LEVER SIGN TEST FOR CHRONIC ACL INJURY: A COMPARISON WITH LACHMAN AND ANTERIOR DRAWER TESTS

ABSTRACT

Objective: This study aims to evaluate the sensitivity and specificity of the lever sign test in patients with and without chronic Anterior Cruciate Ligament (ACL) injuries in an outpatient setting and the inter-examiner agreement of surgeons with different levels of experience. Methods: 72 consecutive patients with a history of previous knee sprains were included. The Lachman, anterior drawer, and Lever Sign tests were performed for all subjects in a randomized order by three blinded raters with different levels of experience. Sensitivity, specificity, positive predictive value, negative predictive value, and inter-rater agreement were estimated for all tests. Results: Among the 72 patients, the prevalence of ACL injuries was 54%. The lever test showed sensitivity of 64.1% (95% CI 0.47-0.78) and specificity of 100% (95% CI 0.87-1.00) for the senior examiner. For the less experienced examiner the sensitivity was 51.8% and the specificity was 93.7%. Positive predictive values (PPV) and negative predictive values (NPV) were 100% and 70.2%, respectively. Conclusion: Lever Sign test shows to be a maneuver of easy execution, with 100% specificity and 100% PPV. Moderate agreement between experienced examiners and low agreement among experienced and inexperienced examiners was found. This test may play a role as an auxiliary maneuver.

Keywords: Anterior Cruciate Ligament. Anterior Cruciate Ligament Injuries. Knee Joint. Joint Instability.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar a sensibilidade e a especificidade do teste da alavanca em pacientes ambulatoriais com e sem lesões crônicas do LCA e a concordância entre examinadores com diferentes níveis de experiência. Métodos: Setenta e dois pacientes consecutivos com histórico de entorse de joelho foram incluídos. O teste de lachman, gaveta anterior e teste de alavanca foram realizados para todos os indivíduos em ordem randomizada por 3 examinadores cegados com diferentes níveis de experiência. Sensibilidade, especificidade, valor preditivo positivo, valor preditivo negativo e concordância interavaliadores foram calculados para todos os testes. Resultados: Entre os 72 pacientes, a prevalência de lesões do LCA foi de 54%. O teste da alavanca mostrou sensibilidade de 64,1% (IC95% 0,47-0,78) e especificidade de 100% (IC95% 0,87-1,00) para o examinador sênior. Para o examinador menos experiente, a sensibilidade foi de 51,8% e a especificidade, de 93,7%. Valores preditivos positivos (VPP) e valores preditivos negativos (VPN) foram de 100% e 70,2%, respectivamente. Conclusão: O teste da alavanca mostra ser uma manobra de fácil execução, com 100% de especificidade e 100% de PPV. Foi encontrada concordância moderada entre examinadores experientes e baixa concordância entre examinadores inexperientes. Este teste pode desempenhar um papel como uma manobra adjuvante.

Descritores: Ligamento Cruzado Anterior. Lesões do Ligamento Cruzado Anterior. Articulação do Joelho. Instabilidade Articular.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are the most common ligament injuries of the knee. Diagnosis is made based on history, physical examination and confirmed by magnetic resonance imaging (MRI) and diagnostic arthroscopy. The most frequently employed physical examination tests are the Lachman, the anterior drawer and the pivot shift, which have high sensitivity and specificity. Among the three tests, the Lachman test is accepted as the most sensitive (85-96%). However, examiner experience, patient’s body habitus and the presence of knee effusion can impair the execution of the tests. Some series

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have shown up to 74% of failure in clinical diagnosis of acute ACL injuries among emergency physicians. The significance of the examiner proficiency is further shown by a study in which primary care physicians identified correctly only 62% of chronic ACL injuries, in comparison to 94% for orthopedic surgeons. In 2016, Lelli et al. described a new maneuver for the diagnosis of ACL injuries, called the Lever Sign test. They reported 100% sensitivity and 100% specificity for both acute and chronic injuries, even in patients with large muscle mass and obese. The test does not reproduce the rapid translational movements between the tibia and the femur, so it might induce less pain and resistance by the patient. Also, the objective assessment of the test positivity is reported to be easier than for the traditional tests, especially for inexperienced examiners. Other authors have investigated the Lever Sign test and found lower sensitivity (38-98%) and specificity (72-100%). Studies are yet to be able to reproduce the results published by Lelli et al. The fact that no study has specifically evaluated the claim that the test might be easier to perform and therefore more accurate for inexperienced or non-specialist examiners is especially interesting. Moreover, its performance has not been previously tested in chronic injury settings.

This study aims to evaluate the performance of the Lever Sign test for chronic ACL injury and to evaluate inter-rater agreement between two experienced examiners and between an experienced and an inexperienced examiner, in comparison to the Lachman and the Anterior Drawer tests.

MATERIALS AND METHODS

The study was conducted from August 2017 to June 2018 in an orthopedic department of a tertiary hospital after approval by the institutional ethics review board. In total, 72 consecutive patients were evaluated at the first outpatient visit in the institution. All patients had a history of knee sprain for more than one month and had been referred for evaluation. Inclusion criteria were age between 18 and 50 years, history of knee sprain for at least 1 month without previous knee surgeries and an available MRI to confirm the diagnosis. ACL injury at MRI was defined as a complete ligament rupture. Patients with other ligament tears, diagnosis of osteoarthritis, and bilateral ACL injuries were excluded. The Lachman, Anterior Drawer, and Lever Sign tests were performed in all patients by the main examiner, a knee surgery specialist, and these data were used to evaluate the tests performance. Furthermore, to evaluate inter-examiner agreement in different levels of examiner experience, the first 35 patients of the study were also examined by another experienced knee surgeon, and an inexperienced one (a first-year resident of the orthopedic program), with little previous physical examination experience in knee ligament injuries. The inexperienced examiner was instructed on the physical examination tests prior to the beginning of this study. All examiners were blind to the diagnosis and other information about the patient or the results of the physical examination by the other examiners. The examined limb, defined as the limb of the patient’s complaint, was indicated by the researcher responsible for compiling the data. This last researcher was also blinded for the MRI and clinical examination tests prior to the beginning of this study. Moreover, its performance has not been previously tested in chronic injury settings.

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Data analysis

For the Lachman, Anterior Drawer, and Lever Sign tests, the values of sensitivity, specificity, positive and negative predictive values were obtained for the main examiner and the resident examiner, with 95% confidence intervals (95% CI), using MRI as the gold standard diagnosis. The inter-examiner agreement between the main examiner and the second experienced surgeon and between the main examiner and the orthopedic resident were evaluated with Cohen’s Kappa coefficient. The agreement was interpreted according to McHugh: none (0-20), minimal (21-39), weak (40-59), moderate (60-79), strong (80-90), almost perfect (>9).

For quantitatively comparing the discriminative ability of the tests, ROC (Receiver Operating Characteristic) curves were produced from the results obtained by the principal examiner. The use of ROC curves for binary diagnostic tests has been previously described. The areas under the curve obtained were compared between the diagnostic tests. The sample size was defined based on the recommendations of Bujang and Adnan, considering an expected prevalence of 50% of ACL injuries among patients with history of knee sprains, expected sensitivity for the Lachman test of 90%, and 80% power to demonstrate a 20% difference of the sensitivity of the tests. The calculated minimum sample was 62 participants, so we chose to enroll 72 patients for safety.
Values of p < 0.05 and differences beyond 95% CI were considered statistically significant. Statistical software SPSS 22 (IBM Corp., NY, USA) and VassarStats (Richard Lowry, Vassar College, NY, USA) were used.

RESULTS
In total, 72 patients were included in the study, 49 men and 23 women, with a mean age of 33.2 ± 8.6 years. The prevalence of ACL injuries was 54% among all knee sprains, of which 39 had ACL rupture and 33 had no injury.

For the main examiner, the Lever Sign test sensitivity was 64.1% (95% CI 47-78%), specificity was 100% (95% CI 87-100%), positive predictive value (PPV) was 100% (95% CI 0.83-1.00), negative predictive value (NPV) was 70.2% (95% CI 0.55-0.82) and accuracy was 80.5%.

The Lachman and Anterior Drawer test for the main examiner were, respectively, 94.8% (95% CI 81-99%) and 82.0% (95% CI 65-91%) sensitivity, 100.0% (95% CI 87-100%) and 84.8% (95% CI 67-94%) specificity, 100% (95% CI 88-100%) and 86.4% (95% CI 70-94%) PPV, 94.2% (95% CI 79-99%) and 80.0% (95% CI 62-90%) NPV, and 97.2% and 32.3% accuracy. Therefore, the Lachman test had a superior specificity to the Lever Sign test beyond the 95% CI.

For the inexperienced examiner, the Lever Sign test percentages were 51.8% (95% CI 32-70%) sensitivity, 93.7% (95% CI 67-99%) specificity, 93.3% (95% CI 66-99%) PPV, 53.5% (95% CI 34-71%) NPV and 67.4% accuracy.

The Lachman and Anterior Drawer test for the inexperienced examiner presented, respectively, 66.6% (95% CI 46-82%) and 62.9% (95% CI 42-79%) sensitivity, 93.7% (95% CI 67-99%) and 93.7% (95% CI 67-99%) specificity, 94.7% (95% CI 71-99%) and 94.4% (95% CI 70-99%) PPV, 62.5% (95% CI 40-80%) and 60.0% (95% CI 38-78%) NPV, and 76.4% and 74.4% accuracy.

The inter-examiner agreement by the Kappa coefficient between the main examiner and the second experienced examiner was 0.60 (moderate) for the Lever Sign test (p = 0.001), 0.92 (almost perfect) for the Lachman test (p < 0.001), and 0.60 (moderate) for the Anterior Drawer test (p = 0.001) (Table 2).

Between the main examiner and the inexperienced examiner, inter-examiner agreement by the Kappa coefficient was 0.35 (minimum) for the Lever Sign test (p = 0.003), 0.42 (weak) for the Lachman test (p = 0.009), and 0.34 (minimum) for the anterior drawer test (p = 0.052) (Table 2).

The ROC curve was 0.974 in area under the curve (AUC) for the Lachman test, 0.834 for the anterior drawer test and 0.821 for the Lever Sign test (Figure 2 and Table 3). The Lachman test AUC was higher than the anterior drawer and Lever Sign tests (p = 0.008 and 0.004, respectively).

DISCUSSION
The main finding of this study is that the Lever Sign test is a maneuver with 100% specificity and 100% PPV despite not having a high sensitivity. It was less sensitive and less accurate than the Lachman test and presented moderate agreement among experienced examiners and a low agreement between an inexperienced and the experienced examiners.

Currently, physical examination tests are not always able to confirm ACL insufficiency, therefore there is great interest in the test described by Lelli et al.,3 which was reported to achieve 100% sensitivity and specificity in their study.

Unfortunately, the test showed to have much higher accuracy in experienced examiners and should not be extrapolated as the gold standard for ACL injury to all emergency physicians or orthopedic surgeons who do not have a knee surgery or sports medicine background, as it was initially speculated. Our results were discordant with those reported by Jarbo et al.,19 who found similar

**Table 1.** Tests performance for the main examiner. 95% confidence intervals in parentheses.

| Test                | Sensitivity | Specificity | VPP    | VPN   |
|---------------------|-------------|-------------|--------|-------|
| Lever Sign          | 64.1%       | 100%        | 100%   | 70.2% |
|                     | (47-78%)    | (87-100%)   | (83-100%) | (54-82%) |
| Lachman             | 94.8%       | 100%        | 100%   | 94.2% |
|                     | (81-99%)    | (87-100%)   | (88-100%) | (79-99%) |
| Anterior drawer     | 82.0%       | 84.85%      | 86.4%  | 80%   |
|                     | (65-91%)    | (67-94%)    | (70-94%) | (62-90%) |

*: statistically significant.

For the inexperienced examiner, the Lever Sign test percentages were 51.8% (95% CI 32-70%) sensitivity, 93.7% (95% CI 67-99%) specificity, 93.3% (95% CI 66-99%) PPV, 53.5% (95% CI 34-71%) NPV and 67.4% accuracy.

**Table 2.** Inter-rater agreement by the Kappa coefficient.

| Test               | Kappa coefficient | p     | Kappa coefficient | p     |
|--------------------|-------------------|-------|-------------------|-------|
| Lever Sign         | 0.60 (0.32-0.88)  | 0.001 | 0.35 (0.05-0.66)  | 0.034 |
| Lachman            | 0.92 (0.78-1.00)  | < 0.001 | 0.42 (0.14-0.71)  | 0.009 |
| Anterior drawer    | 0.60 (0.31-0.88)  | 0.001 | 0.34 (0.02-0.66)  | 0.052 |

Values in parentheses are 95% CI.

**Table 3.** Area under the curve (AUC) for Receiver Operating Characteristic (ROC) curves.

| Diagnostic test | AUC    |
|-----------------|--------|
| Lever Sign      | 0.821† |
| Anterior Drawer | 0.834♣ |
| Lachman         | 0.974† |

*: p = 0.006; †: p = 0.004; ♣: p = 0.85 (not significant).
The Lever Sign test does not contemplate the ACL rotational restriction component and the possible involvement of knee anterolateral structures, which may decrease the accuracy for patients who present greater rotational instability than anterior translation. This occurs in patients with a more significant pivot shift than the Lachman and anterior drawer tests, as it has already been demonstrated in cases of partial injuries of the posterolateral ACL band. Thus, the Lever Sign test has a qualitative character and does not allow the quantification of translational or rotational instability. In this study, the behavior of the different functional bands in the ACL partial ruptures was not separately studied since all patients presented complete ligament rupture. The force to be applied to the thigh is also not well established and since it is not theoretically a comparative test to the contralateral limb, its positivity is based only on the heel elevation at the examination table and it is not known if the use of a greater force could elevate the limb even in the absence of ACL injury. We thus believe that the maneuver should be performed in a comparative bilateral way in order to establish a minimum adequate force to acquire the elevation of the non-affected limb and to define the response pattern for that individual. However, in our study this concern was not verified, and the test presented excellent specificity. In the present study the applied force was not measured or standardized, but the same examiner applied similar force intensity and did it comparatively bilaterally, as is usually done in the outpatient physical examination for the Lachman and anterior drawer tests.

This study presents some limitations, such as the fact that the evaluations were performed only with non-anesthetized patients. It is known that the values of sensitivity, specificity and accuracy increase with the anesthetized patient, but the purpose of the study was to evaluate the diagnosis in the clinical context of the office or emergency room with an awake patient. It is also noteworthy that the gold standard to determine the injury positivity was magnetic resonance imaging evaluated by experienced musculoskeletal radiologists, which, although present high sensitivity and specificity values and 93.5% accuracy, can be cited as a possible limitation. Another limitation is that the first 30 patients were evaluated sequentially by the 3 examiners, for 9 total maneuvers performed on each patient, which may increase discomfort and promote some degree of muscle spasm, altering the results. Thus, the Lever Sign tests proved to be an easy maneuver with moderate agreement between experienced examiners and low agreement among experienced and inexperienced examiner. This test has a role as an adjuvant maneuver, but not isolated for the diagnosis of ACL ruptures.

CONCLUSION

Lever Sign test was shown to be a maneuver of easy execution, with 100% specificity and 100% positive predictive value. Moderate agreement between experienced examiners and low agreement between experienced and inexperienced examiners was found. This test may play a role as an adjuvant maneuver.

AUTHORS’ CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. MFS: intellectual concept of the study, performed test, conducted the bibliographic research, evaluated and interpreted the data collected, and wrote the manuscript; MBB: intellectual concept of the study, performed physical examination, conducted the bibliographic research, evaluated and interpreted the data collected, and wrote the manuscript; GFR: collected data, performed physical examination, drafted the manuscript; PNG: intellectual concept of the study, statistical analysis, drafted and revised the manuscript; CP: analyzed the data collected, performed the final revision of the manuscript, and also contributed to the intellectual concept of the study; MKD: analyzed the data collected, performed the final revision of the manuscript, and also contributed to the intellectual concept of the study.

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