

Stay Ipsilateral: An Analysis of Tibial Tunnel Distance Between Cruciate Ligament Reconstruction and Posterior Meniscal Root Repair



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Purpose: To establish mean distance or identify intersection between tibial tunnels for posterior meniscal root repair in the setting of anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) reconstruction. **Methods:** Twelve cadaver knees and 12 solid foam synthetic tibiae were used. ACL and PCL tunnels were drilled for single-bundle reconstruction, and both medial and lateral posterior root repair tunnels were drilled. Specimens underwent computed tomography scanning and shortest distances between tunnels in all planes were measured by 2 readers. Distances were compared between groups using a *t*-test. **Results:** In ACL reconstruction, the medial meniscal root tunnel was not significantly closer to the cruciate tunnel when drilled from either medial or lateral side ($P = .333$). The lateral meniscal root tunnel was significantly closer when drilled from medial compared to lateral side ($P < .001$). In PCL reconstruction, both medial ($P = .037$) and lateral ($P = .028$) meniscal root tunnels were significantly closer to the PCL tunnel when drilled from the contralateral side of the tibia. **Conclusion:** This study demonstrates that posterior meniscal root repair tunnels are often placed within a few millimeters and can even intersect cruciate ligament reconstruction tunnels in the proximal tibia. **Clinical Relevance:** The information in this study may assist surgeons in planning for cruciate ligament reconstruction with concomitant posterior meniscal root repair.

Recently, there has been increased interest in the surgical management of meniscal root tears as studies have shown that there is an increased risk of developing ipsilateral compartment osteoarthritis when left untreated.¹⁻⁴ The clinical diagnosis of meniscal root tears remains difficult, but well-described magnetic resonance imaging and arthroscopic findings have increased the awareness of orthopaedic surgeons to these injuries.⁵ The prevalence of lateral posterior meniscal root tears has been reported to be as high as 9.8% in patients with concomitant anterior cruciate ligament (ACL) tears.⁶⁻⁸ Additionally, medial meniscus

posterior root tears have been reported to be present in 3% of multiligamentous knee injuries.^{9,10}

One of the most common surgical techniques for posterior meniscal root repair requires the passage of suture through a tibial tunnel, which is then fixed with a device in the outer tibial cortex.¹¹ Two-tunnel repair technique has also been described.¹² When meniscal root repair is performed in isolation, there is minimal concern regarding the placement of the tibial tunnel. However, when multiple ligaments require reconstruction either in a single or staged fashion, there is a high risk of tibial tunnel convergence within the proximal tibia, which may affect reconstruction graft integrity or fixation of the repair.^{13,14} Tunnel intersection has been studied in ACL reconstruction with posterolateral corner reconstruction.^{13,14} Another study also looked at the tibial tunnel relationships of multiple ligament reconstructions.¹⁵ However, there is a paucity of literature describing the relationship between tunnels for posterior meniscal root tunnels in the setting of cruciate ligament reconstructions.

The purpose of this study was to establish mean distances between tibial tunnels for posterior meniscal root repair in the setting of ACL or posterior cruciate ligament (PCL) reconstruction. We hypothesized that

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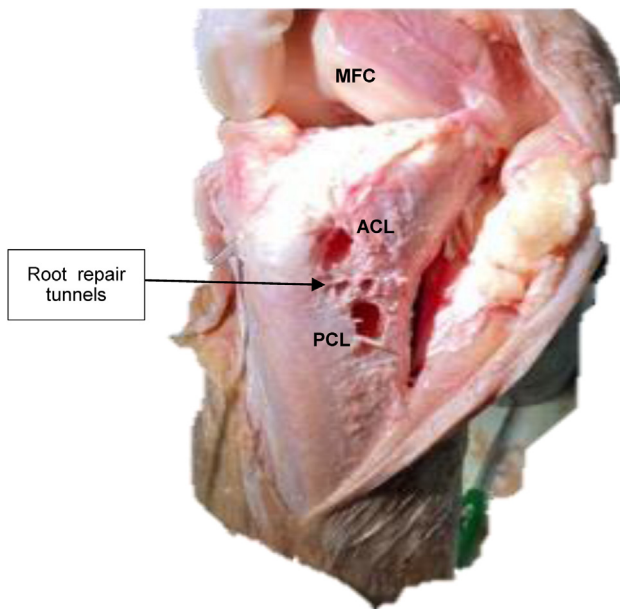


Fig 1. Anteromedial surface of the proximal tibia of a right knee. Specimen has been skeletonized and arthrotomy performed to demonstrate tunnel configuration. Tunnels labeled for ACL, PCL, meniscal root repair. Two tunnels placed, one for medial root and one for lateral root. (MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

ipsilateral approaches to both posterior meniscal roots would avoid tunnel convergence.

Methods

Twelve cadaveric knees were used for this study that were donated after educational laboratory use. Cadaver specimens were excluded if severe osteoarthritis was present, deformity present, or any evidence of intra-articular ligament deficiency or prior surgery. Three specimens were excluded for these reasons.

Arthroscopy was performed, and the ACL and PCL were partially debrided, leaving stumps on native origin and insertion points. Single-bundle ACL tunnels were made in all specimens using an angled guide set at 55° (Arthrex, Naples, FL) and reamed to 9 mm, with external tibial entry point 1 cm medial to the base of the tibial tubercle and intra-articular tunnel centered on the native footprint 5 mm anterior to the medial tibial spine and 9 mm posterior to the intermeniscal ligament.^{16,17} Single bundle PCL tunnels were made using a 60° angled PCL guide (Arthrex) and reamed to 11 mm diameter, with external tibial entry point distal to the ACL tunnel on the anteromedial tibia and intra-articularly centered over the native footprint centered just medial to midline in the coronal plane and 5 to 7mm superior to the champagne drop-off of the posterior tibia.¹⁸

Single tunnel meniscal root repair technique was used. Intra-articular exit points for the posterior meniscal root

repair tunnels were selected on the basis of anatomic insertion visualized by the native meniscal roots. Entry points for root repair tunnels from the outer tibia were decided on the basis of the external tibial cortex available space of each cadaveric specimen. Medially, the meniscal root tunnels were placed as far as possible from the ACL and PCL tunnel apertures on the anteromedial tibia. Typically, the anteromedial-based meniscal root repair tunnels entered between the ACL and PCL tunnels. Lateral-based meniscal root tunnels were started on the anterolateral tibia between Gerdy's tubercle and the tibial tubercle. A universal meniscal root guide (Arthrex) was used, and 3.5 mm pins were used for reaming. The angle on the guide was not fixed and rather was selected on the basis of best anatomic fit per specimen. Angle of the guide was therefore between 55° and 65° for root repair. Tunnel placement is demonstrated in Fig 1 and 2. All tunnels (6 total: ACL/ PCL/ medial root tunnel from medial and lateral / lateral root tunnel from medial and lateral) were placed in each specimen.

The solid foam synthetic tibiae (Sawbones Inc, Vachon, WA) were used as a secondary model for tunnel creation. This was performed to allow a standardized measurement of the cadaver findings as there is no variability in size of these specimens. Medium sized tibiae were used with dimensions similar to that of a female individual.¹⁹ ACL, PCL, and meniscal root tunnels were reamed according to the anatomic bony landmarks described in the literature.^{12,16,18} Aside from using bony anatomic landmarks rather than native

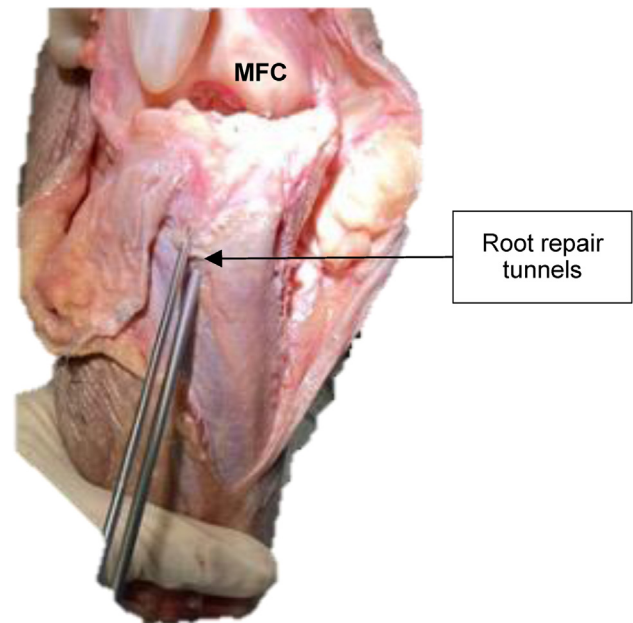


Fig 2. Anterolateral surface of the tibia showing both lateral-based root tunnels (1 to the medial root, 1 to lateral root). Specimen has been skeletonized and arthrotomy performed to demonstrate tunnel configuration. (MFC, medial femoral condyle).

Table 1. Distance to ACL Tunnel

	Coronal (SD)	Sagittal (SD)	Axial (SD)
MR-MED (mm)	6.13 (3.15)	7.81 (5.69)	8.16 (3.93)
MR-LAT (mm)	16.52 (9.26)	9.69 (5.79)	8.54 (5.14)
LR-MED (mm)	3.81 (2.64)	4.68 (2.63)	5.09 (3.61)
LR-LAT (mm)	14.57 (4.82)	8.49 (5.79)	13.38 (5.76)

Mean tunnel distance between various root configurations and ACL tunnel.

Bold denotes the smallest mean distance measured.

LR-LAT, lateral root drilled from anterolateral tibia; LR-MED, lateral root drilled from anteromedial tibia; MR-LAT, medial root drilled from anterolateral tibia; MR-MED, medial root drilled from anteromedial tibia; SD, standard deviation.

tissue, the tunnels were placed in a similar manner as they were in the cadaveric portion of the study.

Computed tomography imaging studies were obtained on all cadaver and sawbones specimens with 3-dimensional reconstruction (2-mm cuts) (Aquilion16; Toshiba Medical Systems, Tustin, CA) to determine the distance between the created tunnels or to determine whether a tunnel collision existed. Radiographic measurements were conducted using the computer’s straight-line measuring tool to determine the tangent distance between all root tunnels and each cruciate ligament tunnel, in all 3 planes of imaging (axial, coronal, sagittal cuts). Measurements were performed at the closest point along the tunnels. Computed tomography scans were read by 2 sports fellowship-trained orthopaedic surgeons (A.C., M.N.). The shortest distance between each root repair tunnel and cruciate tunnel in all planes was measured and recorded. This was then averaged. This mean value was used to perform Student’s *t*-tests comparing mean distances to cruciate tunnels from each root repair tunnel. Statistics were performed in Excel (Microsoft, Redmond, WA).

Results

ACL

No tunnel intersection was found in any cadaver or foam specimens between posterior meniscal root and ACL tunnels. Mean distances in each plane averaged over all cadaver specimens are displayed in Table 1.

Regarding meniscal root repair with ACL reconstruction, there was no significant difference between total tunnel distance from medial root tunnel drilled from the lateral side (MR-LAT) to ACL tunnel (mean 8.87 mm, standard deviation [SD] 5.87) compared to the medial root tunnel drilled from the medial side (MR-MED) (mean 7.91 mm, SD 4.56, $P = .333$).

Regarding lateral meniscal root (LR) repair with ACL reconstruction, mean distance was smallest to the lateral root tunnel drilled from medial (LR-MED) tunnel, averaging 3.81mm in the coronal plane on cadaver specimens and 4.36 mm on foam tibiae. Using a *t*-test

on average distances from all planes, the LR repair tunnel was significantly closer to the ACL tunnel when drilled from MED (mean 4.98 mm, SD 2.94) than when placed from LAT (mean 13.89 mm, SD 5.60, $P < .001$). These results are displayed in Table 2.

PCL

There was no tunnel convergence between root tunnels drilled from ipsilateral sides (MR-MED, or LR-LAT) and PCL tunnels. Mean distances in each plane averaged over all specimens are displayed in Table 3.

Regarding meniscal root repair with PCL reconstruction, tunnel intersection was found between the PCL tunnel and the MR-LAT in 5 of 12 specimens, and all 12 foam tibiae. The medial meniscal root repair tunnel was significantly closer to the PCL tunnel when drilled from the lateral side (mean 2.02 mm, standard deviation [SD] 2.12) than MED (mean 3.83 mm, SD 2.59, $P = .037$).

Regarding LR repair with PCL reconstruction, 3 of 12 cadaveric specimens had tunnel intersection between the PCL tunnel and LR repair tunnel when drilled from the anteromedial tibia (LR-MED). No intersection was found on foam tibiae. The LR repair tunnels were significantly closer to the PCL tunnel when drilled from medial (mean 4.88 mm, SD 3.78) compared to lateral (mean 8.47 mm, SD 4.65, $P = .028$). These results are displayed in Table 2.

Discussion

This study demonstrates that posterior meniscal root repair tunnels are often placed within a few millimeters and can even intersect cruciate ligament reconstruction tunnels in the proximal tibia. Tunnel intersection was found when posterior meniscal root repair tunnels were drilled from the contralateral side of the tibia during PCL reconstruction, and the ACL tunnel was only a few mm away from the lateral meniscal root tunnel when drilled from the medial side. As a result, it

Table 2. Pooled Comparisons

	Mean Distance to ACL			Mean Distance to PCL		
	Mean	SD	<i>P</i> Value	Mean	SD	<i>P</i> Value
MR-MED (mm)	7.91	4.56	.333	3.83	2.59	.037
MR-LAT (mm)	8.87	5.87	.333	2.02	2.12	.037*
LR-MED (mm)	4.98	2.94	<.001*	4.88	3.78	.028*
LR-LAT (mm)	13.89	5.60	0.001	8.47	3.78	.028

Averaged distances in all planes between root and cruciate tunnels for each configuration.

LR-LAT, lateral root drilled from anterolateral tibia; LR-MED, lateral root drilled from anteromedial tibia; MR-LAT, medial root drilled from anterolateral tibia; MR-MED, medial root drilled from anteromedial tibia; PCL, posterior cruciate ligament; SD, standard deviation.

*Denotes significant difference between value and contralateral approach for same root tunnel, for example LR-MED vs LR-LAT.

Table 3. Distance to PCL Tunnel

	Coronal (SD)	Sagittal (SD)	Axial (SD)
MR-MED (mm)	4.21 (3.15)	3.20 (1.96)	4.40 (3.34)
MR-LAT (mm)	2.01 (2.33)	1.90 (2.30)	1.42 (1.83)
LR-MED (mm)	5.56 (3.94)	6.04 (4.27)	4.92 (4.01)
LR-LAT (mm)	10.50 (6.28)	5.70 (3.20)	6.83 (4.11)

Mean tunnel distance between various root configurations and PCL tunnel.

Bold denotes the smallest mean distance measured.

LR-LAT, lateral root drilled from anterolateral tibia; LR-MED, lateral root drilled from anteromedial tibia; MR-LAT, medial root drilled from anterolateral tibia; MR-MED, medial root drilled from anteromedial tibia; PCL, posterior cruciate ligament; SD, standard deviation.

is recommended to drill the meniscal root repair tunnels from ipsilateral to avoid crossing or intersection.

These findings have clinical relevance, despite being performed in cadaveric specimens. As meniscal root repair becomes more commonly performed, the surgeon must be aware of tunnel position if also performing cruciate ligament reconstruction. Tunnel intersection could risk damaging the fixation device or graft. Tunnel placement within a few millimeters of one another risks convergence of the tunnels as well, which could compromise fixation and desired graft position, as well as contribute to widening.

Little is known about tibial tunnel location between posterior meniscal root repair and cruciate ligament reconstruction. LaPrade et al.²⁰ reported posterior medial meniscal root injury during reaming for single-bundle PCL reconstruction. Moatshe et al.^{15,21} described tunnel convergence between the PCL tunnel and posterior oblique ligament tunnel, a medially-based structure, when drilling towards Gerdy's tubercle on the anterolateral tibia. These findings support this study's result of the medial meniscal root repair tunnel crossing through the PCL tunnel when drilled from the anterolateral tibia.

On the basis of these findings, if one wishes to maximize distance between tunnels during ACL reconstruction with meniscal root repair, then drilling the lateral meniscal root repair tunnel from the anterolateral tibia is recommended. For medial root repair with ACL reconstruction, there was no significant difference found in tunnel separation distance, and the root repair tunnel could therefore be placed from either medial or lateral. In PCL reconstruction, the maximal distance would be present between tunnels if medial and lateral root repair tunnels are placed from the ipsilateral side.

Regarding our findings, single-bundle reconstruction tunnels were created for both cruciate reconstructions, as well as single-tunnel meniscal root repairs. Many use double-bundle techniques for ACL or PCL reconstruction, requiring different tunnel placement. However, if tunnel convergence was found using the simple single-tunnel technique, it is likely that multiple tunnels would place the posterior meniscal root repair at an

increased risk for intersection with the cruciate tunnels. In addition, a fixed angle guide of 60° for PCL and 55° for ACL tunnels was used. Depending on patient size and graft length, the tunnel length and angle used may differ. A standard angle was used to compare between specimens, with intra-articular position being consistent on the basis of anatomic native ligament and meniscal landmarks.

Our findings support the use of ipsilaterally-based tunnels when performing cruciate ligament reconstruction if aiming to avoid tunnel collision, particularly in PCL reconstruction in which intersection was commonly observed. As meniscal root repair becomes more frequent in both recognition of the injury and threshold to repair, the understanding of potential surgical pitfalls is essential. Tunnel intersection places both the cruciate graft and meniscal root fixation at risk and should be avoided.²² On the basis of our results, if one aims to maximize distance between cruciate ligament reconstruction tunnels and posterior meniscal root repair tunnels, one should place the meniscal root repair tunnel on the ipsilateral side of pathology.

Limitations

This study has several limitations. First, our standard deviations are large, which indicates that our sample size may not have been sufficient to address anatomic variability and subtle differences in root tunnel location. Second, single-tunnel meniscal root repair and single-bundle cruciate ligament reconstruction configurations were used that do not represent all potential management. Third, even within single-bundle and single-tunnel reconstruction and repair techniques, respectively, a standard angle is not always used during surgery because this can be adjusted on the basis of patient size and graft length.

Conclusion

In ACL reconstruction, the medial meniscal root tunnel was not significantly closer to the cruciate tunnel when drilled from either the medial or lateral side. The lateral meniscal root tunnel was significantly closer when drilled from medial compared to lateral side. In PCL reconstruction, both medial and lateral meniscal root tunnels were significantly closer to the PCL tunnel when drilled from contralateral.

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