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Hamstring tendon harvesting
Reviewing anatomic relationships and avoiding pitfalls

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The gracilis and semitendinosus tendons are popular for autografts in a variety of reconstructive procedures, including augmentation of Achilles tendon repairs, patellar subluxation procedures, chronic patellar tendon ruptures, and primary reconstruction of ligamentous knee injuries. Although the patellar bone-tendon-bone (BTB) autograft remains the graft of choice for many surgeons and the standard with which other grafts are compared for anterior cruciate ligament (ACL) reconstruction, the semitendinosus/gracilis composite autograft (STG) is used widely for its potential advantages over the BTB graft.

Graft site morbidity (patellofemoral pain and crepitus) may be decreased with hamstring harvesting compared with BTB, although this issue has become more controversial with accelerated rehabilitation protocols. The risks of patellar tendon rupture and patella fracture are eliminated, however. The STG graft, when double-looped, has been shown to have an initial load-to-failure greater than the native ACL, and its stiffness more closely approximates the native ACL, which some feel may be important [1]. The STG is often the graft of choice when performing anterior cruciate ligament reconstruction on a skeletally immature patient.

The use of hamstrings has potential disadvantages. Despite newer and stronger fixation techniques for hamstring grafts, concerns remain regarding the rate of tendon healing within bone tunnels. Some surgeons believe that an accelerated rehabilitation program should be used with caution to prevent premature graft failure. Strength and peak torque deficits have been shown to occur following hamstring harvest; however, these deficits have not proved to be of clinical or functional significance [2]. Other studies have shown little or only transient deficit after harvesting the gracilis and semitendinosus tendons [3,4]. Another potential disadvantage of the STG graft is that premature amputation of the tendons can occur during harvesting, resulting in a shorter graft and possibly necessitating an alternate graft choice.

Recent prospective, randomized studies have shown no significant difference in functional outcome or objective stability following ACL reconstruction with STG versus BTB autografts [5,6]. Hamstring tendons will likely continue to be used frequently for ACL reconstruction. Even if the BTB graft remains a surgeon's first choice, proficiency in using the hamstring technique, with special care in harvesting the semitendinosus and gracilis tendons, will be useful in special situations or when BTB grafts are unavailable or undesired. This article details the anatomy of the semitendinosus and gracilis tendons, describes tendon harvesting techniques and potential morbidity associated with harvesting, and discusses how to avoid potential pitfalls.

Anatomy

Basic anatomy

Sartorius

The sartorius muscle originates from the anterior superior iliac spine and courses distally along the anterior thigh from lateral to medial as the most superficial anterior compartment muscle. Distally in the thigh, the tendinous portion of the muscle

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becomes thin and broad, finally inserting onto the proximal anteromedial tibia as the most anterior of the three pes anserinus tendons. It is innervated by a branch of the femoral nerve along the proximal third of the muscle belly [7].

Gracilis

The gracilis muscle originates from the body and inferior ramus of the pubic bone, travels distally along the medial portion of the thigh, and joins the sartorius fascia and semitendinosus tendon to form the pes anserinus, inserting onto the anteromedial surface of the proximal tibia. The gracilis, a long, straplike fusiform muscle, is the most superficial and weakest of the adductor muscle group. It is innervated by the anterior branch of the obturator nerve along the proximal third of the muscle belly [7].

Semitendinosus

The semitendinosus muscle originates from a common origin on the ischial tuberosity with the semimembranosus and the long head of the biceps femoris. It is a long, fusiform muscle that becomes a cordlike tendon approximately two thirds of the way down the thigh. It is superficial to the semimembranosus muscle along its course on the posteromedial thigh before joining the gracilis tendon and the sartorius fascia at the pes anserinus common insertion on the tibia. It is innervated at its proximal third by the tibial division of the sciatic nerve [7].

Anatomic relationships

We performed a cadaveric study to examine the anatomic relationships of the gracilis and semitendinosus tendons as they course distally to their insertion on the tibia. The gracilis and semitendinosus tendons are located between layer I (which includes the sartorius) and layer II (which includes the superficial medial collateral ligament [MCL]) on the medial side of the knee, described by Warren and Marshall and Warren et al [8,9]. Proximal to the insertions of the pes anserinus tendons, the sartorius tendon (part of layer I) is superficial to the gracilis and semitendinosus tendons. The sartorius tendon, however, fuses with the gracilis and semitendinosus tendons distally, forming the pes anserinus, which then inserts onto the proximal anteromedial tibia. This insertion is, on average, 19 mm (range of 10–25 mm) distal (Fig. 1, distance A) and 22.5 mm (range of 13–30 mm) medial (Fig. 1, distance B) to the apex of the tibial tubercle, with an average width of 20 mm (range of 15–34 mm) (Fig. 1, distance C) [10].

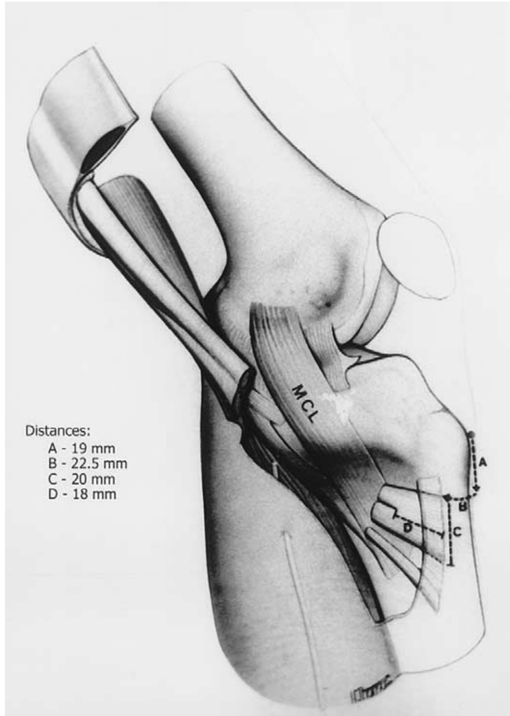

Fig. 1. The distal insertion site of the semitendinosus and gracilis tendons. The overlying sartorius muscle and tendon and segments of the distal portions of the semitendinosus and gracilis tendons have been removed. The semitendinosus and gracilis tendons insert as a conjoined structure on the anteromedial 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. See text for details regarding the distances A, B, C, and D. (*From* Pagnani MJ, Warner JJP, O'Brien SJ, et al. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:566; with permission.)

Proximal and posteromedial to the tibial insertion, the gracilis and semitendinosus tendons become separate and distinct structures beneath layer I. This occurs at an average of 18 mm (range of 10–25 mm) proximal to their combined insertion site (Fig. 1, distance D) [10]. The superficial medial collateral ligament, which composes a portion of layer II, is located deep to the tendons in this area.

The thigh fascia is divided into superficial and deep layers that enclose the sartorius muscle and tendon. The deep portion of this fascia adheres to the gracilis and semitendinosus tendons and commonly forms a dense, 3 to 4 cm band around the tendons, approximately 8 to 10 cm proximal to tendon insertion. The band connects with the medial intermuscular septum and the semimembranosus muscle sheath, and distally the deep fascial layer becomes continuous with the posterior crural fascia [10].

Harvesting techniques

Incision and exposure

The incision used to harvest hamstring and subsequently drill the tibial tunnel is the surgeon's preference. The gracilis and semitendinosus tendons can be harvested through an incision centered approximately 4 cm medial and just distal to the tibial tubercle. An alternative description of the incision location is three fingerbreadths below the medial joint line and centered on the subcutaneous portion of the tibia (between the anterior and posteriomedial subcutaneous borders of the tibia).

The incision can be oriented longitudinally, obliquely, or transversely. The anatomic course of the infrapatellar branch of the saphenous nerve in the area of the incision makes the oblique and transverse incisions more conducive to avoiding damage to this structure. Fig. 2 shows the proximity of the infrapatellar branch of the saphenous nerve when using a longitudinally oriented incision.

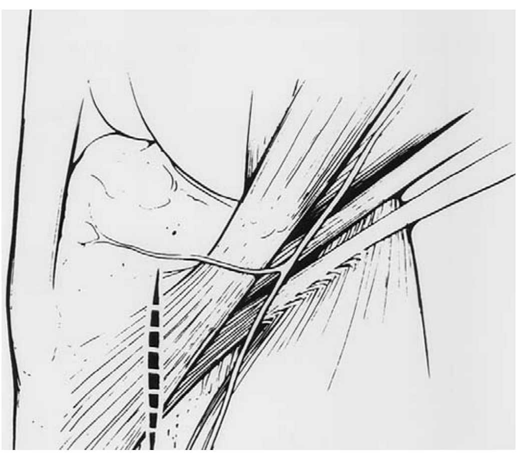

Fig. 2. The medial side of the knee and the proximity of the infrapatellar branch of the saphenous nerve when a longitudinally oriented incision is made to expose the pes anserinus tendons. (*From* Warner JJP, Warren RF, Cooper D. Management of acute anterior cruciate ligament injury. Instr Course Lect 1991;XL:219–32; with permission.)

Dissection is carried down sharply through the subcutaneous tissue and fat to expose the sartorius tendon (layer I). The gracilis (superior) and semitendinosus (inferior) tendons can be palpated deep to layer I and, at this position, are separate structures, as described previously. The gracilis is a round, palpable structure at this level; it is palpated more easily than the flatter semitendinosus tendon.

Exposing tendons

The sartorius tendon (layer I) is incised carefully along the course of the gracilis and semitendinosus, either above the gracilis tendon or between the gracilis and semitendinosus tendon, depending on the surgeon's preference (Fig. 3A, B; Fig 4, center and right). Fig. 4 (left) illustrates the cross-sectional relationship of the pes tendons. Extreme caution must be used not to damage the underlying gracilis and semitendinosus tendons, and equally important, the superficial medial collateral ligament (layer II). Also care must be taken to preserve the integrity of layer I, because it can serve as a valuable soft tissue covering over the graft fixation device on the tibia. Because the tendons commonly adhere to layer I, they must be isolated carefully to avoid damaging the sartorius tendon. The gracilis is isolated first using a clamp to free it from layer I and layer II (Fig. 4, center). At this point, the surgeon may leave the hamstring tendons attached to the tibia or detach them, depending on the technique used. If the tendons are left attached distally, a Penrose drain may be placed around them to aid in traction while isolating them further proximally and while stripping them from their muscle belly. If the surgeon chooses to detach the tendons distally, they should be dissected distally to the point where they become conjoined and amputated there to maximize their length. Again, the tendons should be isolated, detached distally (if this technique is used), dissected proximally, and then stripped one at a time. If the tendons are detached distally, an absorbable braided suture (#1 is ideal; however, a larger suture can be used) is whipstitched in the tendon to aid in tensioning the tendon while dissecting it proximally and stripping it from the muscle belly. Different colored sutures can be used on the tendons to identify them. The tendons should be sewn beginning at the distal end, extending proximally for 4 to 5 cm, then returning to the distal end. Each throw should encircle three quarters to four fifths of the tendon and be 5 mm apart. This creates a Chinese finger trap–like configuration, which constricts the tendon end when tension is imparted on the sutures, facilitating passage of the tendon through drill holes (Fig. 5).

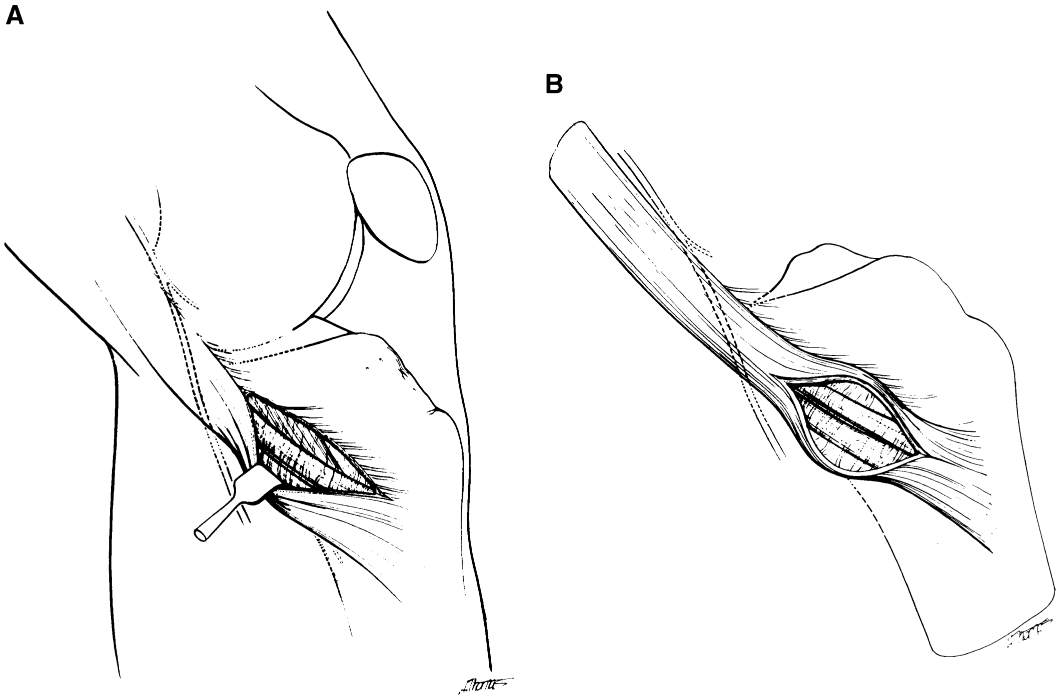

Fig. 3. The sartorius is incised along the course of the semitendinosus and gracilis tendons either (A) at the superior border of the gracilis tendon or (B) between the semitendinosus and gracilis tendons. (*From* Pagnani MJ, Warner JJP, O'Brien SJ, et al. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:568; with permission.)

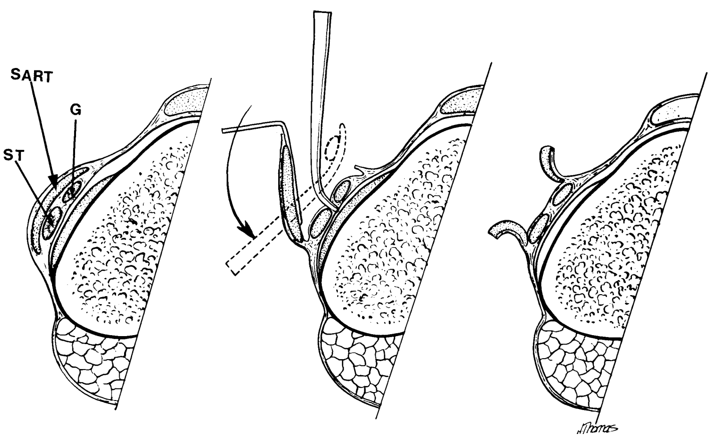

Fig. 4. Cross-sectional illustration demonstrating the relationship between the sartorius and the semitendinosus and gracilis tendons before dissection (*left*). Incision along the superior border of the gracilis tendon and passage of a clamp around the gracilis tendon (*center*). Alternate incision of the sartorius between the underlying semitendinosus and gracilis tendons (*right*). G, gracilis; SART, sartorius; ST, semitendinosus. (*From* Pagnani MJ, Warner JJP, O'Brien SJ, et al. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:569; with permission.)

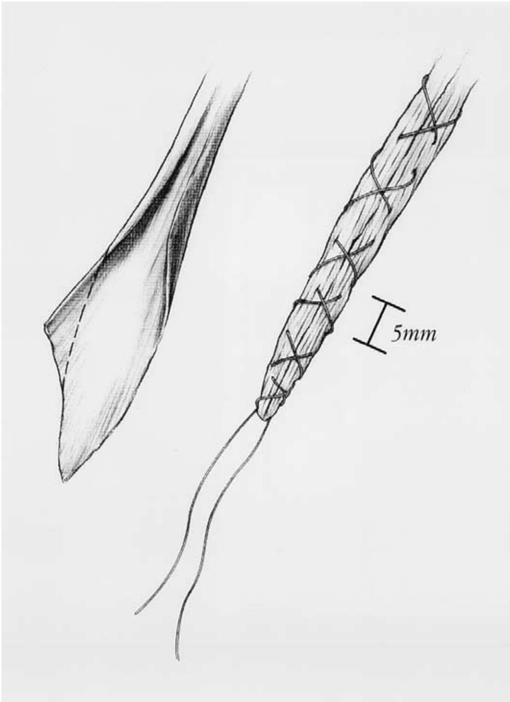

Fig. 5. Technique for creating the "Chinese finger trap" configuration using sutures, which constrict the tendon ends. This technique facilitates passage of the tendons through drill holes regardless of the technique used for hamstring fixation. (*From* Bone mulch screw/washer loc device, p. 4, fig. 2. Developed with Stephen M. Howell, MD. Arthrotek, Warsaw (IN); with permission.)

Tendon isolation and stripping

The knee is placed in either a 90° bent or "figure-of-four" position to improve exposure and relax tension on the tendinous structures and the saphenous nerve, which lies superficial to the gracilis tendon at the posteromedial joint line (Fig. 6).

Using blunt finger dissection and Metzenbaum scissors, the tendons can be isolated proximally towards their musculotendinous junction. Adhesions and accessory bands are dissected carefully away from the tendons to facilitate passage of the stripper over the tendon. Great care must be used when dissecting the semitendinosus proximally, because it can have up to five accessory bands or insertions that need to be released before advancing the tendon stripper. The most consistent accessory insertion diverges from the main tendon an average of 5.5 cm (range of 4.5–8 cm) proximal to the conjoined insertion site and inserts, on average, 3 cm distal to the inferior border of the conjoined tendon insertion site (Fig. 6). The fascial bands, which become continuous with the posterior crural fascia 8 to 10 cm from the pes insertion, may impede advancement of the tendon stripper and must be released.

Once the tendons are free from their accessory insertions and fascial bands, they are ready to be harvested using the tendon stripper. If the tendons remain attached to the tibia distally, a right-angled retractor can be used to apply traction to the tendons. In this case, an open-ended tendon stripper must be used to harvest the tendon (Fig. 7). If the tendons have been detached from the tibia distally, a close-ended stripper is used, and the previously placed sutures are used for traction while harvesting. Once the stripper is placed over the tendon, it is advanced carefully with the leg in

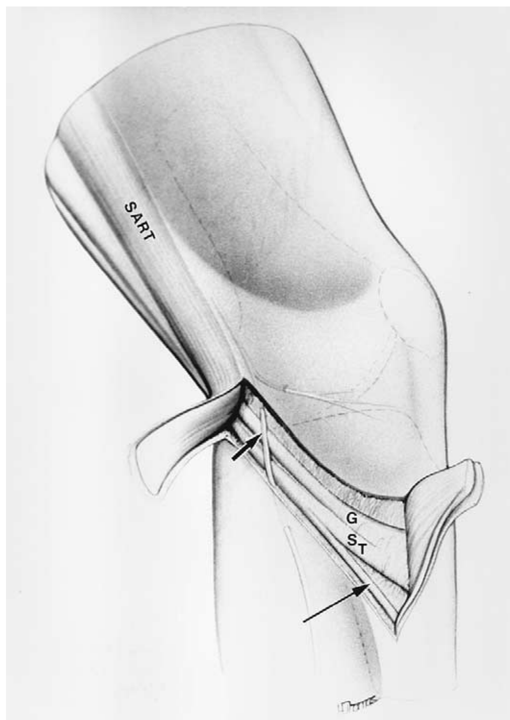

Fig. 6. The saphenous nerve crosses the gracilis tendon at the posteromedial joint line (*short arrow*). The inferior fibers of the semitendinosus tendon often diverge to form an accessory insertion more distally on the tibia (*long arrow*). G, gracilis; SART, sartorius; ST, semitendinosus. (*From* Pagnani MJ, Warner JJP, O'Brien SJ, et al. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:570; with permission.)

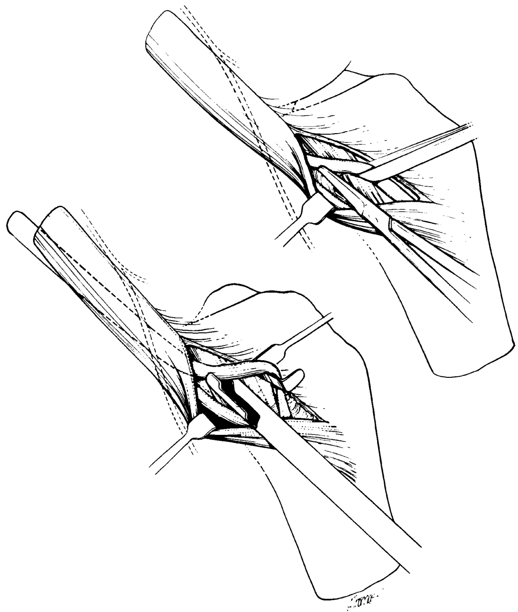

Fig. 7. (*Top*) Countertraction is applied with a Penrose drain as the tendon is freed proximally using scissors. (*Bottom*) A tendon stripper ensnares the tendon while countertraction is applied with a right-angled retractor. Note the location of the saphenous nerve (*From* Pagnani MJ, Warner JJP, O'Brien SJ, et al. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. Am J Sports Med 1993;21:567; with permission.)

the 90° bent or figure-of-four position. When harvesting the gracilis tendon, the stripper is aimed toward the ipsilateral lesser trochanter; when harvesting the semitendinosus, the stripper is aimed toward the ipsilateral ischial tuberosity. This ensures that the stripper is advanced along the natural anatomic course of the tendons to avoid damage to them. If any resistance is met during advancement of the stripper, the surgeon should stop, remove the stripper, and palpate for any additional fascial bands or accessory insertions that may be impeding progress. When all fascial bands and accessory insertions are released from the tendons, they can be harvested using firm and steady, but gentle, pressure while advancing the tendon stripper and simultaneously applying countertraction using the right-angled retractor (if tendons are attached) or the previously placed sutures (if tendons are detached). The harvested tendons are stripped of their residual muscle proximally using a scalpel blade or the blade from a pair of scissors. The proximal end of the tendons are carefully trimmed and tapered, and a whipstitch is placed in both tendons as described previously. A successful harvest should yield approximately 25 to 30 cm of good quality tendon, with both tendons being nearly equal in length. Once the tendons have been harvested and prepared, they are ready to use in reconstructing the anterior cruciate ligament by the technique and fixation methods chosen by the surgeon.

Pitfalls

Premature graft amputation

Premature amputation of the hamstring tendons while advancing the stripper is the major pitfall of the procedure. This pitfall can be avoided easily if one is familiar with the anatomy of the hamstrings at the medial side of the knee. The gracilis and semitendinosus tendons have fascial bands and accessory insertions that can impede the advancement of the tendon stripper. If these bands are not carefully freed from the tendons, the tendon stripper inadvertently can transect the main tendon, leaving the surgeon with a shortened graft. Meticulous dissection cannot be overemphasized. The surgeon should be prepared to use an alternate graft source, including the contralateral hamstring tendons, if necessary. The surgeon also should counsel the patient and family prior to surgery about this potential complication and its remedy.

Medial collateral ligament damage

When exposing the gracilis and semitendinosus tendons, the sartorius fascia (layer I) must be incised carefully. Take extreme care not to plunge with the scalpel, because the underlying tendons, and more importantly, the superficial medial collateral ligament (layer II) can be damaged easily. The medial collateral ligament can be mistaken for one of the hamstring tendons if one is not careful or lacks knowledge of the anatomy, resulting in damage to this structure.

Morbidity associated with graft harvest

Donor site pain

Harvesting of the gracilis and semitendinosus tendons appears to cause minimal restriction of activity. Patients may have soreness initially with activity; however, Yasuda found that soreness rarely persists and resolves by 3 months after surgery [4].

Hamstring weakness

Following harvesting of the gracilis and semitendinosus, it seems intuitive that clinical weakness would ensue. This has not been conclusively determined, however. Many studies have shown that hamstring weakness is minimal or if weakness is present after harvesting, the hamstring returns to normal after a period of rehabilitation [3,4,11]. Yasuda et al showed that by 12 months, isokinetic strength and peak torque of the extremity undergoing harvesting of the gracilis and semitendinosus tendons was 120% of the contralateral extremity [4]. However, one study showed that hamstring weakness is clinically significant compared with knees that underwent ACL reconstruction using autogenous patellar tendon [2]. Several studies have shown that the hamstring tendons may regenerate after a period following harvesting, although not always completely and usually with scar tissue and a more proximal insertion on the tibia than normal [11,12].

Saphenous nerve damage

The saphenous nerve crosses superficial to the gracilis tendon at the posteromedial joint line. While harvesting the tendons, placing the leg in the figure-of-four position maximally decreases tension on the saphenous nerve, thereby decreasing the risk of damage. Damage to this nerve can present with complaints of paresthesias in the anteromedial area of the lower leg and medial-sided knee tenderness, and also it has been associated with the development of reflex sympathetic dystrophy [13]. This neuralgia can mimic other knee disorders, peripheral vascular disease, and lumbar nerve root compression. The easiest step to confirm the diagnosis of neuralgia is to perform an anesthetic blockade. The treatment options for saphenous neuralgia following hamstring harvest include observation combined with analgesics and possibly neuroleptic medication, topical anesthetic patches, neurolysis, or nerve resection. One case report described a woman with saphenous neuralgia, which was diagnosed with an anesthetic blockade, who underwent a neurolysis. Normal cutaneous sensation at the medial aspect of the knee, lower leg, and ankle was regained 6 months after surgery [14].

Summary

The gracilis and semitendinosus tendons remain popular grafts for many reconstructive procedures, including anterior cruciate ligament reconstruction. Surgeons who use other grafts for ACL reconstruction should have the hamstring tendon techniques in their arsenal in the event other grafts are unavailable or undesirable. Detailed knowledge of the anatomy of the medial side of the knee is paramount to avoid potential pitfalls and ensure a successful tendon harvest.

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