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Original Article

Orthopaedics Section

Comparison of the Lever Sign Test, Anterior Drawer Test and Lachman Test in Cases of Anterior Cruciate Ligament Tear: A Prospective Cohort Study

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ABSTRACT

Introduction: The Anterior Cruciate Ligament (ACL) is a very commonly injured ligament of knee. Several physical examination tests are performed for evaluating ACL stability. The Lachman, pivot-shift, and anterior drawer tests are commonly performed for evaluating the knee laxity.

Aim: To compare Lever sign test with anterior drawer test and Lachman test in case of ACL tear, and to assess preanaesthesia and postanaesthesia variability in tests results.

Materials and Methods: This prospective cohort study was conducted at Government Medical College, Kathua, Jammu, India, from October 2018 till September 2019. Total 50 patients were included (age group 18-60 years) with symptomatic ACL tear requiring diagnostic arthroscopy or repair. Three test included Lever sign test, anterior drawer test and Lachman test were performed preanaesthesia and postanaesthesia and findings were recorded. Sensitivity and specificity was calculated preanaesthesia and postanaesthesia. Statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0. The p-value ≤0.05 was considered statistically significant.

Results: Total 50 patients were evaluated and analysed including 60% males (n=30) and 40% females (n=20). The mean age of the patients was 34.5±2.6 years. Sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Values (NPV) and diagnostic accuracy of anterior drawer test preanaesthesia were 83%, 87%, 97%, 50%, and 84%, respectively, and postanaesthesia were 88%, 87%, 97%, 58%, and 88%; for Lachman test preanaesthesia were 88%, 87%, 97%, 58%, and 88%, respectively, and postanaesthesia were 90%, 87%, 97%, 63%, and 90%; and for Lever sign test preanaesthesia were 85%, 88%, 100%, 57%, and 88%, and postanaesthesia were 88%, 100%, 100%, 61%, and 90%, respectively. There was no significant difference in the diagnostic accuracy of the three tests while comparing for preanaesthesia and postanaesthesia or for individual tests (p>0.05).

Conclusion: The lever test showed high specificity, but comparable diagnostic accuracy in the detection of ACL tears in comparison to anterior drawer test and Lachman test. All the tests hold equal importance for diagnosing ACL tears before and after anaesthesia.

Keywords: Diagnostic tests, Knee ligament injury, Management, Sensitivity

INTRODUCTION

The knee is one of the most frequently injured joint. The cruciate ligaments act as stabilisers of the joint and axis around which rotatory motion, both normal as well as abnormal movements take place [1]. The ACL is a very commonly injured ligament. The leading causes include sports injuries and vehicular trauma. Nearly 200,000 ACL injury annually were reported in US and 75000-100,000 ACL reconstruction are performed each year [2,3].

In the case of an ACL injury, knee laxity is usually evaluated by physical examination using the Lachman [4], pivot-shift [5,6], and anterior drawer tests [7]. Galway RD et al., described the pivot shift test in 1972 and Torg JS et al., described the Lachman test in 1976 [8,4]. In 2014 a new test 'Lever sign test' was introduced by Lelli A with 1.00 sensitivity [9]. Previous studies have reported different sensitivity and specificity for these tests for partial and complete tear, chronic and acute injuries, interobserver variability, and preanaesthesia and postanaesthesia variability. It has been reported consistently in many previous studies that the Lachman test had the highest sensitivity (85% to 96%) and the pivot shift test consistently had the highest specificity (97% to 99%) [10,11,12].

An ideal test would have both a high sensitivity and specificity and be easily reproducible. It can be used in both chronic and acute cases, can diagnose both partial and complete tear, same result with or without anaesthesia and with no interobserver variability. A reproducible, split test, which can be easily performed by the practitioners in the emergency room, office, or training room [12].

There is a scarcity of studies conducted in India that compared these tests in resource limited settings especially in terms of pre- and postanaesthesia changes, thus bringing on the novelty of the study. These tests hold the importance as they can be done without any additional cost and can provide a prediction about the ACL tears. Thus, this study was conducted with an aim to compare Lever sign test with anterior drawer test and Lachman test in case of ACL tear and to assess preanaesthesia and postanaesthesia variability in tests results.

MATERIALS AND METHODS

The prospective cohort study was conducted at Government Medical College, Kathua, Jammu, India, from October 2018 till September 2019. Ethical clearance was taken from Government Medical College, Jammu, Institutional Ethical Committee (IEC/GMC/2019/838). An informed consent was taken from patients before enrolling in the study.

Inclusion criteria: The study population included patients in age group 18-60 years with isolated complete ACL tear, with meniscal injury, chondral injuries, and medial/lateral collateral ligament sprains.

Exclusion criteria: Any patients with associated Posterior Cruciate Ligament (PCL) injury, ACL reinjury, periarticular fracture, and ipsilateral lower limb fractures were excluded from the study.

Sample size calculation: The sample size was calculated based on the study of Gürpınar T et al., who observed that sensitivity of Lachman, anterior drawer and lever was 80.6%, 77.4% and 91.9%, respectively and specificity of Lachman, anterior drawer and lever was 62.5%, 68.8% and 93.8%, respectively [13]. Taking these values as reference, the minimum required sample size with desired precision of 20%, 80% power of study and 5% level of significance is 41 patients. To reduce margin of error, total sample size taken was 50.

Total 54 patients belonging to age group 18-60 years with symptomatic ACL tear requiring diagnostic arthroscopy or repair admitted in hospital were evaluated, among which four were lost to follow-up and thus the final data pertains to 50 patients.

Formula used is for testing sensitivity and specificity of single diagnostic test [13]:

1. For sensitivity

$$n = \left(Z_\alpha \times \sqrt{Se \times (1 - Se)} + Z_\beta \times \sqrt{Se_1 * (1 - Se_1)}\right)^2 / difference^2$$

Where, Se is sensitivity, Z_α is value of Z at two sided alpha error of 5% and Z_β is value of Z at power of 80%

2. For specificity

$$n = \left(Z_\alpha \times \sqrt{Sp \times (1 - Sp)} + Z_\beta \times \sqrt{Sp_1 * (1 - Sp_1)}\right)^2 / difference^2$$

Where Sp is specificity, Z_α is value of Z at two sided alpha error of 5% and Z_β is value of Z at power of 80%.

The details pertaining to the demography, injury characteristics, and clinical features, such as pain, swelling, lack of range of motion were noted for all the patients. All the enrolled patients in the study underwent lever test, anterior drawer test and Lachman test twice: once before anaesthesia for the surgery and once again after the anaesthesia. It is because anaesthesia relieves the patient apprehension and pain, thereby allowing for the tests to be solely on the basis of the injury and can lead to better accuracy of the tests in diagnosing the injury.

Tests Employed

Anterior drawer test: The anterior drawer test was done when patient was told to lie in the supine position. Flexion of the hip was done to 45° and that of knee to 90°. For stabilising the leg, the examiner sat on the feet of patient. The forward force was given to the tibia after the hamstring muscles were relaxed. The positive anterior drawer test was suggested in the presence of forward movement of >6–8 mm compared to the normal knee [7]. A representative case is shown as [Table/Fig-1].

Lachman test: The Lachman test was done by flexing the knee to 20°. Afterwards, the distal thigh was grabbed by the examiner by one hand, and the proximal leg was grabbed by the other hand. Afterwards, anterior force was applied on leg. The positive Lachman test was indicated by abnormal forward movement and thus ACL injury [4]. A representative case is shown as [Table/Fig-2].

[Table/Fig-1]: Clinician performing anterior drawer test.
[Table/Fig-2]: Clinician performing Lachman test. (Images from left to right)

Lever sign test: The lever sign test was done with patient in supine position and knees extended on a rigid surface. The examiner stood behind the patient, and closed fist was placed beneath the proximal third of the posterior leg, causing a minor knee flexion. Moderate force was applied with other hand on the distal third of the thigh of patient from anterior to posterior. When passive elevation of the heel does not occur in reference to the plane of the examination table, the test is termed positive. The test was considered negative with the heel rise and thus the ACL was taken into account as intact [9]. A representative case is shown as [Table/Fig-3].

[Table/Fig-3]: Clinician performing Lever sign test.

Positivity of the tests indicated that ACL tear was present while negative test indicated that there was no ACL tear.

Anaesthesia: The patient received a dose of intravenous cefuroxime (1.5 g) at the time of induction of anaesthesia. After the administration of anaesthesia, the patient was positioned supine on the operation table, the three tests were performed again and the results were recorded.

Then a tourniquet was tied around the thigh. The limb was painted and then draped in the standard fashion for knee arthroscopy. The tourniquet was inflated after exsanguinating the limb. Following this, a diagnostic arthroscopy was done and intraoperative findings {medial meniscal tears (current), lateral meniscal tears (current), cartilage injury} were recorded in recorder and ACL was repaired with gracilis hamstring autograft in case of ACL injury [14].

STATISTICAL ANALYSIS

The data was entered in Microsoft (MS) Excel spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0, International Business Machines (IBM) manufacturer, Chicago, United States of America (USA). Categorical variables were presented in number and percentage (%). Positivity and negativity of the tests were used to calculate sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) for predicting the ACL tears by using chi-square test. The p-value <0.05 was considered significant.

RESULTS

Out of total 50 patients, 54% were in the age group 26-40 years, 28% in age <26 years, and 18% in >40 years. The mean age of the patients was 34.5±2.6 years. There were 60% males (n=30) and 40% females (n=20) [Table/Fig-4].

Demographic characteristics	Frequency	Percentage
Age (years)		
<26	14	28%
26-40	27	54%
>40	9	18%
Gender		
Males	30	60%
Females	20	40%

[Table/Fig-4]: Demographic characteristics of the patients.
Total N=50 patients

Sports injury was the most common injury in 24 (48%) patients, followed by fall 13 (26%), road traffic accident 9 (18%), and direct blow in 4 (8%) patients. In 29 (58%) patients, right-side was affected. In majority of the patients 17 (34%) since injury was <3 months, >6-9 months in 10 (20%), and 3-6 months in 9 (18%) patients. Medial meniscus injury was present in 21 (42%) patients, isolated ACL in 9 (18%), and lateral meniscus in 16 (32%) patients [Table/Fig-5].

Injury characteristics	Frequency	Percentage
Mode of injury		
Sports injury	24	48%
Fall	13	26%
Road traffic accident	9	18%
Direct blow	4	8%
Side		
Right	29	58%
Left	21	42%
Time since injury (in months)		
<3	17	34%
3-6	9	18%
>6-9	10	20%
>9-12	7	14%
>12	7	14%
Epidemiology of injury		
Medial meniscus	21	42%
Lateral meniscus	16	32%
Medial collateral	2	4%
Lateral collateral	1	2%
Chondral injury	1	2%
Isolated ACL	9	18%

[Table/Fig-5]: Injury characteristics.
ACL: Anterior cruciate ligament

Among the study patients, Mode of anaesthesia was spinal in 64% (n=32) of patients and spinal and epidural in 36% (n=18) of patients. The postoperative clinical features seen among the patients were numbness 3 (6%), swelling, effusion and pain in 2 (4%) patients each and local infection in only 1 (2%) of the patients. Range of motion at the time of enrolment was 40-50 degrees.

Accuracy of the tests for predicting the ACL tears: Sensitivity, Specificity, PPV, NPV, and diagnostic accuracy of anterior drawer test preanaesthesia were 83%, 87%, 97%, 50%, and 84%, respectively, and postanaesthesia were 88%, 87%, 97%, 58%, and 88%.

Sensitivity, Specificity, PPV, NPV, and diagnostic accuracy of Lachman test preanaesthesia were 88%, 87%, 97%, 58%, and 88%, respectively, and postanaesthesia were 90%, 87%, 97%, 63%, and 90%. Sensitivity, Specificity, PPV, NPV, and diagnostic accuracy of Lever sign test preanaesthesia were 85%, 88%, 100%, 57%, and 88%, respectively, and postanaesthesia were 88%, 100%, 100%, 61%, and 90% [Table/Fig-6].

Diagnostic test	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy	p-value
Anterior drawer test						
Preanaesthesia	83%	87%	97%	50%	84%	0.773
Postanaesthesia	88%	87%	97%	58%	88%	
Lachman test						
Preanaesthesia	88%	87%	97%	58%	88%	1
Postanaesthesia	90%	87%	97%	63%	90%	
Lever sign						
Preanaesthesia	85%	88%	100%	57%	88%	1
Postanaesthesia	88%	100%	100%	61%	90%	

[Table/Fig-6]: Comparison of diagnostic accuracy of the three tests for ACL injury.
Significant p-values <0.05, Chi-square test

There was no significant difference in the diagnostic accuracy of the three tests while comparing for paranaesthesia and post anaesthesia or for individual tests (p>0.05) [Table/Fig-7].

Variables	Preanaesthesia	Postanaesthesia
Anterior drawer test vs Lachman test	0.773	1
Anterior drawer test vs Lever sign	0.773	1
Lachman test vs Lever sign	0.758	0.739

[Table/Fig-7]: Comparison of diagnostic accuracy of the three tests for ACL injury.
Significant p-values <0.05, Chi-square test

All the patients recovered postoperatively with a good range of motion of the knee as it increased from 40-50 degrees preoperatively upto 70-85 degrees, postoperatively.

DISCUSSION

In this study, comparison of Lever sign test with anterior drawer test and Lachman test in case of ACL tear was done. The findings showed that lever sign test is highly sensitive and specific for predicting ACL injury but the diagnostic accuracy of all the tests were comparable with no statistically significant difference. The present study findings are partially in line with the studies by Deveci A et al., and Lelli A et al., who reported that as compared to the anterior drawer, Lachman, and pivot-shift tests, the lever sign test was more sensitive in diagnosing both acute and chronic ACL tears, as well as complete and partial ACL tears [9,15].

Previously, Gürpınar T et al., Deveci A et al., Logan MC et al., Kim SJ and Kim HK, reported that the Lachman test was most accurate and reliable for diagnosis of an ACL rupture; and the pivot-shift test was reported to be the least sensitive of the three [13,15,16,17]. A study by Jarbo KA et al., found that the lever sign test was less accurate compared to the Lachman test [18]. Though the results were consistent to findings of previous studies in terms of Lachman and anterior drawer tests accuracy, but Lever test showed higher accuracy as compared to other tests.

According to a meta-analysis including 16 studies, overall sensitivity and specificity of anterior drawer test were 0.725 and 0.927, respectively and that of the Lachman test were 0.871 and 0.97, respectively [19]. Massey PA et al., showed sensitivity and specificity of anterior drawer test to be 82% and 80%, respectively; sensitivity and specificity of Lachman test were 89 and 85, respectively [20]. These findings are similar to results of the present study for the Lachman test and anterior drawer test.

It is difficult to diagnose acute ACL injuries because of the associated pain, haemarthrosis, reactive synovitis, and swelling [21]. For acute injuries, the sensitivity of Lachman test and the anterior drawer test as reported in literature was 0.78 and 0.22, respectively [22]. Though in the study by Lelli A et al., sensitivity of the lever sign test was 100% for acute injuries [9]. Presently, only few studies have examined the sensitivity of the lever sign test in acute injuries. History shows that for overcoming the lowered sensitivity of previously mentioned tests, Lelli A et al., in 2014 introduced the lever sign test specifically for acute ACL injuries [9].

Jarbo KA et al., evaluated the sensitivity and specificity of the lever sign test for the diagnosis of acute ACL injuries and found that lever sign test had 63% sensitivity and 90% specificity [18]. Massey PA et al., reported that in acute cases the sensitivity of the lever sign test was 90% and the specificity was 77% [20].

It must be kept in mind that the two conditions which may affect the sensitivity of lever sign are partial tear of ACL and unreduced bucket handle tear of meniscus [10,20]. In partial tears, there are still some intact fibers which lift the tibia of the examination table and make test negative. In bucket handle tear, the meniscus get struck between the condyles and make test negative. Also, the factors such as patient resistance, pain, swelling, haemarthrosis, or time from the injury does not affect the sensitivity of the lever sign test. So, Lever test can be avoided in such cases and other tests can be employed [15].

Postanaesthesia, it was observed that the sensitivity of the anterior drawer test was altered the most. However, the change in sensitivity

Studies	Parameters	Anterior drawer test	Lachman test	Lever Sign test
Present study	Sn, Sp, PPV, NPV, DA pre-anaesthesia Post-anaesthesia	85%,88%,100%,57%,88% 88%,100%,100%,61%,90%	88%,87%,97%,58%,88% 90%,87%,97%,63%,90%	83%,87%,97%,50%,84% 88%,87%,97%,58%,88%
Hidayat L et al., [10] (2021) Indonesia	Sn, Sp, PPV, NPV, DA	86.6%,80%,92.8%,66.6%,85%	96.6%,90%,96.6%,90%,95%	-
Sobrado MF et al., [12] (2021)	Sn, Sp, PPV, NPV, DA	82.0%,84.8%,86.4%,80%,32.3%	94.8%,100%,100%,94.2%,97.2%	64.1%,100%,100%,70.2%,80.5%
Gürpınar T et al., [13] (2019) Austria	Sn, Sp, PPV, NPV, DA	77.4%,68.8%,90.6%,44.0%,75.6%	80.6%,62.5%,89.3%,45.5%,76.9%	91.9%,93.8%,98.3%,75.0%,92.3%
Kim SJ and Kim HK [17] (1995) South Korea	Sn, Sp, PPV, NPV, DA	88%,94%,94%,89%,91%	90%,96%,96%,91%,93%	63%,90%,87%,71%,77%
Massey PA et al., [20] (2017) China	Sn, Sp, PPV, NPV, DA	82%,80%,94%,55%,81%	89%,85%,95%,68%,88%	83%,80%,94%,57%,82%
Deveci A et al., [15] (2015) India	pre-anaesthesia assessment Under-anaesthesia assessment	60% 88%	80% 88%	94% 98%
Lelli A et al., [9] (2014) Italy	Pooled sensitivity	0.72	0.62	1.00 Sp: 1.00

[Table/Fig-8]: Previous studies comparing diagnostic accuracy of Anterior drawer, Lachman, and Lever sign tests [9,10,12,13,15,17,20].
Sn-sensitivity, Sp-specificity, PPV-positive predictive value, NPV- negative predictive value, DA-diagnostic accuracy

postanaesthesia was almost similar in lever sign and Lachman test. The specificity of anterior drawer and Lachman tests were similar postanaesthesia, while that of Lever sign increased from 88% to 100%. Overall there was no significant difference in the diagnostic accuracy before and after anaesthesia. In comparison, as reported by meta-analysis by van Eck CF et al., the sensitivity of the anterior drawer test increased from 38% to 63% postanaesthesia [23]. In the study by Gürpınar T et al., the sensitivity of the Lachman and anterior drawer test increased from 83.9% to 89.7% and from 79.0% to 79.5%, respectively, postanaesthesia [13]. However, there was no difference in the sensitivity of the lever sign test preanaesthesia and postanaesthesia (from 91.9% to 91.9%). Deveci AR et al., reported that postanaesthesia sensitivity of Lachman test increased from 80% to 88%, that of anterior drawer test increased from 60% to 88%, and that of lever sign test increased from 94% to 98% [Table/Fig-8] [15].

Based on the findings of the study, it has been demonstrated that accuracy of knee diagnostic tests rose slightly in terms of absolute values under anaesthesia, but it failed to cross statistical boundaries. This may suggest the significance of patient factor in the sensitivity of these tests which needs further validation [23]. The sensitivity and specificity of these physical examination tests is influenced by several factors. Patients may be guarding because of pain as well as fear of subluxation. The physical exam may be obstructed by the concomitant injuries, like bucket handle meniscus tears leading to locking of the knee. Moreover, it is difficult to diagnose partial ruptures as compared to complete ruptures because of the stability provided by the remaining fibers [23]. The comparative review of literature from similar studies has been summarised in [Table/Fig-8] [9,10,12,13,15,17,20].

The use of the combination of the three tests with first line test as lever sign test for diagnosing complete ACL tears, partial ACL tears, and multi-ligament knee injuries should be the focus of future research. Moreover, multicentric studies should be conducted for validating the use and practicality of these tests (after anaesthesia) for diagnosing ACL injuries.

Limitation(s)

The examiners in the present study were not blinded regarding the clinical history and side of the injury of patients. Also, partial, and complete tears were not distinguished in patients who underwent ACL reconstruction. Moreover, interobserver or intraobserver analyses were not performed. As lever sign test was done on the injured side only, thus it was not compared with healthy leg.

CONCLUSION(S)

The lever test is an ideal test for diagnosing ACL injuries, and it is easily performed with high sensitivity, specificity, and diagnostic accuracy in the detection of ACL tears. Overall, lever test can be a good test for clinicians in acute, chronic and postreconstructive ACL injuries. All the three tests become more sensitive under anaesthesia for predicting ACL tears as it overcomes the patient related factors of fear and apprehension. This signifies the practical use of these tests after anaesthesia for better management of the patients.

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