Anterior Cruciate Ligament Tunnel Placement Using the Pathfinder Guide

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Abstract: Reconstruction techniques for the anterior cruciate ligament (ACL) have evolved considerably over the past 3 decades. The femoral tunnel is most commonly made via a transtibial or separate anteromedial portal approach. Benefits and drawbacks for each of these techniques exist. Improper tunnel placement is the cause of failure for ACL reconstruction 70% of the time. We present a hybrid technique for femoral tunnel placement using the Pathfinder ACL guide, which attempts to give the surgeon many of the benefits of both the transtibial and anteromedial portal techniques without the drawbacks.

The anterior cruciate ligament (ACL) is the most frequently injured ligament of the knee requiring surgical reconstruction.[1] The ACL is critical for normal knee biomechanics as it supplies more than 80% of the stability in preventing anterior translation of the tibia relative to the femur, while also acting as a secondary restraint to tibial rotation.[2] Injuries are more common in the female athlete and often occur due to a noncontact pivoting injury. Reconstruction is often required after injury, particularly in young active patients who desire return to previous level of activity. Reconstruction can be performed using a multitude of different graft options, each with good success. The most common cause of failure following ACL reconstruction is tunnel malposition.[3-5] The ideal placement of the tibial tunnel should be 9 mm posterior to the intermeniscal ligament, in line with the anterior horn of the lateral meniscus, and approximately 7 to 10 mm anterior to the posterior cruciate ligament insertion.[6] Ideal placement of the femoral tunnel should be between 9 and 10 o'clock on the lateral wall of a right knee with the knee flexed to 90°, leaving approximately 1 to 2 mm of bone between the tunnel and the back wall of the femur and approximately 7 to 9 mm between the lateral aspect posterior cruciate ligament and medial aspect of the ACL.[7] Classically, this femoral tunnel has been created in one of 2 ways: transtibial (TT) or via a separate anteromedial (AM) portal.

Advantages of a TT femoral tunnel placement include increased familiarity for the surgeon, better visualization of the anatomy (due to keeping the knee at 90° as opposed to the needed hyperflexion with AM portal), decreased operative time, and a lower risk of intraoperative mistakes.[8] The TT technique has demonstrated good to excellent outcomes in over 90% of patients.[9] However, due to reliance on the tibial tunnel, multiple studies have demonstrated that femoral tunnels created via tibial tunnels often are placed in a nonanatomic position when compared with the native knee.[10-13] Using the TT technique, femoral tunnels are more often placed in a vertical fashion high in the notch, leading to continued rotational instability, and may be responsible for up to 72% of failures in high-level athletes.[14]

The major advantage of the AM portal technique is achieving a more anatomic femoral tunnel placement, which leads to a decreased risk of continued rotatory instability.[9,12] However, this approach is more technically demanding for the surgeon due to decreased and unfamiliar visualization of the notch, as the knee must be hyperflexed during tunnel

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Table 1. Advantages and Disadvantages of the Pathfinder Guide

Advantages	Disadvantages
Easy visualization as pin placement and reaming occurs at 90° to 100° of knee flexion (familiar position and no flow issues as with hyperflexion)	Flexible guide pin may be difficult to use in revision cases
Oval femoral tunnel aperture with greater overlap with native anterior cruciate ligament	
Independent femoral tunnel reaming	
Anatomic femoral tunnel	
Decreased risk of posterior wall penetration	
Decreased risk of neurovascular injury	
No risk of medial femoral condyle damage with reamer	
Simple transition for transtibial anterior cruciate ligament users	

placement. Visualization is decreased even further as hyperflexion also leads to a stasis of saline flowing through the knee. The use of the AM portal for tunnel placement also increases the risk of injury to the neurovascular structures and cartilage of the medial femoral condyle as the pin and reamer are introduced into the notch as low and medial as possible to ensure longer tunnels with no posterior cortical perforation. Along with these disadvantages, the AM portal technique has also been shown to produce shorter tunnel lengths, leading to an increased potential for graft-tunnel mismatch and less area of ingrowth.[15,16] For a comparison of the pros and cons of each technique, please see Table 1.

Ideal femoral tunnel creation would combine the positive characteristics of the 2 techniques described above while minimizing the negative characteristics of each. This technique paper describes a technique for femoral tunnel placement using the Pathfinder ACL guide, which is a hybrid TT and AM portal guide.

Technique

Preoperative Setup

The patient is positioned in the supine position with a tourniquet placed on the affected side. A post of the surgeon's preference should be placed on the operative side in order to assist in producing a valgus force for any medial compartment work. The authors recommend the equipment in Table 2 along with standard ACL reconstruction equipment per the surgeon's preference.

Portals

The patella and patellar tendon are outlined using a surgical marker. A standard anterolateral portal is created immediately lateral to the patellar tendon to enable visualization of the wall of the lateral femoral condyle with a 30° arthroscope. A 30° arthroscope is placed into the knee via the anterolateral portal. A standard AM portal is then created under direct visualization. A diagnostic arthroscopy is then performed addressing all concomitant pathology, and the torn ACL stumps are debrided in the usual fashion. Once adequate visualization of the tibia and femur has been accomplished, the tibial tunnel is prepared.

Tibial Tunnel

A standard tibial guide is set to around 55° and is used to create an anatomic tibial aperture with whichever tunnel orientation and length are desired. The tibial tunnel is placed 9 mm posterior to the intermeniscal ligament or 7 to 10 mm anterior to the posterior cruciate ligament insertion with the center of the tunnel ideally being just posterior and medial to the anterior horn of the lateral meniscus. This allows for an anatomic recreation of the tibial footprint of the ACL. A reamer size is chosen based on the dimensions of the graft to be used, and the tibial tunnel is then reamed with a rigid reamer. All bony debris is then cleared from the tibial footprint and tunnel to ensure easy graft passage (Fig 1). A tibial tunnel cannula is used on the tibial tunnel to maintain pressure in the knee (Arthrex, Naples FL). Attention is then turned to the femoral tunnel.

Femoral Tunnel

The knee is then flexed and held at 90°. The Pathfinder ACL guide (DanaMed, Chadds Ford, PA) is then inserted through the standard AM portal and placed over the tibial tunnel aperture. The flexible guide wire with plastic sheath is then inserted through the tibial tunnel and into the slot on the Pathfinder ACL guide (Fig 2). It is important to ensure that the plastic sheath is bottomed out to the stop in the guide as this ensures proper redirection of the flexible guide pin during drilling. The guide is then hooked around the back

Table 2. Recommended Equipment

Equipment
Pathfinder guide (5.5, 7.0, or 8.0 mm offset, right or left)
Flexible guide wire and sheath
Smith and Nephew flexible reamer set
Arthrex tibial tunnel cannula

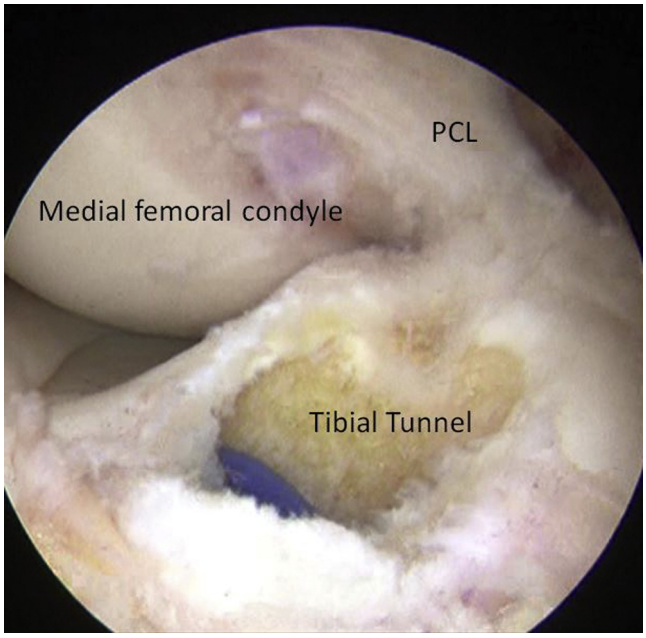

Fig 1. Adequately debrided tibial tunnel to ensure ease of graft passage. Left knee, viewed from the anterolateral portal.

wall of the lateral femoral condyle in the over-the-top position. Due to the guide's geometry and the flexible nature of the wire/sheath construct, the position of the guide will consistently position the guide wire exit hole at the center of the native ACL footprint, which can be difficult to reproduce with the standard TT technique (Fig 3). There are 5.5, 7, and 8 mm offset guides depending on the graft size and surgeon preference. The surgeon's hand is then translated anteriorly to ensure the flange is engaged tightly around the posterior condyle of the femur, and the handle of the guide is dropped at or below the plane of the joint to ensure a safe wire trajectory. The flexible guide wire is then drilled through the femur, out the lateral side, and secured. The guide pin should exit the skin in the anterior half of the thigh to ensure a safe tunnel trajectory with good tunnel length. The plastic sheath is then pulled off of the flexible guide wire using the black handle on the sheath, and the Pathfinder ACL guide is then removed by pushing the guide posterior to the wire pronating the hand and then pulling it out the medial portal. The surgeon should then visualize the pin from the medial and lateral viewing portals to ensure adequate posterior wall for the reamer to be used and anatomic location in the femoral footprint. When the surgeon is satisfied with the position, the femoral tunnel can now be reamed using a flexible reamer (Smith and Nephew, Andover, MA) placed through the tibial tunnel. This results in a femoral tunnel that is straight, in an anatomic position with an intact posterior wall and with a mean length of 38 mm (Fig 4). By drilling the femoral tunnel from a less perpendicular vector, a more oval aperture is created, allowing greater graft/native ACL footprint overlap (Fig 5), versus the more circular tunnel apertures that result from an accessory AM portal technique. Graft passage is performed as per a standard TT technique, typically much easier than with an AM portal approach given the relative collinearity of the tibial and femoral tunnels. Fixation is then performed as per surgeon preference. If fixing the femoral side of the graft with rigid fixation (screws), then using a nitinol guide wire to determine the degree of flexion needed for collinear screw placement has been helpful, as well as then recreating this flexion angle when placing the screw. Please see Table 3 for pearls and pitfalls of using the Pathfinder guide.

Please see Video 1 for a step-by-step guide.

Discussion

Using an AM portal technique for femoral tunnel placement allows for a more anatomic position when compared with the TT technique, but with the downside of decreased visualization, increased risk of medial femoral condyle injury, potentially longer operative time, shorter femoral tunnels, increased risk to neurovascular structures, a round femoral tunnel aperture, and need for an additional assistant. The TT technique for femoral tunnel placement offers a less technically demanding method for femoral tunnel placement via improved visualization (knee at 90°), decreased operative time, surgeon familiarity, and lack of need for an

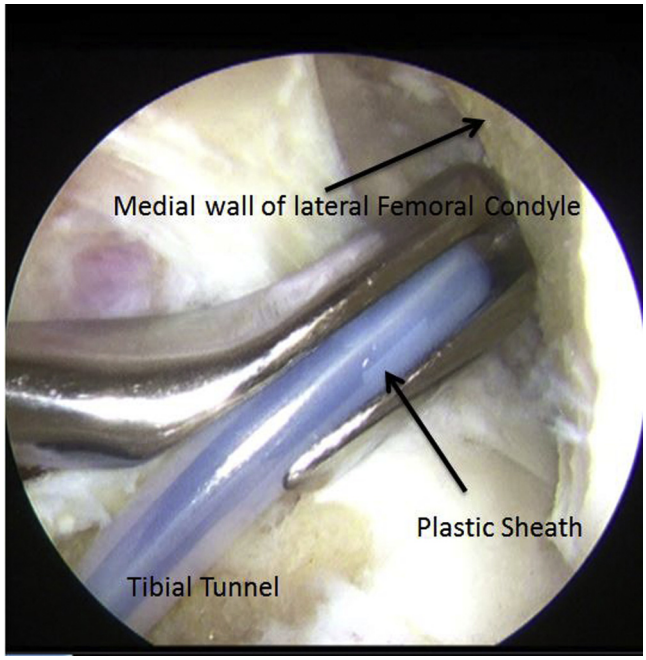

Fig 2. Pathfinder guide in the over-the-top position with plastic sheath. Be certain that plastic sheath is bottomed out on guide to ensure proper direction of femoral tunnel. Left knee, viewed from the anterolateral portal.

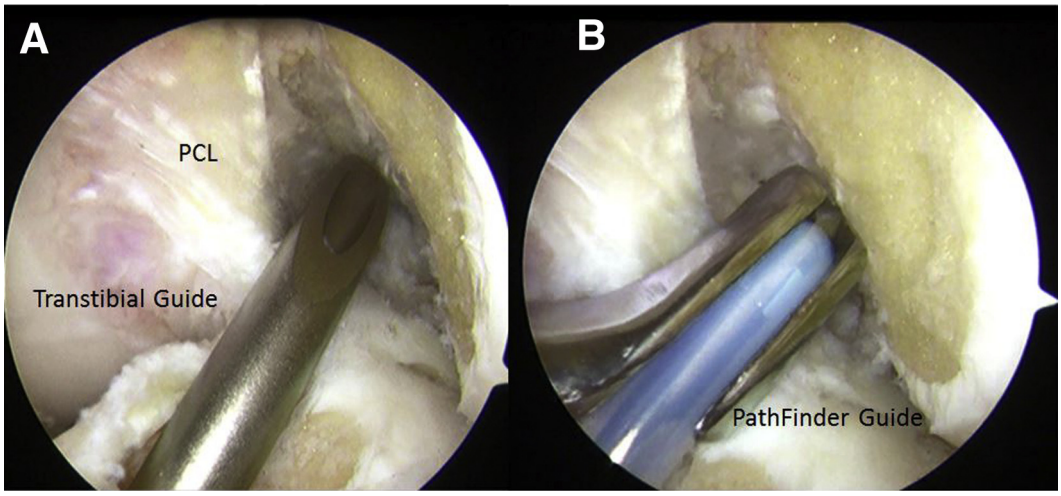

Fig 3. Femoral tunnel position in the standard transtibial technique (A) compared to the Pathfinder guide (B). Note the more vertical orientation via the transtibial technique. Left knee, viewed from the anterolateral portal.

assistant but often results in a nonanatomic femoral tunnel, which can lead to graft failures.[10,12,13,15-17] An ideal method for creation of the femoral tunnel combines the benefits of both methods and minimizes the negatives of each technique. The authors feel that the Pathfinder guide affords the ease of use of the TT technique while also providing the more anatomic placement of the AM portal technique, yet without the previously mentioned negatives associated with the AM portal technique.

Multiple studies have demonstrated improved rotational stability (Pivot Shift), anterior-posterior stability (Lachman), and quicker return to play when the femoral tunnel is created by the AM portal compared with the TT technique.[12,16,18-20] This is thought to be due to a more anatomic position of the graft using the AM portal technique. However, the literature remains split on whether this more anatomic position leads to better patient-reported outcomes. In addition, femoral tunnel placement using the AM portal technique has been shown to have consistently shorter femoral tunnels, leading to potential graft-tunnel mismatch and less surface area for ingrowth.[16,21] A previous cadaveric study has demonstrated that femoral tunnel creation using the hybrid TT technique has more anatomic overlap (94%) with the native ACL compared with the TT technique (37%) and AM portal technique (80%). In addition, the study demonstrated that the hybrid TT technique allows for tunnel length similar to the TT technique (38.5 vs 42.6 mm) compared

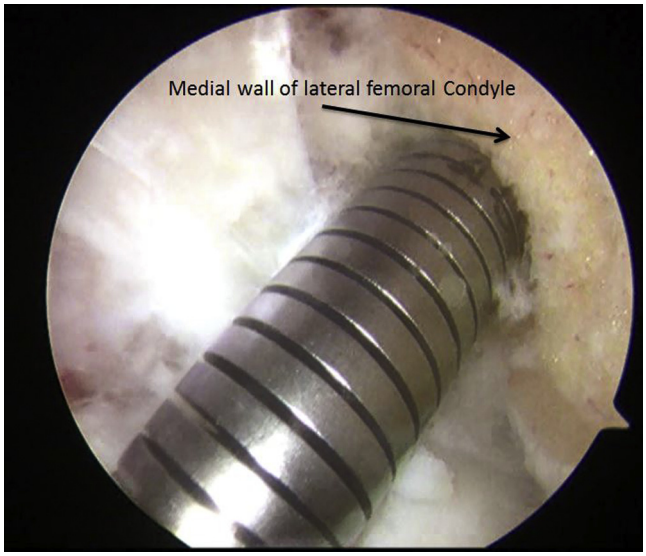

Fig 4. Femoral tunnel should be reamed using a flexible reamer over the guide wire. Left knee, viewed from the anterolateral portal.

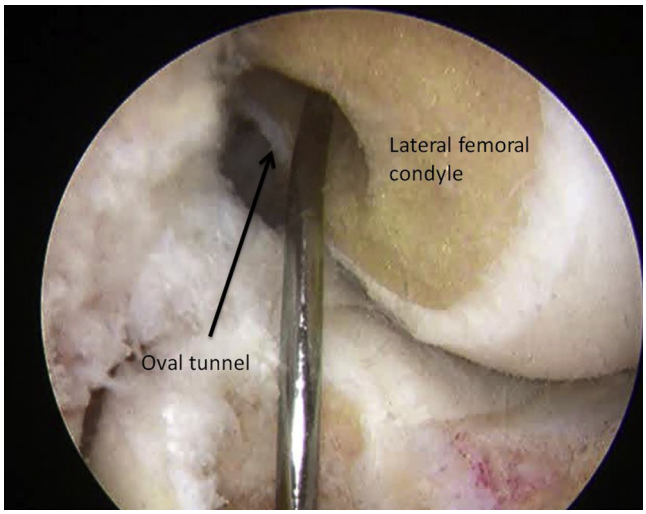

Fig 5. A more oval aperture is created allowing greater graft/native anterior cruciate ligament footprint overlap. Left knee, viewed from the anteromedial portal.

Table 3. Pearls and Pitfalls of Using the Pathfinder Guide

Technical Pearls	Pitfalls
When placing the guide through the anteromedial portal and the pin and sheath through the tibial tunnel, extend the knee to more easily allow them to pair.	If the plastic sheath over the flexible guide pin is not bottomed out, the pin trajectory can be significantly affected.
Ensure plastic sheath over the flexible guide pin is bottomed out to the stop of the guide to ensure proper redirection of pin.	If the guide is not hooked properly on the posterior aspect of the femoral condyle (if the surgeon does not translate hand anterior), the pin trajectory can be too posterior, leading to potential posterior wall disruption.
When positioning the pin, translate the guide's handle anteriorly, ensuring the posterior flange is hooked tightly around posterior condyle and have the knee flexed approximately 90° to 100°.	Flexible reaming sometimes can produce metal debris that should be removed prior to case end.
Pin should exit patient's lateral thigh on the anterior 1/3 of the iliotibial band.	
Check pin position from medial and lateral portals, and measure posterior wall distance from pin to ensure proper position.	
When removing the guide first remove the sheath, then slightly pronate the hand push the guide past the pin and then pull out the anteromedial portal.	

with the shorter tunnel length using the AM portal technique (31.6 mm).[22]

While no clinical studies have been performed to date, basic cadaveric studies indicate that the hybrid technique allows for a femoral tunnel with a reliably anatomic position, adequate femoral tunnel length, and improved surgical visualization.[22] This may allow for a technically easier and safer surgery. Thus, the hybrid technique using the Pathfinder ACL guide for placement of the femoral tunnel allows the surgeon to combine the benefits of both the TT and AM portal techniques.

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