

HOW TO AVOID TUNNEL CONVERGENCE DURING MULTIPLE-LIGAMENT KNEE SURGERY: A PRACTICAL GUIDE

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SUMMARY

Background: Multiple ligament knee injuries, often resulting from high-energy trauma or sports-related dislocations, necessitate complex reconstructive procedures to restore joint stability and functional capacity. A significant intraoperative challenge in these cases is tunnel convergence, where the proximity of multiple osseous tunnels increases the risk of hardware collision, compromised graft fixation, impaired biological integration, and potential iatrogenic fractures.

Objective: This article provides a technical guide and 3D mapping strategy to assist surgeons in optimizing tunnel orientation during multiligament reconstructions, including procedures involving the cruciate ligaments, collateral ligaments, and anterolateral structures.

Key Points: In the tibia, the primary risk of confluence occurs between the posterior cruciate ligament (PCL) and posterior oblique ligament (POL) tunnels; directing the POL tunnel 15–20° toward the Gerdy tubercle mitigates this risk. For combined PCL and medial collateral ligament (MCL) reconstructions, angling the tibial MCL tunnel 30° distally prevents convergence. In the femur, lateral condyle tunnels for the fibular collateral ligament and popliteus should be oriented 20–30° anteriorly to avoid the anterior cruciate ligament (ACL) tunnel. On the medial condyle, the MCL and POL tunnels should be angled 30° anteriorly and 30° proximally to maintain adequate bone bridges and avoid the PCL tunnel.

Conclusion: Precise tunnel orientation is the primary modifiable factor for preventing convergence in multiligament knee surgery. Adhering to specific angular guidelines for tibial and femoral drilling reduces the risk of mechanical failure and optimizes the structural integrity of the reconstruction.

KEYWORDS

Anterior Cruciate Ligament Reconstruction; Posterior Cruciate Ligament; Knee Injuries; Joint Instability; Osteotomy

1. INTRODUCTION

Multiple ligament knee injuries occur either in the context of a violent trauma such as a road accident or during sports practice, with ball sports such as football accounting for 7 to 10% of knee dislocations in the literature. In addition to the initial vascular and neurological risks, ligament injuries themselves can seriously compromise the resumption of sporting activities and jeopardize the career of a top-level athlete. Their appropriate treatment is therefore essential for functional recovery.

Multiple ligament knee surgery often poses a challenge for several reasons. One of them, which is often understated, is the risk of tunnel convergence. In fact, to repair a multiligament injured knee, the surgeon has to create tunnels to fix or integrate the grafts. These tunnels may lie very close together and, if they converge, carry a serious risk of collision. The width of the tunnels will depend on whether they are being used to insert an implant or an anchor. However, whatever the size of the tunnels, their convergence can compromise the quality of the fixation or integration and even carry a risk of fracture.

This article offers a practice guide to help surgeons when performing multiple-ligament reconstructions of the knee. It also covers Lemaire extra-articular reconstructions and reconstructions of the anterolateral ligament, because there has been particular progress with these techniques in recent years involving different locations of the femoral tunnel.

Operating on several ligaments at the same time can be complicated and requires high concentration. We offer a simple 3D map that can be studied prior to the surgery, thus allowing the surgeon to focus on the procedure itself.

2. KNEE LIGAMENT RECONSTRUCTION

The various procedures for repairing the anterior and posterior cruciate, posterolateral, medial collateral and posterior oblique ligaments, as well as Lemaire extra-articular reconstructions and reconstructions of the anterolateral ligament, require different tunnels to be made in the tibia and both femoral condyles. We could also include in this list the tunnels needed to repair posterior meniscal root tears because they may also be prone to collision.

These ligament repair techniques can also be combined in numerous ways, some of which are risk-free, while others are more challenging. This is discussed below.

3. AIM

The primary aim is to minimise tunnel convergence and prevent complications such as damage to the implants in their tunnel; creating an overly narrow bone bridge between two tunnels which could compromise the quality of the fixation or even the bone integration, cause fractures, result in damage to the fixation system or make it less effective; and jeopardise implant integration. Any one of these problems could result in implant failure.

Obviously, the point of entry for these tunnels cannot be changed because this is determined by the anatomical location of the native ligament. The only way to avoid the problems of convergence is to optimise the orientation of the tunnels.

4. PRACTICAL GUIDE

4.1. Tibia

The tibial tunnel for anterior cruciate ligament (ACL) reconstruction rarely causes any collision issues because it lies anteriorly, and only the distal ends of the tunnels for posterior meniscus root repairs could, in theory, conflict with the ACL tunnel. This occurs only rarely because the tunnels, which run through the front of the tibia, are easy to control with the naked eye. The surgeon has a perfectly clear view of the tunnel exits and so can easily avoid this problem.

The tibial tunnel made to reconstruct or fix a posterolateral plasty also poses very few collision issues because it usually lies along the anteroposterior axis in the lateral tibial plateau and does not occupy the space required for any other ligament plasty

(Fig. 1). Only the tunnel for repairing a posterior lateral meniscus root tear lies close, but more medially and more anteriorly.

In fact, in the tibia, the main risk of confluence lies between the posterior cruciate ligament tunnel and the posterior oblique ligament (POL) tunnel. In these cases, the POL tunnel should be aimed towards the Gerdy tubercle (15–20°), distancing it from the tibial tunnel for the posterior cruciate ligament (PCL) graft (Fig. 1).

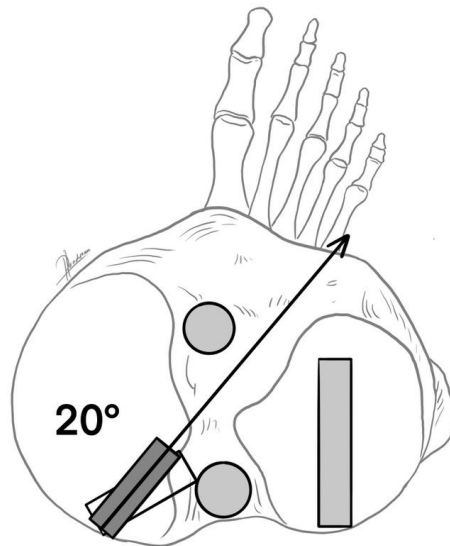


Figure 1: The posterior cruciate ligament (POL) tunnel should be aimed towards the Gerdy tubercle (15–20°), distancing it from the tibial tunnel for the posterior cruciate ligament (PCL) graft. In front and exteriorly are the tunnels for the anterior cruciate ligament and a posterolateral reconstruction. Right Tibia, axial view (from Moatshe et al.)

The second scenario posing a risk of collision in the tibia is combined repair of the superficial medial collateral ligament (MCL) and the posterior cruciate. The risk lies in the distal part of the tunnels. Angling the MCL tunnel 30° distally will avoid confluence with the tunnel for the PCL (Fig. 2).

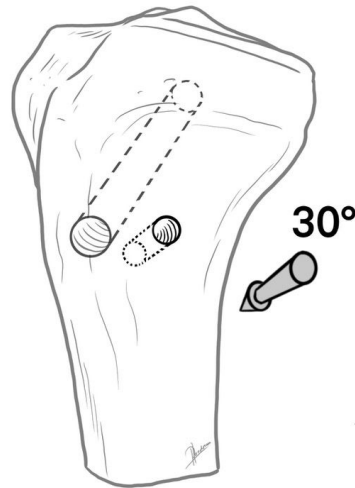
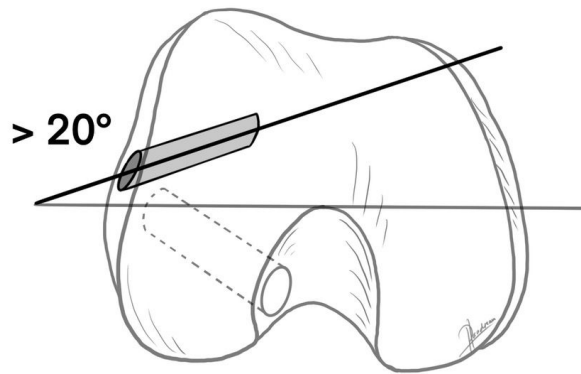


Figure 2: Angling the tibial tunnel for the medial collateral ligament 30° distally will avoid confluence with the tunnel for the PCL. Right tibia, anteromedial view.

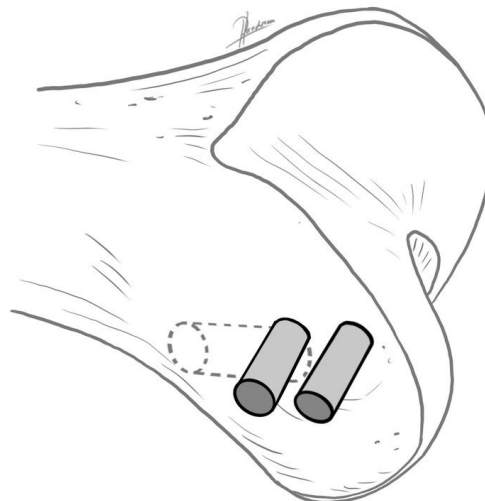
4.2. Femur

4.2.1 Lateral condyle

There is a certain risk of confluence between the femoral tunnel for the anterior cruciate ligament graft (especially with a double-bundle procedure) and the tunnels made to reconstruct the lateral collateral ligament as well as for the popliteus, although to a lesser degree because it lies more anteriorly. Angling these tunnels 20–30° anteriorly will avoid conflict with the ACL tunnel. The tunnel should not lie too deeply to avoid the trochlea (Figs. 3a and 3b).



Figs 3a and 3b: Tunnels for the lateral collateral ligament and popliteal tendon, angled 20–30° anteriorly to avoid conflict with the ACL tunnel. Right knee. Distal view (a) and three-quarter view (b).



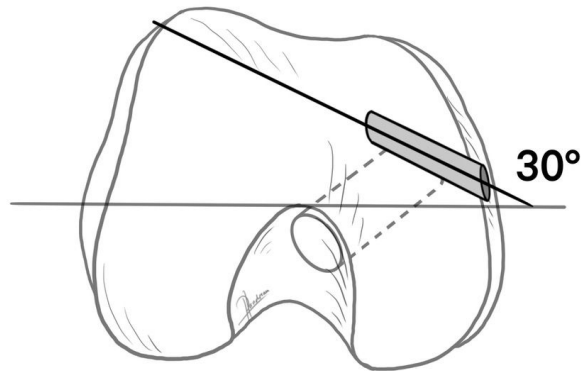
Figs 3a and 3b: Tunnels for the lateral collateral ligament and popliteal tendon, angled 20–30° anteriorly to avoid conflict with the ACL tunnel. Right knee. Distal view (a) and three-quarter view (b).

Anterolateral ligament (ALL) repair and lateral tenodesis also pose a challenge, especially the ALL because its femoral insertion may lie very close to the proximal end of the ACL tunnel. Authors mainly recommend angling the tunnels more anteriorly and proximally to avoid the risk of collision with the ACL tunnel. However, the advice is not as clear-cut as for other reconstructions because there is still a lot of debate about the best anatomical sites.

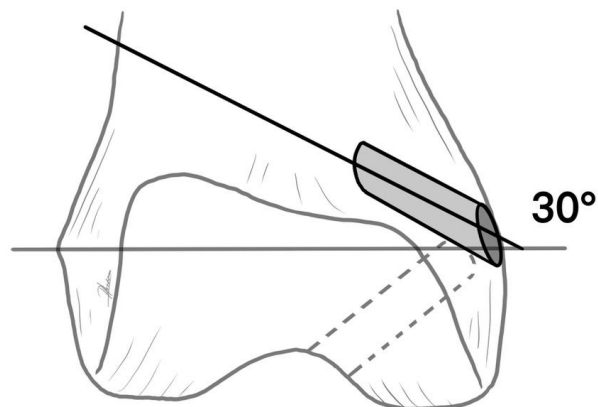
4.2.2 Medial condyle

The risks are significant during PCL repair (especially double-bundle reconstructions) with combined reconstruction of the MCL and posterior oblique. The tunnels for these latter repairs must not be angled too far

back. The tunnel for the MCL should be oriented 40° anteriorly and proximally, and the tunnel for the posterior oblique ligament 20° anteriorly and posteriorly. In practice, these two tunnels should be angled 30° anteriorly and 30° proximally to avoid the tunnel needed for the PCL (Figs 4a and 4b).



Figs 4a and 4b: Angling the two tunnels for the medial collateral ligament and posterior oblique ligament 30° anteriorly and 30° proximally will avoid collision with the PCL tunnel. Right knee. Distal view (a) and frontal view (b). (from Gelber et al.)



Figs 4a and 4b: Angling the two tunnels for the medial collateral ligament and posterior oblique ligament 30° anteriorly and 30° proximally will avoid collision with the PCL tunnel. Right knee. Distal view (a) and frontal view (b). (from Gelber et al.)

5. CONCLUSION

There is a certain risk of tunnel collision during multiple ligament surgery of the knee. Obviously, the point of entry for these tunnels cannot be changed because this is determined by the anatomical location of the native ligament. However, correctly orienting the tunnels using the principles and guidelines explained in this article could limit the risk of graft failure by preventing tunnel collision.

The main risks are to the tibia and femur during combined posterior cruciate and medial collateral ligament repair.

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