

# **Graft Options in Anterior Cruciate Ligament Reconstruction: A Patient's Guide**

Daniel M. Myer, MD

Kelly L. Wright, MPAS, PA-C, ATC

## **Introduction**

The anterior cruciate ligament (ACL) is one of the most commonly injured knee ligaments, and ACL tears are treated with a variety of options. From the young athlete to the active weekend warrior, surgical intervention is often required; however, not all ACL tears need to have surgery. When surgery is performed, the torn ligament is replaced (“reconstructed”) with a new tissue (“graft”). The first decision when it comes to your graft selection is deciding on autograft vs allograft. Autograft is a type of graft that comes from you, the patient. Autograft options include patellar tendon (also known as “BTB” or Bone Tendon Bone), quadriceps tendon and hamstring tendon (semitendinosus and / or gracilis). Allograft is a type of tissue that comes from a cadaver, not from the patient. Allograft options include patellar tendon, quadriceps tendon, hamstring tendon, Achilles tendon, and tibialis tendons.

Graft options and the patient-specific selection process will be an open discussion with you and Dr. Myer. This takes into account your sex, age, sport, activity level, specific injury / surgery plan, and most importantly – your expectations and desires. The purpose of this paper is to discuss all graft options and their basic advantages / disadvantages. Finding the perfect graft selection is an ongoing process that continues to be researched. The bottom line is that there is not always a completely correct or incorrect option, and the discussion between you and Dr. Myer is the most important part of the process.

## **Background Information**

The ACL is an important stabilizer of the knee joint. Its functions are to help the tibia (shin bone) and the femur (thigh bone) rotate together, as well as to prevent the tibia from moving forward with respect to the femur. An estimated 75% of ACL injuries are due to a non-contact, pivoting mechanism - as in basketball, soccer, football and skiing where there is an increase in speed and a sudden change of direction<sup>1,2</sup>. There are multiple risk factors that predispose people to tearing their ACL<sup>2,3</sup>. For example, females sustain ACL injury rate of 2-8 times that of males<sup>1,2</sup>. Arthroscopic ACL reconstruction surgery is one of the most common procedures performed by sports medicine orthopaedic surgeons.

## Treatment options for ACL injury

ACL tears can be managed either surgically or non-surgically. The decision on which avenue is best is based on multiple factors (age, activity level, other injuries, symptoms and expectations) – and these decisions are made through good communication between physician and patient. The patient’s athletic goals, functional abilities and presence of “ACL tear symptoms” all influence decision making. An ACL deficient knee will often buckle and feel unstable (knee shifts or gives way with side-to-side activities / change in direction). The patient – physician team approach is based on whether the patient is trying to get back to a certain level of activity, or just trying to minimize instability symptoms that interfere with activities of daily living. Patients with high physical demands of work, sports, recreation or daily living are often best candidates for surgery<sup>3</sup>. Non-surgical treatment options involve physical therapy rehabilitation, which helps strengthen the surrounding muscles and aid in the knee feeling more stable. The goal we have as orthopaedic surgeons is to provide a stable knee for the patient. Unfortunately, the concern is the injured knee can still be at risk for developing arthritis many years later – even if we intervene with surgery. We do know however, that patients who continue to have buckling or giving way episodes are at higher risk for damaging the cartilage (meniscus and articular cartilage) in the knee. This will ultimately will put that knee at accelerated risk for developing arthritis. The goals of ACL reconstruction surgery is to help restore knee stability within the joint - whether it is high level sports or simple activities of daily living.

## Graft Selection

There are two main graft options: Autograft (patient’s own tissue) versus Allograft (cadaver tissue). There are multiple factors to consider when deciding the best graft: sex, age, sport, activity level, specific injury / surgery plan, and most importantly – patient’s expectations and desires. Autograft has been classically used as the graft of choice in young, active athletes – but there are no set rules. Dr. Myer is a firm believer that there is not one perfect option, and after an open discussion with the patient, the best option is taking all the patient’s factors into consideration.

## Autograft Choices

### ***Bone Patella Tendon Bone Autograft***

Patella tendon autografts have historically been the gold standard autograft for ACL reconstruction. The patella tendon extends from the patella (kneecap) to the tibia (shin bone). The harvest procedure consists of excising (cutting) the middle one-third of the tendon and part of the attached bone from the patella and the tibia, forming bone plugs on either end. The main advocated benefit of patellar tendon autograft is bone incorporation from a healing standpoint. However, the actual tendon size is significantly thinner than a similar sized hamstring or quad tendon autograft. Unfortunately, there are complications associated with harvesting the patellar tendon. For example, there is an increased risk of patella fracture and patella tendonitis / anterior knee pain, especially in jumping sports (basketball and volleyball)<sup>4,13</sup>. In addition, patients who have occupations that require excessive kneeling may also

cause patella tendonitis or anterior knee pain<sup>14</sup>. Another disadvantage of using BTB is that the graft length is fixed and as such, is vulnerable to graft tunnel mismatch when the tunnel length is not adjusted accordingly. The surgeon must be aware of the problem and use back-up fixation as necessary, especially in the setting of a patella alta or baja<sup>15,16,17</sup>. Due to younger patients with open growth plates, the bone healing of BTB graft can negatively affect the bone's growth, and Dr. Myer prefers not to use this graft type in younger, skeletally immature patients<sup>15,18</sup>. Lastly, research has shown that patellar tendon harvest can cause more long term quad tendon weakness than actually harvesting part of the quad tendon – attributed to knee pain with subsequent quad inhibition<sup>19,20,21</sup>.

### ***Hamstring Autograft***

The hamstring tendons are comprised of muscles that act to flex and extend the knee or straighten the hip (semitendinosus, gracilis, semimembranosus, and biceps femoris). The harvest procedure for a hamstring autograft consists of removing the semitendinosus +/- gracilis tendons, whereby a small incision is made on the inside part of the knee (Dr. Myer only takes the semitendinosus). There are no bony plugs associated with hamstring autografts. One advocated benefit of a hamstring autograft compared with patellar tendon is decreased risk of anterior knee pain, and it can be used in patients with open growth plates<sup>18</sup>. However, there are several downsides to hamstring autograft. The graft size is unpredictable and research has shown that a smaller graft can increase the risk of re-tear<sup>4,22</sup>. Another risk of hamstring autograft is that sacrificing these can decrease knee flexion strength and cause increased pain especially with sprinting activities<sup>1,13,20</sup>. This is one of the most important risks of taking part of the hamstring. While rehabbing an ACL injury, these tendons are important to protect an ACL deficient knee. Decreasing hamstring strength is a concern while protecting the ACL injured knee.

### ***Quadriceps Tendon Autograft***

The quadriceps are a group of 4 muscles consisting of the rectus femoris, vastus lateralis, vastus medialis and vastus intermedius. The quadriceps main function is to extend (straighten) the leg, and the quadriceps inserts into the top of the patella (kneecap). The autograft harvest procedure involves making a small incision just above the patella, taking roughly one-fifth of the quad tendon insertion. The graft type can be taken with or without bone graft (Dr. Myer does not take a bone plug). There are both pros and cons to quadriceps tendon autograft. The main negative of quad tendon harvest is delayed quad activity for the first couple months due to harvesting pain / quad inhibition<sup>21</sup>. This is still quicker than harvesting patella tendon, but not as quick as compared to hamstring<sup>19,20,21</sup>.

Not only is the graft large and strong, but a tremendous benefit from quad tendon harvest is not weakening the knee flexion strength (as with hamstring tendon harvest) and not incurring the long-term anterior knee pain (as with patellar tendon harvest)<sup>19,20,21</sup>. Quadriceps tendon autograft has been used for years, and has longstanding good outcomes equivalent with both patellar tendon and hamstring tendon.

In conclusion, studies have shown all three autografts options have similar outcomes and results with long-term follow-up studies. One must consider that each graft has its advantages and disadvantages. Therefore, the autograft options should be chosen selectively and in conjunction based on a physician-

patient centered team model and thoroughly discussed with the patient with respect to age, activity level, sport / occupation, and expectations.

### Allograft Choices

An allograft is a graft that comes from a cadaver tissue. Options include patellar tendon, quadriceps tendon, hamstring tendon, Achilles tendon, and tibialis tendons. One disadvantage of an allograft option is that there is a small chance of disease transmission even though the potential donors undergo a rigorous screening process. The risk of transmission of HIV and Hepatitis C is estimated to be 1 in 1.6 million and 1 in 421,000 respectively<sup>8</sup>. To further reduce the risk of disease transmission, the graft is also treated with chemical or radiation techniques to sterilize the tissue. This process has been found to decreased the graft strength and increase the risk of graft failure<sup>1,9,10,11</sup>. Allografts have also have an increased risk of failure in younger more active patients less than age 25. The MOON study demonstrated an overall 8.9% re-tear rate in allograft primary reconstruction compared to 3.5% with autograft reconstruction in high level athletes or less than 25 years old<sup>4,12</sup>. However, the advantages of allografts can outweigh the disadvantages. Overall, there is less pain associated with the procedure over autografts. There is also an increased recovery of quadriceps strength since there is sparing of the patients own tissue. In addition, there is also less risk of anterior knee pain associated with allograft choices. Furthermore, it is the graft of choice for patients over the age of 25 and in less physically active patients<sup>4</sup>. It is also the “go to” graft of choice for ACL revisions and multiple ligament knee injuries<sup>4</sup>.

### Surgeon’s Treatment

ACL reconstruction is indicated for patients who are symptomatic with buckling or giving way episodes. Age, activity level and quality of life are also determining factors to consider in ACL reconstruction and graft type. The decision in determining which graft is best for the patient depends on various factors such as; age, activity level, job duties and how functioning without an ACL impacts the patient’s quality of life. The decision to choose one graft over the other is carefully discussed with the patient and the surgical team. Well defined goals and expectations are other factors to consider when choosing ACL Reconstruction. Dr. Myer and his team offer open discussion regarding allograft versus autograft choices and how each impacts long-term re-tear rates and post-operative rehabilitation.

### References

1. Ennis, H, Baraga, MG. A PATIENT’S GUIDE TO GRAFTS SELECTION IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION. UHealth Sports Medicine, University of Miami Miller School of Medicine, Miami FL.
2. Sutton, K.M and J.M. Bullock, Anterior cruciate ligament rupture: differences between males and females. J AM Acad Orthop Surg, 2013.21(1):p.41-50.

3. Marx, R.G., et al. Beliefs and attitudes of members of the American Academy of Orthopaedic Surgeons regarding the treatment of anterior cruciate ligament injury. *Arthroscopy*. 2003.19(7):p. 762-70.
4. Mall, NA., Theil, GV., et al. Graft Selection in Anterior Cruciate Ligament Reconstruction. Rush University Medical Center, Department of Orthopaedics, Division of Sports Medicine, University of Michigan, Department of Orthopaedics, MedSport, Rockford Orthopaedic Associates, Rockford, IL.
5. Slone, H.S., et al. Quadriceps Tendon Autograft for Anterior Cruciate Ligament Reconstruction: A Comprehensive Review of Current Literature and Systematic Review of Clinical Results. *Arthroscopy*, 2014.
6. Shaerf, DA., et al., Anterior cruciate ligament reconstruction best practice: A review of graft choice. *World J Orthop*, 2014. 5(1): p. 23-9.
7. Barrett, A.M., et al., Anterior cruciate ligament graft failure: a comparison of graft type based on age and Tegner activity level. *Am J Sports Med*, 2011. 39(10): p. 2194-8.
8. Zou, S., et al., Probability of viremia with HBV, HCV, HIV, and HTLV among tissue donors in the United States. *N Engl J Med*, 2004. 351(8): P.751-9.
9. Park, S.S., et al., Analysis of irradiation on the clinical effectiveness of allogenic tissue when used for primary anterior cruciate ligament reconstruction. *Am J. Sports Med*, 2015. 43(1): p: 226-35.
10. Rasmussen, T.J., et al., The effects of 4 M rad of gamma irradiation on the initial mechanical properties of bone-patellar tendon-bone grafts. *Arthroscopy*, 1994. 10(2):p. 188-97.
11. Roberts, T.S., et al., Anterior cruciate ligament reconstruction using freeze-dried, ethylene oxide-sterilized, bone-patellar tendon-bone allografts. Two year results in thirty-six patients. *Am J Sports Med*, 1991. 19(1): p. 35-9.
12. Spindler, Kurt P., Parker, RD. Prognosis and Predictors of ACL reconstruction using the MOON cohort: A model for comparative effectiveness studies. *Journal of Orthopaedic Research*, 2013: 31 (1): p. 2-9.
13. Allum, R., Complications of arthroscopic reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br*, 2003. 85 (1 :p, 12-16.
14. Lee, G.H., et al. The incidence of acute patellar tendon harvest complications for anterior cruciate ligament reconstruction. *Arthroscopy*, 2008. 24 (2): p.162-6.
15. Sekiya, JK, Ong BC., Bradley, JP. Complications in anterior cruciate ligament surgery. *Orthop Clin North Am* 2003; 34:99-105.
16. Verma N., Noerdlinger MA., Hallab N, Bush-Joseph CA., Bach BR. Effects of graft rotation on initial biomechanical failure characteristics of bone-patellar-bone constructs. *Am J Sports Med* 2003; 31:708-713.

17. Verma NN., Dennis MG., Carreira DS., Bojchuk J., Hayden JK., Bach BR. Preliminary clinical results of two techniques for addressing graft tunnel mismatch in endoscopic anterior cruciate ligament reconstruction. *J knee Surg.* 2005; 18:183-191.
18. Kocher MS., Smith JT., Zoric BJ., Lee B., Micheli LT. Transphyseal anterior cruciate ligament reconstruction in skeletally immature pubescent adolescents. *J Bone Joint Surgery Am* 2007; 89:2632-2639.
19. Cavaignac E., Coulin B. Is quadriceps tendon autograft a better choice than hamstring autograft for anterior cruciate ligament reconstruction; a comparative study with a mean follow-up of 3.6 years. *Am J Sports Med.* 2017 May; 45(6):1326-1332.
20. Feller, JA., K.E. Webster, and B. Gavin, Early post-operative morbidity following anterior cruciate ligament reconstruction: patellar tendon versus hamstring graft. *Knee Surg Sports Traumatol Arthrosc,* 2001. 9(5): p.260-6.
21. Slone, H.S., et al., Quadriceps Tendon Autograft for Anterior Cruciate Ligament Reconstruction: A Comprehensive Review of Current Literature and Systematic Review of Clinical Results. *Arthroscopy,* 2015. 31(3)541-54.
22. Clatworthy, M. Graft diameter matters in hamstring ACL reconstruction. *Orthop J Sports Med,* 2016 4(7suppl5).