Five-Strand Hamstring Autograft for Anterior Cruciate Ligament Reconstruction

Kyle P. Lavery, M.D., Jeffrey F. Rasmussen, M.D., and Aman Dhawan, M.D.

Abstract: Four-strand hamstring autograft is a common choice for anterior cruciate ligament reconstruction. A potential disadvantage of hamstring autograft for anterior cruciate ligament reconstruction is the inherent variability in graft diameter. Multiple studies have shown increased revision rates when using an undersized hamstring graft. Using an EndoButton (Smith & Nephew, Andover, MA) for femoral tunnel fixation, we convert a standard quadrupled hamstring graft into a 5-strand graft by creating 3 equal strands of the typically larger semitendinosus combined with a double-stranded gracilis. This technique may help alleviate some surgeon reluctance to use a hamstring graft by providing an intraoperative "bailout" option for an unexpectedly small tendon. On the basis of current data, increasing the diameter of the graft in these situations may decrease revision rates.

Four-strand hamstring autograft is a common choice for anterior cruciate ligament (ACL) reconstruction. Advocates for its use cite a decreased potential for catastrophic extensor mechanism complications and a decreased incidence of anterior knee pain associated with central-third bone—patellar tendon—bone (BPTB) autograft. In addition, biomechanical testing of 4-strand gracilis and semitendinosus autograft has shown a higher load to failure than that with BPTB autograft.[1,2] Most importantly, clinical outcomes have been equivalent using 4-strand hamstring autograft and using BPTB autograft.[3]

A potential disadvantage of hamstring autograft for ACL reconstruction is the inherent variability in graft diameter (Table 1). Biomechanical testing has shown a correlation between graft cross-sectional area and maximum load to failure. Historically, authors have recommended the use of grafts at least 7 mm in diameter, although limited evidence supports this recommendation.[1,4,5]

Magnussen et al.[6] recently evaluated hamstring autograft diameter as a predictor for graft failure and the need for revision. In a study of 256 patients with hamstring autograft ACL reconstruction, 7.0% required revision at a mean of 14 months' follow-up. Decreased graft diameter and age were shown to be associated with increased revision rates. Grafts greater than 8 mm in diameter had a revision rate of 1.7%, 7.5- to 8-mm grafts had a revision rate of 6.5%, and grafts of 7 mm or less had a revision rate of 13.6%. When grafts of 8 mm or less were used in patients aged younger than 20 years, the revision rate rose to 16.5%.

Because of concern for a potentially undersized hamstring autograft, numerous studies have sought methods to predict graft dimensions preoperatively. In a prospective evaluation, Treme et al.[7] indicated that patients with a weight less than 50 kg, height less than 140 cm, body mass index less than 18, and leg circumference less than 37 cm are at highest risk of a hamstring autograft diameter of less than 7 mm. In addition to anthropomorphic data, preoperative imaging has been

Table 1. Key Points

Hamstring autografts for ACL reconstruction have an inherent variability in graft diameter.
Biomechanical testing has shown a correlation between graft cross-sectional area and maximum load to failure.
Most authors have recommended the use of grafts at least 7 mm in diameter.
By use of an EndoButton for femoral tunnel fixation, a diminutive quadrupled hamstring graft may be converted into a 5-strand graft by creating 3 equal strands of the typically larger semitendinosus combined with a double-stranded gracilis.

From the Department of Orthopaedic Surgery, Robert Wood Johnson Medical School, Rutgers University, New Brunswick, New Jersey, U.S.A.

The authors report the following potential conflict of interest or source of funding: A.D. receives support from Smith & Nephew and Arthrex.

Received September 24, 2013; accepted January 7, 2014.

Address correspondence to Aman Dhawan, M.D., University Orthopaedic Associates, 4810 Belmar Blvd, Ste 102, Wall, NJ 07753, U.S.A. E-mail: sportsandshoulderdoc@gmail.com

2212-6287/13691

http://dx.doi.org/10.1016/j.eats.2014.01.013

used to estimate tendon size. Bickel et al.[5] used axial magnetic resonance images to determine the probability of obtaining a graft considered to be of sufficient size in an adolescent population.

The potential for undersized hamstring autografts may deter some surgeons from considering their use regularly. In this report and Video 1, we present our technique for intraoperative reconciliation of a diminutive hamstring ACL autograft using a 5-strand technique.

Surgical Technique

The semitendinosus and gracilis tendons are harvested by the standard technique and cleared of any residual muscular tissue.[8] The tendons are initially prepared as a typical 4-strand graft, with No. 2 high-strength polyethylene, nonabsorbable, braided suture (No. 2 Ethibond; Ethicon, Somerville, NJ) independently placed in interlocking fashion at each free end. The 4-strand construct is then measured by use of a metal sizing tube. As shown in Video 1, the graft fits loosely through a 7.5-mm measuring tube. This 4-strand graft measures 7.0 mm in diameter, deemed insufficient in size, and the decision is made to proceed with a 5-strand hamstring graft preparation. The 5-strand construct is created around an EndoButton system (Smith & Nephew, Andover, MA), which will ultimately be used for femoral fixation. The length of the button is chosen based on intraoperative measurements and the manufacturer's suggested technique, allowing for at least 20 mm of graft within the femoral tunnel.

First, one end of the semitendinosus tendon is tied to the EndoButton loop using the free tails from its running, locking stitch (Fig 1). These suture tails are left intact because they will be used later to suture 2 of the semitendinosus strands together. The opposite, free end of the semitendinosus is then brought through the EndoButton loop to create 3 equal-length tendon strands (Fig 2). The preserved suture limbs previously used to secure the end of the semitendinosus to the EndoButton loop are used to secure the 2 graft strands connected by a tendon loop distally away from the EndoButton (Fig 3). This is performed in running, locking fashion with each strand of suture; the sutures are then tied together and cut. This effectively tethers 2 of the semitendinosus graft strands to each other, as well as to the EndoButton proper, and brings additional high-strength polyethylene suture attaching the semitendinosus through the EndoButton loop. Three strands of semitendinosus, equal in length and well secured to the EndoButton device, have now been created.

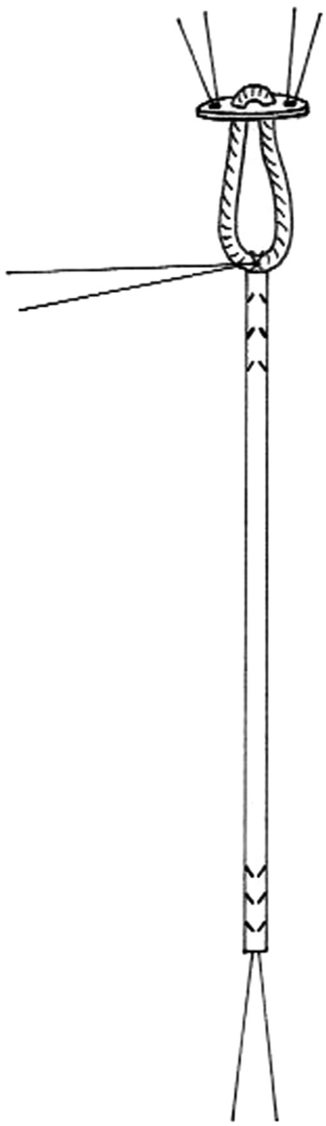

Fig 1. One end of the semitendinosus tendon is tied to the EndoButton loop using the free tails from its running, locking stitch. These suture tails are left intact because they will be used later to suture 2 of the semitendinosus strands together.

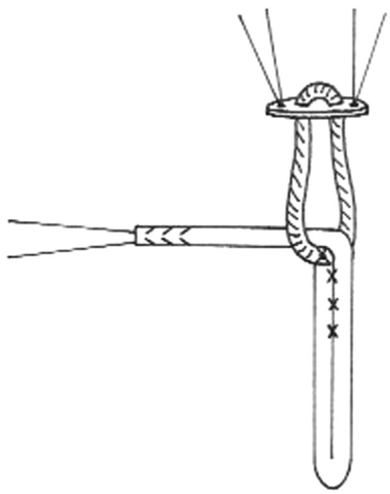

Fig 2. The free end of the semitendinosus is brought through the EndoButton loop to create 3 equal-length tendon strands.

Next, the gracilis tendon is brought through the EndoButton loop, bisecting this in standard fashion, and the 5-strand graft is completed (Fig 4). The graft is re-measured to ensure that it is of a desired diameter. Video 1 shows the hamstring graft fitting snugly through a 9-mm tube, a 2.0-mm increase in diameter. The graft is then marked appropriately based on tunnel lengths and passed in standard fashion through the tibial and femoral tunnels. Femoral fixation is confirmed by the manufacturer's recommended technique. Distally, we use a screw and sheath fixation construct, although our preferred method of fixation may be substituted with another method.

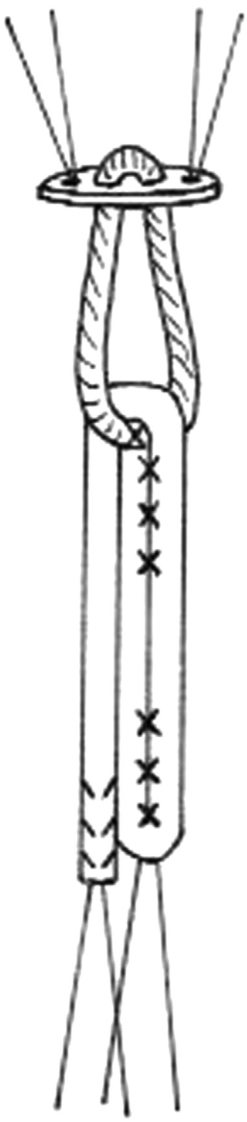

Fig 3. The preserved suture limbs previously used to secure the end of the semitendinosus to the EndoButton loop are used to secure the 2 graft strands connected by a tendon loop distally away from the EndoButton. Three strands of semitendinosus, equal in length and well secured to the EndoButton device, have now been created.

Discussion

Although debate persists over the optimal graft choice for ACL reconstruction, the use of hamstring autograft has seen an increase in popularity over recent years. Historically, central-third BPTB autograft was favored with its proven track record and bone—to—bone tunnel healing. However, BPTB harvest is known to be associated with significant morbidities, including chronic anterior knee pain, quadriceps weakness, patellar fracture, and patellar ligament disruption.

Advocates of hamstring autograft believe it provides a less invasive approach without disturbance of the extensor mechanism, limiting the potential for catastrophic complications. In addition, Hamner et al.[1] showed that combined 4-strand hamstring grafts were stronger and stiffer with greater load to failure than historical results with BPTB autograft. In a similar study by Wilson et al.,[2] superior load-to-failure results were confirmed with 4-strand hamstring autograft (2,422 N) compared with matched BPTB autograft (1,784 N).

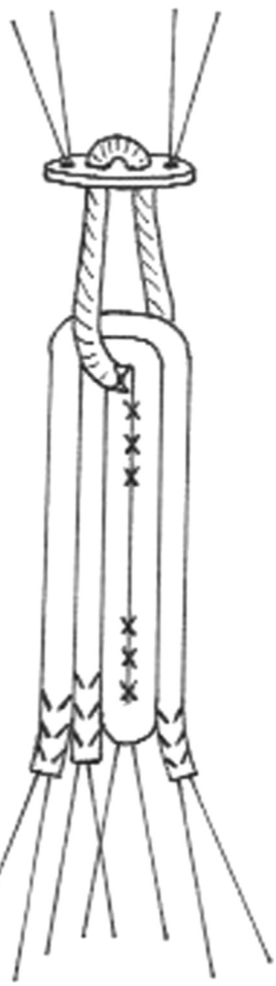

Fig 4. The gracilis tendon is brought through the EndoButton loop, bisecting this in standard fashion, and the 5-strand graft is completed.

Cadaveric analysis has shown a linear correlation between maximum load to failure and graft cross-sectional area.[1] These laboratory data have been confirmed clinically, with Magnussen et al.[6] reporting increased revision rates for smaller-diameter grafts. By use of simple anthropomorphic measurements and standard imaging, efforts have been made to predict semitendinosus and gracilis graft diameter to identify patients at risk of undersized grafts. Despite advances in preoperative evaluation to predict graft size, diminutive hamstring autografts may still be seen.

In Video 1 we present our technique for intraoperative reconciliation of a diminutive hamstring autograft using a 5-strand technique. Using an EndoButton for femoral tunnel fixation, we convert a standard quadrupled hamstring graft into a 5-strand graft by creating 3 equal strands of the typically larger semitendinosus combined with a double-stranded gracilis. This technique may help alleviate some surgeon reluctance to use a hamstring graft by providing an intraoperative "bailout" option for an unexpectedly small tendon. On the basis of current data, increasing the diameter of the graft in these situations may decrease revision rates.[6]

References

1. 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.
2. Wilson TW, Zafuta MP, Zobitz M. A biomechanical analysis of matched bone-patellar tendon-bone and double-looped semitendinosus and gracilis tendon grafts. *Am J Sports Med* 1999;27:202-207.
3. Sajovic M, Strahovnik A, Dernovsek MZ, Skaza K. Quality of life and clinical outcome comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: An 11-year follow-up of a randomized controlled trial. *Am J Sports Med* 2011;39:2161-2169.
4. Maeda A, Shino K, Horibe S, Nakata K, Buccafusca G. Anterior cruciate ligament reconstruction with multi-stranded autogenous semitendinosus tendon. *Am J Sports Med* 1996;24:504-509.
5. Bickel BA, Fowler TT, Mowbray JG, Adler B, Klingele K, Phillips G. Preoperative magnetic resonance imaging cross-sectional area for the measurement of hamstring autograft diameter for reconstruction of the adolescent anterior cruciate ligament. *Arthroscopy* 2008;24:1336-1341.
6. Magnussen RA, Lawrence JT, West RL, Toth AP, Taylor DC, Garrett WE. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy* 2012;28:526-531.
7. Treme G, Diduch DR, Billante MJ, Miller MD, Hart JM. Hamstring graft size prediction: A prospective clinical evaluation. *Am J Sports Med* 2008;36:2204-2209.
8. Williams RJ III, Hyman J, Petrigliano F, Rozental T, Wickiewicz TL. Anterior cruciate ligament reconstruction with a four-strand hamstring tendon autograft. Surgical technique. *J Bone Joint Surg Am* 2005;87(suppl 1, pt 1): 51-66.