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Research Article

Lever test: Role of its assistance in diagnosis of anterior cruciate ligament injury

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Abstract

Introduction: The diagnosis of Anterior Cruciate Ligament (ACL) tear is aided by clinical tests and imaging evaluation with MRI. The main clinical tests include Lachman, Anterior Drawer and Pivot shift test. A newer clinical test called lever test was proposed recently with higher sensitivity compared to traditional tests.

Objective: To investigate the sensitivity, specificity and other statistical parameters of newly proposed lever test for ACL injury in comparison to other established tests, Lachman test, Anterior Drawer test and Pivot Shift test.

Materials and Methods: 242 consecutive patients between ages of 18 to 50 years with a complaint of knee pain and giving way after trauma were included in the study over a period of 4. They were evaluated with clinical tests Lever test, Lachman test, Anterior Drawer test and Pivot Shift test without anaesthesia and under anaesthesia. All patients were subjected to diagnostic arthroscopy who's the results were taken as gold standard and sensitivity, specificity, positive and negative predicative values for all tests were calculated.

Results: The pre-anaesthesia and post-anaesthesia sensitivity of Lever test was 85.57% and 91.75 respectively. This was lower than the sensitivity of Lachman test (Pre-anaesthesia: 93.81%, Post-anaesthesia: 98.97) but higher than the other two tests. (Anterior Drawer Test: Pre-anaesthesia: 80.41%, Post-anaesthesia: 93.81%, Pivot Shift Test: Pre-anaesthesia: 40.21% Post-anaesthesia: 75.26%)

Conclusion: The sensitivity lever test is higher compared to Anterior Drawer test and Pivot Shift test but lower than the Lachman test. Inclusion of lever test may improve diagnostic accuracy of clinical evaluation of ACL tear.

Keywords: anterior cruciate ligament, diagnosis, knee, lachman test, lever sign, sensitivity, specificity

INTRODUCTION

The Anterior Cruciate Ligament (ACL) is one of the most commonly injured ligaments of the knee with an annual incidence of 68.6 per 100,000 person-years [1]. Amateur athletes have a 0.03% to 1.62% chance of developing an ACL rupture every year, while the risk for professional athletes rises up to 3% or more depending on the kind of sport [2]. Early diagnosis and reconstruction are needed to prevent various biomechanical changes in the knee associated with chronic ACL tear [3,4].

The diagnosis of ACL tear is aided by clinical tests and imaging evaluation with MRI. The main clinical tests include Lachman, Anterior Drawer and Pivot shift test [5]. Previous studies in the literature have documented pivot shift test as most specific while the Lachman test is more sensitive in diagnosing ACL tears [6]. But none of these tests are 100% sensitive or specific. In literature the sensitivity ranges from 81%-86%, 18%-48%, and 38%-92% for the Lachman, Pivot Shift and Anterior Drawer test respectively [5,7,8]. These tests also have limitations like poor sensitivity and specificity towards partial tears and in acute injuries [7,8].

A newer test called Lever sign/test was added a few years back claiming to be 100% sensitive and specific in diagnosing ACL tears [9]. Few authors have compared this clinical test with other tests as well as with Magnetic Resonance Imaging (MRI) and/or arthroscopy but many of them are limited by taking MRI as gold standard and failure of inclusion of the effect of anaesthesia on these tests [10-14].

The study aimed to compare the diagnostic accuracy of Lever Sign along with Anterior Drawer, Lachman test, and the pivot shift test performed in the outpatient setting and under anaesthesia compared with arthroscopy findings taken as gold standard. The study was undertaken to calculate the sensitivity, specificity, positive predictive value and negative predictive value for the above-mentioned diagnostic tests both without anaesthesia and under anaesthesia.

METHODOLOGY

This is a prospective longitudinal study conducted from June 2015 to June 2019. Written informed consent was obtained before testing. The ethical clearance to conduct the study was obtained from the institutional review board (IEC.No.05/59/2016/MCT). The minimum sample size was calculated to be 96 and 2 × 2 contingency tables was used to evaluate the sensitivity, specificity, positive and negative predictive values for all tests. The inclusion criteria for this study were subjects aged between 18 to 50 years, presenting with history of knee injury and complaints of give way. The patients with concomitant meniscus tear were retained in the study. The patients who had previous knee ligament reconstruction, any associated fracture around knee and multi-ligamentous injuries were excluded from the study. The examination was conducted by a single licensed arthroscopy surgeon with 15 years' experience. This examination was performed before doing or reviewing any diagnostic evaluation like Magnetic Resonance Imaging (MRI). This was done to avoid the examiner's bias regarding the subject's current condition and complaint.

A total of 242 patients were included in the study. The basic demographic parameters like age, sex, height and weight were recorded along with the time of injury. Those presenting after 4 weeks were grouped as chronic and before that were taken as acute. All patients were clinically evaluated with four physical tests i.e. Lever Sign, Lachman, Anterior Drawer and Pivot Shift test in the same sequence to avoid bias in the OPD. Those suspected of ACL injury were then evaluated with MRI evaluation. All the patients were posted for arthroscopic evaluation irrespective of MRI report. Prior to arthroscopy, patients were again evaluated post anaesthesia for the aforementioned test and documented. Findings of arthroscopy was taken as the gold standard. As the study is done mainly to evaluate lever sign test, way of doing it and the pathomechanics behind it is described below.

LEVER SIGN TEST

The test was described by Lelli et al. [9]. The patient was positioned supine in a hard couch or operating table with both lower limbs extended. Depending on the side of injury the corresponding limb of the examiner is made into a fist and kept under proximal third of the calf. We have used tibial tuberosity as our landmark for doing the test. Keeping the fist under the calf will put the leg into slight flexion with the heel touching the table (Fig. 1). Then a vertical downward force is applied on the distal part of the thigh. This will create two forces; one is the gravity acting on the leg and other is the downward push on the quadriceps. If the ACL is intact the posterior translation of femoral condyle will pull the proximal tibia down. This will produce an upward movement of the leg with the heel getting lifted up from the table. When the ACL is injured, the downward push on the femoral condyles won't get transferred to tibia and the foot won't get lifted.

PATHOMECHANICS

When performing a lever sign test, the patient's heel is lifted off from the table by the posterior directed force applied on the distal thigh. However, in patients with complete ACL tear, patient's heel will remain on the examination table despite the posterior translation force applied on the distal thigh. This explanation is straight forward considering the lever system involved in the study.

The lever test is based on the class 1 lever system (Fig. 2 and 3). The effort is in one direction, fulcrum in the middle and the load moves in the opposite direction. In lever sign test, the fist kept under the tibia functions as the fulcrum, the effort is the posterior translating force applied on the distal thigh and load is weight of the leg distal to the fulcrum. The effort arm is the distance from the downward force applied on the distal thigh to the fulcrum and load arm is the distance from fulcrum to the load. The effort arm in lever sign test is maintained by an intact ACL. Hence in case of a ruptured ACL the effort arm is broken and force will not get transmitted across the knee up to the fulcrum to elevate the load.

STATISTICAL ANALYSIS

The 4 physical examination tests for ACL injury, the Lachman, AD, pivot shift, and lever, were analyzed for sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

Sensitivity = true positives / (true positives + false negatives)

Specificity = true negatives / (true negatives + false positives)

Positive predictive value = true positives / (true positives + false positives)

Negative predictive value = true negatives / (true negatives + false negatives)

Statistical analyses were performed using SPSS software ver. 22.0 (IBM, Armonk, NY, USA), and MedCalc program for Windows.

RESULTS

A total of 242 consecutive subjects were eligible during the study period, of which 182 were males while the remaining 60 were females. The average age of the study population was 27.4 years ranging 17.2 to 49.7 yrs. The average height was 167 cm. Out of the total 242 cases,

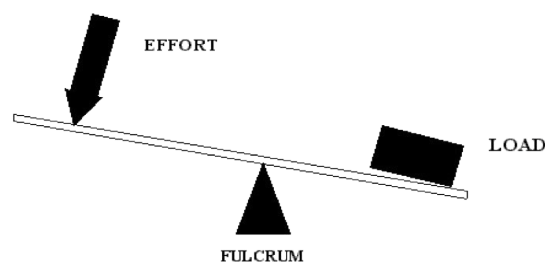


Fig. 1. Class 1 Lever

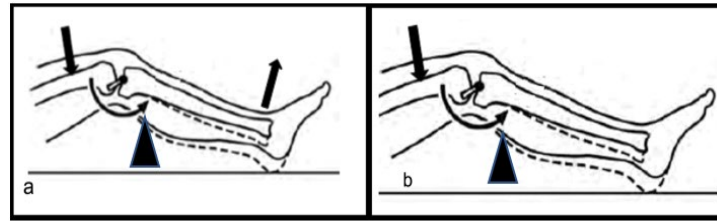


Fig. 2. a) On application of posterior translating force on distal thigh, the foot lifts off in intact ACL; b) When ACL is injured, Posterior translating force is not transmitted to tibia, hence no lift off of heel will happen

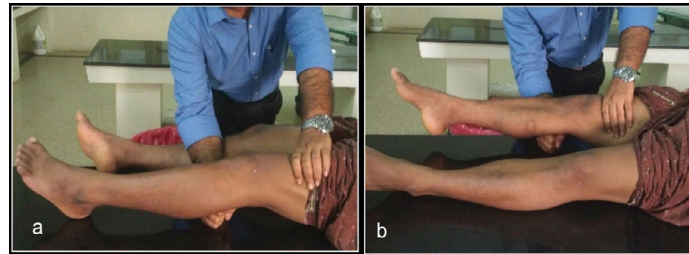


Fig. 3. a) Lever test: Positive test demonstrated in affected Knee; b) Negative test demonstrated in normal opposite knee

Table 1. Test positive and negative rates

Ligament Tests	Result	Without anaesthesia	Under anaesthesia
Lever Test	Positive	202	216
		40	26
Lachman Test	Negative	220	236
		22	6
Anterior Drawer Test	Positive	188	220
		54	22
Pivot Shift Test	Negative	82	166
		160	76

Table 2. The effectiveness of physical examination tests in pre-anaesthesia

	Sensitivity	PPV	Specificity	NPV	Accuracy
Lever Test	85.57%	82.18%	25.00%	30.00%	73.55%
Lachman Test	93.81%	82.73%	20.83%	45.45%	79.34%
Anterior Drawer Test	80.41%	82.98%	33.33%	29.63%	71.07%
Pivot Shift Test	40.21%	80.17%	91.67%	95.12%	50.41%

Table 3. The effectiveness of physical examination tests in post-anaesthesia

	Sensitivity	PPV	Specificity	NPV	Accuracy
Lever Test	91.75%	82.41%	20.83%	38.46%	77.69%
Lachman Test	98.97%	81.36%	36.33%	66.67%	80.99%
Anterior Drawer Test	93.81%	58.33%	20.83%	39.02%	79.34%
Pivot Shift Test	75.26%	87.95%	58.33%	36.84%	71.90%

192 cases presented as chronic injuries (more than 1 month from the time of injury) and the most common side of injury was right side contributing to 68.2%.

Of the 242 patients, 202 cases had lever test positive while 40 patients had test negative without anaesthesia. Post anaesthesia the test was positive in 216 cases and negative in 26 cases. Positive and negative tests pre-anaesthesia and post-anaesthesia is presented in Table 1. These tests were then compared with arthroscopy results which was taken as the gold standard. Compared to gold standard, without anaesthesia the lever test had a sensitivity of 85.57%, specificity of 25.00%, PPV of 82.18%, NPV of 30.00%, and accuracy of 73.55%. Similarly, regarding other tests, the sensitivity and specificity without anaesthesia are documented on Table 2. The results under anaesthesia compared to arthroscopy findings were Lever test was sensitivity, 91.75% specificity, 20.83% PPV, 82.41% NPV, 38.46% accuracy, 77.69%. The results of another test are tabulated and compared in the Tables 2 and 3.

DISCUSSION

Recently there have been multiple studies evaluating the sensitivity and specificity of lever test with varying results. The original study by Lelli et al. documented a sensitivity and specificity of 100% [9]. In the present study, the sensitivity of the lever test without anaesthesia was similar to previous studies. None of other studies done on lever test could reproduce similar results. Few authors commented on the possibility of observer bias which could have been the reason for higher sensitivity and specificity obtained by the author [11]. The recent study by Massey et al. reported a sensitivity and specificity of 83% and 80% respectively for lever test with an accuracy similar to Lachman test [11]. Similar study done by Schoten et al. also reported sensitivity ranging 85%-87% and specificity ranging 91%-94% [15]. The sensitivity of the lever test in this study was 85.57% and specificity was 25.0%. The lower specificity can be attributed to lower true negative studies in our study population. With the influence of anaesthesia, we noted an increase in sensitivity in lever test 91.75%.

In this study the sensitivity of the Lachman test with and without anaesthesia were 93.8% and 98.1% respectively which is higher than the sensitivity of the lever test. These results are contradictory to few previous studies in the literature where the sensitivity of the lever test was on the higher side in comparison to Lachman [10,12,13]. Our results are similar to few other reports in the literature. In the study by Massey et al. Lachman test showed a specificity of 0.97 and a sensitivity of 0.89 without anaesthesia [11]. A recent meta-analysis documented the sensitivity of Lachman as 85% and specificity of 95% [16]. Lange et al. in their meta-analysis of 7 studies showed that the Lachman test had a better range of interobserver reliability [17]. The influence of anaesthesia improved the sensitivity of the Lachman test and similar results were concluded by meta-analysis done by Van Eck et al. [18].

Anterior drawer test in our study has a sensitivity of 80.1% without anaesthesia and 93.8% under anaesthesia. These results are little higher than few other previous reports in the literature. In the study by Deveci et al. the pre anaesthesia and post anaesthesia sensitivities were 60% and 88%, respectively for the anterior drawer test [13]. In a similar study by Thapa and colleagues in 80 patient's sensitivity of anterior drawer test was 80% [19]. Study by Ielli et al. got pre anaesthesia sensitivity of 0.60 and post anaesthesia sensitivity of 0.84.9 The sensitivity of the pivot shift test was 40.21 and 75.26 respectively for pre and post anaesthesia testing. Compared to other tests the specificity of pivot shift was on the higher side even though the sensitivity is much lower than the other standard tests. The sensitivity was 91.67% for the pivot shift test. These results are similar to the previous studies reported in the literature. A meta-analysis by Van Eck et al. reported pre-anaesthesia sensitivity values 0.62 and 0.73 after anaesthesia [18] These are slightly higher values compared to our study results. The low sensitivity of pivot shift compared to other tests has been because the instability tested here is rotational compared to translational instability which is tested by Lachman, lever test and anterior drawer.

The most significant finding of this study is that the sensitivity of the lever test is lower than the Lachman test compared to many previous studies where the lever test was reported to be of higher sensitivity. Another issue we noted with the test is that the mild variation in the position of the wrist can produce false negative results. If the position of the wrist goes below the level of tibial tuberosity the test has been noted to be false negative. Hence the examiner has to be mindful about the same while doing the test. We also noted false negative results obtained were more in persons with low BMI even though no statistical correlation was done in our study. This can be attributed to the remaining soft tissue communications between the femur and tibia like capsule, collateral ligaments which can maintain the lever arm even with ACL injury. The test also needs to be done on a hard surface and presence of any hard or soft form can interfere with the results.

There are multiple limitations in the current study. First is the case selection, where only the patients with probable ACL injury were evaluated which resulted in lower false negative results which contributed to lower specificity of the tests. Another issue is the lack of separate analysis of test in acute and chronic cases as well as partial and complete injury. We also did not evaluate the interobserver reliability of the test.

CONCLUSION

The lever test is easier to apply clinically with a sensitivity slightly lower than Lachman but significantly higher than the other tests. Inclusion of lever test in routine clinical evaluation can improve the diagnostic accuracy but in light of findings of present study other variables like correlation with BMI, position of wrist, partial injuries and also interobserver variations need to be evaluated further.

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