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Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest*

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ABSTRACT

Although the semitendinosus and gracilis tendons have long been used in ligamentous reconstruction procedures of the knee, their anatomic relationships have not been explicitly detailed. Therefore, cadaveric dissections were performed on fresh-frozen adult knees to examine these relationships. Several key anatomic points are useful in the harvest of these tendons. Their conjoined insertion site is medial and distal to the tibial tubercle. They become distinct structures at a point that is farther medial and slightly proximal. Tendon harvest is facilitated by identifying the tendons proximal to this point. The superficial medial collateral ligament lies deep to the tendons in this area and should not be disturbed. The tendons are ensheathed in a dense fascial layer that may impede tendon stripping. The accessory insertion of the semitendinosus tendon (which was present in 77% of the knees dissected) should be identified and transected to avoid tendon damage at harvest. Knee flexion may reduce the risk of injury to the saphenous nerve as it crosses the gracilis tendon. Variation in tendon diameter affects graft strength.

The semitendinosus and gracilis tendons are commonly used as autografts in ligamentous reconstructions of the knee.[2–4,6–8,10–14,16–20,22–24,26,27,29–31,34–37,41,43,44] Obtaining high-quality tendon grafts without complication is an important part of these procedures. Potential complications during graft harvest include inadvertent division of the tendons, damage to the medial collateral ligament, and neurologic injury.

The semitendinosus and gracilis tendons have had a significant historical role in reconstructive procedures designed to treat the injured knee. In 1914, Phillips[30] reported anterior transplantation of the gracilis tendon for augmentation of a ruptured medial collateral ligament. Bosworth[3] advocated anterior mobilization of the semitendinosus tendon and its implantation on the medial femoral condyle for the treatment of medial collateral insufficiency. Hey Groves[11–13] and Macey[22] pioneered the use of the semitendinosus tendon in intraarticular cruciate ligament reconstruction.

The technique of harvest has varied in previous reports, but most authors identified the tendons at their musculotendinous junction in the thigh and then proceeded to free the grafts in a proximal-to-distal direction.[4,8,18,20,22,24,27] In our experience, current technical advances favor the isolation of these tendons from a distal-to-proximal direction, using an anteromedial incision over the proximal tibia. In ACL reconstruction-augmentation procedures, this same incision may be used for subsequent intraarticular placement of a distally based graft through a tibial drill hole.

Previous reports included little mention of the complications related to tendon harvest. Slocum and Larson[35] noted sensory loss in the distribution of the saphenous nerve in three patients after pes anserinus transplantation. Zarins and Rowe[44] observed similar changes after reoperation in two patients who had previously undergone pes anserinus transfer. In a recent article, Sgaglione et al.[34] reported a 37% incidence of infrapatellar paresthesia in patients who had undergone primary repair of a torn ACL with semitendinosus tendon augmentation. This procedure was performed by an open technique, and this finding may be a result of the arthrotomy rather than the tendon harvest. Nevertheless, injuries to the saphenous nerve and its branches, to the medial collateral ligament, and to the tendon graft itself can

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occur. Selection of any technique for tendon harvest should include cognizance of this fact, and methods should be developed to avoid complications while obtaining high-quality tendon grafts.

We commonly use a combined semitendinosus-gracilis graft for the treatment of ACL insufficiency in the acute period,[38] generally reserving patellar tendon grafts for chronic cases. While we recognize the inherent strength of the patellar tendon graft as well as the advantages of fixation with a bone-tendon-bone construction, there are disadvantages to using the patellar tendon, including risks of patellar fracture, patellar tendinitis, and patellar pain syndrome.[33] Our published results after semitendinosus augmentation by an open technique[34] have demonstrated a high degree of success, and we have continued to use the hamstring tendons in arthroscopically assisted ACL reconstructions.

Occasionally, we have used the semitendinosus tendon to reconstruct the medial collateral ligament by a modified Bosworth technique in selected patients with combined anterior cruciate and medial collateral ligament injuries and gross valgus instability. In addition, we have come to consider these tendons for use as free grafts in distant anatomic locations.

We examined the anatomic relationships of the semitendinosus and gracilis tendons to facilitate tendon harvest, to improve the quality of tendon grafts, and to reduce the risk of complications.

MATERIALS AND METHODS

Thirty-one fresh-frozen adult cadaveric knees were dissected. All specimens were obtained by en bloc removal of the knee and approximately 15 cm of tissue on each side of the joint line. There were 17 left knees and 14 right knees. Nineteen were male knees, and 12 were female knees. None of the knees had evidence of significant degenerative or posttraumatic deterioration on examination.

RESULTS

The semitendinosus and gracilis tendons are located at the medial side of the knee between Layers I and II as described by Warren and Marshall[39] and by Warren et al.[40] The tendons insert as a conjoined structure (average width, 20 mm; range, 15 to 34) on the anteromedial surface of the tibia (Fig. 1, Distance C). The proximal point of this insertion is, on average, 19 mm (range, 10 to 25) distal and 22.5 mm (range, 13 to 30) medial to the apex of the tibial tubercle (Distances A and B, respectively). The sartorius tendon, which is part of Layer I, lies superficial to the semitendinosus and gracilis tendons in proximal areas. However, its inferior portion fuses with the semitendinosus and gracilis tendons just proximal to their insertion on the tibia. Together the three tendons of the sartorius, semitendinosus, and gracilis muscles form the pes anserinus.

As dissection proceeds proximally and posteromedially beneath Layer I, the semitendinosus and gracilis tendons

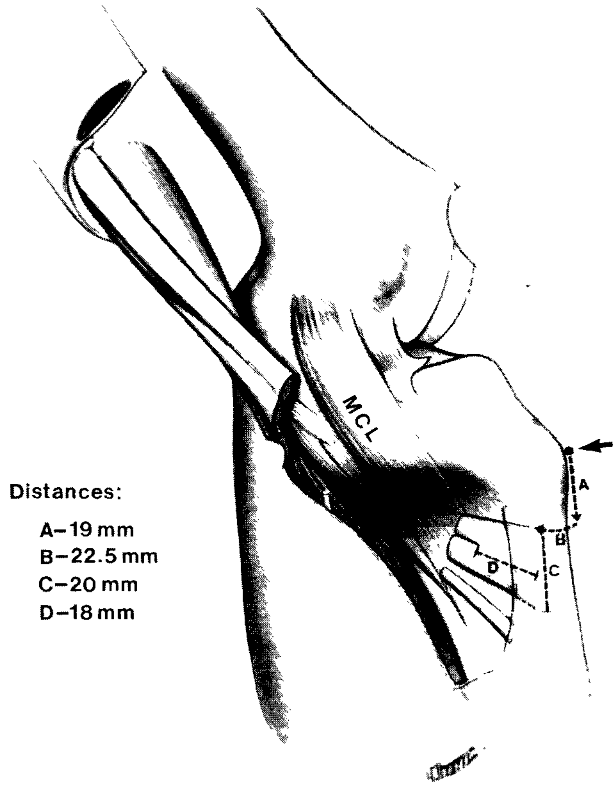

Figure 1. The distal insertion site of the semitendinosus and gracilis tendons. The overlying sartorius muscle and tendon, and segments of the distal portions of the semitendinosus and gracilis tendons have been removed. The semitendinosus and gracilis tendons insert as conjoined structure on the anteromedial tibia. The insertion site is medial and distal to the tibial tubercle. The tendons become distinct structures at a point that is farther medial and proximal. The superficial medial collateral ligament (MCL) lies deep to the tendons in this area. The arrow indicates the apex of the tibial tubercle.

become distinct structures with the semitendinosus tendon occupying the more inferior position of the two. The point at which the tendons become distinct lies, on average, 18 mm (range, 10 to 25) proximal to their combined insertion site (Distance D). The superficial medial collateral ligament (Layer II) lies deep to the tendons in this area.

The fascia of the thigh divides into superficial and deep layers to enclose the sartorius muscle and tendon. The deep portion of this fascia is adherent to the semitendinosus and gracilis tendons. Eight to ten centimeters proximal to the conjoined insertion, this fascial layer commonly forms a dense, 3- to 4-cm band around the tendons. This thickened area interconnects with the medial intermuscular septum and with the semimembranosus muscle sheath. Distally, the layer ensheathing the tendons is continuous with the posterior crural fascia.

Commonly (in 24 of 31 knees), the inferior fibers of the semitendinosus tendon diverge from the main tendon at a mean point 5.5 cm (range, 4.5 to 8) proximal to the insertion site to form an accessory insertion more distally on the tibia (Fig. 2). This accessory insertion is, on average, 3 cm distal to the inferior border of the conjoined insertion of the main bulk of the tendons. The accessory insertion crosses just superficial to the tibial attachment of the superficial medial collateral ligament and may be associated with a tendinous slip from the semimembranosus muscle.

Tendon diameter was measured at a standard point located 10 cm proximal to the insertion site. The average diameter of the semitendinosus tendon was 5.2 mm (range, 4 to 8), while that of the gracilis tendon was 4.2 mm (range, 3 to 7).

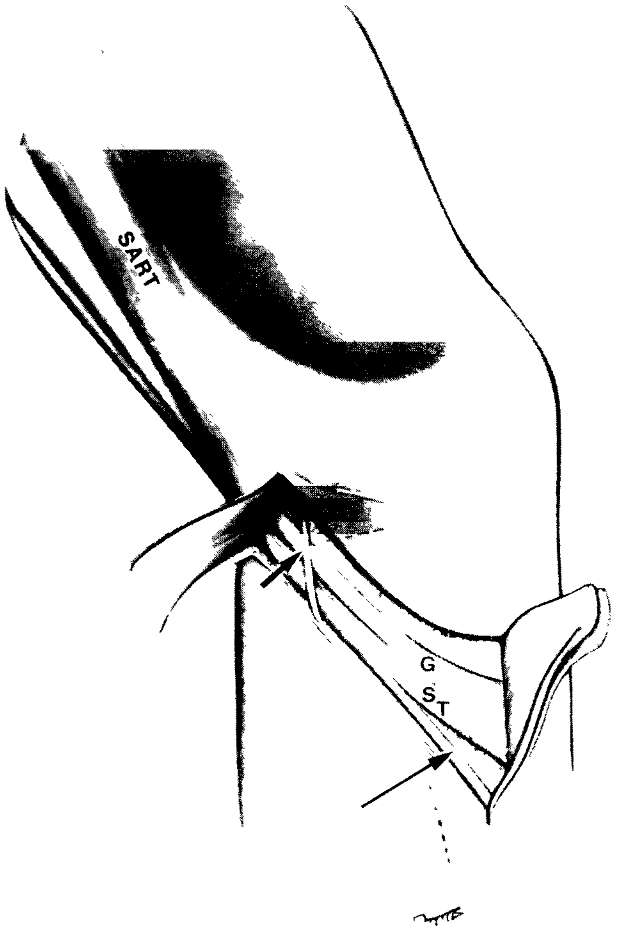

Figure 2. The saphenous nerve crosses the gracilis tendon at the posteromedial joint line (short arrow). The inferior fibers of the semitendinosus tendon often diverge to form an accessory insertion more distally on the tibia (long arrow). G, gracilis; ST, semitendinosus; SART, sartorius.

After leaving the adductor canal, the saphenous nerve follows a posteromedial course toward the medial side of the knee where it emerges between the sartorius and gracilis tendons.[1] The nerve is consistently found lying immediately superficial to the gracilis tendon at the posteromedial joint line. When the knee is extended, the nerve is held taut against the tendon. With the knee flexed, tension on the nerve diminishes. After crossing the gracilis tendon, the nerve often pierces the sartorius tendon and then proceeds distally to provide sensory innervation to the medial aspect of the leg.

Proximal to the point at which the saphenous nerve crosses the gracilis tendon, the infrapatellar branch of the nerve is given off. The infrapatellar nerve then curves beneath the patella to supply the skin over the anterior surface of the proximal tibia.

DISCUSSION

Anatomy

The anatomy of the semitendinosus and gracilis tendons is not explicitly detailed in standard anatomy texts.[5,9,15,25,42] In describing three layers on the medial side of the knee, Warren and Marshall[39] noted that the tendons were located between Layer I (which includes the sartorius tendon) and Layer II (which is composed in part by the superficial medial collateral ligament), but they added little else regarding the anatomy of the tendons.

The accessory insertion of the semitendinosus tendon has been noted in previous reports.[3,21,35,43] Bosworth[3] emphasized the position of the saphenous nerve in limiting proximal dissection.

Technique of tendon harvest

With the current use of arthroscopically assisted techniques for knee ligament reconstruction, we have consistently been able to harvest both the semitendinosus and gracilis tendons through a small (2.5 to 4 cm) anteromedial incision over the proximal tibia. The incision is centered at a point that lies approximately 4 cm medial to the tibial tubercle and that is just distal to the tubercle. This incision may be oriented longitudinally, obliquely, or transversely. (An oblique or transverse incision may reduce the risk of injury to the infrapatellar branch of the saphenous nerve.) An incision at the level of the musculotendinous junction in the medial thigh has not been needed.

The tendons are identified at a point proximal to where they blend into a conjoined structure. The interval between the tendons is palpable through the skin incision. The sartorius (Layer I) is incised along the course of the semitendinosus and gracilis tendons—either along the superior border of the gracilis tendon (Fig. 3A) or between the semitendinosus and gracilis tendons (Fig. 3B). The knee is flexed, and the hip is externally rotated into a "figure-four" position to improve exposure and to minimize tension on the saphenous nerve. A curved clamp is passed into the interval between

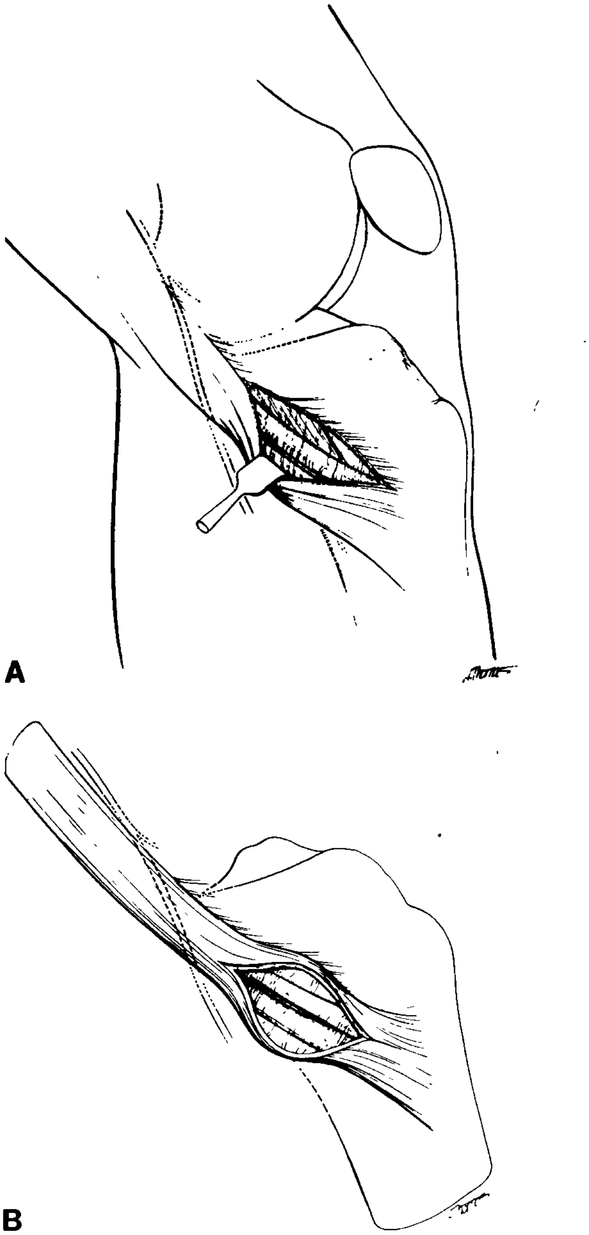

Figure 3. The sartorius is incised along the course of the semitendinosus and gracilis tendons, either (A) at the superior border of the gracilis tendon or (B) between the semitendinosus and gracilis tendons.

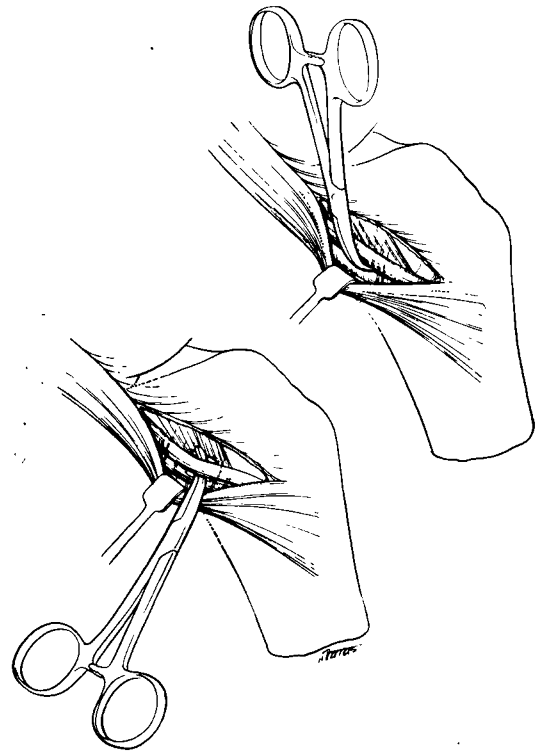

Figure 4. Passage of a curved clamp around the tendon.

the sartorius and the semitendinosus and gracilis tendons (Figs. 4 and 5). Distally, near the tibial insertion site, the semitendinosus and gracilis tendons may be adherent to the undersurface of the sartorius. Caution should be used if this is the case because the medial collateral ligament is deep to the tendons in this area and should not be disturbed. After the tendon is delivered into the wound, a small Penrose drain is passed around it.

If a question exists as to which of the two tendons has been so delivered, dissection may be continued distally to the conjoined insertion; the gracilis tendon forms the superior portion of this insertion while the semitendinosus tendon is inferior.

A traction force is applied to the tendon via the Penrose drain while fascial connections are meticulously freed in a distal-to-proximal direction using scissors (Fig. 6, top). When performing this dissection, it is helpful to remember that the saphenous nerve crosses just superficial to the gracilis tendon at the posteromedial joint line.

When freeing the semitendinosus tendon, one must search for an accessory insertion within the posterior crural fascia. If present, the accessory insertion should be transected to avoid entering the tendon substance when the tendon is freed more proximally.

At this point, with the second tendon still largely undissected and the first tendon freed for several centimeters proximally, a right-angled retractor is used to apply countertraction while a tendon stripper (Concepts, Inc., Largo, FL) is used to carefully ensnare the delivered tendon (Fig. 6, bottom). The knee remains flexed to protect the saphenous nerve, and a firm, continuous force is delivered in a proximal and medial direction to strip the remainder of the tendon while avoiding deeper neurovascular structures.

If the tendon stripper cannot be passed because of a great deal of resistance, it is prudent to remove the stripper and search for the cause of the resistance. One of the most common structures that interferes with passage of the stripper is the accessory insertion of the semitendinosus tendon. If this structure has not been transected when the main

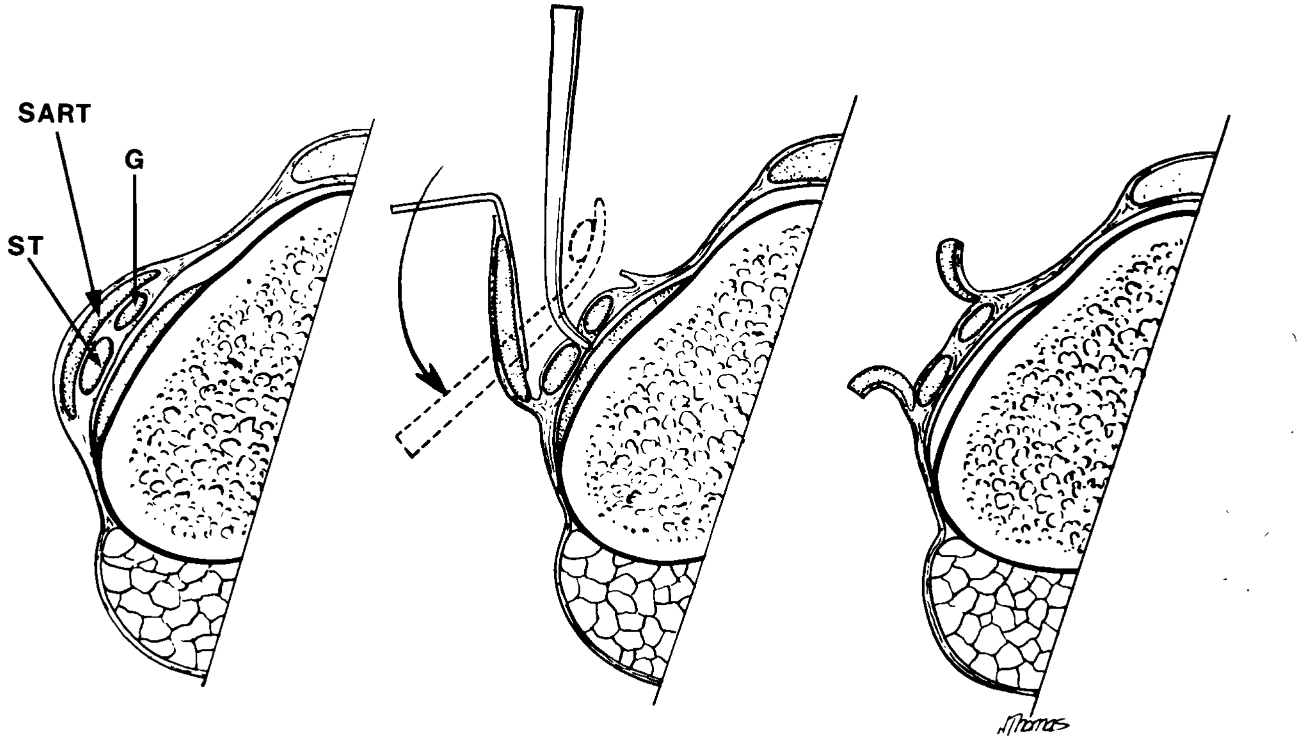

Figure 5. Left, cross-sectional illustration demonstrating the relationship between the sartorius and the semitendinosus and gracilis tendons before dissection. ST, semitendinosus; SART, sartorius; G, gracilis. Center, incision along the superior border of the gracilis tendon and passage of a clamp around the gracilis tendon. Right, alternate incision of the sartorius between the underlying semitendinosus and gracilis tendons.

portion of the tendon is freed distally, the stripper will come to rest in the axilla between the main and accessory insertions. Use of further force at this point may result in cutting into, or across, the main part of the tendon, and the resultant graft may not be of sufficient length or strength for ligamentous reconstruction.

The fascial thickenings located 8 to 10 cm proximal to the insertion site may also impede passage of the stripper. These structures often give way with the application of a firm, constant force to the tendon stripper. In some instances, however, it may be necessary to divide them by carefully sliding scissors along the course of the tendon.

The desired tendon length varies with the procedure being performed (approximately 20 cm is needed for ACL reconstruction). The graft length is measured using calibrations along the shaft of the tendon stripper. When the acceptable length has been obtained, the tendon may be amputated by activating a blade contained in the mouth of the stripper. The proximal portion of the tendon is delivered from the wound while the distal insertion is left intact. The second tendon then may be delivered in a similar fashion.

The same anteromedial incision can be used for the creation of a tibial drill hole in reconstruction-augmentation of the ACL. After the tendons have been freed proximally, dissection is continued distally back to the conjoined insertion to free the tendons for placement through the drill hole. This dissection must be done carefully because the distal insertion can be disrupted if the surgeon is overzealous. When the distal dissection is complete, the insertion is rotated in an attempt to equalize the tension in the two tendons. A Bunnell-type suture is then passed in a proximal-to-distal direction to combine the tendons into a single graft. The prepared tendon graft can then be placed through the drill hole while maintaining its distal insertion.

Results of semitendinosus and gracilis grafts of the knee

Although they suffer from a lack of long-term followup, most recent series report that a high percentage of patients do well functionally and with regard to clinical assessment of knee stability after ACL reconstruction-augmentation with the semitendinosus and gracilis tendons.[8,17–19,27,34,41,43,44] Lipscomb et al.[20] noted no deficit in postoperative hamstring strength when comparing operated and unoperated sides on an isokinetic dynamometer. This finding has been confirmed by others.[32,44]

Near the time that Noyes et al.[28] reported that the strength of a tendon graft consisting of the semitendinosus tendon alone had only 70% of the strength of the normal cruciate ligament, Lipscomb et al.[18] modified their technique of cruciate reconstruction to employ a combined semitendinosus and gracilis graft. Others reported the use of a doubled semitendinosus graft in an attempt to more closely approx-

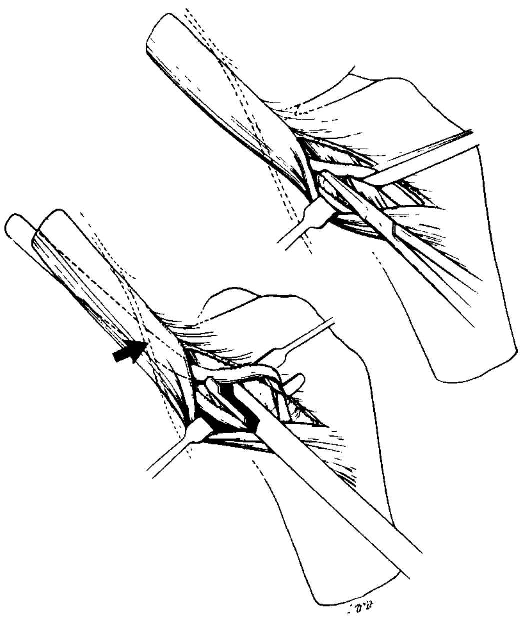

Figure 6. Top, countertraction is applied with a Penrose drain as the tendon is carefully freed proximally using scissors. Bottom, a tendon stripper ensnares the tendon while countertraction is applied with a right-angled retractor. Note the location of the saphenous nerve (arrow).

imate the strength needed to resist forces subjected on ACL substitutions.[8,26,41,43] As this study indicates, however, a great deal of variability exists in the size and strength of these tendons in each patient. One cannot automatically assume a graft strength that parallels the strength of the native ACL.

Expanding the role of the semitendinosus and gracilis tendons

Because of our familiarity with the technique of harvest of the semitendinosus and gracilis tendons and the low associated morbidity, we now can consider these tendons for use as free grafts in other anatomic positions. When insufficient local tissue has been available, these grafts have proved useful in the treatment of lateral ankle instability, massive rotator cuff deficiency, acromioclavicular disruption, and Achilles tendon rupture.

SUMMARY

The semitendinosus and gracilis tendons have a long history of usefulness in the treatment of ligamentous injuries of the knee. A thorough knowledge of the anatomic relationships of the tendons facilitates their harvest and reduces harvest-related morbidity. Special attention should be given to the proximity of the medial collateral ligament and the saphenous nerve. Knee flexion may protect the nerve during proximal dissection. The accessory insertion of the semitendinosus tendon should be identified. Specialized instrumentation improves the ease of tendon stripping and precludes the need for a proximal incision in the thigh.

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