Technical Note

Endoscopic Harvest of Autogenous Gracilis and Semitendinosus Tendons

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Abstract: The hamstring autograft is one of the most popular grafts for anterior cruciate ligament (ACL) reconstruction. Although many techniques for arthroscopic ACL reconstruction using hamstring autografts have been invented, hamstring harvest techniques have not been focused. Hamstrings are harvested using an open technique that requires a 2- to 5-cm skin incision. In this Technical Note, we describe an endoscopic harvest technique of autogenous gracilis and semitendinosus tendon. This technique needs only a 1- to 1.5-cm skin incision and provides surgeons a sufficient view to safely harvest the hamstrings.

The hamstring autograft is one of the most popular grafts for anterior cruciate ligament (ACL) reconstruction because it is easily shaped according to surgeon preference. There are many kinds of ACL reconstruction procedures using hamstring autografts, including single bundle reconstruction, bi-socket reconstruction, double-bundle reconstruction, and allograft augmentation of hamstring autografts. Moreover, combined ACL and anterolateral ligament reconstruction techniques using hamstring autografts were recently developed.

Despite the invention of such techniques, the development of a hamstring harvest technique has not occurred and not much has changed over several decades. Hamstring harvests are performed using an open technique that requires a 2- to 5-cm skin incision. Here we evaluated an endoscopic technique for harvesting hamstring autografts. The present endoscopy technique not only results in a small skin incision length for hamstring harvest, it also provides surgeons a good view to safely dissect the fascial bands and accessory bands of the tendons and harvest the hamstrings. A summary of key steps is provided in Table 1, whereas a summary of the technique is provided in Video 1.

Technique

Patient Positioning

The present surgical technique is performed under general anesthesia with the patient in the supine position. A padded tourniquet is placed on the proximal thigh of the operative leg, which is positioned with a leg holder to keep the thigh horizontal; in the meantime, the contralateral leg is held by a well-leg holder with the hip flexed and abducted to provide a wide working space around the operative knee. The bed is lowered to allow the surgeon to harvest the graft while in a seated position. Alternatively, the leg can be kept on the operating table and placed into a figure four position.

The operative knee is prepared and draped in a standard fashion. The necessary tools include a small retractor, forceps, curved pean, curved Kelly forceps, Metzenbaum scissors, mosquito curved pean, and a closed tendon stripper (Smith & Nephew Endoscopy, Andover, MA) (Fig 1). No special device is necessary.

Endoscopic Graft Harvest

Patella, patellar tendon, and tibial tubercle are marked to ensure accurate incision positioning. The pes anserinus is palpated and drawn along the proximal
Table 1. Key Steps for Endoscopic Harvest of Autogenous Gracilis and Semitendinosus Tendon

| Step | Description |
|------|-------------|
| Identify anatomic landmarks. | 
| Tibial tubercle | |
| Medial joint line | |
| Gracilis tendon | |
| Longitudinal skin incision: approximately 1 to 1.5 cm | 3 cm medial to the tibial tubercle |
| Bluntly dissect the subcutaneous tissue. | |
| Transversely cut the sartorial fascia approximately 1 to 2 cm. | |
| Lift the sartorial fascia using a small retractor. | |
| Introduce a 30° 4-mm diameter arthroscope. | |
| Identify and hook the gracilis and semitendinosus tendons using curved forceps. | |
| Pull the tendons laterally to detach them from the tibial attachment. | |
| Separate the gracilis and semitendinosus tendons. | |
| Whipstitch the gracilis and semitendinosus tendons. | |
| Pull the semitendinosus tendon and disconnect the accessory tendinous band. | |
| Insert arthroscope and dissect the dense fascia, adherent soft tissue, and accessory bands. | |
| Harvest the semitendinosus tendon using the tendon stripper. | |
| Harvest the gracilis tendon using the tendon stripper. | |
| When the tendon stripper stops, reintroduce the arthroscope and reassess other fascial and accessory bands. | |
| Prepare the graft. | |

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edge of the gracilis tendon and the distal edge of the semitendinosus tendon. The skin is incised with a No. 15 scalpel. An approximately 1-cm-long longitudinal incision is made on the proximal edge of the gracilis tendon approximately 3 cm medial to the tibial tubercle (Fig 2). The subcutaneous tissue is bluntly dissected to the level of the sartorial fascia with the gauze grasped by the curved mosquito forceps.

The bump of sartorial fascia due to the underlying gracilis and semitendinosus tendons can be palpated using forceps. The gracilis tendon is located proximal relative to the semitendinosus tendon. An approximately 1- to 2-cm-long transverse cut of the sartorial fascia is gradually made using Metzenbaum scissors in line with the proximal border of the gracilis tendon. The sartorial fascia is lifted together with the underlying hamstring using a small retractor introduced through the sartorial fascia incision.

A 30° 4-mm diameter arthroscope is then introduced into the space between the superficial medial collateral ligament and the hamstring tendons through the same sartorial incision. No joint irrigation liquid is used during the tendon harvest. The subcutaneous fat tissue around the skin incision is spread and cut using scissors to obtain a clear arthroscopy view. Hamstring tendons can be observed at the back side of the sartorial fascia (Fig 3). Using a curved pean or curved Kelly forceps, the gracilis and semitendinosus tendons are dissected free from the sartorial fascia and then hooked and pulled back together outside the skin incision. The tendons are laterally pulled to detach them from the tibial attachment. Because the skin incision is approximately 3 cm medial to the tibial tubercle, the ends of the detached tendons come out of the skin. If the tendons are retracted to inside the skin, the distal ends of the tendons are found arthroscopically and pulled back outside the skin using forceps.

The gracilis and semitendinosus tendons are carefully separated by cutting the intertendinous bands with the scissors. Each end of the tendon is whipstitched with a No. 2 nonabsorbable suture (Ethicon, Somerville, NJ). The semitendinosus tendon is pulled by the suture, after which point the first accessory tendinous band or fascial band of the semitendinosus tendon can be usually seen outside the skin and cut using scissors (Fig 4). Then, by looking with the arthroscope through the same skin incision, the dense fascia ensheathing the tendon that

Fig 1. Tools. A, small retractor; B, forceps; C, curved pean; D, curved Kelly forceps; E, Metzenbaum scissors; F, curved mosquito forceps, G, closed tendon stripper.
adheres to the soft tissue and other accessory bands that may impede tendon stripping is gently dissected using Metzenbaum scissors (Fig 5). After confirmation that both tendons can move smoothly, the tendons are harvested using a closed tendon stripper. Stable traction on the end of the tendon and stable pushing of the tendon stripper are important to smooth tendon release. Although our group usually harvests the semitendinosus tendon first, the gracilis tendon can be harvested first as well. When the tendon stripper stops, other dense fascia, fascial bands, and accessory bands should be reassessed and dissected arthroscopically (Fig 6). Surgeons can then reattempt to harvest the tendon (Fig 7).

The harvested hamstring graft can be prepared for the ACL reconstruction based on the surgeon’s preference. We create the tibial tunnel from the same skin incision and perform single-bundle ACL reconstruction with a 4-stranded tendon graft. We then preserve the remnant whenever possible and affix the graft using absorbable interference screws (30-mm-long BIOSURE HA screw; Smith & Nephew Endoscopy) at the femoral and tibial tunnels.

**Wound Closure**

The wound is closed using conventional skin sutures. The final wound for the hamstring harvest is approximately 1 to 1.5 cm long (Fig 8).
In this Technical Note, we described endoscopic autogenous hamstring harvest for ACL reconstruction using the gracilis and semitendinosus tendons. Because the hamstring autograft has a reduced incidence of patellofemoral crepitance, kneeling pain, and extension loss,\textsuperscript{10,11} it is among the most common grafts for ACL reconstruction. The hamstrings can also be used in other ligament reconstruction procedures, including the elbow\textsuperscript{12} and the ankle\textsuperscript{13-15} ligaments.

Recent evidence indicates that larger hamstring graft diameters are associated with increased tensile strength\textsuperscript{16,17} and secure harvest of the hamstrings is a critical issue. A clear understanding of the anatomy of the hamstring tendons and saphenous nerve course is obviously necessary.

The gracilis and semitendinosus tendons contact each other via the intertendinous bands at an average of 3.18 to 3.6 cm from the tibial crest\textsuperscript{18,19} and become distinct at a more medial point.\textsuperscript{20} Introducing the arthroscope 3 cm medial to the tibial crest is a reasonable approach to easily identifying the 2 tendons. Too medial an incision will make it difficult to create the appropriate tibial tunnel for the transtibial femoral tunnel creation of the ACL reconstruction and make it dangerous to

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**Discussion**

![Fig 5. The dense fascia ensheathing the tendon that adheres to the soft tissue and other accessory bands that may impede tendon stripping are arthroscopically dissected using Metzenbaum scissors. This figure shows anteromedial side of the right knee in the flexed position. Proximal of the knee is on the right upper side.](image1)

![Fig 6. After confirmation that both tendons can move smoothly, the tendons are harvested using a closed tendon stripper (Smith & Nephew Endoscopy). When the tendon stripper stops, other dense fascia, fascial bands, and accessory bands should be reassessed and dissected arthroscopically. This figure shows anteromedial side of the right knee in the flexed position. Proximal of the knee is on the right upper side.](image2)

![Fig 7. The gracilis tendon is harvested using the closed tendon stripper. This figure shows anteromedial side of the right knee in the flexed position.](image3)

![Fig 8. The right knee is extended on the table. The wound is closed using conventional skin sutures. The final wound for the hamstring harvest measures approximately 1 to 1.5 cm. Proximal of the knee is on the right side of the picture.](image4)

and a reduced risk of graft failure.\textsuperscript{16,17} The gracilis and semitendinosus tendons contact each other via the intertendinous bands at an average of 3.18 to 3.6 cm from the tibial crest\textsuperscript{18,19} and become distinct at a more medial point.\textsuperscript{20} Introducing the arthroscope 3 cm medial to the tibial crest is a reasonable approach to easily identifying the 2 tendons. Too medial an incision will make it difficult to create the appropriate tibial tunnel for the transtibial femoral tunnel creation of the ACL reconstruction and make it dangerous to
When the tendon stripper stops, the surgeon should use it to
The arthroscope can be inserted deeply to allow the surgeon to
A clear understanding of the anatomy of the hamstring tendons
No joint irrigation liquid is used during the tendon harvest.
The use of a small skin incision and blunt dissection of the
A longitudinal skin incision is made approximately 3 cm to the
tibial tubercle to avoid the intertendinous bands and enable
the easy identification of the gracilis and semitendinosus
tendons.
The use of a small skin incision and blunt dissection of the
subcutaneous soft tissue prevent damage to small nerves.
No joint irrigation liquid is used during the tendon harvest.
A clear understanding of the anatomy of the hamstring tendons
and course of the saphenous nerve is necessary to ensuring a
safe hamstring harvest.
The arthroscope might reduce its incidence. The IPBSN
damage to the sartorial terminal branch is thought to be
related to the passage of the stripper during the gracilis
tendon harvest. Assessment of the proximal part with
the arthroscope might reduce its incidence. The IPBSN
has been more frequently injured, ranging from 12% to
88%.21,25,26 This evidence indicates that it is very
difficult to completely avoid IPBSN injury. Therefore,
the smaller skin incision is a good alternative to reduce
the incidence and area of IPBSN injuries.
Tuncay et al.27 reported a high incidence of the fascial
band between the semitendinosus and gastrocnemius.
The mean distance from the insertion of the semite-
dinosus to the fascial band was 7 cm. Candal-Couto
and Deehan19 found that accessory bands have high
variability and were seen between tendons, connecting to
the popliteal fascia, sartorius, gastrocnemius, and
pretibial and superficial fascia. Moreover, accessory
bands usually originated more than 10 cm proximal to
the insertion site of the semitendinosus and gracilis
tendon. Because the arthroscope is thinner and longer
than fingers, it is easy to insert it more proximally and
identify those accessory bands.
This report has several limitations. First, the present skin
incision is so small that it is not suitable for double-bundle
ACL reconstruction.4 Second, this procedure is techni-
cally demanding. However, surgeons can expand the
incision and convert to conventional open procedure
anytime when difficulty is encountered. Third, although
this technique theoretically has possible advantages that
reduce nerve injury, premature hamstring amputation,
postoperative scar tissue, anterior knee pain, and the
incidence of skin infections, no evidence has so far been
reported from a comparative study; thus, future studies
are necessary to prove our hypothesis. A summary of
pearls and pitfalls is provided in Table 2.
This endoscopic harvest technique of the autogenous
graft from the gracilis and semitendinosus tendons provides surgeons a
smaller incision, higher safety, and greater reproducibility.

Table 2. Pearls and Pitfalls

| Pearls | Pitfalls |
|--------|----------|
| A longitudinal skin incision is made approximately 3 cm to the tibial tubercle to avoid the intertendinous bands and enable the easy identification of the gracilis and semitendinosus tendons. | The skin incision is so small that it may be very difficult to create 2 tibial tunnels for double-bundle anterior cruciate ligament reconstruction. |
| The use of a small skin incision and blunt dissection of the subcutaneous soft tissue prevent damage to small nerves. | This technique is relatively difficult and has a steep learning curve. However, surgeons can expand the skin incision and convert to a conventional open harvest procedure when necessary. |

References
1. 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.
2. Sonnery-Cottet B, Freychet B, Murphy CG, Pupim BH, Thaunat M. Anterior cruciate ligament reconstruction and preservation: The single-anteromedial bundle biological augmentation (SAMBBA) technique. *Arthrosc Tech* 2014;3:e689-e693.
3. 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* 2001;17:801-807.
4. 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* 2004;20:1015-1025.
5. Jacobs CA, Burnham JM, Makhni E, Malempati CS, Swart E, Johnson DL. Allograft augmentation of hamstring autograft for younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2017;45:892-899.
6. Sonnery-Cottet B, Thaunat M, Freychet B, Pupim BH, Murphy CG, Claes S. Outcome of a combined anterior cruciate ligament and anterolateral ligament reconstruction technique with a minimum 2-year follow-up. Am J Sports Med 2015;43:1598-1605.

7. Helito CP, Bonadio MB, Gobbi RG, et al. Combined intra- and extra-articular reconstruction of the anterior cruciate ligament: The reconstruction of the knee anterolateral ligament. Arthrosc Tech 2015;4:e239-e244.

8. Thaunat M, Clowez G, Saithna A, et al. Reoperation rates after combined anterior cruciate ligament and anterolateral ligament reconstruction: A series of 548 patients from the SANTI study group with a minimum follow-up of 2 years. Am J Sports Med 2017;45:2569-2577.

9. Frank RM, Hamamoto JT, Bernardoni E, et al. ACL reconstruction basics: Quadruple (4-strand) hamstring autograft harvest. Arthrosc Tech 2017;6:e1309-e1313.

10. Chee MY, Chen Y, Pearce CJ, et al. Outcome of patellar tendon versus 4-strand hamstring tendon autografts for anterior cruciate ligament reconstruction: A systematic review and meta-analysis of prospective randomized trials. Arthroscopy 2017;33:450-463.

11. Maletis GB, Cameron SL, Tengan JJ, Burchette RJ. A prospective randomized study of anterior cruciate ligament reconstruction: A comparison of patellar tendon and quadruple-strand semitendinosus/gracilis tendons fixed with bioabsorbable interference screws. Am J Sports Med 2007;35:384-394.

12. Hagemeijer NC, Claessen F, de Haan R, Riedijk R, Eygendaal DE, van den Bekerom MP. Graft site morbidity in elbow ligament reconstruction procedures: A systematic review. Am J Sports Med 2017;45:3382-3387.

13. Paterson R, Cohen B, Taylor D, Bourne A, Black J. Reconstruction of the lateral ligaments of the ankle using semi-tendinosis graft. Foot Ankle Int 2000;21:413-419.

14. Coughlin MJ, Matt V, Schenk RC Jr. Augmented lateral ankle reconstruction using a free gracilis graft. Orthopedics 2002;25:31-35.

15. Guillot S, Archbold P, Perera A, Bauer T, Sonnery-Cottet B. Arthroscopic anatomic reconstruction of the lateral ligaments of the ankle with gracilis autograft. Arthrosc Tech 2014;3:e593-598.

16. Conte EJ, Hyatt AE, Gatt CJ Jr, Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. Arthroscopy 2014;30:882-890.

17. Spragg L, Chen J, Mirzayan R, Love R, Maletis G. The effect of autologous hamstring graft diameter on the likelihood for revision of anterior cruciate ligament reconstruction. Am J Sports Med 2016;44:1475-1481.

18. Ivey M, Prud’homme J. Anatomic variations of the pes anserinus: A cadaver study. Orthopedics 1993;16:601-606.

19. Candal-Coutu JJ, Deehan DJ. The accessory bands of gracilis and semitendinosus: An anatomical study. Knee 2003;10:325-328.

20. Pagnani MJ, Warner JJ, O’Brien SJ, Warren RF. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:565-571.

21. Ruffilli A, De Fine M, Traina F, Pilla F, Fenga D, Faldini C. Saphenous nerve injury during hamstring tendons harvest: Does the incision matter? A systematic review. Knee Surg Sports Traumatol Arthrosc 2017;25:3140-3145.

22. Arthornthurasook A, Gaew-Im K. The sartorial nerve: Its relationship to the medial aspect of the knee. Am J Sports Med 1990;18:41-42.

23. Hunter LY, Louis DS, Ricciardi JR, O’Connor GA. The saphenous nerve: Its course and importance in medial arthrotomy. Am J Sports Med 1979;7:227-230.

24. Sanders B, Rolf R, McClelland W, Xerogeanes J. Prevalence of saphenous nerve injury after autogenous hamstring harvest: An anatomic and clinical study of sartorial branch injury. Arthroscopy 2007;23:956-963.

25. Jameson S, Emmerson K. Altered sensation over the lower leg following hamstring graft anterior cruciate ligament reconstruction with transverse femoral fixation. Knee 2007;14:314-320.

26. Kjaergaard J, Fauno LZ, Fauno P. Sensibility loss after ACL reconstruction with hamstring graft. Inter J Sports Med 2008;29:507-511.

27. Tuncay I, Kucuker H, Uzun I, Karalezli N. The fascial band from semitendinosus to gastrocnemius: The critical point of hamstring harvesting: An anatomical study of 23 cadavers. Acta Orthop 2007;78:361-363.