Comparison of selected clinical tests for the assessment of ACL injury with respect to sensitivity and specificity - a review paper

Angelika Sosulska[1], Dorota Ankowska[2], Barbara Szczurowska[3], Małgorzata Jekiełek[1], Grzegorz Mańko[1]

[1] Department of Biomechanics and Kinesiology, Institute of Physiotherapy, Jagiellonian University Collegium Medicum, Kraków, Poland

[2] Activus Rehabilitation, Węgrzce Wielkie, Poland

[3] Fizjomed Sp.z.o.o., Skrzydlna, Poland

Correspondence to: Dorota Ankowska, email: dorotku@interia.pl

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Abstract

The knee joint is prone to injury due to its complexity and weight-bearing function. Anterior cruciate ligament (ACL) rupture is a common knee injury with severe complications in the young and physically active population. This study aimed to perform a comparative evaluation of the Lachman, Anterior Drawer, Pivot-shift, and Lever tests in terms of sensitivity and specificity. According to existing research, the Lachman test appears to have the highest overall diagnostic accuracy, and the pivot-shift test has the highest specificity but low sensitivity results. The anterior drawer test has average results in both specificity and sensitivity. However, the Lever test can be successfully used by inexperienced individuals and patients immediately after injury (in the acute state).

Key words

anterior drawer test,
Lachman test,
pivot-shift test,
Lever test,
sensitivity,
specificity,
ACL injuries.

Introduction

A partial or complete anterior cruciate ligament (ACL) rupture is a serious knee joint injury. This trauma is particularly common among younger individuals and those involved in sports, as it is, in around 70% of cases, a result of an activity requiring rotation. This refers to high-risk sports such as football, basketball, or alpine skiing [1,2]. In addition, ACL ruptures can be combined with tibial (TCL), and fibular collateral ligament (FCL) tears, with meniscus and cartilage injuries or, less commonly, posterior cruciate ligament (PCL) ruptures. Such coexisting injuries hinder the correct diagnosis of ACL injury, especially during physical examination [2].

Untreated injury presents a significant risk for meniscus pathology and cartilage deterioration, which can predispose patients to developing osteoarthritis and subsequent total joint alloplasty [3]. The rupture is surgically treated and involves ligament reconstruction [2]. Accurate initial diagnosis enables rapid implementation of treatment, while delays are associated with reduced stability and potentially other cartilage damage compared to those who received an instant diagnosis and prompt treatment [3]. An adequate and reliable clinical examination is the essence of further treatment, making the selection of appropriate tests confirming a given dysfunction in this joint extremely important.

This review paper will outline four clinical tests used to assess ACL damage, considering their sensitivity and specificity. The three most widely used and accepted clinical tests for diagnosing ACL damage include the anterior drawer test, the Lachman test, and the pivot-shift test, all of which were first documented in the 1970s [4]. Additionally, the Lever test presented in this paper is a relatively new test, upon which numerous articles have been published in recent years.

Biomechanics of the anterior cruciate ligament

ACL is the main structure that stabilizes the knee joint preventing excessive translation of the tibia relative to the femur. This ligament limits the internal rotation of the tibia [1,2]. In the composition of the above-mentioned structure, we can distinguish two bundles: the anteromedial (AM) bundle and the posterolateral (PL) bundle [5].

ACL is covered by a synovial membrane. Its length varies from 22 to 41 mm, and its thickness is an individually determined trait that ranges from 7 to 12 mm. Additionally, it should be mentioned that ACL is not a unified band across its length; it always remains tense regardless of the degree of knee joint flexion [6].

It is important to remember that the entire ligament complex of the knee joint is interdependent, and their individual functions complement each other [7]. This dependency is mainly observed between ACL and PCL ligaments as well as TCL and FCL ligaments [8]. Many publications point out that ACL, in addition to its mechanical function, is the main proprioceptive component of the knee joint making it the key ligamentous structure of the knee [7].

ACL tightens during internal rotation as it wraps around the PCL, stretches during maximal external rotation (by pressing against the intercondylar fossa), prevents anterior subluxation of the tibia, and, as a secondary stabilizer, provides lateral and medial stabilization of the knee joint (working in collaboration with the PCL) when the primary stabilizers, the collateral ligaments, fail [9].

Most importantly, both cruciate ligaments provide anterior-posterior knee stability, allowing hinged movement in the knee joint while preventing the joint surfaces from moving away from each other [9].

Clinical tests in anterior cruciate ligament injuries

Anterior drawer test

Execution: the patient lies on their back with the hip joint bent at a 45° angle, the knee joint bent at approximately 90° angle, and the foot stabilized on the lounger. The examiner grasps the proximal part of the tibia with both hands, slightly below the tibial tuberosity. The examiner then moves the proximal end of the tibia ventrally while observing the range of this movement and the end resistance [10]. Interpretation: the test result is considered positive when the clinician observes a difference in the range and the end resistance of the movement. Displacement of the femur relative to the tibia by more than 5 mm compared to the healthy limb and soft end resistance may indicate ACL injury, giving a positive test result. In fresh injuries, anterior drawer testing with knee flexion of 90° often yields a negative result because this movement often causes pain, and patients tend to resist reflexively [11]. It is important to remember that in the case of simultaneous ACL and PCL injury, in a test examining the ACL injury, it is possible to obtain a false-positive anterior tibial translation, which would be the sum of the values of the anterior drawer test and the posterior drawer test [12]. The anterior drawer test is presented in **Figure 1**.

Figure 1. The anterior drawer test technique.

Lachman test

Execution: the patient lies on their back. The examiner positions the patient's knee joint at a 15-30° flexion angle, grasping the proximal end of the tibia with one hand and placing the other hand on the distal end of the femur. The subject's heel rests comfortably on the lounger. The examiner pulls the tibia towards themselves (in an anterior direction) while trying to feel the displacement (translation) of the tibia relative to the femur with the thumb [11]. Interpretation: the test result is considered positive when the examiner observes a shift of the tibia towards the center. With an intact, functional ACL, a slight movement towards the anterior displacement of the proximal tibial epiphysis can be observed (2-3 mm), with a so-called 'hard' end stop. The ability to move the tibia forward distinctly with a 'soft' sensation of end resistance is indicative of ACL injury. The test should be performed after prior exclusion of PCL injury. The test should also be performed on the opposite side [11]. The Lachman test is presented in **Figure 2**.

Figure 2. The Lachman test technique.

Pivot-shift test

The pivot-shift test is commonly used to diagnose and assess dynamic instability of the knee joint in ACL rupture cases [4]. A 2008 study conducted by Lane compiles 13 examination techniques published in the literature for the pivot-shift test [2]. Execution: the patient lies on their back. The examiner grasps and fixates the lateral femoral condyle with one hand, and with the other, one grasps the calf, performs internal rotation and abduction (valgus), and then flexes and straightens the knee joint from this position [13]. Interpretation: the test is considered positive if, during the first 30° of flexion, the examiner notices or senses subluxation and/or slippage of the tibia significantly differing from the uninjured side [11]. The pivot-shift test is presented in **Figure 3**.

Figure 3. The pivot-shift test technique.

Lever test

It is a relatively new clinical test developed in 2005 and reported in 2014 by Dr. Alessandro Lelli [3]. The Lever test is a new physical examination tool for diagnosing ACL injury [14]. Execution: the patient lies on their back with a straightened knee joint. The examiner places a closed fist under the proximal part of the patient's calf at the level of the tibial tuberosity. This causes a slight knee joint flexion (the closed fist acts as a point of support and the patient's leg as a lever). On the other hand, the examiner applies a downward force on the distal part of the patient's femur [14]. Interpretation: Intact ACL: the patient's foot will lift off the lounger. Injured ACL: the patient's foot will remain in contact with the lounger with additional downward force on the quadriceps [3]. The Lever test is presented in **Figure 4**.

Figure 3. The Lever test technique.

Sensitivity and specificity

When choosing a diagnostic test to confirm a given impairment, two very important test characteristics must be considered: sensitivity and specificity. The sensitivity and specificity of the diagnostic test influence the selection process. These qualities describe the test's ability to detect the examined characteristic (sensitivity) or its absence (specificity). Both sensitivity and specificity of the test are important indicators of the accuracy of the test and separately do not give a complete overview. Therefore, the obtained values should be calculated as a percentage at the highest possible level [15].

Test sensitivity is the ratio of true positives to the sum of true positives and false negatives. The test sensitivity of 100% means that all individuals with the specific impairment sought will be detected. In other words, sensitivity is the test's ability to make a correct diagnosis. This indicates how many subjects have a specific condition or characteristic [16,17].

Test specificity is the ratio of true negatives to the sum of true negatives and false positives. The test specificity of 100% means that all healthy individuals would be considered healthy according to the diagnostic test performed. This term defines the percentage of healthy individuals who will be labelled as healthy using the test [16,17].

According to the research conducted by Benjaminse et al. [18] in 2006, the anterior drawer test is widely used in the ACL injury diagnostic program. The results demonstrate that this test has low sensitivity and specificity for use in the clinical setting, especially in the acute condition (49% and 58%, respectively). The authors point out the possibility of a false test result due to: reactive synovitis that may unable knee flexion to 90°, protective muscle and tendon activity secondarily to pain, pinning of the posterior horn of the medial meniscus to the posterior edge of the medial femoral condyle and thus excluding the possibility of anterior tibial translation. In the chronic condition, sensitivity and specificity of the anterior drawer test were much better, 92% and 91%, respectively.

The results of a meta-analysis conducted by Decary et al. [11], showed that the Lachman test has a high diagnostic value for both rulings out and confirming ACL injury (sensitivity 81%-89%, specificity 81%-100%). In contrast, a positive pivot-shift test should be used to diagnose ACL injury due to its high specificity (sensitivity 18%-79%, specificity 81%-98%). The authors also determined the sensitivity and specificity of the anterior drawer test to confirm ACL damage, sensitivity was 38%-62%, and specificity ranged from 67% to 92%. Compared with the anterior drawer test, the Lachman test stands out for its good diagnostic accuracy in detecting ACL pathology, both in acute and chronic conditions. Research conducted by Scholten et al. [19] showed a combined sensitivity of 86% and specificity of 91% for the general population.

Nevertheless, the test has some limitations. For instance, examiners with small hands may encounter difficulties diagnosing patients with a large femur circumference. Additionally, the position of the knee joint is critical, as reducing the flexion angle to 10° may result in reduced tibial excursion and a false test result. The same author highlights that the pivot-shift test specificity is very high, reaching 98%. At the same time, the test has a very poor sensitivity of 32% and 40% in acute and chronic conditions, respectively.

Gürpınar et al. [20] in their study conducted on patients with ACL injury where reconstructive surgery has been recommended advise performing the Lever test, especially in acute conditions. The author concludes that regardless of the length of time after the injury, the patient's response to pain associated with the injury and inflammation is another factor that can alter the sensitivity of most diagnostic tests. The Lever test is easy to perform regardless of the limitations

appearing after the injury. In 2019, McQuivey et al. [3] published the results of a pilot study investigating the specificity and sensitivity of the Lever test in diagnosing ACL injury at the acute stage in a hospital rescue unit (HRU). They hypothesized that the accuracy and sensitivity of this test would be higher than the anterior drawer tests or the Lachman test. In the obtained results, the test sensitivity was 100% in the Lever test and 40% in the anterior drawer/Lachman tests. Although the overall accuracy and sensitivity were better in the Lever test, the anterior drawer test/Lachman test had higher specificity (100%) when compared to the Lever test (94%).

Gürpınar et al. [20] found that the sensitivity of the Lachman test, anterior drawer test, and pivot-shift test after anesthesia increased from 83.9% to 89.7%, from 79.0% to 79.5%, and from 56.5% to 77.5%, respectively. However, no difference was observed in the sensitivity of the Lever test before and after anesthesia (91.9% to 91.9%).

Lichtenberg et al. [13] conducted a study between 2014 and 2016, designed to verify the effectiveness of the Lever test in patients after a knee injury. Four diagnostic tests were carried out: the Lever, the anterior drawer, the Lachman, and the pivot-shift tests. In this study, the Lever test showed the highest specificity (100%) and lowest sensitivity (39%) when compared to the other three tests. Combining the Lever test in parallel with the other three tests gave the highest accuracy of 91% (81-94%). The pivot-shift test has been shown to be highly specific (81-99%) but not as sensitive (18-48%) for ACL damage.

Conclusion

ACL is the main structure that stabilizes the knee joint preventing excessive anterior translation and internal rotation of the tibia. The diagnostic validity of tests assessing ACL ligament injury has been widely investigated. The three most commonly explored tests are the Lachman test, the pivot-shift test, and the anterior drawer test. These three tests reach a high specificity and thus can be successfully used alone to make an accurate diagnosis of ACL injury [11].

Professionals encounter many problems when performing clinical tests assessing damage to specific structures. Numerous additional factors can influence the results of performed physical tests. Among these are: the force applied when conducting the physical examination, the size of the examiner's hand, and the circumference of the patient's femur. A recent study conducted by Vajapey et al. [21] also demonstrated that the sensitivity of the most commonly used clinical tests, assessing ACL injury, is reduced in obese individuals compared to non-obese patients. According to the authors of a publication led by Lichtenberg [13], the Lachman and anterior drawer tests are more challenging to perform by examiners with smaller hands or in patients with large, muscular femurs. In addition, the correct diagnosis of an acute ACL rupture remains an ongoing challenge. Physical examination of the knee joint, and thus the correctly executed clinical test, may not be possible in acute situations due to swelling and pain [2]. This is further supported by the results of research conducted by Guillodo et al. [22], which revealed that only 26% of acute ACL injuries were correctly identified at the HRU.

Evidence suggests that of the three explored tests (Lachman, anterior drawer, and pivot-shift tests), Lachman appears to be valid when performed individually to diagnose or rule out ACL injury, while pivot-shift can be used to diagnose ACL injury due to its high specificity [4,11]. However, all the above tests demonstrate good results in chronic conditions. Problems related to the patient's sensations of acute post-traumatic condition were attempted to be ruled out using the Lever test [13]. This test applied to acute conditions was found to have a higher sensitivity (100%) and greater certainty of diagnosis when compared to traditional ACL screening tests. The authors concluded that the accuracy of the Lever test is likely to be independent of the clinician's level of experience, making it a strong screening tool [3].

In order to increase the accuracy of the diagnosis of ACL rupture, it is recommended to combine multiple elements from the medical interview and physical tests. Elements such as a traumatic event with rotation, a popping sensation, and immediate joint effusion can be useful for clinicians to establish an accurate diagnosis [1]. In addition, research shows that using several diagnostic tests together can minimize the risk of false positives and false negatives, thereby increasing the specificity and sensitivity of the tests.

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