Technical Note

Displaced Posterior Cruciate Avulsion Fracture Fixation With Medial Collateral Ligament and Lateral Meniscus Injury Using Combined Open and Arthroscopic Methods

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Abstract: Tibial-sided posterior cruciate ligament avulsion fractures are challenging injuries that often occur concomitantly in the setting of multiligament knee and other soft-tissue injuries. There is no consensus on the optimal surgical approach or timing of treatment for these injuries. This Technical Note describes the fixation of a displaced posterior cruciate ligament avulsion fracture with concomitant grade 3 medial collateral ligament injuries and bucket-handle lateral meniscus tears using open and arthroscopic techniques. This method allows the surgeon to address multiple pathologies in a single stage, although it requires strategic planning and rehabilitation considerations.

Posterior cruciate ligament (PCL) injuries are estimated to comprise 3% to 23% of all knee injuries.[1] PCL avulsion fractures are a rare variant of these injuries. They are commonly the result of motorcycle injuries or dashboard injuries when a posterior force is applied to the proximal tibia while the knee is flexed. Management of PCL injury is varied, depending on concomitant soft-tissue injuries and grade of the tear, although it is generally agreed that PCL avulsion fractures necessitate surgery when displaced.[2]

The results of both arthroscopic and open reduction and internal fixation are favorable.[3,4] Open reduction and internal fixation may be necessary for large fragments, although the concerns with open fixation through a posterior approach include the risk for soft-tissue and neurovascular damage as well as the potential for fluid extravasation when combined with arthroscopy.[5] In this Technical Note and associated video (Video 1), we describe a single-stage technique for addressing a displaced tibial-sided PCL avulsion fracture, bucket-handle lateral meniscus tear, and medial collateral ligament (MCL) avulsion. It is important to recognize that the treatment approach may differ based on the timing of the injury as well as intraoperative findings, including tissue quality.

Surgical Technique (With Video Illustration)

Indications and Preoperative Imaging

Open fixation of PCL facet avulsion fractures is indicated for large avulsion fragments (Fig 1) that are amenable to fixation with at least one screw and displacement of 5 mm or greater (Fig 2). Indications for surgical treatment of concomitant grade 3 MCL injuries include acute proximal or distal avulsions (Fig 3), valgus malalignment, and intra-articular entrapment or displacement over the pes anserinus. When a bucket-handle lateral meniscus tear is present, this necessitates early surgical repair when feasible to avoid further damage to the lateral meniscus, which may preclude repair. Advantages and disadvantages of this technique are shown in Table 1.

Patient Positioning

Patients may either be positioned prone for the open posterior portion of the procedure and then turned

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Received September 10, 2023; accepted November 24, 2023.

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2212-6287/231302
https://doi.org/10.1016/j.eats.2023.11.014

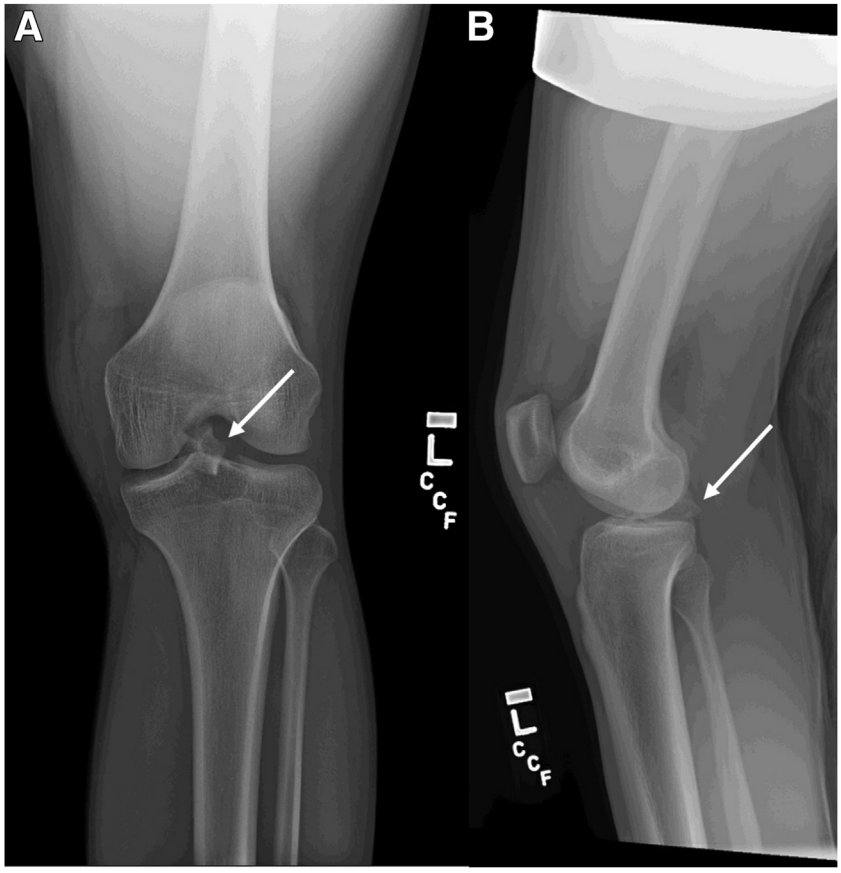

Fig 1. Preoperative radiographs. Preoperative anteroposterior (A) and lateral (B) radiographs of a left knee demonstrate a tibial posterior cruciate avulsion fracture fragment (white arrow) with displacement into the intercondylar notch.

supine for the arthroscopic portion, or a bean bag and side posts can be used to position the patient in a 45° lateral position to allow access to the anterior and posterior aspects of the knee. The anterior or posterior aspects of the knee can be accessed with hip abduction and external rotation or internal rotation of the hip and further pronation of the patient, respectively (Fig 4). An examination under anesthesia is performed on the operative knee, including examination for posterior laxity as well as assessing for valgus laxity at 0 and 30°. In cases of minimally displaced fractures or chronic cases, fluoroscopic stress views can be obtained to evaluate for PCL and MCL laxity.

Diagnostic Arthroscopy and Meniscus Repair

Diagnostic arthroscopy is first performed using standard portals. Intra-articular chondral and meniscal pathology can be addressed at this time. The PCL avulsion

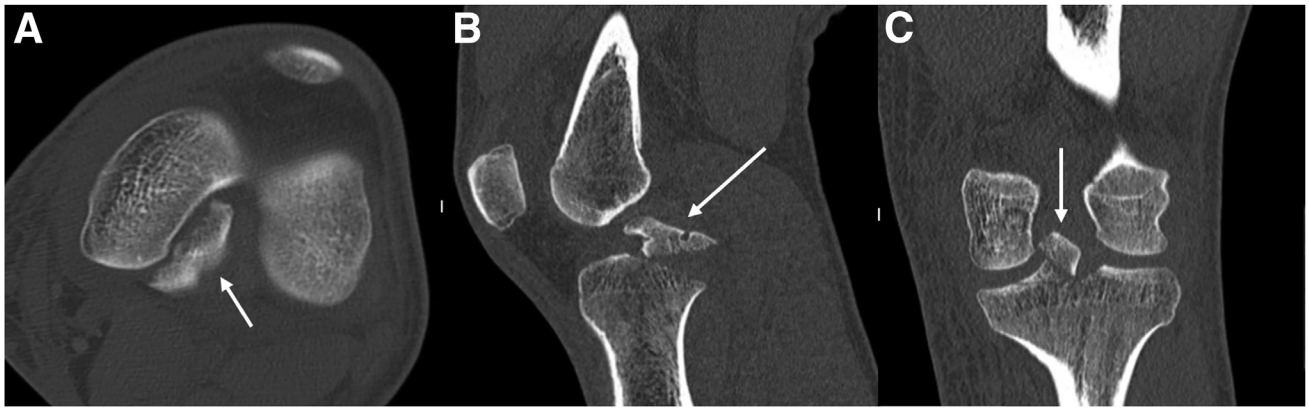

Fig 2. Preoperative computed tomography (CT) images: axial (A), sagittal (B), and coronal (C) CT images of a left knee demonstrate a tibial posterior cruciate ligament avulsion fracture (white arrow) and associated translation and rotation.

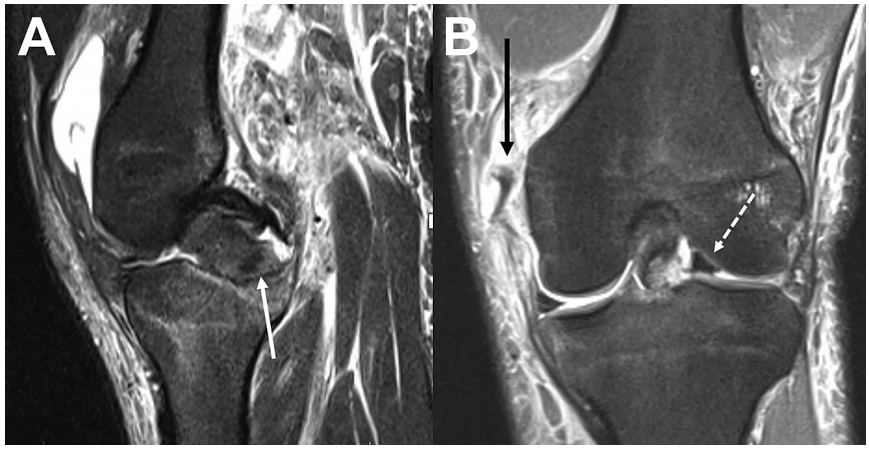

Fig 3. Preoperative magnetic resonance images (MRI): All images are obtained from a left knee. Sagittal MRI (A) demonstrates large tibial posterior cruciate ligaament avulsion fracture fragment (white solid arrow) with the posterior cruciate ligament attached and in continuity. Coronal MRI (B) demonstrates the bucket-handle lateral meniscus tear displaced into the intercondylar notch (B, white dashed arrow) as well as the proximal avulsion of the medial collateral ligament (black solid arrow).

fracture also can be evaluated and, in some cases, may be able to be reduced arthroscopically. The lateral meniscal tear can be reduced and repaired (Fig 5). If this is a chronic injury, then it is more likely that the PCL avulsion fracture and lateral meniscus will be unable to be reduced arthroscopically, and the posterior open approach can be performed first.

Medial Approach and Medial Collateral Ligament Preparation

The patient can be repositioned to access the medial aspect of the knee. For a proximal avulsion, a longitudinal incision is made along the medial aspect of the knee starting just proximal to the medial epicondyle extending to 2 cm distal to the joint line along the medial tibia. Subcutaneous tissues are dissected and flaps are elevated. The MCL tear is identified, and the femoral MCL origin, proximal and posterior to the medial epicondyle, is gently decorticated with curettes. A double-loaded suture anchor (4.5-mm Corkscrew; Arthrex, Naples, FL) is placed just anterior and distal to the MCL origin, and another double-loaded suture anchor (3-mm SutureTak; Arthrex) is placed just posterior and proximal to the MCL origin. The sutures from these anchors are passed though the anterior and posterior MCL as well as the associated capsular flaps in a mattress fashion for later fixation (Fig 6).

Open Reduction Internal Fixation of PCL Avulsion Fracture

The patient is then repositioned and a posterior approach to the knee is performed with a curvilinear "L"-shaped approach with the proximal limb along the popliteal crease and distal limb along the medial aspect of the medial gastrocnemius. The sural nerve and small saphenous vein are identified and protected as they exit the crural fascia. The fascia overlying the medial head of the gastrocnemius is incised longitudinally, and the interval between the medial gastrocnemius and hamstring tendons is developed. Dissection then proceeds laterally, superficial to the posterior knee capsule. Retractors are placed deep to the gastrocnemius to allow visualization of the posterior knee capsule and popliteus while protecting the popliteal neurovascular bundle (Fig 7).

The posterior capsule is then incised longitudinally and the fracture can be visualized. A traction suture (#2 FiberWire; Arthrex) is placed at the base of the PCL. The PCL avulsion fracture is reduced and held provisionally while K-wires were placed perpendicular to the fracture line. Fluoroscopy was used to confirm anatomic reduction of the fracture and appropriate K-wire placement. The posterior cortex is then breached with a 2.7-mm cannulated drill and two 4.0-mm partially threaded cannulated screws with washers (Stryker Co.) are

Table 1. Advantages and Disadvantages of the Proposed Technique

Advantages	Disadvantages
Facilitates anatomic reduction and stable fixation of PCL avulsion fractures, especially for large fracture fragments	Risk of arthrofibrosis with open approach
Useful for acute cases in which concern for significant capsular injury and fluid extravasation might preclude safe arthroscopy	Risk of fluid extravasation and compartment syndrome with prolonged arthroscopy after open approach
Can address plastic deformation of ligament with additional suture and suture anchor fixation	Limited ability to evaluate intra-articular pathology with open approach alone

PCL, posterior cruciate ligament.

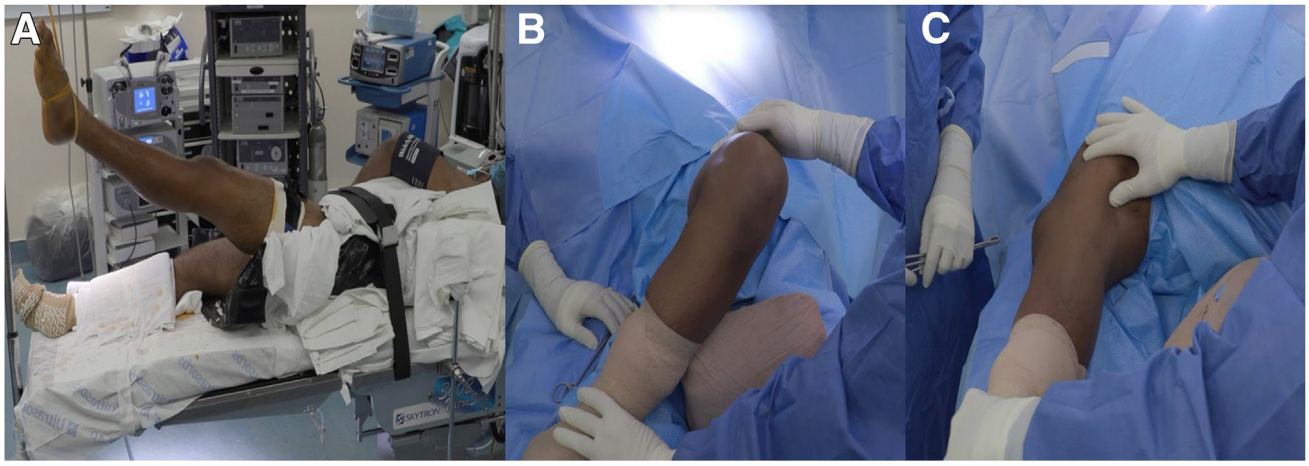

Fig 4. Patient positioning. Proper positioning is critical to facilitate performing both open reduction and internal fixation of a posterior cruciate avulsion fracture while allowing access to the anterior knee for arthroscopy. Secure positioning in the 45° lateral position is accomplished using a bean bag and reinforced side posts, with the patient's caudal direction to the right and cephalad to the left. (A). The patient's left knee is shown in different positions, with hip abduction and external rotation, allowing access to the anterior knee (B), and internal rotation of the hip and further pronation of the patient, allowing access to the posterior knee (C).

placed. Additional fixation of the fracture is obtained by placing a suture anchor (4.75-mm SwiveLock; Arthrex) incorporating the PCL traction suture. This suture anchor is placed distal to the fracture on the posterior tibia. Fluoroscopy is again used to confirm reduction and appropriate screw lengths (Fig 8). The posterior wound is then irrigated and layered closure of the capsule, subcutaneous tissue, and skin is performed.

The operative extremity is then abducted and externally rotated to allow access to the medial knee. The

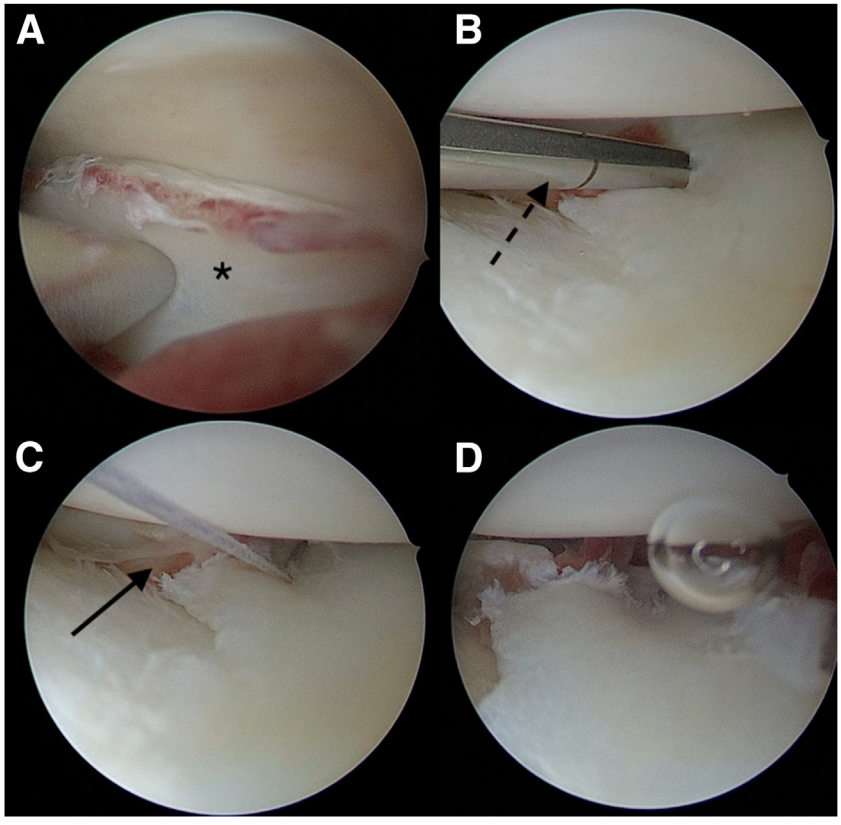

Fig 5. Intraoperative arthroscopic images of lateral meniscus tear and repair. Arthroscopy is performed in a left knee using a 30° arthroscope in the anterolateral portal. A bucket-handle lateral meniscus tear with the fragment trapped in the intercondylar notch (black asterisk) is shown in (A). The reduced tear with an all-inside meniscal repair device (black dashed arrow) is shown in (B) and (C), and there is also noted to be a radial component to the tear (black solid arrow). The final repair is shown in (D).

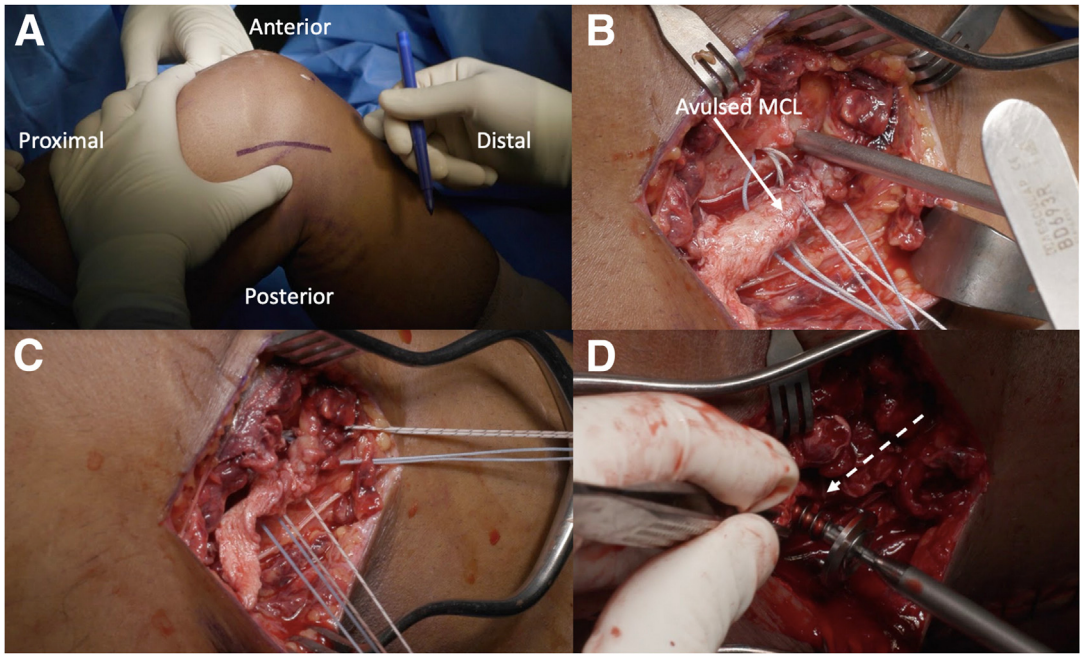

Fig 6. Medial collateral ligament (MCL) repair. Intraoperative images of a left knee are shown with the orientation of the knee as outlined in (A) with the cephalad direction to the left and caudal to the right. The avulsed MCL along with the associated capsular avulsions (white solid arrow) can be seen in (B). Two double-loaded suture anchors are placed both anterior and proximal and posterior and proximal to the MCL origin and the sutures are passed through the MCL and capsule as shown in (C). After the concomitant posterior cruciate ligament avulsion fracture is fixed, the sutures are tied down and additional fixation of the MCL is performed with a 6.5-mm partially threaded screw and 17-mm spiked washer (white dashed arrow) placed at the MCL origin (D).

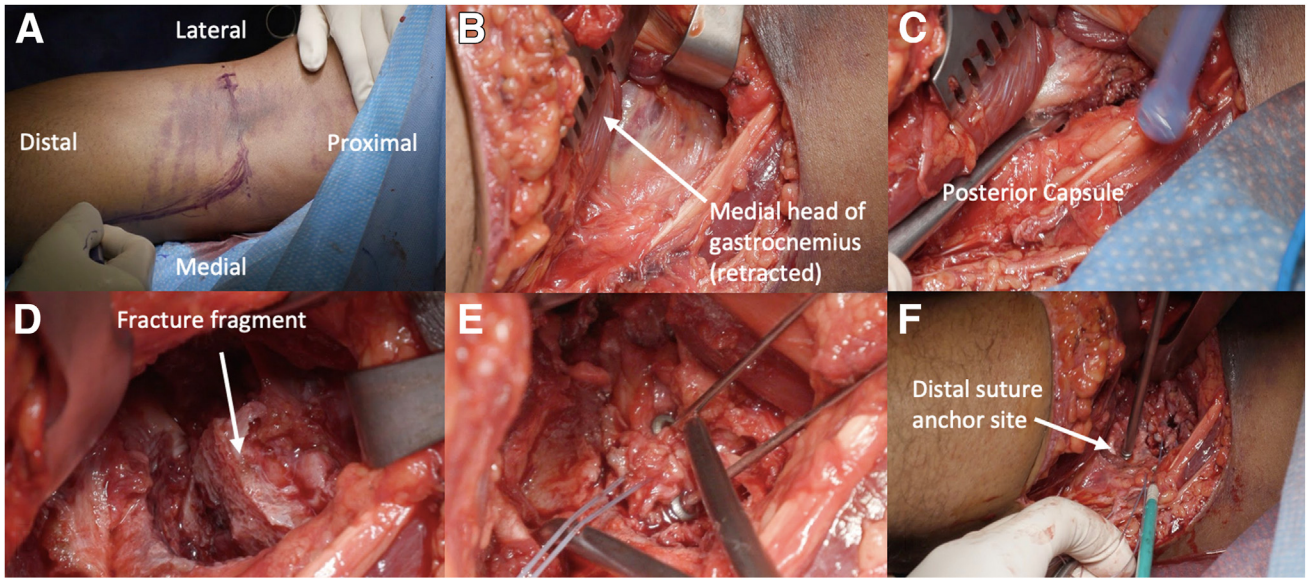

Fig 7. Posteromedial approach to the posterior tibia. Intraoperative images of a left knee are shown here with the orientation as depicted in (A) with the cephalad direction to the right and caudal to the left. A curvilinear incision with the proximal limb along the popliteal crease and distal limb along the medial aspect of the medial gastrocnemius is shown in (A). The interval between the medial head of gastrocnemius and semimembranosus is shown in (B), and the posterior capsule is identified and shown in (C). Once the posterior capsule is incised and medial and lateral flaps are elevated, the posterior cruciate ligament (PCL) facet fragment is shown in (D). The fragment is reduced and held with provisional Kirschner wires, sutures are passed through the PCL, and 4.0-mm partially threaded cannulated lag screws are placed across the fracture as shown in (E). The sutures are placed through a suture anchor distal to the fracture line to augment fixation (F).

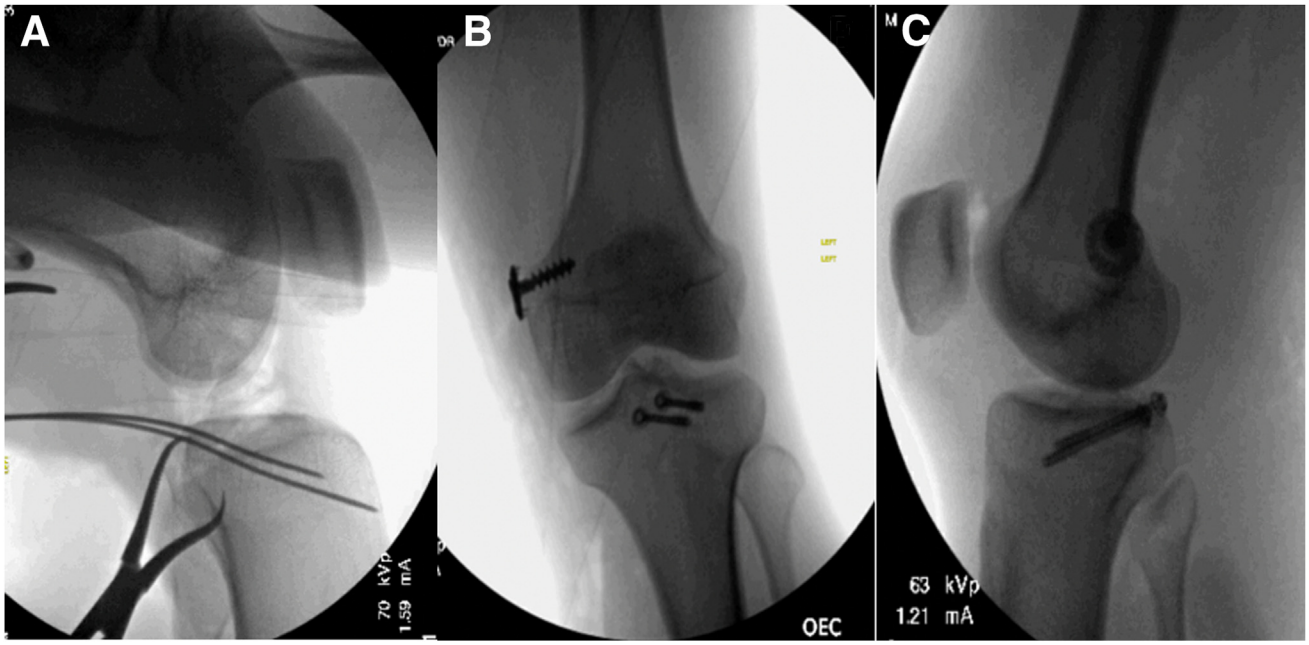

Fig 8. Intraoperative fluoroscopy. Fluoroscopic images of a left knee are shown. A provisional reduction of a posterior cruciate ligament avulsion fracture is obtained with a dental pick and held with a small pointed reduction clamp, and 2 provisional Kirschner wires are placed as shown on a lateral view (A). Final anteroposterior (B) and lateral (C) fluoroscopic images demonstrate the final fixation construct.

previously passed sutures are tied to provisionally fix the MCL. The central MCL tissue is pierced with a scalpel and fixed to the MCL origin with a 6.5-mm partially threaded screw and spiked washer (DePuy Mitek, Raynham, MA), providing additional fixation. These steps are performed with the knee in 30° of flexion and with a varus force applied to the knee.

The knee is then gently examined and found to be stable to valgus and posterior stresses. The medial wound is then irrigated and closed. The arthroscope was then reinserted and anatomic reduction of the avulsion fracture, reduced medial tibiofemoral space, and maintained reduction of the lateral meniscus tear are confirmed. To minimize fluid extravasation through the posterior open approach, it is recommended that the arthroscopic evaluation be performed expediently and with low pressure. Pearls and pitfalls of this technique are shown in Table 2.

Postoperative Rehabilitation Protocol

Postoperatively, the patient is kept non–weight-bearing for 6 weeks in a hinged knee brace locked in extension. Straight-leg raises and ankle pump exercises are started on postoperative day 1. Full range of motion in the unlocked brace, including active and passive range-of-motion exercises, is begun immediately. At

Table 2. Pearls and Pitfalls of the Proposed Technique

Pearls	Pitfalls
Once the lateral capsular flap is raised, a Hohmann retractor can safely be placed laterally under this flap to minimize risk for neurovascular injury.	Failure to use the entire length of the incision to visualize the fracture.
If both supine and prone access are required, the position can be positioned in a 45° lateral position to facilitate access.	Failure to preoperatively recognize and plan for all intra-articular pathology that needs to be addressed in addition to PCL avulsion fracture.
Sutures placed through the PCL can be used as traction sutures to reduce the fracture and placed in a suture anchor distal to the fracture to both augment fixation and address plastic deformation of the ACL.	Prolonged arthroscopy after the open approach can lead to significant fluid extravasation into the calf compartments.
If the medial gastrocnemius is limiting proximal exposure, can place a sterile bump under the ankle to flex the knee to relax the gastrocnemius muscle.	

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

6 weeks postoperatively, if there is radiographic evidence of union, weight-bearing is advanced to full weight-bearing as tolerated, and the brace is weaned at this time.

Discussion

In this Technical Note, the management of PCL avulsion fractures with concomitant MCL and lateral meniscus injuries is demonstrated. It is important to note that the same injury pattern can be treated with multiple approaches based on the specific circumstances of each case; however, the general principles are the same. When MCL tears are associated with other ligamentous injuries being treated acutely, surgical treatment is often indicated to optimize results[6]; however, in more chronic cases, the MCL often heals and does not require separate treatment. Although there is no consensus on treatment methods of PCL avulsion fractures, this technique facilitates anatomic fixation of larger PCL avulsion fractures and concomitant injuries during a single surgery to facilitate rapid rehabilitation. The posteromedial approach described here is a reliable method for obtaining a direct reduction with anatomic fixation of large displaced PCL facet avulsion fractures. Although surgical sequence in multiligament knee injuries often starts with PCL fixation, beginning with arthroscopic meniscal repair can minimize extravasation of fluid.

Several studies have investigated open versus arthroscopic surgical treatment of PCL avulsion fractures. Gavaskar et al.[7] described a minimally invasive approach in a cohort of 22 patients with stable fixation and no complications. Ling et al.[8] performed small randomized study evaluating open screw fixation with or without arthroscopy and found no differences in postoperative range of motion, Lysholm scores, or KT-1000 instrumented side-to-side laxity. A retrospective review by Sabat et al.[3] of patients with PCL avulsion fractures treated with arthroscopic suture fixation versus open fixation favored arthroscopic management with regards to laxity, although functional Lysholm and International Knee Documentation Committee scores were similar between the groups. Whether open or arthroscopic treatment is selected, advanced planning is critical as is awareness of potential pitfalls and complications.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: A.C.K. reports Editorial Board, *Arthroscopy*. J.A.G. reports a relationship with Bioventus LLC, DePuy Mitek, and Smith & Nephew that includes consulting or advisory. He also reports a relationship with Nice Recovery System that includes equity or stocks; and board or committee member, American Shoulder and Elbow Surgeons and Arthroscopy Association of North America. M.J.A. reports a relationship with Bodycad, JRF Ortho, and DePuy Mitek that includes consulting or advisory; a relationship with Orcosa that includes funding grants; publishing royalties, financial or material support from Springer; board or committee member, American Academy of Orthopaedic Surgeons; editorial or governing board, *Arthroscopy*; board or committee member, Arthroscopy Association of North America; and editorial or governing board, *Journal of Cartilage and Joint Preservation*. All other authors (B.J.M., B.M.K., M.E.C., J.D.H.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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