Technical Note

Positioning Technique of the Fixed Knee in Hyperflexion for the Transportal Femoral Tunnel During Reconstruction of the Anterior Cruciate Ligament

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Abstract: During reconstruction surgery of the anterior cruciate ligament, the evolution of the femoral tunnel from the transtibial to the transportal path provides greater accuracy in reaching the desired anatomic point. However, there are also some new challenges, such as correct execution, reproducibility, and minimizing the risk of iatrogenic injury from its use. In an effort to overcome these challenges, we have proposed the use of a positioner, which was developed by our group and allows the leg to stay in the desired position, without variations in the operation or aid from a medical assistant. This manuscript presents our femoral tunnel preparation technique and its application in clinical practice.

There has been increasing interest in anatomic reconstruction of the femoral tunnel in anterior cruciate ligament reconstruction (ACLR). The transtibial technique reportedly does not allow the desired positioning of the tunnel to be achieved, which could worsen functional clinical results.[1,2] The correct positioning of the tunnels in ACLR allows adequate biomechanical function of the knee. Wrong positioning of the tunnels is a common cause of ACLR failure, which arises due to technical error. Desai et al.[3] demonstrated that 50% of ACLR revisions were necessary due to malpositioning of the tunnels. When using the transportal technique, the location of the femoral tunnel reaches a topography that is closer to the posterolateral bundle.[3-5]

Despite presenting many biomechanical and clinical advantages, Geng[5] and Lubowitz[6] enumerated a list of possible complications involving the perforation of the femoral tunnel in transportal ACLR using anatomical techniques. These techniques included iatrogenic lesion of the medial femoral condyle, creation of very short femoral sockets, and rupture of the femoral posterior wall. Besides the risk of injury to the peroneal nerve, other complications include poor visualization using the arthroscope and keeping the limb in the correct position at the same time.[5,6]

To avoid short femoral sockets and neurovascular damage, the transportal technique requires the patient's knee to be hyperflexed.[6] This paper describes a femoral tunnel preparation technique positioning the lower limb in a fixed minimum of 120° of flexion without the aid of an assistant.

Surgical Positioning Technique (With Video Illustration)

The patient is placed on the surgical table, in the dorsal decubitus position, and is under spinal anesthesia

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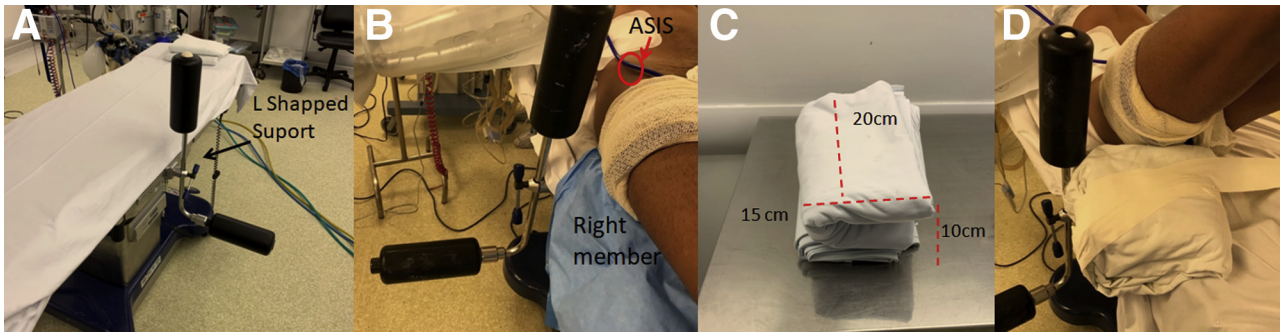

Fig 1. (A) "L"-shaped support developed by our group. (B) Right member. "L"-shaped support attached to the surgical table at the same level as the (ASIS); this is the correct positioning of the L-support, based on our technique. (C) We prepared a cushion 10 cm in height, 20 cm in length, and 15 cm in width composed of 2 sheets that were folded multiple times. (D) We placed the cushion posterior to the pneumatic cuff and fixed it to the surgical table using sticking plaster. (ASIS, anterosuperior iliac spine.)

and femoral nerve block. We place the L-shaped support developed by our group (Fig 1A) on the side of the surgical table at the same height as the anterosuperior iliac spine (Fig 1B) and adjust the position of the supporter so that the horizontal component of the supporter is at 90° with the surgical table. Then, we observe whether the abduction of the lower limb is satisfactory. We place a cushion (10-cm height, 20-cm length, and 15-cm width) posterior to the pneumatic cuff (Fig 1C), which was previously placed to keep the femur parallel to the ground. The knee is hyperflexed, leaving the foot fixed on the horizontal component of the L-arm. We use a goniometer to check whether the angle of knee flexion is at 120° (Fig 2A). If not, we raise the horizontal component of the supporter to achieve the necessary angulation to perform transportal femoral tunneling.

Asepsis and ischemia of the affected limb are performed; removal of the flexor tendon is conducted according to a standard technique. Joint inventory is performed through the anteromedial and anterolateral portals. Meniscal and chondral lesions, if present, are both treated before ACLR. Then, we perform the debridement of the intercondylar notch, leaving the ACL stump intact in the tibia, but not in the femur, where bone visualization of the ACL footprint in the lateral femoral condyle is mandatory.

The femoral ACLR guide (Arthrex, Naples, FL) is meant to be 2 mm larger than the graft radius, and the guide is positioned with its posterior attachment tooth facing toward the lateral femoral condyle. The auxiliary surgeon performs hyperflexion of the knee, fixing the patient's foot on the horizontal component of the supporter in L (Fig 2B). The auxiliary surgeon tests whether the limb is fixed in this position; if so, he releases the leg and returns to assist the main surgeon.

Once the guide is positioned on the footprint of the ACL, in the lateral femoral condyle, we insert the

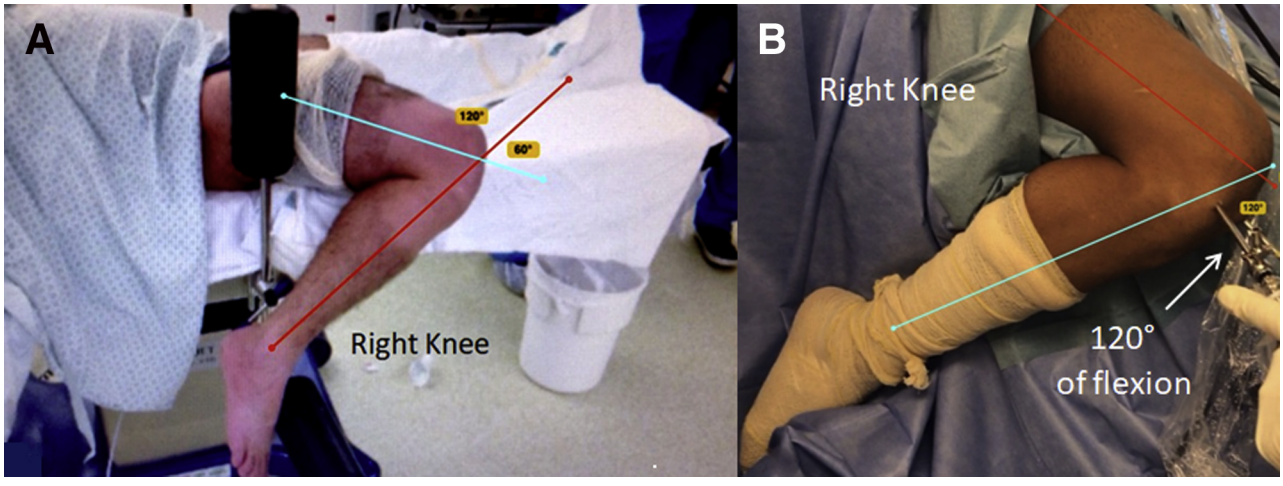

Fig 2. (A) We tested the operative knee (right knee), with the patient under anesthesia, before asepsis and antesepsis; this was only done if we were able to obtain 120° flexion and the correct valgus stress with the L-positioner in the proper position. (B) The right knee during surgery with the knee flexed at 120°.

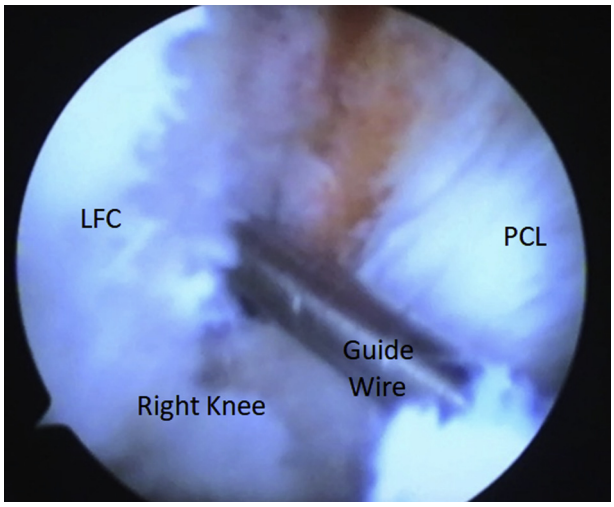

Fig 3. Guidewire making the first drill 5-mm deep to check if the tunnel is in the proper position in the right knee. (LFC, lateral femoral condyle; PCL, posterior cruciate ligament.)

guidewire needle 5 mm deep (Fig 3) and then remove both the wire and femoral guide (Arthrex). The auxiliary surgeon returns the knee to the 90° position, and we check if the prepared hole is in the proper position (Fig 4). If not, the surgeon fine-tunes the correct positioning of the tunnel (Video 1).

If placed in an adequate position, we put the femoral guide (Arthrex) back in the previous location. The auxiliary surgeon hyperflexes the knee again, leaving the foot fixed on the horizontal component of the L-shaped support. With the foot fixed, the auxiliary surgeon inserts the guidewire needle in the same hole previously made in the lateral femoral condyle. After this step, the surgeon performs the femoral (Fig 5) and tibial tunnels in a conventional way, according to

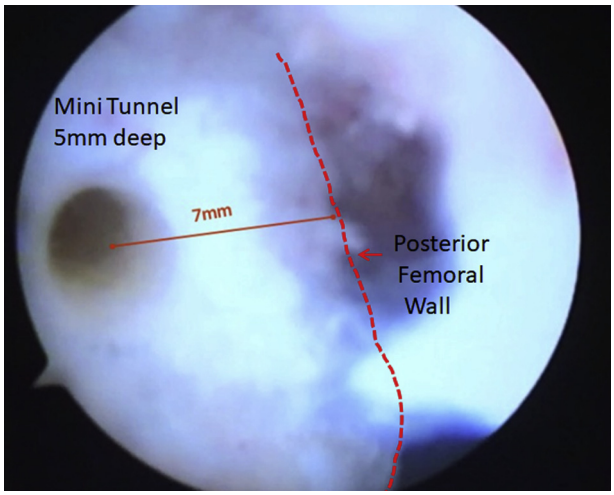

Fig 4. View of the first mini tunnel 5-mm deep, with its radius at a distance of 7 mm from the posterior femoral wall in the right knee.

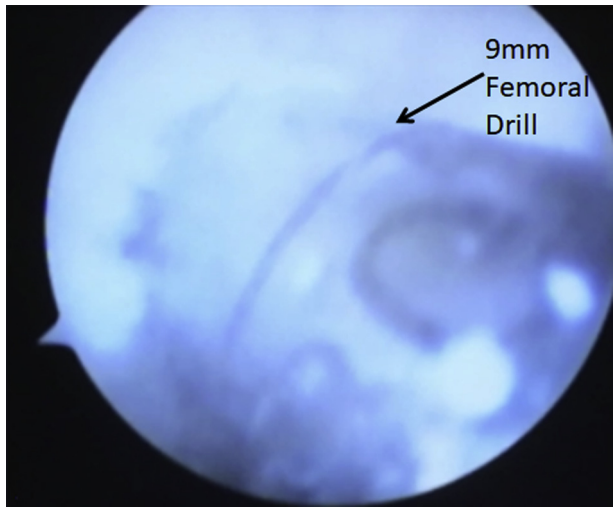

Fig 5. View of the 9-mm thick femoral drill perforating the femoral tunnel in the anatomical position in the right knee.

fixation devices used to fix the graft in the femur and the tibia. The graft is passed through the tunnels, fixated on the femur, and, with the knee extended, is attached to the tibia.

Discussion

Some disadvantages of transtibial ACLR techniques include the creation of very vertical tunnels with important residual rotational instability, rupture of the posterior wall of the socket, elliptical tunnels, the need for notchplasty, and tunnel and screw divergence by interference screws during fixation. Thus, new anatomical reconstruction techniques, where the positioning of the femoral tunnel is independent of the tibial tunnel, have been established.[7]

A recent study evaluated whether the modified transtibial technique could achieve the same positioning as the anatomical technique, comparing such techniques with the use of 3-dimensional tomography analyses. The authors concluded that positioning of the modified transtibial technique is better than that of the transtibial technique, but the correct anatomical positioning of the femoral tunnel is not achieved.[8]

The creation of the femoral tunnel in the anatomical technique allows a more accurate and horizontal positioning and is associated with less anterior and residual rotational instability compared with the transtibial technique.[9,10] Some cadaveric studies have found similar results, showing that positioning of the femoral tunnel in the center of the native femoral insertion of the ACL can normalize anterior translation and rotational stability.[11,12]

The preparation of the appropriate femoral tunnel without rupturing the posterior cortex depends on the hyperflexion of the knee during its perforation. Keeping the knee correctly positioned may be particularly

Table 1. Advantages and Disadvantages of Our Surgical Technique

	Advantages	Disadvantages
"L"-shaped support	Does not allow variation of the angle of flexion during the passage of the guidewire and during preparation of the femoral tunnel	Can only be performed if the L-positioner is available on surgery center
Transportal technique with fixed knee in hyperflexion	Allows the surgeon to perform the femoral tunnel in an anatomical position with the aid of only an auxiliary surgeon and with a smaller surgical team	Necessary to use more surgical fields to cover the L-positioner to avoid contamination of the operated limb when performing hyperflexion
Transportal technique with fixed knee in hyperflexion	Several types of femoral fixation can be used in this technique	A learning curve is required for correct execution

difficult in individuals with obesity or in those with very bulky thighs.[13,14] In standard techniques, keeping the knee hyperflexed requires the help of an assistant.[13]

Different methods may help the surgeon obtain better positioning of the femoral tunnel. The use of anatomical references combined with the use of guides and instruments improves the perforation of the femoral and tibial tunnels.[4]

Jennings et al.[12] described a hybrid technique in which they used a flexible guidewire through the tibial tunnel and a guide inserted into the medial portal with the knee at 90° to prepare the femoral tunnel. They also conducted a cadaveric biomechanical study that compared femoral positioning with transtibial; they also compared the transportal and hybrid techniques, concluding that the hybrid technique results in femoral tunnel positioning that is very similar to positioning produced by the anatomical technique.[12]

Lee et al.[15] described the use of a curved femoral guide that assists in making the femoral tunnel in the anatomical position without hyperflexion. This guide reportedly reduces the risks inherent to the anatomical technique, which is performed conventionally.[15]

However, the use of arthroscopic guides requires a greater learning curve for their correct use, and these anatomical points, such as the "residents ridge," can be difficult to identify, especially for less-experienced surgeons and in cases of ACLR revision.[4] The use of a simple-handling L-positioner can be added to these other mentioned items as another important factor for the correct positioning and perforation of the femoral tunnel. This position allows adequate and stable knee flexion, minimizing the occurrence of iatrogenic lesions and technical errors. Other advantages and disadvantages of our technique are described in Table 1.

Femoral tunnels with opposing or short cortical rupture may limit the use of some fixation devices and do not create a socket of adequate length for graft osseointegration.[13]

Patients are usually positioned near the side edge of the operating table, allowing the limb to hang down on the side of the table, with a post on the side of the thigh, allowing the surgeon to exert valgus stress, facilitating visualization of the medial compartment.[16]

However, when using our technique, care should be taken when positioning the L-support and preparing the patient for surgery. If positioned incorrectly on the operating table, there is a risk that the L-support will come loose during femoral tunnel perforation or during knee hyperflexion. In addition, the L-support may be positioned too far distally on the operating table, limiting the capability of the surgeon to perform the adequate knee valgus stress; this makes it difficult to explore the knee medial compartment. Pearls and pitfalls are described in Table 2.

In our technique, the post is positioned slightly different from the usual position from other techniques; we position it at the level of the anterosuperior iliac spine using a taco-type support. This position allows the hanging leg to be maintained at 120° of static flexion.

Table 2. Pearls and Pitfalls of Our Surgical Technique

Pearls	Pitfalls/Complications and How to Avoid Them
By attaching the L-positioner to the level of the upper anterior iliac crest, good abduction of the limb is achieved; however, the femur has a distal inclination, so we use the cushion to keep the femur parallel to the ground, allowing the surgeon to have a good range of motion by moving the clamps in the arthroscopic portals.	If the patient has obesity or thick musculature of the thigh, a thicker cushion may be necessary. Regardless, the cushion should be well fixed to the table to avoid falling during surgery.
Checking the positioning of the tunnel by inserting only 5 mm of the guidewire is essential for marking the location of and achieving proper positioning of the femoral tunnel.	If this step is not performed, the tunnel may be placed in a very posterior position, with the possibility of fracture of the posterior wall of the femur. This causes fixation of the graft to be lost.

With this, we dispense with the aid of an assistant. Using our technique, we guarantee the reproducibility of our ligament reconstruction, with tunnels long enough for perfect osseointegration and without ruptures of the posterior wall of the femoral socket.

References

1. Kopf S, Forsythe B, Wong AK, et al. Transtibial ACL reconstruction technique fails to position drill tunnels anatomically in vivo 3D CT study. *Knee Surg Sports Traumatol Arthrosc* 2012;20:2200-2207.
2. Driscoll MD, Isabell GP Jr, Conditt MA, et al. Comparison of 2 femoral tunnel locations in anatomic single-bundle anterior cruciate ligament reconstruction: A biomechanical study. *Arthroscopy* 2012;28:1481-1489.
3. Desai N, Andernord D, Sundemo D, et al. Revision surgery in anterior cruciate ligament reconstruction: A cohort study of 17,682 patients from the Swedish National Knee Ligament Register. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1542-1554.
4. Kim MS, KohI J, Sohn S, et al. Femoral offset guide facilitates accurate and precise femoral tunnel placement for single-bundle anterior cruciate ligament. *Knee Surg Sports Traumatol Arthrosc* 2019;27:3505-3512.
5. Geng Y, Gai P. Comparison of 2 femoral tunnel drilling techniques in anterior cruciate ligament reconstruction. A prospective randomized comparative study. *BMC Musculoskelet Disord* 2018;19:454.
6. Lubowitz JH. Anteromedial portal technique for the anterior cruciate ligament femoral socket: Pitfalls and solutions. *Arthroscopy* 2009;25:95-101.
7. Robin BN, Jani SS, Marvil SC, et al. Advantages and disadvantages of transtibial, anteromedial portal, and outside-in femoral tunnel drilling in single-bundle anterior cruciate ligament reconstruction: A systematic review. *Arthroscopy* 2015;31:1412-1417.
8. da Silva RR, Matos MA, Costa VCNB, et al. Tomographic study of femoral positioning in anterior cruciate ligament reconstruction using the transtibial technique. *Knee Surg Relat Res* 2017;29:195-202.
9. Franceschi F, Papalia R, Rizzello G, et al. Anteromedial portal versus transtibial drilling techniques in anterior cruciate ligament reconstruction: Any clinical relevance? A retrospective comparative study. *Arthroscopy* 2013;29:1330-1337.
10. Seo SS, Kim CW, Kim JG, et al. Clinical results comparing transtibial technique and outside in technique in single bundle anterior cruciate ligament reconstruction. *Knee Surg Relat Res* 2013;25:133-140.
11. Herbort M, Domnick C, Raschke MJ, et al. Comparison of knee kinematics after single-bundle anterior cruciate ligament reconstruction via the medial portal technique with a central femoral tunnel and an eccentric femoral tunnel and after anatomic double-bundle reconstruction: A human cadaveric study. *Am J Sports Med* 2016;44:126-132.
12. Jennings JK, Leas DP, Fleischli JE, et al. Transtibial versus anteromedial portal ACL reconstruction: Is a hybrid approach the best? *Orthop J Sports Med* 2017;5. 2325967117719857.
13. Iriuchishima T, Goto B, Okano T, et al. Femoral tunnel length in anatomical single-bundle ACL reconstruction is correlated with height, weight, and knee bony morphology. *Knee Surg Sports Traumatol Arthrosc* 2019;27:93-99.
14. Brown CH Jr, Spalding T, Robb C. Medial portal technique for single-bundle anatomic anterior cruciate ligament (ACL) reconstruction. *Int Orthop* 2013;37:253-269.
15. Lee KB, Kwon BC, Kim JI, et al. Anatomic femoral tunnel creation during anterior cruciate ligament reconstruction using curved dilator system. *J Orthop Surg (Hong Kong)* 2019;27. 230949901984082.
16. Ward BD, Lubowitz JH. Basic knee arthroscopy part 1: Patient positioning. *Arthrosc Tech* 2013;2:e497-e499.