



Suture Augmentation: An Alternative to Reconstruction for Incomplete Posterior Cruciate Ligament Injuries in the Multiple Ligament–Injured Knee

Nicholas A. Trasolini, M.D., and George F. “Rick” Hatch III, M.D.

Abstract: Treatment of posterior cruciate ligament injuries remains controversial, particularly in the case of partial or incomplete tears in the context of a multiple ligament–injured knee. Suture augmentation, or internal bracing, has been shown in other ligament and tendon repairs or reconstructions to provide stable biomechanics and facilitate early return to activity. In the knee, suture augmentation has previously been used for the treatment of medial collateral ligament tears and in the support of anterior cruciate ligament reconstructions. We describe our arthroscopic technique for suture augmentation of incomplete posterior cruciate ligament injuries.

Posterior cruciate ligament (PCL) injuries remain a difficult problem for orthopaedic surgeons, particularly in the context of the multiple ligament–injured knee. Research has shown that restoration of an anatomic PCL is important for restoring knee kinematics and preventing abnormal load transfer to the medial and patellofemoral compartments.¹ Many surgical treatments have been proposed, with good overall results compared with nonoperative treatment.¹ Unfortunately, surgical repairs and reconstructions often require a period of immobilization or decreased activity postoperatively, which can lead to stiffness and decreased function. Obtaining a stable construct that allows for early rehabilitation would theoretically

improve function and patient satisfaction. Recently, the concept of suture augmentation, or internal bracing, of ligament injuries has gained traction. In 2016 Dugas et al.² showed biomechanical equivalence of suture augmentation versus traditional Jobe reconstruction for ulnar collateral ligament injuries, with the benefit of augmentation allowing for less soft-tissue dissection. Similarly, suture augmentation in the modified Broström operation has shown superior biomechanical results and an earlier return to activity.³ In the knee, suture augmentation for medial collateral ligament injuries has been described and shown to be biomechanically superior to isolated repair and equivalent to allograft reconstruction.^{4,5} Recent literature has also described techniques for suture augmentation of anterior cruciate ligament repairs.⁶ We describe an all-arthroscopic technique for suture augmentation of incomplete PCL injuries that preserves the native anatomy and ligament balance while allowing for early range of motion and rehabilitation.

Technique

Positioning and Portal Placement

The patient is positioned supine with the use of a lateral post. A sandbag is taped onto the bed to be used as a footrest. A roll of towels is wedged between the lateral post and the ipsilateral thigh, which helps facilitate keeping the knee in 80° of flexion. A fluoroscopic knee stability examination is performed with the patient under anesthesia. Laxity in the coronal and sagittal plane is

From the Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, Los Angeles, California, U.S.A.

The authors report the following potential conflict of interest or source of funding: G.F.R.H. receives support from Arthrex. No direct payment or influences were made in relation to this paper or the products described in this paper. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received August 1, 2017; accepted August 29, 2017.

Address correspondence to Nicholas A. Trasolini, M.D., Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, 1520 San Pablo St, Ste 2000, Los Angeles, CA 90033, U.S.A. E-mail: ntrasolini@gmail.com

© 2017 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/17918

<https://doi.org/10.1016/j.eats.2017.08.074>

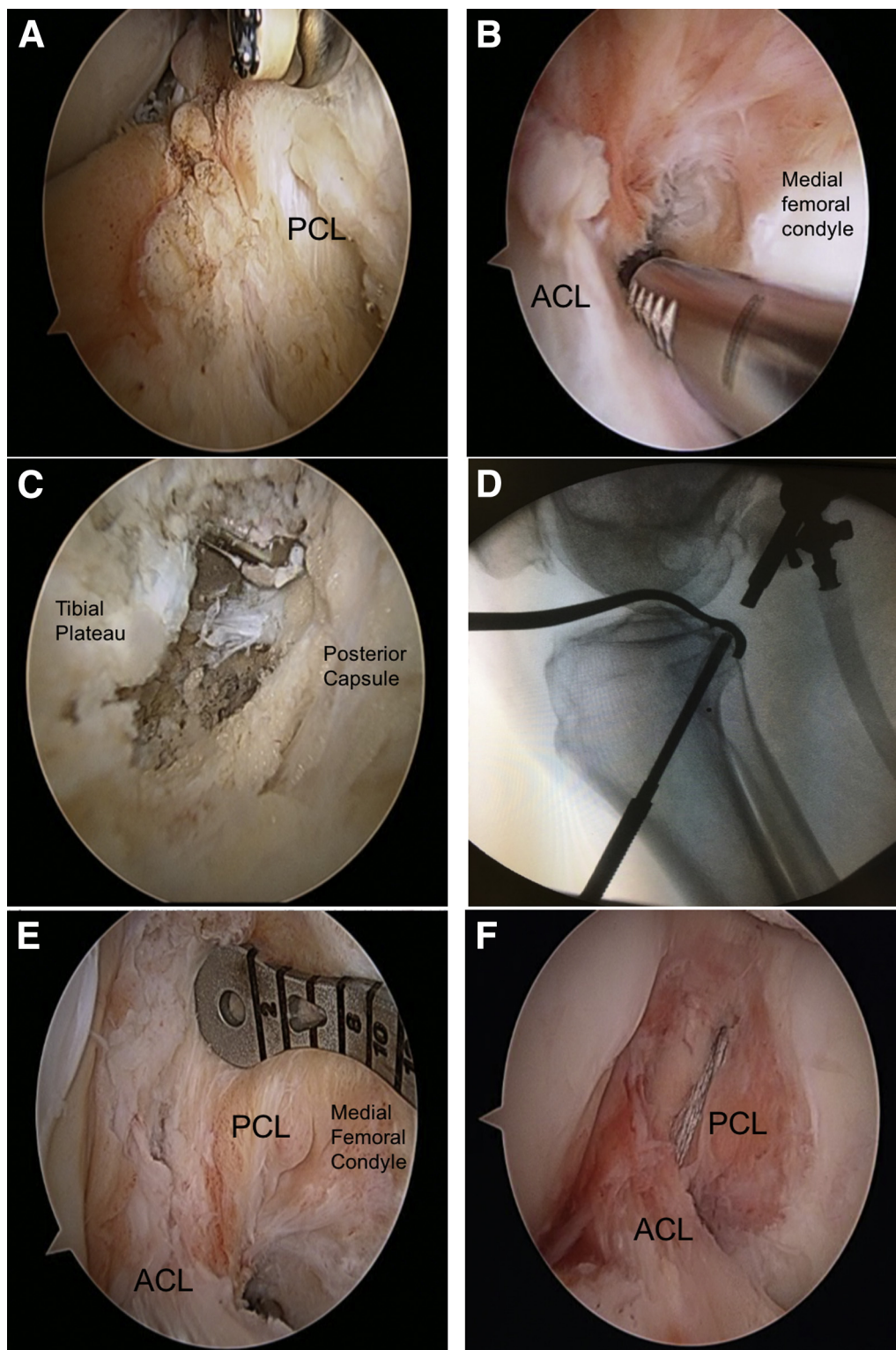


Fig 1. Critical steps of posterior cruciate ligament (PCL) suture augmentation. (A) Partial PCL tear as seen from the posteromedial portal. There is early scar tissue formation about the superior aspect and laxity, but the collagen fibers are in continuity. (B) Reverse notchplasty of the medial femoral condyle as seen from the anterolateral portal. (C) Femoral tunnel placement under direct visualization. This is accompanied by fluoroscopic guidance. (D) Femoral tunnel placement adjacent to the PCL origin without damaging the remaining intact fibers. (E) Fluoroscopic guidance is used to ensure correct tibial tunnel placement and to prevent plunging into the posterior knee. (F) The internal brace is tensioned under direct visualization and with fluoroscopy to match the laxity of the contralateral native ligament. (ACL, anterior cruciate ligament.)

evaluated for the affected knee and compared with the contralateral knee. We use a fixed source-object distance and apply a ruler to the fluoroscopy monitor to measure the laxity in millimeters in the varus, valgus, anterior, and posterior directions. The values are recorded and used later to restore native laxity.

The patient is prepared and draped in a standard fashion. We start with anterolateral and anteromedial portals. A diagnostic arthroscopy is performed. If present, meniscal injuries are addressed first. A posteromedial portal is then developed. We place a spinal needle under direct visualization using a Gillquist view and then dilate the hole with a switching stick, followed by a cannula.

Posteromedial Evaluation and Tunnel Placement

All techniques are shown in [Video 1](#), and critical steps can be seen in [Figure 1](#). By use of a 70° arthroscope from the posteromedial portal, the PCL is evaluated. Accessory instruments are used from the anterior portals using the interval adjacent to the medial femoral condyle in the intercondylar notch. The PCL is assessed for the presence of intact fibers ([Fig 1A](#)). In the case of incomplete tears with a significant percentage of fibers in continuity, we proceed with internal bracing without a reconstruction. The space posterior to the PCL tibial insertion site is carefully developed, and the posterior septum is removed. To improve visualization without damaging the intact ligament, it is typically necessary to perform a “reverse notchplasty,” as has been described for medial meniscus posterior root repairs⁷ ([Fig 1B](#)). This is achieved by removing a small amount of bone from the posterior aspect of the medial notch wall.

A point-to-point guide is then placed through the Gillquist interval. A position is chosen in the very posterior aspect of the intact PCL tibial insertion footprint. A drill is passed by a transtibial approach under fluoroscopic guidance to prevent errant placement or plunging into the deep posterior neurovascular structures ([Fig 1 C and D](#)). The 70° arthroscope, while viewing from the posteromedial portal, is also used to directly visualize the drill tip as it comes through the tibia. We use a 3.5-mm FlipCutter (Arthrex, Naples, FL) to drill but without deploying the flip blade. At this point, a FiberLink passing suture (Arthrex) is threaded through the tunnel using a FiberWire stick (Arthrex).

Attention is then paid to the femoral tunnel, and the 70° arthroscope is exchanged for a standard 30° arthroscope because the orientation is more familiar. The femoral tunnel location is chosen within the anterolateral-bundle portion of the native PCL origin⁸ ([Fig 1E](#)). Extreme care must be taken when drilling the tunnel to not injure the remaining native ligament. Another FiberWire stick is passed in a similar fashion to the tibial tunnel. Both FiberWire passing strands are retrieved out of the anterolateral portal and clamped. Organizing the sutures out of the anterolateral portal

provides more of a “straight shot” for passing the suture augmentation construct.

Suture Augmentation Preparation and Passage

Our construct is then prepared on the back table. We use a combination of FiberTape and TightRope products (Arthrex) to create a multistranded construct ([Fig 2](#)). Once the construct is prepared, we first pass it through the femoral tunnel using our FiberWire strand through the anterolateral portal. Visualization is performed with the 30° arthroscope through the anteromedial portal. A grasper is used to assist passage of a RetroButton (Arthrex) gently through the intact PCL ligament and into the femoral tunnel. We visualize the femoral RetroButton intra-articularly on the medial aspect of the distal medial femoral condyle to ensure it is flush with the bone. If it cannot be visualized, we will confirm the position with fluoroscopy.

Next, we pass the construct through the tibial tunnel. We tension the construct during 20 cycles of full knee range of motion. We use fluoroscopy to confirm

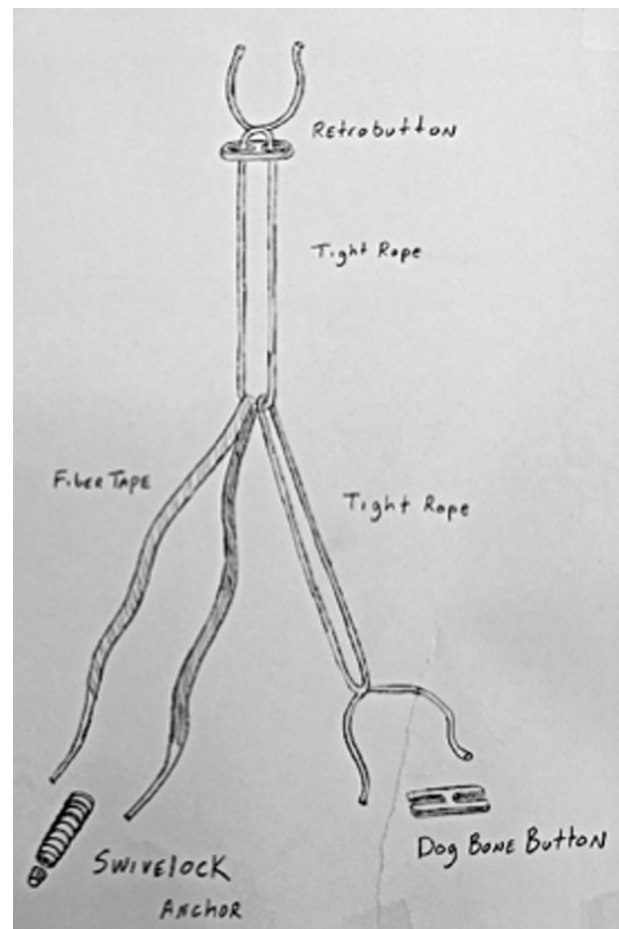


Fig 2. Internal brace construct. The suture-based augmentation consists of 2 inter-connected TightRope sutures, 1 FiberTape suture, and 2 suture buttons. The TightRope products allow for proper tensioning, whereas the FiberTape increases construct stiffness.

Table 1. Pearls and Pitfalls of Suture Augmentation of PCL

Pearls	
Protects against ligament strain or elongation during healing	
Nondestructive to native PCL	
Can be performed in conjunction with multiligamentous reconstruction	
Allows for early rehabilitation	
Pitfalls	
Overconstraint or over-tensioning	
Damage to PCL remnant with tunnel drilling	

PCL, posterior cruciate ligament.

restoration of alignment of the posterior femoral condyles in relation to the posterior tibial plateau. The use of fluoroscopy prevents over-reducing the femur in relation to the tibia and allows the surgeon to match the patient's contralateral native PCL laxity. Then, with the knee in 70° to 90° of flexion, we fix the FiberTape limbs of the construct into a SwiveLock anchor (Arthrex) 1 cm distal to the tibial tunnel orifice. We again cycle the knee through its range of motion and then apply a Dog Bone (Arthrex) to the TightRope portion of the construct and secure it in 30° to 45° of flexion (Fig 1F). We confirm the laxity with the secured construct by performing a posterior drawer test under fluoroscopy. We then release the tourniquet, obtain hemostasis, and close all the incisions. Immediately on completion of the procedure and before breaking down the sterile table, we perform postoperative Doppler and pulse examination to rule out arterial injury.

Postoperative Protocol

It is difficult to generalize a rehabilitation protocol for PCL repairs for incomplete tears because there are often other concurrent ligament injuries. In general, in the

absence of a lateral collateral ligament and/or posterolateral corner injury, we allow patients to be fully weight bearing as tolerated in a locked hinged knee brace with crutches. We encourage weaning off of crutches and unlocking the knee brace once adequate quadriceps control is obtained. Immediately after the operation, patients start using a continuous passive motion machine with no restriction on range of motion. Although our postoperative PCL repair protocol precautions are not as strict as our postoperative PCL reconstruction precautions, we still attempt to minimize posterior tibial sag and direct stress on the PCL repair by limiting open-chain muscle activity for the first 6 to 12 weeks postoperatively. In addition, passive knee flexion with physical therapy is performed with the patient in the prone position for 6 to 12 weeks after surgery, as opposed to the supine position. Our current postoperative protocol favors more liberal postoperative restrictions than what have typically been described for patients after PCL reconstruction.⁹ However, in the setting of a formal PCL reconstruction with allograft, we too prefer a postoperative protocol that is much more protective against stress on the maturing PCL graft. In the case of incomplete PCL injuries that undergo suture augmentation, we wish for patients to regain motion and quadriceps strength as quickly as reasonably possible.

Discussion

Incomplete PCL tears pose a dilemma for the treating surgeon. Unlike anterior cruciate ligament reconstructions, the results and outcomes of PCL reconstructions are less consistent and residual posterior laxity often occurs.¹⁰ Although nonoperative treatment

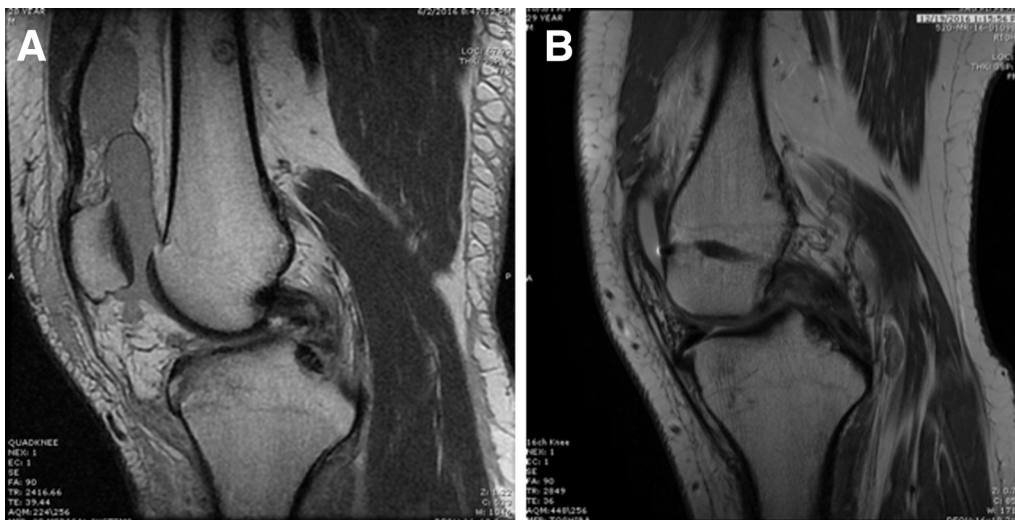


Fig 3. Sagittal T2 magnetic resonance imaging of right knee with incomplete posterior cruciate ligament (PCL) injury before suture augmentation (A) and at follow-up 6 months postoperatively (B). Evidence of the posterior cruciate ligament in continuity can be observed. These magnetic resonance images were read by a musculoskeletal radiologist naive to the suture augmentation as showing an intact PCL reconstruction. In reality, just suture augmentation of the incompletely torn PCL with interval healing was present.

is acceptable and is the standard for incomplete or complete isolated PCL tears, the treatment of incomplete PCL tears in the setting of the multiple ligament–injured knee is more controversial. In the setting of the multiple ligament–injured knee, failure to adequately address all injured ligaments can result in unacceptable residual laxity and even recurrent instability. This jeopardizes the other reconstructed ligaments in the knee and can result in inferior surgical outcomes, including graft failure and the need for revision surgery. We believe addressing the incomplete PCL injury with the described technique, specifically in the setting of the multiple ligament–injured knee, preserves the native ligament and its anatomy while restoring native stability. [Table 1](#) lists pearls and pitfalls of the technique. [Figure 3](#) shows preoperative and 6-month postoperative magnetic resonance imaging results for the case shown in [Video 1](#). Ongoing and forthcoming studies will report on the outcomes of this procedure in terms of biomechanics, biological healing of the supported remnant ligament, and patient satisfaction and function.

References

1. Bedi A, Musahl V, Cowan JB. Management of posterior cruciate ligament injuries: An evidence-based review. *J Am Acad Orthop Surg* 2016;24:277-289.
2. Dugas JR, Walters BL, Beason DP, Fleisig GS, Chronister JE. Biomechanical comparison of ulnar collateral ligament repair with internal bracing versus modified Jobe reconstruction. *Am J Sports Med* 2016;44:735-741.
3. Yoo JS, Yang EA. Clinical results of an arthroscopic modified Brostrom operation with and without an internal brace. *J Orthop Traumatol* 2016;17:353-360.
4. Gilmer BB, Crall T, DeLong J, Kubo T, Mackay G, Jani SS. Biomechanical analysis of internal bracing for treatment of medial knee injuries. *Orthopedics* 2016;39:e532-e537.
5. Lubowitz JH, MacKay G, Gilmer B. Knee medial collateral ligament and posteromedial corner anatomic repair with internal bracing. *Arthrosc Tech* 2014;3:e505-e508.
6. Smith JO, Yasen SK, Palmer HC, Lord BR, Britton EM, Wilson AJ. Paediatric ACL repair reinforced with temporary internal bracing. *Knee Surg Sports Traumatol Arthrosc* 2016;24:1845-1851.
7. Backman AJ, Stuart MJ, Levy BA, McCarthy MA, Krych AJ. Arthroscopic meniscal root repairs using a Cetrax NovoStitch suture passer. *Arthrosc Tech* 2014;3:e643-e646.
8. Narvy SJ, Pearl M, Vrla M, Yi A, Hatch GF III. Anatomy of the femoral footprint of the posterior cruciate ligament: A systematic review. *Arthroscopy* 2015;31:345-354.
9. Edson CJ, Fanelli GC, Beck JD. Rehabilitation after multiple ligament reconstruction of the knee. *Sports Med Arthrosc Rev* 2011;19:162-166.
10. Kim YM, Lee CA, Matava MJ. Clinical results of arthroscopic single-bundle transtibial posterior cruciate ligament reconstruction: A systematic review. *Am J Sports Med* 2011;39:425-434.