Technical Note

Arthroscopic Synthetic Augmentation in Acute Partial Injury of the Anterior Cruciate Ligament

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Abstract: Acute partial injury of the anterior cruciate ligament (ACL) is a challenging condition without a standard treatment. Although ACL reconstruction provided a better outcome previously, recent studies have shown that preserving the ACL stump yields promising results in terms of better vascularization, proprioception, and ligamentization. ACL augmentation is becoming more popular. Therefore, we propose a technique to augment an acute partial ACL injury with synthetic suture material to stabilize the unstable cruciate ligament. The suture material acts as a structural tie for ACL healing without any need for external immobilization. This technique is beneficial in preserving the natural ACL stump and autograft, creating a narrow bone tunnel, and providing a good cosmetic outcome.

Although not as common as a complete rupture of the anterior cruciate ligament (ACL), an acute partial tear of the ACL is a substantial injury accounting for nearly 50% of all torn ligaments.[1] There is no consensus on the treatment plan yet, and various options have been described, ranging from conservative treatment[2-4] or preservation of the ACL stump and augmentation of only the torn bundle[5-7] to complete sacrifice of the ACL stump and reconstruction of the ACL with a graft.[8,9] In the previous literature, ACL reconstruction was preferable because of promising better results than ACL repair.[10,11] Nowadays, with better knowledge of the remaining fibers providing biomechanical, vascular, and proprioceptive advantages for patients, the principle of ACL stump preservation is becoming more favorable.[12] We propose a technique to augment the ACL injury with synthetic suture material while preserving the ACL stump. This technique provides internal splinting with the suture material acting as a structural tie to promote healing of the injured ACL bundle.

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Surgical Technique

Indications

The described technique is indicated for patients with acute partial ACL injuries, especially those with an isolated anteromedial or posterolateral bundle tear. Preoperative magnetic resonance imaging is essential to evaluate the severity of the injuries (Fig 1). If a highly damaged ACL is detected from the arthroscopic view, the surgeon should consider ACL reconstruction. The recommendation for the proper and optimal timing of surgery is when the patient's joint shows a decrease in swelling and gain in range of motion. However, no more than a 2-month period after the injury is advised.

Positioning

Once anesthetized, the patient is placed in the supine position with the surgeon sitting ipsilaterally. The patient's affected leg is held away from the operating table and positioned on the surgeon's thighs. The affected knee is then positioned at a 45° to 90° angle, which allows easy manipulation by the surgeon and his or her assistant (Fig 2). Unless clinically contraindicated, a tourniquet is applied proximal to the knee.

Portal Placement

A general arthroscopic examination is routinely carried out through the anterolateral portal. From the anterolateral viewing portal, some parts of the ACL

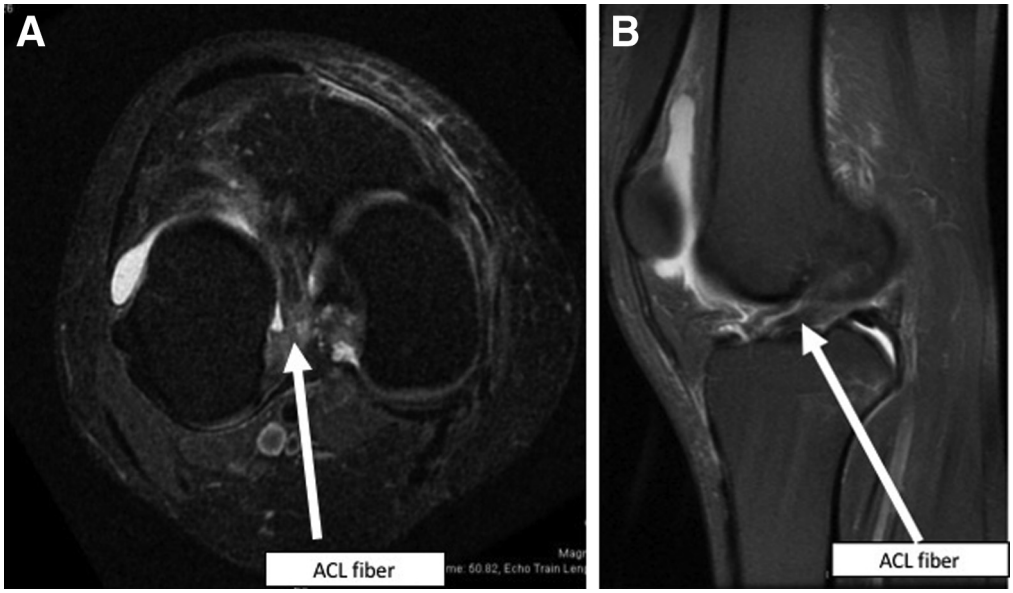

Fig 1. T2-weighted magnetic resonance imaging of example case with right anterior cruciate ligament (ACL) injury. (A) A coronal oblique view of the right knee shows partial hyperintensity signal at the middle to femoral attachment part of the ACL. (B) A sagittal magnetic resonance image shows hyperintensity signal within the ACL. These findings suggest that some fibers of the ACL are still intact, and the described technique is recommended.

fibers are observed to be intact with the femoral footprint whereas others are detached from it. The torn ACL fibers are surrounded by inflamed tissue representing an acute injury (Fig 3). The anteromedial portal is inserted under needle-guided arthroscopic viewing with 70° to 90° of knee flexion. This portal is placed as low as possible as long as the femoral tunnel is created without damaging the femoral cartilage, anterior horn of the medial meniscus, and ACL fibers.

Surgical Procedure

After the aforementioned portal is opened, a femoral tunnel drill guide is placed at the ACL femoral footprint as close as possible posteriorly to the intact fibers (Fig 4). During drilling, the knee is placed in maximum flexion, and the femoral tunnel is reamed with a 4.5-mm cannulated reamer following the drill guide through the skin. The femoral tunnel length is measured by a depth gauge, and a shuttling loop is passed through the femoral tunnel instead of the drill guide. When placing an ACL tibial guide (Smith &

Fig 2. Patient position for arthroscopic procedure (with right leg injury). The patient is placed in the supine position with the surgeon sitting ipsilaterally. The patient's affected leg (right leg) is held away from the operating table and positioned on the surgeon's thighs. The affected knee is then positioned at a 45° to 90° angle, which allows easy manipulation by the surgeon and his or her assistant.

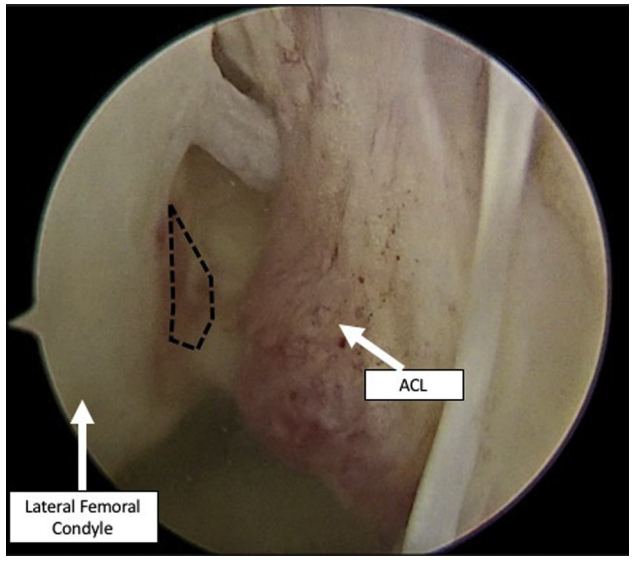

Fig 3. As shown through an anterolateral viewing portal in a patient with partial injury of the anterior cruciate ligament (ACL) in the right knee, some parts of the ACL fibers are observed to be intact with the femoral footprint whereas others are detached from it. The dashed line shows the area of detachment. The torn ACL fibers are surrounded by inflamed tissue representing an acute injury.

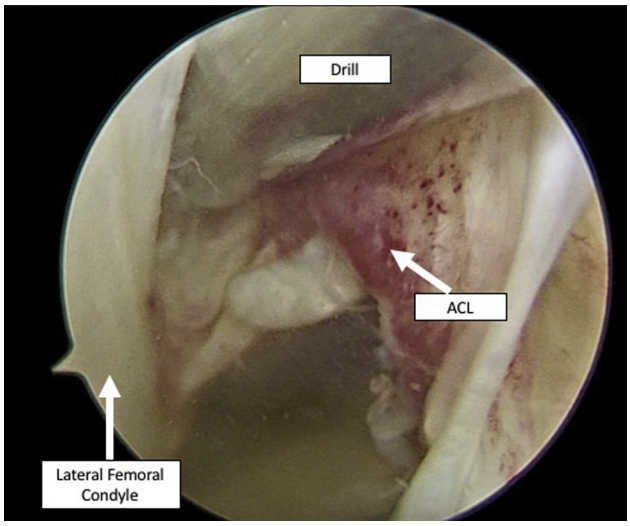

Fig 4. As shown through an anterolateral viewing portal in a patient with partial injury of the anterior cruciate ligament (ACL) in the right knee, the femoral tunnel drill guide is placed at the ACL femoral footprint as close as possible posteriorly to the intact ACL fibers.

Nephew) in an intra-articular manner, we do so just medial to the anterior horn of the lateral meniscus or at the center of the ACL tibial footprint. A tibial tunnel is reamed with a 4.5-mm cannulated reamer at an angle of 60° to 65° to the tibial plateau surface through a mini-incision at the anteromedial aspect of the tibia just above the hamstring tendon insertion. Using an eyelet wire passer inserted through the cannulated reamer, we then retrieve the shuttling suture with a suture retriever and pass a shuttling suture loop through the prepared tibial and femoral tunnel and throughout the lateral thigh by way of the anteromedial portal (Fig 5). We use an EndoButton CL Ultra (Smith & Nephew) and remove the continuous loop and replace it with 5 strands of high-strength suture material (Hi-Fi [ConMed] or Ethibond [Ethicon]) through each of 2 holes in the middle, leaving the ends untied. Each end is marked 11 cm from the EndoButton (Fig 6). The polyester braided No. 5 suture is retrieved through the shuttling loop and passed up through the tibial and femoral tunnel. The EndoButton is then flipped after reaching the landmark at the tibial surface (Video 1). At the tibial inlet, each strand of the suture material is passed through the hole of 3.5-mm suture button (Arthrex). Then, the suture button is tightened by tying the suture material while the knee is positioned in slight internal rotation (Fig 7). A posterior translation force is applied to the tibia while tightening the knot. After tightening is complete, the synthetic ligament should lie straight and be placed close to the remaining ACL fibers (Fig 8).

Postoperative Protocol

The patient is allowed to walk on the first postoperative day. Closed-chain quadriceps exercise and range-of-motion exercise are also initiated. An ambulation program is started with partial weight bearing as tolerated with axillary crutches, progressing to full weight bearing as soon as tolerated by the patient. Low-impact activities are allowed at 4 months postoperatively, and full sporting activities are resumed at 6 to 9 months. Advantages and disadvantages, pearls and pitfalls, and indications and contraindications of the procedure are described in Table 1.

Discussion

Partial injury of the ACL is not a common condition and requires much more study before we can reach a consensus on the standard treatment with the best outcome in these patients. Because of the poor ability to heal and poor outcomes after repair in the previous literature, many authors did not favor ACL repair in the past. However, many recent studies have shown better outcomes, such as that of Bak et al.[3] They evaluated the natural history of partial ACL tears 5 years after the

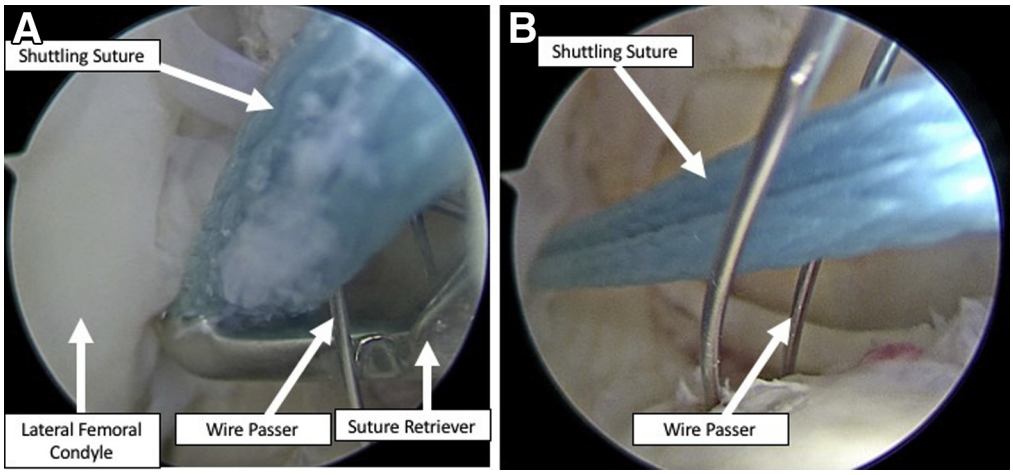

Fig 5. As shown through an anterolateral viewing portal in a patient with partial injury of the anterior cruciate ligament in the right knee, the suture retriever is used to retrieve the shuttling suture through the wire passer from an anteromedial portal (A); after the shuttling suture is retrieved through an eyelet wire passer, a shuttling suture loop is passed through the prepared tibial tunnel (B).

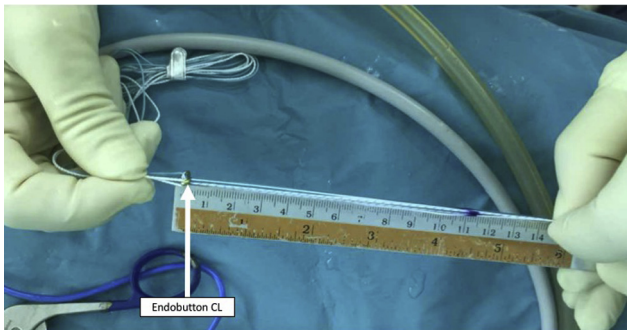

Fig 6. EndoButton CL Ultra. The continuous loop is removed and replaced with 5 strands of high-strength suture material (Hi-Fi or Ethibond) through each of 2 holes in the middle, with the ends left untied. Each end is marked 11 cm from the EndoButton. These landmarks indicate the flipping of the EndoButton when the marks reach the tibial tunnel. However, to create an accurate tunnel range, use of a depth gauge is recommended to measure the femoral tunnel.

initial injury and found that 73% of cases had negative Lachman test results and 62% had good to excellent knee function after conservative treatment. Moreover,

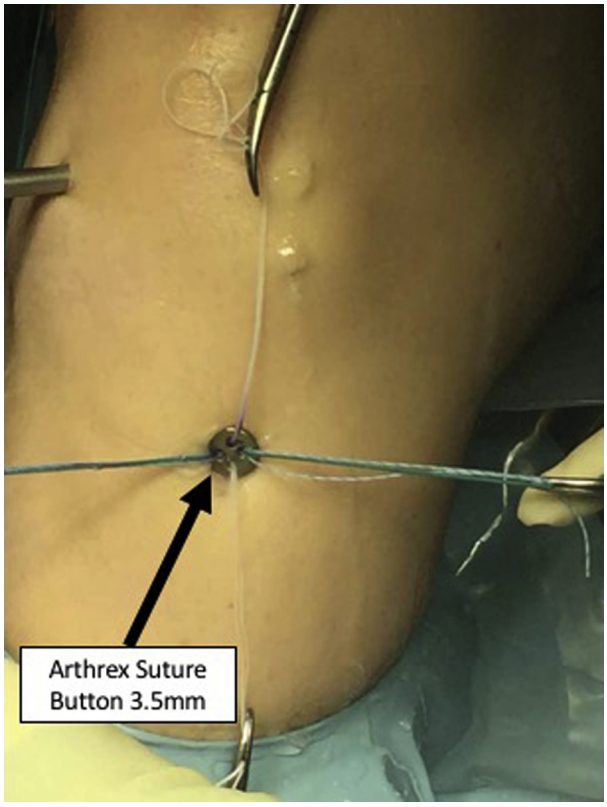

Fig 7. Patient's right knee with anterior cruciate ligament injury. Each strand of the suture material is passed through the hole of the 3.5-mm suture button (Arthrex). The suture button is then placed at the anterior tibial cortex through a mini-open tibial incision. The suture button is tightened by tying the suture material while the knee is positioned in slight internal rotation and a posterior translation force is applied.

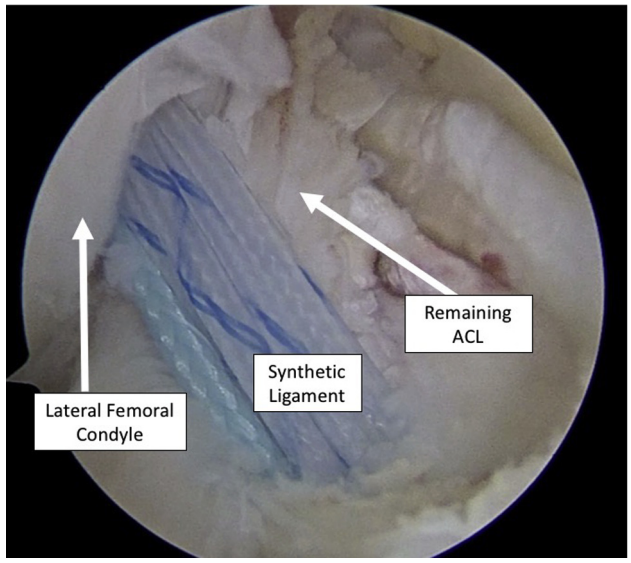

Fig 8. As shown through an anterolateral viewing portal in a patient with partial injury of the anterior cruciate ligament (ACL) in the right knee, after knot tightening, the synthetic ligament should lie straight and close to the remaining ACL fibers.

Pujol et al.[13] showed that partial ACL tears may have the capacity to heal, contrary to what had been thought.

As reviewed by McCarty and McAllister,[14] the primary blood supply to the ACL comes from the middle geniculate artery, which pierces the posterior capsule

Table 1. Advantages and Disadvantages, Pearls and Pitfalls, and Indications and Contraindications of Procedure

Advantages
No need for autograft or allograft, saving graft for other ligament reconstruction
No graft complications
Early mobilization after procedure
Natural ACL provided after healing
Small bone tunnel with less risk of cortical breakage
Small surgical incision with better cosmetic outcome
Disadvantages
Surgical skill required
Possibility of injuring ACL stump
Pearls
Necessity for accurate placement of femoral and tibial tunnels
Use of only a small 4.5-mm reamer for passing EndoButton
Necessity for placement of tibial tunnel at center of tibial ACL footprint
Pitfalls
Placement of femoral tunnel not close to stump, causing impingement
Placement of tibial tunnel too posteriorly behind ACL stump
Indications
Acute partial ACL injury at midsubstance or femoral insertion
Contraindications
Chronic ACL tear
Complete ACL tear without continuity of ACL fibers

ACL, anterior cruciate ligament.

and enters the intercondylar notch near the femoral attachment. An additional blood supply comes from the retropatellar fat pad through the inferior medial and lateral geniculate arteries. These sources play a more important role when the ligament is injured. Therefore, keeping the bundle intact preserves its blood supply, which may aid in the healing process of the graft. The ACL itself also has proprioceptive function as evidenced by the presence of mechanoreceptors in the ligament in a study by Adachi et al.[15] The nerve endings may provide the afferent arc for postural changes of the knee through deformations within the ligament, although the exact contributions of the receptors have not been clearly defined. With preservation of the ACL remnant, we believe that some proprioceptive innervation is maintained with evident benefits for the subjective outcome and for a safer return to sports. Accordingly, we prefer to perform an ACL augmentation to improve vascularization, proprioception, and ligamentization for optimal clinical and functional outcomes. With this technique, the surgeon can stabilize a partial ACL injury without external immobilization and the implant will act as a structural tie for healing. Allograft is preserved for other serious injuries or late reconstruction surgery.

Synthetic augmentation systems are becoming increasingly popular, but the previous synthetic devices caused a great deal of postoperative synovitis. Nonetheless, a recent systematic review by Batty et al.[16] reported lower rates of failure, revision surgery, and sterile effusion or synovitis when assessing the safety and efficacy of synthetic devices in cruciate ligament surgery. We chose high-strength suture material such as Hi-Fi or Ethibond, which is commonly used in arthroscopic procedures with less tissue reaction, as an internal splint while the ACL is healing. The bone tunnels were equally 4.5 mm on both the femoral and tibial sides; an even narrower space on the femoral footprint can be achieved with this method. A contraindication to performing this technique is a chronic injury because of the poor healing potential.

Our technique is an option for partial ACL injury. It not only saves the natural ACL stump but also preserves the autograft, creating only a small skin incision on the tibial cortex without requiring a second operation to remove the fixation device. No external immobilization is needed. The only prerequisite for this technique is timing: It needs to be performed in an acute or subacute injury in which the native ACL still has the potential for healing.

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