

A Bone-Hamstring Autograft for Arthroscopic Anterior Cruciate Ligament Reconstruction



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Abstract: We describe a bone-hamstring autograft for anterior cruciate ligament reconstruction (ACLR). The semitendinosus and gracilis tendons are harvested using an open tendon stripper, keeping these distal tibial insertions intact. The bone-hamstring autograft is harvested using an oscillating saw. This modified autograft has the following advantages: (1) It possesses the potential for healing with the femur owing to its bone plug; (2) it is perfectly suited for various single-bundle reconstruction methods including oval-tunnel and rectangular-tunnel ACLR, as well as other flat ACLR methods; and (3) it is an attractive option for both primary ACLR and revision ACLR owing to its unique characteristics.

Anterior cruciate ligament (ACL) reconstruction (ACLR) is the conventional surgical approach for ACL ruptures. Single-bundle reconstruction is a well-accepted technique for ACLR. During recent decades, double-bundle ACLR has been applied widely because it focuses on re-creating both the anteromedial bundle and posterolateral bundle (PLB).¹ Recently, triple-bundle ACLR (anteromedial bundle, intermediate bundle, and PLB), which makes it possible for the grafts to run as the native ACL, has also been gradually developed.² Because it is difficult for traditional single-bundle ACLR to restore the native ACL dimensions, collagen orientation, insertion sites, and functions, an improved surgical procedure is needed. Represented by Professor Konsei Shino³ and Professor Robert Smigielski,⁴ many surgeons strongly believe that flat or

rounded rectangular single-bundle ACLR could provide a solution to mimic the native ACL.⁵

Undoubtedly, many studies have proved that double-bundle ACLR has a superior ability to maintain post-operative knee rotational stability and to delay the occurrence of knee osteoarthritis when compared with single-bundle ACLR.⁶ We have found that using an oval tunnel and bone-hamstring autograft for single-bundle ACLR, as described in this study, achieves good clinical results.

Surgical Technique

Graft Harvesting and Preparation

Under general or spinal anesthesia, the patient is positioned supine with the knee flexed to about 80°. The leg is routinely disinfected and draped. The ACL rupture, meniscal tear, and cartilage injury are identified via routine arthroscopic medial and lateral infrapatellar portals.

A 3-cm oblique skin incision is made, starting from the anteromedial tibia and extending down to the lower border of the tibial tubercle. The semitendinosus and gracilis tendons are lifted with curved forceps. These 2 tendons are then divided with scissors and released by traction. The tendons are finally taken from the muscle using an open tendon stripper (designed by W.Z.) (Fig 1).

The insertion sites of the semitendinosus and gracilis tendons are marked by an electro-tome. With a size of 12 mm × 12 mm × 5 mm (length × width × thickness), a bone block is harvested by an oscillating saw (RJ-JZ-1; Ruijin Medical Equipment, Wuhu City, China).

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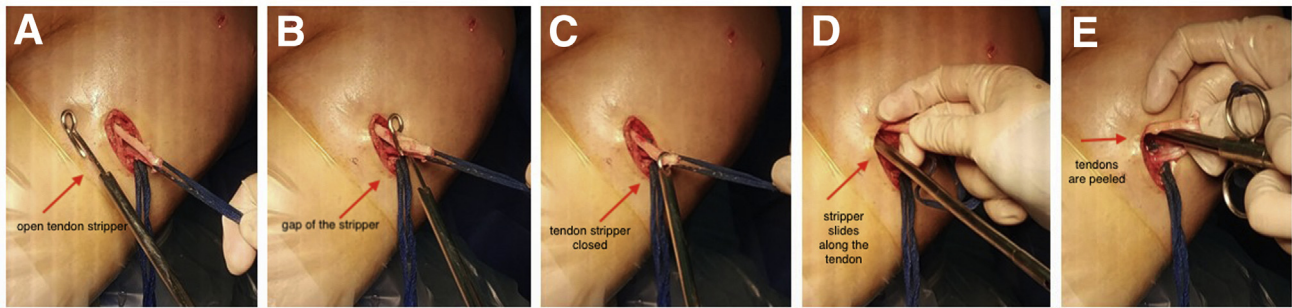


Fig 1. Harvesting the graft via medial oblique incision of left knee in the semi-flexion position. (A) Tendon stripper (designed by W.Z.), with an opening at its neck. (B) The tendon can slide into the circle of the stripper via the gap. (C) The gap of the stripper can be closed; thus, the open tendon stripper becomes a closed tendon stripper. (D) The stripper is pushed, the front end of the stripper will peel off the tendon from the muscle. (E) The tendons are peeled intact; then, the stripper slides out without soft-tissue injury.

Subsequently, we pry under the bone block with an osteotome (FORCE-FX-8c; Covidien, Medtronic, MN) and then remove the bone block, along with the tendons (Fig 2).

On the side table, the bone block is shaped neatly by a bone rongeur. After the muscles are finely removed, the tendons are fashioned into a 6-stranded graft including folded semitendinosus and folded gracilis tendons, with a total length of 7.5 to 8 cm (Fig 3).

A 2-mm hole is drilled slightly off the center in the bone block, away from the tendons. Then, the reflexed part of the tendons is whipstitched by FiberWire (AR-7200; Arthrex, Naples, FL) via the hole of the bone block, and the graft is tied up with TightRope (AR-1588BTB; Arthrex) (Fig 4).

Femoral Socket

Point A, under the resident ridge and 8 mm distal to the cross point of the femoral shaft and the posterior condylar cartilage edge, is made with an awl (Smith & Nephew Endoscopy, Mansfield, MA). Point B is also made with an awl at the cross point of the resident ridge

and a line perpendicular to the anterior edge of the posterior horn of the lateral meniscus, also known as the insertion site of the PLB in double-bundle ACLR.

A line is drawn from point A to point B as the long axis of the oval femoral socket. With the knee in the figure-of-4 position, a tunnel is created at point A in the femur by a 4-mm Kirschner wire (Jinhuan Medical Equipment, Shanghai, China). The length of the tunnel (usually between 32 and 42 mm in our patients) is measured with a depth gauge, which is used to mark the TightRope in the graft.

After the passage of a 2.4-mm Beath pin through the femoral tunnel, a cannular oval chisel (designed by W.Z.) (6 mm × 12 mm) is inserted through the Beath pin into the femur via an arthroscopic accessory medial portal. The long axis of the oval chisel is adjusted to the same direction along line AB. Then, the femoral socket is created by tapping the chisel to a 2-cm depth in the femur. Finally, the femoral socket is dilated by a chisel—usually a 7-mm × 13-mm chisel in female patients and an 8-mm × 14-mm chisel in male patients (Fig 5).

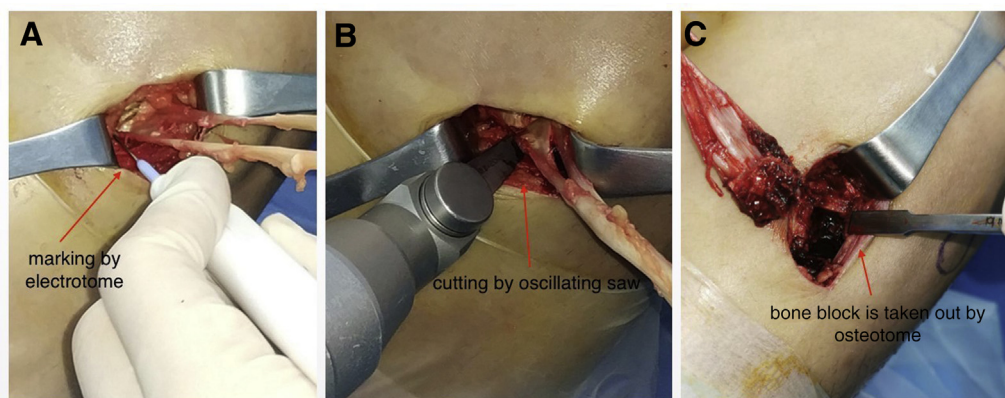
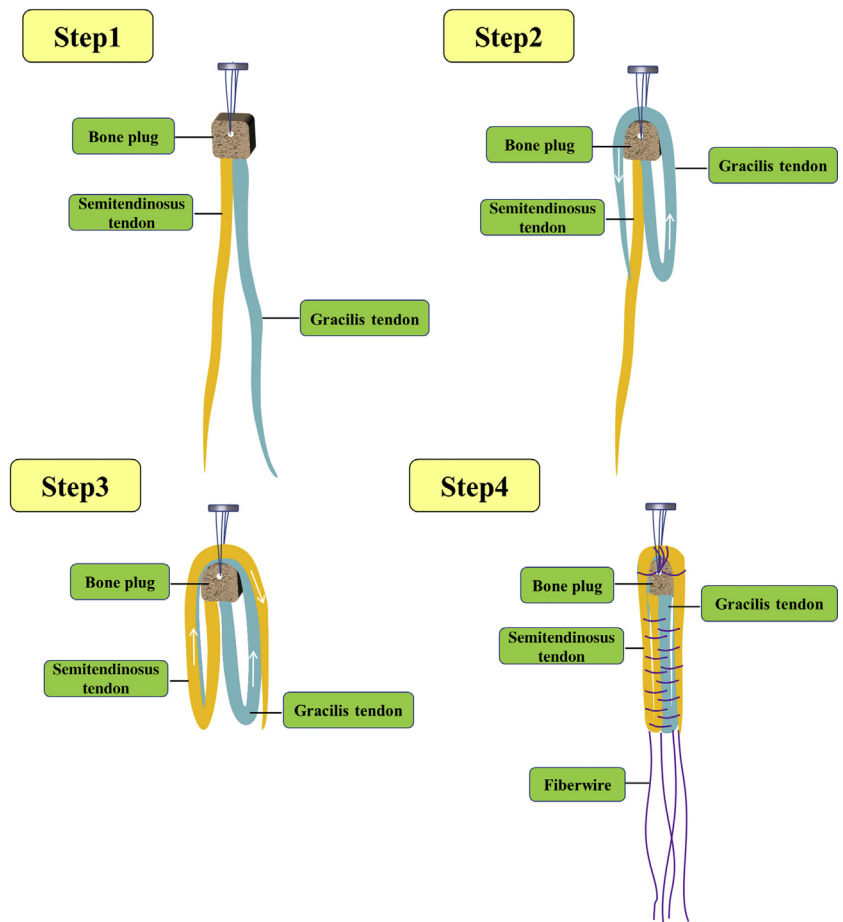


Fig 2. (A) The border of the bone block is attached to the hamstring tendon insertion and is marked by an electrode, with a size of 12 mm × 12 mm. (B) The bone block is cut by an oscillating saw along the marked line. The cutting depth is about 5 mm into the bone surface. (C) The tendons with the bone block are pried under and taken out by an osteotome.

Fig 3. In step 1, the muscle on the tendons is removed finely and the bone block is shaped to a size of 12 mm × 6 mm × 2 mm. A 2-mm hole is drilled slightly off the center of the bone block, away from the tendons, and FiberWire is used to fix the bone block and the adjustable-loop Endo-Button (Smith & Nephew Endoscopy) together (ACL TightRope RT; Arthrex) via this hole. In step 2, the semitendinosus tendon is folded across the bone block; the length is 8 cm. In step 3, the gracilis tendon is folded across the bone block to the same length as the semitendinosus. In step 4, the folded tendons are whipstitched using FiberWire.



Tibial Tunnel

The center of the tibial tunnel is located at the posterior edge of the center of the ACL “C”-attachment, and a 2.0-mm guidewire is drilled through a Director tip aimer (Acufex; Smith & Nephew Endoscopy). Along the guidewire, a tunnel is created by a drill bit (6 or 7 mm in diameter; Acufex). The tibial tunnel is first dilated with a 6-mm × 12-mm chisel and finished with a 7-mm × 13-mm chisel, with the long axis of the oval chisel parallel with the 2 horns of the ACL C-attachment (Fig 6).

Graft Insertion

The graft is pulled into the tibial tunnel in a retrograde manner. The graft is pulled distally to ensure femoral fixation when the mark on the adjustable loop reaches the entrance of the femoral socket. The adjustable loop is fastened until the entire bone block is pulled into the joint. The bone block is internally rotated 180° with a rongeur (Jinhuan Medical Equipment).

The loop is fastened continually until the second mark (2 cm from the top of the graft) reaches the edge of the femoral socket (Fig 7). Isometric testing is performed with 20 circles of full range of motion (ROM).

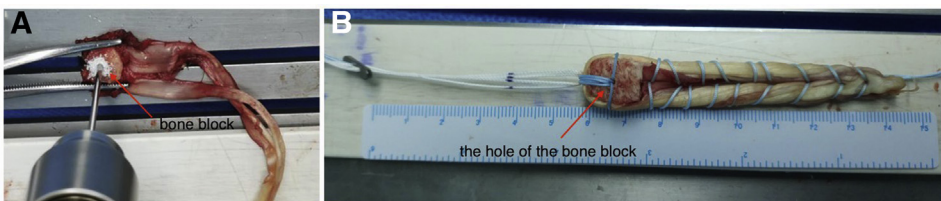


Fig 4. (A) A 2-mm hole is drilled slightly off the center of the bone block, away from the tendons. (B) The bone block and the adjustable loop (ACL TightRope RT) are fixed together via this hole.

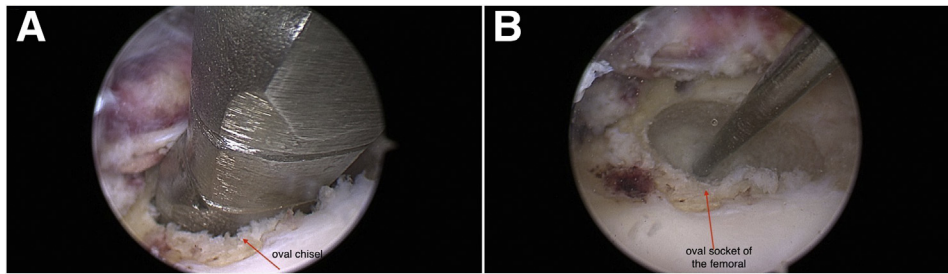


Fig 5. (A) The femoral socket is dilated by an oval chisel—usually an 7-mm × 13-mm chisel in female patients and an 8-mm × 14-mm chisel in male patients. (B) The cross section of the femoral socket is an oval, and the depth of the socket is 2 cm.

A 10-mm interference screw is used for a 7-mm × 13-mm tibial tunnel, whereas an 11-mm interference screw is used for an 8-mm × 14-mm tunnel. The position of the screw is confirmed arthroscopically to avoid intra-articular protrusion before the graft suture ends are tied over a spike-less ligament staple (AR-1006M; Arthrex) (Video 1).

Postoperative Rehabilitation

The postoperative rehabilitation protocol is as follows: A straight leg brace is worn for 6 weeks when walking; partial weight bearing is allowed for the first 2 to 3 weeks, followed by no crutches and full weight bearing for 4 weeks. Passive ROM starts from 2 days postoperatively and is performed for 2 to 3 weeks, ranging from -5° to 110° . Active ROM starts at 3 weeks postoperatively.

Discussion

Many types of grafts have been used in ACLR—autografts, allografts, and artificial ligaments—but the ideal graft, which should have structural and biomechanical similarity to the native ACL, remains debatable. Among the grafts, the most widely used are bone–patellar tendon–bone (BPTB),⁷ hamstring tendon (HT),⁸ and bone–quadriceps

tendon,⁹ as well as the recently described “half-peroneus-longus-tendon graft.”¹⁰ There are many factors that might affect graft selection, including healing, stability, pain, and revision. Traditionally, bone-to-bone healing (BPTB graft reconstruction and bone–quadriceps tendon graft reconstruction) is considerably faster and more reliable than bone-to-tendon healing (HT graft reconstruction). In addition, the bungee-cord effect and windshield-wiper effect are more prevalent with HT graft, with more obvious tunnel and/or socket enlargement, compared with BPTB graft. With BPTB graft, anterior knee pain is likely to develop and patients are at risk of patellar fracture. At the same time, the bone block for BPTB is limited in size when ACL revision is needed. HT graft reconstruction yields fewer donation-site complications.¹¹

Our bone-hamstring autograft has the advantages of BPTB graft and HT graft while avoiding their disadvantages. For example, bone-hamstring autograft has almost no limitations in terms of bone block size. Table 1 presents pearls and pitfalls, and Table 2 lists advantages and disadvantages. There is a potential risk of tibial fracture due to bone block harvesting if the position of the bone block is too close to the front edge of the tibia; however, this has never occurred. Another risk is that the reconstructed ACL may be loose if bone

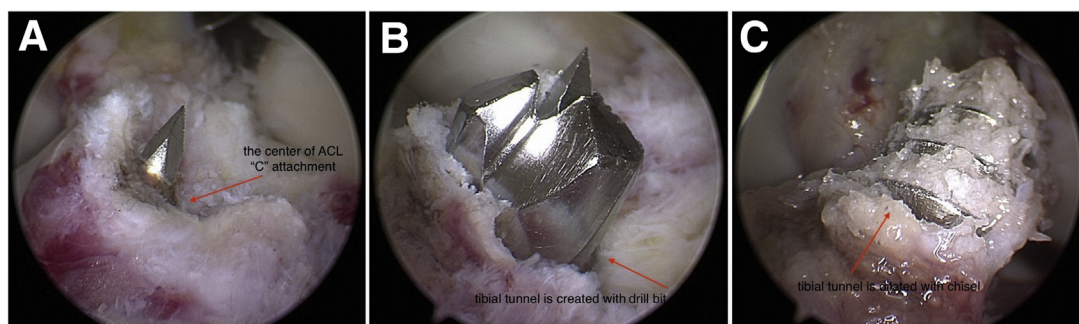


Fig 6. (A) The center of the tibial tunnel is located at the posterior edge of the center of the anterior cruciate ligament (ACL) C-attachment, and a 2.0-mm guidewire is drilled through an Acuflex Director tip aimer. (B) Along the guidewire, a tunnel is created by a drill bit (6 or 7 mm in diameter). (C) The tibial tunnel is first dilated with a 6-mm × 12-mm chisel and then finished with a 7-mm × 13-mm chisel or an 8-mm × 14-mm chisel, with the long axis of the oval chisel parallel with the 2 horns of the ACL C-attachment.

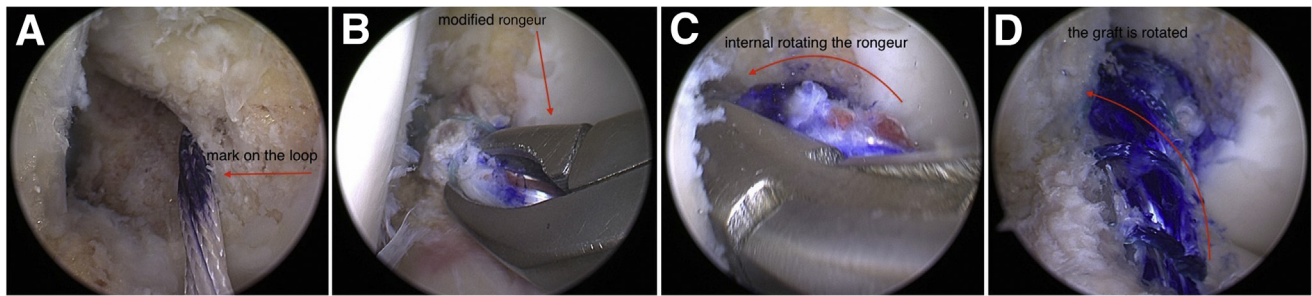


Fig 7. (A) The passing suture is pulled in a retrograde manner through the tibial tunnel and then into the femoral socket until the mark on the adjustable loop reaches the femoral socket edge. The surgeon can pull back on the graft to confirm that the button is out of the femur. (B) While slight tension is held on the graft, the graft is advanced until the entire bone block is pulled into the joint. (C) The bone block is internally rotated 180° with a rongeur. (D) The surgeon fixes the tibial end of the graft while keeping slight tension and 90° of external rotation on the graft.

Table 1. Pearls and Pitfalls

	Pearls	Pitfalls
Femoral socket	<p>The patient's leg should be placed in the figure-of-4 position.</p> <p>Two holes should be made as landmarks to adjust the long axis of the oval chisel (1 hole at the center of the PLB and 1 hole 8 mm from the junction of the shaft cortex and cartilage).</p> <p>A guide hole should be created in the femur with a 4-mm Steinmann pin.</p> <p>The chisel should be punched in to a depth of 20 mm.</p>	<p>The FiberWire that is used to fix the TightRope and bone block should be tied with at least 6 knots to prevent it from loosening.</p>
Tibial tunnel	<p>The center of the tibial tunnel should be located at the posterior edge of the center of the C-attachment with a 2.0-mm Kirschner wire.</p> <p>For a 7- to 8-mm central tunnel, dilation is performed with oval chisels measuring 6 mm × 12 mm, 7 mm × 13 mm, and 8 mm × 14 mm in sequence. A center screw is used.</p> <p>The graft is pulled into the joint in a retrograde manner, and the graft head is internally rotated 180° to fit the femoral socket.</p> <p>Fixation is performed on the tibia via an interference screw plus a staple.</p>	

PLB, posterolateral bundle; ROM, range of motion.

Table 2. Advantages and Disadvantages

Advantages

The described autograft possesses the potential for healing with the femur owing to its bone block.

It is perfectly suited for various single-bundle reconstruction methods including oval-tunnel and rectangular-tunnel ACLR, as well as other flat ACLR methods.

It is an attractive option for both primary ACLR and revision ACLR because of its unique characteristics.

Disadvantages

Although it has never occurred during our procedure, there is a potential risk of tibial fracture owing to the bone block harvesting if the position of the bone block is too close to the front edge of the tibia.

The reconstructed ACL may be loose if bone block resorption occurs postoperatively; this has never happened in our experience.

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction.

block resorption occurs postoperatively, although this has never happened in our experience.

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