Technical Note

Arthroscopic "Crisscross" Fixation Technique for Avulsion Fracture of the Posterior Cruciate Ligament From the Tibia

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Abstract: This study describes a method of fixing posterior cruciate ligament (PCL) avulsion fractures called the arthroscopic crisscross technique. PCL avulsion fracture is a rare injury that generally occurs in young patients. A displaced avulsion fracture at the tibial attachment of the PCL is an indication for surgical reduction and internal fixation given that nonunion, posterior instability, and early degenerative changes of the knee are common consequences of conservative treatment. This study describes all-arthroscopic fixation of the PCL avulsion injury using 2 No. 2 FiberTape sutures (nonabsorbable polyblend; Arthrex) via the arthroscopic crisscross technique. The No. 2 FiberTapes crisscross each other over the avulsed fragment. Through tensioning of both No. 2 FiberTapes, they are fixed anteriorly using a suture button. This technique can be considered a safe and effective method using minimal resources for the fixation of the avulsed PCL from its tibial footprint.

The posterior cruciate ligament (PCL) represents the center of rotation of the knee joint and plays a key role in knee biomechanics and stability. It is the main structure that provides resistance to posterior tibial translation.[1] PCL avulsions are injuries in young and active individuals that occur in the setting of high-energy trauma and motorcycle accidents and, at times, in the setting of lower-energy sports.[2] Better results have been yielded with surgical reduction and fixation of the avulsed fragment of the PCL than with conservative therapy.[3] The PCL avulsion fracture can be treated with the open technique, which is relatively invasive despite its limited operative field, whereas the arthroscopic technique has benefits like addressing a meniscus tear and ACL injuries if any.[4]

This study describes a method of fixing PCL avulsion fractures called the arthroscopic crisscross technique. PCL avulsion fracture is a rare injury that generally occurs in young patients. A displaced avulsion fracture at the tibial attachment of the PCL is an indication for surgical reduction and internal fixation given that nonunion, posterior instability, and early degenerative changes of the knee are common consequences of conservative treatment. This study describes all-arthroscopic fixation of the PCL avulsion injury using 2 No. 2 FiberTape sutures (nonabsorbable polyblend; Arthrex) via the arthroscopic crisscross technique. The No. 2 FiberTapes crisscross each other over the avulsed fragment. Through tensioning of both No. 2 FiberTapes, they are fixed anteriorly using a suture button (14 mm; Arthrex). This technique can be considered a safe and effective method using minimal resources for the fixation of the avulsed PCL from its tibial footprint.

Prior informed consent has been obtained from the patient.

Surgical Technique

Preoperative Investigation

A series of radiographs are obtained, consisting of standing anteroposterior, lateral, and skyline views. Computed tomography (CT) and magnetic resonance imaging are performed to observe the displacement of the fragment and any intra-articular lesions (Fig 1).

Patient Position and Preparation

The patient is placed in the supine position on the bed, and the knee is flexed at 90° during surgery—a position that relaxes the posterior structures of the knee

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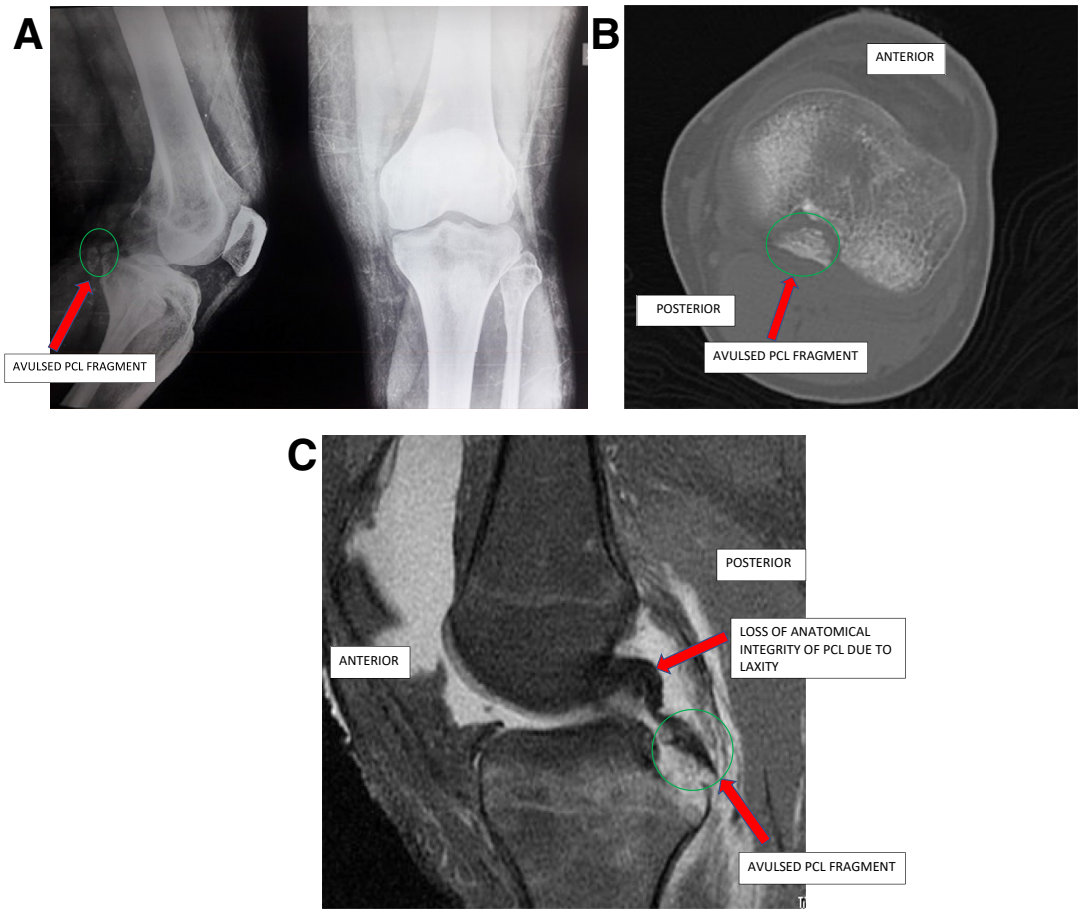

Fig 1. (A) Anteroposterior and lateral radiographic views of knee showing avulsed posterior cruciate ligament (PCL) fragment. (B) Axial-view computed tomography showing avulsed PCL fragment. (C) Sagittal-view magnetic resonance imaging of knee joint showing PCL avulsion.

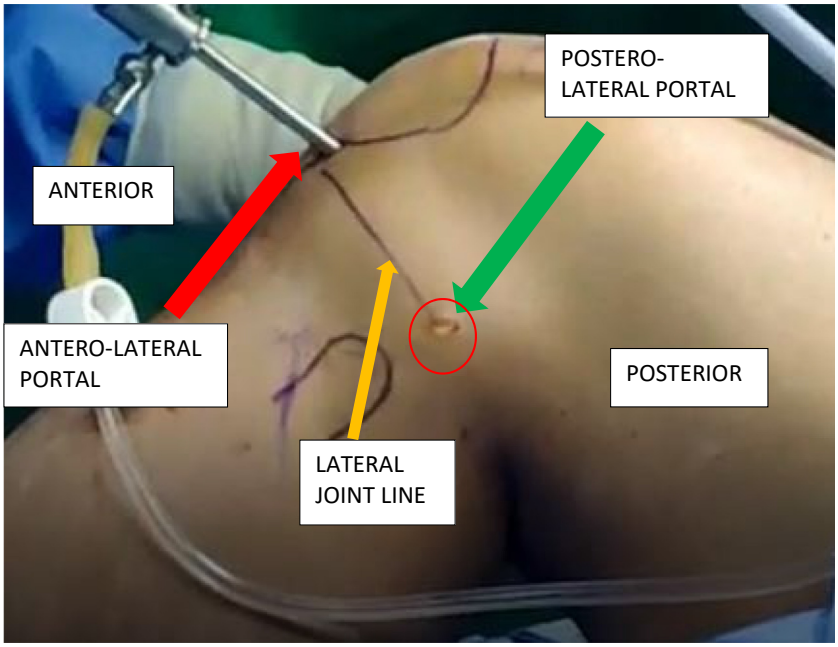

Fig 2. Lateral side, antero lateral viewing portal-creation of posterolateral portal, rail-roading through posteromedial portal, with knee kept at 90° of flexion.

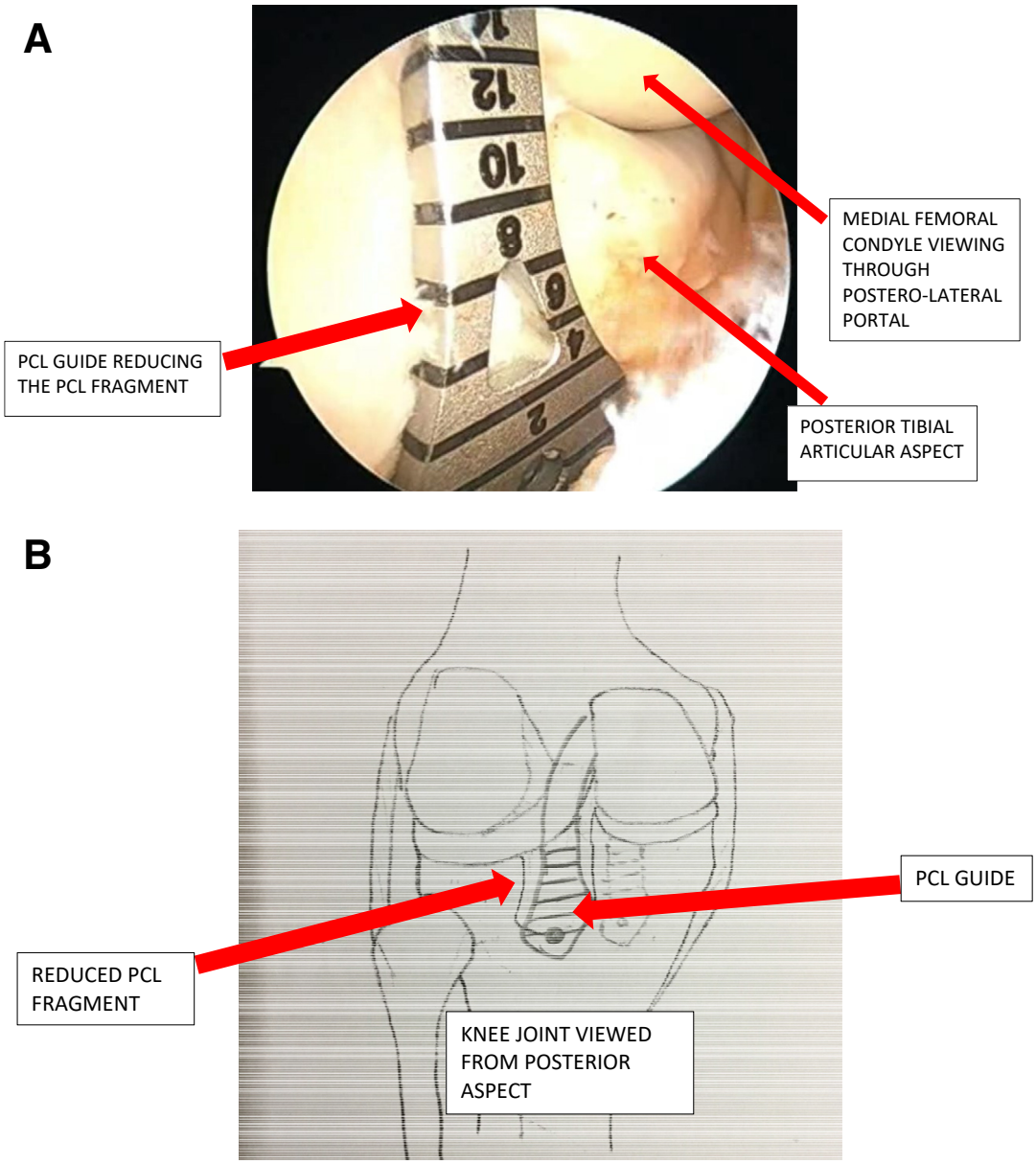

Fig 3. (A) Viewing through the posterolateral portal, the posterior cruciate ligament (PCL) fragment is reduced using a PCL guide (Arthrex) and 2 bone tunnels are made using a guide pin exiting inferomedial and inferolateral to the fragment. Knee in 90° flexion. (B) Posterior aspect of knee showing PCL fragment reduction using PCL guide.

joint. A tourniquet is used during surgery because there are no contraindications.

Operative Technique

Arthroscopy starts from the anterolateral portal. The hematoma is washed out via the anterolateral portal using gravity for irrigation inside the knee. The sloppy anterior cruciate ligament sign and significant PCL laxity are common arthroscopic findings. With the use of a high anteromedial portal, the synovium of the intercondylar notch is shaved and the intervening fat between the anterior cruciate ligament and PCL is partially removed. At this time, any concomitant meniscal and chondral injury is evaluated and managed (Video 1).

Through the space between the lateral femoral condyle and PCL, the posterior compartment is visualized. The posteromedial portal is made using a 20 gauge needle and Wissinger rod, and a 6-mm cannula is inserted; the posterolateral portal at the same level is made from the posteromedial portal through a transseptal approach by using shaver to create a posterior space, and a 6-mm cannula is inserted to make this a viewing portal (Fig 2). By use of the high posteromedial portal for visualization and the posterolateral and anteromedial portals as the working portals, a plane is

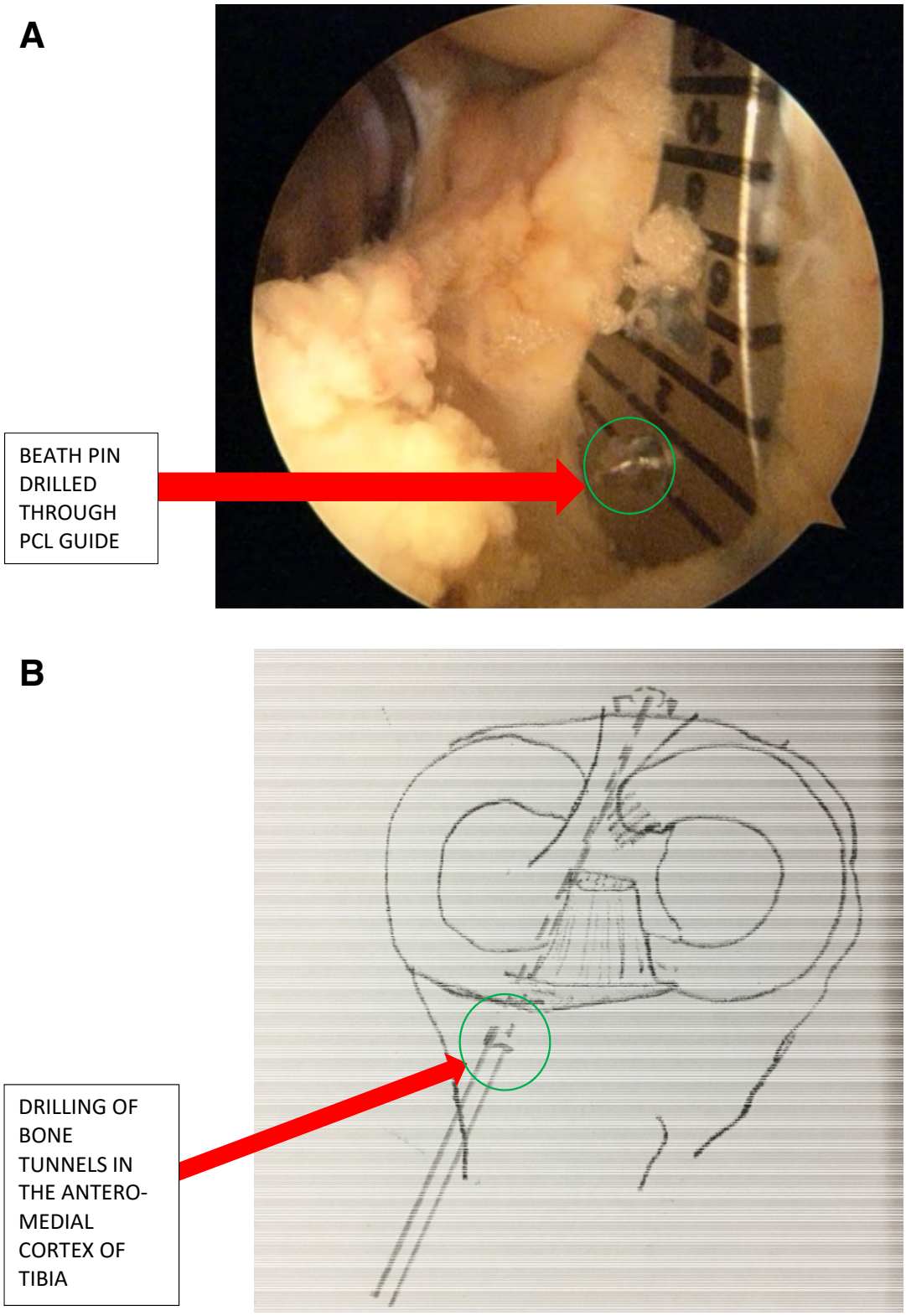

Fig 4. (A) Viewing through the posterolateral portal, guide pins are inserted, creating bone tunnels on the inferomedial and inferolateral aspects of the posterior cruciate ligament (PCL) fragment, which is further drilled with a 4.5-mm drill bit from the anteromedial cortex of the tibia. Knee in 90° flexion. (B) Anterior aspect of knee showing guide pin making bone tunnels on inferomedial and inferolateral aspects of PCL fragment, which is further drilled by 4.5-mm drill bit from anteromedial cortex of tibia. Axial view of the knee.

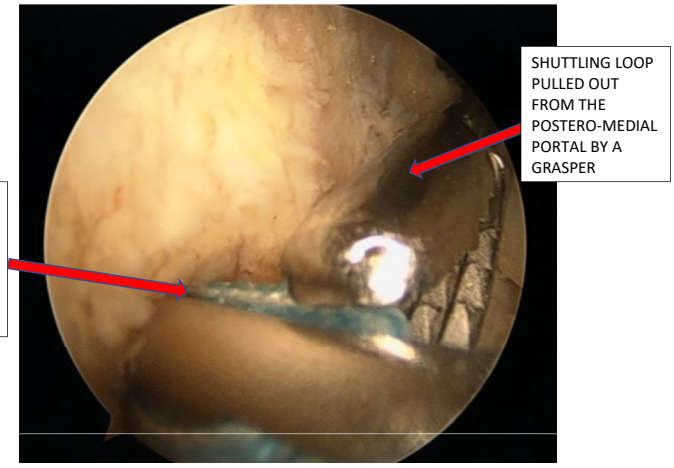

Fig 5. Viewing through the posterolateral portal, the Ethibond loop is shuttled from the anteromedial cortex of the tibia to the posterior compartment and is pulled out from the posteromedial portal. Knee in 90° flexion.

developed between the posterior aspect of the PCL and the posterior joint capsule.

After identification of the bone fragment on the avulsed side, a PCL tibial guide is used to reduce the fragment (Fig 3) through the anteromedial portal. From the anteromedial cortex of the tibia, 2 bone tunnels are made first through a 3-mm guide Beath pin and drilling by 4.5 mm from 2 to 3 cm inferior and medial to the tibial tubercle, exiting from inferomedial and inferolateral to the PCL fossa approximately 10 to 12 mm below the joint line (Fig 4). Visualization is performed using the posterolateral portal, and the posterior-compartment structures are retracted using the Wissinger rod from the posteromedial compartment during the process.

Once the tunnels are created, a shuttle loop (No. 2 Ethibond; Ethicon) is inserted using the Beath pin from the bone tunnels—shuttle loop 1 (green) for medial and shuttle loop 2 (blue) for lateral—which is retrieved from the posteromedial portal (Fig 5). Now, the anterior compartment of the knee is visualized from the anterolateral portal. The anteromedial portal is used as a working portal through which the Knee Scorpion (Arthrex) is taken and the PCL is captured medially and laterally by using FiberTapes. The knots are made in an extracorporeal manner and tied to the PCL; they are manipulated into the posterior compartment using a suture retriever (Fig 6). The medial FiberTape and the lateral FiberTape are retrieved through the posteromedial compartment. Then, in an extracorporeal manner, shuttle loop 1 (green) is tied with the lateral FiberTape, and shuttle loop 2 (Blue) is tied with the medial FiberTape, which is pulled in front through the anterior tibial bone tunnel. The FiberTapes crisscross each other over the avulsed fragment (Fig 7). Through tensioning of both FiberTapes, they are fixed anteriorly using the suture button with anterior drawer tension.

Postoperative Therapy

The knee is placed in a long leg brace with a small support under the lower leg to support the lower leg against the gravity. Isometric exercises to strengthen the quadriceps muscles are started from postoperative day 1. Knee range of motion up to 90° is allowed in the first 2 weeks, with a gradual increase to full range of motion by 4 weeks. Toe-touch weight bearing is permitted in the first 2 weeks, with partial weight bearing after 4 weeks and full weight bearing after 6 weeks (Fig 8). Radiography and CT were performed at 3 months and 6 months later to confirm bone union, after which the patient was allowed to return to his or her job and play sports without any restriction.

Discussion

A number of arthroscopic reduction and internal fixation techniques for PCL tibial avulsion fracture have been reported after the introduction of the approach of Littlejohn and Geissler.[4] Littlejohn and Geissler used multiple Kirschner wires for reduction and cannulated screws for final fixation, which was difficult to compress the avulsed fragment when it is thin. The described procedure is simple to perform and does not require special equipment or implants. The treatment of avulsion fracture of the PCL from the tibial attachment site is indicated when the displacement exceeds 5 mm on a sagittally reconstructed CT image in a hinged-type avulsion or when the fragment is completely detached according to the Griffith classification[5] (Table 1).

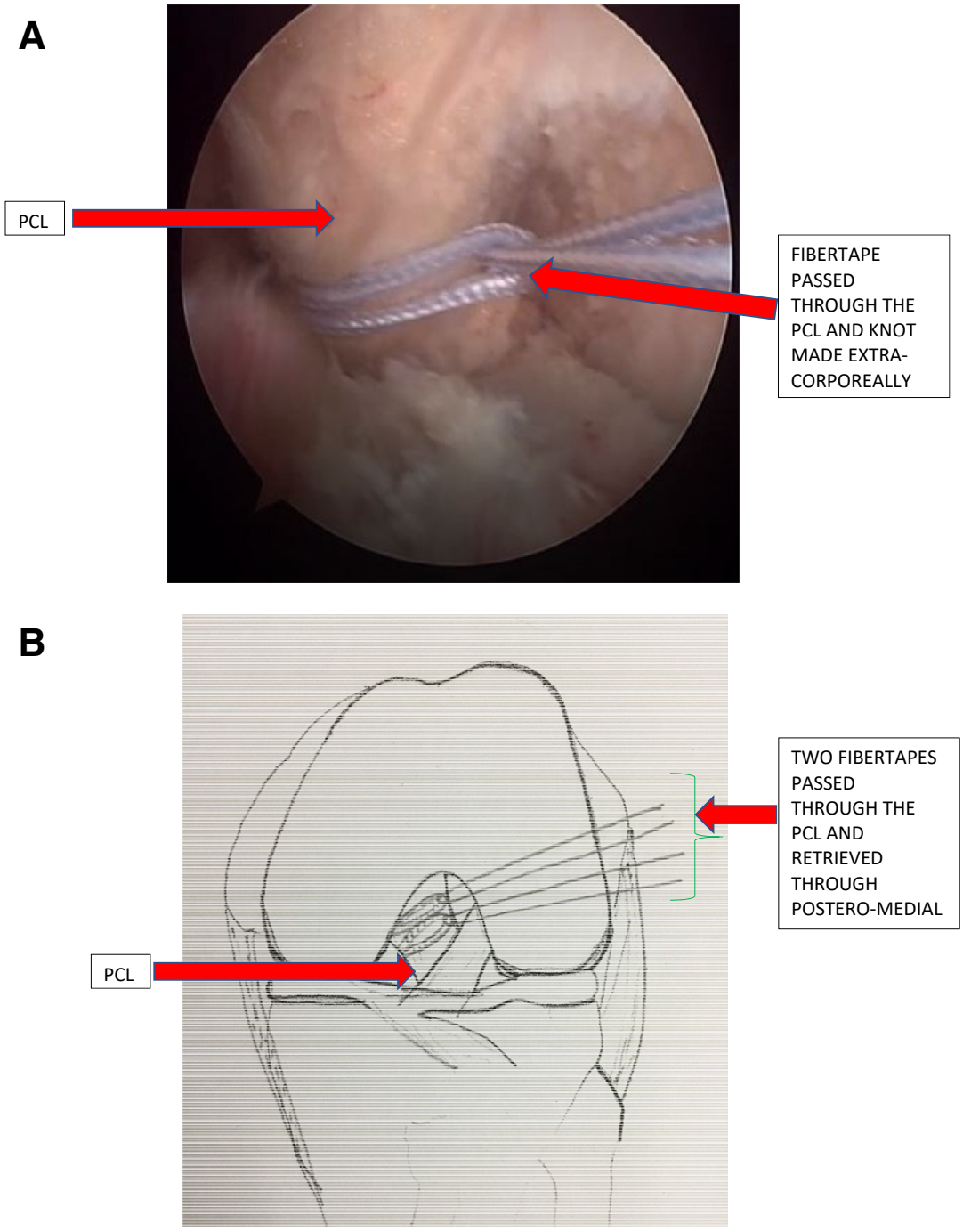

Fig 6. (A) Viewing through the anterolateral portal, the posterior cruciate ligament (PCL) is captured by 2 No. 2 FiberTapes from the anteromedial portal using the Knee Scorpion, and knots are made in an extracorporeal manner. Knee in 90° flexion. (B) Anterior aspect of knee showing PCL captured by 2 No. 2 FiberTapes from anteromedial portal using Knee Scorpion and creation of knots in extracorporeal manner.

In the past, a posterior approach was taken for open reduction and internal fixation of the PCL avulsion fracture, which was invasive, requiring opening the back of the knee, and the risk of neurovascular damage was high.[6] Akagi et al.[7] reported a technique in which an adjustable-length loop device is used for arthroscopic reduction and internal fixation of the PCL with 4 arthroscopic portals (trans-septal) and the fragment is penetrated after reduction to the fracture bed using fluoroscopic guidance. The multiple perforations may cause comminution of the fragment.[7] Another advantage of arthroscopic-assisted PCL

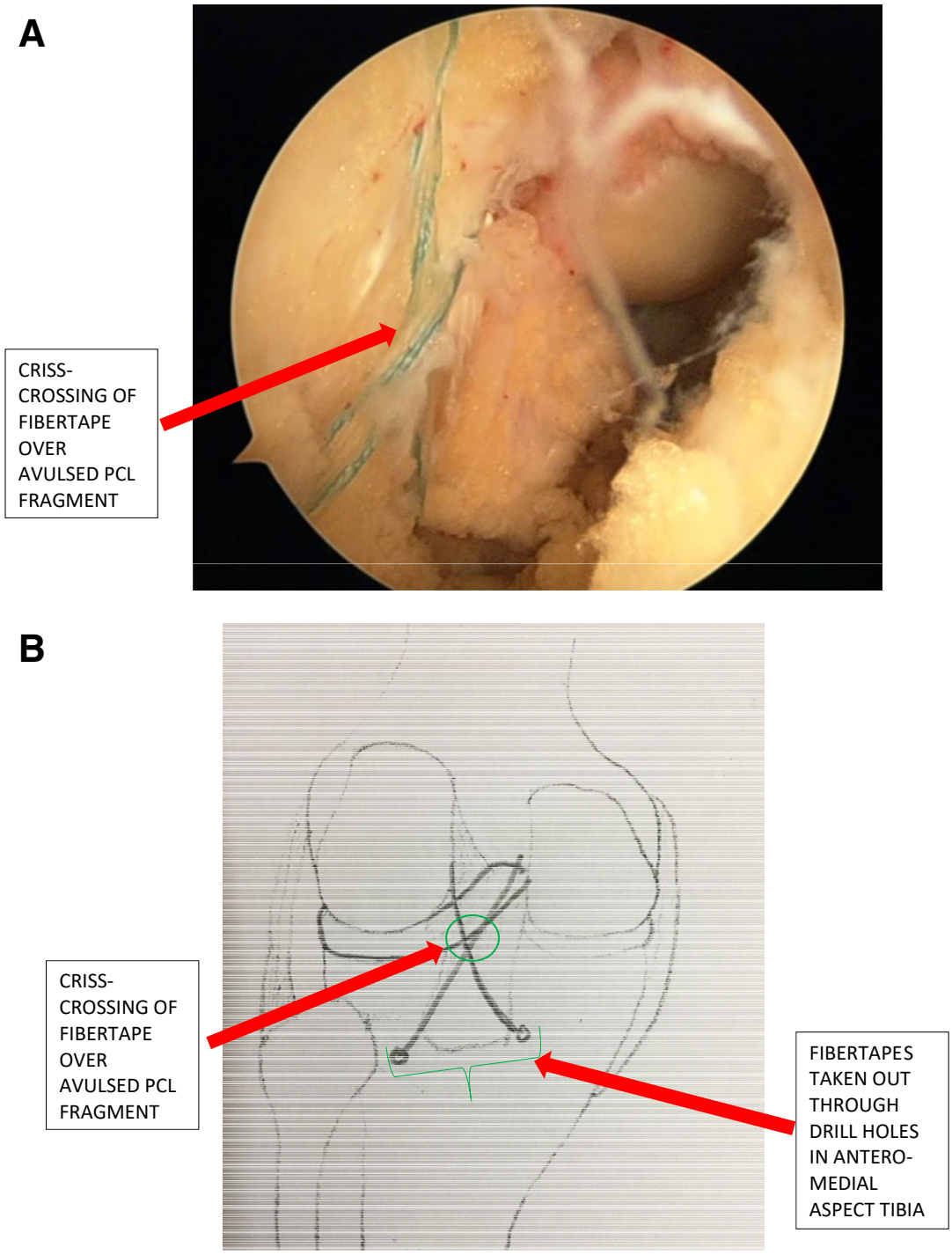

Fig 7. (A) Viewing through the posterolateral portal, the FiberTapes crisscross each other over the avulsed posterior cruciate ligament (PCL) fragment and maintain the reduction. Knee in 90° flexion. (B) Posterior aspect of knee showing crisscross configuration of FiberTape over avulsed PCL fragment.

avulsion treatment is that simultaneous inspection of the whole knee joint is possible and any associated meniscal and ligament injuries can be addressed in the same setting.[8] However, in our procedure, the fragment is approached distal to the fracture bed, No. 2 FiberTape crisscrosses over the avulsed fracture, and fixation is achieved anteriorly using a suture button. By using No. 2 FiberTape and minimal drilling, minimizing soft-tissue debridement around the fragment, the avulsed PCL fragment is secured. In addition, the 4-portal trans-septal approach provides the advantage of direct vision of the posterior compartment and control over the drilling and reduction of the fracture fragment. Finally, we need to evaluate the benefits of

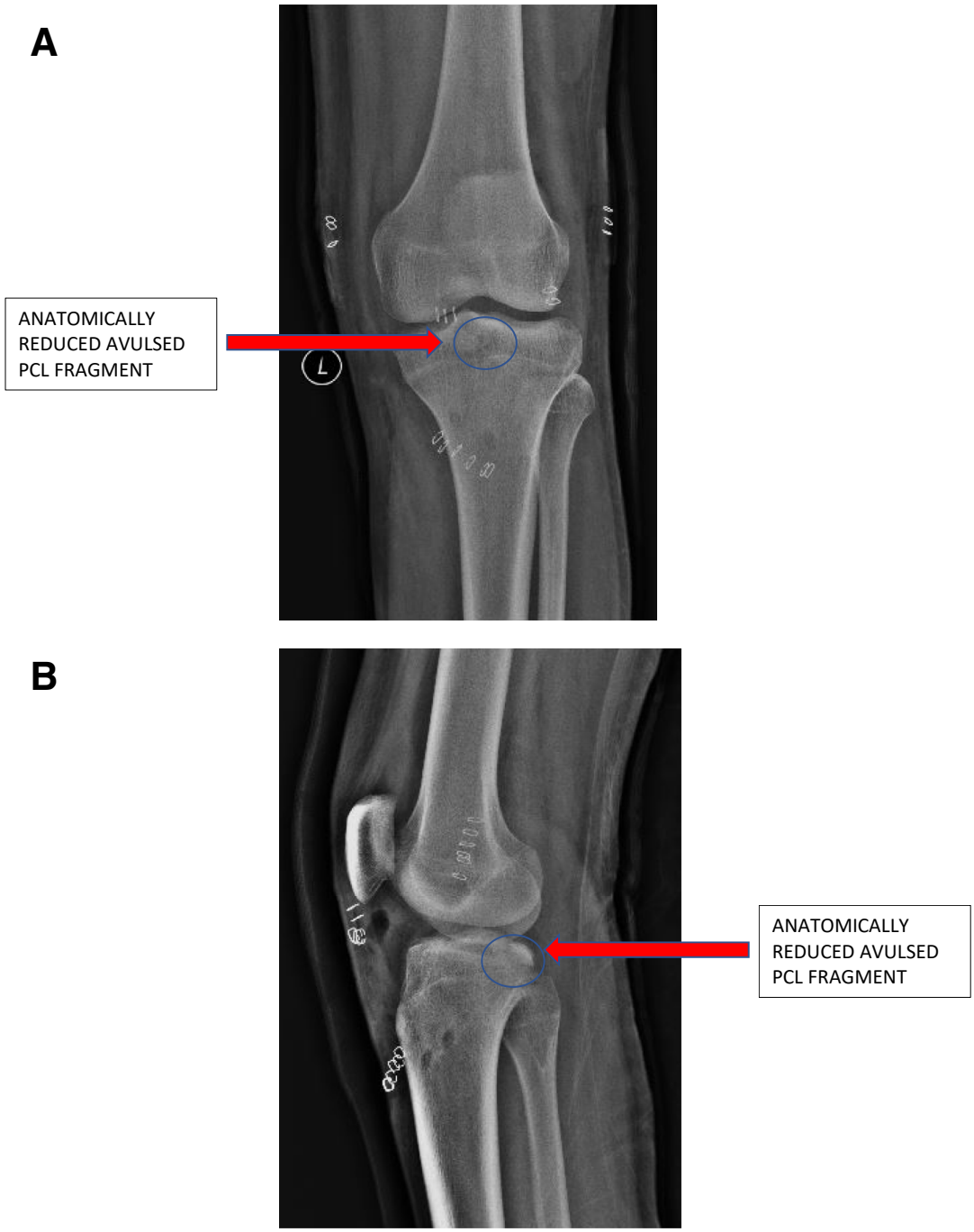

Fig 8. Postoperative radiographs showing anatomic reduction of avulsed posterior cruciate ligament (PCL) fragment: anteroposterior (A) and lateral (B) views. (L, left knee.)

Table 1. Griffith Classification of PCL Avulsion Fractures[5]

Type	Description
I	Minimally displaced avulsion
II	Hinged avulsion
III	Completely detached avulsion

PCL, posterior cruciate ligament.

this technique based on long-term follow-up of outcomes. The advantages and disadvantages of our technique are given in Table 2.

In conclusion, we can achieve good reduction and clinical outcomes for avulsion fracture of the PCL using the criss-cross technique. This procedure is useful in treating avulsed PCL fracture economically and less invasively.

Table 2. Benefits and Risks of Procedure

Benefits
Being an arthroscopic procedure, our technique is less invasive than open techniques and can address other intra-articular pathologies.
This technique does not require special instrumentation and is economically favorable.
Using 4 portals and a trans-septal approach provides direct arthroscopic visualization without interfering with the PCL.
Comminution of the fragment is prevented as drill hole just distal or side of the fragment even when the fragment is thin and small.
Tightening is possible as the crisscross tapes compress a larger area and breakage of small fragments is prevented.
Fluoroscopic images are not required to observe the placement of implants, such as buttons and K-wires.
Risks
There is a risk of injury to the popliteal artery and long saphenous vein.
Saphenous nerve injury may occur at the time of posteromedial portal creation.
Common peroneal nerve injury may occur at the time of posterolateral portal creation.

PCL, posterior cruciate ligament.

Disclosures

All authors (C.T., M.T.M., D.P.) 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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