Technical Note

Arthroscopic Anterior Cruciate Ligament Primary Repair With Suture Combined With Femoral Double Bone Tunnel Suspension Fixation

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Abstract: Anterior cruciate ligament (ACL) injury is a common orthopaedic sports injury. Arthroscopic anterior cruciate ligament reconstruction (ACLR) is the gold standard for treatment. In recent years, with the popularization and precision of arthroscopic techniques, as well as the discovery that acute ACL rupture has the potential to heal itself, arthroscopic ACL primary repair has become an alternative surgical treatment. This Technical Note describes an arthroscopic ACL primary repair with suture combined with femoral double bone tunnel suspension fixation. It tightens the tendon-bone contact, increases the contact area, and strengthens the fixation, all of which contribute to better tendon-bone healing. Thus, this can be used as a surgical method for ACL repair.

Injury of the anterior cruciate ligament (ACL) is among the most common and debilitating sports injuries. The most common treatment is ACL reconstruction (ACLR), which has known efficacy.[1] However, ACLR requires autologous or allogeneic tendons, and tendon-bone healing and tendon revascularization (or crawling replacement) are lengthy processes. Recent studies have found that the ACL stump has the potential to heal itself.[2] Suture anchor repair is the most basic ACL repair technique. It uses a suture through the ACL stump and is fixed to the ACL footprint area on the femoral side by an anchor, which has some problems such as insufficient tendon-bone contact and unstable fixation. In addition, biomechanical experiments have shown that suspension fixation of the femoral cortex has better load-failure biomechanics than suture anchor repair.[3]

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This Technical Note describes an arthroscopic ACL primary repair using suture combined with femoral double bone tunnel suspension fixation. It resembles the natural healing process, improves the kinematics and proprioception of the knee joint, avoids graft acquisition, and preserves bone mass. With closer tendon-bone contact, a larger contact area, and more stable fixation. It can be used as a surgical method for ACL repair.

Surgical Technique

Preoperative Preparation

The study was approved by the Ethics Committee of the First Affiliated Hospital of the University of South China (no. 2021ll0104003). The patient was diagnosed with acute ACL rupture of the femoral side; Sherman classification (Fig 1)[4,5] was identified as type I, and the quality of the ACL stump was satisfactory.

Anesthesia and Posture

After successful neuraxial or general anesthesia, the patient is positioned supine on the operating bed. A pneumatic tourniquet is strapped at the base of the thigh, the lower limb is allowed to drop, and the knee is flexed to 90°.

Surgical Procedures

Arthroscopy Examination

Standard anterolateral and anteromedial portals are established, and routine arthroscopy reveals acute

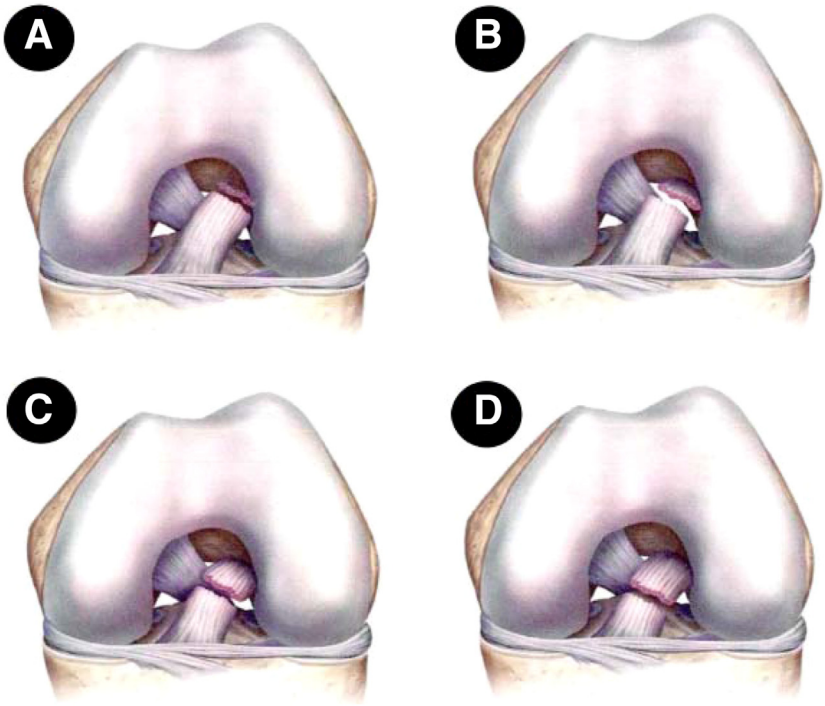

Fig 1. Sherman classification of anterior cruciate ligament (ACL) tear. (A) Type 1 includes injuries where less than 10% of ligaments remain attached to the femoral attachment. (B) Type 2 tears occur when less than 20% of ligaments are connected to the femoral attachment. (C) Type 3 tears occur when less than 33% of ligaments are connected to the femoral attachment. (D) Type 4 refers to a mid-substance tear. Images from DiFelice GS, Villegas C, Taylor S. Anterior cruciate ligament preservation: Early results of a novel arthroscopic technique for suture anchor primary anterior cruciate ligament repair. *Arthroscopy* 2015;31:2162-2171.

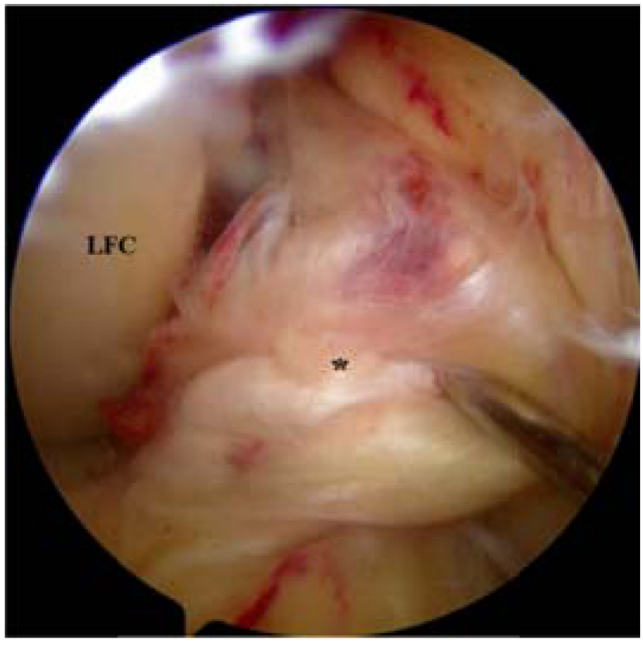

Fig 2. Right knee, supine position, anterolateral approaches, arthroscopy examination: acute femoral anterior cruciate ligament (ACL) rupture, Sherman type I, and satisfactory stump quality . *ACL stump. LFC, lateral femoral condyle.

femoral ACL rupture, Sherman type I, and satisfactory stump quality (Fig 2, Video 1).

In Situ Suturing of the ACL Stump. A medial portal (third approach) is added (Fig 3). The hook is sutured

Fig 3. Right knee, supine position. This intraoperative image demonstrates portal placement and incision. 1, anterolateral viewing portal; 2, medial approach; 3, anteromedial working portal.

with polydioxanone suture (PDS; Ethicon) thread, which serves as a guide for introducing the high-strength suture (REJOIN, nonabsorbable surgical suture), and the suture is woven back and forth from the distal tibial insertion for 2 to 3 stitches. Both ends of the suture are then passed through the anteromedial bundle and posterolateral bundle of the ACL stump, respectively, and the last stitch is sutured with a sleeve lock as the first in situ suture (Fig 4A,

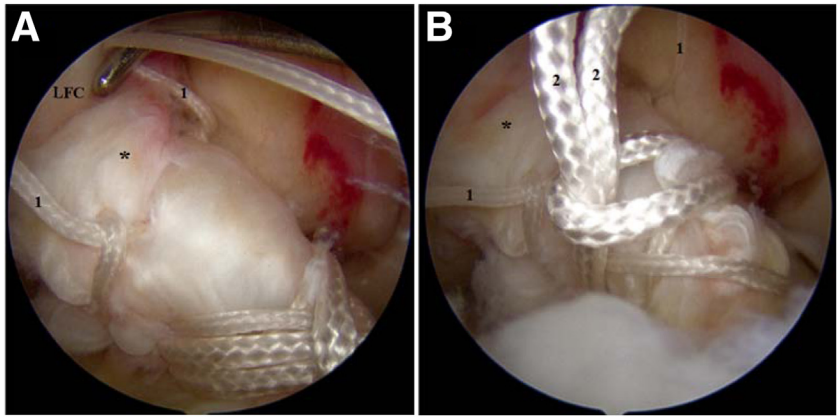

Fig 4. Right knee, supine position, medial approach, in situ suture procedure. (A) The first in situ suture. (B) The second in situ suture. *Anterior cruciate ligament stump. 1, the first in situ suture; 2, the second in situ suture; LFC, lateral femoral condyle.

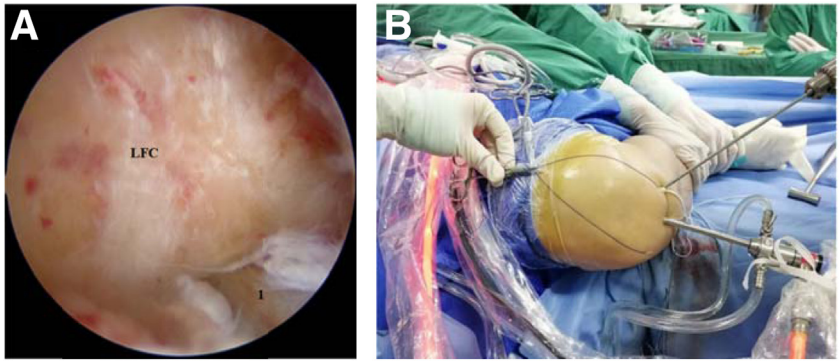

Fig 5. Right knee, supine position, medial approach. (A) the position of the first bone canal is located under arthroscopic supervision, during knee flexion in the figure-of-4 position. (B) The first bone tunnel is drilled with a 3-mm Kirschner wire in a highly flexed knee position. 1, a 3-mm Kirschner wire to locate the first bone tunnel. LFC, lateral femoral condyle.

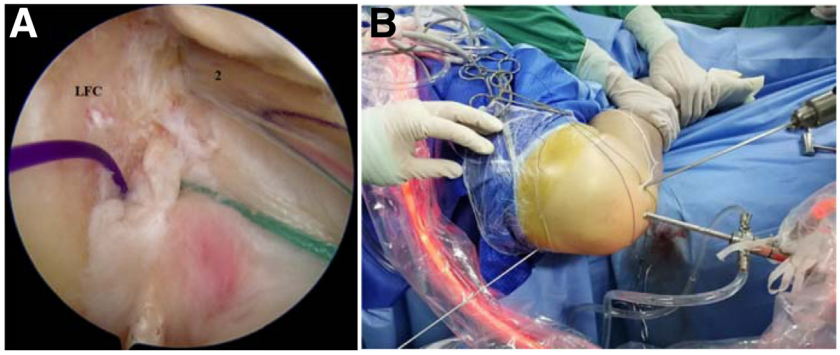

Fig 6. Right knee, supine position, medial approach. (A) The position of the second bone canal is located under arthroscopic supervision during knee flexion in the figure-of-4 position (B) The second bone tunnel is drilled with a 3-mm Kirschner wire in a highly flexed knee position. 2, A 3-mm Kirschner wire to locate the second bone tunnel. LFC, lateral femoral condyle

Video 1). The PDS line is passed behind the parenchymal portion of the ligament, introducing the high-strength suture, and after the ACL is ligated, the suture is used as a second in situ suture (Fig 4B, Video 1). Another PDS thread, penetrating through the parenchyma and exiting from the stump, is left as a traction thread.

Double Bone Tunnel Drilling. The patient is in the supine position with 90° flexion of the knee in the "4" position. Arthroscope access is through the medial portal to expose the anatomic starting point of the anteromedial bundle and the posterolateral bundle of ACL, and a 3.0-mm Kirschner wire is placed through the anteromedial portal (Figs 5A and 6A, Video 1). The knee is changed to a high flexion position; the Kirschner wire is drilled through the lateral condyle and exited through the skin of the distal thigh (Figs 5B and 6B, Video 1). Traction wires are introduced through 2 bone tunnels.

Knot and Secure. The 2 ends of the first and second sutures are threaded through the double bone tunnels to the outside of the cortex under the guidance of the

Fig 7. Right knee, supine position, medial approach. (A) The first and second sutures exit the bone tunnel. (B) The first and second sutures are passed through the wire hole of the suspension titanium plate. The suture is then threaded through the suture loop. (C) The knee is flexed at 30° for the posterior drawer test, and the sutures are knotted for fixation. *Anterior cruciate ligament stump. LFC, lateral femoral condyle.

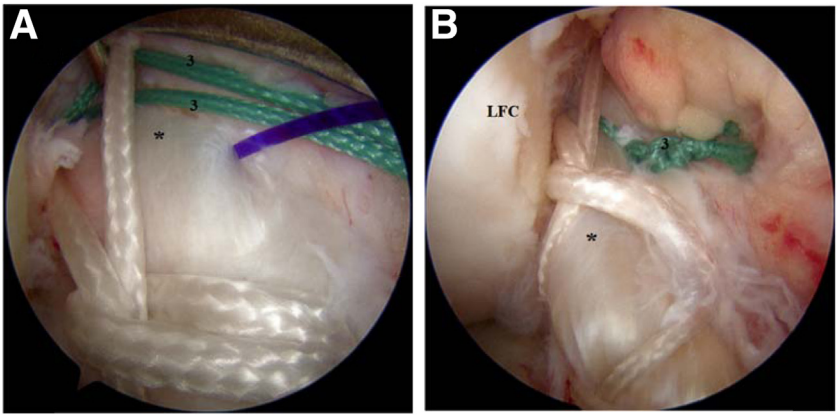

Fig 8. Right knee, supine position, medial approach. (A) The suture that is introduced into the joint cavity, with 1 end passed through the stump of the ligament and the 2 ends knotted and fixed, is used as the third suture in situ. (B) Re-arthroscopy shows that the tension of anterior cruciate ligament (ACL) recovered satisfactorily. *ACL stump; 3, the third in situ suture. LFC, lateral femoral condyle.

traction line (Fig 7A, Video 1). An approximately 2-cm longitudinal incision is made on the lateral side of the lower part of the thigh, the suture is pulled out from the same skin and soft tissue channel, and the first and second sutures are passed through the wire holes of the suspension titanium plate (REJOIN, adjustable loop titanium plate) (Fig 7B, Video 1). A suture is inserted through the suture loop, and the 2 ends of the suture are introduced into the joint cavity through the anteromedial bone tunnel. The knee is flexed at 30° for the posterior drawer test, and the sutures are tightened and knotted (Fig 7C, Video 1). The suture that is introduced into the joint cavity, with 1 end passed through the stump of the ligament and the 2 ends knotted and fixed, is used as the third in situ suture (Fig 8A, Video 1).

Re-arthroscopy Examination. Re-arthroscopy shows that the tension of the ACL is satisfactory (Fig 8B, Video 1).

Postoperative Management

From 0 to 4 weeks postoperatively, the knee joint is braced, with no weightbearing. Quadriceps femoris isometric contraction, straight leg elevation, and ankle pump functional exercise are performed, and knee flexion at 30° is performed 10 times daily. From 4 to 12 weeks, the patients continue to wear a brace and move from partial to full weightbearing, while gradually increasing the range of motion to normal. After 12 weeks, patients resume their usual routine and employment while avoiding strenuous exercise.

Discussion

In recent years, several studies have indicated that acute ACL rupture can express a variety of healing genes, offering the potential for the ligament to heal itself.[2,6,7] In this context, ACL repair has attracted increasing research attention. The advantages of ACL repair include preservation of tissue and proprioception, avoidance of graft acquisition, and preservation of bone reserve.[8] This method can reduce postoperative pain, increase postoperative range of motion, and accelerate postoperative rehabilitation, with better objective indicators such as hamstring muscle strength recovery.[9,10] The incidence of osteoarthritis has also been shown to be reduced.[11] Several randomized controlled trials have confirmed that ACL repair is not inferior to primary ACLR with regard to knee laxity and short-term outcomes.[12-15] In general, Sherman type I or single-bundle ACL injury, patients aged over

Table 1. Advantages and Disadvantages of This Technique

Advantages	Disadvantages
Has a closer tendon-bone contact and a larger tendon-bone area	The technique is limited to patients with acute femoral ACL rupture, Sherman type I, and satisfactory stump
Has high fixation strength and avoids the risk of suture anchor pullout failure	
Deep bone marrow blood and stem cells are derived from drilling the femoral tunnel facilitate tendon-bone healing	
No need for autograft or allograft, saving graft for other ligament reconstruction; no graft complications	The technique of suturing the stump in situ under arthroscopy may be difficult for beginners
Natural ACL provided after healing	
Small bone tunnel with less risk of cortical breakage	

ACL, anterior cruciate ligament.

Table 2. Pearls and Pitfalls of This Technique

Pearls	Pitfalls
Indications must be strictly considered	Requires skilled arthroscopic suture and line crossing techniques
The anterior cruciate ligament was fully explored during this operation; and no other injuries were found	Requires good suture management
The stump tissue was not cleaned as much as possible to ensure tendon-bone healing was not affected	
Postoperative rehabilitation should not be too aggressive	

21 years, surgery within 3 months after injury, and good stump quality are indications for ACL repair.[16-19]

Some scholars have reported that internal brace ligament augmentation (IBLA), dynamic intraligamentary stabilization (DIS), suture anchor repair (SAR), and bridge-enhanced anterior cruciate ligament repair (BEAR) are used in ACL repair, each of which has its advantages and disadvantages, and their efficacy also differs.[20-23] The IBLA adds a suture band bridging the femoral origin and tibial insertion as an internal support based on traditional ACL repair, which can protect the ligament during the ACL healing stage, support early mobilization, and improve the surgical success rate.[24,25] The DIS technique represents a form of resilient fixation methods.[20] A multicenter retrospective study conducted by Senftl et al. showed that DIS had a higher failure rate than autogenous tendon reconstruction surgery, but satisfactory clinical results were obtained in all successfully treated patients.[26] BEAR uses polypropylene sutures and collagen-PRP hydrogel as a bridge to connect the torn ACL stump, but its efficacy requires additional study.[22,27]

Suture anchor repair is considered the most basic ACL repair technique. It uses a suture through the ACL stump and fixed by an anchor to the ACL footprint on the femoral side.[28] However, this method presents issues such as insufficient tendon-bone contact and unstable fixation. Biomechanical experiments have shown that EndoButton (Smith & Nephew Endoscopy) suspension fixation has superior load-failure biomechanics compared with suture anchor repair.[3] The key to successful tendon-bone healing in ACL repair lies in contact area and closeness. In this study, we employed the technique of suturing combined with femoral double bone tunnel suspension fixation. The benefit of this technique is that it does not require an autograft; thus, if the patient has a multiligament injury, the valuable autograft may be saved for other reconstruction purposes.[25] We drill the femoral tunnel using a 3-mm Kirschner wire, which can preserve femoral bone; this is crucial if a revision procedure is required. It can preserve proprioception and feedback mechanisms by preserving the native ACL tissue.[29] The double bone tunnels are drilled in the lateral condyle, and deep bone marrow blood can be continuously extracted along the bone tunnel. The number of stem cells is large and increases, which is conducive to tendon-bone healing. The suspension fixation of the femoral cortex after in situ suture provides high fixation strength and avoids the risks associated with failure due to suture anchor pullout. In addition, compared with the femoral single-bone tunnel suspension-fixation technique, femoral double bone-tunnel fixation provides closer tendon-bone contact and a larger tendon-bone area, which is also conducive to tendon-bone healing. Because the diagnosis in this case was Sherman type 1, the tendon-bone contact is close, and the 3 sutures are firm and reliable; therefore, an internal brace is not required for enhanced protection.

The limitations of this technique are as follows: it is limited to patients with acute femoral ACL rupture, Sherman type I, with a good-quality stump. Additionally, the suture technique for the stump in situ under arthroscopy may be difficult for beginners. Advantages, disadvantages, pearls, and pitfalls of the technique are outlined in Table 1,2.

In conclusion, the presented technique can be considered a safe and effective surgical method for ACL repair.

Disclosures

All authors (C.L., D.C., Z.D.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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