

Autograft Options for ACL Reconstruction. Which Is Best?

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ABSTRACT

Anterior cruciate ligament (ACL) tears are commonly seen in orthopedic practice, and usually restoration is recommended to re-establish normal knee function. Autografts and allografts are viable options. Among autografts the main sources are the patellar tendon, the hamstrings and the quadriceps tendon, each having advantages and drawbacks. Many factors should be taken into consideration when deciding on a graft source for ACL restoration; however, clinical data may aid the surgeon in choosing the right graft for every specific patient in an individualized manner. This short review is intended to highlight the main characteristics and clinical data for each type of autograft.

Keywords: anterior cruciate ligament restoration, autograft, bone-to-bone grafts, hamstring grafts, quadriceps tendon

Anterior cruciate ligament (ACL) tears are commonly seen in orthopedic practice among patients involved in different sports activities, and usually, ACL restoration is recommended to re-establish normal knee function. Autografts are very frequently used for the reconstruction, and the most commonly used are the bone-patellar tendon-bone (BTB) and the four-strand hamstring tendons (HT) grafts.^{1,2} Of these two, in terms of clinical results, there is no clear evidence of one's superiority over the other, at least not with a clear significance.³⁻⁵ However, with regard to graft-associated morbidity, HT are recognized as providing less donor site morbidity compared to BTB grafts.⁶⁻⁸ Recently, there has been an increase in interest in the quadriceps tendon (QT) as an autologous graft option for ACL restoration.

In terms of strength and stiffness, the native ACL resists at a maximum tensile load of about 2150 N and has a stiffness of around 240 N/mm.⁹ A 10 mm BTB graft has been found to resist to tensile loads of up to 2977 N, with a stiffness of

about 620 N/mm.¹⁰ A 4-strand HT graft has a tensile load of up to 4000 N, with a stiffness of about 750 N/mm.¹¹ For the quadriceps tendon graft with a 10 mm diameter the numbers are similar with the BTB graft, having a maximum tensile load of about 2150 N, with a stiffness of about 460 N/mm.¹²

In terms of graft incorporation times, the BTB autograft has the fastest rate of incorporation in the tunnels with the bone-to-bone interface, about 6 weeks, this being one of the most important advantages of this graft. The hamstring graft has an incorporation time of about 12 weeks, and the quadriceps graft takes about 6 to 12 weeks to integrate in the tunnels.

Donor site morbidity is another important aspect to consider when deciding on a graft for ACL restoration. In general, the patellar tendon graft is recognized as the graft with the highest harvest site morbidity including anterior knee pain, kneeling pain, and patellar fracture.¹³ Some of these complications can be reduced with different techniques of harvesting the graft.¹⁴ HT grafts are described as being the least morbid graft option for ACL reconstruction. However, disruption of the infra-patellar branch of the saphenous nerve, premature amputation of the graft, and other complications related to harvest have been described. One important drawback of this graft is the inconsistent size and the inability to measure it preoperatively on the MRI. Another disadvantage is the loss of power in knee flexion, which can be significant in certain sports activities.¹⁵ The quadriceps graft is the least studied option for ACL reconstruction, but it seems to have a low morbidity. If used as a free-bone plug graft, the risk of patella fracture is eliminated.¹⁶ Compared to harvest-related pain, it seems to be even less painful than HT.¹⁷ Other advantages reported with the quadriceps graft are predictable size, great versatility, and the ability to harvest grafts in different widths, thicknesses, and lengths, both for single- and double-bundle techniques.^{18,19}

With regard to clinical results, a large amount of data exists comparing BTB and HT. In a meta-analysis by Poolman *et al.* (2007), they showed reduced morbidity using a HT autograft for ACL reconstruction. The authors stated that the recent endobutton hamstring graft fixation method (2 studies) showed comparable stability to BTB grafts in the Lachman test.²⁰ In another meta-analysis by Biau *et al.* that included 6 randomized clinical trials in which 423 subjects with symptomatic unilateral ACL damage were randomly assigned to reconstruction with patellar tendon or HT autograft, postoperative knee instability was less common after ACL restoration with patellar tendon autograft than with HT autograft.²¹ The difference was noted especially in case of the pivot-shift and for females

and younger patients. Reinhardt *et al.* showed in a systematic review a lower graft failure rate for BTB than for HT (7.2% vs. 15.8% respectively, $p = 0.02$).²² Magnussen *et al.* showed in a systematic review lower graft failure rates for BTB compared to HT, but without statistical significance.⁶ There was no difference in patient-reported outcomes (International Knee Documentation Committee, IKDC). Anterior knee pain and kneeling pain were higher for BTB. More recently, in 2015, Xie *et al.* showed no difference in re-tear rate between the patellar tendon and hamstrings, and no difference for patient-reported outcome measures. However, reconstruction with patellar tendon graft resulted in better rotational stability and return to pre-injury level of activity. Again, anterior knee pain and kneeling pain were greater for BTB.³ Also, some registry studies show a higher overall risk of revision in patients with HT graft compared to BTB graft.²³

When looking at the quadriceps graft, there is little published data compared to the other mentioned grafts. Lund *et al.* did not find any differences in anterior knee pain and functional outcomes in a prospective randomized trial comparing the QT with the patellar tendon. However, knee walking pain was significantly less in case of the QT compared to BTB.²⁴ A systematic review by Slone *et al.* in 2014 showed no difference for stability, range of motion, functional outcomes, and complications between the quadriceps graft and BTB. Also, less donor site morbidity was found in case of QT.²⁵

An interesting study by Ma *et al.* that aimed to study the differences associated with graft maturity on magnetic resonance imaging, found that graft maturity was better at 6 months following ACL reconstruction with QT compared to HT autograft.²⁶

CONCLUSIONS

In conclusion, autografts for ACL reconstruction provide similar functional outcomes. Bone-to-bone grafts are associated with higher rates of extension deficits, anterior knee pain, and kneeling pain, but have faster incorporation in the tunnels.

Hamstring grafts show slightly higher failure rates, especially when they are less than 8 mm in diameter; however, this could theoretically be managed by technical aspects such as the 5–6 strands grafts. Also, there is the concern of losing deep flexion strength, which may be important, especially in some specific sports.

Quadriceps tendons seem to be very versatile grafts. In general, the results are similar with BTB, but with less donor site morbidity.

Many factors should be taken into consideration when choosing a graft source for ACL reconstruction, including the surgeon's experience, tissue availability, and the patient's option and degree of activity. Based on the available data, BTB may be recommended especially for hyper-mobile patients and young, highly active patients with closed growth plates. HT may be recommended for patients with activities that require frequent kneeling and for skeletally immature patients, and the QT graft for hypermobile, highly active or female patients, and for knee flexion athletes with kneeling requirements.

CONFLICT OF INTEREST

Nothing to declare.

REFERENCES

- Samuelsen BT, Webster KE, Johnson NR, Hewett TE, Krych AJ. Hamstring Autograft versus Patellar Tendon Autograft for ACL Reconstruction: Is There a Difference in Graft Failure Rate? A Meta-analysis of 47613 Patients. *Clin Orthop Relat Res*. 2017. doi: 10.1007/s11999-017-5278-9. [Epub ahead of print]
- Tibor L, Chan PH, Funahashi TT, Wyatt R, Maletis GB, Inacio MC. Surgical Technique Trends in Primary ACL Reconstruction from 2007 to 2014. *J Bone Joint Surg Am*. 2016;98:1079-1089.
- Xie X, Liu X, Chen Z, Yu Y, Peng S, Li Q. A meta-analysis of bone-patellar tendon-bone autograft versus four-strand hamstring tendon autograft for anterior cruciate ligament reconstruction. *Knee*. 2015;22:100-110.
- Barrett GR, Noojin FK, Hartzog CW, Nash CR. Reconstruction of the anterior cruciate ligament in females: A comparison of hamstring versus patellar tendon autograft. *Arthroscopy*. 2002;18:46-54.
- Sajovic M, Vengust V, Komadina R, Tavcar R, Skaza K. A prospective, randomized comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: five-year follow-up. *Am J Sports Med*. 2006;34:1933-1940.
- Magnussen RA, Carey JL, Spindler KP. Does autograft choice determine intermediate-term outcome of ACL reconstruction? *Knee Surg Sports Traumatol Arthrosc*. 2011;19:462-472.
- Xie X, Xiao Z, Li Q, et al. Increased incidence of osteoarthritis of knee joint after ACL reconstruction with bone-patellar tendon-bone autografts than hamstring autografts: a meta-analysis of 1,443 patients at a minimum of 5 years. *Eur J Orthop Surg Traumatol*. 2015;25:149-159.
- Aglietti P, Giron F, Buzzi R, Biddau F, Sasso F. Anterior cruciate ligament reconstruction: bone-patellar tendon-bone compared with double semitendinosus and gracilis tendon grafts. A prospective, randomized clinical trial. *J Bone Joint Surg Am*. 2004;86:2143-2155.
- Woo SL, Hollis JM, Adams DJ, Lyon RM, Takai S. Tensile properties of the human femur-anterior cruciate ligament-tibia complex. The effects of specimen age and orientation. *Am J Sports Med*. 1991;19:217-225.
- Cooper DE, Deng XH, Burstein AL, Warren RF. The strength of the central third patellar tendon graft. A biomechanical study. *Am J Sports Med*. 1993;21:818-823.
- Hamner DL, Brown CH Jr, Steiner ME, Hecker AT, Hayes WC. Hamstring tendon grafts for reconstruction of the anterior cruciate ligament: biomechanical evaluation of the use of multiple strands and tensioning techniques. *J Bone Joint Surg Am*. 1999;81:549-557.
- Harris NL, Smith DA, Lamoreaux L, Purnell M. Central quadriceps tendon for anterior cruciate ligament reconstruction. Part I: Morphometric and biomechanical evaluation. *Am J Sports Med*. 1997;25:23-28.
- Milankov M, Kecojević V, Rasović P, Kovacević N, Gvozdenović N, Obradović M. Disruption of the knee extensor apparatus complicating anterior cruciate ligament reconstruction. *Acta Chirurgica Iugoslavica*. 2013;60:13-21.
- Koh E, Oe K, Takemura S, Iida H. Anterior Cruciate Ligament Reconstruction Using a Bone-Patellar Tendon-Bone Autograft to Avoid Harvest-Site Morbidity in Knee Arthroscopy. *Arthrosc Tech*. 2015;4:e179-184.
- Ageberg E, Roos HP, Silbernagel KG, Thomeé R, Roos EM. Knee extension and flexion muscle power after anterior cruciate ligament reconstruction with patellar tendon graft or hamstring tendons graft: a cross-sectional comparison 3 years post surgery. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:162-169.
- Todor A, Caterov S, Nistor DV, Khalilouki Y. Free Bone Plug Quadriceps Tendon Harvest and Suspensory Button Attachment for Anterior Cruciate Ligament Reconstruction. *Arthrosc Tech*. 2016;5:e541-e544.
- Buescu CT, Onutu AH, Lucaciu DO, Todor A. Pain level after ACL reconstruction: A comparative study between free quadriceps tendon and hamstring tendons autografts. *Acta Orthopaedica et Traumatologica Turcica*. 2017;51:100-103.
- Caterov S, Nistor DV, Todor A. Anatomic Double-Bundle Anterior Cruciate Ligament Reconstruction With a Free Quadriceps Tendon Autograft. *Arthrosc Tech*. 2016;5:e1063-e1067.
- Park SE, Ko Y. A novel graft preparation technique of the quadriceps tendon for arthroscopic double-bundle anterior cruciate ligament reconstruction. *Arthrosc Tech*. 2013;1:e197-e200.
- Poolman RW, Farrokhyar F, Bhandari M. Hamstring tendon autograft better than bone patellar-tendon bone autograft in ACL reconstruction: a cumulative meta-analysis and clinically relevant sensitivity analysis applied to a previously published analysis. *Acta Orthopaedica*. 2007;78:350-354.
- Biau DJ, Katsahian S, Kartus J. Patellar tendon versus hamstring tendon autografts for reconstructing the anterior cruciate ligament: a meta-analysis based on individual patient data. *Am J Sports Med*. 2009;37:2470-2478.
- Reinhardt KR, Hetsroni I, Marx RG. Graft selection for anterior cruciate ligament reconstruction: a level I systematic review comparing failure rates and functional outcomes. *Orthop Clin North Am*. 2010;41:249-262.
- Rahr-Wagner L, Thillemann TM, Pedersen AB, Lind M. Comparison of hamstring tendon and pa-tellar tendon grafts in anterior cruciate ligament reconstruction in a nationwide population-based cohort study: results from the Danish registry of knee ligament reconstruction. *Am J Sports Med*. 2014;42:278-284.
- Lund B, Nielsen T, Faunø P, Christiansen SE, Lind M. Is quadriceps tendon a better graft choice than patellar tendon? A prospective randomized study. *Arthroscopy*. 2014;30:593-598.
- Slone HS, Romine SE, Premkumar A, Xerogeanes JW. Quadriceps tendon autograft for anterior cruciate ligament reconstruction: a comprehensive review of current literature and systematic review of clinical results. *Arthroscopy*. 2015;31:541-554.
- Ma Y, Murawski CD, Rahnemai-Azar AA, Maldjian C, Lynch AD, Fu FH. Graft maturity of the reconstructed anterior cruciate ligament 6 months postoperatively: a magnetic resonance imaging evaluation of quadriceps tendon with bone block and hamstring tendon autografts. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:661-668.