

Outside-In Drilling Allows Avoidance of Two-Stage Surgery in Revision Anterior Cruciate Ligament Reconstruction



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Abstract: The presence of preoperative tunnel widening and/or malposition can pose technical challenges for revision anterior cruciate ligament reconstruction. This Technical Note describes the use of outside-in drilling to avoid the need for 2-stage reconstruction in the presence of tunnel widening or semi-anatomic tunnels.

The presence of preoperative tunnel widening and/or malposition can pose technical challenges for revision anterior cruciate ligament reconstruction (R-ACLR). To avoid convergence with previous tunnels and avoid the risk of inadequate graft fixation, many authors advocate for bone-grafting and a 2-stage approach if tunnels are semi-anatomic or >12 mm in diameter.

This Technical Note describes the use of outside-in drilling to avoid the need for 2-stage reconstruction in the presence of tunnel widening or semi-anatomic tunnels. The rationale for this strategy is simply that outside-in drilling is anatomically unconstrained. This means that revision tunnels can be drilled at very different trajectories to those drilled for the failed

primary reconstruction and even if tunnel convergence occurs at the aperture, graft fixation is not compromised.

In contrast, the available tunnel trajectories with transtibial or anteromedial portal techniques are restricted. Therefore, new femoral tunnels drilled at R-ACLR are more likely to converge with previous widened (unless grossly malpositioned), or semi-anatomic tunnels. However, in contrast to an outside-in technique, when convergence occurs, it does so with a similar trajectory to the original tunnel, potentially exacerbating issues of widening and risking the inability to achieve adequate graft fixation.

Surgical Technique (With Video Illustration)

This Technical Note presents a 1-stage technique for R-ACL with outside-in drilling to avoid the need for 2-stage reconstruction in the presence of tunnel widening or semi-anatomic tunnels (Video 1). Advantages and disadvantages and pearls and pitfalls of outside-in drilling for R-ACL are presented in Tables 1 and 2, respectively.

Preoperative Planning

Preoperative imaging is important to confirm graft rupture and evaluate the status of the articular cartilage, menisci, and secondary restraints. Furthermore, it is important to determine whether previous metallic hardware is present and if its location warrants removal at the time of R-ACLR. Preferred preoperative imaging comprises magnetic resonance imaging (MRI) and standard anteroposterior and lateral radiographs of the knee. Computed tomography scans are not routinely

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Table 1. Advantages and Disadvantages of Outside-in Drilling in Revision ACL Reconstruction**Advantages**

- Outside-in drilling is anatomically unconstrained and easily allows divergent tunnels to be created
- Drilling divergent tunnels obviates problems with tunnel widening and graft fixation
- Outside-in femoral tunnel drilling typically results in a round, non-oval tunnel, allowing 360° graft healing
- A coring reamer used for femoral drilling provides an excellent source of cancellous autograft although it is rarely needed
- Two-stage R-ACL surgery can reliably be avoided
- The procedure benefits from cost minimization; specifically, it avoids the expense of 2-stage surgery, uses only routine equipment and interference screw fixation, and does not require the use of allografts or bone graft substitutes

Disadvantages

- An additional incision is needed on the femoral side (compared with a transtibial or transportal technique)
- Recent systematic review demonstrates that only 15% of ACLRs are performed with outside-in femoral tunnel drilling and therefore it is a new technique with an associated learning curve for the majority of orthopedic surgeons

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; R-ACL, revision anterior cruciate ligament reconstruction.

obtained because MRI and plain radiographs have been demonstrated to be equally useful for determining tunnel position and widening.¹

Step 1: Positioning and Diagnostic Arthroscopy

The patient is placed on the operating table in the standard arthroscopy position with a lateral support at the level of a padded tourniquet and a foot roll positioned to stabilize the leg at 90° of knee flexion (Fig 1). High anterolateral and anteromedial portals are established. A diagnostic arthroscopy is performed, and meniscal and cartilage lesions are addressed before R-ACL. The intercondylar notch is debrided of previous graft material and then particular attention is given to the position and size of femoral and tibial tunnels. If widening is present and likely to interfere with new tunnels, then a coring reamer is used to drill the new femoral tunnel. This provides a cylinder of cancellous bone graft that can be used to fill the enlarged tunnel and ensure good graft fixation.

Step 2: Graft Harvest and Preparation

It is our preference to use ipsilateral autograft for R-ACL. Bone–patellar tendon–bone (BPTB) or semitendinosus autograft are frequently used. The main

deciding factor is availability, determined by which graft was used for the primary ACL reconstruction.

If BPTB is used, harvesting is done through a minimally invasive double-incision technique to avoid the risk of injury to the infrapatellar branches of the saphenous nerve. The typical BPTB graft dimensions are a diameter of 10 mm, with a 10 × 25-mm bone plug at the level of the tibial tuberosity and a 9 × 15-mm bone plug at the level of patella. The longer bone block harvested from the tibial tuberosity is prepared for press-fit fixation in the femoral tunnel. Usually, the patellar bone plug is 1 or 2 mm smaller than tibial bone plug. Drill holes are made in each bone block and passing sutures (2-VICRYL) are placed. The patellar tendon defect and paratenon is closed with 0-VICRYL.

If the semitendinosus is selected, the graft is harvested using an open-ended tendon stripper (Pigtail Hamstring Tendon Stripper; Arthrex, Naples, FL) and the tibial insertion is preserved. The semitendinosus tendon is then tripled over itself and tagged with no. 1 ETHI-BOND sutures (Ethicon, Somerville, NJ) to tubularize the graft. The goal is to obtain a graft with a diameter of 8 to 10 mm, with a length of 12 cm from its tibial insertion. Rarely, the gracilis tendon is also used to achieve a sufficient ACL graft diameter (>7 mm), but

Table 2. Pearls and Pitfalls of Outside-in Drilling for Revision ACL Reconstruction**Pearls**

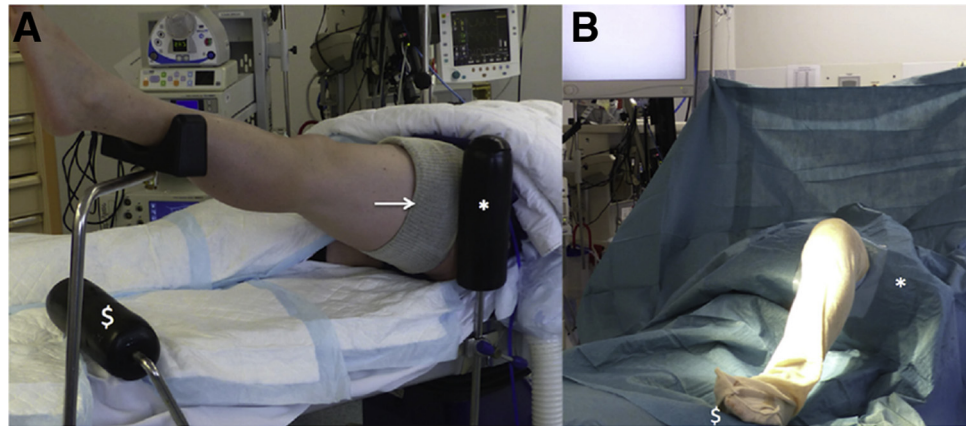
- Palpate and surface mark the lateral collateral ligament to minimize the risk of iatrogenic injury when drilling the femoral tunnel
- Create the femoral tunnel with a coring reamer to obtain a cylinder of cancellous autograft, if needed
- Drill the new femoral tunnel so that it is divergent to the tunnel created for the primary ACL reconstruction
- Position interference screws judiciously in cases of tunnel widening or previous semi-anatomic tunnels, e.g. if the tibial tunnel is slightly too posterior, place the screw posterior to the graft to result in an anatomical position
- Use a footprint guide to ensure that an adequate posterior wall is accounted for and that a blowout will not occur

Pitfalls

- Iatrogenic injury to the LCL
- Failure to use the anatomically unconstrained nature of outside-in drilling and create tunnels with similar trajectories to those used for primary ACLR. This is most likely to occur if the primary ACLR was also performed with an outside-in technique
- Failure to plan for removal of previous hardware (if present, and if needed)
- Collision between the new R-ACL femoral tunnel and a lateral tenodesis. This is most likely if the ACL femoral tunnel is too proximal on the lateral cortex

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; LCL, lateral cruciate ligament; R-ACL, revision anterior cruciate ligament reconstruction.

Fig 1. Patient positioning. Left knee: A lateral post (*) is positioned just proximal to the knee, at the level of the padded tourniquet (white arrow). (A) A foot roll (\$) is used to keep the knee flexion at 90 (B).



more usually it is harvested and set aside for reconstruction of the anterolateral ligament.

Step 3: Drilling of the R-ACLR Femoral Tunnel

The femoral tunnel is created using an outside-in approach. The drill guide (outside-in ACL guide; Arthrex) is placed intra-articularly at the femoral origin of the ACL, in a mid-anteromedial bundle position. The drill guide is then placed on the lateral femoral cortex. The typical location is slightly anterior and distal to the lateral epicondyle. When revising a primary ACL

performed with a transportal or transtibial technique, this location gives near perpendicular divergence between new and old tunnels (Figs 2 and 3).

The guide pin is drilled and correct placement confirmed arthroscopically prior to drilling a tunnel of the same diameter as the graft. A coring reamer (trephine; Arthrex) is routinely used to drill the femoral tunnel. This makes available a cylindrical cancellous bone graft. A shaver is inserted into the new tunnel and used to remove any graft remnant or old suture material.

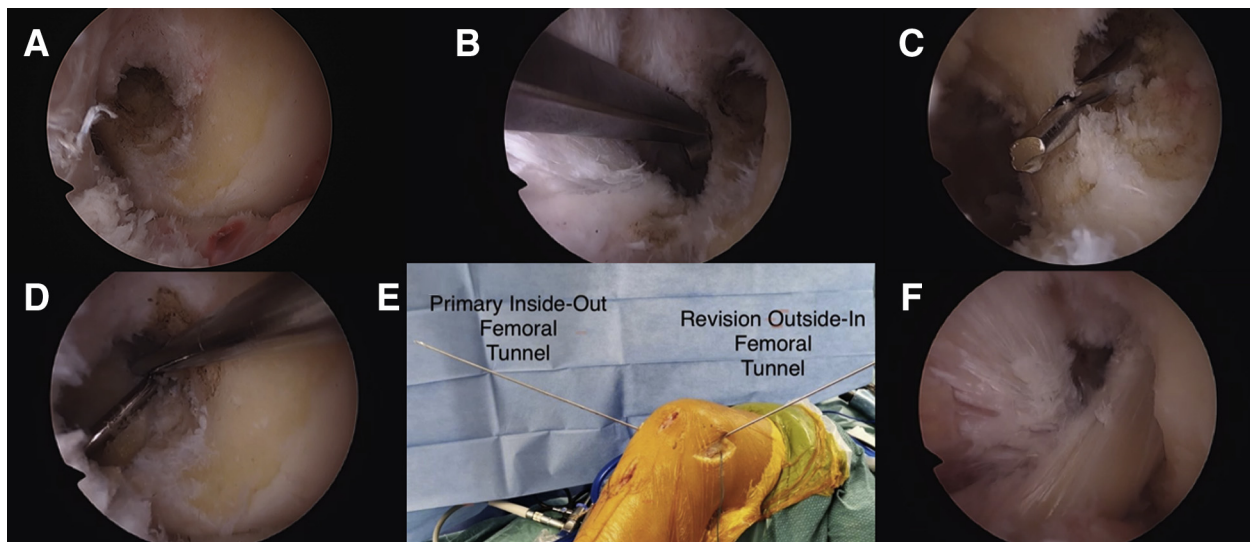


Fig 2. Left Knee. Intraoperative arthroscopic images and external photograph taken during revision (failed primary hamstring ACLR) with ipsilateral BPTB autograft. (A) Arthroscopic view from the anteromedial portal. The previous inside-out femoral tunnel is observed to be located in a mid-bundle position. (B) The femoral drill guide is placed intra articularly at a location proximal to the previous tunnel in order to achieve an anatomic AM position for the revision tunnel. (C) The location of the outside-in placed K wire demonstrates that the new center of the tunnel aperture will be in the AM bundle position. (D) An additional K wire is placed in the original inside-out femoral tunnel simply to demonstrate that both tunnels have a completely different trajectory. (E) An external photograph of the view seen in Figure 3D, demonstrating that the new outside-in tunnel trajectory is nearperpendicular to the previous inside-out tunnel. (F) The final appearance of the BPTB graft at termination of the procedure. (ACLR, anterior cruciate ligament reconstruction; AM, anteromedial; BPTB, bonepatellar tendonebone.)

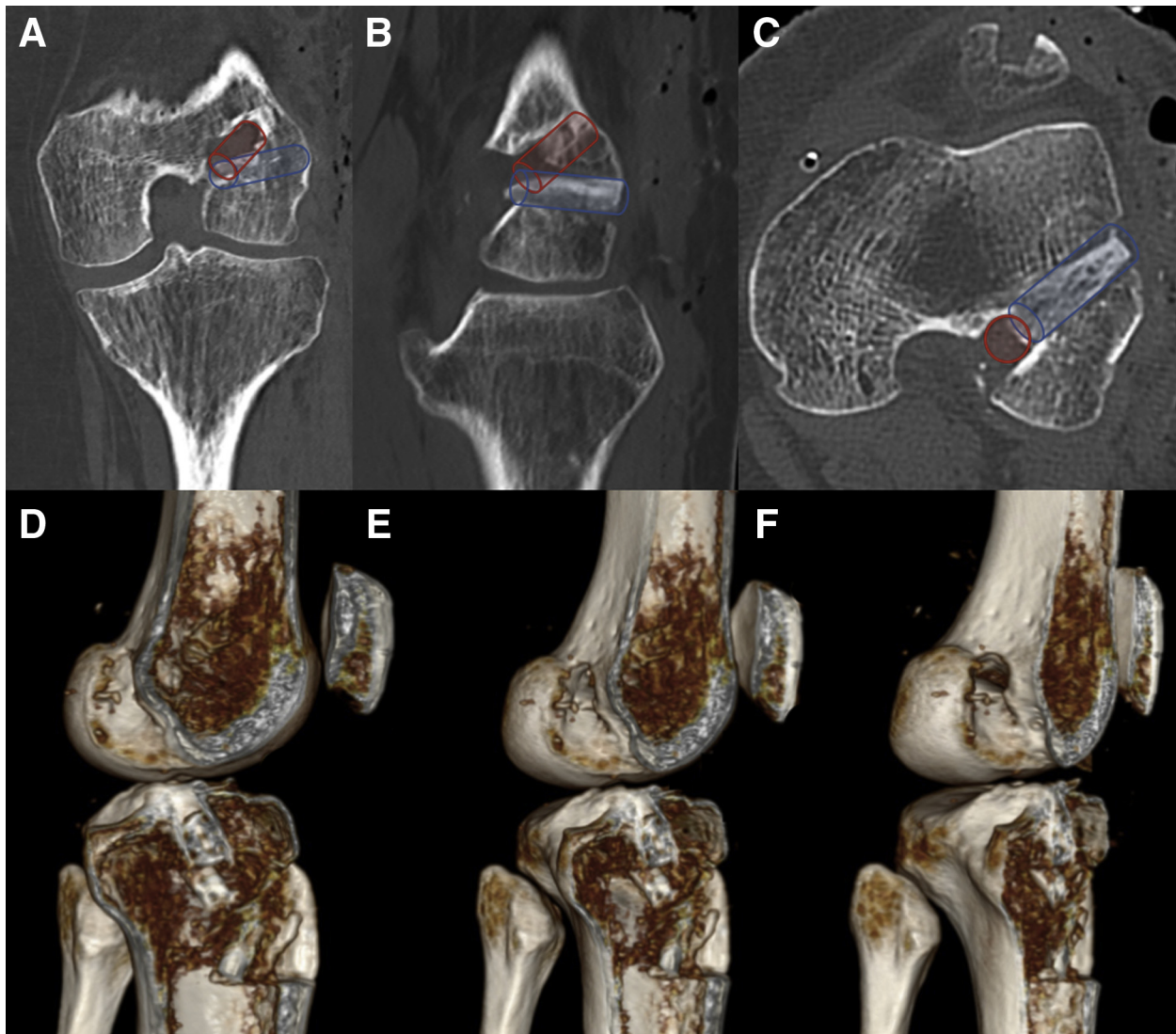


Fig 3. Postoperative computed tomography scan images of the same patient reported upon in [Figure 1](#). Left knee (A) Coronal view demonstrating the previous inside-out femoral tunnel (red) and the revision outside-in femoral tunnel (blue). (B) Coronal view with an obliquity tangent to the femoral tunnel showing a longer tunnel length for the outside-in technique (blue tunnel) than the inside-out (red tunnel). (C) Axial view. Previous inside-out femoral tunnel (red) and revision outside-in femoral tunnel (blue). (D, E, and F) Three-dimensional reconstructions demonstrating the location of the revision femoral tunnel at the anteromedial bundle footprint.

Step 4: Drilling of Tibial ACL Tunnel

The same principles of outside-in drilling are applied to the tibial tunnel. The tibial guide is set at 55° and a guide pin is placed at the center of the ACL footprint, reaming is performed according to graft diameter. Again, any graft remnant or suture material is removed using a shaver.

Step 5: Graft Passage, Tensioning, and Fixation

Using a BPTB Graft

The BPTB graft is passed from the femoral side to the tibial side with a suture shuttle. Press-fit fixation is achieved in the femoral tunnel. The knee is placed at

30° of flexion, and tibial fixation is achieved using a BioComposite interference screw (Arthrex), sized according to the diameter of the ACL graft. Secondary fixation is achieved on the tibial side by tying the shuttling suture over a bone bridge. [Figure 4](#) shows the postoperative MRI with the BPTB graft inside the femoral tunnel.

Using a Hamstring Graft

A suture shuttle is used to pass the ACL graft into the knee and the femoral tunnel, via the tibial tunnel. The graft is fixed with BioComposite interference screws (Arthrex) measuring the same size as the graft

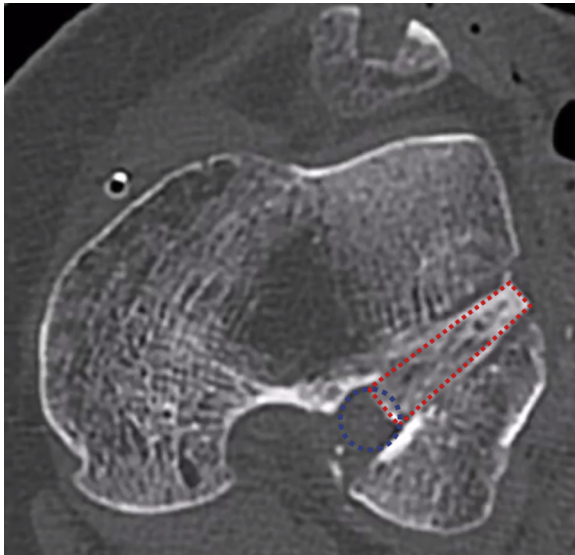


Fig 4. Postoperative MRI. Left knee. Axial view with the BPTB graft inside the femoral tunnel (*red*) and the previous femoral tunnel (*blue*). (BPTB, bone-patellar tendon-bone.)

on both tibial and femoral sides, with the knee at 30° of flexion.

Additional Techniques for Achieving Adequate Graft Fixation and Tunnel Position Without the Need for Two-Stage Surgery

The routine harvesting of a cylinder of cancellous autograft provides an immediate solution for widened tunnels where graft fixation might otherwise be compromised. In the case of semi-anatomic tunnels, this is a potentially useful option because the graft can be placed into the previous tunnel/s in a stacked or “snowman” configuration. However, when using outside-in drilling, the requirement to use graft is

exceptionally rare. More routinely, it can often be sufficient to judiciously use screw placement to achieve an anatomic graft position, e.g. if the tibial tunnel is slightly too posterior, the interference screw is placed posterior to the graft to result in an anatomical position.

Lateral Extra-Articular Procedures

Lateral extra-articular procedures are reported to confer a low-rate of residual laxity and rerupture after R-ACLR.² Furthermore, combined anterolateral ligament reconstruction + R-ACLR is associated with a significantly greater rate of return to the preinjury level of sport when compared with isolated R-ACLR.³ It is our preference to perform anterolateral ligament reconstruction with a hamstring tendon ACL autograft (combined graft) and a modified Lemaire when using a BPTB ACL autograft, in accordance with previously published techniques (Fig 5).⁴

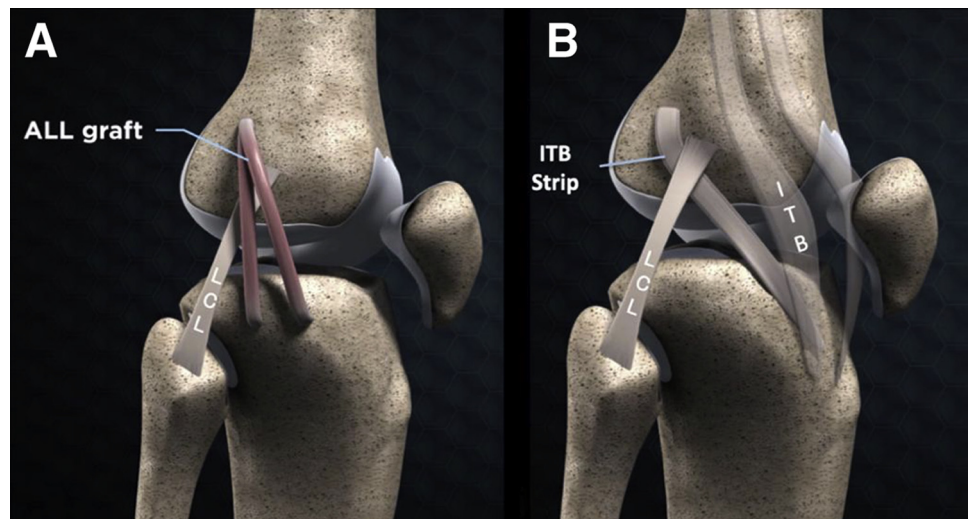
Postoperative Rehabilitation

The postoperative rehabilitation is unchanged from that used following primary ACL reconstruction. Brace-free, full weight bearing with crutches is allowed immediately after the procedure. Early rehabilitation is focused on obtaining full extension and quadriceps activation. Pivoting-contact sports are allowed from 9 months and after neuromuscular recovery.

Discussion

Outside-in drilling offers the major advantage of being anatomically unconstrained. This allows the creation of R-ACLR tunnels that are markedly divergent to the tunnels created for primary ACLR, therefore permitting adequate graft fixation and positioning regardless of the pre-operative presence of tunnel widening or malposition. Other advantages over transtibial and transportal techniques include longer

Fig 5. Lateral extra-articular procedures. Right knee. (A) Anterolateral ligament reconstruction. (B) Modified Lemaire tenodesis. (ALL, anterolateral ligament; ITB, iliotibial band; LCL, lateral collateral ligament.)



femoral tunnels (increasing the likelihood of adequate graft fixation) and a reduced risk of posterior blowout. Furthermore, using a coring reamer provides cancellous autograft and in combination these techniques allow a single-stage approach to R-ACLR regardless of tunnel widening or malposition.

Clinical outcomes of 1- and 2-stage R-ACLR are not significantly different with respect to subsequent revision rates according to 2 recent systematic reviews.^{5,6} It therefore seems logical to avoid a 2-stage procedure whenever possible so that the associated increased morbidity of 2 procedures, a prolonged period of knee instability (before definitive surgery), multiple periods of rehabilitation, and increased health care and societal cost also can be avoided.

Other techniques that can be used to overcome technical challenges during single-stage R-ACLR include the use of fast setting bone substitutes.⁷ Previous authors also have reported the use of stacked screws and/or bioabsorbable screws to fill voids.^{8,9} Although it is important to be familiar with a wide range of techniques, in the experience of the senior author they are rarely needed when outside-in drilling is used (only 2/409 consecutive R-ACLR underwent bone grafting of tibial tunnels, no patients underwent femoral bone grafting, and no patients required stacked screws to fill voids or underwent 2-stage revision; unpublished data and forthcoming series)

Outside-in drilling is a safe technique with a low risk of adverse events. The main risk is iatrogenic injury to the lateral collateral ligament when creating the femoral tunnel drilling. This is easily avoided by palpating and surface marking the lateral collateral ligament before drilling. Additional risks include placing the tunnel too proximal and posterior resulting in posterior cortex blowout. However, this is also easily avoided by using footprint guides to ensure an adequate posterior wall.

It is noteworthy that a recent systematic review demonstrated that only 15% of femoral tunnels at primary ACLR are drilled with an outside-in technique. This finding may reflect that it has previously been suggested that outside-in drilling is associated with an increased graft bending angle, more shear stress and an increased risk of rupture.^{10,11} However, more recent clinical study has debunked this message and instead demonstrated that outside-in drilling reproduces native graft inclination angles in both sagittal and coronal planes, and that neither transtibial or standard anteromedial portal techniques do.¹² It is therefore the opinion of the authors that outside-in drilling is an important technique for R-ACLR surgeons to learn. It offers considerable advantages, particularly the anatomically unconstrained nature and ability to drill

divergent tunnels to obviate the technical issues caused by semi-anatomic tunnels and widening.

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