Primary Repair of Tibial-Sided Avulsion of the Anterior Cruciate Ligament


Abstract: Lesions of the anterior cruciate ligament (ACL) are common; the current gold standard of treatment for such lesions is ACL reconstruction. Tibial-sided soft-tissue avulsion is a rare subtype of ACL injuries. Unlike femoral-sided ACL repair, surgery for acute tibial-sided ACL ruptures has been neither reported nor described. This technical note presents a method for primary anatomic ACL reinsertion for an acute distal soft-tissue avulsion—type ACL injury, using a transosseous pull-out repair technique. Our technique, as an alternative to reconstruction, has the potential to enhance healing due to marrow stimulation (tibial tunneling). It also preserves the native insertion site and proprioceptive function, which may, in turn, reduce the risk of post-traumatic osteoarthritis.

Lesions of the anterior cruciate ligament (ACL) are common, and surgical procedures are advocated to avoid instability, secondary lesions, and early degenerative changes of the injured knee. The age- and sex-adjusted annual incidence is estimated to be 68.6 per 100,000 person-years. ACL reconstruction remains the current gold standard of care for these injuries. Reconstruction, rather than repair, is recommended because the intrinsic healing potential of the ACL is low compared with other knee ligaments. However, reconstruction may not restore the normal joint mechanics, may require tissue harvest from the knee (autograft), and most importantly, is unable to slow the premature onset of osteoarthritis. Recent advances in tissue engineering and regenerative medicine have resulted in a renewed interest in ACL repair.

The ACL rupture site can be classified as proximal, midsubstance, distal, or functional. A tibial-sided soft-tissue avulsion of the ACL is a rare and challenging condition. Unlike femoral-sided ACL repair, surgery for acute tibial-sided ACL ruptures has been neither reported nor described. This technical note presents a method for primary anatomic ACL reinsertion for an acute distal soft-tissue avulsion—type ACL injury, using a transosseous pull-out repair technique.

Surgical Technique

We recommend this technique for patients with acute tibial-sided ACL ruptures. Ideally, the synovial cover is intact and one or both ACL bundles are avulsed from the tibial footprint, with no bony injury (Fig 1A). The technique described is not for intra-substance or femoral attachment ruptures. The technique for this repair is described in the Video 1 accompanying this text.

Diagnostic Arthroscopy

The patient is prepared and draped in a supine position. A tourniquet is used, if not clinically contraindicated, to improve visibility in such cases with acute injuries. Initially, the arthroscopic sheath is inserted in the joint, and a thorough wash is given to remove hematoma (expected in an acute ACL injury). Diagnostic arthroscopy is then performed using a high anterolateral portal. The ACL is thoroughly examined at all flexion angles to determine the exact pattern and site of injury and to verify if it is amenable for reinsertion. Reinsertion is possible in acute distal (soft-tissue avulsion—type) ACL ruptures. A central transpatellar tendon portal is also created (Fig 1B and...
Fig 1. Diagnostic arthroscopy for acute distal soft-tissue avulsion–type ACL injury. (A) Left knee, anterolateral portal view, knee in 90° of flexion. (B) Left knee, central portal view, knee in extension. (C) Left knee, portals as seen from outside, knee in 90° flexion. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle.)

Fig 2. PL bundle suture: left knee, central portal view, knee in 90° of flexion. (A) Accu-pass Suture Shuttle (Left 45° Curve) through PL bundle (anterolateral working portal). (B) No. 2 TigerWire shuttled through PL bundle. (AM, anteromedial; LFC, lateral femoral condyle; MFC, medial femoral condyle; PL, posterolateral.)
C). It is used to reassess the ACL injury and is the principal viewing portal during the repair. All other intra-articular structures are assessed and need to be treated as deemed appropriate.

**Bundle Sutures**

Two nonabsorbable ultra-high molecular weight polyethylene sutures are used to stitch through the ACL bundles. First, employing the lateral portal, a suture passer (Accu-pass Suture Shuttle, Left 45° Curve; Smith & Nephew, Memphis, TN) is used to take a bite through the posterolateral bundle (Fig 2A). The loop-stitch (No. 2 TigerWire; Arthrex) taken (Fig 2B) is temporarily passed outside the lateral portal using an arthroscopic grasper (KingFisher Retriever/Grasper; Arthrex). Similarly, another suture (No. 2 Orthocord; DePuy Mitek, Raynham, MA) can be passed through the anteromedial bundle, using the medial working portal (Fig 3 A and B). These maneuvers can be repeated until a good hold of the ACL fibers is ensured. Parts of the Hoffa fat pad in the anterior part of the knee and around working portals can be pruned to avoid soft-tissue interposition during suture passage. For the same reason, after the loop-stitches are taken, we recommend pulling out all free ultra-high molecular weight polyethylene suture ends through the medial portal.

**Tibial Footprint Tunnels**

Two sockets are created at the tibial footprint using an elbow-aiming ACL tibial tunnel guide (Acufex Director Elbow Aimer; Smith & Nephew). They are positioned overlying the native bundle attachment sites, at the anteromedial and anterolateral edges of the tibial footprint, to ensure adequate coverage after repair. The 2 tunnels must be parallel to each other and at least 5 mm apart to ensure strength of fixation (Fig 4 A and B).
B). A 4.5-mm cannulated drill bit is used to enlarge the tunnels.

Ultra-high molecular weight polyethylene sutures passed through the distal ACL bundles are threaded individually through a loop (Nitinol wire loop; Arthrex), and passed down the tunnels. Sutures from the anteromedial bundle are shuttled through the medial transtibial bone tunnel, whereas sutures from the posterolateral bundle are pulled through the lateral tunnel (Fig 5). Finally, both sutures are manually tensioned and tied over on a bone bridge or to a surgical fixation post (6.5-mm solid cancellous screw with washer) over the anteromedial tibial cortex (Figs 6 and 7).

The following radiologic images are of a representative case with the surgical fixation over a cancellous screw. The preoperative x-rays were “normal” (Fig 8A). The magnetic resonance images indicated a tibial-sided peel-off tear and medial collateral ligament injury (Fig 8B). The patient underwent primary anatomic ACL reinsertion and medial collateral ligament augmentation (Fig 9A). The 6-month follow-up magnetic resonance imaging shows a well-healed ACL (Fig 9B).

**Postoperative Treatment**

A long-knee extension brace is applied for the first 4 weeks. Weight bearing is allowed as tolerated. Isometric muscle activation can be started on the first postoperative day. After 4 weeks, knee range-of-motion exercises are started. Full knee extension and
up to 120° flexion can be achieved during weeks 4 to 6. At about 6 weeks of postsurgery, closed-chain exercises in a hinged knee brace are advocated under guidance. Patients are allowed to be brace-free at weeks 10 to 12, and proprioceptive and neuromuscular training is begun. Nonpivot sports are allowed at 3 months postoperatively. Contact and pivot sports may be allowed as early as 6 months postoperatively, after confirmation of ACL healing.

Discussion

Distal soft-tissue avulsion—type ACL injuries are rare. Though there are reports available describing acute proximal ACL tear repairs, distal soft-tissue avulsions have seldom been the subject of discussion. Ahn et al. reported refixation of a “tibial peel-off tear” of ACL with pull-out sutures, but the case presented had a 10-month-old ACL injury. We believe that the timing of ACL repair surgery is an important consideration, and repairs must be carried out as early as possible to increase the chances of healing.

Arthroscopic loop-stitch and transosseous pull-out repair is an option to treat a specific subtype of ACL injuries (acute tibial-sided soft-tissue avulsion) with primary repair. Preservation of the patient’s original ACL is the greatest advantage of this technique. Successful ACL repair can theoretically provide the patient with multiple advantages over surgical reconstruction, including preservation of proprioception.

Although poor outcomes and high failure rates have been reported for primary ACL repairs, most of these studies have focused on midsubstance and proximal tear repairs.

Healing rates at proximal and distal ends of the ACL stump may be different, because of a difference in vascularity at both ends. Drilling of tibial tunnels to pull out the loop-stitches, in effect, delivers stem cells and growth factors to the site of injury and might be a way

Fig 8. Preoperative images of a representative patient. (A) “Normal” anteroposterior x-ray of the knee joint ruling out a bony avulsion injury. (B) Sagittal T1-weighted magnetic resonance image reveals a distal anterior cruciate ligament peel-off tear from the tibia.

Fig 9. Postoperative images of the same case at the 6-month follow-up. (A) Anteroposterior view shows the healed tunnels with the cancellous screw in place. Solitary staple is evidence of medial collateral ligament augmentation. (B) Sagittal magnetic resonance image shows a well-healing anterior cruciate ligament and the trail of sutures through the tibial tunnels.
to stimulate the healing process. Because there are no reports or studies describing repairs in tibial-sided soft-tissue ACL avulsions, a comparison or an outcome analysis is difficult. Further, the rehabilitation protocol may affect the rate of healing, and studies are needed to elucidate the optimal postoperative treatment.

In summary, we report our primary anatomic ACL repair technique for acute distal soft-tissue avulsion-type ACL injuries. It preserves the native insertion site and proprioception and has the potential to enhance the healing process because of tibial tunneling. This may ensure more normal joint mechanics and decreased risk of post-traumatic osteoarthritis. Table 1 shows the management of a tibial-sided ACL repair in brief.

### References


### Table 1. Management of Tibial-Sided ACL Repair

<table>
<thead>
<tr>
<th><strong>Indications</strong></th>
<th><strong>Contraindications</strong></th>
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<tr>
<td>• Acute ACL soft-tissue avulsion from tibial footprint (distal fibers)</td>
<td>• Chronic ACL tear</td>
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<td>• Acute partial ACL “peel-off” tear (isolated anteromedial/posterolateral bundle injury)</td>
<td>• Midsubstance ACL injury</td>
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<td>• Adequate tissue quality to hold sutures</td>
<td>• Bony tibial ACL avulsion</td>
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<td>• Early-stage surgery ensures that ACL fibers can be easily mobilized to their footprint.</td>
<td>• Femoral ACL avulsion</td>
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<td>• ACL preservation is better than reconstruction</td>
<td>• Disadvantages/Risks</td>
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<tr>
<td>• Normal kinematics of the native knee are preserved</td>
<td>• If the loop-stitches are not taken close to the tibial footprint, on reinserion the ACL fibers may be overstretched</td>
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<td><strong>Pearls</strong></td>
<td>• Success rates cannot be evaluated because of the rare injury pattern</td>
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<td>• Start arthroscopy with a complete washout of the intra-articular hematoma.</td>
<td>• Pitfalls</td>
</tr>
<tr>
<td>• View the tibial footprint from a central transpatellar tendon portal.</td>
<td>• The blood and nerve supply to the ACL may be compromised due to the loop-stitches.</td>
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<td>• Guidewires must be placed at the anterior edge of the tibial footprint to ensure anatomic and stable re-fixation.</td>
<td>• Loop-stitches may cut through the ACL bundles, if they are taken only through the synovial cover.</td>
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<td>• Remove parts of the fat pad around all working portals and pull out free ends of all the ultra-high molecular weight sutures together, to avoid soft-tissue bridges.</td>
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<td>• Perform posterior drawer when reducing the ligament and tying the sutures to a post.</td>
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**ACL**: anterior cruciate ligament.