

A PATIENT'S GUIDE TO GRAFT SELECTION IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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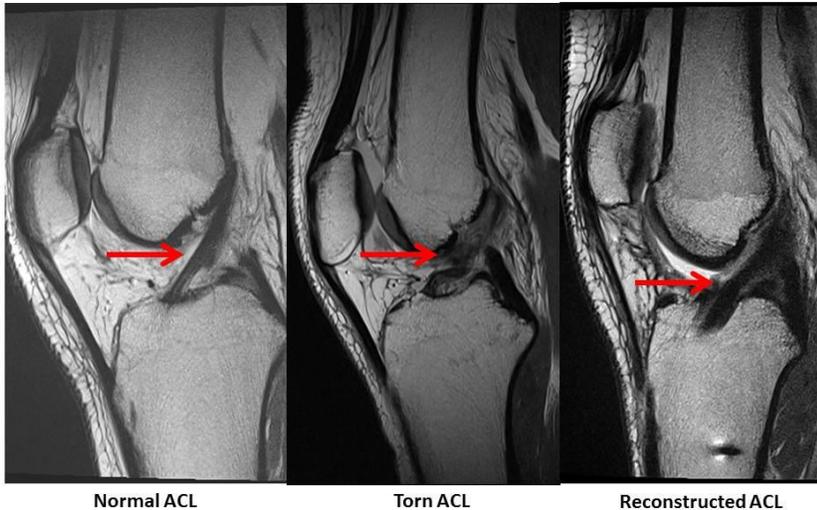
Abstract

Anterior cruciate ligament (ACL) injuries are one of the most common injuries in orthopaedics. ACL injury can be treated either surgically or non-surgically. When surgery is performed, the torn ligament is replaced with a new tissue that will turn into ligament over time. The two main options are autograft, which means that the tissue used to reconstruct the ACL comes from you, and allograft, which means that the tissue used comes from a donor/cadaver. There are several different autograft and allograft options available to patients for ACL reconstruction and these will be discussed below.

Background Information

The ACL is an important stabilizer of the knee and its main function is to prevent the tibia (shin bone) from moving forward relative to the femur (thigh bone). Nearly 75% of ACL injuries are the result of a non-contact mechanism and are usually due to a change in speed and direction¹. This position can be visualized in a basketball player sprinting and pulling up for a jump shot or a football player planting and changing direction to avoid a defender. During these types of movements increased strain is placed upon the knee and can cause the ACL to tear.

ACL injuries represent one of the most common injuries in orthopaedics with about 200,000 occurring per year^{1,2}. Further, females sustain ACL injury at a rate of 2-8 times that of males¹. With increasing rates of participation in sports, it is expected that the amount of ACL injuries will continue to rise in coming years. Therefore, ACL reconstruction surgery is one of the most common procedures performed by both general and sports orthopaedic surgeons. The sports that are most often associated with ACL injuries include skiing, basketball and soccer¹.



Treatment of ACL Injury

Tears of the ACL can be managed either non-surgically or surgically. The decision on treatment route is usually based on patient age, activity level, and symptoms. Most physicians agree that patients with high physical demands or those whose injury interferes with daily living are good candidates for surgery³. The non-surgical option is a rehabilitation program focused on strengthening the muscles of the leg to help the knee feel more stable. A reasonable alternative for patients who are unsure about surgical treatment is a combined approach of physical therapy followed by reassessment. In this option the patient begins a therapy program and is later re-examined to determine if they are still having symptoms of knee instability. Those who are still symptomatic can then undergo ACL reconstruction. This option has been found to be equally as effective as immediate ACL reconstruction and roughly 50% of these patients do not end up needing surgery^{4,5}. In those with persistent instability of their knee, the goal of ACL reconstruction is to restore the knee's stability and prevent development of early osteoarthritis, though having ACL surgery has not been shown to prevent arthritis. This approach is not recommended in younger patients, as delays in surgery after tearing the ACL have been shown to lead to more injuries of the cartilage and meniscus^{6,7}.

Surgery to reconstruct the ACL is done arthroscopically, which means that it is done with the use of a camera through small incisions made in the knee. In reconstructive ACL surgery the patient's damaged ACL is completely removed and replaced using either tissue from you (autograft) or donor tissue (allograft) from a cadaver. In the case of using autograft tissue, two procedures are performed during the surgery. The first is a "harvest" procedure, which involves the removal of tissue from another area around the knee that will be used as the graft. The second procedure is arthroscopic reconstruction,

which involves placing this new graft tissue in the location of the previous ACL. In the case of using allograft tissue only the later procedure is performed since the graft is already available.

Graft Selection

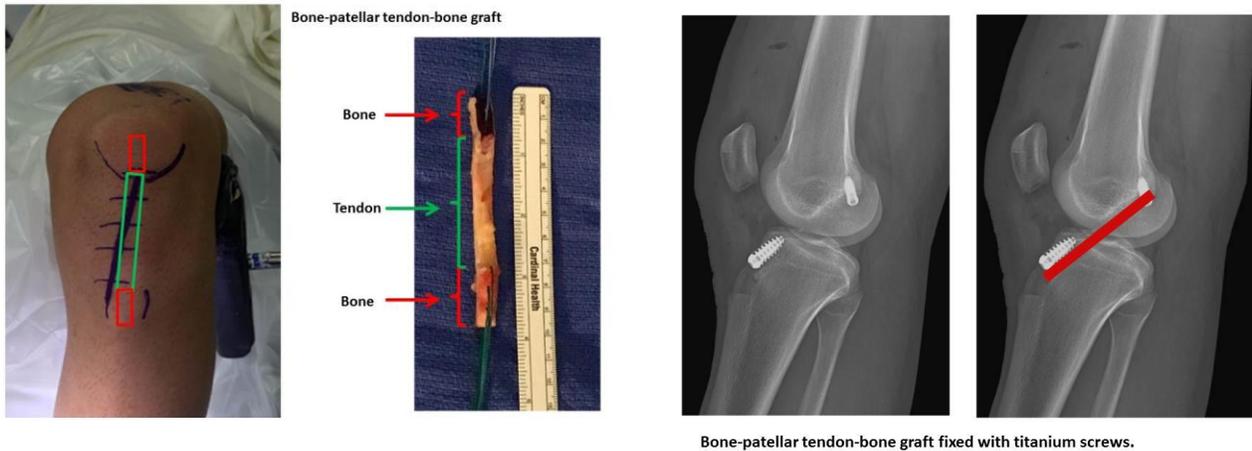
There are several different types of autograft and allograft options that can be used to reconstruct the ACL. The first decision to make is whether to use your own tissue or donor tissue from a cadaver. The choice of autograft versus allograft for ACL reconstruction is dependent upon multiple factors. For some, the thought of having cadaver tissue in their body is untenable, regardless of risks and outcomes; thus, autograft is chosen. The main disadvantage of autograft surgery is the necessity of the harvest procedure (in which tissue is removed from another area around your knee) and potential of associated complications from that procedure. The harvest procedure differs depending on the type of autograft and will be discussed in the following sections of this article. However, the benefits of using autograft are multiple including decreased cost, no risk of disease transmission, and quicker graft incorporation time (healing time) compared to allografts^{8,9}. The most popular types of autografts are patella tendon, hamstring tendons and quadriceps tendon.

For patients open to the idea of allograft, factors such as age, activity level and cost of surgery will play a role in their decision. Appropriate patient age for allograft is a controversial topic. Although not conclusive, some studies have demonstrated an increased failure rate of allografts in younger and more active populations¹⁰⁻¹³. The exact reason is unclear at this time; however one potential reason is that allograft takes longer to incorporate (heal)¹⁴. When this population returns to sport or their normal active life, they may be prone to rupture if the graft is not fully healed. This type of failure can be mitigated by a prolonged rehabilitation course. However, a prolonged rehabilitation course delays return to sport creating issues with compliance that can be a cause of failure in allografts in this patient population¹¹. In contrast to autograft, the major advantage of using allograft tissue is the lack of a harvest procedure, which can decrease the pain associated with surgery. However, cost should be considered when choosing allograft. Allograft surgery is generally more expensive than autograft. The majority of the expense of allograft surgery is tied to the price of the donor tissue. In contrast, the only cost with autograft surgery is related to the slightly increased surgical time for the harvest procedure. After these two factors are compared, allograft surgery is still more expensive than autograft¹⁵⁻¹⁸. How this directly affects the patient is dependent on institution and insurance. Other disadvantages of using allograft besides increased cost include risk of disease transmission and delayed integration (healing) of the graft tissue into the patient's anatomy^{8,9}. The most popular allograft options are Achilles tendon, patella tendon, and tibialis tendon grafts¹⁹.

Autograft Choices

Bone Patella Tendon Bone (BTB) Autograft

The BTB autograft has been historically considered the gold standard autograft for ACL reconstruction. It is the most popular choice for surgeons who cover NFL and Division I college athletes²⁰. The patella tendon runs from the patella (knee cap) to the tibia (bone of the lower leg). The harvest procedure consists of making a vertical incision from the bottom of the patella down to the top of the tibia. The desired portion, usually the middle third, of the tendon is then cut and the bony portions of the patella and tibia are removed as well. The final autograft product is a portion of tendon bookended by two bone plugs from the patella and the tibia²¹. The presence of the bone plugs on both sides of the graft aids in quicker incorporation, or healing, of the graft.



Although rare, complications associated with the harvest procedure include fracture of the patella and rupture of patella tendon²¹⁻²³. Both require additional procedures to repair and a period of immobilization, which complicate and prolong the recovery period. Patients may also complain of increased pain in front of their knee in the acute and chronic settings, as well as more difficulty being able to straighten the knee completely after surgery^{24,25}. Some physicians advise people whose profession involves regular kneeling to avoid this type of reconstruction²³.

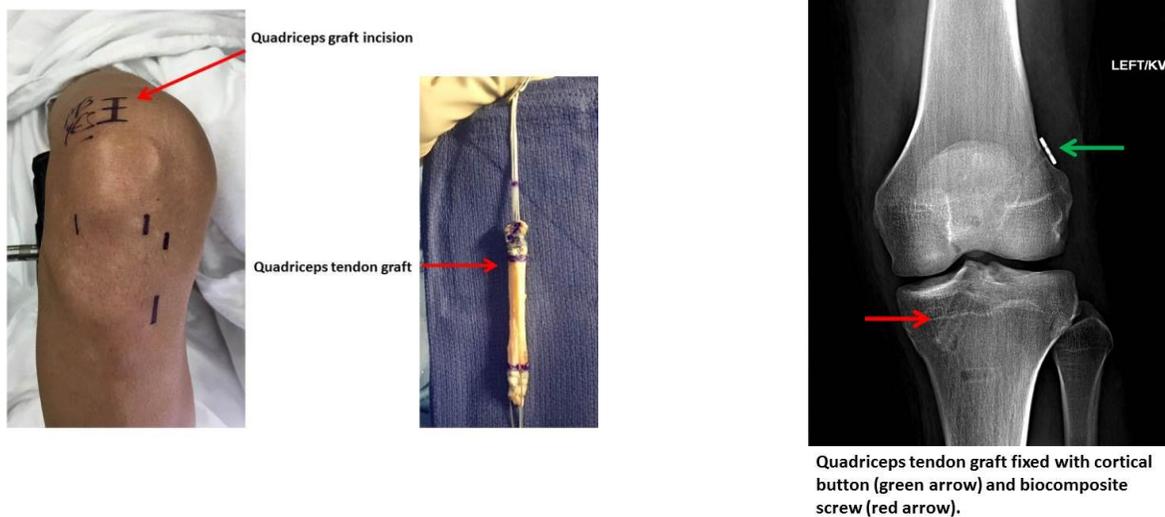
Hamstring Autograft

The hamstring consists of a series of three muscles (semitendinosus, semimembranosus, biceps femoris) and their tendons. The hamstrings function to both flex (bend) the knee and extend (straighten) the hip. Although called the hamstring autograft, it consists of the semitendinosus tendon and the tendon of the gracilis muscle, which itself is not technically part of the hamstrings. The harvest procedure involves a small incision just below and towards the inside of the knee. The tendons are identified and carefully removed. The hamstring autograft has no bony portions, unlike the BTB autograft, and it involves taking the entire two tendons, as opposed to BTB and quadriceps that only take part of the tendons.

The prime benefit of the hamstring autograft is a less morbid harvest procedure since no bone is being removed. When compared to harvesting the BTB autograft described previously, there is decreased surgical complication and decreased knee pain after surgery^{26,27}. One potential drawback to the hamstring autograft is a decrease in strength to bend the knee and pain with sprinting²⁸. This would be problematic for high-level athletes seeking ACL reconstruction. Also, the size of the graft that can be obtained is unpredictable, and this is important because too small a graft may make it more likely to re-tear²⁹, in which case allograft may need to be added to make a larger graft. Some studies have also shown a small but higher failure rate of hamstring autograft than BTB autograft³⁰.

Quadriceps (QT) Autograft

The quadriceps is a large muscle located on the anterior (front) portion of the thigh. Its main function is to straighten the leg. The quadriceps tendon inserts on the top of the patella (knee cap)³¹. The quadriceps is the third most popular autograft option; however, its use has been increasing lately³¹. The harvest procedure for the QT autograft involves making a small incision at the top the patella and only about a third of the tendon is harvested. It can be taken with or without bone from the top of the kneecap. With regards to re-tearing, similar successful results are seen when compared to BTB autograft. However, many of the same complications associated with BTB autograft are present when harvesting QT autograft with bone, including risk of patella fracture, anterior knee pain, and weakness straightening the leg. These are much less frequent when using quadriceps tendon without bone. The performance of the QT graft without bone has been shown to be just as good as with bone but without as many complications, need for less pain medication after surgery, and faster recovery of knee extension, thus making it the preferred choice³¹⁻³³.



Comparisons of Autografts

Numerous studies exist that compare outcomes of the different autografts for ACL reconstruction. The most recent study that compared hamstring autograft to BTB autograft suggests that there was no significant difference in ability of the graft to act like the original ACL; that is to keep the bone in the lower part of the leg from moving forward relative to the bone in the upper part of the leg²⁸. On the other hand, the hamstring autograft displayed less post-operative morbidity and leg straightening deficit than the BTB²⁸.

The most recent study comparing BTB with QT also showed no significant difference between the two with regards to knee stability, range of motion after surgery or quadriceps strength³¹. Complications associated with the harvesting procedure were higher in the BTB group³¹. It is important to note that there is less literature available comparing BTB with QT and future high-level studies still need to be performed before drawing any definitive conclusions.

In conclusion, studies have shown all three autograft options are effectively similar with regard to outcomes. Each graft has its benefits and drawbacks, therefore which autograft option to choose for ACL reconstruction should be selected based on the specific needs and activities of the patient as well as comfort level of the surgeon using the selected graft.

Allograft Choices

For those wishing to avoid complications associated with autograft harvesting, allografts provide another option for ACL reconstruction. An allograft is graft tissue that comes from a cadaver. The most popular allograft options are Achilles tendon, patella tendon, and tibialis tendon— although, additional options such as tensor fascia lata allograft also exist²⁰. The decision on which allograft option to use is typically based on what is available at the hospital where you are receiving surgery and surgeon preference.

Risk of disease transmission is a concern when accepting donor graft tissue from a cadaver. Potential donors undergo a rigorous screening process to evaluate for communicable disease, as well as laboratory testing and processing to detect and kill potential bacteria and viruses. Despite these measures, there is still a risk of disease transmission – the risk of transmission of HIV and Hepatitis C has been estimated to be 1 in 1.6 million and 1 in 421,000, respectively³⁴. However, these current estimates do not reflect more modern serologic tests and the risk may be actually smaller. To further reduce the risk of disease transmission, some will process the graft further with chemicals or radiation; however, this may decrease graft strength and increase the risk of graft failure³⁵⁻³⁷. Furthermore, graft tissue harvested with good sterile (clean) technique, removes the need for secondary sterilization.

After harvesting of the allograft, it is then stored in either a fresh-frozen, cryopreserved or freeze dried format³⁸. The type of processing effects how long the individual graft can be stored, with cryopreservation enabling it to be stored for up to 10 years. Regardless of the storing processed used,

they have not been shown to substantially weaken the graft and good results have been obtained with each³⁹⁻⁴³.

Comparison between Autograft and Allograft

Overall, autograft tissue is the most commonly used graft for ACL reconstruction across the United States⁴⁴. However, there are advantages and disadvantages of both autograft and allograft tissue options that you should be familiar with prior to surgery. The benefits of using autograft are multiple including decreased cost, no risk of disease transmission, and quicker graft incorporation (healing) time compared to allografts. The main disadvantage of autograft surgery is the necessity of the harvest procedure (in which tissue is removed from another area around your knee) and potential of associated complications from that procedure. In contrast to autograft, the major advantage of using allograft tissue is the lack of a harvest procedure and complications associated with the harvest. However, disadvantages of allograft include risk of disease transmission, longer graft incorporation (healing) time, and higher failure rate in some patient populations.

In addition to the above-mentioned pros and cons, it is important to take into account the outcome of patients with each graft type – that is, are patients with allograft or autograft more likely to re-tear their ACL? Current studies do not provide a unanimous answer to this question. Some studies find that there is no difference in re-tear rates^{45,46}. However, other studies show that allograft has about a 5 times greater rate of re-tearing – but that the rate is dependent on the method used to sterilize (clean) the allograft tissue such that when excluding irradiated or chemically processed allografts there is no difference between autograft and allograft re-tear rate⁴⁷. A recent study looking at the results of other studies comparing autograft to allografts showed a 31% risk of failure for irradiated or chemically processed allografts, 19.5% failure for fresh-frozen allografts, and 9.6% failure in autografts in a young, active population of patients less than 25 years old⁴⁸. Therefore, for this demographic of patients autograft is recommended for ACL reconstruction.

Author's Preferred Treatment

ACL reconstruction is indicated in patients that wish to return to a high level of athletic activity or have instability or giving out on activities of daily living or work despite non-surgical treatment. The decision to undergo surgery and the choice of tissue used, autograft versus allograft, is made after discussing with each individual patient their goals and expectations, and an agreement is reached after an understanding of the risks and benefits of each graft option. Many factors go into selecting the right graft for each patient, including age, activity level, and work demands. In general, the senior author (MB) recommends autograft use in patients under 25 years of age, and the option to use allograft in patients over 25, with the most important factor being the patient understanding the graft choice and the risks associated with the selected graft. Though final decision is made with the patient, Dr. Baraga frequently uses the quadriceps tendon autograft without bone, as it has been shown to give the same

results but without the potential complications as the bone-patellar tendon-bone autograft and no graft size concerns as with hamstring autografts.

Conclusion

ACL injuries are common orthopedic injuries and can be treated either non-surgically or surgically – the decision is usually based on patient age, activity level, and symptoms. When treated surgically there are several options for the tissue graft that is used to reconstruct the ACL. The main two groups are autograft (from you) or allograft (from a cadaver). The choice of autograft versus allograft for ACL reconstruction is dependent upon multiple factors and should be discussed with your physician prior to surgery.

Bullet Points

- ACL injuries are common orthopedic injuries that can be treated either non-surgically or surgically.
- There are several options of tissue grafts used to reconstruct the ACL – the choice of which to use is based upon multiple factors and should be discussed with your surgeon prior to surgery.
- Each tissue graft option is associated with unique pros and cons that the patient should be familiar with and discuss with their surgeon.
- For young (≤ 25 years old), highly active patients autograft is recommended over allograft due to higher rates of ACL re-tearing in these patients.

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