ORIGINAL ARTICLE

VALIDITY OF LELLI'S TEST IN DIAGNOSING ACUTE ACL INJURY AND ITS COMPARISON WITH THE OTHER CONVENTIONAL CLINICAL EXAMS

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Background: The anterior cruciate ligament (ACL) is a vital structure in the knee responsible for preventing anterior translation; and countering rotational and valgus stress. The anteromedial and posterolateral bundles of the ACL, which are distinguished by their attachments at the tibia and femur, respectively, make up the ACL. The study is designed to evaluate the diagnostic parameters of lever sign in acute settings when compared against MRI as investigation of choice and compare them with the conventional tests. Furthermore, effect of examination-under-anaesthesia and training level of the examiner on the diagnostic accuracy will be assessed. It was a prospective observational was performed. All the patients that presented to out-patient department of GTTH, Lahore from January to July 2023 and had a final diagnosis of ACL tear were included. **Methods:** Assessment was done by both undergraduates and postgraduates and those who underwent arthroscopy were placed in surgical cohort and arthroscopic findings were included in final analysis. **Results:** Eighty-three patients were assessed. Inferential analysis demonstrated that Lelli's test had highest sensitivity (85.9%), NPV (64%) and diagnostic accuracy (85.5%). However, Lachman was most specific (94.7%) and had highest PPV (98.1). MRI itself is highly accurate (95.83%) when compared to arthroscopic findings. Though the results of each test when performed by postgraduates and under anaesthesia were significantly better; however, least difference was noted in case of Lelli test among awake and anesthetized and pre- and post-graduates' exams. **Conclusion:** The Lelli's test is highly sensitive and accurate when compared to the three conventional tests for ACL injuries. Furthermore, the manoeuvre and its interpretation are simple and reproducible; thus, can be used by highly trained healthcare professionals on awake patients with minimal discomfort. However, further research is needed to validate its biomechanics and role in partial ACL and multi-ligamentous injuries.

Keywords: Anterior cruciate ligament; Lelli's test; Lever sign; Magnetic Resonance imaging

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INTRODUCTION

The anterior cruciate ligament (ACL) is a vital structure in the knee responsible for preventing anterior translation; and countering rotational and valgus stress.[1] The anteromedial and posterolateral bundles of the ACL, which are distinguished by their attachments at the tibia and femur, respectively, make up the ACL.[2,3] Unfortunately, ACL injuries are prevalent, with a reported frequency of 0.38 per 100,000 people. Injury of ACL alone has a significant impact on knee stability and function.[4] Existing clinical tests, including the anterior drawer, Lachman, and pivot-shift tests, have been used to diagnose ACL injuries but have limitations in accuracy due to patient factors and examiner experience.[2,5–7] Recognising the need for an effective clinical test for ACL tears, in this study, we are focusing on the lever sign test, also called the 'Lelli Test': aiming for high sensitivity and specificity in diagnosing acute or chronic, regardless of injury duration. Initial literature on the Lelli's test suggested nearly 100% sensitivity when compared to MRI, motivating further investigation.[8]

In this study, we seek to (1) evaluate the lever sign test's sensitivity and specificity in diagnosing acute ACL injuries with MRI as gold standard; (2) compare its accuracy with established physical examination tests; (3) determine its performance across providers with varying training levels and (4) evaluate its effectiveness with patients awake or under anaesthesia. Our hypothesis posits that the lever sign test's sensitivity, specificity, and accuracy align with current physical examination tests, irrespective of provider expertise or examination setting.[8]

MATERIAL AND METHODS

The study, approved by the Ghurki Teaching Hospital Review Board, was designed to comprehensively evaluate knee injuries in a systematic and unbiased manner. Consecutive patients presenting with acute knee pain and feeling of giveaway within a four-week window of injury or symptom onset were eligible for inclusion. A thorough assessment protocol was established, encompassing detailed medical histories, physical examinations, and standard radiographs. Furthermore, inclusion criteria comprised patients who underwent knee MRI scans.

To minimize potential sources of bias, a dual-cohort approach was adopted. Patients who received surgical interventions from January to July 2023, were included in the surgical cohort. Conversely, non-surgical patients, even if surgery was ultimately indicated, were placed in the non-surgical cohort. ACL injuries were assessed using MRI as the gold standard. The integrity of the ACL was rigorously evaluated through four standardized physical examination manoeuvres: the anterior drawer (AD), Lachman, pivot-shift, and lever sign tests. To ensure objectivity, testers were blinded to patient details, examination results, and diagnostic procedures. To assess the role of training level of test provider, same patients were examined by an undergraduate (a final year student) as well as a final year postgraduate resident: author of the article. In the surgical cohort, assessments were conducted both in the clinic and the operating room, and a different postgraduate tester performed examinations in the operating room to further mitigate potential bias.

This meticulous and unbiased methodology aimed to provide a comprehensive understanding of knee injuries and enhance the reliability of the study's findings. The study compared traditional ACL tests, which are influenced by user and anaesthesia, to the lever sign test. Lever sign, similar to anterior drawer, Lachman, and pivot-shift tests, was simplified into positive (ACL tear) or negative (intact ACL) outcomes. It involved a supine patient with the heel on the table, using a fist as a fulcrum under the calf's proximal third. Pushing the quadriceps muscle, a negative result raised the heel due to the intact ACL countering gravity, while a positive result indicated ACL damage as the heel remained down, signalling tibial anterior movement. This method reduced subjectivity and anaesthesia dependency in ACL evaluation.[8]

RESULTS

In this study with 83 participants, the data revealed that participants' ages ranged from 16 to 57 years, with an average age of approximately 32.88 years and a standard deviation of about 11.48. Gender distribution shows that 71.1% were male and 28.9% were female. The study also examined which side of the body was involved, with 53% affecting the right side and 47% the left side. Moreover, 47% of the participants had a positive arthroscopy result, 10.8% had a negative result, and 42.2% did not undergo arthroscopy.

To estimate the overall effectiveness of these clinical techniques the diagnostic parameters of all the clinical techniques were compared. For the comparison 2-by-2 contingency tables were made based on the clinical findings noted by postgraduates and were compared with the results of MRI. Inferential analysis demonstrated that Lelli's test was the most sensitive test 85.9% sensitivity and has the highest negative predictive value of 64%. However, Lachman was the most specific (94.7%) and had highest positive predictive value (98.1). Further computation revealed that Lelli's test had highest diagnostic accuracy (85.5%): higher than Lachman test (83%): as illustrated in figure 1.

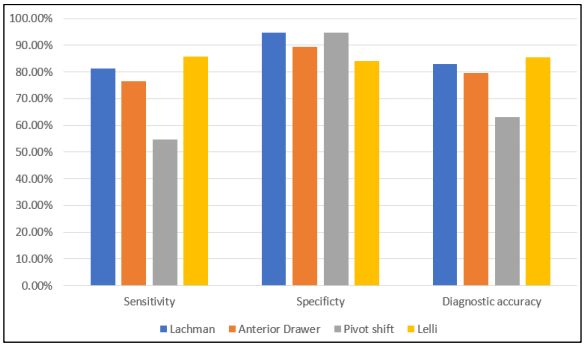

Figure-1: Comparison of all the examination techniques overall diagnostic ability when done by postgraduate residents

For Lachman Test, postgraduates outperformed undergraduates with higher sensitivity (81.3% vs. 75%) and specificity (94.7% vs. 78.9%), resulting in greater overall accuracy (84.3% vs. 75.9%). This difference was statistically significant (chi-square value=36.65) and (p<0.001). Similarly, for the anterior drawer test, postgraduates demonstrated better sensitivity (76.6% vs. 75%) and specificity (89.5% vs. 73.7%) compared to undergraduates, with a significant difference (p<0.001). For the Lelli test, postgraduates and undergraduates showed similar sensitivity (85.9%), but postgraduates had higher specificity (84.2%) and slightly better accuracy (85.54%) compared to undergraduates (78.9.2% and 84.34%). The difference was statistically significant (p<0.001). In the pivot shift test, postgraduates had higher specificity (94.7%) but lower sensitivity (54.7%) compared to undergraduates (78.9% and 53.1%).

Postgraduates achieved an accuracy of 63.85%, while undergraduates achieved 59.03%, with a significant difference (p<0.001).

The Lachman test displayed a sensitivity of 80% and specificity of 90% in awake patients, with a positive predictive value (PPV) of 95.2%. These values improved under anaesthesia, with sensitivity rising to 82.1%, specificity reaching 100%, and PPV increasing to 100%. The test's overall accuracy was 82.85% when patients were awake, and it rose to 85.41% during anaesthesia. Similarly, the Anterior Drawer Test demonstrated a sensitivity of 76% and specificity of 90% in awake patients. In anesthetized patients, sensitivity remained relatively consistent at 76.9%, specificity was 88.9%. The test's accuracy was 80% in awake patients and 79.16% in those under anaesthesia. The pivot shift test, conducted in awake patients, exhibited a sensitivity of 48% and a specificity of 90%. Under anaesthesia, sensitivity improved to 59%, specificity became 100%. The test's accuracy was 60% in awake patients and 66.67% in anesthetized patients. Lastly, the Lelli Test showed a sensitivity of 80% and specificity of 80% in awake patients. When performed under anaesthesia, sensitivity increased to 89.7%, specificity to 88.9%. The Lelli Test's accuracy stood at 80% in awake patients and improved to 89.58% in those under anaesthesia.

Table-1: Comparison of the various examination techniques in terms of diagnostic variables

Test	Examiner	Sensitivity	Specificity	PPV	NPV	Accuracy	Chi-square value	p-value
Lachman	Postgrads	81.3%	**94.7%**	**98.1**%	60%	84.3%	36.65	**<0.001**
	Undergrads	75%	78.9%	92.3%	48.4%	75.9%		
Anterior Drawer	Postgrads	76.6%	89.5%	96.1%	53.1%	79.5%	26.96	**<0.001**
	Undergrads	75%	73.7%	90.6%	46.7%	74.69%		
Lelli	Postgrads	**85.9%**	84.2%	94.8%	**64%**	**85.54%**	34.25	**<0.001**
	Undergrads	**85.9%**	78.9.2%	93.2%	62.5%	84.34%		
Pivot Shift	Postgrads	54.7%	**94.7%**	97.2%	38.3%	63.85%	14.57	**<0.001**
	Undergrads	53.1%	78.9%	89.5%	33.3%	59.03%		

The highest values of diagnostic parameters achieved by any test are mentioned in **bold.** MRI stood out with exceptional sensitivity 97.4% when compared to arthroscopic assessment, although its specificity was lower at 84.2%. The PPV is 88.9%, and the NPV is 42.1%. The overall accuracy of MRI was notably high at 95.83%.

Table-2: Diagnostic capacity of MRI against arthroscopic evaluation

Test	Sensitivity	Specificity	PPV	NPV	Accuracy
Magnetic Resonance Imaging (MRI)	97.4%	84.2%	88.9%	42.1%	95.83%

Table-3: Comparison of diagnostic accuracy among awake and anesthetized patients

Test	Status	Sensitivity	Specificity	PPV	NPV	Accuracy	Chi square value	p-value
Lachman	Awake	80%	90%	95.2%	64.3%	82.85%	36.65	**<0.001**
	Anesthetized	82.1%	**100%**	**100%**	56.3%	85.41%		
Anterior Drawer	Awake	76%	90.0%	95%	60%	80%	26.96	**<0.001**
	Anesthetized	76.9%	88.9%	96.8%	47.1%	79.16%		
Pivot Shift	Awake	48%	90%	92.3%	40.9%	60%	34.25	**<0.001**
	Anesthetized	59%	100%	**100%**	36%	66.67%		
Lelli Test	Awake	80%	80%	90.9%	61.5%	80%	14.57	**<0.001**
	Anesthetized	**89.7%**	88.9%	97.2%	**66.7%**	**89.58%**		

The highest values of diagnostic parameters achieved by any test are mentioned in **bold.**

DISCUSSION

Ligaments around the knee are of utmost therapeutic importance in sports medicine as these readily get injured during sports and effective management can results in early return to the desired activity level alongside prevention of long-term complications. Thus, clinical tests for ACL injury are of prime importance. Among the commonly used clinical tests are Lachman, anterior drawer, pivot shift and Lelli's test. Lelli's method of examination is the most recent examination technique. Before the demonstration of Lelli's sign, Lachman was postulated to be the most reliable and accurate test in diagnosing ACL tears and pivot shift was considered as least sensitive.[9,10] Then Lelli and co-workers presented that Lelli test (lever sign) was more sensitive than Lachman and can be used in acute cases as well.[8] In their study, Lelli and colleagues examined 400 patients; they performed all the three conventional tests alongside Lelli test and compared the examination findings with MRI documented status of ACL. Their study concluded that Lelli test is nearly 100% sensitive in diagnosing ACL injury in both acute (<20 days) as well as chronic (>20 days) ACL injuries. Anterior drawer (AD), Lachman and pivot shift test were 29%, 42%, and 11% sensitive in their study.[8] However since the publication of Lelli and associates various studies have postulated against these findings. Thapa et al. examined 80 cases of knee injuries and compared the results of all four clinical

test with arthroscopy finding as gold standard. They concluded that Lachman test was most sensitive and documented 91% sensitivity of Lachman test. Lelli test was second most sensitive exam with 86% true positive; where anterior drawer and pivot shift showed 80% and 51% sensitivity, respectively.[11] However, the study done by Deveci and colleagues supported the claim of Lelli and colleagues and concluded that Lelli test was most sensitive at diagnosing ACL injury with pre- and post-anaesthesia examination sensitivity of 80% and 88%. Whereas pre- and post-anaesthesia sensitivities for anterior drawer, Lachman and pivot shift were 60% & 88%, 80% & 88%, and 62% & 88%, respectively.[12] Similar results were evident in our study: our inferential analysis concluded that Lelli's test was the most sensitive test with 85.9% sensitivity and has the highest negative predictive value (64%). However, Lachman was most specific (94.7%) and had highest positive predictive value (98.1). Further computation revealed that Lelli's test had highest diagnostic accuracy (85.5%): higher than Lachman test (83%).

Lelli et al. in their study also postulated that the Lelli test is a relatively simpler and easily reproducible test that involves minimal manipulation of the joint. According to their inferences, examiners of various level of training performed Lelli's test with similar accuracy and caused minimal pain to the patient even in acute settings. Thus, they recommended the use of this test in acute injuries as well as by physician of different specialties. This was examined in our study where postgraduates as well as undergraduates performed all the four clinical tests. For the Lelli Test, postgraduates and undergraduates showed similar sensitivity (85.9%), but postgraduates had higher specificity (84.2%) and slightly better accuracy (85.54%) compared to undergraduates (78.9.2% and 84.34%). The difference was statistically significant ($p < 0.001$), however the results of Lelli's test when performed by undergrads were closer to the results of postgraduates in comparison to the other three clinical examination techniques (table 1). Furthermore, among the undergraduates Lelli's test was the most sensitive (85.9%), most specific (78.92%) and most accurate (85.54%) test. Hence, our results validated the original findings of Lelli and colleagues that the Lelli test can be performed effectively by less trained healthcare providers.

Another factor that affects the diagnostic accuracy of these clinical manoeuvres is the laxity of the knee at the time of examination. It has been noted previously that examination on anesthetized patients more accurately depicts status of ACL injury. Deveci and co-workers performed all the four tests in 117 patients before and after induction of anesthesia. Lelli test was most sensitive at diagnosing ACL injury with pre- and post-anaesthesia examination sensitivity of 80% and 88%. Whereas pre- and post-anaesthesia sensitivities for anterior drawer, Lachman and pivot shift were 60% & 88%, 80% & 88%, and 62% & 88%, respectively.[12] Similar results were inferred in our study. diagnostic ability of each test was significantly higher in anesthetized patient; where Lelli test was most accurate with 89.58% diagnostic accuracy, most sensitive with 89.7% sensitivity and had highest negative predictive value of 66.7%. However highest specificity and positive predictive value in anesthetized patients was noted for Lachman test (table 3).

As for the most recent clinical method to evaluate ACL injury, Lelli's test has shown promising results but there are a few limitations of the test. First and foremost is absence of validated biomechanical explanation of the lever phenomenon explained by Dr. Lelli. He proposed that an intact ACL enables the leg to function as a complete ever; that is why in knees with intact ACL the foot gets elevated from the ground on application of downwards force on distal femur. In comparison to inadequacy of biomechanical evidence for Lelli's test, the biomechanics of all the other three tests i-e anterior drawer, Lachman and Pivot shift are very studied and postulated.[11] Furthermore, there is lack of literature on effectivity of Lelli's test in partial or chronic ACL injuries. Another significant shortcoming is the inability of Lelli's test to evaluate the rotational component of the stability that an intact ACL provides. Among the common clinical tests for ACL, only the pivot shift assesses the role of ACL in rotational stability.

The study limitations include uni-centric sampling of the patients and not including the examination findings of the contralateral lateral knees of the sample population for comparison. Furthermore, addition of intra-observer and inter-observer analysis was not conducted.

CONCLUSION

The Lelli's test is highly sensitive and accurate at diagnosing ACL injuries when compared to the three conventional tests for ACL injuries. Furthermore, the manoeuvre and its interpretation are simple and reproducible; thus, can be used by less trained healthcare professionals on awake patients with minimal discomfort. However, further research is needed to validate the biomechanics of the test and its role in partial ACL injuries as well as multi-ligamentous injuries.

AUTHORS' CONTRIBUTION

MU, MAB, MUF: Jointly proposed the study, analysed the data and prepared the final draft. SA, MN,

SAK, AS: Contributed to the study design, data interpretation and review of the final manuscript.

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