CHAPTER 40

Arthroscopic Anterior Cruciate Reconstruction with Hamstring Tendons: Indications, Surgical Technique, and Complications and Their Treatment

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Anterior cruciate ligament (ACL) reconstruction in which a free tendon graft is substituted for the torn ligament is a common surgical procedure for the orthopedic surgeon. Although some patients can function exceptionally well with an ACL-deficient knee,[14,105] most experience pain and recurrent episodes of instability. Because the menisci, articular surfaces, and other restraining structures around the knee are susceptible to injury during episodes of instability, it is generally accepted that ACL reconstruction should be offered to patients who have or are at risk for having recurrent knee instability.

The goal of ACL reconstruction is to restore normal anterior knee stability, and when deciding on surgical intervention, the orthopedist has to determine which graft substitute best accomplishes this goal. The ideal graft is one that retains strength at least equivalent to that of the normal ACL, allows for secure fixation, enables unrestricted rehabilitation, and is associated with minimal graft harvest morbidity.

The majority of orthopedists prefer an autogenous graft, and historically, the patellar tendon has been the most popular graft source.* However, given the associated morbidity,[3,39,94,122,125,134,135,137] many surgeons have turned to autogenous semitendinosus/gracilis (ST/G) tendons.

ACL reconstruction with autogenous hamstring tendons has been well described.† The four-stranded ST/G graft has many advantages over other grafts, including its strength. Biomechanical testing has shown the strength of a four-stranded ST/G graft to vary from 3880 to 4213 N,[24,63,65,69,102,103,145] which makes it approximately 240% stronger than the normal ACL[24,102,103,123,155] and at least 138% stronger than a 10-mm-wide patellar tendon graft.[24,37,102,103]

Another advantage of the four-stranded ST/G graft is its stiffness, which has been measured to be between 805 and 954 N/mm.[63,65,69,145] This property makes it nearly three times stiffer than the normal ACL[37,104,123,155] and twice as stiff as a central-third patellar tendon.[37]

The four-stranded ST/G graft has a large cross-sectional area that closely resembles that of the normal ACL, which has been measured to be 44.4 to 56.5 mm^2.[102,104,123] An 8-mm-diameter hamstring graft has a cross-sectional area of 50 mm^2, which is 1.5 times that of a 10-mm-wide patellar tendon. This larger area is advantageous for maximizing vascular ingrowth and ligamentization.

The biggest advantage of the hamstring graft over autogenous patellar or quadriceps tendon grafts is preservation of the extensor mechanism. As a result, postoperative problems such as patellar fracture,[137] patellar tendon rupture,[94] patellofemoral pain,[2,3,23,26,39,75,109,113,125] patellar tendonitis, quadriceps weakness,[122,125] and flexion contracture[114,125] are minimized. Patellofemoral pain has been a problem when autogenous patellar tendon grafts are used, with a 17% to 56% postoperative incidence of pain.[2,23,109,113] Pain on kneeling has been reported to occur in 42%[26] of those who undergo ACL reconstruction with autogenous bone–patellar tendon–bone grafts. Quadriceps weakness, believed to be a result of graft harvest and to be associated with flexion contracture and patellar irritability, has been reported to occur in as many as 65% of patients.[122,125] Deterioration of the patellofemoral articular surfaces, documented by second-look arthroscopy, has been reported in as many as 57% of patients after the use of an autogenous patellar tendon graft.[135]

The literature is replete with clinical studies of ACL reconstruction using a hamstring tendon graft.* Although various techniques have been described, these studies have reported a negative pivot shift in 69% to 100% of patients.[4,5,13,35,38,56,62,69,70,91,93,111,112,121,136,154] In studies that have provided KT-1000 (MEDmetric, San Diego, CA) data, most have reported a manual maximum side-to-side difference of 3 mm or less in 70% to 100% of patients.†

A review of ACL reconstruction with an autogenous patellar tendon reveals mostly excellent and good results, with several studies reporting greater than 90% excellent and good results.[23,109,113,131-133] On casual comparison with the hamstring graft studies, it appears that the results are improved with a patellar tendon graft. However, keep in mind that some of the poor results previously reported

*References 2, 8, 15, 23, 31, 39, 75-77, 109, 113, 131-134.

†References 4, 10, 13, 15, 20-22, 28, 30, 32, 35, 38, 56, 57, 62, 68-70, 85, 88, 89, 96, 97, 100, 119, 121, 128, 136, 146, 154, 159.

*References 4, 5, 10, 13, 15, 18, 20-22, 26, 28, 30, 32, 35, 38, 56, 57, 62, 67-70, 85, 88-91, 93, 95-97, 100, 111, 112, 119, 121, 128, 136, 139, 146, 154, 159.

†References 22, 28, 35, 38, 62, 69, 70, 91, 93, 111, 112, 121, 128, 136, 154.

with the use of a hamstring graft resulted from the use of an inadequate graft (single-, double-, or triple-stranded graft) and the lack of strong, stiff fixation on both ends of the graft. Studies that have used a four-stranded graft with adequate fixation on both the tibia and femur have reported 90% with an absent pivot shift and 90% with less than 3 mm of side-to-side difference on KT-1000 manual maximum testing.[35,69,70,121,128]

Several clinical studies have compared the results of autogenous hamstring versus patellar tendon ACL reconstructions. Although many of the earlier studies showed improved results with the patellar tendon graft, these studies were not prospective and lacked any form of randomization.[67,112,139] Meta-analyses[49,157] have reported greater stability, higher activity levels, and a lower incidence of graft failure in patients reconstructed with a patellar tendon graft. Some of the nonrandomized comparison studies have shown similar objective results with respect to postoperative laxity, but greater compromise in functional performance and evidence of arthritis in patients reconstructed with patellar tendon grafts.[40,118,124] In the prospective comparison studies,* most have not shown any functional difference between the two grafts. A few of the studies, however, do show a trend toward increased objective laxity in female patients despite equal subjective outcomes.[15,38,55,100] In some of the prospective randomized studies, a higher incidence of patellofemoral pain and quadriceps weakness has been reported in patients who received patellar tendon grafts.[5,26,38,44,47,82,95,129] In some, this morbidity has prevented or delayed return to full activities.[39,95]

Historically, one of the biggest disadvantages of using the hamstring tendons was fixation. To allow for unrestricted rehabilitation, graft fixation should be stronger than the force experienced by the normal ACL during activities of daily living, which has been estimated to be nearly 500 N.[29,39,66,69,81,95] The metal interference screw, with a fixation strength of 416 to 640 N,[80,115,123] has proved to be reliable fixation for the bone–patellar tendon–bone graft and the accepted standard by which other fixations are measured. In the past, because of the lack of bone in the hamstring graft, the fixation had to be outside the bone tunnels. Outside fixation has the potential disadvantage of increasing graft construct length and thereby increasing the chance for graft elongation with cyclic loading.[71] In addition, many outside fixation devices were minimally strong or stiff enough to allow for unrestricted rehabilitation. A recent study comparing femoral fixation on the cortex with aperture fixation, however, found no difference in outcomes.[88] Newer fixation methods have been and continue to be developed to allow the hamstring tendons to be adequately fixated in the femoral and tibial tunnels.

Biomechanical data have shown slippage and lack of stiffness to be problematic for many soft-tissue fixation devices.[42,54,92] In an attempt to increase fixation strength and stiffness, femoral cross-pin fixation has been developed. Many companies market these devices, including Arthrotek (Warsaw, IN), Arthrex (Naples, FL), Stryker Endoscopy (San Jose, CA) and Mitek (Mansfield, MA). Femoral cross-pin fixation is the strongest and stiffest fixation in ACL reconstruction surgery, irrespective of the graft source. Fixation strength varies from 1002 to 1600 N,[32,145] and stiffness has been measured at 176 to 224 N/mm.[46,145] Newer tibial fixation methods, including the Intrafix and Bio-Intrafix (Mitek) and the WasherLoc (Arthrotek), have been developed, and these newer methods of fixation have also helped increase the ultimate strength and stiffness of the graft fixation construct (see Table 40–1).

Another potential disadvantage of hamstring ACL reconstruction is the lack of bone-to-bone healing. Animal studies have demonstrated that the tendons are incorporated into the bone tunnel by 12 weeks.[59,61,120] In addition, animal studies have shown that a semitendinosus autograft is histologically transformed into a structure that is similar to the native ACL.[60] Biopsy specimens from human knees have confirmed this incorporation and the formation of Sharpey-like fibers in the bone tunnels,[117] whereas in another study, the biopsied tissue from the tendon-bone interface resembled granulation tissue without fibers between the tendon and bone.[99] A lack of biological fixation can lead to postoperative instability.[147] In theory, therefore, graft fixation, in most cases, needs to be secure for a minimum of 12 weeks, until such time that the tendons have healed in the bone tunnel.

A four-stranded ST/G graft looped over a femoral cross-pin and secured on the tibia with a central sheath and screw (Intrafix) or washer plate (WasherLoc) is a strong and stiff graft construct that easily allows for unrestricted and aggressive rehabilitation without the risk of graft elongation or failure. We currently recommend this graft fixation construct for ACL reconstruction.

The four-stranded ST/G graft is our graft of choice for patients less than 200 lb, women, patients with open physes, low-demand patients, patients with small patellar tendons, patients with vocations/avocations that require "bent-knee" activities (such as carpet layers, carpenters, plumbers), and those with preoperative patellofemoral pain. Some authors have reported less successful results with use of the hamstring graft in female patients.[15,38,100] We have not had the same experience. We advocate use of the bone–patellar tendon–bone graft in some high-performance athletes who require an early return to training and those who may require strong knee flexors for their sport or occupation.

SURGICAL TECHNIQUE

Graft Harvest

The semitendinosus and gracilis tendons are harvested through a 1.5-inch incision centered approximately 2 cm medial to the tibial tubercle (Fig. 40–1). Dissection is carried down to the sartorius fascia, which is incised parallel and distal to the palpable semitendinosus tendon. The semitendinosus and gracilis tendons are then released from their tibial attachment and reflected proximally to visualize the undersurface and their natural separation

*References 5, 7, 12, 15-18, 26, 38, 41, 44, 45, 47, 74, 82, 93, 95, 111, 129.

Table 40–1. Fixation Options

	ULTIMATE STRENGTH (N)	STIFFNESS (N/mm)	SLIPPAGE UNDER CYCLIC LOAD	EXTENSION AT FAILURE (mm)
Metal interference screw with bone–patellar tendon graft	416-640 N[80,115,123]	51-58 N/mm[80,123]		12.6 mm[123]
Knotted loop of Mersilene tape	493 N[140]			
Knotted loop of No. 5 Ethibond	302 N[140]			
Femoral Devices for Hamstring Grafts				
Arthrex Bio-TransFix	746-1392 N[6,46]	176 N/mm[46]	1.4 mm after 100 s of 250 N cyclic loading[6] 3.1 mm after 100 cycles of 150 N[46]	
Arthrex TransFix	1002-1235 N[42,46]	181 N/mm[46]	1.7-3.4 mm after 1000 cycles of 150 N[42,46]	
Continuous-loop EndoButton (CL)	Single: 864-1086 N[6,42,78] Double: 1324 N	106 N/mm[46]	Single: 3.9 mm after 1500 cycles of 200 N[78] 1.8 mm at 1000 cycles of 150 N[42] 1.75 mm after 100 s of 250-N cyclic loading[6] Double: 1.6 mm at 1000 cycles of 150 N[42]	
Bone Mulch Screw (Arthrotek)	1112-1126 N[78,145]	115-225 N/mm[78,145]	2.2 mm after 1500 cycles of 200 N[78]	
Mitek-Depuy Cross Pin	35-mm pin: 1003 N[32] 70-mm pin: 1604 N[32]			
Mitek RIGIDfix (bioabsorbable cross-pins)	638-868 N[6,78,158]	77-226 N/mm[78,158]	3.7 mm after 1500 cycles of 200 N[78] 5.07 mm after 1000 cycles of 250 N[158] 8.6 mm after 1000 cycles of 450 N[158] 6.02 mm after 100 s of 250-N cyclic loading[6]	
EndoButton	352-703 N[20,58,123,145]	8-98 N/mm[20,58,123,145]	Failure occurred in 5 of 5 trials between 1041 and 29,260 cycles of 155 N. None with stood the testing condition of 250,000 cycles.[43] (Note: Graft tunnel motion increases as the length of the loop of tape increases[50])	23.6 mm[123]
RCI screw	336-546 N[46,56,78,116]	51-68 N/mm[46,78]	6.8 mm after 1100 cycles of 150 N[56,116] 3.9 mm after 1500 cycles of 200 N[78]	
Arthrex metal soft screw	226 N[56,116]			
Bioabsorbable screw (Arthrex)	327-539 N[6,11]		5.4 mm with cyclic loading for 100 s of 250 N[6]	
Bioscrew (Linvatec)	310-589 N[42,78,153]	26-66 N/mm[78,153]	4.0 mm after 1500 cycles of 200 N[78] 4 of 5 failed before 1000 cycles of 150 N[42]	
Bioscrew with EndoPearl	659 N[153]	42 N/mm[153]		
FastLok (Neoligaments)	11 mm with ST/G: 600 N[34]			
	11 mm with Leeds-Keio Lig.: 1258 N[34]		1.1 mm after 1.5 million cycles of 200-500 N[34]	
	8 mm with Leeds-Keio Lig.: 1027 N[34]		1.4 mm after 1.5 million cycles of 200-500 N[34]	
	6 mm with No. 2 Ethibond: 483-510 N[34]	55-66 N/mm[34]		7.4-9.4 mm[34]
	6 mm with No. 5 Ethibond: 735 N[34]	149 N/mm[34]		4.9 mm[34]

Table continues on next page

Table 40–1. Fixation Options—Cont'd.

	ULTIMATE STRENGTH (N)	STIFFNESS (N/mm)	SLIPPAGE UNDER CYCLIC LOAD	EXTENSION AT FAILURE (mm)
Clawed washer with 6-mm screw	502 N[54]		6.7 mm after 300 cycles of 150 N[54]	
Two 6-mm soft-tissue washers	821 N[142]	29 N/mm[142]		26 mm[142]
Sutures tied over a 6.5-mm screw post	573 N[142]	18 N/mm[142]		22 mm[142]
20-mm spiked washer with 6.5-mm screw	248 N[72]			
Tibial Fixation for Hamstring Grafts				
Intrafix (Mitek)	796-1332 N[25,79] Force required to produce 2 mm of laxity = 216 N[141]	49-223 N/mm[25,79]	1.5 mm after 1500 cycles[79]	17.3 mm[25]
Bio-Intrafix (Mitek)	1275 N[138]			
WasherLoc plate/screw (Arthrotek)	903-975 N[79,92]	87-273 N/mm[79,92]	0.8-2 mm at 500 N[92] 3.2 mm after 1500 cycles[79]	
Tandem AO washers/screws	1159 N[92]	259 N/mm[92]	0.5 mm at 500 N[92]	
Evolgate device	1237 N[48]	168 N/mm[48]		
AO washer/screw and sutures around screw post	768 N[92]	181 N/mm[92]	0.9 mm at 500 N[92]	
Tandem bicortical screws with spiked washers (Linvatec)	769 N[79]	69 N/mm[79]	4.2 mm after 1500 cycles[79]	
RCI screw	350-419 N[92,151] Force required to produce 2 mm of laxity = 167 N[141]	40-248 N/mm[92,151]	3.7 mm at 500 N (4 of 7 failed at 500 N)[92]	
Arthrex bioabsorbable screw (35-mm length)	647 N[25]	64.5 N/mm[25]		10.9 mm[25]
Various bioabsorbable screws	439-830 N[79,149,150,152] Increasing screw length improves fixation strength[149]	41-115 N/mm[79,150,152]	3.8-4.7 mm after 1500 cycles[79] Corticocancellous fixation stronger than cancellous-only fixation[64]	
Sutures over a screw post	374-442 N[92,101]	24-60 N/mm[92,101]	4.9 mm at 500 N	
Double soft-tissue staple	785 N[92]	118 N/mm[92]	3.3 mm at 500 N[92]	
20-mm spiked washer/screw	724 N[92]	126 N/mm[92]	3.5 mm at 500 N[92]	
Stirrup (Corifix)	898 N[54]		2.1 mm after 1100 cycles of 150 N[54]	

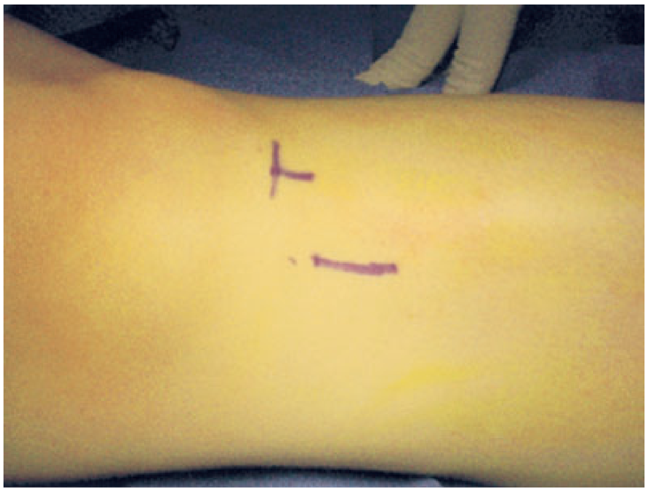

Figure 40–1. Picture of a skin incision for hamstring tendon harvest. The 1.5-inch incision is made approximately 2 cm medial to the tibial tubercle.

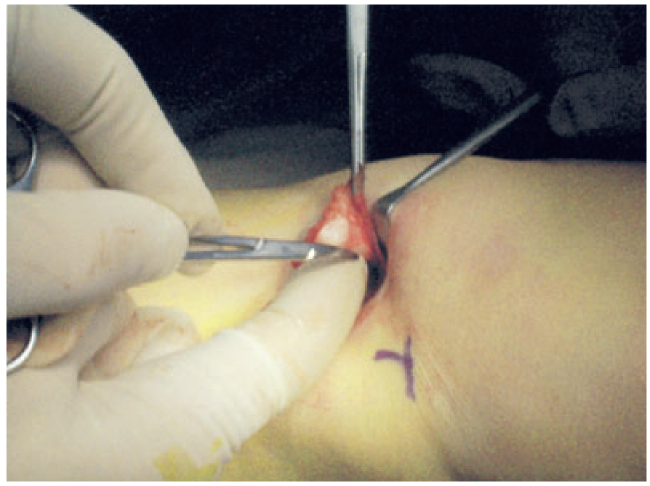

Figure 40–3. Extratendinous bands from the semitendinosus tendon.

Figure 40–2. Visualization of the undersurface of the semitendinosus and gracilis tendons. Note the natural separation.

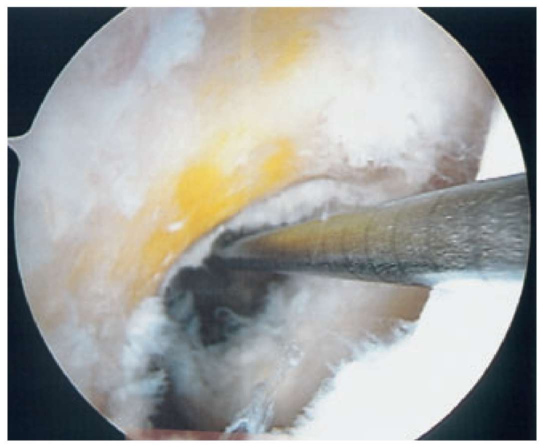

Figure 40–4. Arthroscopic view of the posterolateral wall of the notch after débridement of scar and the ACL remnant.

(Fig. 40–2). The tendons are separated, and each tendon is whipstitched with nonabsorbable suture. Using blunt dissection, the tendons are freed from surrounding adventitia. In addition, Intrafix extratendinous bands are incised to completely free up the tendons to their respective sheaths (Fig. 40–3). It is important to incise these fascial bands to prevent premature amputation of the tendon short of its muscle belly. The tendons are then harvested with a blunt-ended tendon stripper and taken to the back table, where they are prepared by removing attached muscle. The tendons are cut to give an overall length of 24 cm, and the free ends are whipstitched with No. 2 braided polyester suture. The tendons are looped to give a four-stranded graft, and the graft is sized in preparation for tunnel drilling.

Arthroscopy and ACL Reconstruction

All arthroscopies are videotaped so that the surgeon can review the case. Standard anterolateral and anteromedial arthroscopic portals in the knee are fashioned, and diagnostic arthroscopy is performed. A pressurized fluid delivery system is routinely used for all ACL reconstructions. Articular and meniscal cartilage lesions are treated as indicated. After exsanguination and application of a thigh tourniquet, the notch is débrided of scar and the old ACL remnant to clearly visualize the ACL footprint on the tibia, as well as the posterolateral wall of the notch (Fig. 40–4). A bony notchplasty or roofplasty is not routinely performed unless there is evidence of notch stenosis or notch/roof impingement on the graft.

A tibial guide is used to aim and drill a guide pin through the ACL footprint, approximately 5 to 7 mm anterior to the posterior cruciate ligament (Fig. 40–5). Before the surgeon drills the tibial tunnel, the knee is placed in

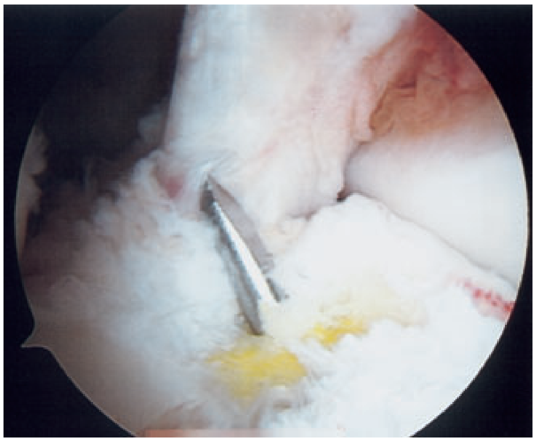

Figure 40–5. Arthroscopic view of a drill pin through the ACL footprint, approximately 5 to 7 mm anterior to the PCL.

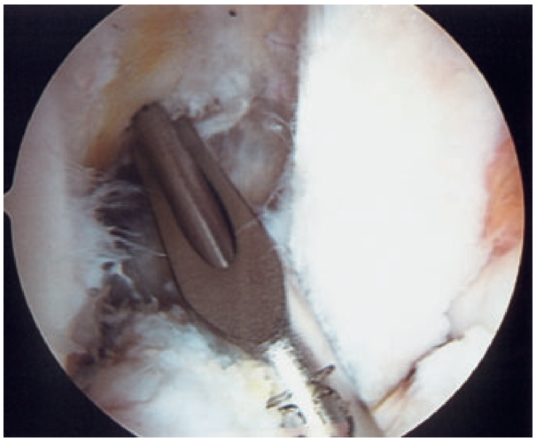

Figure 40–6. Five-millimeter offset femoral tunnel guide inserted through the tibial tunnel and locked in the over-the-top position by flexing the knee to 90 degrees.

full extension and checked for any roof impingement by the guide pin. The tibial tunnel is initially drilled with a cannulated drill corresponding to the diameter of the four-stranded graft. Previously, we sequentially enlarged the tibial tunnel with tunnel impactors to the desired tunnel diameter to, theoretically, increase the strength of tibial tunnel interference screw fixation as a result of increased bone density in the tunnel. Recent cadaveric studies,[106,107] however, have shown that tunnel impaction does not increase fixation strength, and thus we have abandoned this technique. After tibial tunnel drilling, the intra-articular entrance of the tunnel is smoothed with a hand rasp or powered chamfering tool.

Attention is then directed to making the femoral tunnel. A transtibial offset guide is used to direct a guide pin in the desired location of the femoral tunnel. The guide is inserted through the tibial tunnel and locked in the over-the-top position by flexing the knee to 90 degrees (Fig. 40–6). The guide pin is directed at the 10-o'clock (right

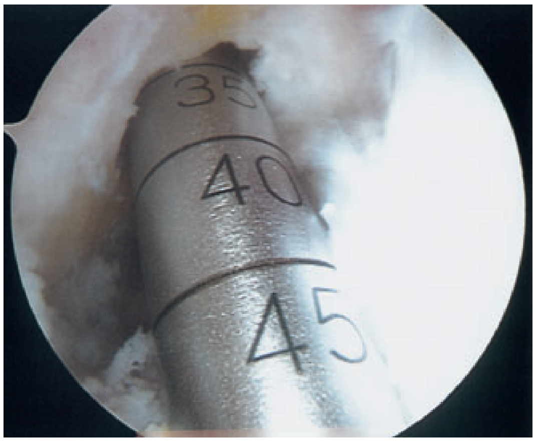

Figure 40–7. Femoral tunnel cannulated reamer, drilled to 35 to 40 mm.

Figure 40–8. Femoral tunnel cannulated reamer, drilled to 35 to 40 mm. (Courtesy of Arthrex.)

knee) or the 2-o'clock (left knee) position and drilled to the anterior femoral cortex. In the past, we attempted to create the insertion point at the 11- and 1-o'clock positions, respectively. However, recent data suggest that a more obliquely oriented femoral tunnel is better at resisting complex rotatory loads.[87,126] The femoral tunnel is drilled to 35 to 40 mm with the appropriately sized cannulated reamer (Figs. 40–7 and 40–8). The guide pin and cannulated reamer are then removed from the knee.

The Arthrex TransFix II femoral guide, with a tunnel hook that corresponds to the diameter of the femoral tunnel, is placed through the tibial tunnel and into the femoral tunnel. A small stab incision is made over the lateral femoral condyle, and dissection is carried down through the iliotibial band to the cortex. The guide pin sleeve is then seated onto the lateral femoral condyle. (Note: The femoral drill pin will enter the femoral tunnel eccentrically if the guide sleeve is positioned too firmly against the lateral femoral condyle.) A 3-mm drill pin is then drilled through the guide sleeve and tunnel hook and made to exit out on the medial side of the knee (Fig. 40–9). A cortex broach is used to open the lateral cortex to 5 mm (Fig. 40–10). A nitinol graft-passing wire is connected to the 3-mm guide pin slot. The guide pin is pulled medially to pull the nitinol wire through the tunnel hook and across the knee (Fig. 40–11). The TransFix II femoral guide is retracted out of the knee, thereby pulling a loop of the nitinol wire out of the tibial tunnel (Fig. 40–12). The semitendinosus and gracilis tendons are looped over the wire, and the wire is then tensioned medially and laterally, which pulls the graft into the femoral tunnel (Fig. 40–13). The Bio-TransFix Dilator may be inserted over the nitinol wire to ensure proper graft positioning (Fig. 40–14). A 40- or 50-mm Bio-TransFix implant is then inserted over the nitinol wire and made to seat flush on the lateral femoral cortex (Fig. 40–15). To aid in passing of the TransFix device, the wire should be tensioned by pulling on the wire both medially and laterally. The wire is then removed. If a metallic cross-pin device is used, adequate seating of the cross-pin on the lateral femoral condyle can be ensured by fluoroscopy (Fig. 35–16).

The knee is taken through several cycles of motion before tibial fixation. Cycling of the graft theoretically helps precondition the graft and eliminate creep and is also a means for the surgeon to assess the tension behav-

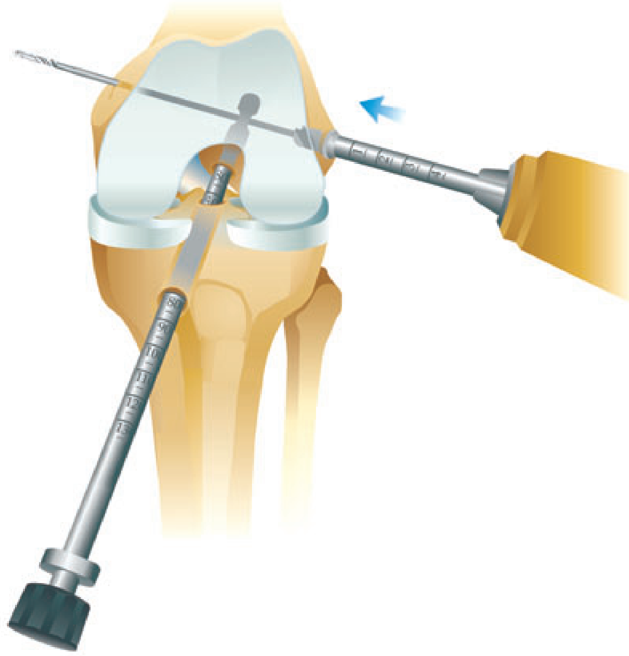

Figure 40–10. The lateral cortex is opened to 5 mm with a cannulated cortex broach. (Courtesy of Arthrex.)

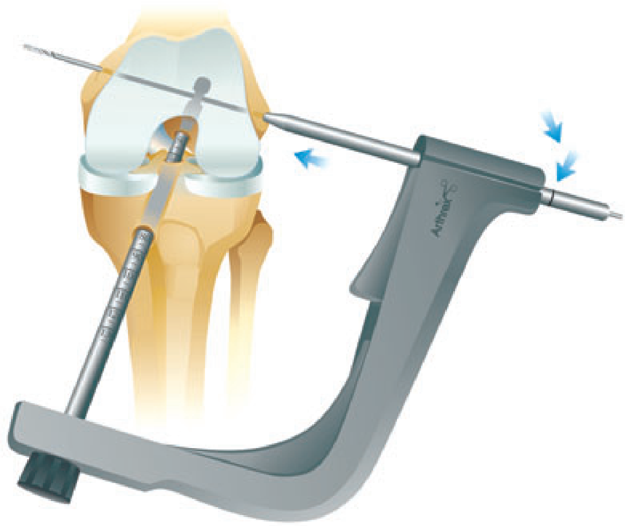

Figure 40–9. TransFix II femoral guide with a pin guide sleeve against the lateral femoral cortex and a 3-mm drill pin drilled across the femoral tunnel. (Courtesy of Arthrex.)

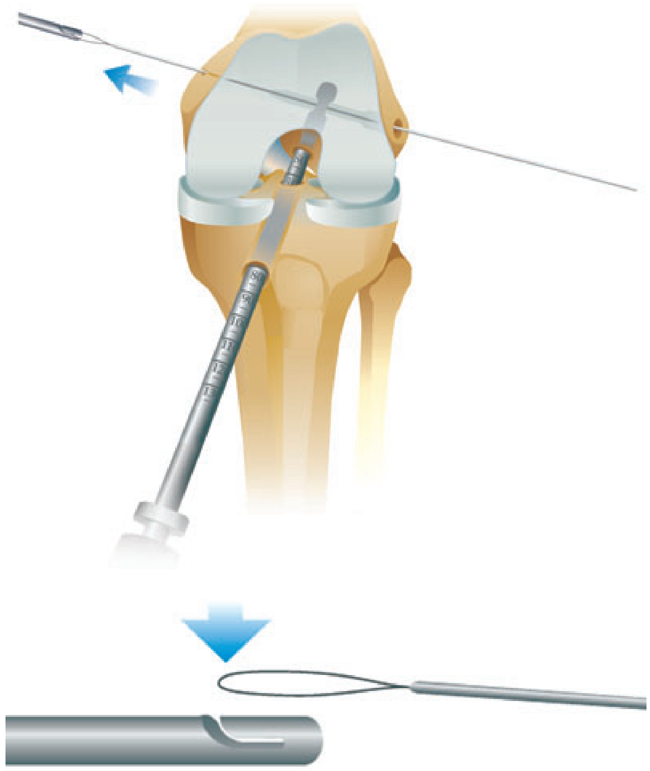

Figure 40–11. A nitinol wire is connected in the slot on the 3-mm drill pin and pulled across the femoral tunnel. (Courtesy of Arthrex.)

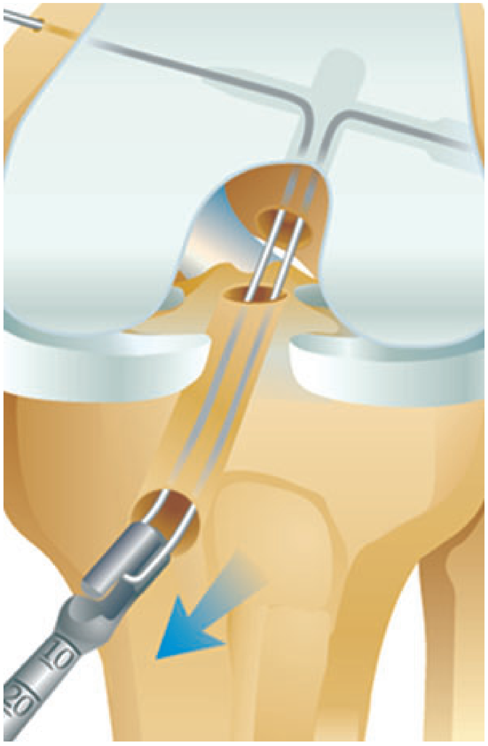

Figure 40–12. The TransFix II guide is retracted out of the knee, with a loop of the nitinol wire pulled out of the tibial tunnel. (Courtesy of Arthrex.)

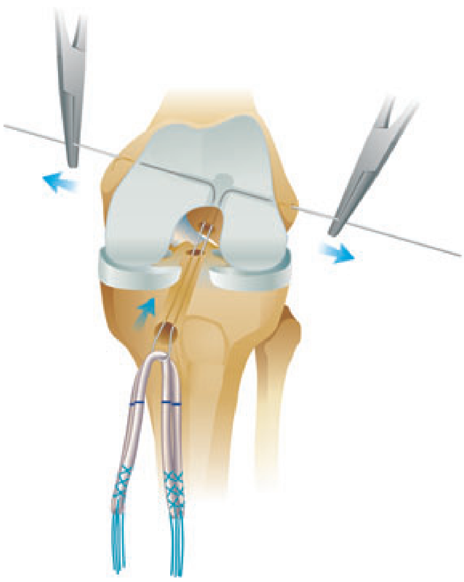

Figure 40–13. The semitendinosus and gracilis tendons are looped over the nitinol wire and pulled into place in the femoral tunnel by tensioning the nitinol wire both medially and laterally. (Courtesy of Arthrex.)

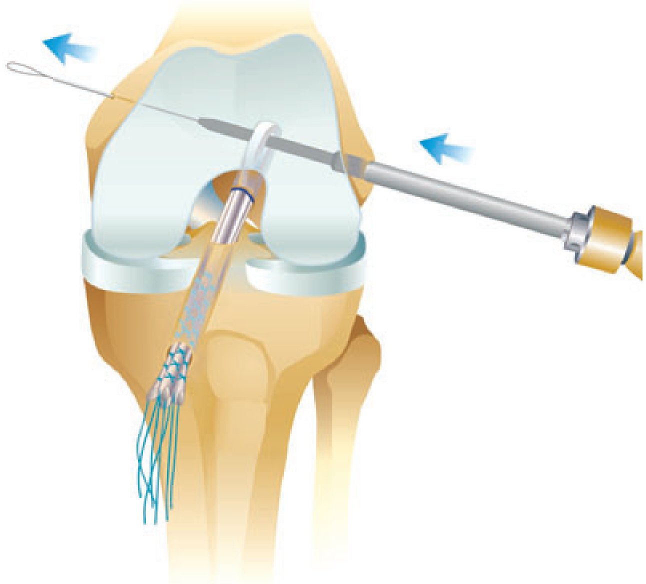

Figure 40–14. A TransFix dilator can be inserted over the nitinol wire to ensure proper graft positioning. (Courtesy of Arthrex.)

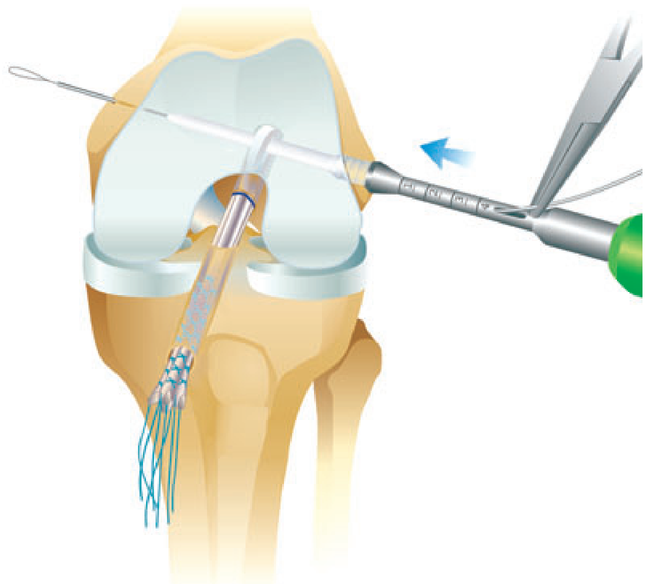

Figure 40–15. The Bio-TransFix implant is inserted over the nitinol wire and made to seat flush with the lateral femoral cortex. (Courtesy of Arthrex.)

ior of the graft with flexion and extension. Initial graft tension has been demonstrated to decrease with cyclic loading.[19,108] A recent study showed a 60% decrease in graft tension within 60 minutes after fixation and thus has called into question the ability of preconditioning of the graft to eliminate its intrinsic viscoelasticity.[108] Nevertheless, we continue to precondition and cycle the graft before tibial fixation. The knee is positioned between full extension and approximately 20 degrees of flexion. Tibial fixation is achieved by using the Mitek Intrafix device. The four-limb graft tie tensioner is connected to the limbs of the graft, and 25 lb of longitudinal tension is applied (Fig. 40–17). The tunnel is dilated with the Intrafix Sheath Trial

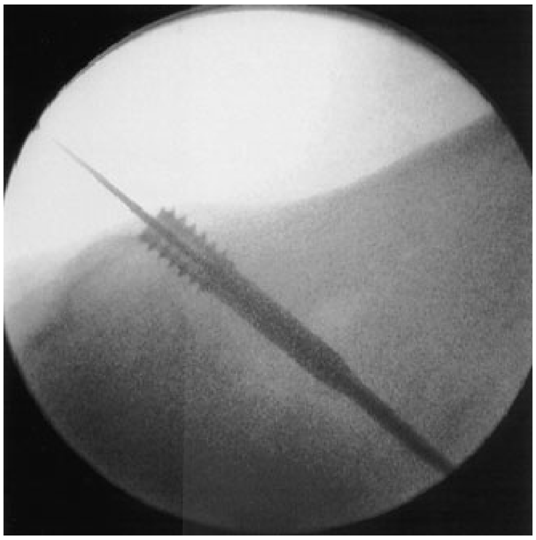

Figure 40–16. Fluoroscopic view of a metallic femoral cross-pin to ensure that the pin is adequately seated on the lateral femoral condyle.

Dilator (Fig. 40–18), and the 30-mm Intrafix tibial sheath is then inserted so that each limb of the graft is in one of the four quadrants (Fig. 40–19). A tapered polyethylene screw, an 8/10-mm tapered screw in most cases, is then inserted into the center of the sheath to compress the graft limbs against the sides of the tibial tunnel (Figs. 40–20 and 40–21).

The wounds are irrigated well and closed in layers, and a sterile dressing is applied. A range-of-motion brace and cold flow therapy are routinely used in all patients.

POSTOPERATIVE MANAGEMENT

ACL reconstructions are performed on an outpatient basis. Patients are encouraged to use the ice therapy unit as much as tolerable and to bear weight as tolerated with the use of crutches. Patients are instructed to change their dressing after 48 hours.

The excellent graft strength and fixation, as well as the lack of extensor mechanism disruption, allow patients to rehabilitate the knee aggressively. An accelerated rehabilitation program, originally described for use after ACL reconstructions with a patellar tendon autograft,[131-133] has been shown to be equally successful after ACL reconstructions with a hamstring graft.[68-70,89] In cases in which fixations are not as strong or stiff as the femoral TransFix or tibial Intrafix, aggressive and early return to sports may lead to postoperative laxity.[51] Unlimited range of motion, with an emphasis on full extension, and weightbearing are encouraged immediately postoperatively. Physical therapy is started at the 1-week postoperative visit. The goal of therapy is to allow a return to unlimited sporting activities by 4 to 6 months postoperatively. Our current postoperative rehabilitation protocol is shown in Table 40–2.

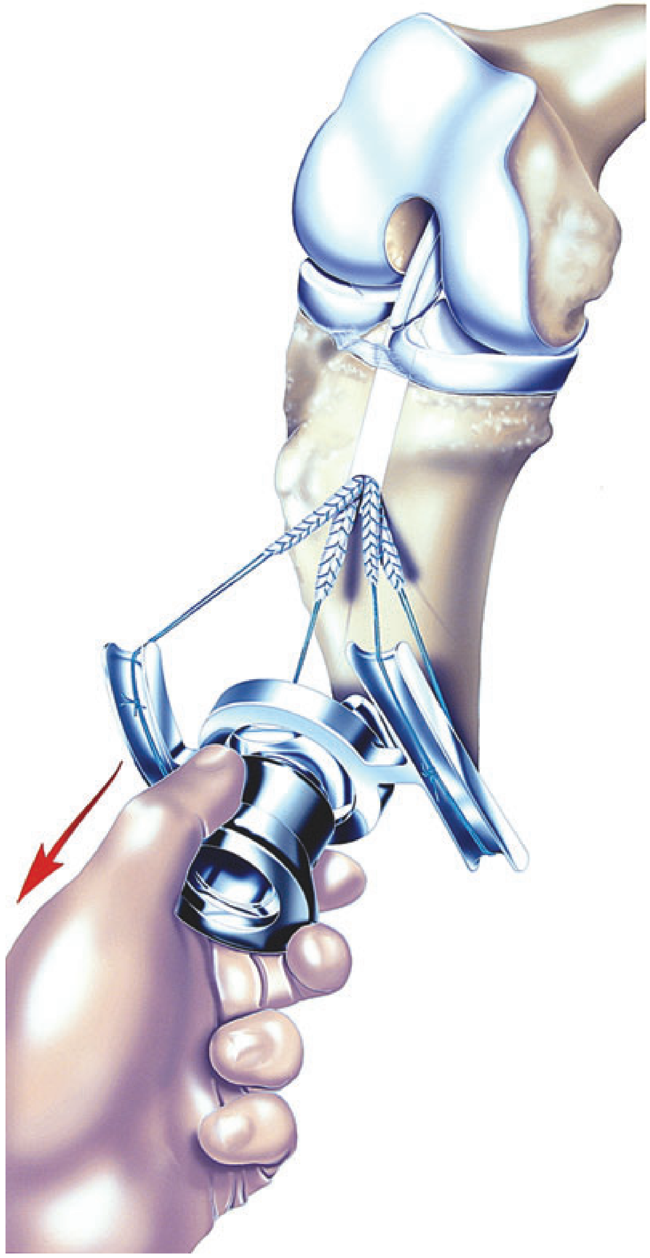

Figure 40–17. The four limbs of the graft are connected to the tie tensioner, and 25 lb of traction is applied. (Courtesy of Arthrex.)

COMPLICATIONS AND THEIR TREATMENT

Complications in ACL surgery can be classified as intraoperative complications (errors in technique) and postoperative complications. Intraoperative complications, such as improper tunnel placement, and postoperative complications, such as arthrofibrosis, motion problems, infection, hemarthrosis, injury to the infrapatellar branch of the saphenous nerve, and deep venous thrombosis, are not unique to ACL reconstructions with hamstring tendons and are not discussed in this chapter.

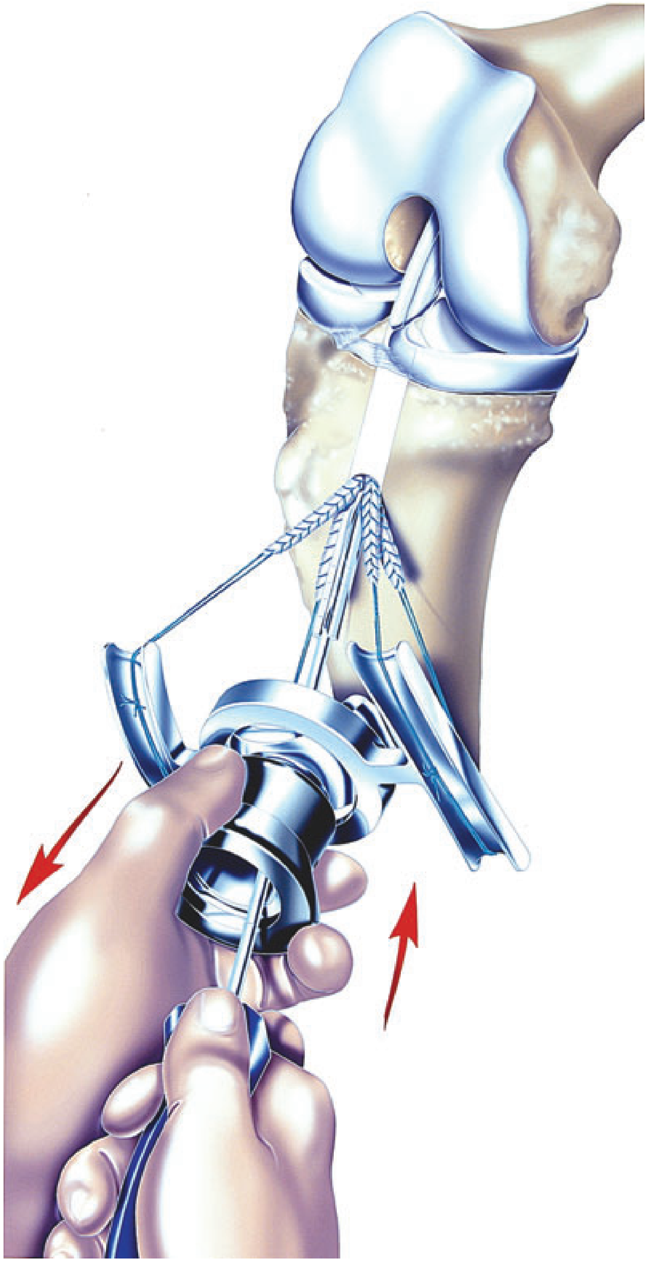

Figure 40–18. The tibial tunnel is dilated to 8 mm with the Intrafix Sheath Trial Dilator. (Courtesy of Mitek.)

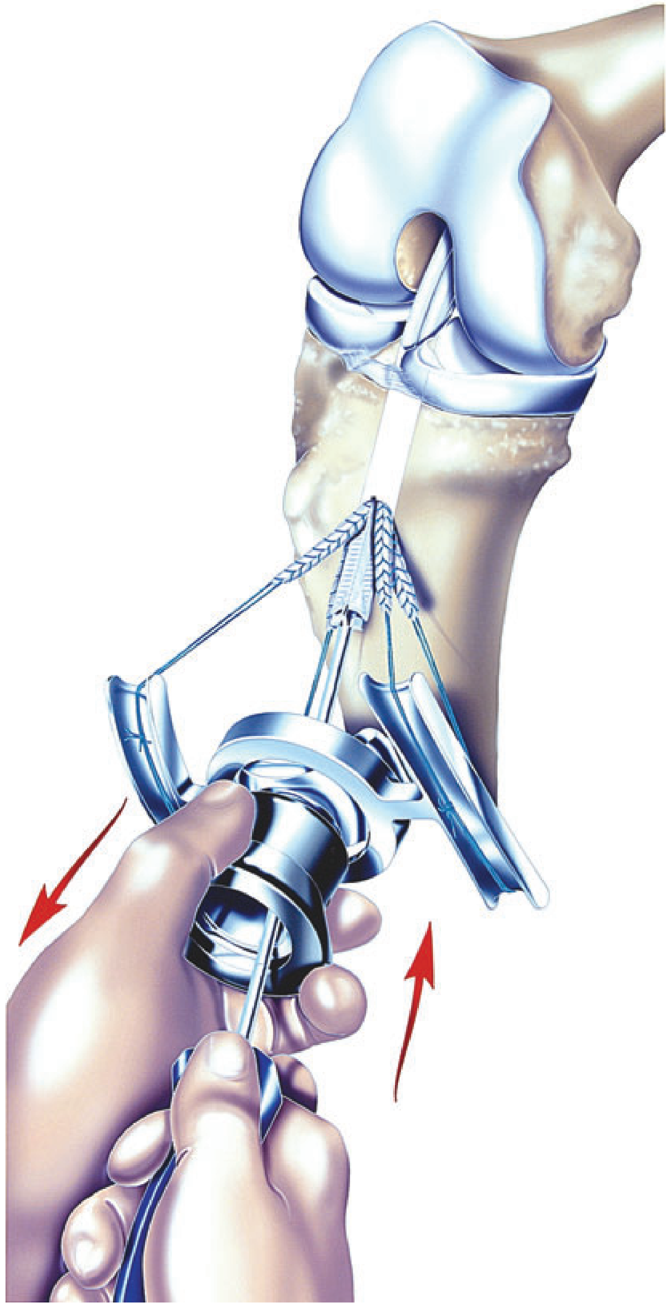

Figure 40–19. A 30-mm Intrafix tibial sheath is inserted into the tibial tunnel with one limb of the graft in each of the four quadrants. (Courtesy of Mitek.)

One of the most common complications seen in hamstring ACL reconstructions is that of premature amputation of the pes tendons because of the surgeon's failure to incise all extratendinous fascial bands (see Fig. 40–3). If these bands are not appreciated or recognized, the tendon stripper can take an aberrant path, and the tendons will be cut short of their muscle belly. If this occurs, the tendon can still be used in the reconstruction, provided that at least 12 cm of tendon is harvested, which is the minimum length that will allow the tendon to be doubled and still have at least 15 mm of graft in the femoral and tibial tunnels. Short grafts can be accommodated by using fixation devices with polyester tape (EndoButton, Acufex, Smith and Nephew, Mansfield, MA, or FastLok, Neoligaments, Ltd., Leeds, UK) or by using a fixation device that secures the graft in the femoral tunnel, such as a femoral cross-pin. A short graft can be accommodated on the tibial side by extending the graft with polyester tape woven through the tendons and secured onto the tibial cortex with FastLok or a similar device. Sutures and polyester tape are relatively elastic.[140] By incorporating these materials into the graft, the entire construct (fixation–polyester tape–graft–polyester tape–fixation) dramatically loses

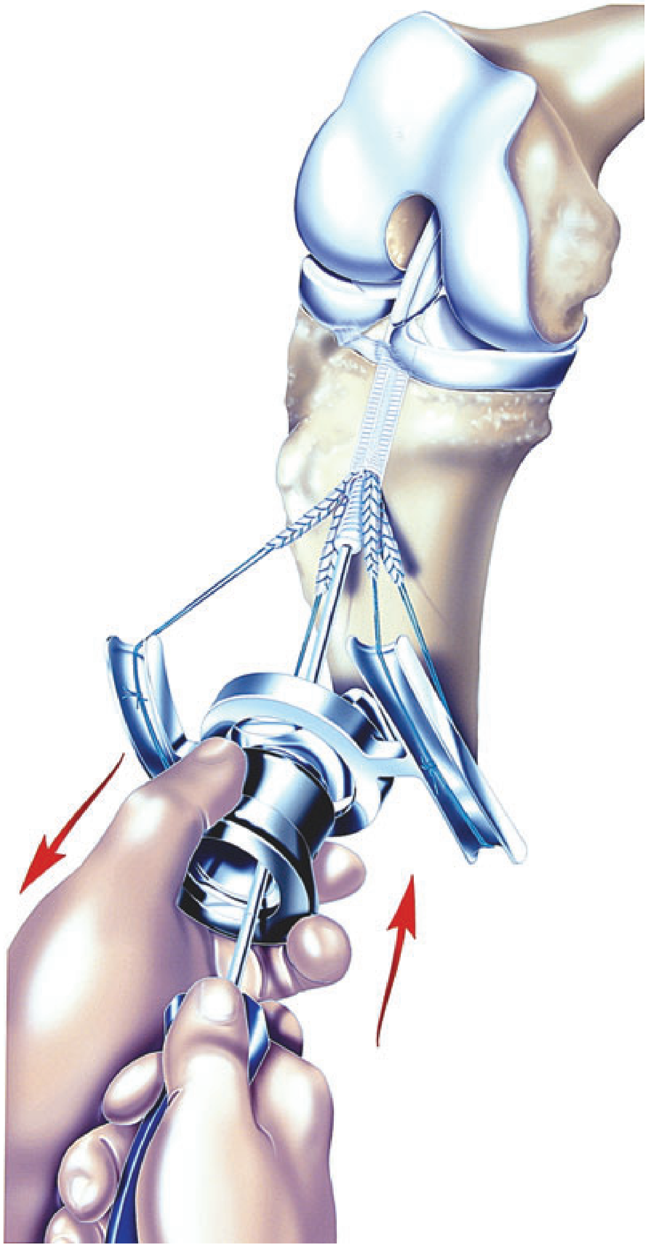

Figure 40–20. A tapered polyethylene screw in inserted into the center of the Intrafix sheath to compress the graft against the sides of the tunnel. (Courtesy of Mitek.)

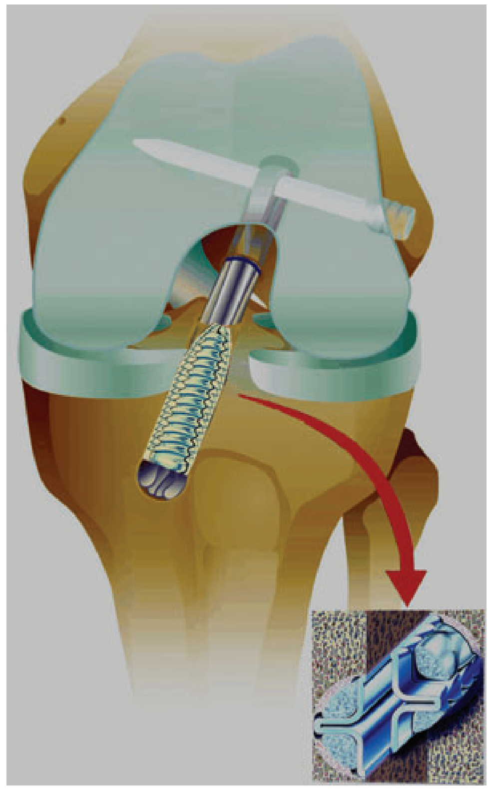

Figure 40–21. Final graft fixation in the femur and tibia. (Courtesy of Arthrex and Mitek.)

stiffness to the point that it may not withstand the force seen with full range of active motion and full weightbearing. Consideration should be given to modifying the postoperative rehabilitation protocol should this situation arise.

Failure of fixation, which includes loss and slippage, has been a concern of many of the surgeons who perform ACL reconstructions with hamstring tendons and probably the biggest reason that some surgeons are reluctant to change from the patellar tendon graft. Loss of fixation[42,43,58] and slippage of fixation[56,92,142] have been a problem only with fixations that relied on a polyester suture or tape interface with the tendon graft. The BioTransFix femoral fixation technique and the tibial fixation technique of Intrafix avoid the suture/tape interface and, as such, are strong enough to withstand the force seen during activities of daily living. In addition, these fixation methods are less susceptible to graft slippage during these applied loads.[6,42,46,79] All ACL surgeons, however, must be familiar with various fixation options, including the suture post, screw/washer devices, FastLok, and others, should the primary fixation method prove to be unsatisfactory during the procedure. Failure of fixation can occur in the femoral tunnel if the surgeon plans to use a soft-tissue interference screw and the posterior wall of the femoral tunnel is disrupted (back wall blowout). If such disruption occurs, the surgeon must be familiar with the cross-pin technique, the EndoButton technique, and the two-incision technique to allow for fixation on the femoral cortex.

Another theoretical concern of ACL reconstructions with hamstring tendons is that of postoperative hamstring weakness. Some authors[86,91,156] have demonstrated that postoperative hamstring weakness is of little functional significance, whereas others[27,36,143] have shown persistent knee flexor weakness postoperatively. Regrowth of the semitendinosus has been reported to occur,[53,83,143] and the regenerate tendon may have an effect on minimizing postoperative weakness. Several recent articles[1,98,110,143,144] have suggested that the peak flexion torque and total work performed are not different from that in the nonoperative limb postoperatively. However, the flexion angle at peak torque is shifted to a shallower angle. From a practical standpoint, patients may complain of knee flexor weak-

Table 40–2. Hamstring ACL Reconstruction Rehabilitation Protocol

GOALS	EXERCISES
Phase I (Initial 2 Weeks Postoperatively)	
Alleviate pain/inflammation	ROM, PROM positioning for knee extension
Full, symmetric extension by 1 week	Hamstring stretch
90 degrees of flexion by 1 week	Heel slides/wall slides without brace
Weightbearing as tolerated with crutches	1/2 revolutions on nonresistant bicycle
Discard crutches at 2 weeks	Patellar/soft-tissue and scar mobilization Multiple-angle closed-chain isometrics Prone knee flexion Theraband to ankle 4-quadrant hip exercises (weight above knee) Standing weight shifts and minisquats (0-30) Electrical stimulation as needed
Phase II (2-6 Weeks Postoperatively)	
Decrease swelling/prevent quadriceps atrophy	Continue PROM at 0-125 degrees, emphasis on full extension
Full symmetric extension	Continue phase I exercises
Flexion to 125 degrees	Stairmaster/Nordic Track at 2-3 weeks
Increase quadriceps/hamstring strength	Leg press
Increase hip strength	Trampoline and BAPS board for balance Electrical stimulation as needed Continue closed kinetic chain exercises Calf raises Pool therapy at 3 weeks Hinged brace for prolonged ambulation
Phase III (6 Weeks to 4 Months Postoperatively)	
Full, symmetric ROM	Continue phase II exercises
Independent ambulation without brace	Increased closed kinetic chain rehabilitation (step-ups, minisquats) Increase proprioception training (sport cord, body blade, Plyoballs) Light jogging at 3 months
Phase IV (4 Months to Full Activity)	
Development of strength, power, and endurance	Continue strengthening exercises
Prepare for return to full activity	Initiate hard running and agility drills
Begin sport-specific training	Sport-specific training and drills Return to full sports at 5-6 months

BAPS, biomechanical ankle platform system; PROM, passive range of motion; ROM, range of motion.

ness in activities that require high flexion angles, such as removing a cowboy boot. Persistent weakness in internal rotation has also been reported.[9,127,148] The clinical implications of internal rotation weakness have not been determined.

Tunnel expansion and widening appear to occur universally after ACL reconstruction with autogenous hamstring tendons[33,52,73,84,88,154] and to a greater degree than seen with the use of autogenous patellar tendon grafts.[33] Expansion of the femoral tunnel diameter by up to 77% and the tibial tunnel diameter by up to 42% has been reported.[33,88] Tunnel expansion, however, has not been shown to correlate with outcome[33,52,73,84,88,154] and occurs despite the presence or absence of aperture fixation.[88] Magnetic resonance imaging studies have shown that this tunnel expansion is due, in part, to an accumulation of periligamentous tissue around the graft.[73] Although tunnel expansion does correlate with outcome, it can be a treatment challenge in patients who require a revision ACL reconstruction.

The final complication that can occur after ACL reconstruction with the semitendinosus and gracilis tendons is that of graft failure. Graft failure is usually due to improper tunnel placement, tension, or fixation. However, the surgeon can expect an approximately 2% retearing rate per year after reconstruction, even when the procedures are performed satisfactorily.[130] Freedman and colleagues' meta-analysis of hamstring and patellar tendon grafts showed graft failure to be less common in patellar tendon patients.[49] A recent article by Williams[154] reported a 11% failure rate at a mean of 28 months' follow-up, 7% of which were thought to be due to traumatic reinjury/tearing of the graft and 4% not due to any further trauma. Toritsuka et al[146] reported on the findings of second-look arthroscopy 5 to 51 months after ACL reconstruction with a hamstring graft. They found that although all patients were considered a clinical success, 11% of the grafts showed evidence of laxity and 34% had partial tearing.[146]

Graft failure because of technical error can occur for a variety of reasons, including graft impingement on the roof or lateral sidewall of the notch and improper tunnel placement leading to overtension in the graft. It is important for the surgeon to check pin placement before drilling the tibial and femoral tunnels. It is also important to check that there is ample clearance for the tibial guide pin from the roof and lateral sidewall when the knee is fully extended. A roofplasty and lateral notchplasty should be performed if there is any concern of graft impingement. However, graft impingement should not be a common problem, provided that the tibial and femoral tunnels are properly placed. As mentioned, the tibial tunnel should be in the center of the ACL footprint, approximately 5 to 8 mm anterior to the posterior cruciate ligament and 70 to 80 degrees in the coronal plane. The femoral tunnel should be at the 10-o'clock (right knee) or 2-o'clock (left knee) position and should have a posterior wall 1 to 2 mm thick.

SUMMARY

ACL reconstruction is a common procedure in the orthopedic community and is successful in restoring anterior stability to the knee in 75% to 90% of patients. ACL reconstruction with hamstring tendons is an excellent surgical option for most patients. The hamstring graft has many advantages, including strength, stiffness, and relative lack of donor site morbidity. Hamstring graft fixation with a femoral cross-pin (Bio-TransFix) and an interference screw/sheath device (Intrafix) on the tibial side is a strong and stiff ACL construct that easily allows patients to begin an aggressive rehabilitation program immediately postoperatively.

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