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ANTERIOR CRUCIATE LIGAMENT INJURY: A NARRATIVE REVIEW OF CURRENT UNDERSTANDING AND MANAGEMENT STRATEGIES

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ABSTRACT Anterior cruciate ligament (ACL) injuries are prevalent, especially among athletes in high-demand sports such as soccer, basketball, and skiing. With an annual incidence rate of approximately 1 in 3,500, female athletes are particularly at higher risk, with incidence ratios 2 to 8 times greater than their male counterparts. Key risk factors include a narrower intercondylar notch, increased posterior tibial slope, poor neuromuscular control, and high knee abduction moments. The mechanisms of ACL injuries often involve sudden deceleration, cutting, or pivoting motions, leading to a combination of anterior tibial translation and knee valgus. Physical examination for ACL injuries involves the Lachman test, anterior drawer test, and pivot shift test. Diagnosis is confirmed with magnetic resonance imaging (MRI). Treatment includes acute management with the RICE protocol, non-surgical options focusing on physical therapy, and surgical reconstruction using autografts or allografts. Postoperative rehabilitation is essential for restoring knee function, with return to sport typically occurring after 9-12 months.

KEYWORDS : Anterior Cruciate Ligament Injuries, Knee Injuries, Ligaments, Articular, Sports Medicine, Physical Therapy Modalities.

INTRODUCTION

Anterior Cruciate Ligament (ACL) injuries are among the most common and debilitating injuries affecting athletes and active individuals. The ACL, a crucial stabilizing ligament of the knee, plays a pivotal role in maintaining knee stability during dynamic activities. Each year, approximately 100,000 to 200,000 ACL ruptures occur in the United States alone, highlighting the significant impact of this injury on the population. This narrative review aims to provide a comprehensive overview of current understanding and management strategies for ACL injuries. It will delve into the anatomy and function of the ACL, the epidemiology of ACL injuries, and the mechanisms by which these injuries occur (1).

Methods

The review was conducted by systematically searching PubMed, Google Scholar, and Cochrane Library databases using keywords such as "Anterior Cruciate Ligament," "ACL Injury," "Knee Stabilization," "Sports Medicine," "Noncontact Injuries," "Contact Injuries," "Physical Examination," "MRI," "Ultrasound," "Arthroscopy," "Surgical Reconstruction," "Autografts," "Allografts," "Rehabilitation," and "Prehabilitation." Articles published in the last 10 years were prioritized. The final review included fifteen references, focusing on the latest advancements and evidence-based practices in ACL injury management.

Epidemiology and Risk Factors

Anterior cruciate ligament (ACL) injuries are prevalent, particularly among athletes engaged in high-demand sports. ACL injuries are most common in sports that involve sudden stops, jumping, or changes in direction, such as soccer, basketball, and skiing. The annual incidence rate in the general population is approximately 1 in 3,500, with higher rates observed among athletes. Notably, female athletes are at a greater risk of ACL injuries compared to male athletes, with incidence ratios of 2 to 8 times higher in sports like soccer and basketball (2).

Several risk factors contribute to the likelihood of sustaining an ACL injury. Anatomically, a narrower intercondylar notch width and increased posterior tibial slope are significant risk factors. Neuromuscular factors include poor neuromuscular control and coordination, which can lead to improper landing mechanics and knee valgus during dynamic movements. Biomechanical risk factors involve high knee abduction moments and excessive quadriceps force during landing or cutting maneuvers. External factors, such as playing surface and footwear, also play a crucial role. For example, artificial turf surfaces have been associated with a higher risk of ACL injuries compared to natural grass (3).

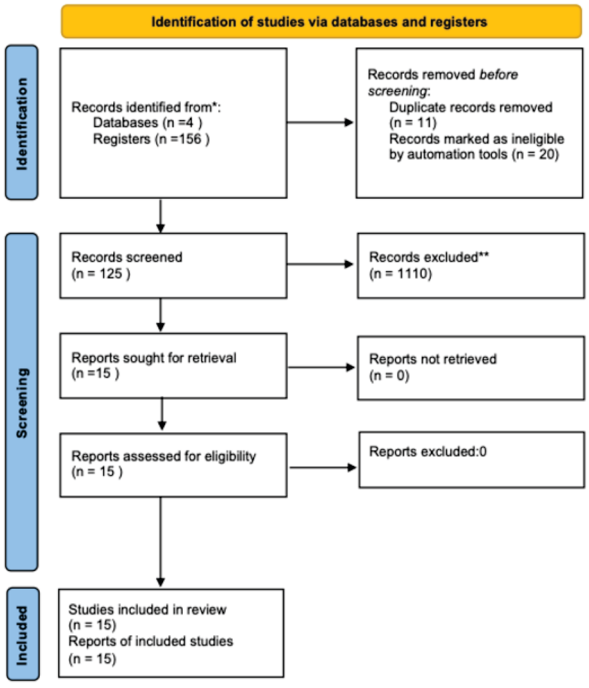

Figure 1. Prisma.

Mechanism and Physical Examination

The mechanisms of anterior cruciate ligament (ACL) injuries typically involve high-energy and low-energy scenarios, with noncontact injuries being the most common. Noncontact mechanisms, which account for approximately 70% of ACL injuries, usually occur during activities that involve sudden deceleration, cutting, or pivoting motions. These actions create a combination of anterior tibial translation and knee valgus that places significant stress on the ACL, leading to rupture. For instance, an athlete may sustain an ACL injury when landing from a jump with the knee in a valgus position and minimal knee flexion, or during rapid changes in direction. Contact injuries, though less frequent, often result from a direct blow to the lateral aspect of the knee, causing hyperextension or valgus deformation (4).

Physical examination of a suspected ACL injury involves a detailed assessment of the knee's stability and function. Key

diagnostic maneuvers include the Lachman test, anterior drawer test, and pivot shift test. The Lachman test is performed with the knee flexed at 30 degrees, assessing the anterior translation of the tibia relative to the femur. A positive Lachman test, indicated by increased translation and a soft or absent endpoint, suggests an ACL tear. The anterior drawer test, performed with the knee at 90 degrees of flexion, also evaluates anterior tibial translation. The pivot shift test assesses the rotational stability of the knee and is often used to confirm an ACL injury. In addition to these tests, a thorough physical examination includes assessing for associated injuries, such as meniscal tears, which commonly coexist with ACL ruptures. Accurate diagnosis through physical examination is crucial for determining the appropriate management and treatment plan (5).

Diagnosis

Diagnosis of an anterior cruciate ligament (ACL) injury involves a combination of clinical examination and imaging techniques. Clinically, the Lachman test, anterior drawer test, and pivot shift test are crucial for assessing ACL integrity. A positive result in these tests indicates a high likelihood of ACL rupture. Imaging techniques such as magnetic resonance imaging (MRI) are employed to confirm the diagnosis and evaluate associated injuries like meniscal tears. MRI is highly sensitive and specific for detecting ACL tears, providing detailed images of the knee structures, and aiding in comprehensive injury assessment and treatment planning (6).

Treatment of Anterior Cruciate Ligament Injury

Acute Management

The acute management of an anterior cruciate ligament (ACL) injury focuses on reducing pain and swelling while preserving knee function. Initial treatment typically follows the RICE protocol: Rest, Ice, Compression, and Elevation. Nonsteroidal anti-inflammatory drugs (NSAIDs) are commonly used to manage pain and inflammation. Patients may require crutches to avoid weight-bearing on the injured knee. Early physical therapy is crucial to regain range of motion, strengthen surrounding muscles, and prevent muscle atrophy. The goal during the acute phase is to control symptoms and prepare the knee for potential further treatment (6,7).

Non-Surgical Management

Non-surgical management, also known as conservative treatment, may be suitable for patients with low functional demands or those who do not participate in pivoting sports. This approach includes physical therapy focused on strengthening the quadriceps, hamstrings, and hip muscles to stabilize the knee. Neuromuscular training to improve proprioception and balance is also integral. Functional bracing may be recommended to provide additional knee support during high-risk activities. Studies suggest that with rigorous rehabilitation, many patients can return to pre-injury activity levels. However, there is a risk of recurrent instability and secondary injuries, such as meniscal tears, in those who opt for non-surgical treatment (7).

Surgical Management

Surgical reconstruction of the ACL is often recommended for patients with high functional demands, athletes, or those experiencing significant knee instability. The surgery involves replacing the torn ligament with a graft, which can be autografts (tissue from the patient's own body) or allografts (donor tissue). The most common autograft sources are the patellar tendon, hamstring tendon, and quadriceps tendon (7,8).

Patellar Tendon Graft: Known for its high initial strength and bone-to-bone healing, which promotes strong graft fixation. However, it can be associated with anterior knee pain and patellar tendonitis (8).

Hamstring Tendon Graft: Offers less postoperative pain and a lower risk of anterior knee pain. The procedure involves folding the tendon to create a strong graft. However, it requires tendon-to-bone healing, which can be slower (8).

Quadriceps Tendon Graft: Increasingly popular, this graft provides a robust option with reduced donor site morbidity compared to patellar tendon grafts (8).

Postoperative rehabilitation is critical for restoring knee function and ensuring successful recovery. It involves a structured program of physical therapy to regain range of motion, strength, and proprioception. Return to sport typically occurs after 9-12 months of rehabilitation, depending on individual progress and the specific demands of the sport. Surgical management aims to provide greater knee stability, reduce the risk of further injuries, and enable patients to return to their previous levels of activity (9).

Rehabilitation

Early Phase

In the early phase of rehabilitation, focus is placed on reducing swelling and pain while restoring the range of motion. Gentle exercises such as heel slides, quadriceps sets, and straight-leg raises are initiated to maintain muscle activity without putting stress on the healing ligament. Use of cryotherapy and elevation helps in managing inflammation (10).

Strengthening Phase

As pain and swelling subside, the rehabilitation program progresses to strengthening exercises. Emphasis is placed on the quadriceps, hamstrings, and hip muscles to ensure balanced support around the knee. Closed kinetic chain exercises, such as mini-squats and leg presses, are preferred to avoid excessive strain on the ACL. Proprioception and balance training are also crucial during this phase to improve neuromuscular control (11).

Functional Phase

In the functional phase, exercises become more sport-specific, incorporating agility drills, plyometrics, and activities that simulate real-life movements. This phase aims to prepare the patient for a safe return to sports or high-demand activities (12).

Return to Activity

The final phase focuses on gradually reintroducing sport-specific movements and activities. Criteria for return to sport include achieving symmetrical strength and functional performance between the injured and non-injured legs, as well as psychological readiness. Typically, return to sport occurs around 9 to 12 months post-injury or surgery, depending on the individual's progress and the specific sport demands (13,14).

Ongoing maintenance exercises are recommended to ensure continued knee stability and prevent future injuries. A well-structured rehabilitation program, tailored to the individual's needs, is essential for optimal recovery and successful return to pre-injury activity levels (15).

CONCLUSION

Effective management of ACL injuries involves a combination of acute care, tailored rehabilitation, and, when necessary, surgical intervention. Comprehensive rehabilitation is crucial for restoring knee function and preventing re-injury, enabling individuals to return to their pre-injury activity levels and enhancing overall outcomes.

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