Technical Note

Primary Anterior Cruciate Ligament Single-Bundle Repair With Augmentation for a Partial Anterior Cruciate Ligament Tear

Aaron Michael Gipsman, M.D., Nicholas Trasolini, M.D., and George F. "Rick" Hatch III, M.D.

Abstract: Although anterior cruciate ligament (ACL) reconstruction remains the gold standard for the treatment of ACL tears, repair is regaining popularity as a treatment option for proximal or distal ACL avulsions. Historically, ACL repairs had poor outcomes. To remedy this, techniques were developed using graft-based augmentation but never gained widespread popularity. Recently, there has been a renewed interest in primary ligament repairs, with newer techniques incorporating modern synthetic materials to augment the repair site. The term "internal bracing," or ligament repair with augmentation, has been used to describe the new philosophy for primary ligament repair and augmentation. We present our technique for arthroscopic primary ACL repair with augmentation for a proximal posterolateral bundle tear. The advantages of this technique include preservation of the intact fibers of the anteromedial bundle, intuitive suture augmentation with standard ACL tunnel placement techniques, and the ability to calibrate ligament tension.

Single-bundle autograft anterior cruciate ligament (ACL) reconstruction is the current gold standard treatment for an ACL tears; however, there are associated morbidities and complications.[1-4] Research into the treatment of ACL injuries has focused on optimizing reconstructions with modifications in parameters such as graft choice and tunnel placement.[5] Reconstruction has remained the procedure of choice due to unsatisfactory historical results with primary ACL repair.[6] However, ACL repair has the potential to preserve ligament orientation, knee kinematics, and native proprioception.[7-9] New technical modifications could allow us to reach satisfactory biomechanics, making primary repair a viable option. There are reported strategies for improving ACL repair outcomes with graft augmentation, but this has not gained widespread use except in the form of remnant-preserving ACL reconstructions.[10-13] The advent of new, high tensile strength suture materials has created the potential for synthetic augmentation. ACL repair with suture-based augmentation has been described and is of increasing popularity.[14,15] We present our technique for arthroscopic primary repair of the native ACL with augmentation.

Surgical Technique

Figures 1-9 and Video 1 show all techniques. The patient is positioned supine on a radiolucent table to allow use of fluoroscopy. A tourniquet is applied high on the thigh. The patient is then prepped and draped in a standard sterile fashion. Standard inferolateral and inferomedial arthroscopic portals are made.

A diagnostic arthroscopy is performed. In this case, it shows a proximal rupture of the majority of the posterolateral bundle and the leading edge of the anteromedial bundle of the ACL. Distally the ACL is intact. In general, we reserve repair for proximal or distal avulsions with some ligament fibers in continuity. If diagnostic arthroscopy shows a mid-substance tear or

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

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Address correspondence to Aaron Michael Gipsman, M.D., Department of Orthopaedic Surgery, University of Southern California/Keck School of Medicine, 1520 San Pablo Street, Suite 2000, Los Angeles, CA 90033, U.S.A. E-mail: Aaron.Gipsman@med.usc.edu

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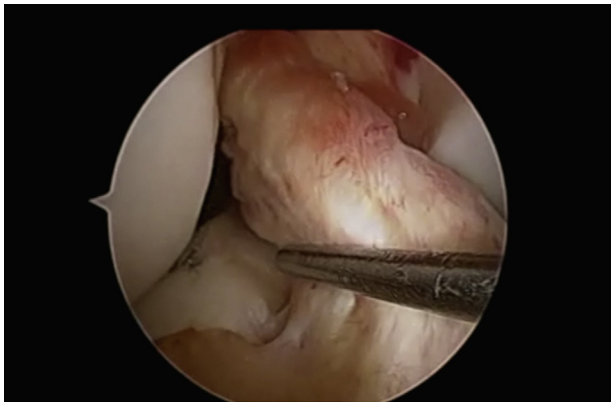

Fig 1. Anterolateral portal, 30° scope, right knee. ACL femoral avulsion with intact anteromedial bundle.

poor integrity of the native ligament, we proceed with reconstruction rather than repair.

Once the tear is identified, a passport cannula (Arthrex, Naples, FL) is placed in the medial portal while viewing through the lateral portal. A scorpion suture passer (Arthrex) is then used to pass 4 FiberLinks (Arthrex), each color-coded (2 blues, 2 whites, alternating), into the remnant ACL. The suture passer is aimed so the needle deploy toward the lateral femoral condyle. This will result in the sutures exiting the lateral aspect of the ligament. This allows for appropriate orientation of the ligament when repaired back native ACL origin off of the lateral aspect of the intercondylar notch. A locking stitch is easily created by the use of a FiberLink No. 2 suture (Arthrex). All passed sutures are then brought outside the cannula.

Preparing the Femoral Origin

The native posterolateral bundle origin is lightly debrided with a shaver, taking care not to injure the origin of the intact anteromedial bundle fibers or the native ligament. Gently pulling medial tension on the newly placed sutures within the native ACL stump can assist in exposing the ACL femoral footprint. Next, while viewing through the medial portal and instrumenting through the lateral portal with an ACL FlipCutter guide (Arthrex) set on approximately 110°, the guide is placed in the avulsed portion of the ACL where the fibers originated from. A small incision in the distal lateral thigh is then made through the skin and subcutaneous tissues, and underlying iliotibial band to drill with the FlipCutter. Of note, we use this to drill but do not flip the blade. A No. 2 fiberstick Fiberwire (Arthrex) is brought out of the lateral portal and is then used to shuttle a total of 2 color-coded FiberLoop stitches for transport.

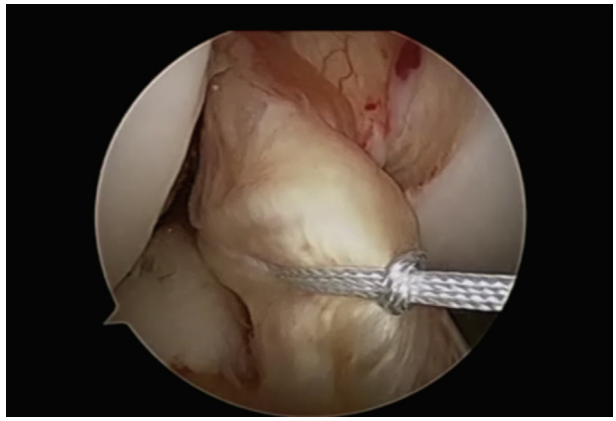

Fig 3. Anterolateral portal, 30° scope, right knee. Pass 4 FiberLinks (Arthrex, Naples, FL), 2 blue and 2 white, through ACL remnant.

Returning ACL to Its Origin

While viewing through the lateral portal, the sutures within the ACL stump (which have been sitting outside of the medial portal for storage) are brought back into the medial cannula and loaded into one of the color-coded femoral transport sutures (which had been stored outside of the lateral portal). The ACL stump sutures are then transported back into the knee and into the femoral tunnel. This puts tension back into the

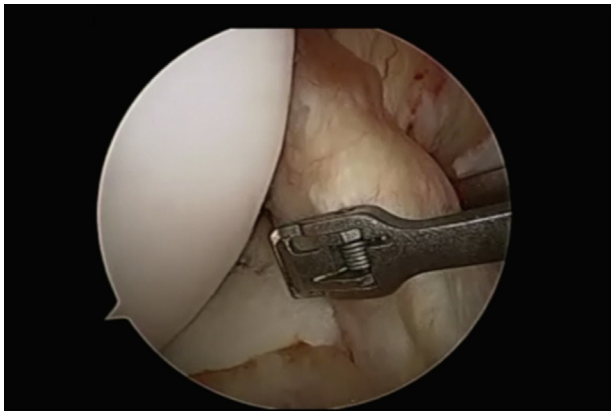

Fig 2. Anterolateral portal, 30° scope, right knee. Pass 4 FiberLinks (Arthrex, Naples, FL) 2 blue and 2 white, through ACL remnant.

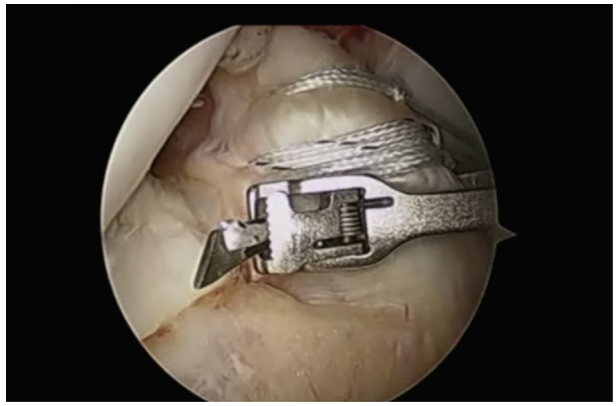

Fig 4. Anterolateral portal, 30° scope, right knee. Pass 4 FiberLinks (Arthrex, Naples, FL) 2 blue and 2 white, through ACL remnant.

Fig 5. Anterolateral portal, 30° scope, right knee. Femoral drill guide set to 110 degrees through the anterolateral portal. Position guide within avulsed femoral origin and then drill.

ACL, recreating the ACL contour, and returning the ACL back to its origin in the intercondylar notch.

Creating and Preparing the Tibial Tunnel

With the ACL back in place, an ACL tibial guide set at 55° to 60° is inserted at the ACL footprint. Using the Flipcutter without deploying it, the tibial tunnel is then drilled, taking care not to injure the body of the ACL. Next, a No. 2 fiberstick (Arthrex) is passed through this tunnel to bring in a passing suture.

Augmentation of the Primary Repair

A No. 2 FiberTape is looped and passed up into the femoral tunnel through the second color-coded FiberLink passing suture passed into the tibial tunnel using the tibial transport suture.

Securing the Construct

On the femur, the looped end of the No. 2 FiberTape is secured by looping it over an ABS Dog Bone fixation device (Arthrex). The repair sutures (the 4 color-coded No. 2 FiberLinks) from the ACL stump are then organized by color on the opposite sides of the button to eventually be tied down to each other (blue to blue, white to white). The Dog Bone is then placed on the femur while holding the sutures in place and the knee is cycled for 30 repetitions of flexion and extension for preconditioning.

The knee is placed in 20° degrees of flexion with a posterior drawer. The ACL stump sutures are then tied down in a total of 2 separate knots over the button (blues to blues, whites to whites). Next, the knee is cycled again for 30 more repetitions. The knee is then placed in near full extension with a gentle posterior drawer, whereas the tibial portions of the augmentation sutures are secured in a SwiveLock suture anchor, just distal to the tibial tunnel orifice. Care is taken not to over tension the augmentation sutures as it is meant to merely reinforce the ACL primary repair. The ACL repair with augmentation is now complete and spans the entire distance of the ligament (Figs 10 and 11).

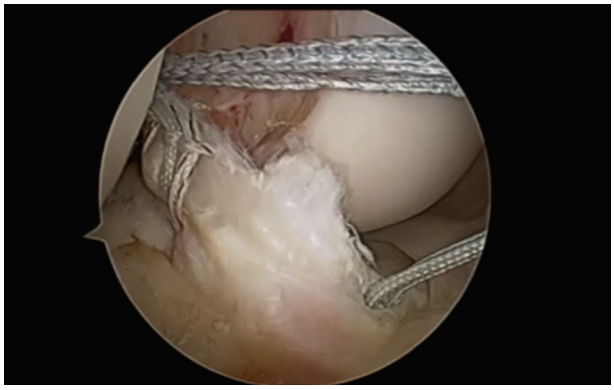

Fig 7. Anterolateral portal, 30° scope, right knee. Pass looped FiberTape (Arthrex, Naples, FL) into the femoral tunnel using a passing suture.

Fig 6. Anterolateral portal, 30° scope, right knee. Position tibial drill guide within the center of the footprint, set on 55 degrees. Do not deploy flipcutter to avoid damage to native fibers.

Fig 8. Anterolateral portal, 30° scope, right knee. Pass looped FiberTape (Arthrex, Naples, FL) into the tibial tunnel using a passing suture.

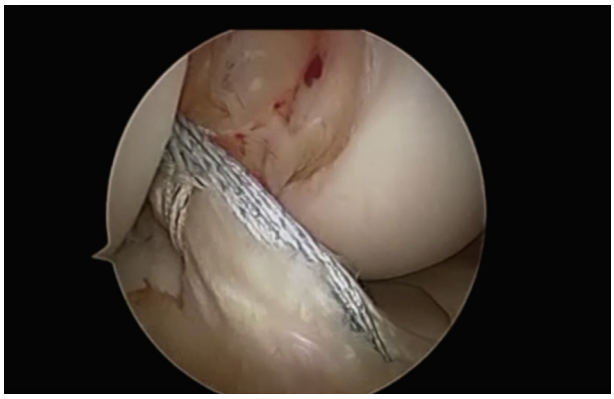

Fig 9. Anterolateral portal, 30° scope, right knee. Tension repair and augmentation to desired tension. Cycle knee, and then tie sutures over button on femoral side with knee in full extension and a slight posterior drawer. Then, use a suture anchor for tibial side.

Rehabilitation

The rehabilitation protocol uses no brace or crutches and attempts facilitate return to activity as quickly and safely as possible. During the first postoperative week, we allow full weight bearing as tolerated and full range of motion with the goal of maintaining full passive extension. During the second week, we begin formal physical therapy with quadriceps isometrics, straight leg raises, active flexion, and active-assisted extension exercises. We allow return to work at this time for desk jobs or light duty. During the third and fourth weeks, we progress to strengthening with quad sets, straight leg raises, partial squats, toe raises, stationary bike, elliptical machine, leg presses, and leg curls. We also have a goal of flexion to 120° by this point. In the 4- to 6-week span, we continue strengthening and progress to balance exercises. Starting at week 12, we introduce jogging as well as light running and agility drills. Finally, we allow return to sport at 24 weeks if quadriceps and hamstring strength is at least 80% of the

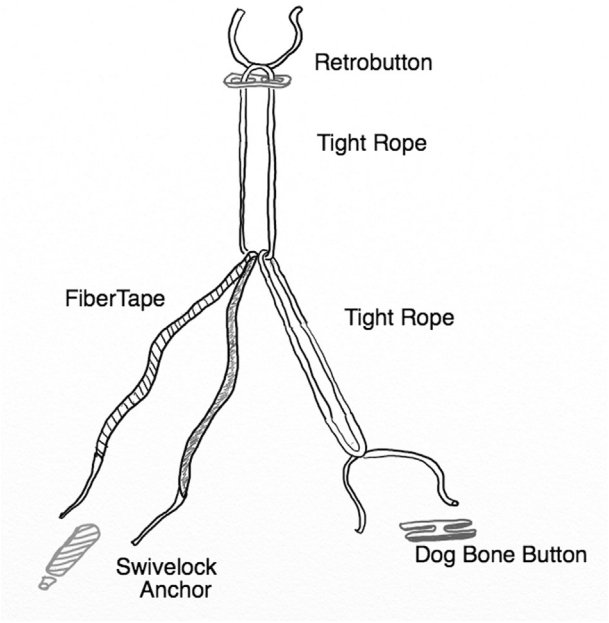

Fig 10. Diagram of the augmentation construct.

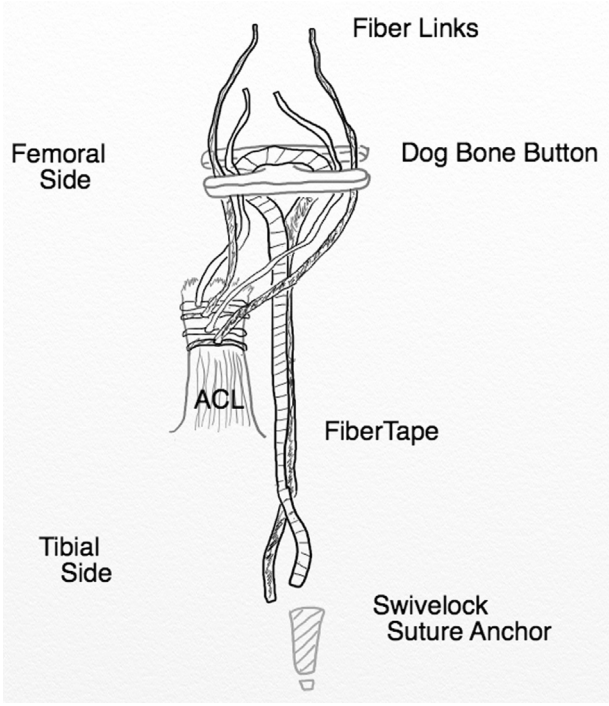

Fig 11. Diagram of the primary repair incorporated with the augmentation construct. (ACL, anterior cruciate ligament.)

Table 1. Advantages and Disadvantages of ACL Primary Repair With Augmentation

Advantages	Disadvantages
• Less morbidity, revision not as complicated if necessary • Protects against ligament strain or elongation during healing • Nondestructive to native ACL fibers • Can be performed in conjunction with multiligamentous reconstruction • Allows for earlier rehabilitation, ROM, and mobilization[19] • Native ACL has mechanoreceptors and feedback mechanisms important for knee proprioception and quad control[16] • Allografts and autografts have much less mechanoreceptor ability as compared with native[16]	• More technically demanding • Lack of long-term clinical outcome data • Relies on the mechanical properties of remnant ACL fibers that may be compromised from the initial injury

ACL, anterior cruciate ligament; ROM, range of motion.

Table 2. Pearls and Pitfalls of ACL Primary Repair With Augmentation

Pearls	Pitfalls
• Pass sutures through the ACL with the suture passer from medial to lateral • Color-code sutures • Cannula in the medial portal to prevent formation of suture bridges • Store sutures outside of the cannula until ready to use them • Drill without deploying Flipcutter to avoid damage to native ACL fibers • Pass sutures in ACL up the femoral tunnel and apply gentle tension before drilling the tibial tunnel for internal brace • Pass the looped end of the augmentation suture up the femoral side first and the tails through the tibial side second	• Potential to overtension • Risk of damaging native fibers • Risk of drilling out the remnant ACL

ACL, anterior cruciate ligament.

normal leg, there is full motion, no swelling, good stability, and the patient is able to complete a running program.

Discussion

Single-bundle autograft ACL reconstruction is the current gold standard treatment for an ACL tear, but ACL repair may have the potential to improve outcomes in a select group of patients. Primary repair of the native ligament, with or without augmenting, allows for a less invasive approach while preserving the native anatomy and biology. The biologic benefit was shown by a prospective comparative study by Young et al.[16] that evaluated mechanoreceptor reinnervation. In that study, biopsies were taken and stained for neurofilament protein (NFP) and compared with the native ACL. There was no difference in NFP analogs when comparing autograft with allograft, but there was a significant decrease in NFP in autograft and allograft compared with native ACL tissue, implying improved proprioception with native tissue.

Arthroscopic primary ACL repair was recently repopularized by DiFelice et al.[17] in 2015. The authors reported promising early short-term results (minimum 2-year follow-up) with primary ACL repair in a small group (n = 11) of carefully selected patients with proximal ACL avulsions and good quality tissue. Achtnich et al.[18] compared primary ACL repair with suture anchor to single-bundle ACL reconstruction. They had a failure rate in the primary repair group of 15% compared with 0% in the reconstruction group; however, this was not statistically significant. They found no significant differences in Lachman testing, pivot shift testing, objective International Knee Documentation Committee score, and KT-1000 scores. Both DiFelice and Achtnich used suture anchors for the femoral fixation. Augmentation provides biomechanical protection to reduce tension on healing ligamentous tissue. In 2016, MacKay et al.[14] described a technique for ACL repair with internal brace augmentation (Arthrex), and Smith et al.[15] modified the MacKay et al. technique in the pediatric population, using an all-epiphyseal approach in the same year.

Our technique differs from that of MacKay et al in the fixation of the femoral-sided sutures. MacKay et al. use a tightrope fixation on the femoral side, whereas our technique employs suspensory fixation, which secures the femoral side with an ABS Dog Bone button. In addition, the augmentation construct (FiberTape) is looped over the Dog Bone, and the FiberLinks are then tied on top of it independently. This has an added benefit that if either the loop or the tape fails, the other remains intact. Refer to Table 1 for the advantages and disadvantages, and Table 2 for the pearls and pitfalls of ACL repair with suture augmentation.

Video 1 is a narrated step-by-step guide to our arthroscopic technique for ACL repair with suture augmentation. The whole video is from the same case in a right knee. The viewing portal is indicated in the top-left corner throughout.

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