Technical Note

# Anterior Cruciate Ligament Stump Elongation Technique for Anterior Cruciate Ligament Restoration

Matthew J. Schultz, D.O., A.T.C., Hannah R. Popper, D.O., and Sean McMillan, D.O.

**Abstract:** There is renewed interest in anterior cruciate ligament (ACL) preservation techniques. Prior studies have shown good outcomes and low failure rates with ACL preservation in patients with good tissue quality and more proximal tears. We describe a technique intended to assist surgeons in obtaining maximal length of the ACL stump during ACL preservation surgery. We find this to be effective in reapproximating the ACL remnant to its origin on the femoral wall in many cases, even those with a relatively short-appearing stump on preoperative imaging. This technique may allow for surgeons to feel more comfortable offering ACL repair or restoration to patients with a smaller distal ACL remnant.

Anterior cruciate ligament (ACL) preservation techniques have gained renewed interest in recent years. Patient selection remains paramount for these procedures.[1-3] In addition to tissue quality and timing of repair, tear location should be considered when determining whether a patient may be a candidate for ACL preservation rather than reconstruction.

Systematic reviews have shown good functional outcomes and low overall failure rates with ACL repair of proximal ACL tears,[1] suggesting that an ACL remnant amenable to reapproximation to the femoral wall plays an important role in successful repair. Sherman et al.[2] originally described a classification system for ACL tear location based on intraoperative findings; later, the modified Sherman classification was proposed in which tear location is described based on magnetic resonance imaging (MRI) to aid clinicians in determining preoperative candidacy for ACL preservation (Table 1).[4]

*From Jefferson Health—New Jersey, Stratford, New Jersey, U.S.A. (M.J.S., H.R.P.); and Virtua Health System, Marlton, New Jersey, U.S.A. (S.M.).*

*Received April 2, 2024; accepted May 24, 2024.*

*Address correspondence to Sean McMillan, D.O., Virtua Health System, 2103 Mount Holly Rd, Burlington, NJ 08016, U.S.A. E-mail: mcmillansean@hotmail.com*



*2212-6287/24569*

*https://doi.org/10.1016/j.eats.2024.103140*

Modern ACL restoration techniques offer the prospect of expanding the indications for ACL preservation to include tear patterns with a smaller distal ACL remnant.[5] Regardless, any technique that permits better reapproximation of the ACL without compromising tissue integrity should impart a biological and mechanical benefit. We describe a simple technique for ACL stump elongation to assist surgeons in performing ACL preservation surgery.

## Surgical Technique

### Patient Positioning

The patient is positioned supine on a standard operating room table. A soft post is placed laterally at the level of the mid thigh, which prevents the leg from falling off the table and allows for medial joint space widening when valgus stress is applied. After induction of anesthesia, the patient is prepared and draped in a sterile manner.

### Arthroscopic Technique

A standard diagnostic arthroscopy is performed through a lateral portal. For this procedure, the medial portal is modified to allow for improved access to the ACL tissue and implantation of a biological augmentation later in the case. For this portal, a vertical 2-cm medial arthrotomy is created adjacent to the patellar tendon. Next, a transpatellar portal is localized using a spinal needle with the knee flexed to 90°. This is created approximately 5 mm below the central portion of the patella (Figs 1 and 2).

**Table 1.** Common ACL Remnant Classifications Based on Tear Location

| | Sherman Classification | Modified Sherman Classification |
|---|---|---|
| Type I | Proximal soft-tissue avulsion | >90% distal remnant |
| Type II | Proximal stump, 20%; distal stump, 80% | 75%-90% distal remnant |
| Type III | Proximal stump, 33%; distal stump, 67% | 25%-75% distal remnant |
| Type IV | Proximal stump, 50%; distal stump, 50% | 10%-25% distal remnant |
| Type V | | <10% distal remnant |

NOTE. The Sherman classification is based on intraoperative findings, whereas the modified Sherman classification is based on preoperative magnetic resonance imaging.
ACL, anterior cruciate ligament.

After portal placement, a blunt obturator is inserted through the medial portal to release adhesions to the remnant ACL stump from the posterior cruciate ligament and the medial and lateral femoral wall, as well as any cyclops lesions (Fig 3). Meticulous dissection should be undertaken to preserve as much native tissue as possible. It is recommended to avoid using a mechanical shaver or electrocautery to protect the health of the remaining tissue and to avoid injury to the remaining ACL.

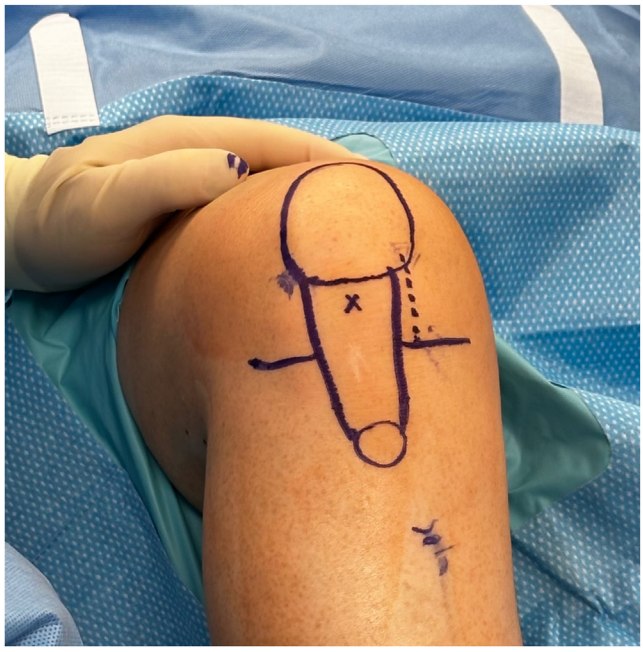


**Fig 1.** Pictured above is a right knee prepared for surgery. The viewing portal is noted with the purple circle. The recommended medial and transpatellar portal placement. The medial portal (dotted line) is 2 cm in length and adjacent to the medial border of the patellar tendon. The transpatellar portal (X) is 5 to 10 mm in length and is located in the central portion of the tendon approximately 5 mm below the inferior pole of the patella.

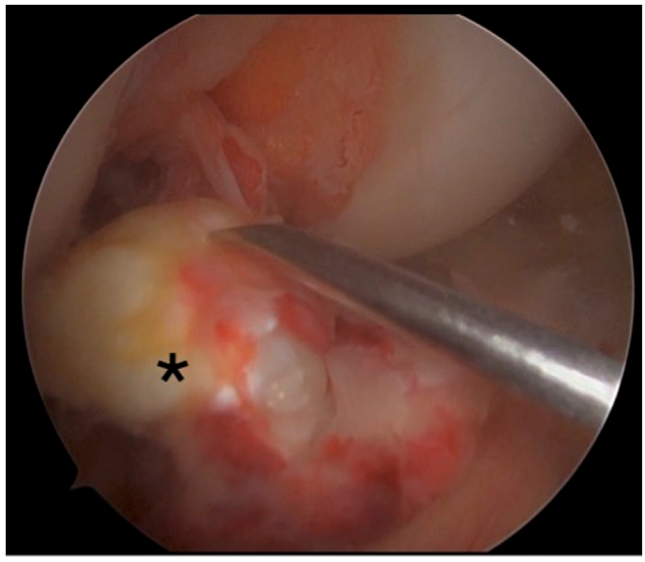


**Fig 2.** Arthroscopic localization of transpatellar portal. With visualization through the lateral portal with the knee in 90° of flexion, a spinal needle is inserted through the planned location of the transpatellar portal. The surgeon should be able to manipulate the anterior cruciate remnant (asterisk) in 360°.

Once the ACL has been freed of adhesions, a cannula is placed through the medial portal. A grasping device is placed through the transpatellar portal to grab the tip of

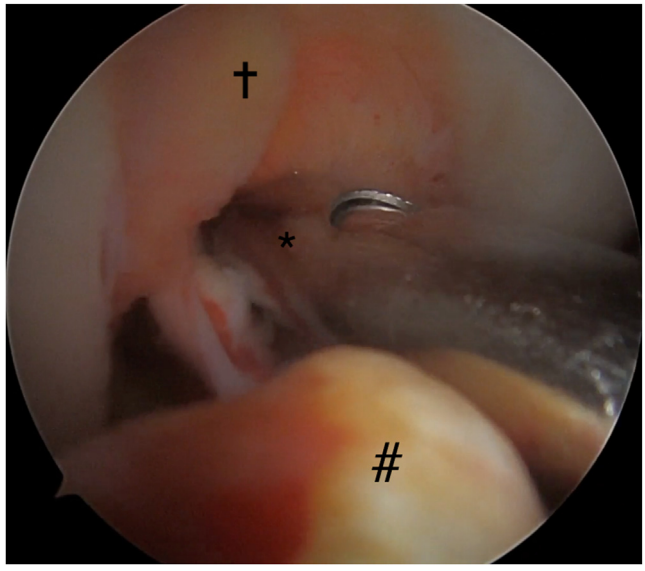


**Fig 3.** Release of adhesions to remnant anterior cruciate ligament (ACL). With visualization through the lateral portal with the knee in 90° of flexion, a blunt obturator (asterisk) is inserted through the medial portal and used to release adhesions (dagger) to the remnant ACL (pound sign). While preserving any ACL fibers that remain attached to their femoral origin, the ACL remnant should be freed of adhesions to the medial and lateral walls and the posterior cruciate ligament, as well as any cyclops lesions, to allow for maximal excursion.

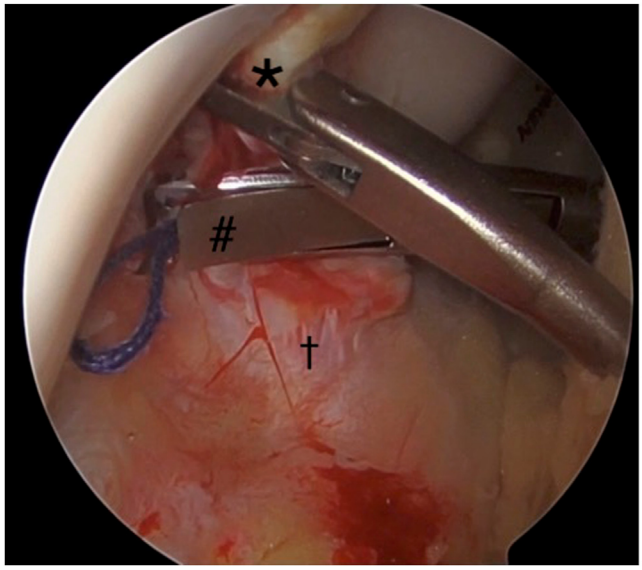


**Fig 4.** Suture passage through anterior cruciate ligament (ACL) stump during elongation with grasping device. With visualization through the lateral portal with the knee in 90° of flexion, the grasping device is placed through the transpatellar portal and the stump is grasped at the proximal portion (asterisk). While pulling upward (superiorly) with the grasping device, a low-profile self-catching suture-passing device is used to begin passing suture (pound sign) at the tibial insertion (dagger) of the ACL.

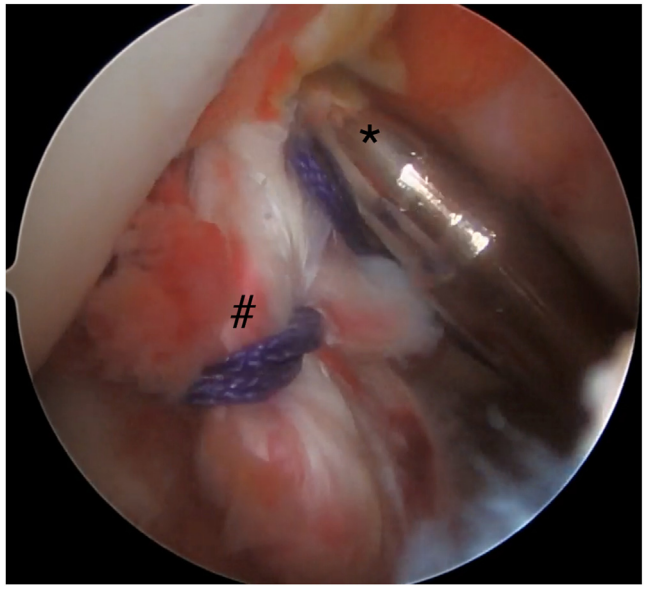


**Fig 5.** Confirmation of anterior cruciate ligament (ACL) remnant length and reduction to lateral wall. With visualization through the lateral portal with the knee in 90° of flexion, a blunt obturator is inserted through the medial portal to reduce the ACL remnant to its origin on the lateral wall. The final length of the ACL remnant can be determined at this point. Consideration of ACL restoration is recommended for remnants that cannot be fully reapproximated to the lateral wall at this point. The "*" denotes the trochar tip and the "#" symbol indicates the ACL.

the ACL stump. While lifting upward (superior) on the ACL with the grasping device to gain maximal length, a self-catching suture passing device (EXPRESSEW III Autocapture Flexible Suture Passer; DePuy Synthes, Raynham, MA) is placed through the medial cannula to begin passing suture through the ACL stump (Fig 4). We prefer No. 2 Vicryl suture (Ethicon, Somerville, NJ), as originally described by Murray et al.,[5] because it is nonabrasive to the tissue and the small diameter allows for multiple suture passes to be placed. Beginning at the tibial insertion of the ACL and advancing toward the femoral side, multiple passes can be made through the elongated tissue in alternating directions of passage. If a cyclops lesion is present, the grasper, placed in the transpatellar portal, can be used to approximate it to majority remnant fibers for incorporation. It is recommended to perform at least 3 passes of the suture through the tissue. If the suture is not secured through the tissue or if inadvertent locking of the suture occurs, a tip-to-tip device can be used to undo the suture pass. The sutures that have been placed can be used in a gentle traction manner to allow for visualization of remaining ACL tissue or to allow for a small notchplasty. In the event that there are remaining fibers of the native ACL at the native femoral attachment site, it is recommended to attempt to incorporate the elongated ACL stump into this. Placing the knee into the figure-of-4 position can facilitate access deep into the notch with the passing device. Similarly, if the angle is too steep for tissue penetration from the medial portal, the suture passer can be percutaneously placed through the transpatellar portal and used to deliver the suture. After sufficient suture fixation has been obtained through the ACL stump, the obturator can be placed to reduce the ACL to its origin on the femur to assess length and attachment site placement (Figs 5 and 6).

## Discussion

ACL repair has shown good functional outcomes and low failure rates in patients with proximal ACL tears.[1] Similarly, early studies investigating the reason for unacceptably high rates of mid-term failure in ACL repair showed a trend toward worse outcomes in patients with more distal tears.[2] With the advent of ACL restoration techniques that theoretically obviate complete reapproximation of the torn ligament to its bony attachment site,[5] there is debate whether current ACL preservation techniques can be considered in patients with more distal tears.

The modified Sherman classification describes ACL tear location based on preoperative MRI (Table 1).[4] The initial study reported strong interobserver reliability ($\kappa = 0.67$) and excellent intraobserver reliability ($\kappa = 0.93$).[4] A subsequent study found that ACL tears were

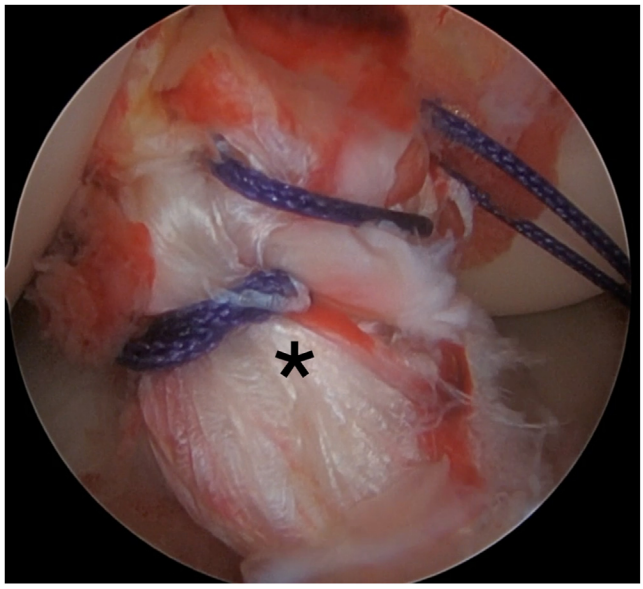

**Fig 6.** Restoration of anterior cruciate ligament (ACL) length after stump elongation. With visualization through the lateral portal with the knee in 90° of flexion, the ACL remnant (asterisk) has been adequately lengthened for ACL repair.

amenable to repair in 93% of patients with modified Sherman type I and II tears with good tissue quality (also measured on preoperative MRI) versus only 33% of patients with type III tears and good tissue quality.[6] Accordingly, a small distal ACL remnant identified on preoperative imaging may dissuade surgeons from considering an ACL preservation technique. Other surgeons may attempt ACL preservation but convert to a reconstruction technique if initial intraoperative evaluation of the ACL remnant reveals insufficient length or tissue quality.

We perform the described stump-lengthening technique in all patients undergoing ACL preservation prior to making a final determination about ACL remnant length. We find that this technique often produces an ACL remnant that can be reapproximated to the femoral wall, even in patients with modified Sherman type III or IV tears. The case described in Video 1 is one such example. As was found in the study of Sherman et al.,[2] tissue quality is important when contemplating tissue elasticity for elongation.[6] Although the optimal time to surgery has yet to be truly established, we believe that if this technique is to be considered, relative urgency is necessary to optimize tissue quality.

The described technique is not without its limitations. Some ACL remnants cannot be reapproximated to the femoral wall with this technique. We perform an ACL restoration procedure (BEAR Implant; Miach Orthopaedics, Westborough, MA) in these cases and use the stump-lengthening technique to effectively decrease the length of the "bridge" between the torn ends of the ACL.[5] Additionally, this technique uses a transpatellar portal, which poses the risk of iatrogenic damage to the patellar tendon. We believe this portal is necessary because it allows the ACL stump to be maximally tensioned and manipulated in 360° during passage of the sutures. Table 2 presents an additional list of technical recommendations that should aid surgeons in adopting this technique.

**Table 2.** Technical Recommendations for ACL Stump Elongation Technique

| Pearls | Pitfalls |
|---|---|
| The surgeon should use a transpatellar portal to grasp the ACL stump during elongation. | The surgeon should not use electrocautery or a shaver with suction when releasing adhesions from the ACL stump. |
| The surgeon should gently pull upward on the ACL stump when passing suture. | Tissue quality or integrity should not be compromised to obtain a greater stump length. |
| A cannula should be placed in the medial arthrotomy to prevent soft-tissue bridges when passing suture. | The surgeon must avoid unintentionally incorporating the PCL when passing suture. |
| The surgeon should consider placing the knee into the figure-of-4 position to allow greater access to the tissue in the notch. | The surgeon should not remove cyclops lesions or tissue scarred into the fat pad. |
| The surgeon should consider a small notchplasty to allow access to the tissue in the notch. | |
| The surgeon should consider using a self-capturing low-profile suture retriever (EXPRESSEW III Autocapture Flexible Suture Passer). | |

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

In summary, this article describes a technique intended to assist surgeons in obtaining maximal length of the ACL stump when performing ACL preservation surgery. We find this technique to be effective in reapproximating the ACL remnant to its origin on the femoral wall in many cases, even those with a relatively short stump identified on preoperative imaging. Using this technique appropriately may allow for surgeons to feel more comfortable offering ACL repair or restoration to patients with a smaller distal ACL remnant. Future studies may compare the ultimate length that can be achieved with this technique with the presumed length based on preoperative imaging and initial intraoperative evaluation.

## Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: S.M. reports a consulting or advisory relationship with Miach Orthopaedics. Both other authors (M.J.S., H.R.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.

## References


1. Vermeijden HD, Van Der List JP, Benner JL, Rademakers MV, Kerkhoffs GMMJ, DiFelice GS. Primary repair with suture augmentation for proximal anterior cruciate ligament tears: A systematic review with meta-analysis. *Knee* 2022;38:19-29.
2. Sherman MF, Lieber L, Bonamo JR, Podesta L, Reiter I. The long-term followup of primary anterior cruciate ligament repair. Defining a rationale for augmentation. *Am J Sports Med* 1991;19:243-255.
3. Taylor SA, Khair MM, Roberts TR, DiFelice GS. Primary repair of the anterior cruciate ligament: A systematic review. *Arthroscopy* 2015;31:2233-2247.
4. van der List JP, Mintz DN, DiFelice GS. The location of anterior cruciate ligament tears: A prevalence study using magnetic resonance imaging. *Orthop J Sports Med* 2017;5, 2325967117709966.
5. Murray MM, Kalish LA, Fleming BC, et al. Bridge-enhanced anterior cruciate ligament repair: Two-year results of a first-in-human study. *Orthop J Sports Med* 2019;7, 2325967118824356.
6. van der List JP, DiFelice GS. Preoperative magnetic resonance imaging predicts eligibility for arthroscopic primary anterior cruciate ligament repair. *Knee Surg Sports Traumatol Arthrosc* 2018;26:660-671.