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Anterior cruciate ligament reconstruction creating the femoral tunnel through the anteromedial portal. Surgical technique

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Abstract The anterior cruciate ligament reconstruction is a common procedure that improves stability and function of the knee. The surgical technique continues to evolve and many issues are still under debate. These mainly include: (1) graft selection (patellar tendon, hamstring, quadriceps tendon, or allografts), (2) surgical technique (double versus single bundle), and (3) femoral tunnel drilling. Currently, the most controversial one is the femoral tunnel drilling (transtibial vs. anteromedial portal drilling). Common opinion is that drilling the femoral tunnel through the anteromedial (AM) allows a more anatomic placement of the graft and a better rotational stability; therefore, this technique is gaining in popularity compared with the transtibial drilling despite a greater difficulty and the risk of medial condyle damage, tunnel back wall blowout, and inadequate socket length. The aim of this article is to describe the surgical technique of the anterior cruciate ligament reconstruction (single and double bundle), drilling the femoral tunnel through the AM portal.

Keywords Anterior cruciate ligament reconstruction · Antero medial portal · Femoral tunnel drilling · Surgical technique

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Introduction

The anterior cruciate ligament (ACL) reconstruction is the sixth most common procedure in orthopedic surgery, with more than 100,000 surgeries performed in the USA per year [1]. It is widely accepted that ACL reconstruction improves stability and function of the knee and reduces the risk of chondral and meniscal injuries. In the athletes with a torn ACL, the reconstruction of the ligament is the only way to achieve pre-injury level of performance. However, ACL reconstruction does not seem to protect the knee from degenerative arthritic changes [2] and the conservative treatment can still be indicated in older and inactive patients.

Although widely accepted and investigated, ACL reconstruction continues to evolve and many technical issues are still under debate.

Due to all these open issues and the lack of a "gold standard", in most cases, the surgical technique is still a matter of preference of the surgeon. In the last years, the most important innovation is to create the femoral tunnel through the anteromedial (AM) portal. This technique allows an independent creation of the femoral tunnel from the tibial tunnel and a more anatomic placement.

Patient positioning

The patient is administered spinal or general anesthesia and positioned supine on the operating table. A tourniquet is located on the proximal thigh. Intravenous antibiotic prophylaxis is performed and lateral post is positioned at the level of the proximal third of the thigh. The patient

positioning should allow leg abduction away from the operative table and knee flexion up to 120°, in order to facilitate arthroscopic procedures and femoral drilling and fixation, respectively.

Under anesthesia, the stability of the knee is evaluated in all planes to confirm the ACL tear and to rule out any other ligamentous injuries. When the injured side shows anterior tibial translation greater than 5 mm compared to the uninjured side, and a positive pivot shift test, the graft harvesting can be performed. Otherwise, a diagnostic arthroscopy is performed first to evaluate the ACL integrity.

Graft harvesting

Bone-patellar tendon-bone

A 5–6 cm incision is performed from the inferior patellar pole to the tibial tubercle following the midline of the knee. After an adequate subcutaneous dissection has been carried out medially, laterally, proximally, and distally, the peritenon is incised in line with the skin incision. Once the medial and lateral edges of the patellar tendon are identified, the width of the tendon is measured with a ruler and the central third (around 10 mm) is cut with a 15 blade. A ruler and an electrocautery (or a surgical marker) are used to mark the tibial and patellar bone plugs (usually around 9×22 mm). Harvesting bone plugs longer than 25 mm markedly increases the risk of intraoperative and postoperative patellar fractures. An oscillating saw, with a 10 mm blade, is used to cut the tibial cortex (medially, laterally, and distally).

The lateral and medial cuts are made convergent and inclined 45° respect to the horizontal plane. To avoid burning the bone, saline drops are added to help dissipate the heat. A 10-mm chisel is inserted into the distal cut and used to detach the bone plug with a gentle lever. The goal is to achieve trapezoidal bone plugs, with the base being the anterior cortex. Then, the patellar tendon vincula to the fat pad are removed with scissors. The distal end of the graft is pulled with one hand in order to displace the patella inside the incision. The oscillating saw is used, as previously described, to create the medial, lateral, and proximal cuts of the patellar bone plug. The chisel is then positioned at the level of the inferior patellar pole, parallel to the floor, and 9–10 mm posterior to the anterior patellar surface. In this fashion, the patellar bone plug is detached with the chisel from distal to proximal and at the desired depth, without the risk of patellar fractures.

The bone-patellar tendon-bone (BPTB) graft can be harvested also using a mini-incision technique. An upper incision is made on the apex of the patella and a lower incision is centered on the anterior tibial tubercle. After the peritenon is separated, the patellar tendon is first incised at its patellar insertion; then is split longitudinally to the anterior tibial tubercle insertion. Mini-incisions are used to obtain bone plugs as first described; then Kelly forceps allow graft extraction [3].

Gracilis-semitendinosus tendon (hamstrings/GST)

With patient's leg placed in A4 position, a small transverse incision is created on the tibial anteromedial corner of the affected knee over the pes anserinus. After subcutaneous and fascial dissection, the distal part of gracilis and semitendinosus tendons are identified and freed from surrounding tissues. The tendons, maintained in tension, are stripped proximally using a blunt tendon stripper with the knee flexed [4]. The distal dissection is obtained freely at the tibial insertion.

Graft preparation

BPTB (single bundle only)

The graft is taken to a side table and prepared for implantation by the assistant surgeon. The bone plugs are trimmed in order to match the size of the femoral and tibial tunnels. The tibial plug, usually intended for the femoral side, is trimmed to slide easily through a 9-mm tunnel spacer. The patellar plug is trimmed to obtain a 9–10 mm diameter. A 1.5 mm K wire is used to create two holes in each plug. The holes of the patellar plug are oriented at 90° angles to each other to minimize the chance of suture laceration by the interference screw and detensioning of the graft during tibial fixation. Four no. 2 non-absorbable braided sutures are inserted into the holes.

The length of the tendon and the bone plugs are measured. The bone–tendon junction of the tibial plug is marked with a sterile surgical pen. The graft is then placed in moist gauze.

GST (single or double bundle)

Harvested tendons are first freed from soft tissue and fat. In double-bundle technique, tendons are cut in half and folded in a double-strand fashion, while in single-bundle technique the tendons are only folded and not cut. If semitendinosus length allows, it can be folded three or four times, while gracilis tendon can be doubled. Tendons are then maintained in tension and sutured together tightly with three flexidene n.2 stitches [4]. The graft obtained should slide easily through a 9–10 mm tunnel spacer and the graft length should not be less than 9 cm. The points corresponding to graft's tibial and femoral socket entry are marked with a

sterile surgical pen. Loops are created around graft edges, and the graft is then placed in moist gauze. If EndoButton CL (Smith & Nephew, Andover, MA, USA) device is expected, it will be attached at proximal edge's loop.

Arthroscopy

A complete diagnostic arthroscopy is performed through AM and anterolateral (AL) portals. Anteromedial portal should be carefully placed 1 cm medial to the patellar tendon in order to allow a perpendicular reaming of the medial wall of lateral condyle, and avoid medial condyle damages, during Beath pin or reamer insertion [5]. Furthermore, the portal should be as close to the tibia as possible, paying attention not to damage the anterior horn of the medial meniscus. A spinal needle can be used in this stage.

Once created, AM portal can be enlarged, because it will be used as working portal. Alternatively, an accessory AM portal can be created on the upper part of the principal one in order to allow instrument insertion and direct visualization of the lateral wall of the intercondylar notch during femoral tunnel reaming [6••].

Meniscal tear and cartilage injury are identified and treated at this point. Remaining ACL stump is removed with a mechanical shaver until the tibial and femoral footprints are well visualized. Especially in chronic case, a minimal notchplasty can be performed with a shaver or an acromioplasty burr, in order to visualize the over-the-top position and obtain a flat medial wall of the lateral femoral condyle. This operation avoid the impingement of the graft with the lateral wall of the medial condyle in knee flexion

Tibial tunnel creation

Single bundle

The tibial tunnel is drilled first with a 55° angled ACL guide inserted into the joint through the AM portal. Landmarks for the correct positioning of the tibial tunnel are: the posterior cruciate ligament (PCL), the anterior horn of the lateral meniscus, and the tibial spines. The ACL guide is positioned about 7 mm anterior to the PCL, posterior to the anterior horn of the lateral meniscus and on the lateral wall of the medial tibial spine in order to locate the tibial tunnel in the medialposterior part of the native ACL tibial insertion [5].

The length of the tibial tunnel is determined by measuring the length of the graft and subtracting the femoral bone plug and the intraarticular portion of the graft (usually 30 mm). A pin is drilled into the proximal tibia from a point located halfway between the tibial tubercle and the posteromedial corner of the tibia. The length of the tibial tunnel can be then double checked, measuring the intraosseous portion of the guide pin and directly the graft on surgical table. A cannulated reamer with the same diameter of the bone plug meant for the tibia is used to drill the tibial tunnel on the guide pin.

Double bundle

Two Kirschner wires are used as guide pins. The tibial guidewire for AM bundle should be drilled about 45° from the axial plane and about 15° from the sagittal plane. The guide should come out in articulation from the tibial plate at the anterior portion of ACL footprint, 11 mm anterior to the posterior cruciate ligament, posterior to the anterior horn of the lateral meniscus and on the lateral wall of the medial tibial spine.

The guide for posterolateral (PL) bundle should be set about 40° from the axial plane and 45° from the sagittal plane and should come out in articulation 6 mm posterior and lateral to the AM guide. The lengths of the tibial tunnels are then checked measuring the intraosseus portion of the guidewires, taking account of the graft length in order to avoid tunnel length errors. Cannulated reamers plug are used to drill the tibial tunnel on the guidewires. The diameter of the tunnels are usually 6–7 mm [7, 8•]

Anteromedial portal femoral tunnel drilling

Under arthroscopy, the first step of the femoral tunnel creation through AM portal is the visualization of the "over-the-top" position and of the AM and PL footprint of the native ACL. An enlarged AM portal or an accessory portal is basic.

After the visualization, the entry point of the femoral tunnel must be marked with a pin. To do this, the knee is positioned in 90° flexion to avoid the medial condyle obstruction. A femoral endoscopic aimer, 30° angled offset tip can be helpful to the surgeon to minimize the impingement against the medial condyle and to avoid iatrogenic damage to the cartilage [6••].

In single bundle technique, the femoral tunnel entry must be marked with the row anterior to the AM footprint and 6–7 mm anterior to the posterior cortex at "10-o'clock position" for a right knee and at the "2-o clock position" for a left knee.

The femoral tunnel position is lightly anterior compared to the double-bundle technique; therefore, it is easier to prevent tunnel back wall blowout. In double-bundle reconstruction, femoral tunnels are created at the anatomic insertion of the AM and AL bundles. AM femoral tunnel

position can vary from 10/2-o'clock to 11/1-o'clock position, while PL femoral tunnel can be placed between the 9/3-o clock and 9.30/2.30 position [8•].

The over-the-top guides are available with different offsets. The appropriate offset should be decided in order to preserve a 2 mm posterior wall. For example, if a 10 mm diameter (5 mm radius) femoral tunnel is planned, a 7 mm offset guide is used to maintain 2 mm of the posterior wall (7–5=2 mm). A visualization of the back wall of the notch is easier in 90° flexion [5–7].

Once the entry point is marked, the joint can be flexed at 120° and the guide pin can be inserted until it passes the lateral cortex of the lateral femoral condyle. The guide pin direction must be paralleled to the back wall of the intercondilar notch. The exit point of the pin through the skin of the lateral thigh should be evaluated [4]. If it is exiting too posterior with respect to the femoral shaft, the pin should be repositioned in order to minimize the risk of posterior wall disruption during the drilling. Knee hyperflexion is required in this passage to avoid neurovascular injury and guarantee a sufficient tunnel length. Inadequate socket length can result in a bicortical reaming [6••].

At this time, femoral tunnel/s can be drilled with a cannulated reamer over the guide pin. This passage can be difficult because hyperflexion produces the portal tightening, a worst visualization of the ACL footprint, and the ingress of the fat pad whenever the reamer advances. Moreover, clearing the medial condyle without cartilage damage requires dexterity.

The femoral tunnel size should match the diameter of the femoral bone plug and be 2–3 mm longer than the plug in BPTB technique. The socket length varies from 25 to 32 mm depending on the femoral size. Tunnel/s is usually drilled 1 mm smaller than the desired size and dilators in 0.5 mm increments can be used to enlarge the diameter. The diameter of the tunnel is usually 6–7 mm for double bundle and 9–10 mm for single bundle technique. Once drilled, a shaver is placed into the tunnel to remove the debris [4].

Graft insertion

A no. 2 braided shuttling suture is looped and passed through the eyelet of the guide pin. The guide pin is pulled from the lateral side of the thigh, retrieving the two free ends of the suture proximally and keeping the loop outside the AM portal. The free ends are secured with a Kelly clamp. An arthroscopic grasper is inserted into the tibial tunnel and the loop of the suture is then retrieved out of the tibial tunnel distal aperture.

After drilling the femur, the integrity of the posterior wall of the femoral tunnel should be verified arthroscopically.

The graft is now taken from the back table. The sutures of the femoral plug of the graft in BPTB, or the loop of the femoral edge of hamstrings (depending on the graft used) are inserted into the loop of the shuttling suture and retrieved from the proximal thigh. The graft is pulled into the joint and a probe or an arthroscopic grasper can be used to correctly orient it into the tunnel. The marks on graft will help confirm that it is properly sitting in its tunnel.

Fixation

The most common fixation devices are interference screw or EndoButton CL for the femoral side and interference screw for the tibial side [8•]

With the knee at 110–120° of flexion, a guidewire for the cannulated interference screw is inserted through the AM portal. It is placed superoanteriorly into the femoral tunnel, between the cancellous surface of the bone plug or the hamstrings tendons (depending on the technique) and the superoanterior wall of the tunnel. Bioabsorbable, metal, or titanium interference screws are available with different diameter and length. A 23-mm long screw with a diameter of 1 mm smaller than the tunnel is usually used.

Alternatively, an EndoButton CL device, indirectly link to the graft using a loop of polyester, is flipped and fixed on the lateral cortical of the lateral femoral condyle. EndoButton is useful especially in hamstring graft technique [9].

In double-bundle technique, the PL bundle is first introduced in the femoral socket; once positioned, AM bundle can be placed.

The femoral fixation of the graft is tested by firmly pulling on the distal arming sutures.

The knee is cycled several times while pulling the distal sutures and palpating for movement of the graft in the tibial tunnel. More than a few millimeters of excursion may indicate improper placement of the tunnels and that the neoligament is not isometric. Full range of motion should be achieved, without impingement of the graft under arthroscopic visualization. The graft is kept tensioned and a 9×28 or 10×28-mm interference screw is then inserted for tibial fixation. In double-bundle technique, the anteromedial bundle is tensioned in 60° of flexion and the posterolateral bundle in 0°–10° [10].

The knee is placed again through a full range of motion and failure of the fixation is ruled out arthroscopically. The pivot shift and Lachman test are performed, and, if unacceptable, the graft needs to be retensioned. If the stability of the knee is satisfactory, the wounds can be closed.

Conclusions

Which portal is the best for femoral drilling is still on debate.

Advantages in AM portal technique are: a better visualization of the lateral wall of the intercondylar notch; a more anatomic graft placement because the socket is created independently of the tibial tunnel; a more horizontal graft placement leading to a greater knee rotational stability: in interference screw fixation, a parallel socket and screw angle; any fixation type is compatible; in all, inside technique is the only way to create the femoral tunnel; revisions may be easily performed [11–16].

Many authors still prefer the transtibial femoral drilling because of the difficulty of the AM technique. Risks in AM portal technique are: medial condyle cartilage damage, tunnel back wall blowout, inadequate socket length, a more difficult instrument introduction when the knee is hyperflexed, an exit point of the pin from the thigh dangerous for peroneal nerve, and deep flexion of the knee required, that is difficult or impossible to obtain in obese patients [6••].

In conclusion, drilling the femoral tunnel through the AM portal is more difficult, but as the tunnel placement is associated to the graft survival rate, we can observe in the future best results in ACL reconstruction studies with this technique.

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References

Papers of particular interest, published recently, have been highlighted as:

- • Of importance
- •• Of major importance

1. Brown CH, Carson EW. Revision anterior cruciate ligament surgery. Clin Sports Med. 1999;18:109–11.
2. Asano H, Muneta T, Ikeda H, et al. Arthroscopic evaluation of the articular cartilage after anterior cruciate ligament reconstruction: a short-term prospective study of 105 patients. Arthroscopy. 2004;20(5):474–81.
3. Gaudot F, Leymarie J-B, Drain O, Boisrenoult P, Charrois O, Beaufils P. Double-incision mini-invasive technique for BTB harvesting: its superiority in reducing anterior knee pain following ACL reconstruction. Orthop Traumatol Surg Res. 2009;95(1):28–35.
4. Marcacci M, Paladini Molgora A, Zaffagnini S, et al. Anatomic double-bundle anterior cruciate ligament reconstruction with hamstrings. Arthroscopy. 2003;19(5):540–6.
5. Harner CD, Honkamp NJ, Ranawat AS. Anteromedial portal technique for creating the anterior cruciate ligament femoral tunnel. Arthroscopy. 2008;24(1):113–5.
6. ••Lubowitz JH, Anteromedial portal technique for the anterior cruciate ligament femoral socket: pitfalls and solutions. Arthroscopy. 2009 Jan;25(1):95–101. *This study describes important pearls of the surgical technique.*
7. Asagumo H, Kimura M, Kobayashi Y, et al. Anatomic reconstruction of the anterior cruciate ligament using double-bundle hamstring tendons: surgical techniques, clinical outcomes, and complications. Arthroscopy. 2007;23(6):602–9.
8. •Van Eck CF, Schreiber VM, Mejia HA, Samuelsson K, van Dijk CN, Karlsson J, Fu FH. "Anatomic" anterior cruciate ligament reconstruction: a systematic review of surgical techniques and reporting of surgical data. Arthroscopy. 2010 Sep;26(9 Suppl):S2-12. *This study is the only systematic review that evaluate the studies published on ACL reconstruction.*
9. Miller CD, Gerdeman AC, Bennett CG. A biomechanical comparison of the EndoButton CL using transtibial drilling and EndoButton direct using anteromedial arthroscopic drilling. Arthroscopy. 2010;26(10):1311–7.
10. Fu FH, Ranawat AS. Tensioning in double-bundle ACL reconstruction. Arthroscopy. 2007;23(9):1027.
11. Bedi A, Musahl V, O'Loughlin P, Maak T, Citak M, Dixon P, et al. A comparison of the effect of central anatomical single-bundle anterior cruciate ligament reconstruction and double-bundle anterior cruciate ligament reconstruction on pivot-shift kinematics. Am J Sports Med. 2010;38(9):1788–94.
12. Markolf KL, Park S, Jackson SR, McAllister DR. Simulated pivot-shift testing with single and doublebundle anterior cruciate ligament reconstructions. J Bone Joint Surg Am. 2008;90(8):1681–9.
13. Bedi A, Raphael B, Maderazo A, Pavlov H, Williams 3rd RJ. Transtibial versus anteromedial portal drilling for anterior cruciate ligament reconstruction: a cadaveric study of femoral tunnel length and obliquity. Arthroscopy. 2010;26(3):342–50.
14. Golish SR, Baumfeld JA, Schoderbek RJ, Miller MD. The effect of femoral tunnel starting position on tunnel length in anterior cruciate ligament reconstruction: a cadaveric study. Arthroscopy. 2007;23:1187–92.
15. Scopp JM, Jasper LE, Belkoff SM, Moorman III CT. The effect of oblique femoral tunnel placement on rotational constraint of the knee reconstructed using patellar tendon autografts. Arthroscopy. 2004;20:294–9.
16. Musahl V, Plakseychuk A, VanScyoc A, et al. Varying femoral tunnels between the anatomical footprint and isometric positions: effect on kinematics of the anterior cruciate ligament reconstructed knee. Am J Sports Med. 2005;33:712–8.