

# Acl reconstruction surgery



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MECHANICAL ENGINEERING DEPARTMENT ACL RECONSTRUCTION SURGERY

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reconstruction to minimize stress concentration of the graft and imitate

natural location of tendons. 1.

CAD of Femur and Tibia with closest anatomical similarity to real human bone (Human Skeleton or Skeleton, typically in \*. stl). 2. Find where the tendons have their natural insertion to the bone, which will be considered the optimum location of grafts. 3. Understand the surgical technique for ACL reconstruction. 4. At the end present your conclusion of the optimum angle for the graft to minimize stress concentration of graft and imitate natural location of tendons.

1. Solid Works Femur & Tibia CADs Figure 1. 1: Normal Human Femur Bone Solidworks 3D CAD Figure 1. 2: Normal Human Tibia Bone Solidworks 3D CAD . Tendons Natural Insertion to the bone The ACL is located at a 55 degrees average from the sagittal plane. It connects from the posterior lateral part of the femur to an anterior medial part of the tibia. It is attached to the depression in front of the intercondyloid eminence of the tibia, being blended with the anterior extremity of the lateral meniscus. An approximate location or the exact displacement would be an optimum location for the surgery positions the grafts that going to hold the replacement tendon (ACL). Figure 3: Natural Position of the ACL in an intact knee 3.

**ACL Reconstruction Surgical Technique What Is The Anterior Cruciate Ligament?** The anterior cruciate ligament (ACL) is one of the most important of four strong ligaments connecting the bones of the knee joint. It is often injured. Ligaments are strong, dense structures made of connective tissue that stabilize a joint. They connect bone to bone across the joint. The function of the ACL is to provide stability to the knee and minimize stress across the knee joint: \* It restrains excessive forward movement of the lower leg bone (the tibia) in relation to the thigh bone (the femur). It limits

rotational movements of the knee. A tear to the anterior cruciate ligament (ACL) results from overstretching of this ligament within the knee. \* It's usually due to a sudden stop and twisting motion of the knee, or a force or "blow" to the front of the knee. \* The extent of the tear can be a partial or a complete tear. \* Individuals experiencing a tear to the ACL may or may not feel a pop at the time of the injury. \* It is often injured together with other structures inside the knee joint. \* After the initial injury, the knee may swell and become painful. Instability or a sensation the knee is "giving out" may be a major complaint following this injury. Often, but not always, depending on a person's activity level, a torn ACL needs to be fixed. Unfortunately a simple repair by suturing the torn ligament together again is not effective. A successful repair involves completely replacing the torn ligaments, and there are a number ways that this can be done. Understanding The Knee The knee is a hinge joint made up of three bones held firmly together by ligaments that stabilize the joint.

The bones that meet at the knee are the upper leg bone (the femur), the lower leg bone (the tibia), and the knee cap (the patella). A smooth protective layer called cartilage, which allows the bones to glide smoothly upon each other, lines the bones inside the joint. In arthritis, this smooth lining becomes damaged. Ligaments Ligaments are dense structures of connective tissue that fasten bone to bone and stabilize the knee. Inside the knee joint are two major ligaments: \* The anterior cruciate ligament (ACL) \* The posterior cruciate ligament (PCL)

These cross in the center of the knee (that's why they're called cruciate ligaments -a crucifix is a cross). They control the backward and forward

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motion of the knee. The ACL in particular restrains excessive forward motion of the knee as well as the inward twisting or rotation of the knee. The ACL is frequently injured in severe twisting injuries of the knee. Two other major ligaments are actually located outside the knee joint, on the outer and inner side of the knee. They act to stabilize the knee's sideways motion. The ligament on the inner side of the knee is called the medial collateral ligament (MCL) (medial means inner side).

The ligament on the outer side of the knee is the lateral collateral ligament (LCL) (lateral means outer side). The patellar tendon (the 'ligament' of the knee cap) connects the lower part of the kneecap (patella) to the upper part of the tibia, specifically to the lump one can feel just below the knee on the lower leg bone (the tibia). Part of this tendon is commonly used in reconstructing a torn ACL.

Facts About Anterior Cruciate Ligament Tears: \*

The anterior cruciate ligament (ACL) provides almost 90% of the stability to the knee joint. \* More than 11. million visits are made to physicians' offices because of a knee problem. It is the most often treated anatomical site by orthopedic surgeons. \* Of the four major ligaments in the knee, the anterior cruciate ligament and the medial collateral ligament are most often injured in sports. \* Reconstruction of a torn ACL is now a common procedure, with over 50, 000 hospital admissions per year. \* ACL ruptures occur at a rate of 60 per 100, 000 people per year. With society's increasing interest in physical fitness, primary care physicians are seeing more athletic injuries.

Along with these injuries are the commonly experienced ACL ruptures in athletes and non-athletes alike. Today's athletes have greater than a 90% chance of returning to their pre-injury level of sports participation. \* ACL

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reconstruction is a highly successful operation. With good rehabilitation, 90% to 95% of individuals who undergo this surgery can expect to return to full sports participation within six months. Surgery For ACL Tears If it has been decided that you are a candidate for surgery it is important to be both mentally and physically prepared.

This includes understanding the injury, the surgery, and the rehabilitation goals. \* Preparing for Surgery \* How is the ACL repaired? Preparing For Surgery The initial goals before surgery are to: \* Reduce swelling in the knee. \* Get back the normal range of motion of the knee. \* Walk normally. This may take anywhere from one week to as long as two months depending on how the knee responds to the initial injury). Depending on your age, certain preoperative tests will be arranged, such as blood tests, urine tests, chest x-ray, and an EKG. Leg measurements may be taken to order a knee brace.

Your rehabilitation program will be discussed in detail with you. You will meet the anesthesiologist, who may offer you a choice of anesthesia: \* If you choose a general anesthetic, you will be asleep during the procedure. \* If you choose an spinal, an injection is given into the back that numbs the lower half of the body. This wears off a couple of hours after surgery. If you have an spinal anesthetic, you can often watch the whole operation on the television monitor. How Is The ACL Repaired? There are a number of different techniques available to repair a torn ACL.

Each surgeon has his preference for each particular situation. In fact we don't talk about ACL "repair" but rather about ACL "reconstruction." This is

because a torn ACL cannot simply be repaired by sewing it together again. This was the method tried in the early days of repairing ACL tears, but it was shown to be ineffective. Thus, newer methods were developed which involve reconstructing the ACL ligament, including substituting a new ligament for the damaged one. Using tendons from other parts of the body as a substitute for the ACL was found to be the most effective way of reconstructing the torn ACL.

Currently, the two most popular methods in use are using part of the patella tendon or using a hamstring muscle tendon. Today ACL reconstruction is essentially an arthroscopic procedure, though many surgeons throughout the world still prefer to open the knee. If this route is chosen, depending on how the ACL is repaired, then the incisions may not be very different from those done arthroscopically. An arthroscope is a pen-shaped instrument to which a tiny video camera is attached. It contains optical fibers, a light source, and lenses that can magnify images 25 to 30 times. The camera attached to the end of the arthroscope sends images to a video screen. The surgeon looks at the screen and is able to get an exceptionally clear view of the inside of the joint. Because the procedure can be done using an arthroscope, and using small specialized instruments without big incisions and excessive trauma to the tissues, it is really well suited to be an outpatient procedure (one that does not require an overnight stay at the hospital). Most ACL reconstructions are commonly performed as outpatient procedures.

However, many doctors prefer to keep patients overnight in the hospital following surgery. Before actually reconstructing the torn ligament, the surgeon uses the arthroscope to carefully survey the whole joint, looking at

and evaluating each key structure. During this portion of the procedure, any additional damage to any of the other knee structures can be identified, and where appropriate, is corrected surgically. There are a number of choices available to the orthopedic surgeon in determining how best to reconstruct the torn ACL. They all involve a "graft" using something to substitute for the torn ACL.

Each of the available ACL graft tissue choices requires a unique harvesting technique. Furthermore, there are usually different methods used for fixing the grafts in the bone tunnels, depending on the characteristics and properties of the tissue selected. Because of these differences in graft techniques, the type of surgery chosen is frequently made by the surgeon based on his or her experience and comfort level with the chosen technique. Typically, an ACL reconstruction takes two to two and a half hours. The anesthesia may be general anesthesia or a spinal anesthesia.

General anesthesia allows the individual to be asleep through the entire procedure. Spinal anesthesia involves an injection in the back that numbs only the lower body. A medication is also administered with a spinal anesthesia to keep the individual sedated throughout the procedure. There are several available operative procedures: 1. Patellar tendon graft procedure 2. Hamstring graft procedure 3. Allograft procedure Patellar tendon graft procedure Since it was popularized in the mid-1980s, the patellar tendon graft has been the "gold standard" choice for ACL reconstruction.



This type of ACL replacement uses the middle third of the person's own patella tendon and is referred to as a bone-tendon-bone (BTB) graft. In this particular technique, \* Two tiny incisions for arthroscopic instruments are usually placed on either side of the patellar tendon. \* A one- to two-inch incision is made over the patellar tendon on the front of the knee and the tendon is exposed. The middle one-third of the patellar tendon is carefully removed, together with two bits of bone on either end (hence it is called a 'bone-tendon-bone graft'). Two small tunnels are then drilled into the bones on either side of the joint, in the area where the torn ACL normally attaches to the bone, to allow for fixation of the new ligament. \* The patellar tendon graft is then passed into the joint, placed in a position similar to the original ACL, with the bone pieces at each the end of the graft fitting nicely into the tunnels that have been drilled in the bone. \* The new ACL is then secured with a specialized headless screw in each tunnel. The patellar tendon graft is tightly secured at the time of the surgery.

The knee is stable enough to begin motion and weight-bearing as tolerated, as per the surgeon's instructions. As healing occurs, the bone tunnels fill in to further secure the tendon ends of the graft in a bone-to-bone relationship. This occurs over the next six to eight weeks. Advantages \* The fixation is very strong \* The patellar tendon replacing the ACL is as strong as the injured ACL (or even stronger). Disadvantages \* A few people have mild discomfort on the front of the knee, especially when kneeling. This generally settles down within a year.

Workers who kneel frequently may need to look at other graft options. \* A normal patellar tendon has been altered. However, this does heal fully again.

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Hamstring graft procedure Hamstring reconstruction is an alternative to the bone-patellar-bone graft fixation and is growing in popularity. In this procedure, rather than using the patellar tendon, the surgeon uses the patient's own hamstring tendon, either the semitendinosus or gracilis tendons from the same leg. There are several variations of this technique.

Newer hamstring fixation techniques have been developed to match and even exceed the initial pullout strength of the patellar tendon bone procedure described above. Special screws with threads designed not to cut the hamstring tendons are able to fix the tendon within the bone tunnel, as described with the patellar tendon bone technique. In younger patients who have torn their ACLs but still have growing bones, the hamstring tendon graft is a good choice because there is less chance of damaging the 'growth plates'- the area responsible for growth of the bone. Advantages The hamstring incision is away from the patella, allowing patients to kneel comfortably. \* The patellar tendon is left intact. Disadvantages \* Soft tissue-to-bone healing occurs at a slower rate than bone-to-bone healing. \* Unlike the patellar tendon, the hamstring tendons do not grow back after graft harvest resulting in a slight loss in hamstring strength (approximately average of 10%) after recovery. However, most people do not notice this slight decline in strength. Allograft Procedure Another option is the use of tissue from a cadaver (a deceased person) called an allograft.

Patellar tendon, hamstring tendon, or Achilles tendon allografts can be used as tissues inserted and fixed with the same techniques that are used for autografts (grafts using the individual's own tissue). Allografts are a good choice when the patient's own tissue availability is limited. They are useful

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for complicated ligament reconstructions needing more than one graft (for example, if both anterior and posterior cruciate ligaments need to be replaced) or if both the ACL and patellar tendon are damaged. Advantages \*

No risks, pain, or scars from the donor site \* Operative time is quicker

Disadvantages

The very low risk of contracting a serious infection from the cadaver tissue.

Newer techniques of tissue radiation have minimized this risk. 4. Optimum

Angle to Minimize Stress The Anterior Medial (AM) Technique will achieve proper placement of femoral tunnel for ACL reconstruction than the

transtibial technique. It was chosen a human male with a weight of 165

pounds, the corresponding graft force to hold that person's weight is an 89

N/cm<sup>2</sup> and a tendon area of 4.5 cm<sup>2</sup>, (i. e. The average natural insertion of the grafts of the ACL are positioned on a 55° of inclination viewing by the sagittal plane of the human skeleton body).

It was calculated the optimum angle with the weight of the person and the graft force all resulting a 57.3° of inclination for which it will going to be the optimum location to drill the holes on the human knee and slide the tendon thru both holes between the femur and the tibia, occurring less stress when the knee is flexed between the 30 to 60 degrees. Figure 4: ACL Natural

Insertion vs. Optimum Surgery Angle Figure 5: ACL Optimum Angle Front

View Solidworks CAD Figure 6: ACL Optimum Angle Side View Solidworks

CAD Figure 8: Optimum Angle Front View Figure 7: Optimum Angle Side View