Anterior cruciate ligament (ACL) reconstruction is a common orthopedic procedure aimed to restore normal knee kinematics.\(^1\) Although the choice between single- and double-bundle techniques remains debated, agreement exists in the literature regarding the need to perform an anatomical reconstruction to reduce the long-term incidence of osteoarthritis.\(^2\)\(^,\)\(^3\) The concept of anatomic or footprint ACL reconstruction reduced the applicability of transtibial drilling of the femoral tunnel because it failed to replicate the anatomical femoral footprint of the ACL.\(^5\)\(^,\)\(^7\) For these reasons, the anteromedial and outside-in techniques for femoral tunnel reaming resulted in an anatomic ACL reconstruction.\(^8\)

Although a wide variety of single- or double-bundle anatomical ACL reconstruction using hamstrings tendons are described in the literature, all of these procedures require the detachment of the tendons from their tibial insertion.\(^9\)\(^,\)\(^10\) It has been demonstrated that preservation of the hamstrings tendons insertion allows preservation of the neurovascular supply of the tendons, resulting in lower residual proprioceptivity and better ligamentization of the graft.\(^11\) Until now, the only techniques that spare the hamstrings tendons insertion encompass a femoral over-the-top passage. Although these techniques are able to guarantee a successful clinical outcome, even at long-term follow-up, the over-the-top femoral route is not anatomical.\(^12\)\(^,\)\(^13\)

This report describes a new technical tip capable of permitting an anatomic single-bundle ACL reconstruction technique using distally inserted doubled hamstrings tendons fixed at the femoral level using a second-generation cortical suspensory device.

**Surgical Technique**

Surgery is performed under general or spinal anesthesia with the patient in a supine position on the operating table, with a C-shaped leg holder at the proximal thigh. A pneumatic tourniquet is positioned, and the leg is prepped. Anteromedial and anterolateral portals are performed. After treatment of the meniscal tear and cartilage injury, the ruptured ACL is identified and tested with a probe. The ACL tibial and femoral footprint are carefully debrided (Figure 1).

A vertical 3-cm skin incision is made approximately 2 cm medial to the apex of anterior tibial tuberosity. As an alternative, to avoid damaging the infrapatellar branch of the saphenous nerve, the incision can be performed in the same direction as the hamstrings tendons. A fascial incision is made parallel to the orientation of the pes tendons, and the gracilis and semiten-
Figure 1: Arthroscopic view of the tibial (A) and femoral (B) anatomic footprint of the anterior cruciate ligament.

Figure 2: Photographs showing the tendon collection using a blunt tendon stripper (A). The harvested tendons are then sutured together using 2 nonabsorbable No. 2 stitches (B).

Figure 3: Photograph of the surgical field showing the marked origin of the tibial tunnel (A). Arthroscopic view of the guide pin placed at the level of the medial tibial spine (B).

dinosus tendons are bluntly freed from the surrounding fascial attachments. The tendons are collected using a blunt tendon stripper while the knee is in more than 90° of flexion. The tibial insertion of the tendons must not be disturbed to maintain their neurovascular supply.

The harvested tendons are then sutured together using 2 nonabsorbable No. 2 stitches (Figure 2). A guide pin is inserted from the anteromedial portion of the tibial metaphysis approximately 1 cm medial and 1 cm proximal with respect to the tibial insertion of the hamstrings tendons (Figure 3A). The pin is advanced under arthroscopic visualization until it emerges at the level of the medial tibial spine (Figure 3B). A reamer is inserted along the guide pin to create the tibial tunnel. The diameter of the reamer depends on the ligament diameter. A messenger wire is inserted in the joint through the tibial tunnel and retrieved from the anteromedial portal (Figure 4).

The femoral half-tunnel can be created using either the anteromedial or outside-in technique. For the anteromedial technique, the transportal ACL femoral guide (TPG; Arthrex Ltd, Naples, Florida) is used. The guide is inserted through the anteromedial portal with the knee at 90° of flexion. The knee is then brought to 110° of hyperflexion (Figure 5A). The tip of the guide is placed at the level of the posterior wall of the lateral femoral condyle and the guide is positioned at the level of the ACL femoral footprint. A millimetered guide wire is advanced in the aimer until it reaches the second cortical to evaluate the width of the lateral femoral condyle (Figures 5B, C). A millimetered reamer is advanced over the guide wire according to the previous measurement to obtain at least a 25-mm socket with 7 mm of cortical bone bridge (Figure 5D). Once the drilling of the socket has been completed, a messenger wire is inserted through the anteromedial portal and through the femoral socket (Figure 5E).

For the outside-in technique, a second-generation retrograde drill is used (Flipcutter; Arthrex Ltd). With the arthroscopic in the anteromedial portal, the ACL femoral marking hook is inserted through the anterolateral portal and placed at the level of the femoral ACL footprint. The Flipcutter guide pin sleeve is advanced to the skin level at a point approximately 1 cm anterior to the posterior border of the iliotibial tract and 1.5 cm proximal to the lateral femoral epicondyle (Figure 6A, B). After measurement of the femoral intraosseous distance, the guide pin is advanced until its entrance in the joint. The guide pin end is flipped to create a retrograde drill, and a 25-mm retrosocket is produced (Figures 6C, D). A messenger wire is advanced through the femoral socket and retrieved through the anteromedial portal (Figure 5E).

Graft Passage and Fixation

The femoral messenger wire is retrieved outside the tibial tunnel using the tibial messenger wire (Figure 7A). A femoral ACL Tightrope (Arthrex Ltd) is placed over the graft. The messenger wire is then used to shuttle the femoral Tightrope suture through the tibial tunnel, the femoral socket, and outside the lateral femoral condyle (Figures 7B, C). Once the button is flipped over, the cortical of the lateral femoral condyle the femoral pull suture is then retrieved outside the anteromedial portal and the femoral pull suture is then tightened in the inserted portion of the hamstrings tendons (Figures 8A, B). With the knee at 90° of flexion, femoral fixation is achieved by pulling the femoral pull suture (Figures 8C, D). With the knee at 30° of flexion, the graft remnant is then fixed with a titanium staple placed at the level of the tibial metaphy-
isis distally with respect to the hamstrings tendon insertion (Figures 8E, F).

**Pearls and Pitfalls**

The entry of the tibial tunnel should be placed high enough to prevent kinking of the tendon, which would result in damage to the vascularization and reduction of mechanical resistance. During the drilling of the femur, perform the reaming in more depth to prevent the graft from touching the bottom of the tunnel during the tensioning. Care should be taken when placing the tunnels—poor tunnel placement is a common cause of failure in ACL reconstruction. The diameter of the tunnels must be adequate to allow the entry of the graft; avoid small reamers.

**Case Series and Preliminary Results**

Fifty-seven patients affected by unilateral ACL injury were operated on using the described technique at the authors’ institution. Patients included 32 men and 25 women with a mean age of 23.3 years (range, 16-32 years). Mean time from injury to surgery was 2.9 (range, 1-6 months) months. All patients were involved in sports at a recreational level. Evaluations were performed using the International Knee Documentation Committee score, Tegner activity scale, and KT-1000 preoperatively and at 3, 5, and 12 months and final follow-up 16.0 ± 2.5 months postoperatively.

Intra- and postoperatively, no complications were observed. Normal range of motion was observed in all patients at final follow-up. The mean International Knee Documentation Committee subjective score at final follow-up was 97.1 ± 1.4. According to the International Knee Documentation Committee objective score, at final follow-up, 50 patients were rated A and 7 patients were rated B. Among the patients rated B, 4 reported anterior knee pain related to a patellofemoral chondropathy despite an objective stable knee. The other 3 patients rated B had an objective mild instability; in 1 patient, both the Lachman and the pivot-shift tests showed an objective mild instability, whereas only the Pivot shift test was nearly normal for the other 2 patients.

Arthrometric analysis performed at final follow-up showed a side-to-side difference of 0.9 ± 0.2 and 0.7 ± 0.2 mm according to the manual maximum displacement test and to the passive displacement test, respectively. Return to sport was observed in all patients at a mean of 154.7 ± 15.2 days. Among the patients who resumed sport activity, 5 changed type of sport practiced for fear of reinjury. According to the Tegner Activity scale, the mean preslesional level of activity was 7.0 and was 6.9 at final follow-up.

**Discussion**

A variety of anatomic ACL reconstruction using hamstrings tendons have been described in literature, but in all of them, hamstrings tendons Tibial detachment has been reported. The importance of preserving the hamstrings tendons insertion is evident considering that the tendons insertion is well vascularized and innervated by vessels and nerves that proceed along the tendon unit. Preservation of this neurovascular supply could enhance the neoligamentization...
The ability to preserve the hamstring tendon insertion is one of the key reasons for the successful outcome of ACL reconstruction using the femoral over-the-top route. Otherwise, the nonanatomical reconstruction obtained with this technique remains a cause for concern.

The described technique is able to overcome this drawback, permitting an anatomic ACL reconstruction using double-strand hamstrings tendons with preservation of the tendons insertion. The development of this technique has been possible due to the evolution of cortical suspensory fixation button devices, with graft loops with adjustable length that can be tightened after the button flips becoming fixed on the cortex. This permits the graft to slide over the loop to tense the inserted portion of the hamstrings tendons graft before tightening of the loop with fixation of the ascending portion of the graft.

Sparing the hamstrings tendon insertion avoids graft fixation on the tibial side, which is commonly achieved with a bioabsorbable interference screw and reduces the costs and complications related to this fixation method, such as postoperative stiffness, cyst and abscess formation, tunnel enlargement, screw breakage, and intra-articular migration.

On the femoral side, the technique requires the drilling of a femoral socket without a second incision, resulting in a better cosmesis for the patient. The use of a socket instead of a tunnel results in a monocortical reaming with a better bone-graft contact that further enhances the ligamentization process.

The femoral socket can be reamed using either the anteromedial or the outside-in technique. The anteromedial technique is effective in reaching the femoral ACL footprint but is extremely technically demanding with a long and insidious learning curve. The outside-in technique seems to overcome the majority of the technical issues connected with the anteromedial technique, with the only drawback being higher costs.

The advantages of this technique are the ability to obtain anatomic ligament reconstruction using an au-
tologous graft; preservation of the integrity of the extensor mechanism through the use of the hamstring tendon graft; maintaining distal insertion of the tendons, as in the over-the-top technique, with better ligamentization of the graft; precise adjustment of the tension of the graft due to a second-generation cortical suspensory device; and using only 1 suspensory device with reduced costs.

However, some disadvantages must be considered, particularly with respect to the all-inside technique: the joint cavity is not maintained isolated from the outside because it uses a full tibial tunnel; it always requires a tibial incision to pick the tendons and prepare the tibial tunnel; it is not applicable in cases of previous use of the hamstring tendons or their alterations; and it cannot be performed with an allograft.

Indications for this technique are comparable with those of the other anatomical techniques, particularly in young athletes who require a rapid recovery. However, it cannot be used in cases of reoperations, in cases of nonvalidity of the hamstrings tendons, and in the presence of bone changes (especially at the femoral level) that do not allow for the correct execution of the half-tunnel.

**CONCLUSION**

The described technique permits an anatomical ACL reconstruction with the advantage of the preservation of hamstrings tendon insertion and the creation of a femoral socket with an enhancement of the ligamentization process of the graft. The ability to choose between anteromedial and outside-in femoral drilling makes this technique suitable for all surgeons.

**REFERENCES**


