Anterior Cruciate Ligament Remnant—Preserving Reconstruction Using a "Lasso-Loop" Knot Configuration

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Abstract: Anterior cruciate ligament (ACL) rupture predisposes to altered kinematics and possible knee joint degeneration. Graft fiber maturation and ligamentization may eliminate this risk during ACL reconstruction procedures. ACL remnant—sparing techniques support the theory that the preserved tissue enhances revascularization, preserves the mechanoreceptors, and leads to anatomic remodeling. The purpose of this article is to present a simple and reproducible technique of tensioning the preserved ACL remnant over the femur. A nonabsorbable suture is passed through the ACL remnant with a "lasso-loop" technique using a curved rotator cuff hook. Femoral and tibial tunnel preparation is performed according to a standard surgical technique for the EndoButton device (Smith & Nephew Endoscopy, Andover, MA). The free ends of the ACL remnant suture are retrieved through the tibial tunnel and passed through each outside hole of the EndoButton device. The hamstring graft is passed through the tibial and femoral tunnels and fixed to the femoral cortex by flipping the EndoButton and to the tibia by an interference screw. Finally, non-sliding half-stitch locking knots are made to secure the ACL remnant suture on the EndoButton device, by use of a knot pusher. This technique offers simple and secure tensioning of the ACL remnant on the fixation device.

Anterior cruciate ligament (ACL) rupture is one of the most common knee injuries, predisposing to altered knee kinematics, loss of neuromuscular feedback, increased medial compartment contact, and shear forces.[1,2] In an effort to decelerate this degenerative process, arthroscopic anterior cruciate ligament reconstruction (ACLR) using tendon autografts has been one of the most popular surgical interventions worldwide.[3] However, despite the numerous surgical techniques described, ACLR improves the patient's activity level and reduces, but does not eliminate, the risk of joint degeneration and the necessity for further surgery.[2,3]

Restoration of normal ACL anatomy requires anatomic remodeling, fiber maturation, and ligamentization of the applied graft. Early ACL remnant—sparing techniques support the theory of preserving the proprioceptive receptors, enhancing the revascularization process, and finally, achieving "cellular ligamentization."[4] However, ACL remnant—retaining procedures can be technically demanding and predispose to cyclops lesion formation.[5] The purpose of this study is to present a simple and reproducible technique of tensioning the preserved ACL remnant over the femur using a "lasso loop" reeved through the femoral EndoButton (EndoButton CL; Smith & Nephew Endoscopy, Andover, MA).[6]

Surgical Technique

Joint Assessment and Graft Preparation

The patient is positioned supine with a thigh tourniquet and a standard leg holder allowing full knee range of motion. With a 4.0-mm 30° arthroscope, standard anterolateral and anteromedial (AM) portals are made. The knee joint is evaluated, and other associated lesions are assessed and addressed appropriately. The ACL tear is confirmed, and the neighboring hamstring autograft is harvested. The 4-strand hamstring tendon graft is prepared by placing a No. 2 nonabsorbable Ethibond suture (Ethicon, Somerville, NJ) in a whipstitch interlocking fashion 4 cm from the free tendon ends.

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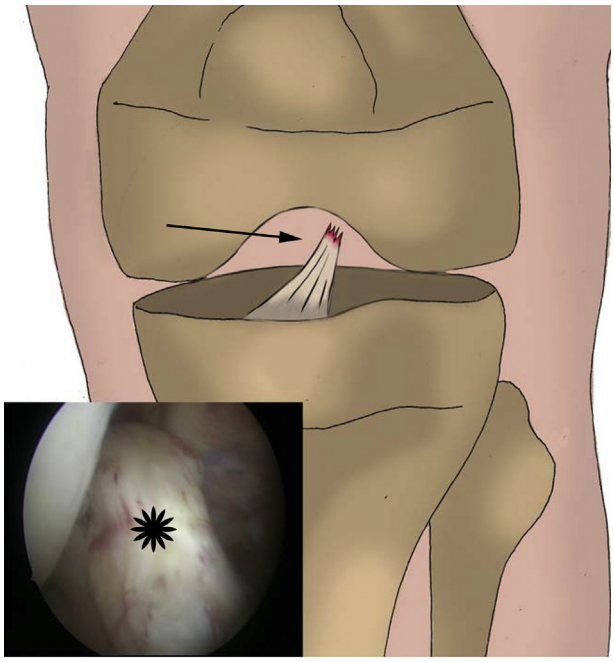

Fig 1. Anterior cruciate ligament tear (arrow, asterisk) from its femoral-side insertion.

Lasso Loop Through ACL Remnant

The ACL is most commonly torn from its femoral insertion and frequently adhered on the posterior cruciate ligament[7] (Fig 1). With a motorized shaver, careful dissection of the ACL remnant is performed. Through the AM portal, a No. 2 white or co-braid ultrahigh-molecular-weight polyethylene fiber Magnum Wire (ArthroCare, Austin, TX) is introduced into the joint by use of an arthroscopic grasper. With a curved rotator cuff hook, the torn end of the ACL is sutured by a lasso-loop technique[6] (Fig 2). The free ends of the suture are retrieved through the anterolateral portal, permitting clear visualization of the medial wall of the lateral femoral condyle and of the tibial insertion of the ACL.

Femoral and Tibial Tunnel Preparation

According to the width of the prepared 4-strand hamstring tendon graft, a cannulated aiming device with the appropriate offset hook is introduced from the AM portal into the joint. Under 120° of knee flexion, a 2.7-mm guide-passing pin (Smith & Nephew Endoscopy) is drilled through the femur until it penetrates the lateral femoral cortex. A 4.5-mm cannulated drill (Smith & Nephew Endoscopy) is used over the pin to produce the first passing channel, and sequentially, another cannulated drill (Smith & Nephew Endoscopy) that matches the graft diameter is selected for the final femoral tunnel. The depth is calculated according to the ACLR technique using an EndoButton device (EndoButton CL). The free ends of a No. 2 Ethibond suture loop are advanced out the anterolateral thigh using the guide-passing pin.

Under 90° of knee flexion and through the AM portal, an ACL tibial drill guide (Smith & Nephew Endoscopy), set at 55°, is advanced into the joint. The tip of the aimer is positioned behind the remnant tissue approximately at the level of the posterior margin of the anterior horn of the lateral meniscus. A 2.4-mm guide pin is drilled into the tibia, and a cannulated reamer that matches the graft diameter is used for the final tunnel preparation. The surgeon should try to minimize iatrogenic injury to the ACL remnant during tibial tunnel drilling, to anatomically place the graft within the native ligament attachment, and to avoid undesirable impingement of the ACL graft against the lateral femoral condyle or the posterior cruciate ligament.

Graft Passage and Remnant Securing on EndoButton Device

By use of a suture retriever, the free ends of the lasso-loop sutures and of the No. 2 Ethibond suture loop that runs through the femoral socket are pulled out of the joint through the tibial tunnel. A No. 5 Ethibond suture is attached to one outside hole of the EndoButton to lead and pass the device. In addition, a trailing No. 2 polyester braided suture is attached to the opposite outside hole of the EndoButton to rotate the device as it exits the anterolateral femoral cortex. Finally, the 2 free ends of the ACL remnant suture are passed through each outside hole of the EndoButton device (Fig 3).

All the sutures (No. 5 Ethibond, No. 2 polyester braided, and ACL remnant suture) are shuttled through both tunnels (tibial and femoral) and retrieved through the lateral femoral cortex by use of the No. 2 Ethibond suture loop. The looped hamstring graft is passed through the tibial and femoral tunnels and fixed to the lateral femoral cortex by flipping the EndoButton. The graft is cycled through the full range of motion, tensioned, and secured on the tibial side in 10° to 15° of knee flexion with an interference screw. The tension and position of the graft are checked arthroscopically, and the No. 5 Ethibond and No. 2 polyester braided sutures of the EndoButton are removed.

As described earlier, the free ends of the ACL remnant suture are passed through the outside holes of the secured EndoButton. The suture end that does not pass through the ACL remnant lasso loop is provisionally pulled through the lateral femoral cortex, and the position and tension of the remnant are checked arthroscopically. Because of this configuration, non-sliding half-stitch locking knots are made to secure the suture on the EndoButton device, by use of a knot pusher (Fig 3). The end that does not form the lasso loop is used as the post. After the final configuration of ACL remnant tension, the sutures are cut with an arthroscopic suture cutter (Table 1, Video 1).

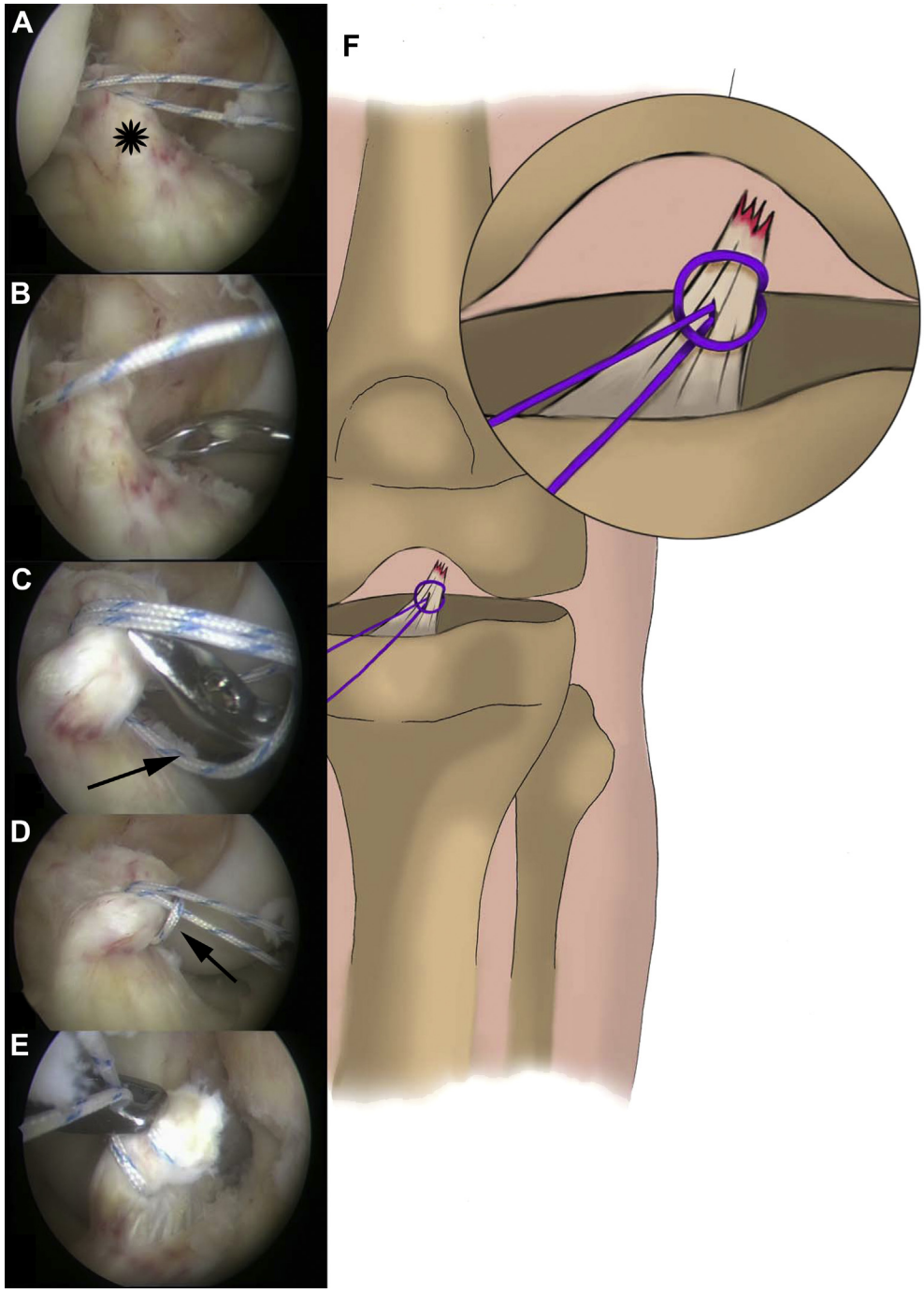

Fig 2. (A) Through the anteromedial portal, the middle of a No. 2 co-braid ultrahigh-molecular-weight nonabsorbable suture is introduced into the joint behind the anterior cruciate ligament (ACL) remnant (asterisk) using a suture retriever. (B, C) A curved rotator cuff hook is used to penetrate the mid portion of the ACL remnant and retrieve the co-braid suture, forming a loop (arrow). The rotator cuff hook is passed through the loop, and 1 free end of the suture is retrieved. (D) The torn end of the ACL is sutured using the lasso-loop technique (arrow). (E) The free ends of the suture are retrieved through the anterolateral portal, permitting clear visualization of the medial wall of the lateral femoral condyle and of the tibial insertion of the ACL. (F) Lasso-loop configuration.

Discussion

Despite numerous techniques being used in ACLR surgery, reported rates of persistent knee pain and instability symptoms range between 10% and 30% of patients, raising questions about the successful graft incorporation.[5] It has been described that the ACL is not only a mechanical stabilizer but also a sensory organ of the knee joint.[8] The ACL contains mechanoreceptors, most of which are located in the subsynovial layer near the tibial insertion, whereas most ACL ruptures occur in the proximal half at the femoral-side insertion.[5] According to Crain et al.,[7] there are 4 major patterns of ACL remnant tissue: (1) scarred to the posterior cruciate ligament, (2) scarred to the roof of the notch, (3) scarred to the lateral wall of the notch, and (4) no identifiable

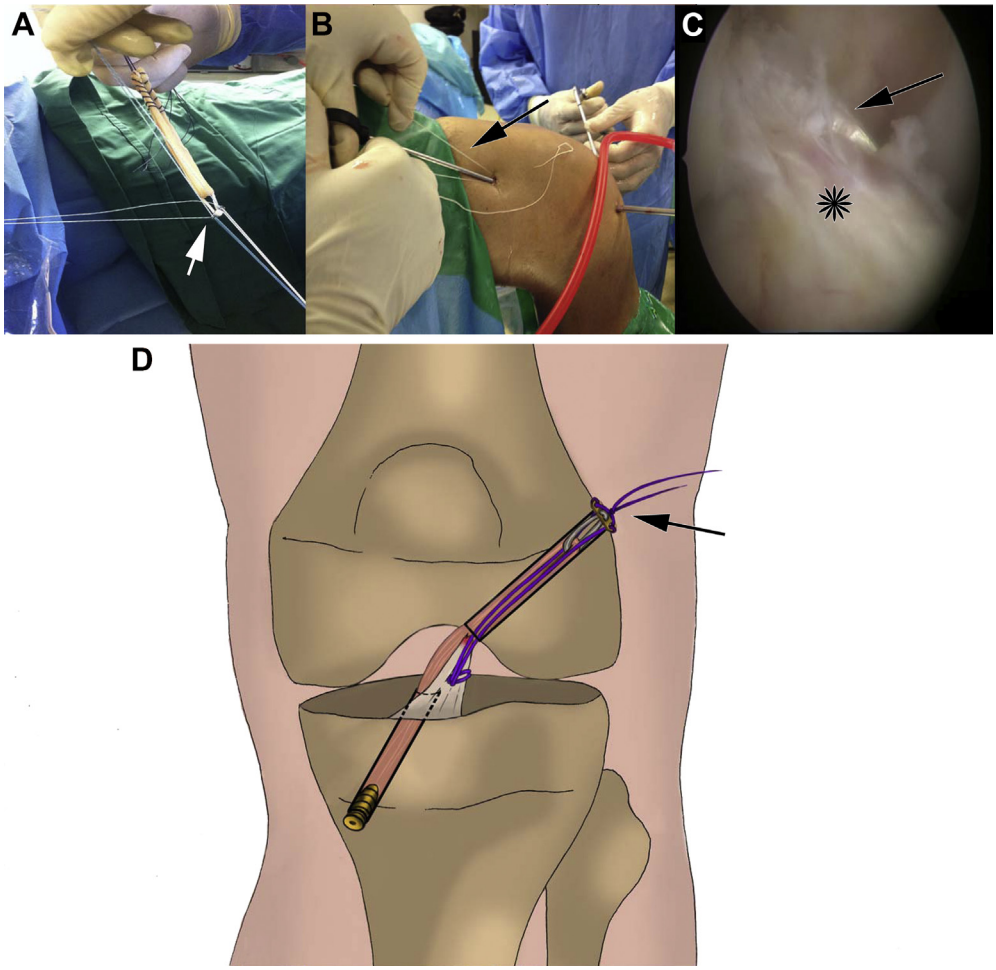

Fig 3. (A) The 2 free ends of the anterior cruciate ligament (ACL) remnant suture are passed through each outside hole of the EndoButton device (arrow). Sequentially, all the sutures and the graft are passed through the tibial and femoral tunnels. (B) Non-sliding half-stitch locking knots are made to secure the suture of the remnant on the EndoButton device, using a knot pusher. The end that does not form the lasso loop is used as the post (arrow). (C) Final arthroscopic image of ACL reconstruction using hamstring autograft (arrow) and preserving the amount of remnant tissue (asterisk). (D) Tensioned and secured ACL remnant over the EndoButton device (arrow).

ligament tissue remaining. Remnant-preserving procedures have theoretical advantages including enhancement of the biological environment, maintenance of neural elements, earlier revascularization, ligamentization of the applied autograft, and better final clinical results.[4,5,8-10]

Ochi et al.[9] described the surgical technique of preserving and augmenting the ACL remnant that remains attached to the femur. In other cases the remnant was sacrificed, and no tensioning methods were described. Similarly, Lee et al.[8] published an excellent technique that preserves the remnant. However, during their procedure, another incision is necessary on the lateral side of the femur and no sutures are passed through the remaining ACL tissue, predisposing to possible loosening. Most recently, Ahn et al.[5] reported a technique of remnant preservation and tensioning through the femoral tunnel to avoid the formation of cyclops mass lesions. However, the tunnel preparation was transtibial, and the sutures placed at the ACL remnant were simple with no interlocking fashion, predisposing to possible longitudinal tissue tearing during final tensioning.

Our technique for tensioning the preserved ACL remnant is reproducible and easy to perform with a minimally increased surgical cost and time. The non-sliding locking lasso-loop configuration provides secure tightening of the remnant at right angles with the direction of its fibers, thus preventing midsubstance tearing caused by sliding suture.[6] The remnant's tightening suture is passed through the holes of the EndoButton device together with the sutures inserted for passing the graft and flipping the EndoButton. No additional tunnel creation or pin insertion is needed, and the remnant is tensioned and secured by use of the same fixation device that is used for the ACL graft.[8] Finally, the parallel course of the graft and the remnant's sutures through the same tunnel allows the remnant to achieve better wrapping and coverage around the graft (Table 2).

Although this study is only a technical note presentation, it should be noted that it has several limitations.

Table 1. Steps of Surgical Technique

Knee joint preparation
Use standard anterolateral and anteromedial knee arthroscopic portals.
Perform arthroscopic knee joint evaluation.
Assess and address concomitant lesions initially.
Perform hamstring tendon autograft harvesting.
Suture passage and lasso loop through ACL remnant
Using a curved arthroscopic rotator cuff hook for grabbing, pass a No. 2 white or co-braid ultrahigh-molecular-weight polyethylene fiber through the ACL remnant (from the AM portal), performing a lasso-loop configuration.
Retrieve the sutures through the AL portal.
Femoral and tibial tunnel preparation using EndoButton technique
Perform femoral tunnel preparation through the AM portal (cannulated aiming device with offset, 2.7-mm guidewire, 4.5-mm drill to produce first passing channel, final drill according to graft diameter, No. 2 Ethibond loop through tunnel).
Perform tibial tunnel preparation through the AM portal (ACL tibial drill guide set at 55°, 2.4-mm guidewire, final tunnel preparation according to graft diameter).
Graft passage and remnant securing on EndoButton device
Retrieve the sutures for the ACL remnant and the suture from the femoral tunnel through the tibial tunnel.
Pass the 2 free ends of the ACL remnant suture through each outside hole of the EndoButton device.
Using the No. 2 Ethibond, retrieve all sutures through the lateral femoral cortex.
Pass the graft, and secure it using an EndoButton at the femur and an interference screw at the tibia.
Remnant fixation and knot tying
Secure the No. 2 suture (passed from remnant with lasso-loop configuration) on the EndoButton device using non-sliding half-stitch locking knots.
For the post, use the suture end that does not form the lasso loop.

ACL, anterior cruciate ligament; AL, anterolateral; AM, anteromedial.

No long-term results are available, and a blinded comparison with the standard single-bundle technique is needed. In conclusion, we believe that the described technique is easy and reproducible, with no need for special instrumentation, minimal increases in surgical time and cost, good coverage with improved biological characteristics of the inserted graft, and sufficient tensioning of the ACL remnant.

Table 2. Indications, Contraindications, Tips and Pearls, Key Points, Complications, and Advantages of Technique

Indications
ACL torn from its femoral insertion
Good-quality ACL remnant
Contraindications
Chronic tears/atrophy of ACL remnant
ACL avulsed from its tibial insertion or midsubstance tears
Tips and pearls
In many acute tears, pass the lasso-loop stitch before ACL remnant dissection.
To easily grasp the suture with the rotator cuff hook that penetrates the remnant, bring the limb into a figure-of-4 position.
During suture retrieval from the tibial tunnel, first retrieve the lasso-loop sutures.
During the knot-tying step, bear in the mind that the knot pusher has to "penetrate" the iliotibial band and secure the non-sliding knots over the EndoButton device.
Key points
The end that does not form the lasso loop is used as the post.
Experience in arthroscopic shoulder knot-tying techniques is helpful.
Complications and pitfalls
Loose remnant fixation and possible cyclops lesion formation
Advantages
Preservation of all of the available remnant
No additional tunnel drilling
High-strength locking lasso-loop configuration
No longitudinal midsubstance remnant tearing during tensioning
Securing of remnant with the same fixation device
Easy suture retrieval through tunnels
Parallel course of graft and remnant sutures
Medial-portal ACL reconstruction
Tensioning of remnant—minimizing cyclops formation
No increased cost (1 additional suture)
Easy and reproducible

ACL, anterior cruciate ligament.

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