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Selected Topics: Sports Medicine

IMPLEMENTING THE LEVER SIGN IN THE EMERGENCY DEPARTMENT: DOES IT ASSIST IN ACUTE ANTERIOR CRUCIATE LIGAMENT RUPTURE DIAGNOSIS? A PILOT STUDY

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☐ Abstract—Background: Within the emergency department (ED) setting, anterior cruciate ligament (ACL) rupture is commonly misdiagnosed, leading to improper treatment and potential meniscal injury and total joint replacement. Utilizing traditional clinical tests to diagnosis ACL rupture leads to the correct diagnosis in about 30% of cases. The lever sign is a new and effective clinical test used to diagnose ACL rupture with 100% sensitivity. Objective: We aim to study if the lever sign used in the ED setting is more sensitive to diagnose ACL rupture than traditional tests. Methods: Patients between 12 and 55 years of age were examined utilizing either traditional methods or the lever sign. Diagnostic findings in the ED were compared with those of a sports medicine specialist using magnetic resonance imaging as the diagnostic standard. A survey was given to ED providers to collect data on diagnosis and physician confidence in diagnosis. Results: The sensitivity of the lever sign was 100% (94.7% accuracy, 93.75% specificity), whereas the sensitivity of the anterior drawer/Lachman test was 40% (87.5% accuracy, 100% specificity). Physician confidence in diagnosis was higher utilizing the lever sign vs. the anterior drawer/Lachman test at 8.45 (±1.82) compared with 7.72 (±1.82) out of 10, respectively. There was no statistically significant association between diagnostic accuracy with either test and level of training of the ED provider. Conclusion: Implementation of the lever sign in the ED setting resulted in a higher sensitivity, higher physician confidence in screening test diagnosis, and a decrease in the number of undiagnosed ACL ruptures.

☐ Keywords—ACL; lever sign; lever test; anterior cruciate ligament

INTRODUCTION

Rupture of the anterior cruciate ligament (ACL) is one of the most prevalent knee injuries in the United States. It is estimated that there are up to 200,000 cases of ACL rupture in the United States every year (1,2). Untreated, this injury represents a significant risk factor for meniscal pathology and cartilage wear, which may predispose patients to the development of osteoarthritis and resultant total joint arthroplasty (3–6). On initial presentation, patients with suspected ACL injuries are often in severe pain, making it extremely difficult to perform a thorough knee examination in the acute setting (7–9). A recent study demonstrated that only 26% of acute ACL ruptures were correctly identified in the emergency department (ED) setting (10). This represents 148,000 potential cases of ACL rupture per year that are missed upon initial presentation (1,2). For these reasons, undiagnosed ACL ruptures represent a significant public health burden to the U.S. health care system (11).

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Ideally, accurate initial diagnosis of acute ACL rupture among emergency physicians leads to timely repair of the injury. This is of paramount importance, as delayed ACL repair has been shown to be associated with decreased stability, and potentially, other meniscal/chondral injury, when compared with those who receive more immediate repair (12–15). The diagnosis of an ACL tear is usually confirmed with a detailed history and physical examination, magnetic resonance imaging (MRI), or diagnostic arthroscopy. In the ED setting, a high suspicion for ACL rupture is needed to ensure subsequent appropriate imaging and prompt follow-up with an orthopedic surgeon. Two widely accepted screenings for ACL ruptures are the anterior drawer and the Lachman tests. These tests have been studied extensively and have been shown to have a wide range of diagnostic accuracies, ranging from 18–92%, and specificities ranging from 55–99% (16).

The lever sign test is a new clinical test that has been demonstrated to have at or near 100% sensitivity in multiple studies (17–19). To date, there are no studies analyzing the efficacy of the lever sign test in the acute setting such as the ED. The primary objective of this pilot study is to test the accuracy and sensitivity of the lever test in diagnosing ACL tears in the acute setting. We hypothesize that the accuracy and sensitivity of this test will be greater than either the anterior drawer or Lachman tests. Instructions on how to perform the lever sign test are provided below (Figure 1):

1. The patient is placed supine with the knees fully extended on the examination table.
2. The examiner places a closed fist under the tibial tuberosity of the affected knee. This causes the knee to flex slightly.
3. With the other hand, the examiner applies moderate downward force to the distal femur. With this configuration, the patient's leg acts as a lever over a fulcrum—the clinician's fist.

Intact ACL: Patients foot will rise off the bed with the addition of downward force to the distal quadriceps.

Ruptured ACL: The patient's foot will remain in contact with the bed with addition of downward force to the distal quadriceps.

METHODS

During a 9-month period, patients aged 12 to 55 years who were evaluated in the ED for acute knee injury were screened for inclusion into the study. Training on how to perform the lever test was conducted by an emergency medicine fellowship director and a board-certified emergency physician, and occurred on three separate occasions: 1) As a part of didactic lectures for the emergency medicine residents/fellows, 2) During an individualized session for the physician assistants, and 3) During an individualized session for attending physicians. As part of the training, a brief presentation was given about the lever sign test, videotaped examples on how to perform the lever sign test were shown, and a hands-on practice session was held. Each training session was approximately 30 min in duration and was directed once to the residents/fellows, once to the physician assistants, and once to the attending physicians. Each care provider demonstrated proficiency at the training session, as determined by the instructor. Care providers were also provided with an educational handout highlighting important techniques and learning points regarding the tests. Further instruction was available upon request during clinical shifts.

All training sessions were completed prior to the start of the study. Only patients with acute knee injuries were considered for inclusion in the study. Inclusion criteria included patients with probable acute ACL tears without other previous or simultaneous knee pathology in patients ages 12–55 years. Patients were excluded if initial evaluation revealed simultaneous knee pathology or chronic knee disorders, including degenerative joint disease or meniscal pathology. Patients were also excluded if they presented with polytrauma requiring hospital admission. A history of prior knee injury was additional grounds for exclusion from the study. Patients who failed to receive an MRI were also excluded from the study. After patient enrollment, the health care providers completed questionnaires that included patient demographic data, mechanism of injury, screening test used to determine presence of ACL injury, and finally, the level of provider confidence in their examination findings on a scale of 1–10 (Appendix).

Patients presenting in the first 4.5 months of the study were evaluated using the lever sign as part of the acute knee injury evaluation. Patients presenting in the second 4.5 months of the study were evaluated using either the anterior drawer or Lachman test. After the initial

Figure 1. How to perform the Lever sign.

Table 1. Demographics of Study Population

Variable	Lever Sign	Traditional Tests	*p*-Value
Gender			<0.001
Male	14 (67%)	11 (46%)	
Female	7 (33%)	13 (54%)	
Age	31.2 years (12–54 years)	34 years (13–54 years)	0.535
Knee			0.941
Right	12	13	
Left	9	11	
Activity			
Competitive sports	10	6	
Running	2	8	
Walking	3	1	
Biking	2	3	
Stairs	2	3	
Other	2	3	

examination, the emergency physician recorded a definitive diagnosis on the survey ("yes ACL rupture" or "no ACL rupture") followed immediately by the confidence in their diagnosis on a scale of 1 to 10. All patients enrolled in the study were discharged from the hospital and given follow-up instructions.

On initial follow-up, an orthopedic sports medicine specialist conducted a standardized evaluation that included a complete knee examination and an MRI scan. Visit information was then reviewed to affirm the diagnosis received from the patient over the telephone. The sports medicine physician was blinded to the survey and the results of the lever sign test completed by the emergency physician, as these results were not included in the electronic health record. MRI was used as the gold standard for definitive ACL rupture.

Descriptive statistics were performed for all patient characteristics collected. The sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of each diagnostic test were calculated and reported with 95% confidence intervals. All data analysis was performed utilizing SPSS v24 (IBM, Chicago, IL) and Microsoft Excel (Microsoft Corporation, Redmond, WA).

RESULTS

Patient Demographics

Forty-five patients met inclusion criteria and were enrolled in the study; 20 were female (44%) and 25 were male (56%). The mean age of all enrolled patients was 33 years. See Table 1 for study population demographics. Twenty-one patients were evaluated using the lever sign test (47%) and 24 patients were evaluated with either the anterior drawer or Lachman test (53%). Of the 45 total patients enrolled in the study, 8 were found to have an MRI-confirmed ACL rupture (18%). Of those patients with MRI-confirmed ACL rupture, mean age was 29.3 years (range: 14–53). See Figure 2 for a flow diagram of study participants.

Aim 1: Diagnostic Values

Diagnostic accuracy was 95% with the lever sign, vs. 88% when utilizing the anterior drawer/Lachman tests (Table 2). Test sensitivity was 100% vs. 40% with the lever sign test vs. anterior drawer/Lachman test, respectively. Although the overall accuracy and sensitivity

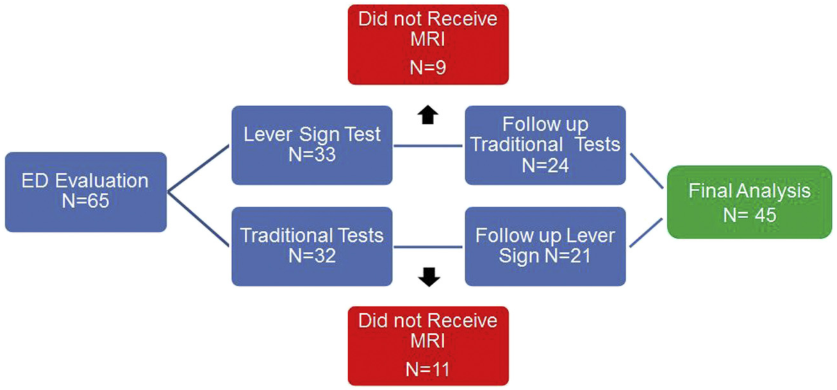

Figure 2. Study design. ED = emergency department; MRI = magnetic resonance imaging.

Table 2. Evaluation of Screening Tests in the ED

Variable	Lever Sign Test		Lachman/Anterior Drawer	
Statistic	Value	95% CI	Value	95% CI
Sensitivity	100.0%	29.2–100%	40.0%	5.3–85.3%
Specificity	93.8%	69.8–99.8%	100.0%	82.4–100%
Positive likelihood ratio	16%	2.4–106.7	N/A	N/A
Negative likelihood ratio	N/A	N/A	60	0.3–1.2
Positive predictive value	75.0%	31.0–95.2%	100.0%	N/A
Negative predictive value	100.0%	N/A	86.4%	75.6–92.8%
Accuracy	94.7%	74.0–99.9%	87.5%	67.6–97.3%

ED = emergency department; CI = confidence interval.

was superior with the lever sign test, the anterior drawer/ Lachman test had a higher specificity (100%) when compared with that of the lever sign test (94%) (Figure 3).

Aim 2: Physician Confidence in Diagnosis

Diagnostic confidence was not significantly different when comparing the different physical examination maneuvers. Mean confidence among care providers who utilized the lever sign test was 8.45 (± 1.82) out of 10, and anterior drawer/Lachman test was 7.72 (± 1.82) out of 10.

Aim 3: Differences in Diagnostic Accuracy Among ED Providers Using the Lever Sign Test

Of the 8 patients that were seen by a physician assistant, 7 received the correct diagnosis (88%). Twelve of 13 (92%) patients evaluated by residents were correctly diagnosed. Of the 2 patients seen by a fellow, both received the correct diagnosis (100%). Finally, 20/22 patients (91%) seen by attending physicians were correctly diagnosed. The differences in diagnostic accuracy between provider groups were not statistically significant (Figure 4).

DISCUSSION

Properly diagnosing ACL rupture in the acute setting remains an ongoing challenge. The use of traditional ACL screening tests has resulted in many false negatives, which could potentially hinder patient outcomes (14,15,20). We sought to be the first study to evaluate the efficacy of the lever sign test in the emergency setting.

We found the lever sign test to have superior sensitivity (100%), and higher confidence in diagnosis among providers using the lever sign test when compared with the more traditional ACL rupture screening tests. We also found that the accuracy of the lever sign test is likely independent of the level of training of the provider administering the screening test, thus rendering it a good screening tool for providers with a broader scope of practice.

In the acute setting, there are several variables that make the traditional screening tests difficult to perform and interpret. These include soft tissue swelling, joint effusion, hemarthrosis, patient guarding from pain associated with the pulling or twisting involved with the tests, the size and strength of the physician's hands/arms performing the tests, the size of the patient's leg, and finally, observer error while interpreting the results (7,8,17). The lever sign test is a new clinical test developed in 2005 and reported in 2014 by Dr. Alessandro Lelli (17). This new test is simple to both perform and interpret. Unlike the anterior drawer or Lachman test, its accuracy is independent of the size and strength of the physician's hands or arms, the size of the patient's leg, and is argued to be less invasive, resulting in less patient guarding. The interpretation of the lever sign is also very simple and is less subject to observer error (20). We attempted to objectively demonstrate the simplicity of administration and the ease of interpretation of the lever sign test using the confidence in diagnosis rating. ED care providers who used the lever sign test reported higher confidence in diagnosis score (8.45) on a scale of 1–10 when compared with the more traditional screening tests (7.72).

Previous studies have compared the accuracy of the lever sign with traditional ACL screening tests (16,17,19,20). In both the acute (<20 days) and the chronic (>20 days) setting, Lelli et al. found the sensitivities of the anterior drawer and Lachman test to be 29% and 42%, respectively, compared with a 100% diagnostic

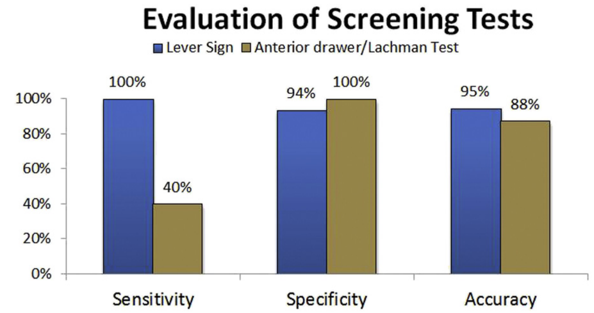

Figure 3. Evaluation of screening tests.

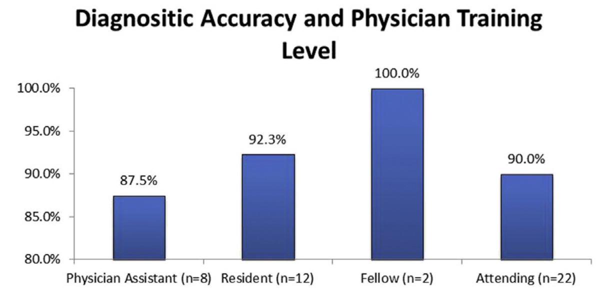

Figure 4. Accuracy among emergency department providers.

sensitivity of the lever sign (17). The second study conducted by Thapa et al. did not mention the time lapsed from injury to initial evaluation, but reported the following sensitivities: anterior drawer 80%, Lachman test 91%, and lever sign 86% (16). The third study, by Deveci et al., evaluated patients with chronic (>4 weeks) ACL tears confirmed by arthroscopy (19). Evaluation took place both with and without anesthesiology, and sensitivities were compared. The anterior drawer test resulted in 60% and 88%, the Lachman test 62% and 88%, and the lever sign 98% and 94%, with and without anesthesiology, respectively. The lever sign, unlike the other tests, avoids rapid manipulation of the injured joint, which minimizes patient guarding and pain, as suggested by fixed sensitivities of the lever sign in patients with and without anesthesia (19,20). Implementation of the lever sign in the ED may better enable ED providers to evaluate patients who may be difficult to examine in the acute period due to co-existing pain.

The most recent study conducted by Jarbo et al. demonstrates the relative ease and accuracy of utilizing the lever sign (20). In their study they compared the sensitivities of the lever sign test between two groups of care providers. The first group was composed of undergraduate/medical students, and the second group was composed of residents/attending physicians. Using MRI as the reference standard, Jarbo et al. found no significant difference in the accuracy of the lever sign when performed by undergraduate/medical students compared with resident/attending physicians (84% vs. 88%, respectively) (20). This analysis on sensitivity of the lever sign test stratified by care provider training level was also consistent with our findings (Figure 4). These data suggest that the accuracy of the lever sign test is likely independent of the level of training of the provider administering the screening test. In other words, the lever sign test is a good screening tool for those with a broader scope of practice. This test can easily and accurately be performed by a variety of different providers from diverse training backgrounds to arrive at a reasonably quick and accurate diagnosis. Similar to the study by Lelli et al., we found 100% sensitivity when utilizing the lever sign (17). Importantly, the sensitivity was not dependent on the level of training (20). This was not the case for the anterior drawer and Lachman test. The ease of learning and implementation of the test makes it an ideal diagnostic tool at all levels of the care ladder.

Limitations

There are several limitations to this study. This pilot study is a nonrandomized trial, and as such it is difficult to ascertain homogeneity between the two treatment groups. Providers used only the lever sign test for the first 4.5-month time period and transitioned to using only the traditional screening tests during the subsequent 4.5-month period. In addition, examiners were not blinded to the patient's history of present illness during their initial ED encounter.

CONCLUSIONS

In this pilot study, our findings suggest that implementing the lever sign in the ED could lead to fewer false negatives, and a higher clinical suspicion of ACL rupture in those that actually have a rupture. This could potentially allow patients to receive a more rapid initial diagnosis of acute ACL rupture, a more timely repair, and better long-term clinical outcomes. With this, we recommend implementing the lever sign as a single part of the standard knee injury evaluation in the ED setting.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jemermed.2019.09.003.

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ARTICLE SUMMARY

1. Why is this topic important?

Recent literature suggests only 26% of acute ACL ruptures are correctly diagnosed in the ED setting. The lever sign could address this problem with its increased sensitivity in the hyper-acute setting.

2. What does this study attempt to show?

Our study attempts to elucidate the high sensitivity of the lever sign test is superior to more traditional ACL screening tests in the hyper-acute setting.

3. What are the key findings?

The lever sign test is 100% sensitive in the hyper-acute setting and demonstrates that the test is simple to perform and easy to interpret. Care providers may be more confident in using the lever sign test than traditional tests for ACL rupture in the ED.

4. How is patient care impacted?

The results of this study suggest that the lever sign test could be utilized in the ED to decrease the number of false negative diagnoses of ACL rupture.