

# Arthroscopic Primary Anterior Cruciate Ligament Repair With Suture Augmentation



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**Abstract:** Historically, poor results of open primary repair of anterior cruciate ligament (ACL) injuries have been reported. In hindsight, however, appropriate patient selection (i.e. proximal tears and good tissue quality) was not performed, because it has recently been recognized that good outcomes of primary ACL repair are possible when selectively performed in patients with proximal tears and good tissue quality. Moreover, with modern-day advances, arthroscopic primary repair can be an excellent treatment option for patients with proximal tears. Preserving the native ACL has several advantages, including maintaining native proprioceptive function and biology. The procedure is also minimally invasive and prevents the need for formal ACL reconstruction. Recently, it has been suggested that additional suture augmentation of the primary repair technique may be beneficial for protecting ligament healing during early range of motion. In this Technical Note, we present the surgical technique of arthroscopic primary repair with suture augmentation for patients with proximal ACL tears.

Primary repair of the anterior cruciate ligament (ACL) was a popular treatment in the 1970s and 1980s using an open procedure.<sup>1</sup> Although the short-term outcomes were initially good, they deteriorated at longer term follow-up and were considered unpredictable. In the early 1990s, Sherman et al.<sup>2</sup> suggested that tear location was a possible explanation for these unpredictable outcomes when noting a trend toward better results with open primary repair of proximal tears. Although some surgeons indeed showed excellent results of open primary repair of proximal tears,<sup>3</sup> the concept of primary repair was abandoned, and ACL reconstruction became the gold standard for all tear types.<sup>1</sup>

Several disadvantages of ACL reconstruction, however, exist, including not preserving proprioception, not

restoring native kinematics, not preventing osteoarthritis, and potential problems with revision surgery. Therefore, a resurgence of interest has recently been noted in ACL preservation using arthroscopic primary repair.<sup>4,5</sup> In 2008, DiFelice et al.<sup>4</sup> performed the first arthroscopic primary repair in patients with proximal tears, and recently reported excellent outcomes at an average of 3.5 years' follow-up on his first 11 patients. A few years later, Achtnich et al.<sup>5</sup> performed arthroscopic primary repair and noted that the outcomes and stability examinations were equivalent when compared with ACL reconstruction.

In 2015, Mackay et al.<sup>6</sup> presented the concept of suture augmentation that could be added to arthroscopic primary repair, which is thought to protect ligament healing during early range of motion (ROM). In this Technical Note, we describe the surgical technique of arthroscopic primary ACL repair with suture augmentation using a suture anchor approach. This surgical technique can be used for all patients with proximal ACL tears that have sufficient length for reapproximation to the femoral wall and sufficient tissue quality to withhold sutures. The procedure can be performed in patients of all age groups and activity levels, and for both isolated ACL injuries as well as ACL injuries in the multiligamentous injured knee.

## Surgical Technique

### Patient Selection

Learning from earlier experiences, appropriate patient selection is critical with this technique (Video 1).<sup>2</sup>

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**Table 1.** Indications and Contraindications of Arthroscopic Primary Anterior Cruciate Ligament Repair With Suture Augmentation

Indications	Absolute Contraindications
Proximal avulsion tears	Midsubstance tears
Sufficient tissue quality	Poor tissue quality
Patient with chronic proximal avulsion tears in which ACL is reattached to PCL <sup>8</sup>	Re-rupture of a repaired ligament
Patients of all age groups	Relative Contraindications
Isolated ACL injuries and ACL injuries in multiligamentous injured knees	Fair tissue quality (depending on surgical experience)

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

Arthroscopic primary repair is only performed in patients with proximal tears (type I tears<sup>2,7</sup>) and excellent tissue quality to have good re-approximation of the ligament toward the femoral wall. These conditions are usually seen in the acute phase (i.e. first 3 months<sup>4-6</sup>), but can be seen in the chronic setting if the ACL is reattached to the posterior cruciate ligament<sup>8</sup> (Table 1).

### General Preparation

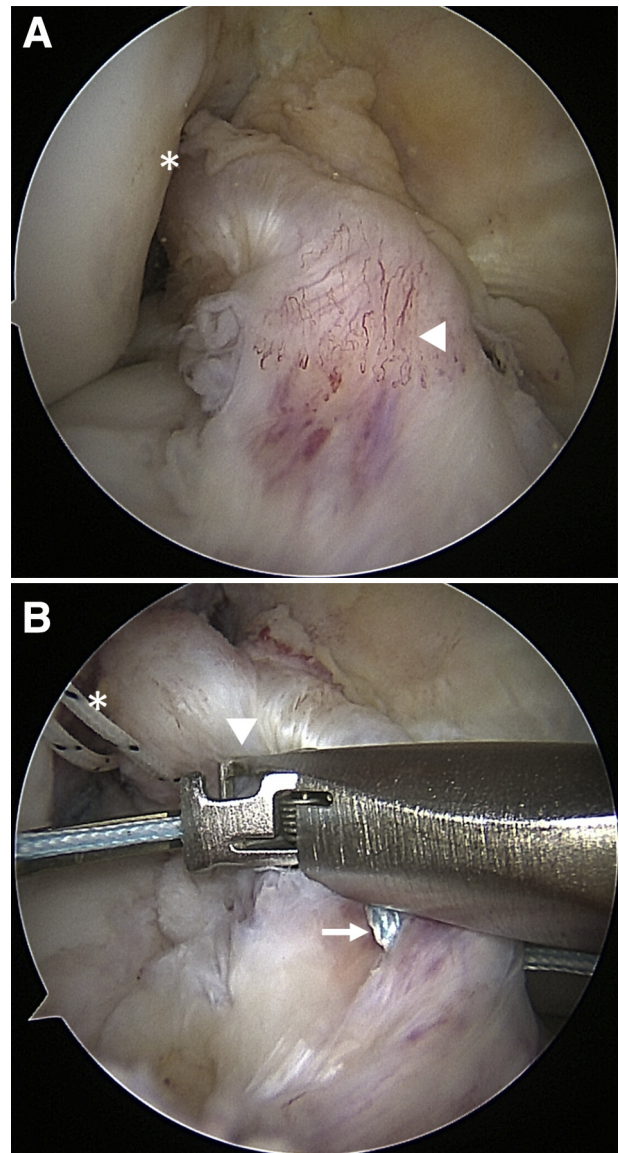
The patient is placed in the supine position, and the operative leg is prepped and draped as for standard knee arthroscopy. First, anteromedial and anterolateral portals are created, and a malleable Passport cannula (Arthrex, Naples, FL) is placed in the anteromedial portal for suture passage and management. A general inspection of the knee is performed for tear type and tissue quality, assessing the possibility of primary repair surgery (Fig 1A).<sup>7</sup>

### Suturing of Bundles

The first part of this surgical technique is similar to arthroscopic primary repair without suture augmentation.<sup>9</sup> First, the anteromedial and posterolateral bundles of the ACL are identified, and the suturing is commenced. The sutures are passed through the anteromedial bundle using the Scorpion Suture Passer (Arthrex) with a No. 2 FiberWire suture (Arthrex) from the intact distal end in an alternating, interlocking Bunnell-type pattern toward the avulsed proximal end (Fig 1B). Three to four passes can usually be made before the final pass exits the proximal end toward the femur. Similarly, the suturing of the posterolateral bundle is performed using a No. 2 TigerWire suture (Arthrex). It should be noted that the suture-passing device should be repositioned if great resistance is experienced, because this can lead to transection of the previously passed suture.

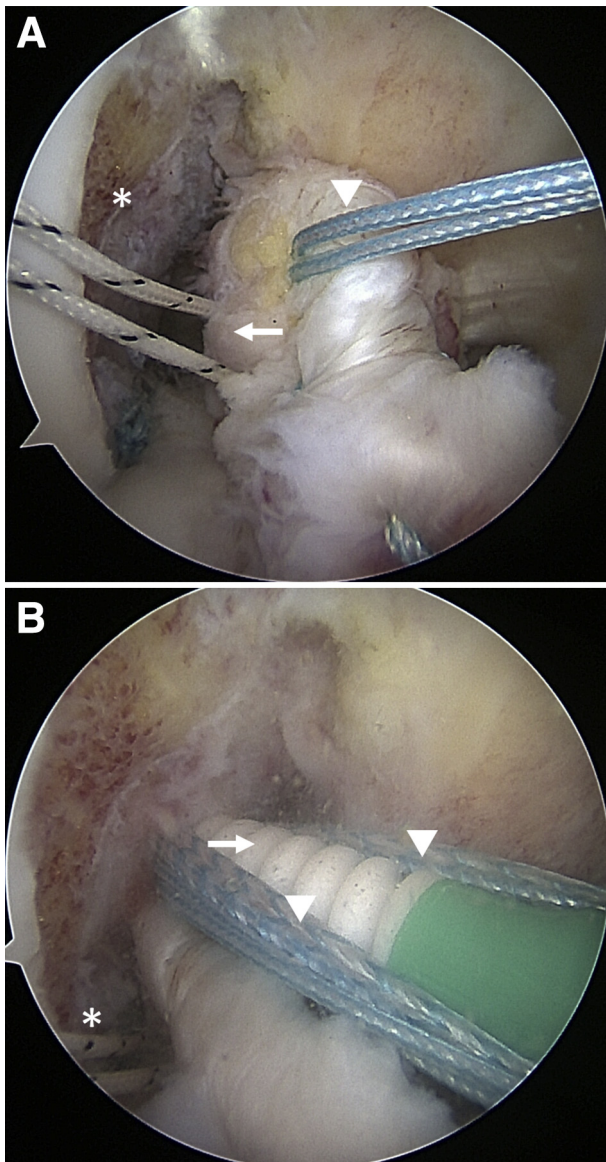
The sutures are then docked in an accessory portal just above the medial portal and the ligament can be retracted away for good visibility of the femoral footprint (Fig 2A). Bleeding of the notch wall is then induced using a shaver or burr by performing a small

opening notchplasty to encourage healing, but the femoral footprint is left alone. With the knee in flexion and under direct visualization, an accessory inferomedial portal is then created for direct access to the femoral footprint.



**Fig 1.** (A) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. The anterior cruciate ligament is shown with a type I avulsion tear (asterisk) and an intact distal and middle part of the ligament with excellent tissue quality and vascularity (arrowhead). (B) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. A suture passer (arrowhead) is used to pass a No. 2 FiberWire suture through the anteromedial bundle. The suture is passed in an alternating, interlocking Bunnell-type pattern and advancing proximally when compared with the previous stitches (arrow). In the left top corner of the image, the No. 2 TigerWire sutures of the posterolateral bundle are seen (asterisk), because these were performed first in this patient.





**Fig 2.** (A) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. Sutures are passed through both the anteromedial bundle (arrowhead) and posterolateral bundle (arrow). In the left top corner of the image, the femoral footprint can be seen, which has been roughened to induce a healing response (asterisk). (B) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. The suture anchor of the anteromedial bundle is deployed in the anteromedial region within the femoral footprint (arrow). The arrowheads show the FiberTape suture augmentation. In the left bottom corner of the image, the sutures of the posterolateral bundle can be seen (asterisk).

### Suture Anchor Fixation

With the knee at 90° flexion, a 4.5 × 20 mm hole is drilled, punched, or tapped (depending on the bone density), into the origin of the anteromedial bundle within the femoral footprint. The FiberWire sutures are

then retrieved through the accessory portal and passed through the eyelet of a 4.75-mm Vented BioComposite SwiveLock suture anchor (Arthrex) that is preloaded with FiberTape (Arthrex) that will act as the suture augmentation. With the knee flexed at 90° for optimal visualization, the first suture anchor is deployed into the femur toward the anteromedial origin while tensioning the ACL remnant to the wall to prevent gap formation (Fig 2B). This procedure is then repeated for the posterolateral bundle with the FiberWire sutures and a non-preloaded suture anchor at 110° to 115° of flexion, which is necessary for optimal visualization and prevention of posterior condyle perforation. Once the anchors are deployed and flush with the femoral footprint, the handle is removed, the core stitches are unloaded, and the free ends of the repair sutures are cut with an Open Ended Suture Cutter (Arthrex).

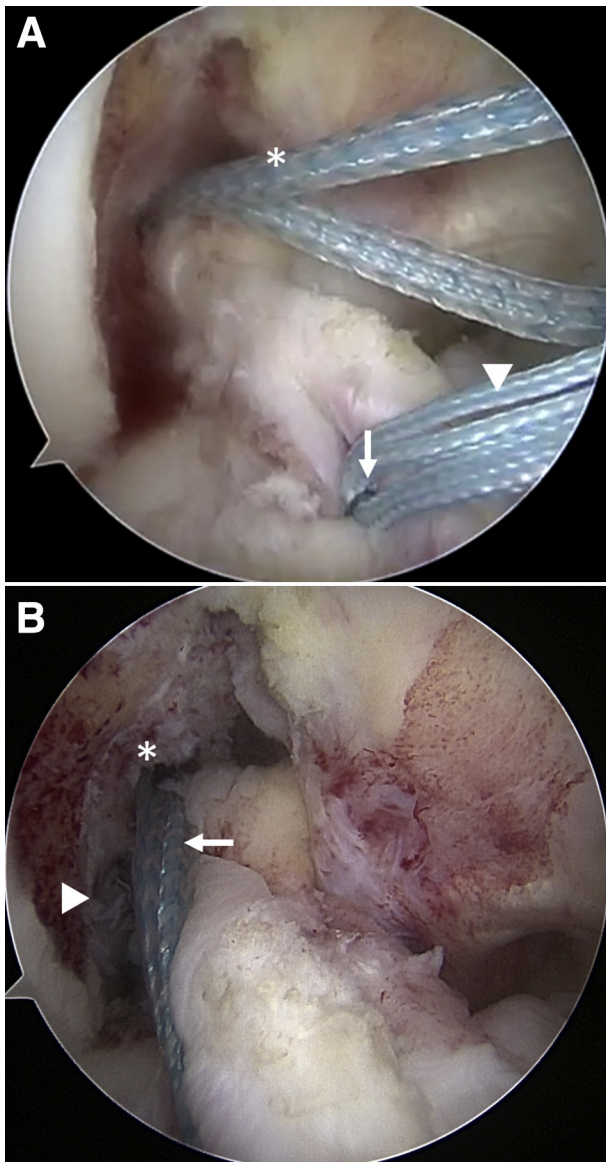
### Suture Augmentation Fixation Distally

The FiberTape suture augmentation is now fixed through the anteromedial suture anchor proximally and needs to be fixed distally. First, an ACL guide is used to drill a 2.4-mm drill pin up through the tibia from the anteromedial cortex and into the anterior half of the ACL tibial insertion. This is then switched for a Straight Microsuture Lasso (Arthrex), and the nitinol wire is retrieved out the anteromedial portal with the FiberTape. The FiberTape is then passed through the nitinol wire and shuttled along the ACL substance (Fig 3A) and down through the tibia where it is fixed with a suture anchor perpendicular to the tibial cortex after cycling the knee and tensioning near full extension. It should be checked that the suture anchor is flush with the tibial cortex to avoid hardware irritation, and the FiberTape is then cut short.

The repair with suture augmentation is now complete (Fig 3B), and the ACL remnant is tested for tension and stiffness with a probe. ROM and anatomic positioning should be visualized without graft impingement, and intraoperative Lachman testing should reveal minimal anteroposterior translation with a firm endpoint.

### Rehabilitation

Postoperative management is similar as for arthroscopic primary repair without suture augmentation.<sup>4,9</sup> Patients leave the operating room with a brace locked in extension. For the first 4 weeks, patients can weight bear with a brace as tolerated and perform ROM exercises without a brace. After volitional quadriceps control has returned, the brace is unlocked for ambulation. After 4 weeks, formal physical therapy is started and a standard ACL rehabilitation program is followed. Early recovery tends to be significantly faster than ACL reconstruction, likely due to the minimal invasive procedure.



**Fig 3.** (A) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. The suture anchor of the anteromedial bundle with the suture augmentation (asterisk) has been deployed in the femoral footprint. A micro suture lasso (arrow) with channel sutures (arrowhead) is used to channel the suture augmentation (asterisk) through the drilled tibial tunnel. (B) Arthroscopic view of a right knee, viewed from the anterolateral portal with the patient supine and the knee in 90° flexion. A completed primary repair of the anterior cruciate ligament reinserting both the anteromedial bundle (asterisk) and the posterolateral bundle (arrowhead) into the anatomic femoral footprint can be seen. The suture augmentation (arrow) is channeled along the ligament and provides stability in the early phases of rehabilitation, and thus enables early range of motion and fast recovery.

### Discussion

Recently, a resurgence of interest has been noted in ACL preservation using arthroscopic primary repair of

proximal tears.<sup>4,5</sup> DiFelice et al.<sup>4</sup> reported excellent outcomes after this procedure without suture augmentation with 1 failure (9%) at a mean 3.5-year follow-up. Moreover, Achtnich et al.<sup>5</sup> compared primary repair with the gold standard of ACL reconstruction and noted equivalent functional outcomes after both procedures with a trend toward more revision after primary repair.

The surgical procedure of arthroscopic primary repair with suture augmentation can be performed in patients of all age groups (i.e. both pediatric and adult patients) and activity levels. Patients are indicated for this procedure when a type I tear is noted, which is a proximal soft tissue avulsion tear that occurs in approximately 16% of the adults according to a recent magnetic resonance imaging study.<sup>10</sup> Absolute contraindications for this technique are patients with tears that have a distal remnant that is too short for reinsertion, tissue quality that cannot withstand sutures (i.e. poor tissue quality), or rerupture of a repaired ACL. Relative contraindications for this technique are surgical experience and surgical familiarity with the procedure; more familiarity and experience with the procedure can lead to the ability to also perform primary repair with suture augmentation in patients with fair tissue quality (i.e. tissue can withstand sutures but is not a perfect tissue quality; Video 1).

Very recently, Mackay et al.<sup>6</sup> have described the suture augmentation technique with the rationale of protecting the ligament during early rehabilitation. Experimental studies have assessed the role of augmenting the repair on biomechanical and histological outcomes during the first year.<sup>11,12</sup> Seitz et al.<sup>11</sup> recreated proximal avulsion tears in sheep, and either performed primary repair, or primary repair with augmentation with a 3-mm polyethylene terephthalate band. Histologically, they noted that ACL healing occurred in both groups, but that healing was achieved after 16 weeks for the augmented repair sheep, and after 26 weeks for the nonaugmented repair sheep. They suggested that augmentation protected the ligament from necrosis and ligamentization, and therefore earlier healing was observed in the augmentation group. In another study, Seitz et al.<sup>12</sup> assessed the biomechanical outcomes in both groups, and noted that sheep with augmented repair had more anteroposterior stability in early postoperative phase (until 6–16 weeks) but that this difference was not evident at longer follow-up. Furthermore, they noted that the augmented repair group at 1 year had more ligament stiffness and tensile strength when compared with the non-augmented repair group. They concluded that augmented repair, especially in the early phases, had superior biomechanical results compared with nonaugmented repair.

In the studies of DiFelice et al.<sup>4</sup> and Achtnich et al.,<sup>5</sup> some patients suffered ligament re-injury within 3 months after surgery following low-energy trauma.



**Table 2.** Surgical Pearls and Pitfalls of Arthroscopic Primary Anterior Cruciate Ligament Repair With Suture Augmentation

Pearls	Pitfalls
Magnetic resonance imaging can be used to identify proximal tears	Fixing FiberTape at flexion, which could cause overconstrain of the knee
Use a cannula in the anteromedial portal for suture management	Not deploying suture anchor deep enough in tibial cortex (hardware irritation)
Use a self-retrieving suture passer to pass sutures	
Load the anteromedial suture anchor with FiberTape as the suture augmentation	
Use a low accessory inferomedial portal to optimize angle for suture placement	
Flex knee at 90° for anteromedial bundle anchor placement and 110° for posterolateral bundle anchor placement to avoid posterior perforation	
Cycle the knee first and fix the FiberTape distally at near full extension for optimal function	

Bearing in mind the aforementioned findings by Seitz et al., it is possible that these injuries could have been prevented if the repair was internally braced. However, studies assessing reinjury rates after arthroscopic primary ACL repair with and without suture augmentation are clearly needed. The senior author now prefers primary repair with suture augmentation over primary repair without suture augmentation or reconstructive surgery in patients with a repairable proximal type I tear.<sup>7</sup> Pearls and pitfalls, and the advantages and disadvantages of this procedure are noted in Tables 2 and 3, respectively. The procedure is preferred over ACL reconstruction in all eligible patients (i.e. proximal tears and sufficient tissue quality), and this is not dependent on age, activity level, or concomitant injuries. In patients with a failed primary ACL repair, however, ACL reconstruction is preferred over a second attempt to repair the ligament. Primary repair has the advantages of early return of ROM, low complications,

and not burning any bridges when compared with ACL reconstruction.<sup>13</sup>

In conclusion, a recent resurgence of interest in ACL preservation has been noted using arthroscopic primary repair in patients with proximal tears. To protect healing of the ligament and enable ROM during the early phases of rehabilitation, suture augmentation can be added to the primary repair technique. In this Technical Note, we have described the surgical technique of arthroscopic primary suture anchor repair of proximal ACL tears with suture augmentation.

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**Table 3.** Advantages and Disadvantages of Arthroscopic Primary Anterior Cruciate Ligament Repair With Suture Augmentation

Advantages	Disadvantages
Relatively short procedure (50-70 min)	Only in selective group of patients
Minimally invasive (no tunnels)	Long-term outcomes (≥5 yr) unknown
No graft harvesting complications	
Early range of motion with ligament protection	
Suture augmentation can be removed without damaging the repaired anterior cruciate ligament, if necessary	
No bridges burned for later ACL reconstruction	
Growth plate-sparing treatment for pediatric patients	
Faster recovery than ACL reconstruction	
Prevents osteoarthritis in experimental studies	
Preserves proprioception and native kinematics	

ACL, anterior cruciate ligament.

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