Principles for Using Hamstring Tendons for Anterior Cruciate Ligament Reconstruction

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HISTORY

Hamstring tendons continue to gain in popularity as a graft source for anterior cruciate ligament (ACL) reconstruction. The excellent biomechanical properties of the double-looped hamstring (DLHS) graft, low harvest morbidity, improved fixation, and multiple level I and level II evidence from clinical studies demonstrating outcomes equal to those obtained with other autogenous graft sources used for ACL reconstruction provide numerous reasons for this gain in popularity [1–6]. Previous clinical outcome studies showing that knees with hamstring grafts were inferior to knees with bone-patella tendon-bone (BPTB) graft ACL reconstruction might have resulted from poor fixation and the use of single-bundle or single-looped graft constructs. Several biomechanical studies have shown that the DLHS graft is two times stronger and stiffer than a 10-mm autogenous BPTB graft [7,8]. With the advent of newer fixation devices designed specifically for the DLHS graft and with tunnel placement techniques designed to prevent graft impingement, functional outcomes and stability using autograft hamstring tendons have been improved. No study to date demonstrates a superiority of any graft source for ACL reconstruction in terms of stability and functional outcomes, but many believe that the morbidity of hamstring graft harvest is less than the morbidity of BPTB harvest [6,9,10]. The incidence of anterior knee pain, knee extension loss, kneeling pain, and arthritis have been demonstrated to be statistically greater with BPTB grafts than with DLHS grafts used for ACL reconstruction [3,11]. A recent prospective study of two groups equally matched in demographics,
meniscal tears, and cartilage injury and with a minimum 5-year follow-up demonstrated a statistically higher incidence of osteoarthritis of the knee in patients who had a BPTB graft (50%) than in patients who had a DLHS graft (17%) for ACL reconstruction [3]. The study found no differences in stability and functional outcomes between the two groups. It remains unknown if longer follow-up of patients who have had DLHS ACL reconstruction will demonstrate an incidence of osteoarthritic changes similar to that seen in patients who have BPTB autografts. Nonetheless, autograft hamstring tendons remain an excellent graft source for ACL reconstruction while minimizing graft-harvest morbidity.

OVERVIEW OF STRUCTURAL PROPERTIES OF FIXATION DEVICES

Despite the excellent biomechanical properties of autogenous hamstring tendons and the low morbidity associated with hamstring harvest, sound fixation of soft tissue grafts for ACL reconstruction is paramount to ensure good stability and functional outcomes. Fixation devices should resist slippage under cyclical load, provide high stiffness and high strength, and promote biologic healing of the graft to the tunnel wall so that aggressive rehabilitation can be initiated safely. The healing of a soft tissue graft to a bone tunnel takes longer than the healing of a bone-plug graft [12]. Therefore, soft tissue graft-fixation devices must maintain their structural properties for resistance to slippage, stiffness, and strength for longer periods of time, because the hamstring graft and the fixation together function as the ACL until a secure attachment is formed between the graft and bone. Surgeons need to know the structural properties of both tibial and femoral soft tissue fixation devices available to determine the optimum fixation of a soft tissue graft and ensure excellent outcomes.

Tibial Fixation

The weakest biomechanical link of any ACL reconstruction is the tibial fixation. Therefore the device used for tibial fixation is the more important fixation device and determines the properties of a soft tissue ACL construct. The WasherLoc (Arthrotek/Biomet, Warsaw, Indiana), interference screws, Intrafix (Depuy Mitek, Raynham, Massachusetts), CentraLoc (Arthrotek/Biomet, Warsaw, Indiana), bone staples, and suture posts have all been used for tibial soft tissue graft fixation. The authors prefer to use the WasherLoc device exclusively for tibial fixation, based on biomechanical testing and clinical outcomes. The WasherLoc is a screw and washer device designed to achieve distal intratunnel fixation using lag screw fixation to cortical bone. The distal intratunnel position gives the screw and washer a low profile, thereby significantly reducing the need for hardware removal because of prominence. The 13 tines of the washer penetrate the tendon graft, and the lag screw compresses the washer and graft against the corticocancellous bone of the posterior wall of the tibial tunnel. The WasherLoc hamstring graft construct has high strength (905 newtons [N]), stiffness (248 N/mm), and resistance to graft slippage under
cyclical load conditions when tested in human cadaveric bone [13]. The WasherLoc fixation of a DLHS graft is the only tibial fixation device that approximates the biomechanical properties of the native ACL when tested in human bone [14]. In addition, when tested in an in vivo animal model, WasherLoc fixation of a soft tissue graft maintains its biomechanical properties over time and promotes biologic healing of the graft–bone tunnel interface, a stark contrast to interference screw fixation of a soft tissue graft [15]. Another advantage of the WasherLoc is that the device allows bone grafting of the tibial tunnel, which eliminates voids, increases stiffness, enhances tendon–bone tunnel healing, and prevents tunnel widening [16–18]. Finally, the structural properties of the WasherLoc and its performance in vivo ensure safe use of aggressive rehabilitation and an early return to sports at 4 months with high clinical success [19].

Femoral Fixation
Numerous femoral fixation devices designed specifically for hamstring ACL reconstruction exist for soft tissue ACL graft fixation. Cross-pin devices such as the EZLoc (Arthrotek/Biomet, Warsaw, Indiana), Bone Mulch Screw (Arthrotek/Biomet, Warsaw, Indiana), RigidFix (Depuy Mitek, Raynham, Massachusetts), and Transfix (Arthrex, Naples, Florida) devices afford better ultimate tensile failure load and stiffness data than other types of femoral fixation such interference screw fixation, EndoButton (Smith and Nephew; Andover, Massachusetts), and suture posts. For femoral fixation, the authors prefer the EZLoc fixation device because of the device’s biomechanical properties and its ease of use. The EZLoc provides high strength and stiffness fixation with minimal slippage under cyclical loading conditions. The strength of the EZLoc is greater than 1400 N tested on the bench top. The stiffness of the EZLoc implant fixed in human bone is high because the device is seated directly against cortical bone. The slippage of the implant and graft therefore should be negligible, because the graft is looped directly over the cross-pin of the device, avoiding the use of any linkage material. Avoiding the use of linkage material improves the stiffness of fixation while minimizing graft motion in the bone tunnel during biologic healing to the tunnel wall. The properties of the EZLoc device allow the safe use of an aggressive rehabilitation protocol. The EZLoc also affords the surgeon the ability to confirm 100% graft capture by the fixation device. The graft is passed through the cross-pin loop of the EZLoc outside the patient before tunnel graft passage. With other cross-pin devices such as the RigidFix and Transfix, “blind” graft passage and fixation must be performed with no guarantee of complete graft capture and with the added possibility of graft laceration and damage [20]. Without complete graft capture or with graft damage, the functional cross-sectional area of the graft tissue is diminished, resulting in a weaker graft fixation construct. The EZLoc also allows the surgeon to tension all four bundles of a soft tissue graft equally. Because the grafts are pulled individually over the cross-pin, all graft bundles can be tensioned equally, maximizing the properties of the graft tissue. Finally,
the EZLoc can help promote the biologic healing of a soft tissue graft to the bone tunnel by allowing a snug fit of the graft in the bony tunnel. The EZLoc allows sizing of the graft and femoral tunnel so that the snugness of fit can be optimized at the time of graft sizing.

**TUNNEL PLACEMENT**

Precise tunnel placement is the single most important technical issue associated with outcomes of ACL reconstruction. No graft source, fixation, or rehabilitation protocol can overcome the complications associated with poor tunnel placement. Poor tunnel placement can lead to roof impingement, posterior cruciate ligament (PCL) impingement, and abnormal tensile graft forces. Complications of impingement lead to loss of knee motion with increased graft laxity and instability. The best treatment for avoiding complications associated with impingement is prevention.

Numerous tunnel techniques exist for femoral and tibial tunnel placement for ACL reconstruction. Transtibial, transportal, and two-incision techniques are used for tunnel placement, and successful outcomes have been documented for each. Tunnel placement, however, is more exacting for a hamstring graft because the intra-articular cross-sectional area of collagen is greater for a hamstring graft than for a BPTB graft. It also is important for surgeons to realize that the anatomy of graft sources cannot duplicate the native anatomic insertion site of the ACL; surgeons can, however, duplicate the anatomic intra-articular ACL position with the ACL graft. The authors prefer the transtibial technique for tunnel preparation, using a tibial guide (65° guide, Arthrotek, Warsaw, Indiana) that references the bone of the intercondylar roof with the knee in full extension and the use of size-specific femoral aimers through the tibial tunnel for femoral tunnel positioning. The 65° guide seats in the intercondylar notch with the knee in full extension. The guide takes into account the variability of intercondylar roof angles and knee extension that exists in individual patients, enabling surgeons to customize the position of the ACL graft for any given patient. The 65° guide therefore serves to position the ACL graft posterior and parallel to the intercondylar roof when the knee is in full extension, duplicating the anatomic position of the native ACL. Multiple studies have demonstrated the validity and reliability of tibial tunnel placement within the native ACL tibial footprint while positioning the graft posterior and parallel to the intercondylar roof and avoiding roof impingement [21,22]. Roof impingement is the result of too anterior a position of the tibial tunnel leading to an error in sagittal-plane positioning of the tibial tunnel. Roof impingement leads to increased knee laxity, graft failure, knee effusions, anterior knee pain with attempted terminal extension, and flexion contractures [23,24].

With the transtibial tunnel technique, surgeons focus on precise positioning of one tunnel: the tibial tunnel. Surgeons then rely on the position of the tibial tunnel in the sagittal and coronal planes to help determine the position of the femoral tunnel. Thus, the critical tunnel is the tibial tunnel. The position of the
femoral tunnel in the sagittal and coronal planes determines tensile graft behavior and is essentially automatic once the tibial tunnel is positioned properly. Posterior femoral tunnel placement in the sagittal plane is achieved consistently using size-specific femoral aimers through the tibial tunnel. With the transtibial tunnel technique, the tibial tunnel must be positioned between the tibial spines at an angle of 60° to 65° in the coronal plane to establish tensile graft behavior similar to that of the native ACL and to avoid PCL impingement [25]. An error in coronal plane positioning of the tibial tunnel thus leads to an error in coronal-plane positioning of the femoral tunnel, because little change can be made in the coronal plane when positioning the femoral tunnel using the tibial tunnel. The 65° guide includes a coronal alignment rod to increase the accuracy of tibial tunnel positioning in the coronal plane [26]. Tibial tunnels positioned too vertically in the coronal plane or too medial in the tibia lead to PCL impingement and abnormal tensile graft behavior when a transtibial tunnel technique is used. PCL impingement is the result of an error in coronal-plane positioning of the tibial tunnel and leads to loss of knee flexion and increased graft laxity and instability [26].

Surgery

Patient Positioning

The patient is positioned supine on the operating table. After induction of anesthesia, an examination under anesthesia is performed. A tourniquet is placed around the proximal thigh of the operative leg. The operative leg is placed in a standard knee arthroscopy leg holder with the foot of the operating table flexed completely. Alternatively, the surgeon may decide to use a lateral post instead of a leg holder. The contralateral leg is positioned in a gynecologic leg holder with the hip flexed and abducted with mild external rotation (Fig. 1). Proper padding is used to ensure that no pressure is placed on the peroneal

Fig. 1. Preferred patient set-up.
nerve and calf. Alternatively, surgeons can position the operative leg flexed over the side of the table using a lateral post and maintaining the contralateral leg extended on the operating table.

Preferred Surgical Technique

**Tendon harvest**

After sterile prep and drape, the leg is exsanguinated, and the tourniquet is inflated. A 2- to 3-cm incision is made along the anteromedial crest of the tibia centered three fingerbreadths below the medial joint line (Fig. 2). The incision should be positioned posterior enough on the anteromedial tibia so that the tip of the gloved finger reaches the popliteal crease medially (Fig. 3). A vertical incision allows the surgeon a more extensile incision should it be necessary to lengthen the incision for ease of hamstring harvest. Alternatively, oblique and horizontal incisions can be used. The incision is taken down sharply through the skin and subcutaneous fat to the sartorius fascia. The hamstring tendons are palpated, and the sartorius fascia is incised horizontal and parallel to the inferior border of the gracilis tendon. A finger is passed in the proximal direction deep to the sartorius fascia along the gracilis tendon. The finger is flexed to capture the gracilis tendon. A Penrose drain is looped around the tendon, and any fascial slips are released from the gracilis. The gracilis tendon is stripped from its musculotendinous junction using a blunt tendon stripper. The gracilis tendon is pulled, and the semitendinosus tendon is identified along the inferior border of the gracilis. An additional Penrose drain is looped around the semitendinosus tendon. Any fascial slips to the medial gastrocnemius originating from the inferior border of the semitendinosus tendon are identified and

**Fig. 2.** Hamstring tendons generally are three fingerbreadths below the medial joint line.
The tendon then is stripped using an open-ended tendon stripper. The tendons are prepared by stripping the muscle from the tendon using scissors or a broad periosteal elevator. A stitch of the surgeon’s choice is placed in the end of each tendon. The tendons are double-looped and sized using sizing sleeves (Fig. 4). The tendons should slide freely through the sizing sleeve. The tendons are removed subperiosteally from the anterior tibial crest at their common tendinous insertion including 5 to 10 mm of periosteum. A stitch of the surgeons’ choice is placed in the common tendinous insertion. The tendons are stored in the sizing sleeve along with a damp sponge in a kidney basin on the back table. The kidney basin is covered with an occlusive plastic sheet to ensure the safety of the graft on the back table (Fig. 5).
Portal placement

Inferolateral and inferomedial portals touching the edges of the patella tendon, starting 1 cm distal to the inferior pole of the patella, are established. Alternatively, a transpatellar inferolateral portal can be used with a medial portal placed along the medial border of the patella tendon. The medial portal must touch the edge of the patella tendon because, if it is placed more medially, the tibial guide may not stay seated in the intercondylar notch with the knee in full extension. An optional outflow portal can be established superiorly.

A diagnostic arthroscopy is performed. Meniscal or articular cartilage injuries are treated. The torn remnant ACL stump is identified and removed. It is not necessary to denude the tibial insertion of the native ACL tissue. In fact, retaining the insertion of the native ACL helps seal the edges of the ACL graft at the joint line and does not result in roof impingement if the tibial tunnel has been positioned appropriately. Synovium and soft tissue in the notch are removed to expose the lateral edge of the PCL (Fig. 6). Any of
the ACL origin from the over-the-top position is removed using an angled curette and shaver.

**Tibial tunnel placement**

The tibial guide is inserted through the medial portal. The guide is advanced into the intercondylar notch (Fig. 7). The tip of the guide is 9.5 mm wide. If the guide makes contact with and deforms the PCL as it enters the intercondylar notch, a lateral wallplasty is performed by removing bone in slivers 1 to 2 mm wide from the lateral wall until the tip of the guide passes into the notch without deforming the PCL. This technique creates an area wide enough for a graft 8 to 10 mm wide. No bone should be removed from the intercondylar roof, because the roof anatomy is crucial for proper positioning of the tibial guide pin in the sagittal plane using the 65° tibial guide. The lateral wallplasty fragments are removed.

The 65° tibial guide is inserted through the anteromedial portal that touches the medial edge of the patella tendon into the intercondylar notch between the PCL and lateral femoral condyle to ensure the notch is wide enough for the ACL graft (see Fig. 7). The knee then is extended fully (Fig. 8). The surgeon should determine arthroscopically that the tip of the guide is captured inside the notch and that the arm of the 65° tibial guide contacts the trochlea groove (Fig. 9). The patient’s heel is placed on a Mayo stand to maintain the knee in maximum hyperextension. The surgeon stands on the lateral side of the leg and inserts the coronal alignment rod through the proximal hole in the guide. The 65° guide is rotated in varus and valgus until the coronal alignment rod is parallel to the joint and perpendicular to the long axis of the tibia. The combination bullet guide/hole changer is inserted into the 65° guide, and the bullet is advanced until it is seated against the anteromedial cortex of the tibia (Fig. 10). The guide then is lifted up while the knee is pushed into hyperextension and the coronal alignment rod parallel to the joint is maintained (see Fig. 10).

*Fig. 7. The 65° guide positioned in the intercondylar notch.*
The tibial guide pin is drilled through the lateral hole in the bullet until it strikes the guide intra-articularly. The bullet from the tibial guide is removed, and the guide is taken out of the notch. The guide pin is tapped into the notch and to assess its position (Fig. 11).

The tibial guide pin is positioned properly in the coronal plane when it enters the notch midway between the lateral edge of the PCL and the lateral femoral condyle. The guide pin should not touch the PCL (see Fig. 11). The tibial guide pin is positioned properly in the sagittal plane when there is 2 to 3 mm of space between the guide pin and the intercondylar roof with the knee in full extension. This space can be assessed by manipulating a nerve hook probe 2 mm wide between the between the guide pin and the intercondylar roof in the fully extended knee.
The tibial tunnel is prepared by reaming the tibial cortex with a reamer with the same diameter as the prepared ACL graft. A bone dowel is harvested from the tibial tunnel by inserting a bone dowel harvester and centering rod 8 mm in diameter over the tibial guide pin. A mallet is used to drive the bone dowel harvester until it reaches the subchondral bone. The dowel harvester containing the cancellous bone dowel is removed. If the tibial guide pin is removed with the bone dowel, it should be replaced by inserting it through an 8-mm reamer that has been reinserted into the tunnel created by the bone dowel harvester. The remainder of the tibial tunnel is reamed with the appropriate diameter reamer.

PCL impingement is checked by placing the knee in 90° of flexion and inserting the impingement rod into the notch. A triangular space at the apex of the

![Fig. 10. (A) External view of 65° guide adjusted with the coronal alignment rod parallel to the knee joint. (B) External view of guide held in proper position by the surgeon during drilling of the tibial guide pin.](image)

![Fig. 11. Assess guide pin position. Note the entry of tibial guide pin below the remnant of ACL footprint tissue.](image)
notch and no contact at the base of the notch between the PCL and impingement rod confirms the absence of PCL impingement (Fig. 12). Roof impingement is checked by placing the knee in full extension and inserting an impingement rod the same diameter as the tibial tunnel into the intercondylar notch (see Fig. 12). Free pistoning of the impingement rod in and out of the notch with the knee in full extension confirms the absence of roof impingement.

**Femoral tunnel placement**

The femoral tunnel is placed using the transtibial technique. The size-specific femoral aimer is inserted through the tibial tunnel with the knee in flexion. The size of the offset of the femoral aimer is based on the diameter of the ACL graft and is designed to create a femoral tunnel with a 1-mm back wall. The knee is extended, and the tip of the femoral aimer is hooked in the over-the-top position. The knee is allowed to flex, using gravity, until the femoral guide seats on the femur. The femoral aimer is rotated a quarter turn lateral away from the PCL, which positions the femoral guide pin farther down the lateral wall of the notch, minimizing PCL impingement. A pilot hole in the femur is drilled through the aimer, and both the guide pin and femoral aimer are removed (Fig. 13).

The femoral guide pin is redirected to shorten the femoral tunnel from 35 to 50 mm in length, using the following technique. The femoral guide pin is reinserted into the pilot hole, and the knee is flexed to $90^\circ$ to $100^\circ$. The guide pin is drilled through the lateral femoral cortex. A cannulated 1-inch reamer the same diameter as the ACL graft is passed over the guide pin. The femoral tunnel is reamed. The surgeon should confirm that the back wall of the femoral tunnel is only 1 mm thick (Fig. 14) and that the center of the femoral tunnel is midway between the apex and base of the lateral half of the notch. A femoral tunnel placed correctly down the sidewall does not allow room for a second

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**Fig. 12.** The position of the impingement rod in the intercondylar notch.
posterolateral tunnel. Finally, the length of the femoral tunnel should be measured using the transtibial tunnel depth gauge (Fig. 15).

**Preparing the WasherLoc**

The distal aspect of the tibial tunnel is exposed by removing a thumbnail portion of the surrounding soft tissue and periosteum. The counterbore aimer is inserted into the tibial tunnel. The guide is rotated to aim toward the fibular head. The counterbore awl is impacted to create a pilot hole in the tibial tunnel (Fig. 16). The anterior tibial tunnel is drilled using the counterbore reamer seated in the pilot hole and aimed toward the fibular head. The anterior distal tibial tunnel is reamed until flush with the posterior wall of the tibial tunnel (Fig. 17). The surgeon should not ream deeper than the posterior wall into the tibia. The bone from the flutes of the reamer is saved for bone grafting.

**Fig. 13.** The femoral aimer inserted through tibial tunnel with the femoral guide pin advanced into femur.

**Fig. 14.** Femoral tunnel position posterior with posterior wall 1 to 2 mm thick.
**EZLoc sizing and insertion**

The EZLoc femoral fixation device is available in two diameters and three lengths to maximize fixation on the cortical bone and optimize bone tunnel surface area and graft length. For femoral tunnels of 7 or 8 mm in diameter, the 7/8 EZLoc device is used, and for femoral tunnels 9 or 10 mm in diameter, the 9/10 EZLoc device is used. For femoral tunnel lengths of 35 to 50 mm, as determined by depth gauge measurement, a “standard” length implant is chosen. For femoral tunnel lengths less than 35 mm, a “short” length implant is

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**Fig. 15.** Depth gauge showing femoral tunnel length.

**Fig. 16.** Counterbore awl creates pilot hole in distal tibial tunnel aimed toward fibular head. (From Lawhorn KW, Howell SM. Scientific justification and technique for anterior cruciate ligament reconstruction using autogenous hamstring tendons and allogeneic soft tissue grafts. Orthop Clin North Am 2003;34(1):25.)
used, and for femoral tunnel lengths greater than 50 mm, a “long” implant is used.

With the appropriate sized EZLoc device chosen, the passing pin connected to the EZLoc is inserted into the tibial tunnel and out of the femoral tunnel under arthroscopic visualization. The passing pin is pulled out the lateral thigh until the EZLoc implant is just outside the tibial incision and tibial tunnel entrance. The graft is passed through the loop of the EZLoc device. Alternatively, the graft can be passed through the device before the passing pin is inserted into the tibia and femoral tunnels. The ends of the graft are made even, and the sutures from the ends of the tendons are tied together. The distal aspect of the gold lever arm of the EZLoc is measured with a ruler, and a measurement corresponding to the length of the femoral tunnel is marked on the graft with a pen. This mark will ensure the EZLoc has passed lateral and proximal to the most proximal aspect of the femoral tunnel. The EZLoc is pulled into the joint and oriented so that the gold lever arm enters the femoral tunnel along the lateral wall of the tunnel (Fig. 18). Once the marked portion of the graft enters the femoral tunnel, the suture on the EZLoc and passing pin is cut. The passing pin is removed, and tension is pulled on the Ezloc suture, deploying the lever arm. The graft strands are tensioned, and the graft/EZLoc device is rocked
back and forth to ensure the EZLoc is seated on the cortical bone of the lateral femur. The knee is cycled 20 to 30 times while tension on the graft is maintained.

**WasherLoc tibial fixation**

After cycling, the knee is positioned in full extension. All graft sutures are tied together, and an impingement rod is passed through the suture loops. The WasherLoc is assembled to the inserter and drill guide. The WasherLoc inserter awl is placed thorough the pilot hole, and the strands of the graft are captured within the long tines of the WasherLoc. An assistant puts tension
on all graft strands equally by pulling on the impingement rod. With all graft strands isolated between the long tines of the WasherLoc, the WasherLoc is driven into the graft and bone by a mallet. The inserter awl is removed, and a hole is drilled into the far cortex with a 3.2-mm drill through the drill guide. The drill guide is removed, and the length of the drill hole is determined. A small amount of bone wax is placed around the cutting threads of the appropriate-length self-tapping 6.0-mm cancellous screw. The screw is inserted through the WasherLoc, compressing the WasherLoc and graft against the posterior wall of the tibial tunnel (Fig. 19).

**Bone graft tibial tunnel**

The tibial tunnel dilator is inserted into the distal aspect of the tibial tunnel. In many cases the dilator can be advanced up the tunnel by hand. Alternatively, the dilator should be driven gently up the tibial tunnel by tapping lightly with a mallet. The plastic sleeve is placed over the tip of the bone dowel harvest tube and positioned so the plastic sleeve at the tip of the harvest tube is against the dilated opening of the tibial tunnel. The inner plunger rod is struck to deliver the cancellous bone dowel from the harvest tube into the tibial tunnel. The arthroscope is reinserted into the joint to inspect the graft. The knee is taken through a full range of motion to ensure there is no roof or PCL impingement (Fig. 20). The hamstring harvest site is closed in layers, the portal sites are closed, a sterile dressing is applied, and the tourniquet is deflated.

**POSTOPERATIVE CARE AND REHABILITATION**

Aggressive brace-free rehabilitation can be implemented safely with a DLHS graft using the EZLoc and WasherLoc fixation. Patients are allowed weight bearing as tolerated immediately after surgery. Patients can begin full active and passive range-of-motion exercises following surgery. The early focus is
on terminal extension and should be easy for the patient because the tibial tunnel is prepared with the knee in full extension. Once the patient has 110° of flexion, stationary bicycle exercises can begin. An exception is made for patients undergoing a concomitant meniscal repair. These patients are prescribed a brace and allowed partial weight bearing with the brace locked in full extension for 4 to 6 weeks. Range of motion is limited to zero to 90° for 4 to 6 weeks. Patients then progress to weight bearing as tolerated with unrestricted motion. Once full range of motion is achieved, patients can begin treadmill exercises and lower-extremity strengthening exercises. Jogging is typically begun at 10 to 12 weeks postoperatively. Agility exercises are begun after 12 weeks, and unrestricted full activity is allowed after 4 months if muscle strength is 85% of that of the contralateral normal knee. In patients undergoing a concomitant meniscal repair, unrestricted pivot activities are permitted after 6 months.

References


