Technical Note

Arthroscopic Primary Repair of Proximally Based Anterior Cruciate Ligament Tear With Augmentation and All-Epiphyseal Fixation

Dillon L. Morrow, M.D., Austin G. Hughes, M.D., Richard D. Murray, M.D., and Jeremy R. Bruce, M.D.

Abstract: Arthroscopic anterior cruciate ligament (ACL) reconstruction has been the gold standard of care for ACL injuries for many years. Recently, there has been growing literature and interest in arthroscopic primary ACL repair in select patients with predominantly proximally based ACL tears. This Technical Note demonstrates a surgical technique that offers an efficient minimally invasive and physeal-sparing anatomic ACL repair with all-inside internal brace augmentation that in the short term has offered good results for our patients.

Anterior cruciate ligament (ACL) repair was the first procedure ever reported in the history of ACL surgery; however, the results of these pioneering surgeries were never trustworthy. Since the beginning of modern ACL surgery, dating back to the 1960s, the results of ACL repair, as reported by several authors over the years, were overall unsatisfactory, leading knee surgeons to the conclusion that a torn ACL was irreparable.[1] In the last few years, however, there has been an increasing number of papers on direct repair of ACL injuries published in the international literature to suggest that ACL repair should be reconsidered as an alternative to reconstruction, with authors consequentially taking advantage of new surgical materials, devices, and techniques.[2,3] Advocates performing primary ACL repair advise performing the procedure only on select patients with proximal tears.[4] Clinically, the outcomes of ACL repair with advanced arthroscopic techniques and modern rehabilitation protocols have shown improvement and encouraging results with greater potential for early healing and equivocal functional outcomes as compared with reconstruction surgery.[5-8] Several ACL repair techniques have been described; however, the primary aim of this article is to describe the step-by-step technique for a primary ACL repair using a physeal-sparing construct that augments the ACL repair with an internal brace.

Patient Evaluation, Imaging, and Indications

All procedures were performed in compliance with relevant laws and institutional guidelines. The treatment of all patients undergoing arthroscopic ACL repair always begins with a thorough patient history, physical examination, and review of indicated imaging to reach a correct diagnosis. A comprehensive history addressing the mechanism of injury, presence of a "pop," generalized pain, and immediate onset of swelling must be obtained from the patient. When patients tear their ACL, they often describe a loud "pop," and instability of the knee.[9] After the injury, hemarthrosis and knee effusion usually occur rapidly, and patients complain of their knee giving way. This giving-way sensation can be explained by the tibia moving forward and rotating internally because it is not resisted by the torn ACL. In the acute setting, the physical examination is often limited by guarding from pain, and ligamentous laxity often can be hard to assess. If possible, assessment for ligamentous laxity should still be performed. The Lachman test and pivot shift will evaluate for increased anterior tibial translation and rotatory laxity,

From the Department of Orthopaedic Surgery, University of Tennessee College of Medicine Chattanooga, Tennessee, U.S.A.

Received January 10, 2024; accepted April 2, 2024.

Address correspondence to Dillon L. Morrow, M.D., Department of Orthopaedic Surgery, University of Tennessee College of Medicine Chattanooga, 975 East Third St., Hospital Box 260, Chattanooga, Tennessee, 37403, U.S.A. E-mail: dillonmorrow@gmail.com

2212-6287/2444
https://doi.org/10.1016/j.eats.2024.103040

respectively.[10] The Lachman and the pivot shift test have respective sensitivities of 0.87 and 0.49 and specificities of 0.97 and 0.98.[10]

When an injury to the ACL is suspected, imaging starting with standard radiographs of the knee should be obtained. On standard radiographs, the presence of a Segond fracture can help clue you in to the presence of an ACL injury; nonetheless, magnetic resonance imaging is still strongly recommended to be part of the diagnostic evaluation. The use of magnetic resonance imaging helps evaluate for additional pathology and confirmation of ACL tear with a sensitivity and specificity of 97% and 100%, respectively.[10]

Indications for ACL repair revolve around identifying ACL ligament tear patterns with the potential to heal. The Sherman classification was established to help identify proximally based tear patterns that have the most healing potential.[11] The Sherman classification organizes ACL tears by location to the proximal half of the ACL. Type 1 tears are true proximal avulsion tears, type 2 tears have 20% of the ligament on the femoral wall, type 3 tears have up to 33%, and type 4 tears have up to 50% of the ligament tissue on the femoral wall.[11] Only acute and subacute type 1 tears were traditionally recommended to be repaired, but more recently, a modified classification system recommends that ACL repair indications can be extended to proximal 25% ACL location tears from distal to proximal length.[12] In summary, indications for ACL repair with this article's technique are patients of any age group with proximal 25% avulsion tears of sufficient ACL remnant tissue quality. Contraindications of using this articles technique for ACL repair are patients with midsubstance tears, tears with poor tissue quality, and a re-rupture of an already repaired ligament.

Patients should be counseled that even if a proximal-based tear is suspected on the basis of imaging, the ultimate decision between ACL repair and ACL reconstruction is decided intraoperatively on the basis of tear type and tissue quality identified during the diagnostic arthroscopy, thus possible graft options for reconstruction are discussed before proceeding with surgery.

Surgical Technique

Surgical Positioning

After induction of anesthesia, the patient is transitioned to a standard operating table and placed in the supine position. A clinical examination of the patient under anesthesia is performed of the affected knee. A thigh tourniquet is placed on the affected extremity and the thigh is then secured with an arthroscopic leg holder. The foot of the bed is then dropped to allow free mobility of the leg. Wide surgical preparation is performed, and the patient is draped in standard fashion to allow possible ACL graft harvest if needed.

Diagnostic Arthroscopy

Standard anterolateral and anteromedial (AM) portals are made, and the arthroscopic camera is introduced into the knee joint to perform the diagnostic scope. All 3 compartments should be visualized to ensure all pathology is being addressed. The ACL tear location and quality of the remaining tissue is scrutinized and if the ACL tear is determined to be in the proximal 20% to 25% and the tissue is of good quality, primary ACL repair can be considered (Fig 1). If the tear does not meet these qualifications, then ACL reconstruction is performed. Any other intra-articular pathology is addressed at this time.

ACL Preparation and Lateral Femoral Wall Preparation

Use a self- retrieving suture-passing device (FastPass Scorpion Suture Passer; Arthrex, Naples, FL) to place multiple (between 2 and 3) luggage tag stiches consisting of 1.3-mm width FiberLink suture tape from Arthrex in the midsubstance of the junction of the ACL remnant AM and posterolateral bundles traveling from distal to proximal (Fig 1). For each FiberLink suture tape, outside the joint, the FiberLink is prepared for passage by placing the small ring portion of the suture over the end of the suture passer (to ensure luggage-tag construct) and loading the single end of the suture into the bottom jaw of the suture passer, leaving approximately 3 cm of suture as a "tail." The FiberLink is passed through the ACL remnant through the AM portal. Once the suture passer is removed from the joint, the suture is release and tension is pulled on the tail of the suture to synch down the luggage tag. Place enough suture so that good ligament remnant control is achieved

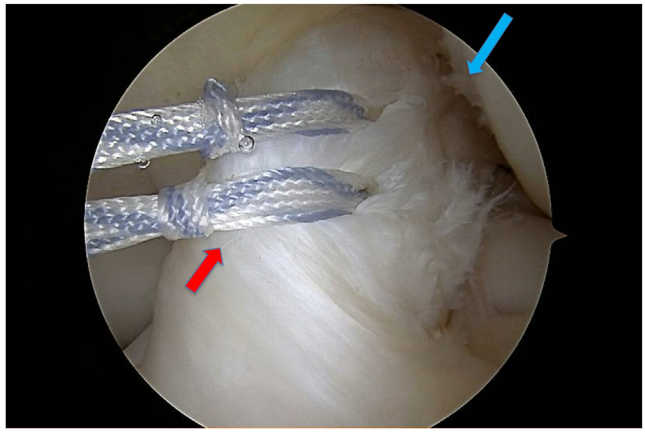

Fig 1. Arthroscopic view of a left knee from an anterolateral portal identifying an ACL proximal avulsion tear off of the lateral femoral condyle (blue arrow). The distal ACL remnant is observed with 2 sutures already placed through its midsubstance, at the junction of the ACL remnant anteromedial and posterolateral bundles (red arrow). (ACL, anterior cruciate ligament.)

Table 1. Pearls and Pitfalls to Consider While Performing Technique

Pearls	Pitfalls
1. Quality of the ACL tissue and ACL tear type should be accurately evaluated.	1. Failure to recognize poor tissue may result in failure of repair.
2. The sutures should be passed through the midsubstance fibers of the ACL remnant for adequate purchase.	2. Poor purchase of the sutures in the ACL remnant can occur if they are not passed through the midsubstance and aren't spaced well.
3. Space the sutures out appropriately for good ACL remnant control (up to 3 sutures).	3. Poor tension assessment when docking the ACL remnant in the femur could result in failure of the ACL to heal into the femur.
4. Make sure adequate tension is kept on the sutures when docking the sutures into the femur so that the ACL remnant is pulled against the prepared bone bed.	

ACL, anterior cruciate ligament.

(Table 1). The sutures are pulled through the AM portal for docking. While viewing through the anterolateral portal, the ACL origin on the medial aspect of the lateral femoral condyle is freshened up using a combination of ablator and shaver used in bone cutting mode to gently decorticate down to bleeding bone (Fig 2). The hope is to induce a healing response by creating a bed full of healing factors that should encourage the repaired proximal ACL stump to heal.

Femoral Side Repair

The accessory anteromedial portal (AAM) is then made to obtain the ideal angle to drill into the middle of the origin of the femoral ACL attachment on the lateral femoral condyle. The drill guide for the 3.9-mm PEEK SwiveLock (Arthrex) anchor is placed and subsequently drilled to appropriate depth (Fig 3). The ideal location for placing this anchor is 2 to 3 mm anterior to the posterior margin of the medial aspect of the lateral femoral condyle. The 3 luggage tag sutures are pulled through the AAM portal using a suture grasper then loaded into a 3.9-mm PEEK SwiveLock anchor. The anchor with the loaded suture is then placed through the AAM portal and inserted into the drill tunnel on the femur and docked (Fig 4). This will bring the proximal ACL tissue back to its femoral attachment against the previously prepared bleeding bone bed.

All-Inside Internal Brace

An 18-guage spinal needle is then used to triangulate the ideal trajectory of the accessory anterior superior medial (AASM) portal (Fig 5). This portal is just inferior and medial to the patella and often is just superior to the AAM portal (Fig 6). The AASM portal is used to drill and dock the suture into the tibia to establish the all-inside internal brace construct. The ideal docking location on the tibia is in the central anterior aspect of the ACL footprint on the tibia. Take care not to damage the meniscus. After establishment of the AASM portal, the 3.9-mm peak SwiveLock drill guide is placed and drilled in the correct position on the tibia (Fig 7). The

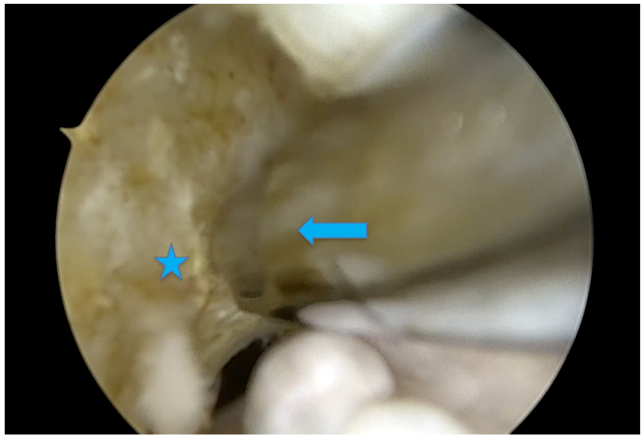

Fig 2. Arthroscopic view of a right knee through the anterolateral portal with the arthroscopic shaver (blue arrow) being used through the anteromedial portal. This is demonstrating gently decorticating the lateral femoral condyle ACL origin (star) down to bleeding bone in hopes of inducing healing of the ACL repair. (ACL, anterior cruciate ligament.)

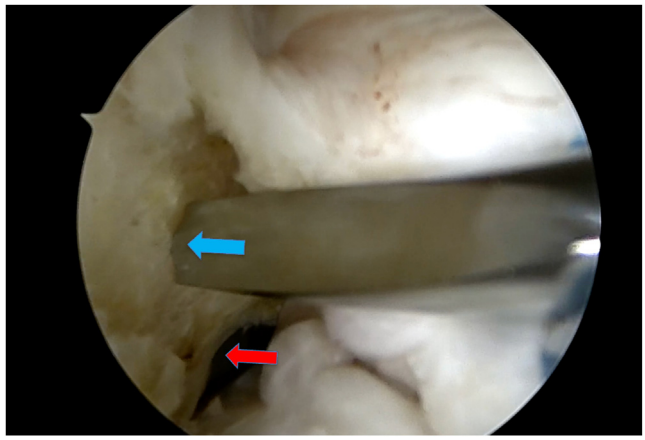

Fig 3. Arthroscopic view of a right knee through the anterolateral portal demonstrating the utilization of the accessory anteromedial portal. The drill guide for the 3.9-mm PEEK SwiveLock (Arthrex) anchor is placed and subsequently drilled to appropriate depth centered on the femoral origin on the lateral femoral condyle (blue arrow). The ideal location for placing this anchor is 2 to 3 mm anterior (blue arrow) to the posterior margin of the medial aspect of the lateral femoral condyle (red arrow).

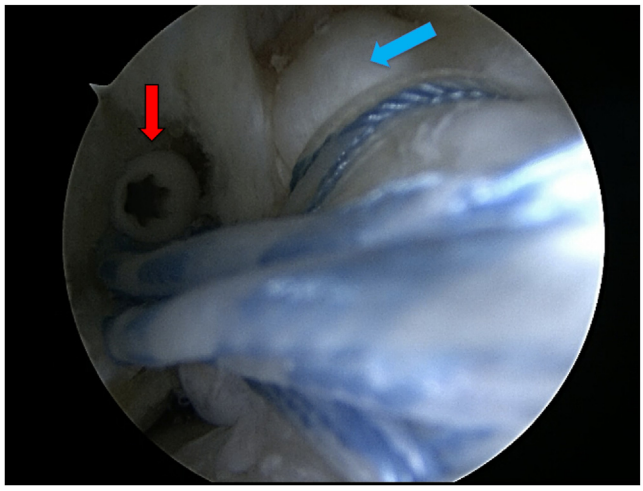

Fig 4. Arthroscopic view of a right knee through the anterolateral portal demonstrating the docking of the suture into the ACL origin on the lateral femoral condyle. The ACL remnant is pulled back to its femoral origin (blue arrow). The SwiveLock anchor is shown by the red arrow. Take care to ensure good tension is kept on the suture when docking. (ACL, anterior cruciate ligament.)

suture tails from the proximal docking location are pulled through the AASM portal using a suture grasper and then loaded into a second SwiveLock anchor and are docked home on the tibia with the knee in >90° flexion through the AASM portal (Fig 8). During insertion of the anchor, make sure to maintain ideal

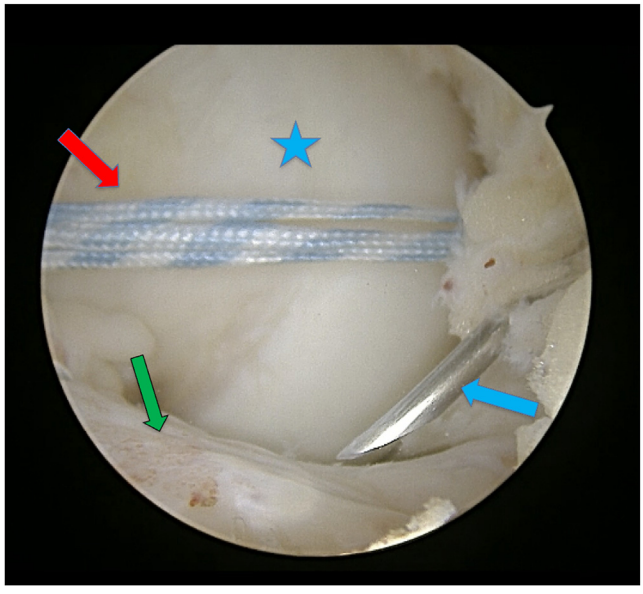

Fig 5. Arthroscopic view of a right knee through an anterolateral portal, this view demonstrates how to use an 18-gauge spinal needle (blue arrow) to establish the correct location of the accessory anterior superior medial portal. ACL (green arrow), suture tails pulled through the accessory anteromedial portal (red arrow), medial femoral condyle (blue star).

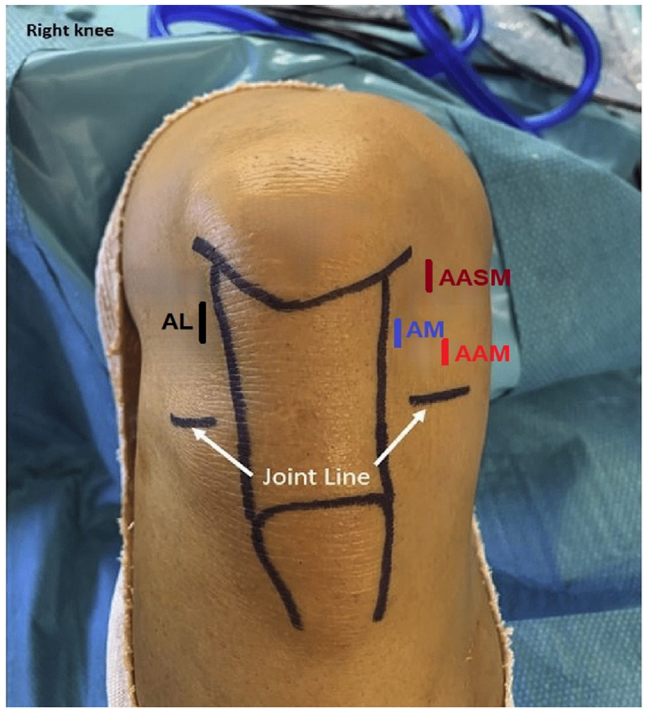

Fig 6. This demonstrates the general position of the portals used in our technique on a right knee. The anterolateral (AL), anteromedial (AM), accessory anteromedial (AAM), and accessory anterior superior medial (AASM) portals.

tension on the suture tails to ensure a good ACL internal brace augmentation. The suture tails are then cut with an arthroscopic suture cutter. The ACL repair construct is then probed to assess tension and the knee is taken through the entire range of motion (Fig 9). Lachman and anterior draw examinations are performed while viewing arthroscopically to ensure no

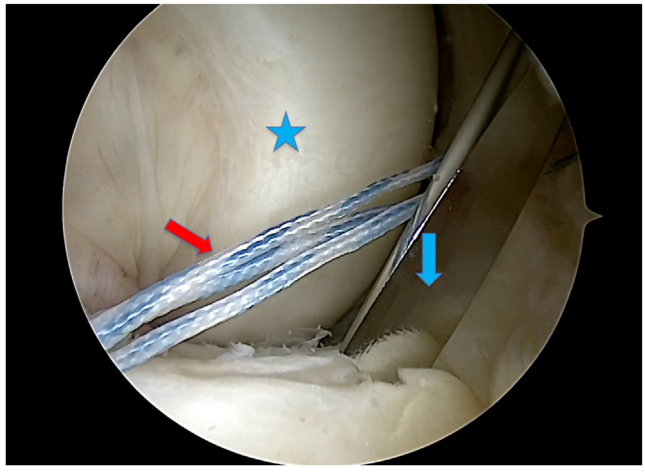

Fig 7. Arthroscopic view of a right knee through the anterolateral portal demonstrating the drilling of the tibial footprint of the ACL (blue arrow). The suture tails from the proximal docking site (red arrow). Medial femoral condyle (blue star).

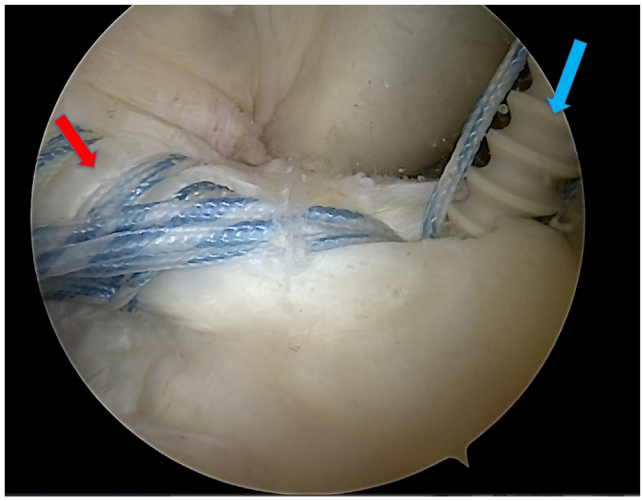

Fig 8. Arthroscopic view of a right knee from an anterolateral portal demonstrating docking of the suture tails into the tibia at >90° flexion to complete the internal brace construct (blue arrow). The ideal docking location on the tibia is in the central anterior aspect of the ACL footprint on the tibia. Take care not to damage the meniscus. ACL (red arrow).

gapping or fraying of the repair occurs, and that the repair offers a stable knee. If examination determines the knee to be stable, then the final repair construct is complete (Fig 10); however, any concern for tissue viability or construct stability at any point during the procedure (Video 1) are grounds to convert to ACL reconstruction.

Postoperative Care/Rehabilitation

In the immediate postoperative period (1-14 days), the goal is to protect the ACL repair while initiating early range of motion (ROM), concentrating on getting full knee extension.[12] The patient is to be weight-bearing as tolerated in a postoperative hinged knee brace locked out in extension when ambulating and sleeping until good quadricep control is achieved. Crutches are often needed in this phase. At week 3, early gentle postoperative strengthening/proprioceptive training is started. At this stage, if the patient is able to demonstrate good quadriceps control (able to complete 20 straight leg raises without extension lag), then the patient can wean out of the postoperative brace and full weight-bearing with no crutches is allowed. Knee flexion to within 30° of the unaffected side is the ROM goal. Closed-chain exercises predominate. By week 5, the patient should have full ROM and has begun to increase strength and proprioceptive control, demonstrated by the ability to single-leg squat equal to 80% of contralateral limb. By week 8, running program can be started if patient can pass straight leg hop test. At 12 to 16 weeks, plyometric exercises begin and are advanced to include sport-specific movements. Return-to-sport consideration begins around the 6-month mark once the patient demonstrates full ROM, full strength compared with the uninvolved limb, can run and jump without any pain or limp, has completed a sport-specific functional progression program, and ACL-return to sport injury scale score is 100%.

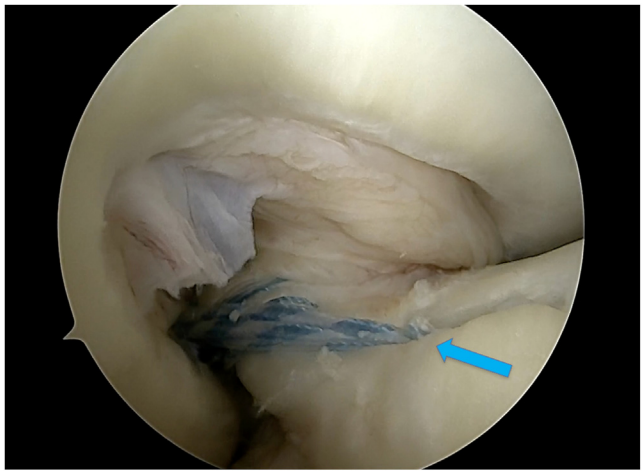

Fig 9. Arthroscopic view of a right knee from anterolateral portal showing arthroscopic assessment of the completed ACL repair construct (blue arrow) with the knee being taken through full range of motion.

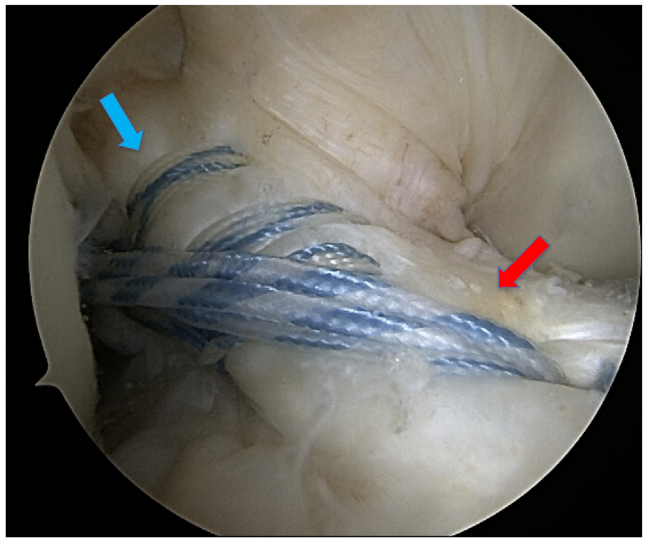

Fig 10. Arthroscopic view of a right knee through the anterolateral portal demonstrating the final physeal sparing anatomic ACL repair (blue arrow) with all-inside internal brace augmentation construct (red arrow).

Discussion

This article describes a technique for the repair of proximal-based ACL tears. This procedure can be performed in patients of all age groups and activity levels. At our institution, it has been used in patients as young as 10 years old, given its an all-epiphyseal

physeal-sparing technique; however, it was first used on the 35- to 55-year-old population, as they are less at risk for retear.[13,14] The surgical preservation of the native ACL has traditionally been overshadowed by concerns about its limited healing potential secondary to poor vascularity in the native ACL remnant, driving surgeons toward reconstruction.[15] Recent studies reveal there is indeed healing capacity in the proximal ACL specifically.[16] The proximal ACL can heal well to the notch supported by good vascularity there, in contrast to midsubstance tears, which face reduced healing likelihood as the result of inferior vascularity.[16] Patient selection is therefore crucial for optimal outcomes; only patients with proximal 25% tears of the ligament with good-to-excellent tissue quality are good candidates.[7,16] In addition, ACL repair is preferentially performed within 4 to 6 weeks of injury occurrence because of the possibility of degeneration and shrinkage of the ACL stump;[7] however, assessment of tissue quality can be performed during arthroscopic evaluation to determine potential for repair.

ACL repair offers multiple advantages (Table 2). Sparing of the ACL nerve endings/proprioceptive abilities with repair might help restore native knee kinematics after full recovery.[5] Another advantage is the less-invasive nature of ACL repair. No drill tunnels or graft harvesting is needed, so there is no donor-site morbidity, a known complication of ACL reconstruction that can often lead to persistent symptoms. In addition, the less-invasive nature of ACL repair surgery and preservation of native ACL tissue may decrease the risk of osteoarthritis.[17] This contrasts ACLR surgery, which does not reliably restore native kinematics, potentially increasing osteoarthritis risk, especially in the young.[17] This is especially problematic, as most patients undergoing reconstructive surgery are young, and studies have shown an incidence of osteoarthritis up to 78% at 14-year follow-up.[7] Furthermore, patients aged 18 to 25 years have a failure rate with ACL reconstruction of 15%.[18,19] In these high-risk young patients, ACL reconstruction failure can complicate revision surgery as the result of multiple factors, leading to potentially poorer outcomes. ACL repair failure poses fewer obstacles, facilitating smooth transition to primary reconstruction if needed.

Multiple different ACL repair surgical techniques are published.[20] Initial surgical techniques focused on repair of the ACL without suture augmentation, but recent studies have advocated augmenting the repaired ligament using suture tape.[21-26] Augmentation gives the repair construct a suture bridge that acts as a protective primary stabilizer that's especially important throughout early healing, resisting reinjury, and allowing for better early motion/mobilization.[21] Both animal and human biomechanical studies demonstrate that adding an internal brace to a repaired ACL is stronger.[13,21] Indeed, augmenting the ACL repair has been shown to have a greater mean load to failure, and some suggest that ACL repair with suture augmentation might completely restore the native ACL function.[22,24] Regarding the technique used in this article, DeFelice and van der List[18,19] first described using suture anchor for fixation of the repair and showed that it was a safe and effective treatment option for proximally based tears with good remnant tissue. A more recent technique published by Strassman et al.[27] mentions concern with using suture anchors for fixation of the repair, as they might interfere with ACL remnant healing by occupying space on the femoral wall. They now advocate for using a TightRope (Arthrex) with FiberRing sutures (Arthrex) and an internal brace for augmentation, citing the benefit to this technique is a knotless adjustable-loop device that is retensionable after ranging the knee.[27]

Clinically, multiple studies show low overall failure rates and good-to-excellent functional outcome scores.[14,25] Recently, a study by Douoguih et al.[25] reviewed the efficacy of ACL repair compared with conventional ACLR. In this study, they compared 30 patients who had suture-augmented ACL repair for proximal avulsion ACL tears or high-grade partial tears with 30 patients who underwent conventional ACLR. With a 2-year follow up, they reported no significant difference in the retear rate or the percentage of patients who met or exceeded the minimal clinically important different in outcomes measures between the

Table 2. Advantages and Disadvantages/Limitations of Technique

Advantages	Disadvantages/Limitations
1. Minimally Invasive (no drill tunnels)	1. Only select patients are indicated
2. Able to be performed on skeletally immature or mature patients (physeal sparing)	2. Long-term outcomes >5 years are still relatively unknown
3. Preserves proprioception by sparing native ACL	3. Concern regarding the femur suture anchor inhibiting some ACL remnant healing back to the bony origin
4. Short procedure (20-30 min)	
5. No graft harvesting (avoidance of autograft donor-site morbidity)	
6. Still allows for "primary" ACL reconstruction if repair fails	
7. Allows for earlier range of motion	

ACL, anterior cruciate ligament.

2 groups. Also, the ACL repair group reported significantly greater early patient-reported outcomes.[25] Wilson et al.,[13] in a recent systematic review of a total of 347 patients having undergone ACL repair with internal bracing, revealed a failure rate of 10.4% with 2.7 years of follow-up. Van der List et al.,[6] in a recent systematic review, reported failure rates after static augmentation as compared with nonaugmented repair and dynamic augmented repair as 7% versus 10% vs 11%, respectively. When reviewing the outcomes between younger and older patients treated with augmented ACL repair, younger patients (younger than 18 years) do have a greater rate of failure (17.4% vs 6.3%, respectively).[8] Even with gold standard ACL reconstruction, failure rates in young patients are also high (upwards to 15%).[28] Nonetheless, there is still much controversy regarding ACL repair in young athletes and more studies do need to be performed.

The main advantages of this technique are that it's minimally invasive and completely physeal sparing and thus is able to be performed in all age groups. The main limitations (Table 2) in this technique include limitations in ACL tear patters that allow repair using this technique, and the relatively unknown long term outcome results of patients undergoing this technique. In the correct patient, our surgical technique offers an efficient, minimally invasive, and physeal-sparing anatomic ACL repair with all-inside internal brace augmentation that, in the short term, has offered good results for our patients.

Disclosures

All authors (D.L.M., A.G.H., R.D.M., J.R.B.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank Robbie Miles for his involvement in the development of the rehabilitation protocol to be used for the patients undergoing this procedure.

References

1. Ferretti A. To heal or not to heal: The ACL dilemma. *J Orthop Traumatol* 2020;21:11.
2. DiFelice GS, Villegas C, Taylor S. Anterior cruciate ligament preservation: Early results of a novel arthroscopic technique for suture anchor primary anterior cruciate ligament repair. *Arthroscopy* 2015;31:2162-2171.
3. Ferretti A, Monaco E, Annibaldi A, et al. The healing potential of an acutely repaired ACL: A sequential MRI study. *J Orthop Traumatol* 2020;21:14.
4. Hoogeslag RAG, Brouwer RW, de Vries AJ, Boer BC. Huis In 't Veld R. Efficacy of nonaugmented, static augmented, and dynamic augmented suture repair of the ruptured anterior cruciate ligament: A systematic review of the literature. *Am J Sports Med* 2020;48:3626-3637.
5. Vermeijden HD, van der List JP, O'Brien R, DiFelice GS. Patients forget about their operated knee more following arthroscopic primary repair of the anterior cruciate ligament than following reconstruction. *Arthroscopy* 2020;36:797-804.
6. van der List JP, Vermeijden HD, Sierevelt IN, DiFelice GS, van Noort A, Kerkhoffs GMMJ. Arthroscopic primary repair of proximal anterior cruciate ligament tears seems safe but higher level of evidence is needed: A systematic review and meta-analysis of recent literature [Erratum in: *Knee Surg Sports Traumatol Arthrosc*. 2022;30:1123-1125]. *Knee Surg Sports Traumatol Arthrosc* 2020;28:1946-1957.
7. van der List JP. Arthroscopic primary repair of the anterior cruciate ligament: rationale, patient selection and early outcomes (PhD Academy Award). *Br J Sports Med* 2022;56:1053-1054.
8. 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.
9. Kaeding CC, Leger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med* 2017;36:1-8.
10. Musahl V, Karlsson J. Anterior cruciate ligament tear. *N Engl J Med* 2019;380:2341-2348.
11. 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.
12. Irfan A, Kerr S, Hopper G, Wilson W, Wilson L, Mackay G. A criterion based rehabilitation protocol for ACL repair with internal brace augmentation. *Int J Sports Phys Ther* 2021;16:870-878.
13. Wilson WT, Hopper GP, Banger MS, Blyth MJG, Riches PE, MacKay GM. Anterior cruciate ligament repair with internal brace augmentation: A systematic review. *Knee* 2022;35:192-200.
14. Hopper GP, Aithie JMS, Jenkins JM, Wilson WT, Mackay GM. Satisfactory patient-reported outcomes at 5 years following primary repair with suture tape augmentation for proximal anterior cruciate ligament tears. *Knee Surg Sports Traumatol Arthrosc* 2022;30:253-259.
15. Petersen W, Tillmann B. Structure and vascularization of the cruciate ligaments of the human knee joint. *Anat Embryol (Berl)* 1999;200:325-334.
16. Nguyen DT, Ramwadhdoebe TH, van der Hart CP, Blankevoort L, Tak PP, van Dijk CN. Intrinsic healing response of the human anterior cruciate ligament: An histological study of reattached ACL remnants. *J Orthop Res* 2014;32:296-301.
17. Murray MM, Fleming BC. Use of a bioactive scaffold to stimulate anterior cruciate ligament healing also minimizes posttraumatic osteoarthritis after surgery. *Am J Sports Med* 2013;41:1762-1770.
18. DiFelice GS, van der List JP. Arthroscopic primary repair of proximal anterior cruciate ligament tears. *Arthrosc Tech* 2016;5:e1057-e1061.

19. van der List JP, DiFelice GS. Preservation of the anterior cruciate ligament: Surgical techniques. *Am J Orthop (Belle Mead NJ)* 2016;45:E406-E414.
20. Robinson JD Jr, Williamson T, Carson T, Whelan RJ, Abelow SP, Gilmer BB. Primary anterior cruciate ligament repair: Current concepts. *J ISAKOS* 2023;8:456-466.
21. Mackay GM, Blyth MJ, Anthony I, Hopper GP, Ribbans WJ. A review of ligament augmentation with the InternalBrace™: The surgical principle is described for the lateral ankle ligament and ACL repair in particular, and a comprehensive review of other surgical applications and techniques is presented. *Surg Technol Int* 2015;26:239-255.
22. He J, Kanto R, Fayed AM, et al. Augmenting ACL repair with suture tape improves knee laxity: A biomechanical study. *Orthop J Sports Med* 2023;11:23259671221146013.
23. Bachmaier S, DiFelice GS, Sonnery-Cottet B, et al. Treatment of acute proximal anterior cruciate ligament tears—part 2: The role of internal bracing on gap formation and stabilization of repair techniques. *Orthop J Sports Med* 2020;8:2325967119897423.
24. Massey P, Parker D, McClary K, Robinson J, Barton RS, Solitro GF. Biomechanical comparison of anterior cruciate ligament repair with internal brace augmentation versus anterior cruciate ligament repair without augmentation. *Clin Biomech (Bristol, Avon)* 2020;77:105065.
25. Douoguih WA, Apseloff NA, Murray JC, Kelly RL, Svoboda SJ. Suture-augmented ACL repair for proximal avulsion or high-grade partial tears shows similar side-to-side difference and no clinical differences at 2 years versus conventional ACL reconstruction for near-complete and mid-substance tears or poor ACL tissue quality. *Arthroscopy* 2024;40:857-867.
26. Vermeijden HD, van der List JP, DiFelice GS. Arthroscopic primary repair of proximal anterior cruciate ligament tears with suture augmentation. *Video Journal of Sports Med* 2021;1(3).
27. Strassman AM, Stokes DJ, Sanchez RA, et al. Anterior cruciate ligament repair using a re-tensionable all-suture construct. *Arthrosc Tech* 2024;13:102890.
28. Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: A systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861-1876.