Technical Note

Arthroscopic Anterior Cruciate Ligament Primary Repair With Synthetic Augmentation and Fixation With the Knotless Suture Anchor

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Abstract: An anterior cruciate ligament (ACL) tear is one of the most common ligament injuries in athletes. The arthroscopic ACL reconstruction procedure is the gold standard for treatment. However, the improvement in injury classification and suture materials has subsequently made arthroscopic ACL primary repair an alternative surgical treatment option. This Technical Note describes an arthroscopic ACL primary repair with synthetic augmentation made of several high-strength sutures and fixation with the knotless suture anchor. The reinforced synthetic material acts as a structural tie to support the ACL while it heals.

Introduction

The anterior cruciate ligament (ACL) is a critical structure for knee biomechanics, as it ensures stability and proprioception.[1] ACL injuries are common, and surgical treatment has become the standard for restoring the injured knee's function.[2,3] The first attempt at surgical treatment was to repair the ACL through an open arthrotomy, a standard procedure in the 1970s and 1980s.[4,5] However, this technique was eventually abandoned because of poor mid-term results reported by Feagin et al.[6] Several prospective clinical trials confirmed the authors' findings, revealing that ACL reconstructions provide better outcomes.[7] ACL reconstruction rates have increased significantly over the last two decades.

Nevertheless, Sherman et al. reported favorable outcomes following open primary ACL repair in patients over the age of 22, a Type 1 tear, good tissue quality, and a low-grade pivot.[8-10] The clinical trial revealed a comparable return to sport and failure rate.[11,12] Theoretical benefits of ACL repair, such as proprioception preservation, fewer complications, and earlier return to sport, have recently sparked renewed interest. Internal bracing of the ACL ligament has increased interest nowadays.[13-16] This Technical Note describes an arthroscopic ACL primary repair with synthetic augmentation made of several high-strength sutures and fixation with the knotless suture anchor. The reinforced synthetic material acts as a structural tie to support the ACL while it heals.

Preoperative Evaluation

The plain radiographs and magnetic resonance imaging (MRI) are performed to evaluate the location of the ACL tear by Sherman's classification, quality of the ACL tissue, and preoperative planning.

Surgical Technique (With Video Illustration)

Patient Positioning

The examination under anesthesia is done to determine associated intra-articular injuries. The patient is

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positioned supine after spinal anesthesia, with the surgeon sitting ipsilaterally. A tourniquet is applied to the affected thigh.

Arthroscopic Examination

Standard anterolateral and anteromedial portals are created for examination (Fig 1). The ACL stump and tissue quality were found to be suitable for primary repair during the arthroscopic examination (Fig 2, Video 1).

Synthetic Augmentation

The femoral tunnel is located distal to the lateral intercondylar ridge and posterior to the bifurcate ridge. The leg is then placed in the figure-four position. A femoral tunnel is created with a guide beath pin and reaming with a 4.5-mm cannulated drill along the femoral tunnel. (Fig 3A, Video 1) A shuttling suture is passed through the tunnel (Fig 3B, Video 1). The tibial tunnel is created posteriorly and laterally to the native ACL stump. A pin with the ACL tibial guide (ConMed, Utica, NY) is used for aiming, and a 1.0-cm vertical incision is made on the medial side of the proximal tibia before drilling and reaming with a 4.5-mm cannulated drill (Fig 3C, Video 1). The wire loop is then passed through the 4.5-mm cannulated drill and retrieved the shuttling suture down to the opening of the tibial tunnel (Fig 3D, Video 1). The six HiFi sutures (ConMed) are passed through Endobutton (Smith & Nephew, Andover, MA) and folded into 12 strands (Fig 4). The button is passed through the tibial and femoral tunnels. Then, it is flipped after passing through the outer femoral cortex (Fig 5, Video 1). Then, the Endobutton is tightened up by tying the sutures, while the knee is positioned into semiextension.

Fig 1. Left knee, supine position. Intraoperative picture demonstrates portal placement and incision. 1, anterolateral viewing portal; 2, anteromedial working portal; 3, inferomedial open for tibial tunnel.

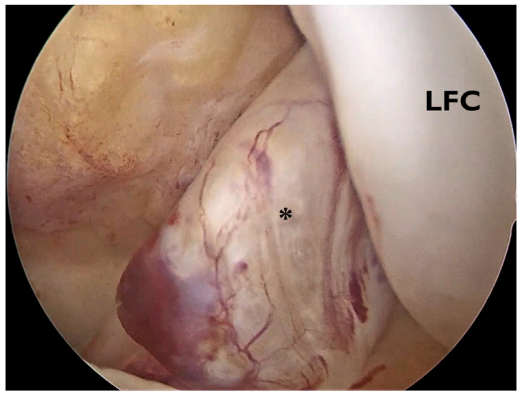

Fig 2. Left knee, supine position, viewing from anterolateral portal. The anterior cruciate ligament (ACL) stump and tissue quality were found to be suitable for primary repair during the arthroscopic examination. * denotes ACL stump. LFC, lateral femoral condyle.

ACL Primary Repair Using Knotless Suture Anchor

The proximal stump of the ACL is then sutured with the HiFi sutures (ConMed, Utica, NY), followed by two wrap-around stitches using mini FirstPass suture passer (Smith & Nephew) (Fig 6A, Video 1). The free end of the HiFi sutures is then loaded into the 4.5-mm PopLok knotless anchor (ConMed). At the femoral footprint, the anchor is inserted distally to the synthetic augmentation (Fig 6B, Video 1). Fixation security is checked, and soft tissue debris is removed with an arthroscopic shaver. The wounds are closed by nonabsorbable sutures. The final repair construct is shown in Fig 7 and Video 1.

Postoperative Care

On the first postoperative day, closed-chain quadriceps and range-of-motion exercises are begun. An ambulation program begins with partial weight bearing, as tolerated with axillary crutches and progresses to full weight bearing at 2 weeks postoperatively. Low-impact activities are allowed at 4 months postoperatively, and full sporting activities are resumed at 6 months.

Discussion

Since 1895, the outcome of ACL repair has been unfavorable, resulting in a high failure rate from retear and stiffness. At the time, surgeons believed that ACL had a poor healing capacity because of its intra-articular

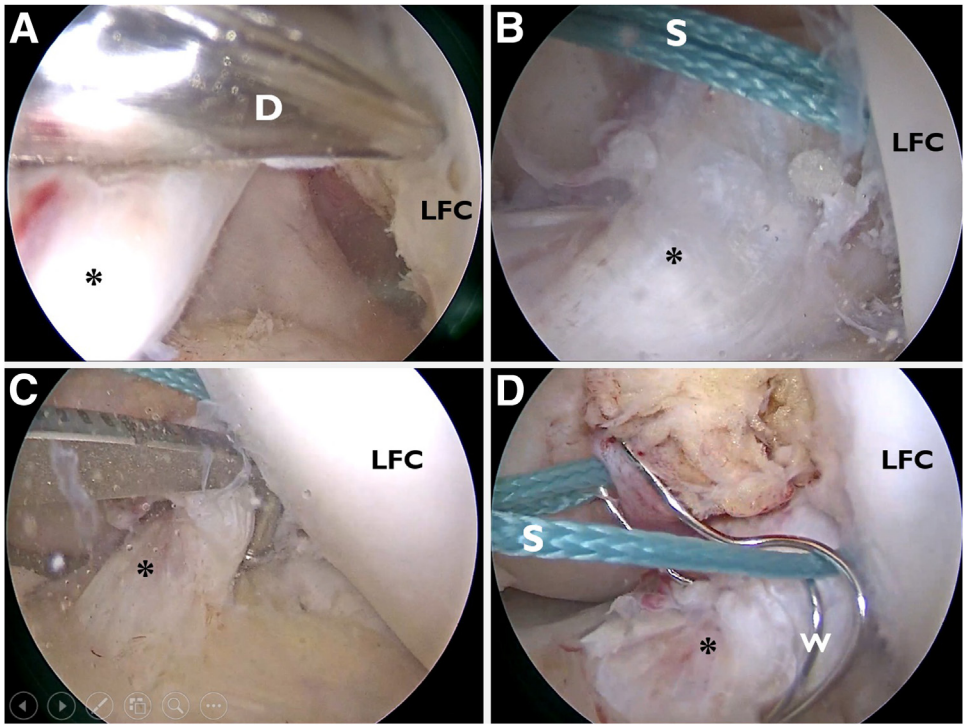

Fig 3. Left knee, supine position, viewing from anterolateral portal. (A) A femoral tunnel is created with a guide beath pin and reaming with a 4.5-mm cannulated drill along the femoral tunnel. (B) A shuttling suture is passed through the tunnel. (C) The tibial tunnel is created posteriorly and laterally to the native anterior cruciate ligament (ACL) stump. A pin with the ACL tibial guide (ConMed, Utica, NY) is used for aiming. (D) The wire loop is then passed through the 4.5-mm cannulated drill and retrieved the shuttling suture down to the opening of the tibial tunnel. * denotes ACL stump. D, 4.5-mm cannulated drill; LFC, lateral femoral condyle; S, shuttling suture; W, wire loop.

nature. As a result, performing the reconstruction is the gold standard for ACL tears. Recent studies have shown that ACL's healing capacity derives from formation of a fibrin clot as a scaffold at the end of the torn site. Still, the challenges are in the nature of ACL, which is placed intra-articularly. Hence, the fibrin tends to dissolve prematurely, and the constant distraction movement creates a gap before the healing process is complete. These can be interpreted as biological and mechanical factors. So, to improve the biological factor, a new technique called bridge-enhanced ACL repair (BEAR) was developed, which involves injecting a scaffold with autologous blood, mesenchymal stem cells, or growth factors. The technique yielded results that were not inferior to ACLR.[17-19]

As a new high-strength suture material was developed, a technique for ACL repair with internal brace augmentation was also developed, with the result demonstrating that anterior translation is less than the ACLR.[20] Overall, the outcome of ACL repair with internal brace augmentation is not inferior to that of ACLR, with no significant difference in outcome score or failure rate.[20-22] Recently, there have been many published surgical techniques for ACL repaired with internal brace augmentation.[23-25] The internal brace technique is classified into two types: augmentation (using suture material to augment the graft and set tension together with the graft) and reinforcement (setting tension separately with the graft).[26] This surgical technique employs the reinforcement principle by

Fig 4. The six HiFi sutures (ConMed, Utica, NY) are passed through Endobutton (Smith & Nephew, Andover, MA) and are folded into 12 strands.

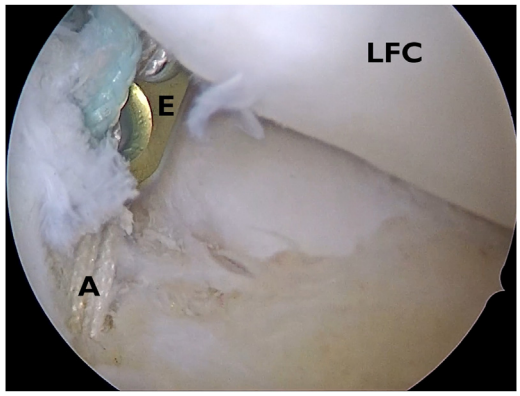

Fig 5. Left knee, supine position, viewing from anterolateral portal. The button is passed through the tibial and femoral tunnels. Then, it is flipped after passing through the outer femoral cortex. A, synthetic augmentation; E, Endobutton; LFC, lateral femoral condyle.

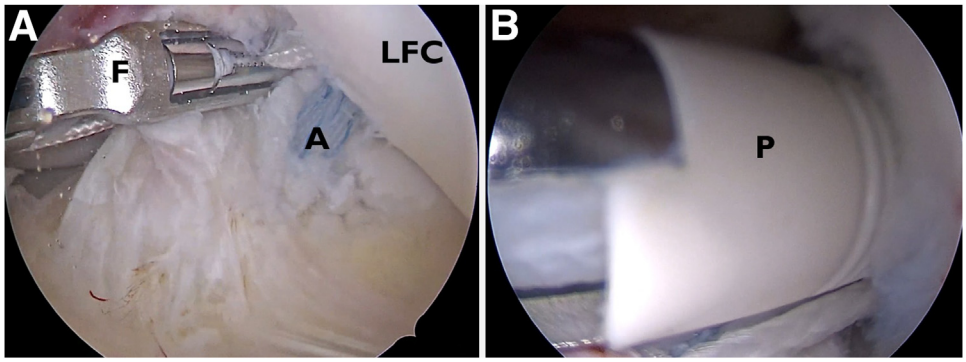

Fig 6. Left knee, supine position, viewing from anterolateral portal. (A) The proximal stump of the anterior cruciate ligament (ACL) is then sutured with the HiFi sutures (ConMed, Utica, NY), followed by two wrap-around stitches using mini FirstPass suture passer (Smith & Nephew, Andover, MA). (B) The free-end of the HiFi sutures is then loaded into the 4.5-mm PopLok knotless anchor (ConMed). At the femoral footprint, the anchor is inserted distally to the synthetic augmentation. A, synthetic augmentation; F, mini FirstPass suture passer; LFC, lateral femoral condyle; P, PopLok knotless anchor.

adjusting the tension of the internal brace independently of the native ACL. The benefit of this technique is that it avoids overconstraining the joint, and elongation of repaired ACL results in a higher ultimate failure load. The internal brace acts as a "dynamic safety belt," preventing the repaired ACL from further elongation while the healing process occurs.[26] Using a knotless anchor suture for ACL repair reduced the amount of bone loss caused by the femoral tunnel, which is crucial if a revision procedure is required in the future. This technique did not require an autograft, so if the patient has a multiligament injury, the valuable autograft may be safe for other reconstruction purposes. We could expect to preserve proprioception and feedback mechanisms by preserving the native ACL tissue.[27]

Other factors influencing the outcome of ACL repair include tear site and age; proximal tears performed better than midsubstance and distal tears.[28] Patient age is also an important consideration, as one study found that adolescent patients who underwent ACL repair had a tenfold higher retear rate than ACLR patients.[29]

The limitation of this technique is patient selection; in our institute, the requirements are Sherman classification type I, and the timing should be within 3 months. The final decision will be made by arthroscopic examination. Advantages, disadvantages, pitfalls, indications, and contraindications of the technique are further described in Table 1.

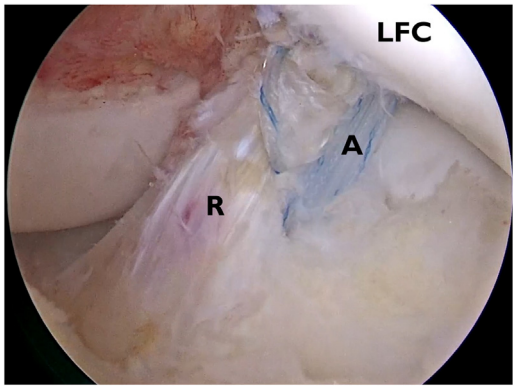

Fig 7. Left knee, supine position, viewing from anterolateral portal. The final repair construct is shown. A, synthetic augmentation; LFC, lateral femoral condyle; R, repaired anterior cruciate ligament.

Table 1. Advantages, Disadvantages, Pitfalls, Indications, and Contraindications of the Technique

Advantages	No need for autograft or allograft, saving graft for other ligament reconstruction
	No graft complications
	Early mobilization
	Natural ACL provided after healing
	Small bone tunnel with less risk of cortical breakage
	Small surgical incision with the better cosmetic outcome
	Provide structural support while healing is in the process
Disadvantages	Surgical skills required
	Possibility of injuring ACL stump
Pitfalls	Placement of the femoral tunnel too anterior, causing impingement
	Placement of tibial tunnel too posteriorly behind ACL stump
Indications	Acute or subacute injuries
	Proximal tears
	Good tissue quality and sufficient tissue length
Contraindications	Chronic injuries
	Mid substance ACL tears
	Poor tissue quality

ACL, anterior cruciate ligament.

In conclusion, this presented technique is a reproducible method and a safe surgical technique to repair the proximal ACL tears.

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