Technical Note

A Convergent Tibial Tunnel Technique for Concomitant Anterior Cruciate Ligament Reconstruction and Meniscal Root Repair

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Abstract: Modern arthroscopic knee-reconstruction techniques involve the use of multiple bone tunnels and fixation devices to restore the anatomy and stability of the knee after traumatic injury. In these injuries, however, tunnel collision can be problematic, especially when combining anterior cruciate ligament reconstruction with meniscal root repairs or multiligament reconstructions. We describe a multiple tibial tunnel technique to allow fixation of both anterior cruciate ligament graft and meniscal roots through convergence to a single tibial cortical aperture.

With the advent of modern arthroscopic techniques, reconstructing the traumatically injured knee involves not only cruciate ligament reconstruction but the repair of meniscal and chondral injuries. Meniscal root tears are devastating injuries that render the knee in a "total meniscectomy" state. This impacts the chondroprotective function of the meniscus and also its ability to function as a secondary stabilizer of the knee.[1] Lateral meniscus posterior root tears are the most common and are associated injuries in up to 12.4% of anterior cruciate ligament (ACL) tears.[2] Many techniques for isolated meniscal root repair have been described.[3-6] One of the more common techniques is transosseous tibia fixation. When incorporating multiple bone tunnels for combined ACL reconstruction and meniscal root repair, care must be taken to avoid tunnel collision and potentially compromising fixation of either the tibial-sided ACL graft or sutures for the meniscal root repair. Current techniques include performing a root repair using a separate tibial tunnel from the ACL graft.[7,8] Other authors have described using an intra-articular suture anchor to avoid a tibial tunnel altogether,[9] or even nonanatomic transtibial methods.[10,11]

Gursoy et al.[12] recently published a cadaveric study that found a high risk of tunnel convergence if both ACL and meniscal root tunnels were placed on the anteromedial proximal tibia. To reduce this risk, they advocate reorientating the meniscal root tunnels parallel with the ACL tunnel. Further studies have argued both staying more medial or staying lateral to the ACL tibial tunnel.[13,14]

In this Technical Note, we describe a simple technique to drill multiple anatomic intra-articular tunnels converging to a single tibial aperture to allow suspensory cortical fixation in combined ACL reconstruction and meniscal root repair.

Indications

Our indications for root repair are listed in Table 1. These include preserved alignment within 5° of neutral, Kellgren Lawrence grade 1 or 2.

Evaluation

Our patients are evaluated with in clinical with a thorough history and examination. Significant laxity is noted if present on clinical examination. Patients undergo

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Table 1. Indication for Root Repair

Alignment within 5° of neutral
Kellgren–Lawrence grade 1 or 2
Acute tear
Chronic tear with amenable tissue quality

imaging, including preoperative magnetic resonance imaging to assess for ligament, chondral, and meniscal injury.

Surgical Technique (With Video Illustration)

Meniscal root repairs commonly occur with concomitant ACL reconstruction. In this technique, we perform the meniscal root repair after ACL reconstruction.

Patient Positioning

The patient is placed supine on an operating table with a high thigh tourniquet, lateral support, and 2 foot supports. The supports positioned for 70° and 130°—hyperflexion for anteromedial femoral tunnel drilling (Fig 1).

ACL Reconstruction

We perform a standard ACL reconstruction using a standard anteromedial portal drilling technique. Various grafts are used at our institution, with graft selection depending on the clinical scenario. Graft length varies depending on the size of the patient, and we aim to have 20 mm of graft in each tunnel and diameter ≥8 mm.

Diagnostic arthroscopy is performed via anterolateral and anteromedial portals, and the meniscal root tear is confirmed using an arthroscopic probe (Video 1). As part of our standard diagnostic arthroscopy, we evaluate whether any meniscal extrusion is present in the medial and lateral gutters. We believe that this indicates meniscal dysfunction and helps to confirm that a significant root injury is present.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Use grasper to check excursion of meniscus and reducibility to root footprint	Loss of meniscal tissue may mean reduction back to anatomic footprint is not possible
Use appropriate instrumentation including curved aimer guide for root repair a) Curve helps to position guide around tibial spine b) Smaller elbow angle helps get into tight spaces	Inability to repair root anatomically without proper instrumentation
Use angled bullet to ensure guide is firmly placed in tibial tunnel	Potential to fracture bone bridge between tunnels
Drill tibial tunnel before passing root sutures into meniscus	Can capture suture in pin or drill damaging root suture and/or meniscal tissue
When using suture passer, turn passer away from articular surface	Avoid damaging articular surface with suture passer needle
Retrieve root sutures down tunnel before passing graft	Take care to avoid tangling root and ACL graft sutures in tunnel
Visualize root when tying sutures to ensure adequate reduction and tension	Can lose reduction of root repair without direct visualization

ACL, anterior cruciate ligament.

Standard femoral ACL tunnel preparation occurs. The tibial ACL footprint is debrided, and an elbow guide is used to drill a Beath pin under direct visualization. The knee is brought into full extension to confirm no impingement. Cylindrical tibial reamers are used to drill the tibial tunnel based on graft size.

Root Repair

The ACL tibial tunnel is plugged to avoid excess fluid extravasation as we prepare for the root repair. We carefully inspect the meniscus to determine the footprint for

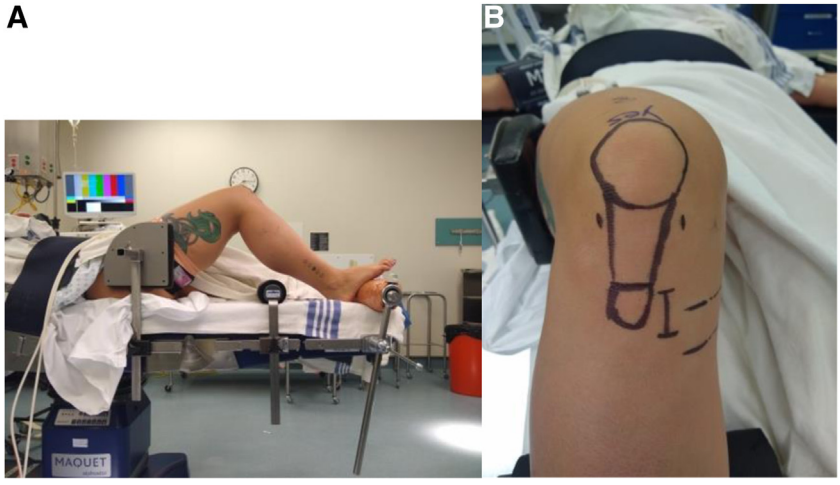

Fig 1. (A) The right knee is positioned with a lateral support and foot bolsters that position the knee at 70° knee flexion for routine arthroscopy and 130° knee flexion for anteromedial portal femoral tunnel drilling. (B) Incisions are marked preoperatively with vertical anteromedial and anterolateral portals and a vertical incision overlying the pes anserinus for hamstring ACL reconstruction. (ACL, anterior cruciate ligament.)

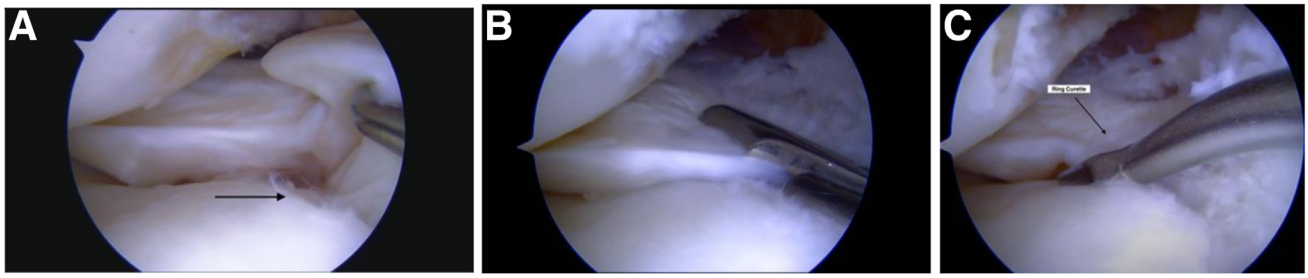

Fig 2. Diagnosis and evaluation of the root tear in the right knee is first done by (A) visualizing and probing the lateral meniscus posterior root tear. (B) Reduction of the root is evaluated. (C) Footprint is prepared using a ring curette

the meniscal root, 5.3 mm posteromedial to the apex of the lateral tibial eminence as described by LaPrade et al.[2] A grasper is used to confirm the meniscal root is reducible to the anatomic footprint (Table 2). Considerations for nonanatomic footprint placement for the repair include missing meniscal tissue or poor excursion of the existing meniscal tissue despite appropriate mobilization techniques. Once identified, a sharp ring curette is used to prepare the bony footprint surface for later drilling of the root repair tunnel (Fig 2). The Smith & Nephew root repair guide (Memphis, TN) is used with the tip of the guide inserted into the meniscal root footprint. The angled trochar for the root repair guide is inserted into the same tibial aperture of the ACL tunnel and is advanced until cancellous bone is engaged. A Beath pin is drilled into the footprint of the meniscal root, followed by a 4.5-mm cannulated drill. Drill tunnels are visualized arthroscopically, demonstrating 2 separate tibial tunnels with one tibial cortical aperture (Fig 3).

A FirstPass Mini suture passing device (Smith & Nephew) is used to pass an Ultratape suture (Smith & Nephew) looped suture through the posterior meniscal root as a luggage tag stitch—1 or 2 stitches are placed depending on the condition of the meniscus. A suture separator is then passed up the meniscal root tunnel to retrieve the sutures out the tibial tunnel (Fig 4).

The passing sutures for the ACL graft are retrieved through the tibial tunnel. Care is taken to avoid inadvertent crossing of the root repair suture with the ACL graft passing suture. The ACL graft is passed up via the tibia tunnel up into the femoral tunnel and, under direct visualization through the anteromedial portal, the Ultrabutton is flipped on the far femoral cortex and confirmed to be seated by pulling the graft sutures retrograde. Next, an Xtendobutton Round cortical button (Smith & Nephew) used to secure the Ultrabutton and graft on the tibial side. While the ACL is being tensioned, constant tension is placed across the meniscal root sutures and the ends of the 2 sutures are loaded through the auxiliary holes present in the size medium and large Xtendobutton Round devices (Fig 5). There are no auxiliary holes in the size small button; however, as we always aim for a graft diameter greater than 8 mm, we do not often use the small button, which is reserved for graft sizes less than 7.5 mm. Once the graft has been preliminarily tensioned, the knee is cycled and a final tensioning of the ACL graft construct is performed. The graft is then carefully probed and the knee taken through a full range of motion along with direct visual examination of the graft in full terminal extension to assess for graft impingement

With tension on the meniscal root sutures, the arthroscope is brought into the lateral compartment of the knee one final time to confirm reduction of the meniscal root. Under direct visualization with the arthroscope in the knee, half-hitch throws are used to tie the sutures over the button fixing the root to the tibial plateau. The meniscal root repair is then carefully probed and reduction to the

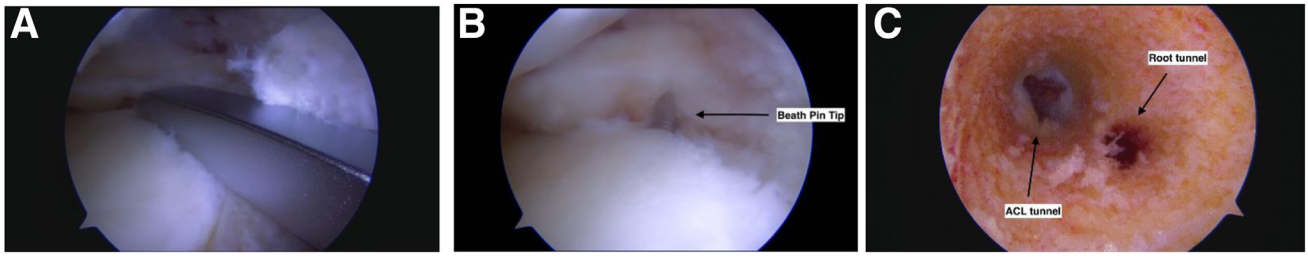

Fig 3. ACL tibial reaming is performed on the right knee. (A) The root repair guide is inserted into the anatomic footprint for the lateral meniscus posterior root attachment with the angled bullet inserted into the tibia tunnel through the same cortical aperture on the anteromedial proximal tibia. (B) A 2.4-mm passing pin is inserted through the guide into the center of the footprint. With the arthroscope in the cortical aperture of the tibial tunnel, both tunnels can be visualized, with tunnel divergence seen and a solid bony bridge between the 2 tunnels. (ACL, anterior cruciate ligament.)

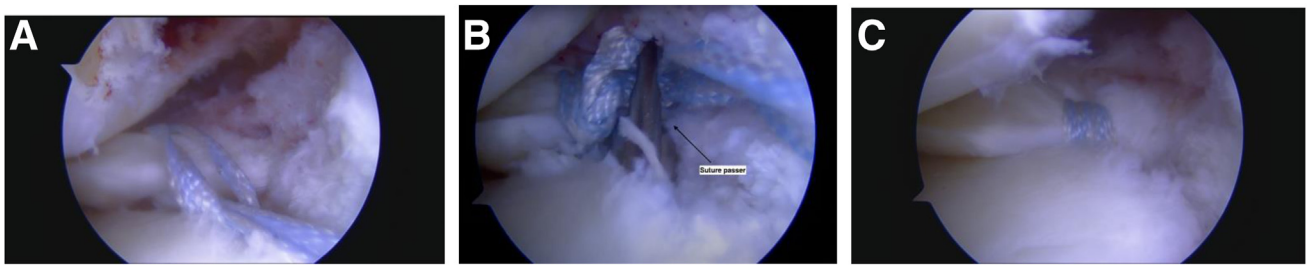

Fig 4. (A) A FirstPass Mini (Smith & Nephew, Andover, MA, or Memphis, TN) suture passer is used to place a luggage tag suture into the posterior lateral meniscus root in the right knee. (B) A suture passer is brought out through the root repair tunnel and is used to shuttle the luggage tag suture down the tunnel. (C) Reduction of the lateral meniscus posterior root repair is shown.

footprint is assessed. This probing also allows for assessment for associated meniscocapsular tear, which, if visualized, can be repaired.

Postoperative Protocol

Our postoperative protocol is patient-dependent, given the lack of good evidence in the literature regarding standardized rehabilitation protocols. Our goals are a balance between protection of the meniscal repair and restoration of range of motion as a guiding principle in ACL reconstructive surgery. One advantage of our technique is the transosseous nature may allow for more aggressive early range of motion.[3,15] Typical protocol has unlimited range of motion while supine or seated with protected weight-bearing for up to 6 weeks postoperatively. Deep squatting past 90° flexion is avoided for 3 months.

Discussion

We have described a convergent tibial tunnel technique when combining ACL reconstruction with meniscal root repair. This technique has been used for posterior root injuries of both medial and lateral menisci in isolation or in association with concomitant ACL tear. In addition, we have had several cases of simultaneous medial and lateral posterior root repairs associated with concomitant ACL tear, and this technique was used with all 3 tunnels converging at the same tibial cortical aperture on the proximal tibia but with separate tunnel apertures at the respective footprints intraarticularly. Lastly, we have used this technique for fixation of anterior meniscal root tears and tibial spine fixation using a modified suture lever reduction technique.[16] To our knowledge, this is the first described technique to bring separate intra-articular tunnels into a single convergent tibial aperture. This single cortical aperture removes the danger of tunnel collision, without compromising fixation.

Although we describe this technique using suspensory fixation on the tibia, this technique can be used with other fixation methods. We routinely use this in revision ACL reconstruction, with the interference screw securing the ACL graft in the tibial tunnel. The senior author frequently performs secondary fixation for revision ACL cases with a Richard's staple (Smith & Nephew). One of the limbs of the meniscal root repair suture is placed under the staple along with the ACL graft. Both sutures for the meniscal root repair are then tensioned along with the ACL graft while the staple is secured into the proximal tibia. Alternatively, a screw-post-washer or suture anchor

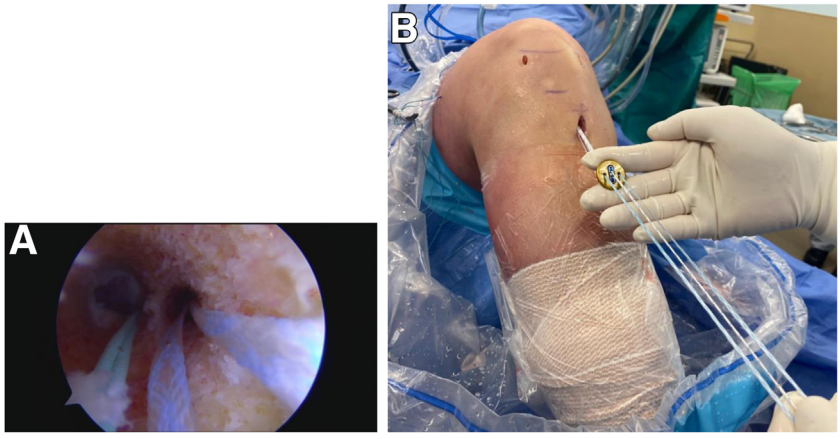

Fig 5. (A) The arthroscope is looking up the tibial tunnel through the single cortical aperture in the anteromedial proximal tibia of the right knee. The passing suture for the ACL graft (green suture) and the luggage tag suture for the lateral meniscus posterior root repair (blue suture) can be seen as 2 divergent tunnels each directed to their respective anatomic footprints is visualized. (B) The Ultrabutton is inserted into the Xtendobutton round cortical suspensory implant for the tibia. The root repair sutures can be seen passing through the auxillary eyelets in the Xtendobutton implant. The root repair sutures are held under tension during the tensioning of the ACL graft and then the root is reduced under direct visualization and subsequently tied with half hitches over top of the button. (ACL, anterior cruciate ligament.)

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
Avoidance of tunnel collision	Suture configuration can be challenging in multiple root tear scenarios
Single incision improves cosmesis	Luggage tag sutures can be tangled within the ACL graft passing sutures
Single aperture possibly leading to less post-operative pain	Shorter root tunnel length
Allows anatomic root repair	Squeaking from sutures can occur with cortical button fixation
Applicable for all root tears	
Can be used in multiple root repair scenarios	
Can be used with multiple types of fixation	
Can be used for primary or revision ACL reconstruction, PCL reconstruction, tibial spine avulsion fractures without fear of tunnel collision	

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

technique also could be used to secure the meniscal repair into the proximal tibia.

The advantages of this technique begin with the common tibial aperture. This allows for meniscal root repairs at the time of ACL reconstruction, without the need for extending or making another skin incision. The common tibial aperture also allows for a single fixation button to be required. The convergent tibial aperture also takes away the risk of crossing or conversion into articular tunnels while still allowing intraarticular anatomic footprints. It is also advantageous in the ability to fix any of the meniscal roots with this same single aperture technique. Multiple types of fixation can be used with this technique, including interference screw fixation in addition to suspensory fixation with a cortical button. Disadvantages of this technique are the shorter tunnels as well as suture configuration, which can be challenging in multiple root scenarios (Table 3).

This is a powerful technique with a large number of applications in primary and revision ligament reconstruction with meniscal root repairs and even tibial spine avulsion fractures. Various fixation methods can be used successfully. Consider this technique when drilling multiple tunnels in the proximal tibia to avoid tunnel collision.

Disclosures

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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