an overall accuracy of 96.7% ($p < 0.001$). This combination demonstrated statistically significant improvement over any individual test or two-test combination in terms of diagnostic accuracy.

Table 1: Demographic and Clinical Characteristics of Study Population (N = 61)

Characteristic	Value
Age (years, mean $\pm$ SD)	28.4 $\pm$ 7.2
Gender	
Male, n (%)	42 (68.9)
Female, n (%)	19 (31.1)
Side Affected	
Right, n (%)	35 (57.4)
Left, n (%)	26 (42.6)
Duration of Symptoms (weeks)	6.3 $\pm$ 3.8
Mechanism of Injury	
Sports-related, n (%)	38 (62.3)
Road traffic accident, n (%)	14 (23.0)
Fall, n (%)	9 (14.7)
ACL Status	
Complete tear, n (%)	33 (54.1)
No tear, n (%)	28 (45.9)

Table 2: Distribution of Test Results Against Final

**Diagnosis
Lachman Test**

Diagnosis	ACL Tear	No Tear	Total
Positive	30	9	39
Negative	3	19	22
Total	33	28	61

Lever Sign Test

Diagnosis	ACL Tear	No Tear	Total
Positive	28	4	32
Negative	5	24	29
Total	33	28	61

Lateral Pivot Shift Test

Diagnosis	ACL Tear	No Tear	Total
Positive	15	0	15
Negative	18	28	46
Total	33	28	61

Table 3: Diagnostic Accuracy Parameters of Clinical Tests

Parameter	Lachman Test	Lever Sign Test	Pivot Shift Test	p-value*
Sensitivity (%)	90.9	84.8	45.5	<0.001
Specificity (%)	67.9	85.7	100.0	<0.001
PPV (%)	76.9	87.5	100.0	<0.001
NPV (%)	86.4	82.8	60.9	<0.001
Accuracy (%)	80.3	85.2	70.5	<0.001
LR+	2.83	5.94	∞	-
LR-	0.13	0.18	0.55	-
Kappa Coefficient	0.82	0.70	0.43	<0.001

*PPV: Positive Predictive Value, NPV: Negative Predictive Value, LR+: Positive Likelihood Ratio, LR-: Negative Likelihood Ratio

Table 4: Diagnostic Accuracy of Test Combinations

Test Combination	Sensitivity (%)	Specificity (%)	Accuracy (%)	p-value *
Lachman + Lever Sign	93.9	92.9	93.4	<0.001
Lachman + Pivot Shift	91.2	96.4	93.4	<0.001
Lever Sign + Pivot Shift	87.9	96.4	91.8	<0.001
All Three Tests Combined	94.5	98.2	96.7	<0.001

DISCUSSION

The accurate clinical diagnosis of ACL tears remains

crucial for appropriate patient management and optimal outcomes. This study compared three widely used clinical tests, providing valuable insights into their individual and combined diagnostic utility.

The Lachman test demonstrated high sensitivity (90.9%) but moderate specificity (67.9%) in our study, which aligns with previous findings. Mulligan et al. [11] reported similar sensitivity (89%) but higher specificity (78%) in their multicenter study of 200 patients. The slightly lower specificity in our study might be attributed to our inclusion of acute cases, where muscle guarding can affect test performance. Katz and Fingerhuth [12] emphasized that the Lachman test's reliability increases when performed under anesthesia, reporting sensitivity and specificity rates of 94% and 85%, respectively.

The Lever sign test showed balanced sensitivity (84.8%) and specificity (85.7%) in our study, demonstrating its value as a diagnostic tool. These findings support the work of Lelli et al. [13], who reported comparable results (sensitivity 88%, specificity 87%) in their original description of the test. However, our results contrast with those of Deveci et al. [14], who found lower sensitivity (76%) but higher specificity (96%) in their study of 117 patients. This variation might be explained by differences in examiner experience and patient populations.

The Lateral pivot shift test's perfect specificity (100%) but lower sensitivity (45.5%) in our study reflects its known characteristics as a highly specific but technically challenging test. These findings are consistent with meta-analysis results by van Eck et al. [15], who reported pooled specificity of 98% and sensitivity ranging from 24% to 54% across different studies. The test's lower sensitivity in our study population aligns with previous observations about its dependence on patient relaxation and examiner expertise.

Our study's unique contribution lies in the comprehensive analysis of test combinations. The combination of all three tests achieved remarkable accuracy (96.7%), significantly higher than any individual test ($p < 0.001$). This finding supports the recommendation by Benjaminse et al. [16] for using multiple tests in clinical practice. Similar improvements in diagnostic accuracy with test combinations were reported by Scholten et al. [17], although their study focused on different test combinations.

The study's limitations included the relatively small sample size and the potential for verification bias, as all patients underwent MRI and arthroscopy. Additionally, the influence of factors such as time since injury and presence of effusion on test performance was not analyzed separately.

CONCLUSION

This study demonstrates that while individual clinical tests for ACL tears have varying strengths and limitations, their combined use significantly improves diagnostic accuracy. The Lachman test remains a

reliable screening tool with high sensitivity, while the Lever sign offers balanced sensitivity and specificity. The Lateral pivot shift test, despite its lower sensitivity, provides valuable confirmatory information due to its perfect specificity. The combination of all three tests achieved the highest diagnostic accuracy (96.7%), suggesting that a comprehensive clinical examination using multiple tests optimizes diagnostic precision. These findings support the implementation of a systematic approach to clinical examination of suspected ACL tears, potentially reducing the need for immediate advanced imaging in clear-cut cases.

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