Comparing the Diagnostic Accuracy of Two Selective Tissue Tests for Anterior Cruciate Ligament Injuries: A Critically Appraised Topic

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Clinical Question: In patients with acute knee injuries, is there evidence to support that the lever sign test is more accurate in diagnosing an anterior cruciate ligament sprain than the Lachman test? Clinical Bottom Line: The evidence does not indicate that the lever sign test can be used in isolation in lieu of the Lachman test, but there is sufficient evidence to support adding the lever sign test to the examination of potential anterior cruciate ligament sprains.

Keywords: athletic training, clinical evaluation, lever sign test, Lachman test

Clinical Scenario
Anterior cruciate ligament (ACL) sprains are one of the most common lower extremity injuries within physically active individuals. In the United States alone, approximately 250,000 ACL sprains occur annually.1 ACL sprains are one of the most costly lower extremity injuries, due to magnetic resonance imaging (MRI), surgery, and rehabilitation.2 The three most widely accepted selective tissue tests to diagnose an ACL sprain include the anterior drawer, Lachman test, and pivot-shift test, all of which were initially described in the literature beginning in the 1970s.3 The accuracy of these three examination techniques may be affected by patient factors such as swelling, pain, muscle guarding, and examiner experience.3 In 2005, a new selective tissue test called the lever sign test was put into practice.4 The lever sign test has been reported to be superior to other manual tests, being equally definitive for partial as well as complete tears of the ACL.4

When administering the lever sign test, the patient is placed supine with both knees fully extended. The examiner stands on the same side as the knee being tested and places a closed fist under the proximal third of the lower leg of the involved limb, allowing the knee to flex slightly. With the other hand, a moderate downward force is applied to the distal third of the thigh. With this formation, the patient’s leg acts as a lever over a fulcrum—the clinician’s fist. There are two downward forces on the patient’s leg: the force of the clinician’s hand on the thigh and the force of gravity on the foot and lower leg. A negative test is shown if the patient’s heel lifts off the table, due to the intact ACL being able to counteract the downward force. A positive test is shown when the heel stays on the table, indicating that the patient’s ACL is not able to attenuate the downward force, and therefore indicating that the ACL is compromised.3,4 A new and possibly more accurate selective tissue test would contribute significantly to the physical examination of ACL sprains.

Focused Clinical Question
In patients with acute knee injuries, is there evidence to support that the lever sign test is more accurate in diagnosing an ACL sprain than the Lachman test?

Search Strategy
An initial computerized search was conducted in January 2018 (Figure 1) and a second computerized search was conducted in March 2018. The following search terms were used:

- Patient/Client group: ACL, ACL tears, ACL sprain or anterior cruciate ligament
- Intervention: lever sign test, Lelli test
- Comparison: Lachman test
- Outcome: Diagnostic accuracy (using specificity [ability of test to correctly identify those with the condition] and sensitivity [ability of test to correctly identify those who do not have the condition])

The following resources were searched:

- PubMed
- Medline
- CINAHL plus with full text
- SPORTDiscus
- Health Source
- Hand search

The following inclusion criteria were used to determine eligibility for this study:

- Sensitivity and specificity values provided or able to be calculated from data provided in study for both Lachman test and lever sign test

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The following exclusion criteria were used to determine ineligibility for this study:

1. Did not include sensitivity and specificity values for both lever sign and Lachman test, or values could not be calculated from data provided
2. Studies that were lower than Level 2b evidence, or Level 2b evidence that scored lower than 20/30 on the Standards for Reporting Diagnostic Accuracy Studies (STARD) scale. In the absence of evidence for an existing acceptable high-quality evidence score for the STARD, the authors compared the cutoff score for the Physiotherapy Evidence Database (PEDro). Maher et al. reported that a randomized control trial with a score of 6/10 or higher on the PEDro was considered to be high-quality evidence.6 The authors took that PEDro cutoff score of 6/10 (or 60%) and chose to use a more conservative STARD score of 20/30 (or 66.7%) in the evaluation of evidence quality.
3. Not in English

Evidence Quality Assessment

The quality of these studies was determined using the 30-item STARD. The three authors (RS, BR, JC) individually reviewed and scored each study. After independent review, the three authors (RS, BR, JC) reached a consensus on the scores for each study.

Results of Search

Summary of Search, Best Evidence Appraised, and Key Findings

The literature search yielded eight studies. After reviewing the articles, five studies were excluded, as they did not meet the eligibility criteria.4,7 Figure 1 shows the flow chart for inclusion in the study. Three studies met the eligibility criteria for this study.3,11,12 The included studies compared the sensitivity and specificity values for the lever sign test and the Lachman test.3,11,12 One study11 included cohorts of patients under anesthesia when the tests were administered, and the others had cohorts of awake patients.3,12 Jarbo et al. compared results of the tests to the reference standard of MRI.3 Mulligan et al. compared tests to either MRI or the gold standard, arthroscopic visualization.11 Lichtenburg et al. compared tests to arthroscopic visualization.12 Mulligan et al. found the sensitivity and specificity values for the lever sign test to be 33% and 50%, respectively. In comparison, the Lachman test had values of 65% and 100%, respectively.11 Jarbo et al. found the sensitivity and specificity for the lever sign test to be 63% and 90%, respectively.3 They found the values for the Lachman test to be 90% and 96%.3 In both studies, the Lachman test had better sensitivity and specificity values compared to the lever sign test.3,11 Lichtenburg et al. found the sensitivity and specificity for the lever sign test to be 39% and 100%, respectively.12 They found the values for the Lachman test to be 87% and 91%, respectively. While Lichtenburg et al. also found that the sensitivity of the lever sign test was significantly lower than the Lachman test, it contradicts the other two studies by showing the specificity of the lever sign to be better than the Lachman test.3,11,12

Results of Evidence Quality Assessment

The study by Mulligan et al.11 received a score of 24/30 on the STARD. Jarbo et al.3 received a score of 25/30 and Lichtenburg et al.12 received a score of 22/30. These scores are included in Table 1. In the included studies, the examiners were blinded to the evaluation of the patient, including patient history, clinical evaluation, and imaging results. Mulligan et al. randomized the order of the examination techniques,11 whereas Lichtenburg performed the examination techniques in a predetermined order.12 All three studies compared the results of the examination tests to either arthroscopic visualization or MRI.3,11 Mulligan et al. and Jarbo et al. claim to have an adequate sample size via power analysis,3,11 whereas Lichtenburg performed the examination techniques in a predetermined order.12 All three studies compared the results of the examination tests to either arthroscopic visualization or MRI.3,11 Mulligan et al. and Jarbo et al. claim to have an adequate sample size via power analysis,3,11 while Lichtenburg et al. did not mention whether a power analysis was conducted.12 Mulligan et al. and Jarbo et al. lost points because neither article explained how indeterminate index tests were handled nor how missing data were handled, and neither conducted an analysis of variability in diagnostic accuracy.3,11 Lichtenburg et al.12 was deducted points on the STARD because the authors did not explain how they handled indeterminate index tests, nor did they provide an analysis of the variability in diagnostic accuracy. Furthermore, they did not predetermine an intended sample size, and also did not provide a diagram showing the flow of participants.12

Figure 1 — Summary of search results and included studies.
### Table 1 Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study Title</th>
<th>Mulligan et al.</th>
<th>Jarbo et al.</th>
<th>Lichtenberg et al.</th>
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<tbody>
<tr>
<td>Participants</td>
<td>Participants (n = 60) with a complaint of knee pain (age: 42 ± 13.4 years [18–65], 38 males and 22 females)</td>
<td>Participants (n = 102) with symptomatic knees (mean age: 23 years [15–66], 58 males and 44 females)</td>
<td>Participants (n = 94) with knee trauma indicating arthroscopic surgery (age: 34 ± 15 years, 57 males and 37 females)</td>
</tr>
<tr>
<td>Inclusion/Exclusion Criteria</td>
<td><strong>Inclusion:</strong> Complaint of knee pain rates as less than 7/10 on a verbal numerical rating scale and at least 2–20 degrees of knee range of motion</td>
<td><strong>Inclusion:</strong> Patients with a chief concern of acute knee pain who came for an evaluation within 4 weeks of their injury or the onset of symptoms</td>
<td><strong>Inclusion:</strong> A minimum age of 16 years, trauma to the knee, and an indication for knee arthroscopic surgery</td>
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<tr>
<td>Intervention Investigated</td>
<td>The examination was conducted by an experienced physical therapist before any other diagnostic evaluation was conducted. The uninvolved knee was evaluated first to establish a baseline. The Lachman test was performed with the subject lying supine and prone on a firm examination table and the knee flexed to 20–30 degrees. The lever sign test was conducted with the subject supine on an examination table with a rigid transfer board placed underneath the involved extremity during testing. For 19 subjects, the gold standard for diagnostic accuracy was direct arthroscopic visualization of the ACL at the time of surgery. For the remaining 41 subjects, ACL status was categorized as intact or sprained based on a cluster of clinical findings.</td>
<td>To assess the integrity of the ACL, the anterior drawer, Lachman test, pivot shift test, and lever sign tests were performed on each symptomatic knee. A single randomly-assigned undergraduate student, medical student, orthopedic resident or orthopedic fellow performed the tests. In the nonsurgical group, the four tests were performed during the initial visit and, in the surgical group, the four tests were performed in the operating room with the patient under anesthesia. The testers were blinded to the patient history, office physical examination, radiographic and MRI findings, and operative procedure. The definitive ACL status was determined by MRI in nonsurgical patients and by arthroscopic surgery in surgical patients.</td>
<td>A trauma surgeon or orthopedic surgeon at the outpatient clinic screened each patient. The surgeon examined each patient’s knee in a predetermined order: (1) lever sign test, (2) anterior drawer test, (3) Lachman test, and (4) pivot shift test. The results of each test were documented as positive or negative. When possible, this procedure was repeated by a physical therapist within 1 week. The physical therapist was blinded to the test results of the surgeon. Additionally, arthroscopic surgery results were collected after surgery.</td>
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<td>Outcome Measures</td>
<td>Lever sign test, prone Lachman test, supine Lachman test; arthroscopic surgery and clinical findings for ACL status</td>
<td>Anterior drawer test, Lachman test, pivot shift test, lever sign test; MRI and arthroscopic surgery for definitive ACL status</td>
<td>Lever sign test, anterior drawer test, Lachman test, pivot shift test; arthroscopic surgery for ACL status</td>
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<td>Results</td>
<td>The sensitivity of the lever sign, prone, and supine Lachman tests were 38%, 83%, and 67%, respectively, and the specificity was 72%, 89%, and 97%.</td>
<td>The overall accuracy of the lever sign test was 77% (63% sensitivity, 90% specificity). The accuracy was similar between patients under anesthetics (77%) and awake (76%). The accuracy of the lever sign test was similar when performed on female (75%) versus male patients (79%) and when performed by undergraduate students and medical students (84%) compared with orthopedic residents and fellows (88%). The accuracy was highest for the Lachman test (93%) and lowest for the lever sign test (77%).</td>
<td>The lever sign test and pivot shift test had kappa values exceeding 0.80 for inter-rater reliability, while the Lachman test and anterior drawer test had kappa values between 0.61 and 0.80. The lever sign test showed the highest specificity (100%) and the lowest sensitivity (39%) compared to the other three tests. The diagnostic accuracy, using arthroscopic surgery as the gold standard, of the lever sign test, anterior drawer test, Lachman test, and pivot shift test were 71%, 82%, 94%, and 78%, respectively. Clustering the lever sign test parallel with the other three tests resulted in the highest accuracy of 91%.</td>
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Table 1 (continued)

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<tr>
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<th>Mulligan et al.(^{11})</th>
<th>Jarbo et al.(^ {3})</th>
<th>Lichtenberg et al.(^ {12})</th>
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<tr>
<td><strong>Level of Evidence</strong></td>
<td>2b</td>
<td>2b</td>
<td>2</td>
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<tr>
<td><strong>STARD Score</strong></td>
<td>24</td>
<td>25</td>
<td>22</td>
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<tr>
<td><strong>Support for the Answer</strong></td>
<td>The lever sign test, in isolation, does not accurately detect the status of the ACL. The lever sign test should be used as an adjunct to the gold standard manual assessment technique of a Lachman test in either prone or supine positions.</td>
<td>Although the lever sign test has a high diagnostic accuracy, this study challenges the previously reported exceptionally high sensitivity and specificity values (both 100%), as reported by the original author of the test. The lever sign test should be used as an adjunct to the Lachman test when evaluating an ACL injury.</td>
<td>The lever sign test has a high interrater reliability, is the most specific test, and is easy to perform. However, the test has a low sensitivity, so instead of being used on its own, the lever sign test is a useful addition to the physical examination of a suspected ACL injury.</td>
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Abbreviations: ACL = anterior cruciate ligament; MRI = magnetic resonance imaging; PCL = posterior cruciate ligament; STARD = Reporting Diagnostic Accuracy Studies.

**Clinical Bottom Line**

There is consistent, high-quality evidence to suggest that the lever sign test is not as accurate to use in isolation as a selective tissue test to diagnose ACL sprains. However, there is sufficient, high-quality evidence to support the use of the lever sign test in conjunction with the Lachman test in the clinical examination of ACL sprains.\(^ {3,11,12}\) Further research needs to be conducted to increase the body of literature surrounding the diagnostic accuracy of the lever sign test.

**Strength of Recommendation**

Mulligan et al.\(^ {11}\), Jarbo et al.\(^ {3}\), and Lichtenberg et al.\(^ {12}\) are all categorized as Level 2b evidence according to the Centre for Evidence-Based Medicine (CEBM) levels of evidence.\(^ {5}\) There are consistent findings that the lever sign test is not as sensitive or specific as the Lachman test. Therefore, the evidence supports a grade B recommendation based on the Strength of Recommendation of Taxonomy.\(^ {13}\)

**Implications for Practice, Education, and Future Research**

This critical appraisal of the existing literature demonstrates that there is consistent evidence showing that the Lachman test has superior sensitivity and specificity to the lever sign test in the diagnosis of ACL sprains. The first published study that described and examined the accuracy of the lever sign test was done by Lelli et al.\(^ {4}\) The lead author of that study, Dr. Alessandro Lelli, is the creator of the lever sign test. The study had 400 patients who had confirmed ACL tears by MRI. They were split into four, equal-numbered groups based on clinical phase (acute or chronic) and severity (complete or partial). The affected limb of every patient was tested with the anterior drawer, pivot shift, Lachman test, and lever sign test. Further, the unaffected limbs were tested with only the lever sign test. Lelli et al. reported a specificity and sensitivity of 100%, each for the lever sign for all four groups. In contrast, they reported the overall sensitivity for the Lachman test to be only 42%, which contradicts previously published literature.\(^ {14,15}\) However, the study has several limitations. First, the examiner was not blinded to knowing that every patient had an ACL sprain, nor was the examiner blinded to the affected side. In addition, there was only one examiner who did all the tests, introducing bias to the results.\(^ {4}\)

Mulligan et al. conducted a prospective cohort study with 60 patients with suspected ACL tears.\(^ {11}\) The selective tissue tests were performed before any other diagnostic evaluation, including history or review of imaging results, so the examiner was blinded to the patient’s condition while performing the physical examination. Following completion of the examination, the examiners created 2×2 contingency tables and calculated diagnostic statistics for each test, such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). The results of the study showing sensitivity and specificity values can be found in Table 1. Overall diagnostic accuracy was not provided in the study, but using the 2×2 contingency tables provided, diagnostic accuracy was calculated by the authors of this appraisal. They were found to be 0.58 for the lever sign test, and 0.85 for the Lachman test.\(^ {11}\) The conclusion of the study was that the lever sign test is not an accurate test in the detection of ACL sprains, and therefore cannot be used in isolation. However, they believe the test should be added to the clinical examination for suspected ACL sprains. The main limitation to this study was the sample size was too small, even if they met the sample size determined by their power analysis, because the confidence intervals were relatively wide.\(^ {11}\)

Jarbo et al. also conducted a prospective cohort study to determine the diagnostic accuracy of four tests—Lachman, anterior drawer test, pivot shift test and lever sign test—in 102 patients.\(^ {3}\) The examiners were blinded to the condition of the patient and the MRI findings. Diagnostic statistics calculated for this study were sensitivity, specificity, PPV, NPV, and diagnostic accuracy, which can all be found in Table 1. Jarbo et al. concluded that while the Lachman test was determined to be the most accurate test in the study, they found that the lever sign test was easy to learn and reproduce, and the ability to perform the test is not impacted by the size of the patient. Results of this study indicate that while the lever sign test is insufficient specific, it is not adequately sensitive. Therefore, the author’s recommendation was that the lever sign test should be added to the clinical examination for suspicions of ACL sprains.\(^ {3}\) This study has a few limitations. First, the authors did not compare the clinical results from the tests between different clinicians. Second, only a single examiner was used to administer the tests to each patient rather than using a multiple examiner approach. The authors also did not calculate interrater reliability or other analyses. Third, the inclusion of the undergraduate student could have altered the results, as that student was not a licensed healthcare professional. Lastly, the results of the tests compared to arthroscopic visualization in the surgical cohort were not reported.\(^ {3}\)

Lichtenberg et al.\(^ {12}\) conducted a prospective cohort examining the diagnostic accuracy of four selective tissue tests—the Lachman test, lever sign test, anterior drawer test, and pivot shift test.
test—compared to the diagnostic gold standard of arthroscopic visualization. The sensitivity and specificity values from this article can be found in Table 1. This study also added the lever sign test to a cluster of parallel tests to evaluate its additional value in the diagnosis of ACL sprains. Cluster 1 included the Lachman’s, anterior drawer and pivot shift test, and cluster 2 included the tests in cluster 1 plus the lever sign test. They found the sensitivity and specificity of cluster 1 to be 88% and 91%, respectively. Both the sensitivity and specificity for cluster 2 were shown to be 91%.12 While the addition of the lever sign minimally improved the sensitivity of the tests and did not affect specificity, this study still supports the use of the lever sign test in conjunction with the other selective tissue tests in the diagnosis of ACL sprains. This study has several limitations, however. The first is that the study used a predetermined order of tests, with the lever sign being the first test administered. This could have introduced bias, as the examiners knew the results of the previous tests. Another limitation was that the study had a substantial group of patients in which the lever sign and pivot shift tests could not be performed properly, and thus the results from those patients were not utilized.12

Most of the literature that has been published since the original Lelli study have refuted the findings from Lelli et al.4 Chong et al. calculated sensitivity found by different healthcare providers.8 The sensitivity for the lever sign test were 0.82, and 0.88 between the two clinicians, while the sensitivity for the Lachman test were 0.67 and 0.94. Specificity was not calculated because each patient was found to have an ACL sprain. Thappa et al., the study that passed the eligibility criteria for inclusion in this Critically Appraised Topic but was excluded due to low-quality evidence, still found the sensitivity of the lever sign to be 0.86 and specificity to be 0.91, while the sensitivity for the Lachman was 0.91 and specificity was 0.96.7 Deveci et al.9 is the only study that contradicts the findings in the literature that has been published after the study by Lelli et al. This study found preanesthesia, the sensitivity of the lever sign test was 0.94, while the sensitivity for the Lachman test was 0.8. Under anesthesia, those values were 0.98 and 0.88, respectively. Only patients undergoing an ACL reconstruction were included in the study, so specificity rates were not calculated.9

Methods for clinical diagnosis of ACL sprains is a widely studied topic where a few published meta-analyses are available that compare sensitivity and specificity of different tests, not including the lever sign test.14,15 Huang et al. found pooled sensitivity and specificity for the Lachman test to be 0.87 and 0.97, respectively.14 Van eck et al. found that, for the Lachman, sensitivity and specificity were both 0.81.15 To compare these values of the Lachman test from systematic reviews, pooled sensitivity and specificity values were calculated for the three studies included in this CAT. The pooled sensitivity and specificity values for the lever sign test, calculated from the three studies included in this CAT, were 0.49 and 0.89, respectively. These values indicate that the Lachman test is the more sensitive test, however, it is yet to be determined whether the Lachman test or the lever sign test is more specific.3,11,12

In order to make more accurate conclusions, further research on the lever sign test is needed. First, there needs to be more high-quality cohort studies to measure sensitivity and specificity with an increased number of patients in the population.8,11,12 While most of the studies appraised in this manuscript claim to have met the sample size determined by power analysis, the total number of patients in Mulligan et al.,11 Jarbo et al.,3 and Lichtenburg et al.12 combined is 249, with an age range of 15–66 years old. Second, there is a need for high-quality evidence that examines interrater variability between different healthcare providers for the lever sign test.3,15 Third, as mentioned in the Jarbo et al.3 study, a biomechanical study must be done to validate the mechanism for the lever sign test that was proposed by Lelli et al.3 Lastly, once more high-quality studies have been completed, a systematic review and possibly a meta-analysis should be done to compare all the studies and pool all the data to make accurate conclusions about the diagnostic accuracy of each test used to diagnose ACL sprains.

The Lachman test has so far been shown to be the most accurate test in the diagnosis of ACL tears.14,15 The lever sign test is a new proposed clinical examination test that was shown to have 100% sensitivity and specificity in the developer of the test’s own study.4 Several studies completed since that first study that compare the lever sign test to other clinical tests have shown that the Lachman test is more accurate at correctly diagnosing ACL injuries compared to the lever sign test, based on several diagnostic statistics, such as sensitivity and specificity, among others.3,11,12 None of the studies included in this appraisal support the use of the lever sign test in isolation, but there is evidence to support inclusion of the lever sign test and other diagnostic tests for patients with suspected ACL sprains in conjunction with other selective tissue tests. Therefore, clinicians should use the lever sign test as it can assist in the diagnosis of ACL sprains, and is an easy test to perform. This CAT should be reviewed in 2 years to determine if additional evidence will alter the recommendation for the clinical utility of the lever sign test in patients with suspected ACL sprains.

**CAT Kill Date: July 2021**

CATS have limited life and should be revisited approximately 2 years after publication (see https://doi.org/10.1123/ijatt.2018-0093).

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