Advances in Anterior Cruciate Ligament Reconstruction
Current Concepts and Controversies in ACL Surgery

Bertram Zarins, MD, Samuuel Van De Velde, Thomas Gill, MD
Department of Orthopaedic Surgery, Massachuestts General Hospital, Boston, Massachusetts

In the past three decades, a variety of methods to stabilize the knee in which the anterior cruciate ligament (ACL) has been torn have been tried and discarded. Techniques that have not withstood the test of time include primary repair of the torn ACL, lateral extra-articular reconstruction (Ellison, McIntosh), dynamic operations (pes anserinus), synthetic augmentation (ligament augmentation device), prosthetic replacement (Gortex, Leeds-Keio, Dacron), vascularized grafts and thermal shrinkage. Intra-articular replacement of the torn ACL with a biologic graft has evolved to be the most commonly used operation today. This is not a surprising development, since restoring normal anatomy has always been the goal of surgery.

The graft that is most commonly used graft to replace the torn ACL is the middle third of the patella tendon. This bone-tendon-bone graft can be either an autograft or an allograft. Other parts of the extensor mechanism, such as quadriceps tendon-patella, are occasionally taken for grafts. Hamstring tendons (semitendinosus and gracilis) are also commonly used as grafts.

BONE-PATELLAR TENDON-BONE VERSUS HAMSTRING GRAFTS

Considerable debate continues as to whether a BPTB autograft or a multi-strand hamstring tendon autograft is preferable for ACL reconstruction. Both intra-articular reconstructions are well-established techniques[2, 6, 20, 33] and comparative studies have shown little difference between the two autografts in patient satisfaction and ligament stability outcome at medium- to long-term follow-up[2, 3, 7, 9, 11, 12, 14, 18, 20, 24, 26, 27, 29, 30]. For more than two decades, the BPTB autograft has been regarded as the graft of choice in ACL reconstruction[8, 10, 15, 34]. ACL reconstruction using multi-strand hamstring tendons has been advocated as an alternative standard procedure to using the BPTP graft to improve its several disadvantages such as slow recovery in quadriceps muscle strength, difficulties of full extension, and anterior knee pain[6, 8, 11, 13, 14, 19, 28, 30-32]. However, some reports comparing the outcome of hamstring and BPTB surgeries have indicated preferable results from BPTB surgery with regard to knee stability and sporting activity recovery[2, 4-6, 11, 13, 17, 32].

ALLOGRAFT VERSUS AUTOGRAFT

SINGLE BUNDLE VERSUS DOUBLE BUNDLE GRAFTS

Renewed interest has arisen in the double-bundle hamstring tendon technique[21] in an attempt to reproduce more closely the natural anatomy of anteromedial and posterolateral bundles of the ACL. Recent in-vitro biomechanical studies have shown that the anatomic reconstruction of the ACL produces a better biomechanical outcome, especially close to knee extension[25] and during rotatory loads[35]. However, it remains unclear whether these promising in-vitro results translate in improved clinical outcome. A few studies have found that the anterior laxity of the anatomic double-bundle ACL reconstruction was significantly better than that of the single-bundle reconstruction with the hamstring tendon graft[22, 23, 36, 37], although there were no significant differences in International Knee Documentation Committee evaluation scores[22, 37]. Other clinical studies then again have reported that there were no significant differences in stability or clinical outcome between the single-bundle and double-bundle ACL reconstruction techniques[1, 16].

SUMMARY

We believe that the mid-third patella tendon is a better graft than a hamstring graft because it allows bone-to-bone healing within the femoral and tibial tunnels. We have been able to minimize complications of taking a graft from the middle third of the patella tendon by utilizing an accelerated postoperative rehabilitation program, as described by Shelbourne. This requires the use of continuous passive motion (CPM) for 23 hours a day for the first seven days after surgery.

We prefer to use autografts in patients who are younger than about 40 years. If the patient is older than 40, we give the patient the option of choosing an allograft after explaining the benefits and potential risks. If the patient has had prior ACL reconstruction using an mid-third patella tendon autograft and has recurrent instability, we prefer to use a mid-third patella tendon graft allograft (and no postoperative CPM).

Since the results of using single bundle and double bundle grafts are reported to give similar results, we think it is better to use the single bundle method. This is less complicated to perform, requires less drilling of the femoral and tibial condyles, and has withstood the test of time.

References

1. **Adachi N, Ochi M, Uchio Y, et al.** Reconstruction of the anterior cruciate ligament. Single- versus double-bundle multistranded hamstring tendons. *J Bone Joint Surg Br.* May 2004;86(4):515-520.
2. **Aglietti P, Buzzi R, Zaccherotti G, et al.** Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. *Am J Sports Med.* Mar-Apr 1994;22(2):211-217; discussion 217-218.
3. **Aglietti P, Giron F, Buzzi R, et al.** 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.* Oct 2004;86-A(10):2143-2155.
4. **Barrett GR, Noojin FK, Hartzog CW, et al.** Reconstruction of the anterior cruciate ligament in females: A comparison of hamstring versus patellar tendon autograft. *Arthroscopy.* Jan 2002;18(1):46-54.
5. **Beynnon BD, Johnson RJ, Fleming BC, et al.** Anterior cruciate ligament replacement: comparison of bone-patellar tendon-bone grafts with two-strand hamstring grafts. A prospective, randomized study. *J Bone Joint Surg Am.* Sep 2002;84-A(9):1503-1513.
6. **Corry IS, Webb JM, Clingeleffer AJ, et al.** Arthroscopic reconstruction of the anterior cruciate ligament. A comparison of patellar tendon autograft and four-strand ham string tendon autograft. *Am J Sports Med.* Jul-Aug 1999;27(4):444-454.
7. **Ejerhed L, Kartus J, Sernert N, et al.** Patellar tendon or semitendinosus tendon autografts for anterior cruciate ligament reconstruction? A prospective randomized study with a two-year follow-up. *Am J Sports Med.* Jan-Feb 2003;31(1):19-25.
8. **Engebretsen L, Benum P, Fasting O, et al.** A prospective, randomized study of three surgical techniques for treatment of acute ruptures of the anterior cruciate ligament. *Am J Sports Med.* Nov-Dec 1990;18(6):585-590.
9. **Eriksson K, Anderberg P, Hamberg P, et al.** A comparison of quadruple semitendinosus and patellar tendon grafts in reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br.* Apr 2001;83(3):348-354.
10. **Feagin JA, Jr., Wills RP, Lambert KL, et al.** Anterior cruciate ligament reconstruction. Bone-patella tendon-bone versus semitendinosus anatomic reconstruction. *Clin Orthop Relat Res.* Aug 1997(341):69-72.
11. **Feller JA, Webster KE.** A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. *Am J Sports Med.* Jul-Aug 2003;31(4):564-573.
12. **Frank CB, Jackson DW.** The science of reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Am.* Oct 1997;79(10):1556-1576.
13. **Freedman KB, D'Amato MJ, Nedeff DD, et al.** Arthroscopic anterior cruciate ligament reconstruction: a metaanalysis comparing patellar tendon and hamstring tendon autografts. *Am J Sports Med.* Jan-Feb 2003;31(1):2-11.
14. **Gobbi A, Mahajan S, Zanazzo M, et al.** Patellar tendon versus quadrupled bone-semitendinosus anterior cruciate ligament reconstruction: a prospective clinical investigation in athletes. *Arthroscopy.* Jul-Aug 2003;19(6):592-601.
15. **Grontvedt T, Engebretsen L, Bredland T.** Arthroscopic reconstruction of the anterior cruciate ligament using bone-patellar tendon-bone grafts with and without augmentation. A prospective randomised study. *J Bone Joint Surg Br.* Sep 1996;78(5):817-822.
16. **Hamada M, Shino K, Horibe S, et al.** Single- versus bi-socket anterior cruciate ligament reconstruction using autogenous multiple-stranded hamstring tendons with endoButton femoral fixation: A prospective study. *Arthroscopy.* Oct 2001;17(8):801-807.
17. **Holmes PF, James SL, Larson RL, et al.** Retrospective direct comparison of three intraarticular anterior cruciate ligament reconstructions. *Am J Sports Med.* Nov-Dec 1991;19(6):596-599; discussion 599-600.
18. **Jansson KA, Linko E, Sandelin J, et al.** A prospective randomized study of patellar versus hamstring tendon autografts for anterior cruciate ligament reconstruction. *Am J Sports Med.* Jan-Feb 2003;31(1):12-18.
19. **Kleipool AE, van Loon T, Marti RK.** Pain after use of the central third of the patellar tendon for cruciate ligament reconstruction. 33 patients followed 2-3 years. *Acta Orthop Scand.* Feb 1994;65(1):62-66.
20. **Marder RA, Raskind JR, Carroll M.** Prospective evaluation of arthroscopically assisted anterior cruciate ligament reconstruction. Patellar tendon versus semitendinosus and gracilis tendons. *Am J Sports Med.* Sep-Oct 1991;19(5):478-484.
21. **Mott HW.** Semitendinosus anatomic reconstruction for cruciate ligament insufficiency. *Clin Orthop Relat Res.* Jan-Feb 1983(172):90-92.
22. **Muneta T, Koga H, Morito T, et al.** A retrospective study of the midterm outcome of two-bundle anterior cruciate ligament reconstruction using quadrupled semitendinosus tendon in comparison with one-bundle reconstruction. *Arthroscopy.* Mar 2006;22(3):252-258.
23. **Muneta T, Sekiya I, Yagishita K, et al.** Two-bundle reconstruction of the anterior cruciate ligament using semitendinosus tendon with endobuttons: operative technique and preliminary results. *Arthroscopy.* Sep 1999;15(6):618-624.
24. **O'Neill DB.** Arthroscopically assisted reconstruction of the anterior cruciate ligament. A prospective randomized analysis of three techniques. *J Bone Joint Surg Am.* Jun 1996;78(6):803-813.
25. **Petersen W, Tretow H, Weimann A, et al.** Biomechanical Evaluation of Two Techniques for Double-Bundle Anterior Cruciate Ligament Reconstruction: One Tibial Tunnel Versus Two Tibial Tunnels. *Am J Sports Med.* Nov 12 2006.
26. **Pinczewski LA, Deehan DJ, Salmon LJ, et al.** A five-year comparison of patellar tendon versus four-strand hamstring tendon autograft for arthroscopic reconstruction of the anterior cruciate ligament. *Am J Sports Med.* Jul-Aug 2002;30(4):523-536.
27. **Roe J, Pinczewski LA, Russell VJ, et al.** A 7-year follow-up of patellar tendon and hamstring tendon grafts for arthroscopic anterior cruciate ligament reconstruction: differences and similarities. *Am J Sports Med.* Sep 2005;33(9):1337-1345.
28. **Sachs RA, Daniel DM, Stone ML, et al.** Patellofemoral problems after anterior cruciate ligament reconstruction. *Am J Sports Med.* Nov-Dec 1989;17(6):760-765.
29. **Sajovic M, Vengust V, Komadina R, et al.** 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.* Dec 2006;34(12):1933-1940.
30. **Shaieb MD, Kan DM, Chang SK, et al.** A prospective randomized comparison of patellar tendon versus semitendinosus and gracilis tendon autografts for anterior cruciate ligament reconstruction. *Am J Sports Med.* Mar-Apr 2002;30(2):214-220.
31. **Shino K, Nakagawa S, Inoue M, et al.** Deterioration of patellofemoral articular surfaces after anterior cruciate ligament reconstruction. *Am J Sports Med.* Mar-Apr 1993;21(2):206-211.
32. **Spindler KP, Kuhn JE, Freedman KB, et al.** Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring: does it really matter? A systematic review. *Am J Sports Med.* Dec 2004;32(8):1986-1995.
33. **Steiner ME, Hecker AT, Brown CH, Jr., et al.** Anterior cruciate ligament graft fixation. Comparison of hamstring and patellar tendon grafts. *Am J Sports Med.* Mar-Apr 1994;22(2):240-246; discussion 246-247.
34. **Webb JM, Corry IS, Clingeleffer AJ, et al.** Endoscopic reconstruction for isolated anterior cruciate ligament rupture. *J Bone Joint Surg Br.* Mar 1998;80(2):288-294.
35. **Yagi M, Wong EK, Kanamori A, et al.** Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. *Am J Sports Med.* Sep-Oct 2002;30(5):660-666.
36. **Yasuda K, Kondo E, Ichiyama H, et al.** Anatomic reconstruction of the anteromedial and posterolateral bundles of the anterior cruciate ligament using hamstring tendon grafts. *Arthroscopy.* Dec 2004;20(10):1015-1025.
37. **Yasuda K, Kondo E, Ichiyama H, et al.** Clinical evaluation of anatomic double-bundle anterior cruciate ligament reconstruction procedure using hamstring tendon grafts: comparisons among 3 different procedures. *Arthroscopy.* Mar 2006;22(3):240-251.