Femoral Tunnel Drilling Angles for the Posterolateral Corner in Multiligamentary Knee Reconstructions: Computed Tomography Evaluation in a Cadaveric Model

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Purpose: The goal of this study was to determine the best angle at which to drill the femoral tunnels of the popliteus tendon (PT) and fibular collateral ligament (FCL) in combined reconstructive procedures so as to avoid either short tunnels or tunnel collisions with the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) femoral tunnels. **Methods:** Eight cadaveric knees were studied. ACL/PCL femoral tunnels were arthroscopically drilled. PT and FCL tunnels were drilled at 0° and 30° axial and coronal angulations. They were scanned by computed tomography to document relations of the PT and FCL tunnels to the intercondylar notch and ACL/PCL tunnels. A minimum tunnel length of 25 mm was required. **Results:** Drilling the PT tunnel at 0° axial angulation was associated with an increased risk of tunnel collision with the ACL ($P < .001$). Interference with the PCL tunnel can be avoided only if the K-wire guiding the PT tunnel is drilled with 30° coronal angulations ($P < .001$). The minimum tunnel length of the PT could be obtained only with both axial and coronal angulations of 30° ($P = .003$). Sufficient tunnel lengths of the FCL were obtained at all angulations evaluated ($P = .036$). However, only the tunnels drilled at 30° axial and 0° coronal angulations did not collapse with the ACL tunnels ($P < .001$). No intersections between FCL and PT tunnels were observed. **Conclusions:** When posterolateral reconstructions are performed in combination with concomitant anterior and posterior cruciate procedures, PT tunnels should be drilled at 30° axial and 30° coronal angulations. FCL tunnels should be drilled at 30° axial and 0° coronal angulations. These angulations should minimize such potential complications as short tunnels or collisions with the ACL/PCL tunnels. **Clinical Relevance:** Specific drilling angles are necessary to avoid short tunnels or collisions between the drilled tunnels when FCL and PT femoral tunnels are performed in multiligament knee reconstructions.

Untreated injuries of the posterolateral corner (PLC) of the knee can lead to chronic disability as a result of persistent instability and articular cartilage degeneration. Biomechanical and anatomic studies have shed light on the importance of the PCL to knee stability.[1,2]

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These studies have shown that the 2 most important stabilizing structures of the PLC are the fibular collateral ligament (FCL) and the popliteus complex. PLC injuries are often associated with tears of the anterior cruciate ligament (ACL) and, especially, the posterior cruciate ligament (PCL) (from 43% to 80%).[3,4] Awareness of the need to treat PLC injuries has increased as untreated PLC injuries have been shown to increase the failure rate of both ACL[5,6] and PCL[7] reconstructions. For this reason, it has been suggested that PLC injuries should be concomitantly addressed in the setting of a concurrent cruciate ligament reconstruction.[5,7]

In recent years, ACL surgery has evolved toward an anatomically oriented reconstruction. Although double-bundle ACL reconstruction is not recommended in patients with multiligament injuries,[8] several studies have found biomechanically that placing the femoral tunnel in a single-bundle technique at the center of the anatomic origin of the ACL restores rotational stability closer to that of the normal knee than does standard tunnel reconstruction high and deep in the notch, near the so-called "over the top position."[9-11] With this technique, tunnel placement is closer to the main posterolateral complex. Tunnel convergence and loss of graft fixation are thus more likely with combined anatomic ACL and PLC reconstruction. PCL grafts might even be compromised during these multiligament knee reconstructions. Although the femoral tunnel of the PCL is established in the medial condyle, the guidewires used to establish FCL and popliteus tendon (PT) tunnels will cross into the medial femoral condyle and may break into the PCL tunnel or lacerate the reconstructed PCL graft. Although some authors advocate drilling a common femoral tunnel for both structures,[12] others have shown the importance of drilling independent tunnels at their femoral insertions.[2,13,14] When a surgeon has to drill 2 or 3 tunnels in the distal femur, it may be difficult to determine the best angle for drilling so as to avoid tunnel collisions. Tunnel collisions may lead to graft rupture or to excessively short tunnels. In a recent study that evaluated the feasibility of concurrent establishment of a femoral FCL tunnel and a femoral tunnel of the posterolateral bundle of the ACL,[15] the risk of tunnel collision in such situations was found to be high. However, no study has assessed the feasibility of combined anatomic single-bundle ACL and PCL reconstructions with not only FCL but also PT femoral tunnels.

The purpose of this study was to determine the best angle at which to drill the femoral tunnels of the popliteus tendon and fibular collateral ligament in combined reconstructive procedures to avoid either short tunnels or tunnel collisions with single-bundle ACL and PCL femoral tunnels and the intercondylar notch. Because of tunnel proximity and the anatomy of the intercondylar notch, the hypothesis was that very specific FCL and PT drilling angles would be necessary to ensure safe placement of the tunnels during concomitant cruciate ligament reconstructions.

Methods

Eight fresh cadaveric knees from adult human volunteer donors were studied. There were 4 male and 4 female donors (5 left, 3 right). Age ranged from 65 to 87 years (mean, 74.7). The specimens, which had been stored at −18°C, were thawed at room temperature for 24 to 36 hours before testing. None of the knees showed macroscopic signs of previous surgery. Only knees with none or mild degenerative changes were included. Preoperative mobility, measured with a goniometer, gave minimum flexion of 135°. Full extension was still possible. The specimens were mounted on a knee holder (Extremity Holder, Sawbones, Malmö, Sweden).

Arthroscopic Procedure

The surgery was performed with 2 other authors present and in agreement with tunnel placement. Only when the 3 experienced surgeons agreed on the tunnel placement was it drilled. The knees hung freely at 90° of flexion except when the femoral tunnels were being drilled. A high anterolateral (AL) portal was established as the initial viewing portal. A parapatellar anteromedial portal (AM) was also then established as a viewing portal so that the medial wall of the lateral condyle could be better seen. Finally, an accessory anteromedial (AAM) portal was established as the working portal for the ACL femoral tunnel. After excision of the cruciate ligaments, the intercondylar notch was cleared with the help of a shaver, leaving 1 to 2 mm of the ACL and PCL femoral stump. The ACL femoral tunnel was drilled as if a suspensory fixation system was going to be used. Tunnel placement was selected with the help of the BullsEye femoral guide (ConMed Linvatec, Largo, FL) introduced through the AAM portal. This guide has been positively tested for correct anatomic placement of the ACL femoral tunnel.[16] The center of the tunnel was drilled at a point between the AM and PL femoral footprints or in the center of the lateral bifurcate ridge when this had been clearly identified. The procedure was as follows in each knee: (1) a 2.4-mm K-wire was drilled at 110° of knee flexion and subsequently over-reamed with a 5-mm cannulated reamer; (2) the K-wire was drilled at the same entry point but at 130° of knee flexion and then it was also over-reamed to 5 mm; (3) the entire tunnel, except for the most lateral 10 mm of the femoral tunnel, was over-reamed to 9 mm.

The PCL femoral tunnel was placed at the center of its anterolateral bundle footprint, high in the notch and 7 mm deep from the articular cartilage margin of the medial femoral condyle. It was established using an outside-in technique. Thus, a 9-mm tunnel was drilled through all of the medial condyle (Fig 1).

Dissection and Posterolateral Tunnel Drilling

The skin and subcutaneous tissue of the posterolateral aspect of the knee were removed. The fascia lata was removed to more easily assess the lateral aspect of the femur. The lateral aspect of the knees was carefully dissected to identify the femoral insertion of the FCL and PT. A 2.4-mm guidewire was drilled through the center of the femoral attachment of the PT and FCL at 4 different guidewire orientations, with the help of a manual goniometer, in every specimen (Fig 1). The first orientation was 0° axial angulation with reference to the transepicondylar axis and 0° coronal angulation with reference to a line perpendicular to the femoral anatomic axis. A 0.8-mm metallic wire was pulled from the medial side with the guidewire and left in place. The metallic wire later made it easier to recognize the drilled

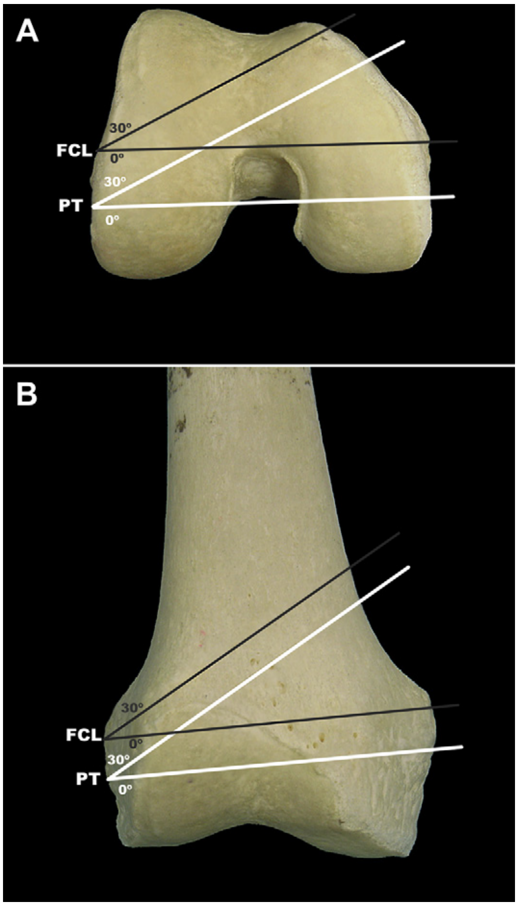

Fig 1. In both the axial (A) and coronal (B) planes, fibular collateral ligament and popliteus tendon tunnels were created at 0° and 30°. The neutral position (0,0) was considered when the guidewire was placed parallel to the transepicondylar axis and perpendicular to the femoral anatomic axis, respectively.

tunnels on the computed tomograms. Consecutively, at the same entry point and following the same steps as with the guidewire tunnel, other metallic wires were left in tunnels (Fig 2A) established at the femoral origin of both the FCL and PT at 0° axial angulation and 30° coronal angulation; 30° axial angulation and 0° coronal angulation; and 30° axial angulation and 30° coronal angulation. On the basis of data reported in a recent study,[15] additional orientations were excluded.

Overdrilling the FCL and PT tunnels in every specimen to those drilled in the clinical setting would have been impractical in the design. Thus, to determine the safety of each drilling tunnel, a 7-mm tunnel was the theoretical diameter to be overdrilled in the clinical setting. Then, an additional 2.3-mm-wide tunnel had to be considered. This comes from the difference between half of the 2.4-mm drilled tunnel (1.2 mm) and the supposed 7-mm clinical tunnel (3.5 mm). A minimum of 2.5 mm was finally chosen as the minimum safe distance.

A minimum tunnel length of 25 mm for proper graft−tunnel healing is usually recommended.[17] Thus, to evaluate the role of FCL and PT tunnel depth as a possible cause of tunnel collision, a 25-mm tunnel was a requirement in considering a safe drilling angle.

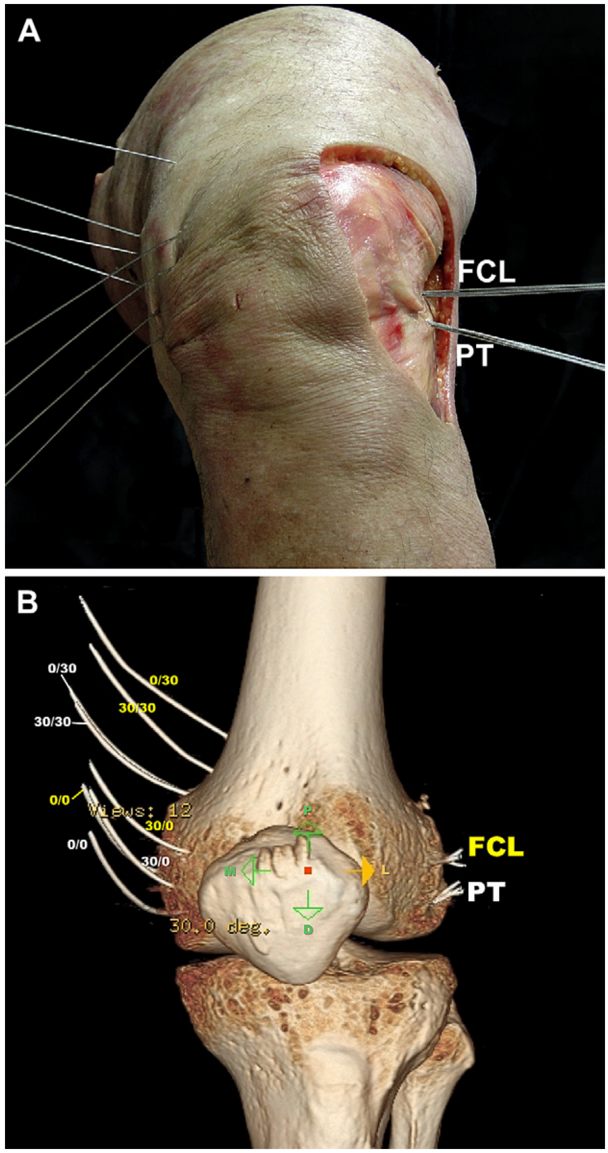

Fig 2. Four tunnels were drilled at the 4 angulations tested from the same entry point corresponding to the fibular collateral ligament and the popliteus tendon femoral insertions. A 0.8-mm metallic wire was left inside each tunnel for easier recognition in the following computed tomography evaluation. (A) Left knee of a cadaveric specimen. (B) 3-dimensional CT image of the same knee. See the 4 different orientations of the metallic wires inside the tested tunnels (axial angulation/coronal angulation) introduced through the same entry point of the fibular collateral ligament (FCL, yellow) and popliteus tendon (PT, white). (Green arrows: P, proximal; D, distal; M, medial; yellow arrow: L, lateral.)

Computed Tomography Scanning

All knees were placed in full extension and imaged on multiple planes on a LightSpeed VCT Pro 5-Beat

Cardiac with AW VolumeShare (GE Healthcare, Waukesha, WI) to generate multiplanar reconstructions of axial, sagittal, and coronal plane CT images. Volume-rendering 3-dimensional CT reconstructions were also performed (Fig 2B), and 3-dimensional images were then obtained to determine tunnel position of the cruciate ligaments. With OsiriX Medical Imaging Software Version 1.7.1, an open-source software for navigating in multidimensional DICOM images,[18] different quantitative parameters were evaluated.

Two expert musculoskeletal imaging radiologists performed all measurements and then averaged them. Both radiologists were blinded to the subject and purpose of the study. The radiologists first confirmed that the actual tunnel angles drilled for the ACL/PCL and FCL/PT matched approximately the authors' intended angles. Then, the shortest distance to every tunnel and to the intercondylar notch was measured. Any possible intersection between the FCL and PT tunnels was also studied. Axial, coronal, and sagittal views were superimposed and only the shortest distance observed in any of the 3 different planes was the final measure considered for data purposes. Each measurement was performed from the distal border of the corresponding 2.4-mm tunnel to the nearest point of the cortex of the cruciate femoral tunnels or to the intercondylar notch. All the following measurements were performed in 0.1-mm intervals:

- Minimum distance to the ACL tunnel
- Tunnel lengths from the entry point to the ACL tunnel in case of tunnel collision
- Minimum distance to the PCL tunnel
- Tunnels drilled through the intercondylar notch
- Tunnel lengths from the entry point to the intercondylar notch
- Tunnels not drilled through the intercondylar notch which had at least 2.5 mm of bone wall between them
- Collision with the ACL tunnel

Statistical Analysis

Categorical variables are expressed as percentages and frequencies. Means and standard deviations as well as medians, minima, and maxima were calculated for each continuous variable. Quartiles were not calculated because of the small number of cases.

Repeated-measures analysis of variance (ANOVA) was used for multiple comparisons of the mean values of the different drilling angles. The Greenhouse−Geisser test was used to avoid any possible violation of the sphericity assumption.

Interobserver agreement was analyzed using the intraclass correlation coefficient (ICC) in the case of quantitative variables. In those relevant cases, a 95% confidence interval was also calculated. For categorical variables, interobserver agreement was estimated with the κ-coefficient.

Statistical analysis was performed using SPSS 19 (SPSS, Chicago, IL). Statistical significance was set at 0.05.

Results

Relation to ACL Tunnel

When the PT tunnel was drilled at 0° axial angulation, there was an increased risk of tunnel collision with the ACL ($P < .001$) a few millimeters from the entry point (Table 1). All FCL tunnels collided with the ACL tunnel and also failed to reach minimum tunnel length, with the exception of the tunnels drilled at 30° axial and 0° coronal angulations (Fig 3, Table 1) ($P < .001$).

Relation to PCL Tunnel

Interference of the PT tunnel with the PCL tunnel can be avoided only if the K-wire guiding the PT tunnel is drilled at a 30° coronal angulation ($P < .001$) (Table 2). Interference of the FCL tunnel with the PCL tunnel was observed only when the tunnel was angled 0° on both the axial and coronal planes ($P < .001$) (Table 2).

Intercondylar Notch and Tunnel Length

All of the PT tunnels drilled at 0° on either plane violated the intercondylar notch (Fig 4), with a minimum length slightly below 25 mm. Thus, only those tunnels angled 30° in both axial and coronal planes were safely drilled and attained the minimum required tunnel length ($P = .003$). These tunnels had a minimum distance of 5.3 mm to the intercondylar notch (Table 2).

The FCL showed adequate tunnel length from the entry point to the intercondylar notch at all trajectories

Table 1. Distances From the Popliteus Tendon and Fibular Collateral Ligament Tunnels to the Anterior Cruciate Ligament Tunnel

	ACL Tunnel	Tunnel Length−ACL Tunnel
Popliteus tendon tunnel		
0° axial/0° coronal	1.8 (6.6 ± 3.7), 3/8	1.9 (3.1 ± 0.6)
0° axial/30° coronal	0 (1.7 ± 1.4), 5/8	2.7 (5.2 ± 2.6)
30° axial/0° coronal	7.5 (10.5 ± 2.9), 0/8	
30° axial/30° coronal	3.9 (5.7 ± 2.1), 0/8	
P value	<.001	.001
Fibular collateral ligament tunnel		
0° axial/0° coronal	1.9 (6.3 ± 2.6), 1/8	7.1 (10.8 ± 3.2)
0° axial/30° coronal	0 (3.6 ± 3.1), 3/8	8.6 (13.8 ± 3.4)
30° axial/0° coronal	5 (10.2 ± 2.8), 0/8	
30° axial/30° coronal	0 (6.6 ± 3.7), 2/8	12.4 (10.1 ± 3)
P value	<.001	.001

NOTES. All data are expressed in millimeters as minimum (mean ± SD); number of cases at distances <2.5 mm/total number of cases.

ACL, anterior cruciate ligament; ACL tunnel, distance to drilled ACL tunnel; Tunnel length−ACL tunnel, length of drilled tunnel from entry point to collision with the ACL tunnel.

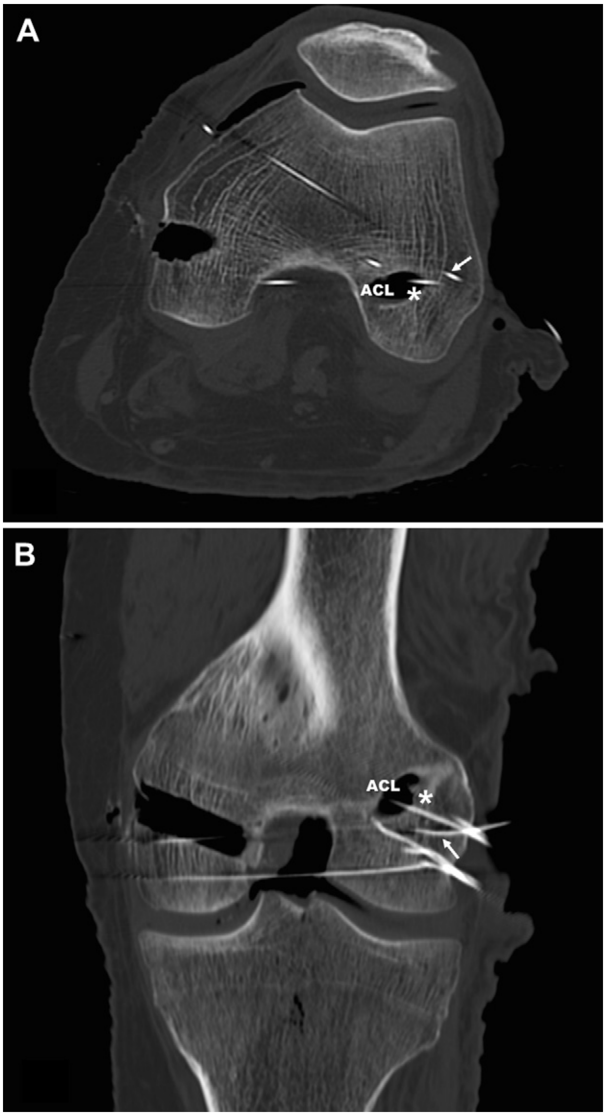

Fig 3. Only fibular collateral ligament (FCL) tunnels drilled at 30° axial and 0° coronal angulations did not collapse with the anterior cruciate ligament (ACL) tunnel. (A) In this axial CT view, the FCL drilled at 0° axial angulation (*) passed through the ACL tunnel (ACL), whereas the FCL drilled at 30° axial angulation (white arrow) did not. (B) Coronal CT view of the same knee, where the FCL drilled at 30° (*) went across the ACL tunnel (ACL), whereas the FCL drilled at 0° avoided it (white arrow).

(P = .036). Although at 0° axial and coronal angulations, 50% of the FCL tunnels violated the intercondylar notch, the minimum length of these 4 tunnels was 32.6 mm (Table 2).

Optimal PT and FCL Tunnel Angulations

Considering all the variables studied, the safest PT tunnels were obtained in the group drilled at 30° on both the axial and coronal planes. Relative to the FCL tunnels, the safest combination was observed when the tunnel was drilled at 30° on the axial plane and 0° on the coronal plane (Fig 5).

Evaluation of the Experimental Design

The actual angles of the drilled tunnels were in the range ± 5.4° of the intended angles in all cases. In addition, no intersection between FCL and PT tunnels were observed at any angulation studied. Finally, the ICC obtained was considered excellent (0.92).[19] The high calculated κ-coefficient (0.92) also revealed excellent agreement between observers.

Discussion

The current study confirmed the high risk of short tunnels or collisions between tunnels when the posterolateral corner of the knee is being reconstructed concomitantly with cruciate ligaments. However, our study found that such complications could be avoided by directing the FCL tunnel anteriorly with an axial angulation of 30° and coronal angulation of 0° and also by directing the PT tunnel with 30° axial angulation but also including a cephalad direction on the coronal plane of 30°.

During recent years and because of the high rates of persistent rotatory instability observed after placement of the ACL femoral tunnel high in the notch,[20] interest in ACL anatomic reconstruction has increased. Several studies have recently found, biomechanically, that placing the femoral tunnel in a single-bundle technique at the center of the anatomic origin of the ACL more closely restores rotational stability to the knee than does the standard tunnel reconstruction high and deep in the notch.[9-11] In this study, the ACL femoral tunnel was carefully placed in the center of its femoral footprint. To better achieve correct visualization of the femoral footprint, a central portal was used for visualization and the working portal was the AAM portal. This portal has shown to allow easier placement of the femoral tunnel in the center of the ACL femoral footprint in comparison with the transtibial drilling technique.[16,21-24] Despite the biomechanical advantages of anatomic tunnel placement, many surgeons worldwide still perform ACL reconstructions with the transtibial drilling technique. The fact that anatomic femoral tunnel placement of the ACL through the AAM was the only ACL femoral tunnel established might limit wider generalization of the results. This limitation is in general inherent to any evaluation of experimental surgical techniques. In fact, a similar study performed by Camarda et al[15] evaluated different FCL femoral tunnel angulations, but only in relation to the posterolateral bundle ACL tunnel. However, it was asserted that a single-bundle ACL reconstruction would be preferred in patients with multiligament injuries because of the risk of impairment of the vascular supply to the lateral femoral condyle, increasing the risk of fracture and vascular necrosis.[8]

The PCL has a posteromedial bundle and a stronger anterolateral bundle.[25] In the present study, the

Table 2. Distances From the Popliteus Tendon and Fibular Collateral Ligament Tunnels to the Intercondylar Notch

	Intercondylar Notch	Tunnel Length—ICN	PCL Tunnel
Popliteus tendon tunnel			
0° axial/0° coronal	Always	22.9 (26.2±2.9)	50% of cases
0° axial/30° coronal	Always	25.8 (29.5±2.3)	Never
30° axial/0° coronal	Always	24.5 (30.6±4.4)	25% of cases
30° axial/30° coronal	5.8 (9.6 ± 2.6)		Never
P value	<.001	.003	<.001
Fibular collateral ligament tunnel			
0° axial/0° coronal	50% of cases	32.6 (35.4 ± 2.5)	Always
0° axial/30° coronal	4.7 (11.8 ± 3.8)		Never
30° axial/0° coronal	12.1 (15.3 ± 2.1)	0.036	Never
30° axial/30° coronal	7.8 (16.5 ± 3.7)		Never
P value	<.001		<.001

NOTE. All data are expressed in millimeters as minimum (mean ± SD).

Intercondylar notch, distance to the intercondylar notch in those cases in which the tunnel was not drilled through it; Tunnel length—ICN, length of the drilled tunnel from its entry point to its end at the intercondylar notch; PCL tunnel, intersection of tunnels evaluated with PCL tunnel.

femoral tunnel of the PCL was centered in the footprint of the anterolateral bundle. It was systematically placed high in the notch at 1 o'clock (right knee) and about 7 mm deep from the cartilage margin of the medial femoral condyle, as is usually described.[26]

Posterolateral corner reconstructions are performed in different clinical situations. Although most PLC injuries are addressed with PCL and/or ACL reconstructions, there are indications for isolated PLC reconstructions. Thus, different clinical situations may challenge surgeons. In the present study, it was shown that the femoral tunnel of the PT should always be angled 30° anteriorly on the axial plane and 30° proximally on the coronal plane. This orientation was proven to avoid short tunnels of the PT itself and compromise of the cruciate grafts that are placed inside the corresponding tunnels. On the other hand, when the femoral tunnel of the FCL is being reconstructed, a wider range of safe drilling angles are observed. The FCL tunnel should be angled 30° anteriorly on the axial plane and 0° proximally on the coronal plane in cases with concomitant anatomic ACL reconstructions, in agreement with the only similar study that has, to our knowledge, been published.[14] In that investigation, the authors assessed the feasibility of concurrent establishment of the femoral FCL tunnel and the femoral tunnel of the posterolateral bundle of the ACL. They also found that tunnel collisions could be avoided by directing the FCL tunnel anteriorly with an axial angulation of 20° or 40° and parallel to the distal condylar line. Interestingly enough, that same group had previously suggested that if the PT and FCL femoral tunnels were aimed not only anteriorly, but also proximally, they would not encounter either an ACL or a PCL graft tunnel.[14] This was in concordance with our findings on PT tunnels, but clearly in contrast to our observations on FCL tunnels and a later study[15] by the same group that performed both referenced investigations. In the current study, it was also observed that in cases with isolated PLC injuries or in cases associated only with PCL reconstructions, the FCL tunnel could be drilled at almost any of the evaluated angulations (Table 3).

Awareness of the need to understand and treat PLC injuries has increased because untreated PLC injuries have been shown to increase the failure rate of both ACL[5,6] and PCL[7] reconstructions.

The posterolateral aspect of the knee has a complex anatomy, in part because of evolutionary changes. This anatomy has been described in several publications, but controversy persists. In the current study the femoral insertions of the FCL and PT were easily found as the PLC was not injured in these specimens. In addition, tunnels with all combinations of drilling angles for both

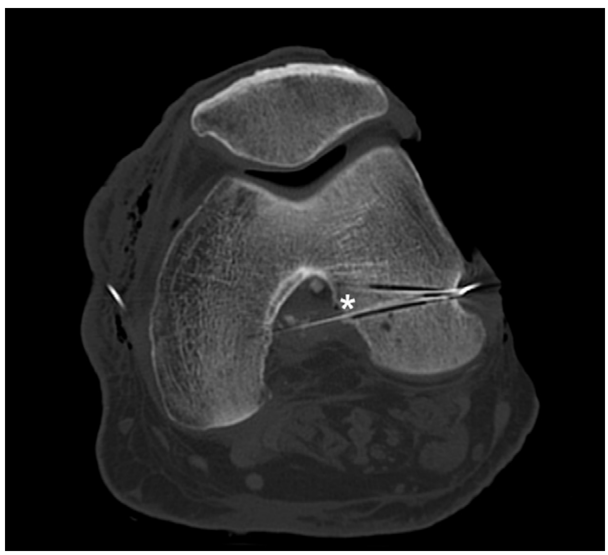

Fig 4. Axial computed tomogram of a left knee. The tunnel of the popliteus tendon drilled at 0° with respect to the trans-epicondylar axis passes through the intercondylar notch (*).

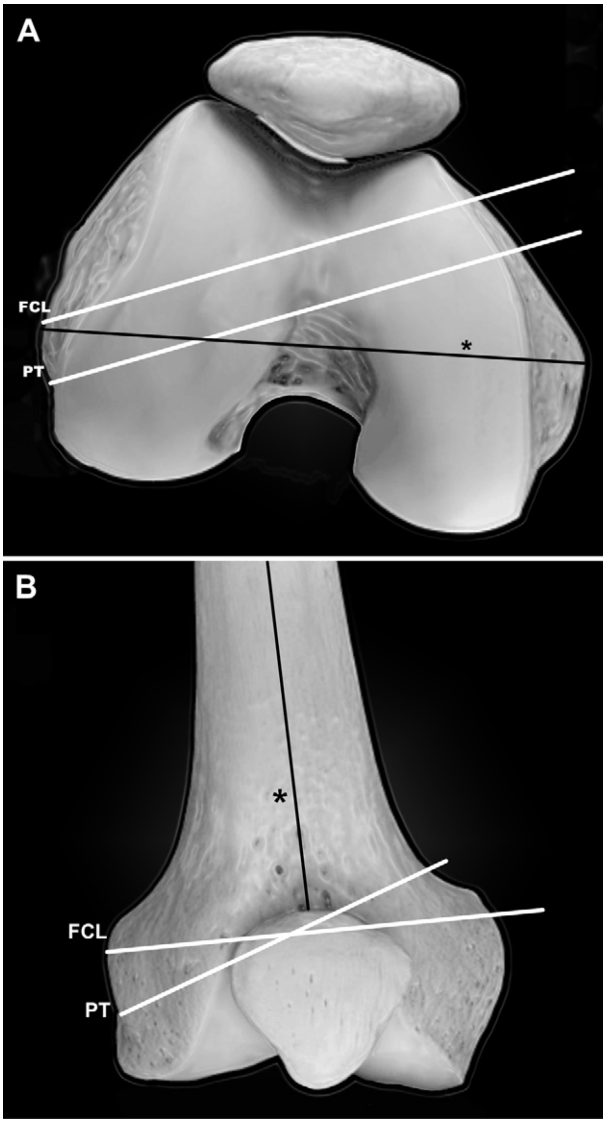

Fig 5. (A) In the axial plane, the fibular collateral ligament (FCL) and the popliteus tendon (PT) should be drilled at 30° axial angulation with respect to the transepicondylar axis (*). (B) In the coronal plane, the FCL should be at 0° and the PT at 30° with respect to a line perpendicular to the femoral anatomic axis (*).

the FCL and PT were drilled in each specimen to exclude anthropometric differences. The treating surgeon must have a thorough understanding of the complex anatomy of the PLC and the corresponding radiographic landmarks to ensure a successful anatomic reconstruction. The angulations of the evaluated tunnels were assessed during the procedure using only a manual goniometer. Although this device might provide low accuracy and it might be seen as a limitation of the study, it was chosen to more closely reproduce the clinical situation. In addition, the CT scan evaluation found that the tunnels were drilled at the intended angle. With respect to evaluation of tunnel placement and its relations, computed tomography is currently considered the gold standard for assessing tunnel relations in reconstructions of knee ligaments.[16,27] Specifically in PLC reconstructions, a recent study also showed the reliability of multiplanar reconstructions of CT views and volume-rendering 3-dimensional CT images that were used in the current study.[15]

Controversy exists over what tunnel length is necessary for safe graft to bone tunnel healing. Although there are no consistent scientific data supporting a specific tunnel length, authors usually recommend tunnels at least 20 mm[14] or 25 mm[16,17] long, which was also the minimum length considered in the current investigation.

There are very few studies evaluating tunnel collisions in knee surgery. More specifically and to our knowledge, this is the first study that has evaluated different angulations of both FCL and PT femoral tunnels when they are established concomitantly with anatomic single bundle cruciate ligament reconstructions. This might be of critical clinical relevance as tunnel collisions may lead to graft rupture or to excessively short tunnels.

Limitations

There are some limitations to the present study: First, only 4 different drilling angulations were evaluated in the study. On the basis of data reported in a recent study,[15] additional orientations were excluded. This previous study found differences only between those tunnels established at 0° axial and coronal angulations and those at 20° or 40° axial and coronal angulations. Thus, only 0° and an intermediate tunnel at 30° were chosen for the current investigation. Another important limitation was that the ACL was reconstructed using one specific technique, and this technique might offer some variations. For instance, different positions of the

Table 3. Recommended Drilling Angles for Popliteus Tendon and Fibular Collateral Ligament Reconstructions in Different Clinical Situations

<table>
<tr><th></th><th>Concomitant ACL/PCL Reconstruction</th><th>Concomitant ACL Reconstruction</th><th>Concomitant PCL Reconstruction</th><th>Isolated PLC Reconstruction</th></tr>
<tr><td>PT tunnel</td><td colspan="4">30° axial/30° coronal</td></tr>
<tr><td>FCL tunnel</td><td>30° axial/0° coronal</td><td>30° axial/0° coronal</td><td>0° axial/30° coronal
30° axial/0° coronal
30° axial/30° coronal</td><td>Any of the evaluated angles</td></tr>
</table>

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner; PT, popliteus tendon; FCL, fibular collateral ligament.

AAM portal or different degrees of knee flexion at the time of femoral tunnel drilling result in different ACL femoral tunnel angles.[17] This might limit generalization of the results observed in this investigation. Similarly, only one PCL reconstruction technique was tested in the investigation. In the same way, although the diameters chosen for the drilled tunnels were intended to be similar to those used in the clinical situation, other tunnel diameters were not evaluated. A 10-mm tunnel might have worked better. However, in our experience with cadaveric studies, the specimens we work with are usually smaller than those in average-sized people. Thus, we believed that a larger tunnel might involve too much of the lateral condyle. Also, the graft is commonly fixed with an interference screw in the clinical setting. This screw may cause some tunnel distortion, which was not evaluated in the investigation. Finally, the fact that the wires were left in situ may have affected the trajectory of the subsequently drilled wires.

Conclusions

When posterolateral reconstructions are performed concomitantly with anterior and posterior cruciate procedures, PT tunnels should be drilled at 30° axial and 30° coronal angulations. FCL tunnels should be drilled at 30° axial and 0° coronal angulations. These angulations should minimize such potential complications as short tunnels and collisions with ACL/PCL tunnels.

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