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Anterior Cruciate Ligament

Introduction

The anterior cruciate ligament(ACL) is a major ligament found in the knee joint. This ligament is one of the most injured ligaments in athletics. This is due to the structure of it and how it used during certain movements. Once the ACL is fully ruptured, reconstructive surgery is an option for anyone who tore it, but almost mandatory to return back to sports. The purpose of this paper is to address the function and purpose of the ACL and where it is located, to explain the possible injuries that may occur and what the process is like following an ACL tear, the mechanism of injury, surgery, rehabilitation, and return to play. Although, this injury is very demanding when it comes to the treatment process, there is a positive success rate of returning back to sport or activities. Female athletes however, are more likely to tear their ACL compared to male athletes.

Structure and Function

The knee is a very important and very vulnerable joint in the human body. Although the only motion of the knee joint is flexion and extension, making it a hinge joint, it undergoes many injuries or disruptions due to outside forces. The knee joint is composed of the femur, the tibia, the fibula, and the patella. All of these bones are held together by ligaments that help stabilize and keep the joint together. The four ligaments are anterior cruciate ligament, posterior

cruciate ligament, lateral collateral ligament, and medial collateral ligament. The anterior cruciate ligament(ACL) is a band-like structure of dense connective tissues. The ACL is attached to a fossa on the posterior aspect of the medial surface of the lateral femoral condyle and the is attached to a fossa in front of and lateral to the anterior tibial spine.

The function of the ACL is to resist anterior tibial translation and rotational loads. It runs diagonally in the middle of the knee and prevents the tibia from sliding out forward in front of the femur. The ACL also helps prevent hyperextension of the knee as well as provides rotational stability.

Mechanism of Injury

ACL injuries are classified by grades 1, 2 and 3. Grade 1 is ripping of the ligament, grade 2 is a partial tear, and grade 3 is a complete tear of the ligament. Complete ACL rupture can induce other pathological knee conditions including knee instability, damage to menisci and the chondral surface, and osteoarthritis. Studies have repeatedly shown that patients with complete ACL rupture have chronic knee instability and secondary damage to menisci and chondral surfaces. A mechanism of injury in sports involves sudden deceleration, landing and pivoting maneuvers are repeatedly performed (Yu and Garrett). “Mechanically, ACL injury occurs when an excessive tension force is applied on the ACL. A non-contact ACL injury occurs when a person themselves generates great forces or moments at the knee that apply excessive loading on the ACL. Therefore, an understanding of the mechanisms of ACL loading during active human movements is crucial for understanding the mechanisms and risk factors for non-contact ACL injuries”(Yu and Garrett). Knowing how the ACL is injured helps to understand how to detect a possible injury or even to prevent this injury from occurring by learning proper technique in

certain movements. “Decreased knee flexion angle and increased quadriceps muscle force and posterior ground reaction force causing an increased knee extension moment are requirements for increased ACL loading. Although the external knee valgus moment has been demonstrated to be associated with ACL injuries, the current literature contains no evidence that knee valgus-varus and internal-external rotation moments can produce non-contact ACL injuries in and of themselves without these high sagittal plane forces” (Yu and Garrett). It has been said that the way your kneecaps face, either valgus or varus, can make a person at a greater risk for tearing an ACL or other knee injuries. This study, however, says that based on the other plane forces that this many not be the complete case. Overall, based on the anatomy of the knee and the variations between people, some are at a greater risk for tearing an ACL compared to others.

Most ACL injuries can be detected during clinal examination. However, pain and swelling might make it difficult to determine an injury so magnetic resonance imaging(MRI) is needed to diagnose an ACL injury.

Reconstruction

ACL reconstruction is surgery to reconstruct the ligament in the center of your knee. The tissue to replace your damaged ACL will come from your own body or from a donor. A donor is a person who has died and chose to give all or part of their body to help others. Tissue taken from a person’s own body is called an autograft. The two most common places to take tissue from are the knee cap tendon or the hamstring tendon (Zhu, Biao, et al.). The hamstrings are the muscles behind your knee. Tissue taken from a donor is called an allograft. The procedure is usually performed with the help of knee arthroscopy. “With arthroscopy, a tiny camera is inserted into the knee through a small surgical cut. The camera is connected to a video monitor in

the operating room" (Zhu, Biao, et al.). The surgeon will use the camera to check the ligaments and other tissues of the knee. The surgeon will make other small cuts around the knee and insert other medical instruments. "The surgeon will fix any other damage found, and then will replace the ACL by following these steps: The torn ligament will be removed with a shaver or other instruments" (Zhu, Biao, et al.). If the tissue is being used to make a new ACL, the surgeon will make a larger cut. Then, the autograft will be removed through this cut. "The surgeon will make tunnels in the bone to bring the new tissue through. This new tissue will be put at the same place as your old ACL" (Zhu, Biao, et al.). "The surgeon will attach the new ligament to the bone with screws or other devices to hold it in place. As it heals, the bone tunnels fill in. This holds the new ligament in place. At the end of the surgery, the surgeon will close the cuts with sutures and cover the area with a dressing" (Zhu, Biao, et al.).

Rehabilitation

"Following ACL injury or reconstruction, athletes undergo an extensive period of vigorous rehabilitation targeting functional impairments. These targeted rehabilitation protocols strive for full symmetrical range of motion, adequate quadriceps strength, walking and running without frank aberrant movement, and a quiet knee: little to no joint effusion or pain"(Failla et al.). Rehabilitation is extremely important to return back to normal as well as possibly correcting the anatomical reasons the ACL was torn in the first place. "Motor learning is defined as the process of an individual's ability to acquire motor skills with a relatively permanent change in performance as a function of practice or experience. Instructions and supplementary feedback are important influencing factors to support motor learning processes. In almost any training situation where motor skills are to be learned, athletes are given instructions about the correct

movement pattern or technique" (Gokeler et al.). Following a correct motor learning program will help reduce the risk of a second ACL injury. The first type of motor learning is external focus of attention. "In almost any rehabilitation situation where motor skills are to be (re-)learned, patients receive instructions about the deemed correct movement technique. These instructions typically refer to the coordination of the patient's body movements, including the order, form, and timing of various limb movements" (Gokeler et al.). These certain instructions help direct the patients attention to their own movements. "Patients received an instruction with either an internal focus or an external focus before performing a single-leg hop jump. The instructions for the internal focus group were "Jump as far as you can. While you are jumping, I want you to think about extending your knees as rapidly as possible" and for the external focus group "Jump as far as you can. While you are jumping, I want you to think about pushing yourself off as hard as possible from the floor." During landing, the external focus group had significantly larger knee flexion angles at initial contact, peak knee flexion, total range of motion, and time to peak knee flexion" (Gokeler et al.). The little differences between the internal and external cues can have a large effect on how the human body generates that movement. This is important for ACL rehabilitation because based on the certain cues given by a physical therapist, the way the patient performs certain exercises can create a greater chance of doing the correct movement which will benefit the patient more than a wrong movement. The second type of motor learning is implicit learning. "The aim of implicit learning methods is to minimize the amount of declarative (explicit) knowledge about movement execution during learning. For this purpose, implicit learning can be induced by providing analogies rather than explicit instructions during the acquisition of motor skills" (Gokeler et al.). This is useful for patients who have never undergone rehabilitation before or do not know what certain exercises

are. During ACL rehabilitation it is important to forget about movements you were able to do prior to injury and further understand how to learn how to do these movements based on cues given by the physical therapist. An example of explicit instructions is telling the patient to stand with your feet shoulder-width apart, while implicit instructions is telling the patient to think about keeping a big ball between your knees. “Differential learning is based on the theory of dynamical systems. When using differential learning in the practice of movement skills, the movement patterns themselves are intentionally varied during practice. This theoretical principle suggests that by having athletes perform a variety of movement patterns, a self-organized process of learning is initiated” (Gokeler et al.). This type of learning is relevant for athletes to help them anticipate potential high risk situations to avoid and prevent future injuries. “In most rehabilitation situations, clinicians determine the details of the training session. For example, they decide in which order tasks are practiced, the practice duration, and when or if instructions or demonstrations will be given. Thus, while clinicians generally control most aspects of practice, patients assume a relatively passive role” (Gokeler et al.). This allows patients to ask for feedback on their own. All of these types of motor learning play a significant role in the outcome of ACL rehabilitation and whether or not the athlete can return back to sports like they once were. “Motor learning should be applied to support neuroplasticity after ACL injury. Because every person (and brain) is different, the optimal solution may require motor learning principles individually tailored to the injured athletes” (Gokeler et al.).

Prevention

There are six principles of a prevention program; age, biomechanics, compliance, dosage, feedback, and exercise variety. It is encouraged that ACL prevention programs are started at a

young age. “Fewer ACL injuries were documented in younger athletes who performed a neuromuscular training program compared to older athletes who performed the same program” (Nessler et al.). An increased strain on the ACL correlates to having faulty biomechanics. Knee valgus is one of the greatest indicators of a possible ACL injury. “Compliance of performance of an ACL prevention program is vital to the ability of the program to be successful at reducing injury rates” (Nessler et al.). As long as more than 66% of athletes comply there is a reduction rate for ACL injuries of 82%. If less than 66% of athletes comply the reduction rate for ACL injuries is 44%. More participation in ACL prevention programs will result in a decrease risk for ACL injury. “Most studies agree that each session should be between 20 and 30 min and should be performed several times per week. Optimally, they should be initiated in the pre-season and continued throughout the season to attain the full effectiveness of the program” (Nessler et al.). Just like in motor learning, feedback shows to decrease ACL injuries. Feedback can come in different forms, whether verbal like cues from a coach or visual such as videos used in training. Feedback is either internal or external. External feedback “is directed toward the outcome or effects of the movement, assists the automation of movements, and accelerates the learning process” (Nessler et al.). Internal feedback “is directed toward specific movements, such as “keep your knees out,” and this constant focus on correct movement can lead to a reduction in athlete’s motivation. Thus, it is recommended that a feedback system be implemented in an ACL prevention program with an external focus” (Nessler et al.). Lastly, a variety of exercises are needed for a good ACL injury prevention program. A program that “included a variety of different exercises have a greater incidence of decreasing injury risk versus programs that include only one type of exercise or component (plyometric, balance, strengthening)” (Nessler et al.). There are three components of exercise in a prevention program; plyometrics,

neuromuscular training, and strengthening. Plyometrics specifically improves proper technique and body mechanics to allow for a reduction in ACL injuries. Neuromuscular training improves "he ability to generate optimal muscle firing patterns, increase dynamic joint stability, and to perform movement patterns and skills necessary during activities of daily living and sports activities. This may include balance exercises, proprioceptive activities on balance and wobble boards, single-leg stability activities, dynamic joint stability exercises, jump training, plyometric exercises, agility drills, and sport-specific exercises. These types of proprioceptive and balance training can improve postural control and side-to-side imbalances in lower extremity measures" (Nessler et al.). Strength training is shown to be the most effective at lowering the risk of ACL injuries, but is better when paired with the other components.

Female Athletes

ACL injuries are three to five times more common in females than males. The intercondylar notch, the groove in the femur through which the ACL passes, is naturally smaller in women than in men. Accordingly, the ACL itself is smaller in women, which makes it more prone to injury. Women more commonly have "knock-knee" alignment, meaning that their knees bend inward when they land from jumps (Willadsen, Erica M., et al). When a knee buckles, it puts a strain on the ACL to maintain the knee's stability. Women often land flat-footed, instead of on the balls of their feet, after a jump (Willadsen, Erica M., et al). This improper landing puts pressure on the knee when the calf muscles should be absorbing the force. Women tend to have an imbalanced quadriceps/hamstring ratio (Willadsen, Erica M., et al). A female athlete is more likely to rely on her quadriceps muscles to decelerate or change speed, putting more pressure on

the knee. Women run in a more upright position than men, adding stress to the ACL and resulting in less control over rotation of the knee joint (Willadsen, Erica M., et al).

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