



## COMPREHENSIVE REVIEW OF ANTERIOR CRUCIATE LIGAMENT INJURY: ETIOLOGY, DIAGNOSIS, AND TREATMENT STRATEGIES

**Merlyn Yulieth Ortiz Zuluaga** MD. Unidad Central del Valle del Cauca – UCEVA

### ABSTRACT

Anterior cruciate ligament (ACL) injury is a common and debilitating condition, particularly among athletes. This comprehensive review examines the etiology, diagnosis, treatment strategies, and outcomes associated with ACL injury. Anatomical factors, such as the orientation of the femoral and tibial tunnels, influence ACL injury risk. Biomechanical studies have highlighted the role of dynamic knee stability in ACL injury mechanisms. Diagnosis involves a combination of physical examination maneuvers and imaging modalities. Treatment options range from conservative management to surgical reconstruction using autografts or allografts. Factors such as age, activity level, and associated injuries influence treatment decisions and outcomes. Rehabilitation plays a crucial role in optimizing outcomes and reducing the risk of reinjury. Future research should focus on refining prevention strategies, improving surgical techniques, and enhancing rehabilitation protocols to optimize outcomes for individuals with ACL injury.

**KEYWORDS :** Anterior Cruciate Ligament Injuries, Etiology, Rehabilitation.

### INTRODUCTION

Anterior Cruciate Ligament (ACL) injury is a prevalent and debilitating musculoskeletal condition, particularly affecting individuals engaged in sports and physical activities. The complex interplay of anatomical, biomechanical, and neuromuscular factors contributes to the etiology of ACL injuries, with specific risk factors including age, sex, and previous knee trauma.

Diagnosis of ACL injury involves a thorough clinical assessment encompassing patient history, physical examination, and often imaging modalities such as magnetic resonance imaging (MRI). Treatment strategies for ACL injury have evolved significantly, with current approaches emphasizing individualized care based on patient characteristics and functional goals.

While surgical reconstruction remains a standard intervention, particularly for individuals seeking to return to high-demand activities, nonoperative management can be a viable option for select patients, especially those with lower functional demands or higher surgical risks.

This comprehensive review aims to synthesize the latest evidence and provide a comprehensive overview of the etiology, diagnosis, and treatment strategies for ACL injury, addressing key controversies and advancements in the field (1,2).

### METHODS

A systematic search was conducted in the PubMed, Embase, and Cochrane Library databases up to December 2023 using relevant keywords such as "anterior cruciate ligament injury," "etiology," "diagnosis," and "treatment strategies." Additionally, reference lists of relevant articles were manually reviewed to identify additional studies. Studies were included if they provided insights into the etiology, diagnosis, or treatment strategies of anterior cruciate ligament (ACL) injuries. Exclusion criteria included studies not written in English, animal studies, case reports, and studies with insufficient data.

A total of 15 studies were included in this narrative review. Data extraction was performed independently by two reviewers, and any discrepancies were resolved through discussion with a third reviewer.

The extracted data were synthesized to provide a comprehensive overview of ACL injury management.

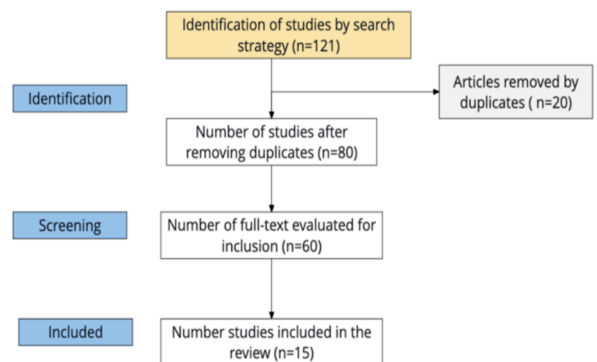


Figure 1. PRISMA.

### Anatomy, Epidemiology, and Risk Factors

The anterior cruciate ligament (ACL) is one of the primary stabilizing structures of the knee, originating from the posteromedial aspect of the lateral femoral condyle and inserting into the intercondylar eminence of the tibia. Its main functions include limiting anterior translation of the tibia on the femur and providing rotational stability to the knee joint (3).

ACL injuries are among the most common knee injuries, with an estimated incidence of 68.6 per 100,000 person-years. They often occur during sports that involve sudden stops, changes in direction, or direct blows to the knee. Factors that increase the risk of ACL injury include female gender, anatomical factors such as increased Q angle and narrow intercondylar notch, neuromuscular factors such as quadriceps dominance and hamstring weakness, and environmental factors such as playing surface and footwear (4).

### Mechanism and Presentation

Anterior cruciate ligament (ACL) injuries are commonly encountered in sports and activities requiring sudden changes in direction, jumping, or pivoting. These injuries often occur through non-contact mechanisms, such as landing from a jump with the knee in a valgus and internally rotated position or during a sudden deceleration maneuver with the knee near full extension. Contact injuries, such as a direct blow to the knee, can also lead to ACL tears (5).

The presentation of an ACL injury is typically characterized by an acute onset of knee pain, swelling, and instability. Patients often report hearing or feeling a "pop" at the time of injury, followed by the inability to continue the activity. Swelling

usually develops rapidly within the first few hours due to hemarthrosis, indicating intra-articular bleeding (6).

On physical examination, patients with an ACL injury may demonstrate tenderness along the joint line, effusion, and limited range of motion due to pain and swelling. The Lachman test and pivot shift test are commonly used to assess for ACL laxity and rotational instability. The Lachman test, performed with the knee flexed at 20-30 degrees, assesses the anterior translation of the tibia relative to the femur. The pivot shift test evaluates rotational instability and is positive when a subluxation of the lateral tibial plateau occurs with knee flexion and extension (6,7).

It is crucial to diagnose ACL injuries promptly to prevent further damage to the knee and reduce the risk of long-term complications, such as meniscal tears and osteoarthritis. Treatment options vary based on the extent of the injury, patient's age, activity level, and goals. Non-surgical management includes physical therapy to strengthen surrounding muscles and improve knee stability, as well as bracing to provide external support. Surgical intervention, such as ACL reconstruction, may be recommended for individuals who wish to return to high-demand activities or who have concurrent injuries requiring surgical repair (7).

#### Physical Examination and Diagnosis

The evaluation of anterior cruciate ligament (ACL) injuries requires a comprehensive physical examination to assess knee stability, identify associated injuries, and guide treatment decisions. The physical examination should include a detailed history, inspection, palpation, range of motion assessment, and specific provocative tests to assess ligamentous integrity and overall knee function (8).

#### History:

A thorough history should be obtained, including the mechanism of injury, onset of symptoms, previous knee injuries, and functional limitations. Patients often report a non-contact twisting injury, accompanied by a "pop" sensation at the time of injury, followed by immediate swelling and instability (9).

#### Inspection:

Visual inspection of the knee may reveal signs of swelling, bruising, or deformity. A comparison with the uninjured knee can help identify asymmetries and detect subtle abnormalities (9).

#### Palpation:

Palpation of the knee joint is essential to identify areas of tenderness, swelling, or abnormal bony landmarks. Tenderness along the joint line, especially at the lateral aspect, is suggestive of an ACL injury (9).

#### Range of Motion:

Assessment of knee range of motion should be performed to evaluate for any limitations or pain with movement. Loss of full extension or flexion may indicate intra-articular pathology (9).

#### Provocative Tests:

Several tests can be used to assess ACL integrity and knee stability:

#### Lachman Test:

With the knee flexed at 20-30 degrees, the examiner stabilizes the femur with one hand and applies an anterior force to the tibia with the other hand. A positive test is indicated by increased anterior tibial translation compared to the uninjured knee (9).

#### Anterior Drawer Test:

With the knee flexed at 90 degrees, the examiner stabilizes the foot and tibia with one hand while applying an anterior force to the proximal tibia with the other hand. Increased anterior translation of the tibia compared to the uninjured side indicates a positive test (9).

#### Pivot Shift Test:

This test assesses rotational instability of the knee. With the knee in slight flexion, the examiner applies a valgus and internal rotation force while extending the knee. A positive test is indicated by a subluxation of the lateral tibial plateau, which reduces with knee extension (9).

#### Imaging:

While a thorough physical examination is crucial for diagnosing ACL injuries, imaging studies such as magnetic resonance imaging (MRI) are often used to confirm the diagnosis, assess for associated injuries (e.g., meniscal tears, collateral ligament injuries), and guide treatment decisions (10).

#### Treatment of Anterior Cruciate Ligament (ACL) Injury

The management of ACL injuries is multifaceted, involving conservative measures and surgical intervention tailored to the individual patient's needs, functional goals, and activity level. Treatment aims to restore knee stability, optimize function, and prevent long-term complications such as meniscal and articular cartilage damage (10).

#### Conservative Management:

##### Physical Therapy:

Initial treatment often involves a structured physical therapy program focusing on quadriceps and hamstring strengthening, neuromuscular retraining, and proprioceptive exercises to improve knee stability and function (10).

##### Bracing and Orthotics:

Functional knee braces may be used to provide external support and improve knee stability during activities. Custom orthotics can help address foot alignment issues that may contribute to knee instability (10,11).

##### Activity Modification:

Patients are advised to modify activities that place excessive stress on the knee, such as pivoting sports, to prevent further injury and allow for healing (11).

#### Surgical Intervention:

##### Indications:

Surgical intervention is recommended for active individuals with ACL-deficient knees who have persistent instability despite conservative treatment, as well as for athletes who wish to return to high-demand sports (12).

##### Surgical Options:

The primary surgical intervention for ACL reconstruction involves using autograft or allograft tissue to reconstruct the torn ligament. Common graft choices include the patellar tendon, hamstring tendon, or quadriceps tendon (12).

##### Surgical Technique:

ACL reconstruction is typically performed arthroscopically, allowing for smaller incisions, reduced pain, and faster recovery compared to open surgery. The torn ACL is removed, and the graft is secured in place using screws or other fixation devices (13).

##### Postoperative Rehabilitation:

Following surgery, a structured rehabilitation program is essential to restore knee range of motion, strength, and function. Physical therapy focuses on strengthening the quadriceps and hamstring muscles, improving

neuromuscular control, and gradually reintroducing functional activities (14).

#### Return to Sport:

Return to sport is typically allowed after a period of intensive rehabilitation, usually 6 to 12 months postoperatively. Athletes must demonstrate adequate strength, stability, and neuromuscular control before returning to high-demand activities (15).

In conclusion, anterior cruciate ligament (ACL) injuries are prevalent, especially in young athletes, with increasing rates noted in recent years. Understanding the epidemiology, risk factors, and mechanisms of ACL injuries is crucial for effective prevention strategies and optimal management in clinical practice.

#### REFERENCES

1. Fu FH et al. Current trends in anterior cruciate ligament reconstruction. Part 1: Biology and biomechanics of reconstruction. *Am J Sports Med* 1999; 27:821.
2. Kennedy JC et al. Nerve supply of the human knee and its functional importance. *Am J Sports Med* 1982; 10:329.
3. Miyasaka KC et al. The incidence of knee ligament injuries in the general population. *Am J Knee Surg* 1991; 4:43.
4. National Collegiate Athletic Association. NCAA Injury Surveillance System Summary. Indianapolis, Ind: National Collegiate Athletic Association; 2002.
5. National Federation of State High School Associations. 2002 High School Participation Survey. Indianapolis, Ind: National federation of State High School Associations; 2002.
6. Agel J et al. Collegiate ACL Injury Rates Across 15 Sports: National Collegiate Athletic Association Injury Surveillance System Data Update (2004-2005 Through 2012-2013). *Clin J Sport Med* 2016; 26:518.
7. Beck NA et al. ACL Tears in School-Aged Children and Adolescents Over 20 Years. *Pediatrics* 2017; 139.
8. Kooy CEVW et al. Major Increase in Incidence of Pediatric ACL Reconstructions From 2005 to 2021: A Study From the Norwegian Knee Ligament Register. *Am J Sports Med* 2023; 51:2891.
9. Zbrojkiewicz D et al. Increasing rates of anterior cruciate ligament reconstruction in young Australians, 2000-2015. *Med J Aust* 2018; 208:354.
10. Sutherland K et al. Marked increase in the incidence of anterior cruciate ligament reconstructions in young females in New Zealand. *ANZ J Surg* 2019; 89:1151.
11. Weitz FK et al. The incidence of paediatric ACL injury is increasing in Finland. *Knee Surg Sports Traumatol Arthrosc* 2020; 28:363.
12. Best MJ et al. Anterior Cruciate Ligament Injuries in the Older Athlete. *Sports Health* 2021; 13:285.
13. Takahashi S et al. Epidemiological survey of anterior cruciate ligament injury in Japanese junior high school and high school athletes: cross-sectional study. *Res Sports Med* 2017; 25:266.
14. Montalvo AM et al. Anterior Cruciate Ligament Injury Risk in Sport: A Systematic Review and Meta-Analysis of Injury Incidence by Sex and Sport Classification. *J Athl Train* 2019; 54:472.
15. Chia L et al. Non-contact Anterior Cruciate Ligament Injury Epidemiology in Team-Ball Sports: A Systematic Review with Meta-analysis by Sex, Age, Sport, Participation Level, and Exposure Type. *Sports Med* 2022; 52:2447.