Technical Note

Suture Pullout Technique of Acute Anterior Cruciate Ligament Femoral Avulsion Repair

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Abstract: It was in the early 1900s that anterior cruciate ligament (ACL) repair was first described with its resurgence in the mid-1900s. It however failed to gain popularity because of unsatisfactory early outcomes as a result of poorly selected patients. We describe a suture pullout technique of acute ACL repair in a carefully selected cohort of patients. Healing capabilities similar to that of the proximal medial collateral ligament have been shown in the proximal ACL avulsions. Adding microfracture of the lateral wall of the notch further enhances the healing environment by countering the synovial fluid environment. Acute ACL repair when performed in a carefully selected patient leads to good results and saves the patient of a reconstruction procedure.

Anterior cruciate ligament (ACL) repair has been established as a method of treating ACL injuries since the early 1900s.[1,2] It however gained significant popularity in the mid-1900s in the works of O'Donoghue et al.,[3] Feagin and Curl,[4] and Marshall et al.[5] With not too promising mid-term results in spite of initial good outcomes, these techniques went into disregard.[6] Sherman et al.[7] classified the ACL tear type and suggested that ACL repair should only be performed in type 1, proximal avulsion tears. We describe a suture pullout technique of proximal ACL avulsion repair.

Operative Technique

Isolated ACL femoral avulsions (type 1), confirmed on magnetic resonance imaging, presenting in the acute stage (<2 weeks) are treated with arthroscopic ACL repair using our suture pullout technique (Video 1).

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Setup and Patient Positioning

We perform all the surgeries under spinal anesthesia with the patient supine and leg flexed to 90° on the operation table. All cases are operated by the same team of surgeons.

Diagnostic Arthroscopy

Diagnostic arthroscopy is performed using the standard anterolateral and anteromedial (AM) portals. ACL femoral avulsion is confirmed (Fig 1, Video 1). The joint is assessed for any chondral changes and associated meniscus tear.

Preparation of the ACL Stump

A transpatellar tendon portal is established and a cannula placed (Fig 2, Video 1). Two nonabsorbable high-strength sutures of different colors are used to weave the 2 bundles of the remnant ACL using a SutureLasso (ACCU PASS, Smith & Nephew, Andover, MA) (Fig 3, Video 1). Two to three passes are made before the final exit from the avulsed end to create a locking Bunnell-type pattern (Fig 4, Video 1). The sutures are parked in the transpatellar tendon portal.

Preparation of the Femoral Footprint

Standard bony landmarks are used to identify the femoral footprint. The ACL bed is shaved and multiple microfractures are created around the ACL footprint using a microfracture awl. It is hypothesized that the microfractures would release stem cells to enhance the healing process. With knee flexed to approximately 100° to 110° of flexion, a 2.4-mm guidewire is passed

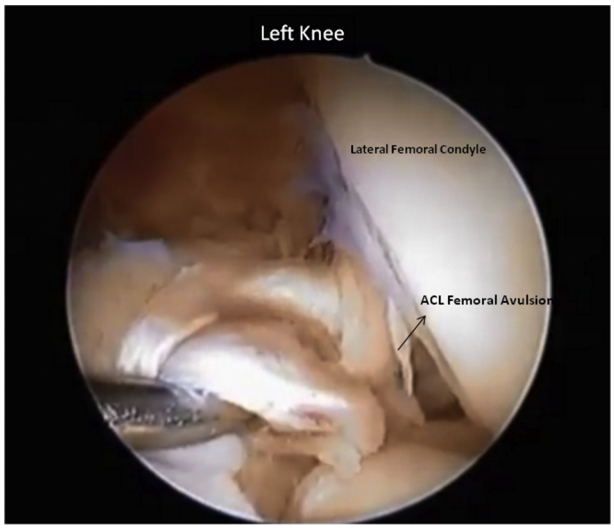

Fig 1. Proximal ACL avulsion in a left knee confirmed on arthroscopy viewing from the standard anterolateral portal with the knee in 90° flexion on the table. (ACL, anterior cruciate ligament.)

through the footprint from the AM portal. The guidewire is over-reamed with a 7-mm reamer from outside in to prevent any damage to the remnant ACL tissue by the reamer (Fig 5, Video 1).

Shuttling of Sutures

The ACL stump sutures are shuttled out from the femoral tunnel using a stainless steel wire loop (Fig 6, Video 1) passed through the reamer while still in situ. The 7-mm tunnel allows a few fibers of the ACL to enter the tunnel. This is hypothesized to allow better healing than would have been achieved by surface healing.

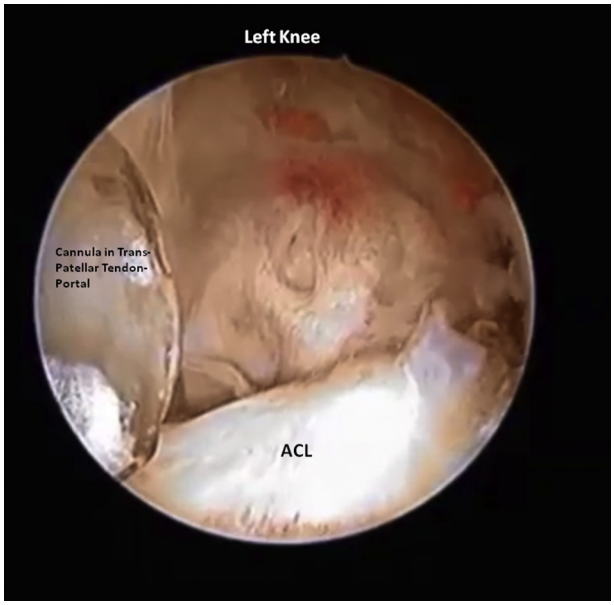

Fig 2. Transpatellar tendon portal established and cannula placed for suture management while maintaining the standard anterolateral portal as the viewing portal in the left knee. (ACL, anterior cruciate ligament.)

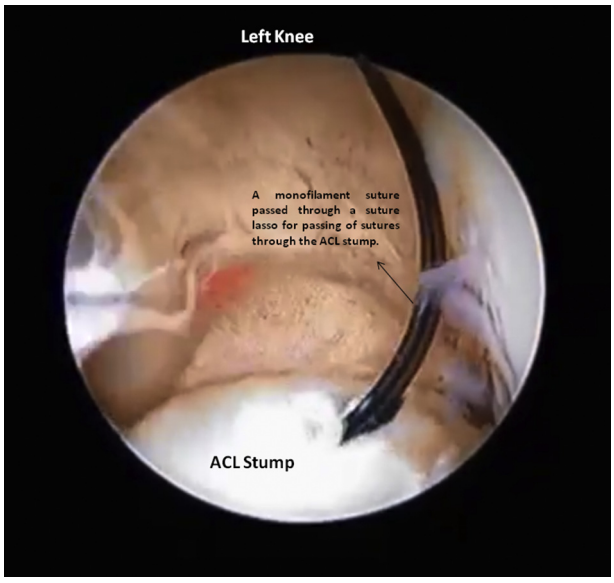

Fig 3. SutureLasso from the anteromedial portal used to pass sutures through the ACL stump, maintaining the left knee in 90° flexion. (ACL, anterior cruciate ligament.)

Final Fixation

A suture button (Suture Washer, Hib Surgicals, Mumbai, India) is used for final tying of the sutures on

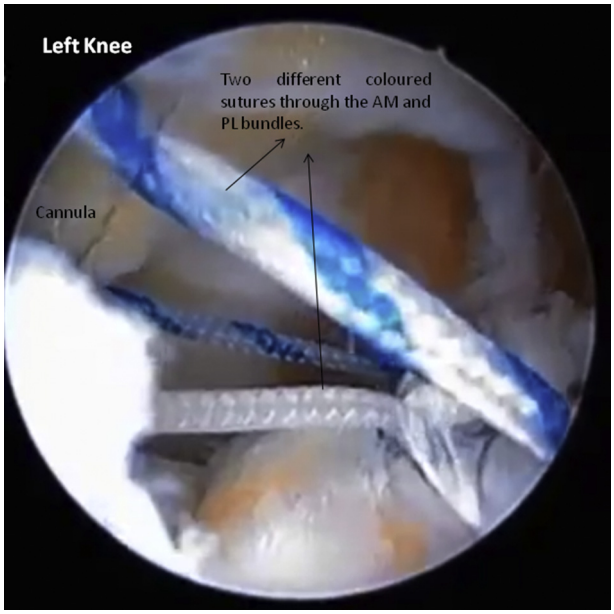

Fig 4. Two differently colored sutures passed through the 2 anterior cruciate ligament bundles to allow complete repair and differential tightening of the 2 bundles. The anterolateral portal is still being used for viewing and the standard anteromedial and transpatellar tendon portal as working portals in the left knee. (AM, anteromedial; PL, posterolateral.)

Fig 5. A 7-mm reamer being used to drill an outside-in femoral tunnel over a 2.4-mm guide pin passed from the anteromedial tunnel through the ACL femoral footprint of the left knee. The tunnel is reamed outside in to prevent damage to the ACL fibers while reaming inside out. (ACL, anterior cruciate ligament.)

the lateral femoral cortex (Fig 7, Video 1). The sutures through the AM bundle are tied with the knee in 30° of flexion, and the sutures through the posterolateral bundle with the knee in full extension. A negative Lachman and Pivot are confirmed on the table. The final tautness of the ACL is rechecked using a probe (Fig 8, Video 1).

Postoperative Rehabilitation

For 3 to 4 weeks, we advise the use of an extension knee brace. Intermittent ice packs are advised from the immediate postoperative period to control swelling and pain. The range of motion is restricted to 90° in the first month; however, full weight bearing is allowed as per

Fig 6. Stainless steel wire loop passed through the reamer from outside and pulled out from the transpatellar tendon portal in the left knee that had the sutures parked to shuttle the sutures out from the femoral tunnel.

Fig 7. Sutures tied on the lateral femoral cortex over a suture button with the left knee in 30° flexion for the AM bundle and in full extension for the PL bundle ensuring differential tightening of the 2 bundles. (AM, anteromedial; PL, posterolateral.)

pain tolerance. Active quadriceps exercises are advised along with straight leg raise. Sutures are removed at 2 weeks. The brace is weaned at 4 to 6 weeks postoperatively, and the patients are put on a standard ACL rehabilitation protocol with the aim of returning to sports at 6 months.

Discussion

Primary ACL repair is not a new concept. However, it is not a very commonly performed procedure citing the poor outcomes in previous literature. Also, very rarely does the patient present in the acute stage. Studies have suggested previously that the arthroscopic repair may reduce the need for later reconstructions, thus cutting

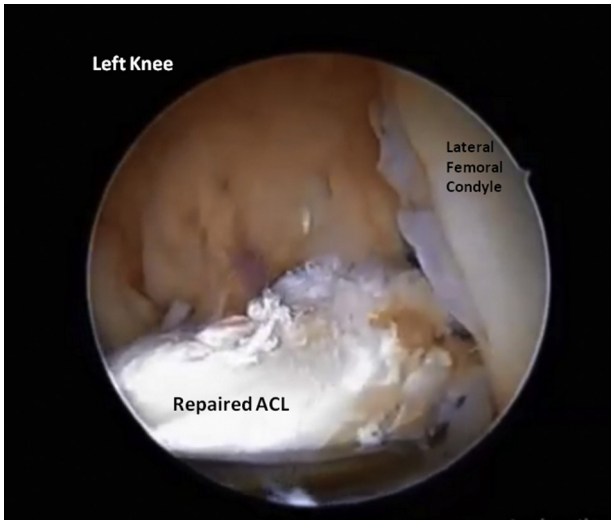

Fig 8. Final tautness of ligament checked with a probe viewing from the anterolateral portal in the left knee. (ACL, anterior cruciate ligament.)

Table 1. Pearls and Pitfalls of Our Proximal ACL Avulsion Repair Technique

Pearls	Pitfalls
1. Preserves the natural ACL 2. Microfracture of the lateral wall of the notch stimulates and enhances the healing response 3. Drilling of the femoral tunnel allows better integration of the repair 4. Outside-in tunnel prevents further damage to the avulsed ACL stump 5. Using separate sutures for the AM and PL bundles allows their differential tightening	1. Transpatellar tendon portal may cause patellar tendinitis and Hoffa's fat pad inflammation 2. Pulling both the sutures from the same tunnel effectively reduces the femoral footprint and may affect the differential function of the 2 bundles

ACL, anterior cruciate ligament; AM, anteromedial; PL, posterolateral.

down on patient morbidity, provided the cases were selected carefully to produce good results.[8]

Sherman and Bonamo[9] asserted that many authors along with Feagin and Curl[4] did not take into consideration factors such as type of tear and quality of tissue that could have affected the outcome, thereby condemning their poor outcomes of ACL repair. Selection of the tear pattern rather than the technique was responsible for the high failure rates in the previous studies.[7,8,10,11]

ACL repair has shown better outcomes in terms of secondary osteoarthritis when compared with ACL reconstruction.[12]

The healing potential of proximal ACL avulsion is similar to that of the proximal medial collateral ligament. Primary repair brings the stump to the bleeding bone bed at the femoral footprint, thus optimizing the healing potential and countering effects of the synovial fluid environment.[13] Reaming of the femoral tunnel and creation of microfractures further enhanced the healing potential.

Time since injury is another important factor affecting outcomes in ACL repair. Resorption of the avulsed stump has been shown to occur as early as 2 weeks affecting the results of repair.[3] Repairing in the acute stage is thus crucial for a good outcome.

Table 2. Advantages and Disadvantages of Proximal ACL Avulsion Repair

Advantages	Disadvantages
1. Preserves the hamstrings for any future ligament reconstruction if required 2. Preserves the natural ligament along with its proprioceptors and vascular supply allowing better restoration of knee biomechanics	1. Healing may be variable depending on time since injury and intensity of trauma 2. If ACL fails to heal, it may require a ligament reconstruction at a later date

ACL, anterior cruciate ligament.

To ensure maximal purchase of the ACL fibers and a stronger repair, the 2 bundles were individually stitched with 2 separate sutures.

Acute femoral ACL avulsion repair allows preservation of the native ligament with its native proprioceptors and vascular supply. It is postulated that this would allow better restoration of the knee biomechanics as against an ACL reconstruction. This is further supplemented by having maintained the natural tibial attachment. Repairing the ACL also preserves the patient's hamstrings for any future ACL injury necessitating a reconstruction (Table 1).

Proximal ACL avulsion repair must however be restricted to type 1 tears without any interstitial ligament injury. Also this technique is indicated only for acute tears and must not be used for tears more than 2 weeks old. This technique may not be appropriate when the ACL stump has adhered to the PCL (Table 2).

The credibility of this technique is limited by the absence of a comparison with ACL reconstruction in such patients. We do not have any follow-up arthroscopy to ascertain the healing status at the repair site.

Conclusions

In a carefully selected patient cohort, ACL repair in the acute stage gives good results and saves the patient of a reconstruction procedure. The suture pullout technique allows better incorporation of the ACL fibers into the tunnel producing a stronger repair.

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