Joints

Femoral tunnel in revision anterior cruciate ligament reconstruction

FRANCESCO GIRON, MICHELE LOSCO, LUCA GIANNINI, ROBERTO BUZZI

Traumatology and General Orthopaedics Unit, Careggi University Hospital, Florence, Italy

Abstract

The failure rate after anterior cruciate ligament (ACL) reconstruction performed by expert surgeons is estimated to be in the range of 10-15%, and only 60% of patients undergoing this surgery are able to resume sporting activities comparable to those they engaged in prior to the traumatic incident.
Incorrect femoral tunnel placement is one of the main causes of failed ACL reconstruction and this must be remembered when undertaking revision surgery.
There are various possible errors that can be committed and, to plan revision surgery correctly, it is fundamental to study the position of the existing femoral tunnel(s) both on classic anteroposterior and lateral plain radiographs and on computed tomography scans with frontal, sagittal, and coronal sections, and also using three-dimensional reconstruction.
In-depth anatomical knowledge and familiarity with the various possible surgical techniques are also mandatory for a successful surgical outcome.

Key Words: anterior cruciate ligament, revision, femoral tunnel, reconstruction.

Over 200,000 anterior cruciate ligament (ACL) reconstructions are performed each year in the world, making this the sixth most frequently performed procedure in orthopedic surgery. Most surgeons (>85%) who perform ACL surgery carry out fewer than 10 reconstructions per year. The failure rate after ACL reconstruction by expert surgeons is estimated to be in the range of 10-15%, and only 60% of patients undergoing this surgery are able to resume sporting activities comparable to those they engaged in prior to the traumatic incident (1). There are many variables that need to be taken into account both when performing primary ACL reconstructions and when planning revision surgery. This brief paper focuses solely on femoral tunnel placement and creation in revision ACL reconstruction surgery.
Correct femoral tunnel positioning, together with a correct choice of graft and graft fixing technique and an adequate rehabilitation protocol, constitutes a cornerstone of successful ACL reconstruction surgery. Indeed, the positioning of the femoral tunnel determines the elongation and tension patterns of the new ligament throughout the knee range of motion. Therefore, in both single- and double-bundle reconstructions, every effort is made, during surgery, to identify anatomical ligament attachment sites. However, even though we may seek to reproduce the native anatomy, it must be appreciated that precise landmarks often cannot be identified during the operation and that, even when there remain residual traces of the ligament on the wall of the intercondylar notch, these are rarely of any real help in positioning the femoral tunnel(s).
Furthermore, the healthy ACL varies so greatly in size and shape from individual to individual (1) that there exist no predefined methods able to guarantee correct and reproducible placement of femoral tunnel(s) in every knee.
Incorrect femoral tunnel placement is one of the main causes of failed ACL reconstruction and this must be remembered when undertaking revision surgery (2, 3). Indeed, there are various possible errors that can be committed. If the tunnel is too shallow (**Fig.1**) there will be excessive graft tension during knee flexion,

Corresponding Author:
Francesco Giron, MD
Traumatology and General Orthopaedics Unit
Careggi University Hospital
Largo P. Palagi 1, 50139 Florence, Italy
E-mail: francescogiron@gmail.com

Joints

Fig. 1. Shallow femoral tunnel.

Fig. 2. Excessively deep femoral tunnel.

which will determine joint stiffness and ultimately failure of the new ligament. Conversely, if the tunnel is too deep (**Fig. 2**), there is a risk of rupturing the posterior wall of the femur, either immediately, when drilling the tunnel, or when fixing the graft; in the latter case, if an interference screw is used, the rupture may be due to divergence of the screw from the direction of the tunnel, or to fragility of the bone wall. If the femoral tunnel is placed not in the center of the wall of the intercondylar notch, but close to its edge or even in its roof, the new ligament will be vertically positioned and poorly able to guarantee anterior-posterior and rotational stability (**Fig. 3**).

In the case of reconstructions performed using the double-bundle technique, it is necessary to remember that positioning errors can involve one or both tunnels, and also that the tunnels must not be allowed to converge.

It is necessary to consider that in ACL reconstruction there are several possible approaches with different guide systems. Basically, there exist three drilling techniques: the transportal approach, the transtibial approach and the outside-in technique. In the transtibial approach, the femoral tunnel is created with the help of drill guides that are introduced through the tibial tunnel. In this case, the precise placement of the femoral tunnel depends on the correct positioning of the tibial one. If, with this approach, the placement of the femoral tunnel on the wall of the notch is not satisfactory, there is little the surgeon can do to modify the insertion point of the new ACL, apart from resorting to one of the other two techniques. Furthermore, with this approach, the femoral tunnel aperture assumes an oval rather than a round shape after drilling as the guide wire strikes the wall at a very sharp angle (1, 4-6). The transportal approach, which involves passing through the anteromedial portal, allows the guide wire entry point to be positioned freely on the wall of the notch. However, the knee should be flexed to at least 120°, which restricts the view. In order to see the wall of the notch, an accessory anteromedial portal is also needed. In this case, given the angle of the drill guide in relation to the wall of the notch, the aperture tends, once again, to be oval because of the guide tilt in shallow and inferior directions (1). The outside-in technique does not entail any limitations terms of arthroscopic view and guide wire positioning. It allows the guide wire to be inserted perpendicular to the wall of the notch, thereby allowing round holes at the level of intra-articular exits of the tunnels. Most surgeons, however, prefer to avoid making a second skin incision and are more familiar with the transtibial approach.

All these are considerations that should be weighed up when planning revision surgery. It is fundamental to study the position of the existing femoral tunnel(s) both on classic anteroposterior and lateral plain radiographs and on CT scans with frontal, sagittal and

coronal sections, and also using three-dimensional reconstruction (2, 3, 7). These investigations make it possible not only to precisely locate the position of the femoral tunnel aperture on the wall of the intercondylar notch, but also to identify any bone loss within the tunnel itself due to the windshield-wiper effect (8), and to consider whether or not it is necessary to remove fixation devices that could interfere with the planned femoral tunnel.

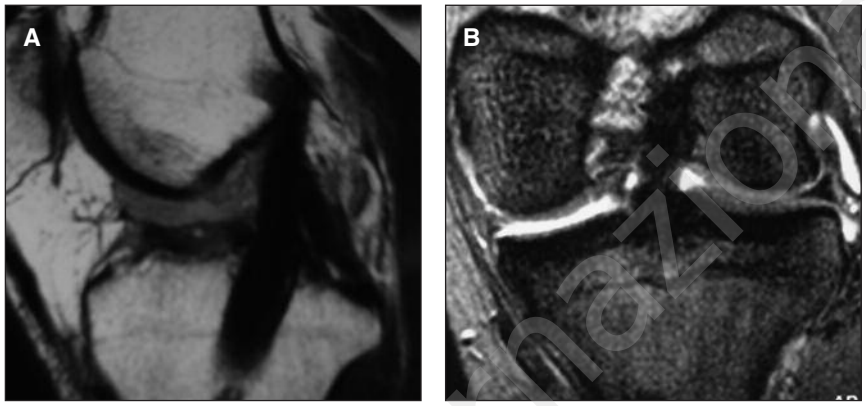

Fig. 3. MRI sagittal (A) and coronal (B) views showing a too vertical femoral tunnel.

During the revision surgery it is crucial to have the various arthroscopic drill guide systems to hand on the instrument table, so as to be able to adapt the technique to any unforeseen circumstance. It is also very important to position the patient in a way that favors complete mobility of the knee, both in flexion-extension and in internal and external rotation. During arthroscopy, all residue from the previous operation must be carefully removed so as to have a clear view of the entire bone wall; to this end, it is sometimes useful to remove the synovial layer covering the lateral aspect of the posterior cruciate ligament. It is, in fact, crucial to view the lateral wall of the intercondylar notch through both the anterolateral and the anteromedial portal so as to precisely determine both the spatial dimensions and any changes resulting from the previous surgery.

The greatest difficulties, when deciding where to position the femoral tunnel, are encountered in the presence of existing tunnels that were correctly positioned but have become enlarged as a result of bone loss or the presence of fixation devices. Paradoxically, when a previous tunnel was incorrectly positioned, the lateral wall of the intercondylar notch at the point where the new tunnel is to be created will be intact, and the creation of the tunnel, using an anteromedial or outside-in technique, will be quite straightforward, as in a primary reconstruction (**Fig. 4**).

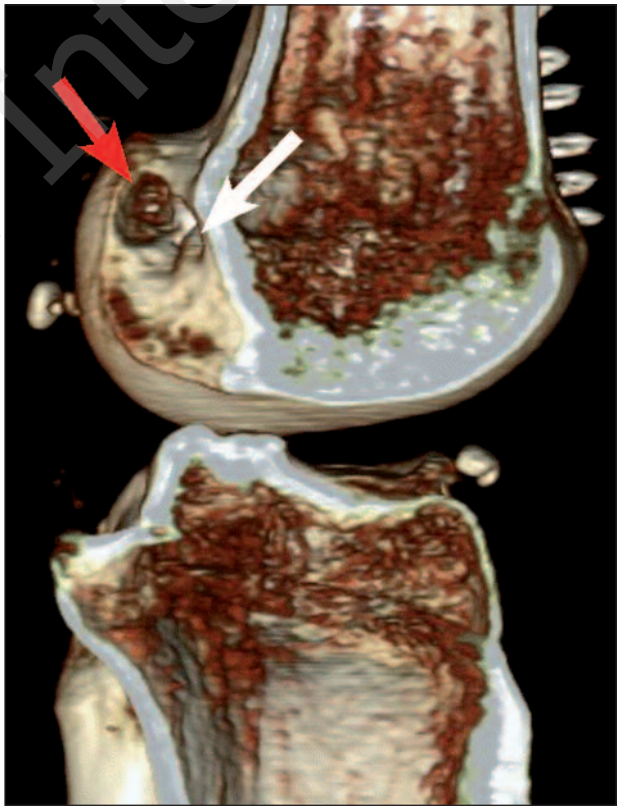

Fig. 4. New femoral tunnel positioned correctly (red arrow) compared with the previous vertical one (white arrow).

When there is bone loss at the level of the tunnel, the surgery can be performed in a single session (9), although it is preferable to plan a two-stage procedure. During the first stage it is necessary to remove any fixation devices present (e.g. interference screws or transverse fixation systems), clean the bone, removing any fibrous tissue present, and fill the defect left by the fixation devices and the previous tunnel with (preferably autologous) bone graft plugs harvested from the iliac crest or tibial plateau (10-12). Around 4-6

months later, with the bone graft integrated, the revision reconstruction can be performed, creating the tunnel in the desired position in intact bone.

To date there are no well-defined landmarks allowing exact localization of the guide wire entry point for creating a femoral tunnel. It has, however, been shown that femoral tunnel placement (as opposed to tibial tunnel placement) is what influences the tension of the reconstructed ligament and thus the outcome of the procedure itself. For years, it has been recognized as advantageous to seek to achieve isometric tunnel placement, aiming to reconstruct the anteromedial bundle. In laboratory studies, this bundle has been found to show less tension and length variation than the posterolateral bundle throughout the range of motion of the knee and is defined as the most isometric. Recent studies have shown that a more anatomical placement guarantees greater stability of the knee against rotational and anteroposterior stresses (1). To this end, on the basis of cadaver studies, several suggestions have been advanced to help the surgeon identify the center of the ACL femoral insertion. As already mentioned, it is important to view the entire lateral wall of the intercondylar notch through both the anterolateral and the anteromedial portal. The knee is kept flexed to at least 90° and the most posterior portion of the cartilage of the lateral femoral condyle (in the over-the-top position) is viewed. The center of the anteromedial insertion point can be identified by drawing an imaginary line tangent to the border between cartilage and bone and extending as far as the wall of the notch (**Fig. 5**). If we remain, on the wall of the notch, below that line and above the joint cartilage, then we can be reasonably sure of being in the center of the native ACL insertion.

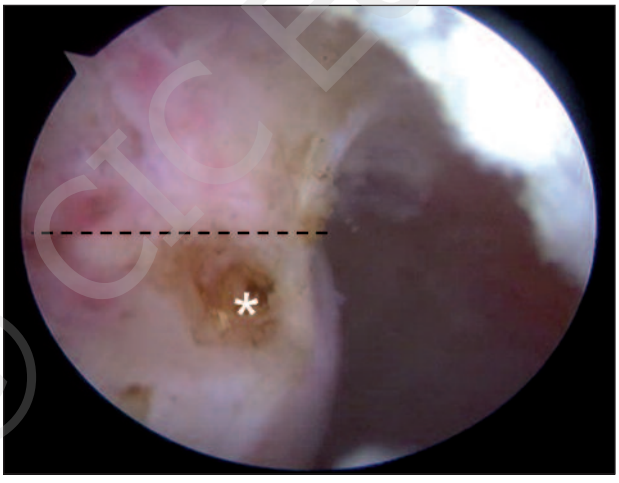

Fig. 5. The dotted line indicates the area under which the femoral insertion point of the new ligament (asterisk) is located.

References

1. Fu HF, Clancy W, Johnson D, Kurosaka M. Anterior cruciate ligament: tunnel placement and graft selection in 2010. 2010 AAOS Congress Instructional Course Lecture Handout, New Orleans, March 9-13, 2010.
2. Carlisle JC, Parker RD, Matava MJ. Technical considerations in revision anterior cruciate ligament surgery. J Knee Surg 2007; 20:312-322.
3. George MS, Dunn WR, Spindler KP. Current concepts review: revision anterior cruciate ligament reconstruction. Am J Sports Med 2006; 34: 2026-2037.
4. Arnold MP, Kooloos J, van Kampen A. Single-incision technique misses the anatomical femoral anterior cruciate ligament insertion: a cadaver study. Knee Surg Sports Traumatol Arthrosc 2001; 9:194-199.
5. Giron F, Buzzi R, Aglietti P. Femoral tunnel position in anterior cruciate ligament reconstruction using three techniques. A cadaver study. Arthroscopy 1999; 15: 750-756.
6. Kopf S, Forsythe B, Wong AK, Tashman S, Irrgang JJ, Fu FH. Transtibial ACL reconstruction technique fails to position drill tunnels anatomically in vivo 3D CT study. Knee Surg Sports Traumatol Arthrosc 2012; 20: 2200-2207.
7. Magnussen RA, Debieux P, Benjamin B, Lustig S, Demey G, Servien E, Neyret P. A CT-based classification of prior ACL femoral tunnel location for planning revision ACL surgery. Knee Surg Sports Traumatol Arthrosc 2012; 20: 1298-1306.
8. Wilson TC, Kantaras A, Atay A, Johnson DL. Tunnel enlargement after anterior cruciate ligament surgery. Am J Sports Med 2004; 32: 543-549.
9. Barrett GR, Brown TD. Femoral tunnel defect filled with a synthetic dowel graft for a single-staged revision anterior cruciate ligament reconstruction. Arthroscopy 2007; 23: 796.
10. Franceschi F, Papalia R, Di Martino A, Rizzello G, Allaire R, Denaro V. A new harvest site for bone graft in anterior cruciate ligament revision surgery. Arthroscopy 2007; 23: 558.
11. Shetty GM, Wang JH, Chae IJ, Han SB. A simple and effective technique of femoral tunnel bone grafting in revision anterior cruciate ligament reconstruction. Arch Orthop Trauma Surg 2008; 128: 1269-1271.
12. Vaughn ZD, Schmidt J, Lindsey DP, Dragoo JL. Biomechanical evaluation of a 1-stage revision anterior cruciate ligament reconstruction technique using a structural bone void filler for femoral fixation. Arthroscopy 2009; 25: 1011-1018.