Anatomic Single-Bundle Anterior Cruciate Ligament Reconstruction With Remnant Preservation Using Outside-In Technique

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Abstract: This report describes a modified anatomic single-bundle anterior cruciate ligament (ACL) reconstruction technique using the FlipCutter guide pin (Arthrex, Naples, FL) as a retrograde drill and a cortical suspensory fixation device (TightRope; Arthrex) with an adjustable graft loop length. Preservation of the ACL remnant as a biological sleeve for the graft is an important issue from the viewpoints of acceleration of revascularization and ligamentization, preservation of the proprioceptive nerve fibers, enhancement of the biological environment for healing, and maintenance of the anchor point at the native tibial attachment, in addition to yielding a lower incidence of tibial bone tunnel enlargement. The goal of our technique is to obtain some advantages of the remnant-preserving technique through an anatomic single-bundle ACL reconstruction, which is performed to minimize damage to the ACL tibial remnant.

Historically, surgical treatment for ruptures of the anterior cruciate ligament (ACL) has evolved in different ways. Recently, attention has been brought to anatomic double-bundle (DB) ACL reconstruction and the importance of anatomic tunnel placement. Advocates of the DB technique suggest that it improves rotational control and overall function and possibly decreases radiographic evidence of postoperative degenerative joint disease, although there are reports that the clinical outcomes of DB reconstruction are not always significantly different from those of single-bundle (SB) reconstruction.[1,2] The DB technique is considered complex, more time-consuming, and technically difficult. Several recent studies have shown that SB ACL grafts placed in the center of their anatomic insertions can provide nearly normal knee kinematics and the procedure was comparable with DB procedures.[3] It is difficult to restore the anatomic femoral origin of the ACL using the traditional transtibial technique despite technical modifications of the coronal angle and starting position. However, a new technique drilling from the outside in with the FlipCutter (Arthrex, Naples, FL) facilitates placement of the femoral tunnel in the correct position.[4] Recently, there has been growing interest in the potential role of the remnant of the ACL after a tear (Fig 1A). Taking these recent new trends in ACL reconstruction into consideration, we focused our technique on anatomic SB remnant-preserving drilling from the outside in with the FlipCutter.

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Surgical Technique

The patient is positioned supine, and the operative proximal thigh is fixed in a leg holder. With 90° of knee flexion and by use of leg-drop position, standard anterolateral and anteromedial (AM) portals are made and routine arthroscopy is performed.

After an arthroscopic evaluation and treatment of possible associated lesions, the semitendinosus and gracilis tendons are harvested through a small incision placed 2 cm medial to the tibial tubercle. The harvested grafts are prepared by folding them at their midsection and placing whip-stitched sutures (No. 2 Ethibond; Ethicon, Somerville, NJ) in each strand. A 4-stranded graft is sized by passing the tendons through a sizing block.

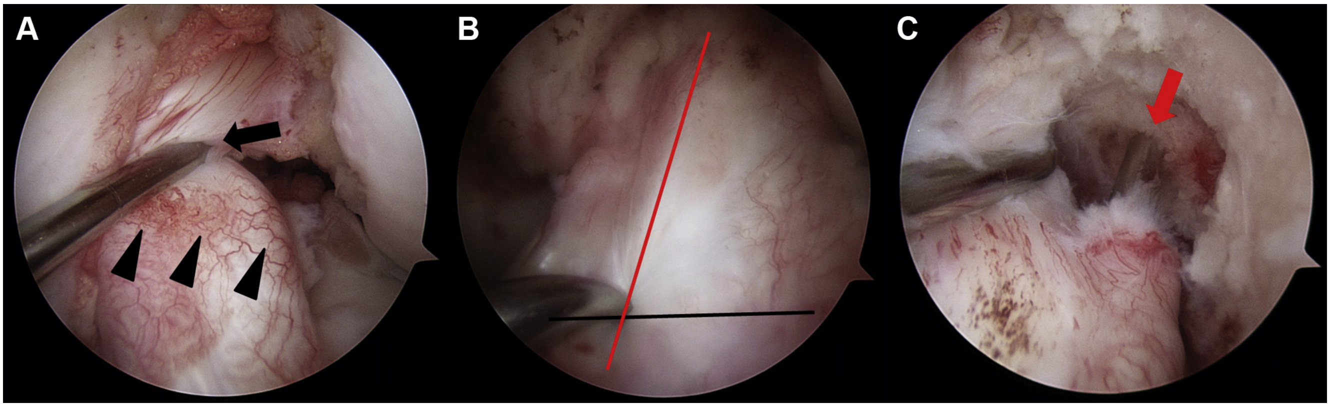

Fig 1. Tibial tunnel preparation in a left knee. (A) Arthroscopic observation of the acutely torn anterior cruciate ligament through the anterolateral portal (arrow). One should note the well-preserved tibial remnant surrounded by synovium with almost normal vascularity (arrowheads). (B) The marking hook tip of the tibial tunnel drill guide is placed in the center of the tibial insertion site, at which the midline of the medial and lateral intercondylar eminences (red line) intersects with the midline between the posterior border of the anterior horn of the medial meniscus and the posterior border of the anterior horn of the lateral meniscus (black line). (C) The guidewire (arrow) is introduced through the tibial tunnel and the anterior cruciate ligament remnant.

For tibial tunnel preparation, a tibial tunnel drill guide with a marking hook (Arthrex) is set to make a tibial tunnel with the same diameter as the hamstring graft. The intra-articular exit point of the guide pin is directed at the center of the tibial insertion site, at which the midline of the medial and lateral intercondylar eminences (about 5 mm lateral to the medial tibial spine) intersects with the midline between the posterior border of the anterior horn of the medial meniscus and the posterior border of the anterior horn of the lateral meniscus (Fig 1B, Table 1). The pointed tip of the marking hook is placed, a 3.2-mm guidewire is passed into the base of the tibial insertion site, and reaming is performed with a cannulated reamer (Fig 1C). The tunnel is drilled carefully under arthroscopic control in millimeter increments. Perforation of the tibial intercondylar eminence has to be performed at low speed under visual control and must be stopped immediately after the joint has been entered to avoid any damage to the tibial stump.

The proximal end of the remnant tibial stump is minimally debrided with a shaver and a thermal device to expose and identify the anatomic insertion sites of the AM and posterolateral (PL) bundles. The lateral intercondylar ridge and the lateral bifurcate ridge, which separates the AM and PL footprints at the femoral attachment, are identified and used as landmarks for femoral tunnel placement (Fig 2A). A mark for the femoral tunnel is then placed centrally between the AM and PL footprints. The femoral outside-in guide with its target pin is positioned on the previously marked ACL footprint center between the AM and PL footprints. The FlipCutter is inserted into the joint through a guide sleeve over the shoulder of the lateral femoral condyle (Fig 2 B and C). The blade is rotated 90° into the cutting position using a probe and is locked into position by rotating the blue hub clockwise (Fig 2D). Continued forward drilling with a retrograde force is applied to a depth of 25 mm. The FlipCutter is then removed after setting the blade upright. The looped wire is passed into the joint and retrieved through the tibial tunnel.

Table 1. Key Points

The intra-articular exit point of the guide pin should be directed at the center of the tibial footprint, at which the midline of the medial and lateral intercondylar eminences (about 5 mm lateral to the medial tibial spine) intersects with the midline between the posterior border of the anterior horn of the medial meniscus and the posterior border of the anterior horn of the lateral meniscus.
Drilling of the tibial tunnel has to be performed at low speed under visual control and should be stopped immediately after the joint has been entered to avoid any damage to the tibial stump.

The 4-stranded autogenous hamstring graft is passed from the tibial tunnel to the femoral tunnel using 2 leading sutures (Fig 3A). Once the graft is secured, it lies inside the intact ACL stump with circular synovial coverage of its major part. Once the button has been flipped, the operator pulls hard on the graft to ensure solid femoral fixation (Fig 3B) and applies tension back and forth on each free end of the femoral pull suture (TightRope; Arthrex), tensioning the graft up into the socket until the graft reaches the socket orifice (Fig 3C). After graft passage, pre-tensioning of the graft is performed (Fig 3D). Double tibial fixation is performed with a bioabsorbable interference screw and a spiked washer and screw. All the aforementioned procedures are summarized in Video 1.

Discussion

ACL reconstruction has progressed from the transtibial placement of isometric SB grafts to the complex

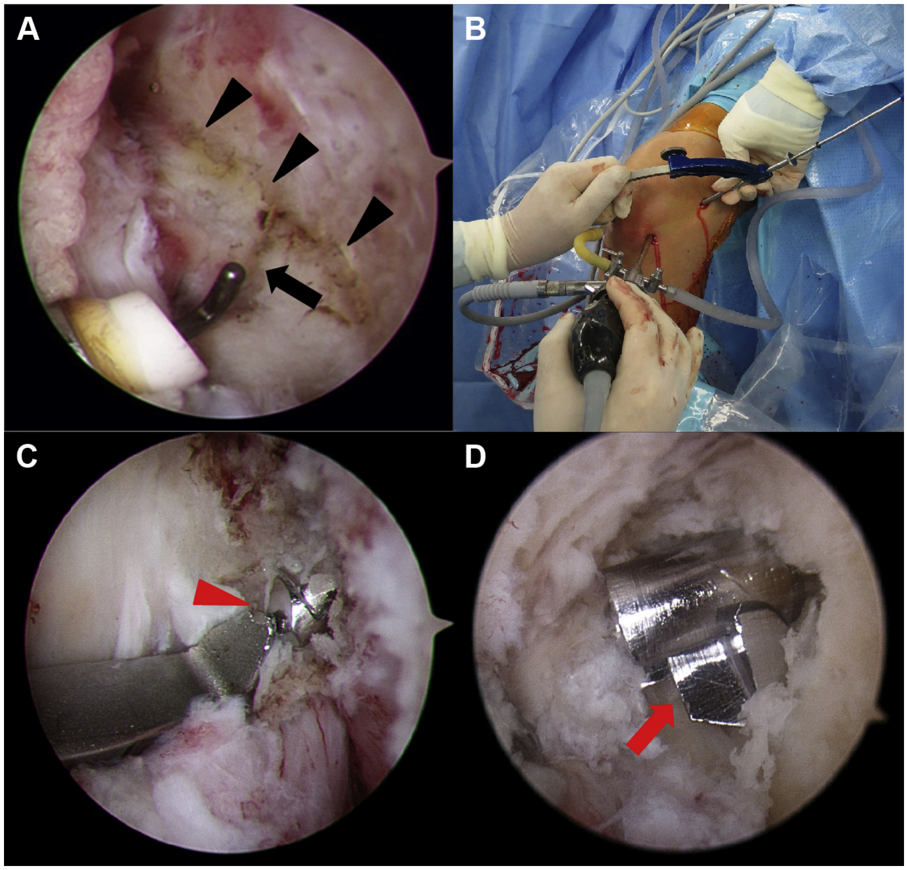

Fig 2. Femoral socket preparation. (A) Bony anatomy at anterior cruciate ligament (ACL) femoral insertion site. The lateral intercondylar ridge (arrowheads) delineates the upper margin of the ACL femoral insertion, whereas the lateral bifurcate ridge (arrow) separates the anteromedial bundle from the posterolateral bundle. (B) The FlipCutter guide pin sleeve has been impacted into the femoral cortex and is held in place. (C) The femoral outside-in guide with its target pin (arrowhead) has been positioned in front of the anatomic footprint of the ACL. (D) The femoral socket has been drilled in a retrograde manner with the blade rotated 90° into cutting position (arrow).

surgical procedure of DB reconstruction. With increasing study, more has become understood about the anatomy of the ACL, and nonanatomic femoral tunnel placement has been recognized as one of the most common causes of failed ACL reconstruction. Traditionally, nonanatomic and isometric SB ACL reconstructions were successful in restoring anterior stability to the knee but not in restoring rotational stability, as evidenced by the pivot-shift phenomenon. The insufficient control of rotational laxity led to the development of DB ACL reconstruction.[1]

Recent studies comparing anatomic SB reconstruction with DB reconstruction support the argument that DB reconstruction may not be a better method to restore knee stability. Anatomic SB reconstruction is a relatively easy, reproducible technique that has few complications and a minimal learning curve, whereas anatomic DB reconstruction is not only technically difficult but also inappropriate in patients who have small or narrow intercondylar notches.

When using the traditional transtibial technique, it is difficult to restore the anatomic femoral origin of the ACL because of tibial constraint when performing femoral drilling, despite technical modifications of the coronal angle and starting position. Therefore the desire to perform independent drilling during femoral tunnel formation has prompted interest in both the transportal technique and the outside-in technique.[4]

A new technique drilling from the outside in with the FlipCutter is another method for placing the femoral tunnel in the correct position without putting the knee in a position of hyperflexion.[4] The anatomic position may be determined precisely when viewing from the AM portal. Avoiding the hyperflexion position makes it easier to convert from the transtibial technique. Second-generation buttons (TightRope; Arthrex) have graft loops that are adjustable in length, such that after the button flips and becomes fixed on the cortex, the graft loop may be tightened, pulling the graft into the socket in a manner that completely fills the socket with graft substance. When performing this technique, tibial tunnel placement is important. For maximal preservation of the remnant, the aiming point should be the center of the ACL footprint.

Recently, there has been great interest in the potential role of the remnant of the ACL after a tear. The presence of mechanoreceptors in the ACL has led several authors to suppose that these receptors influence motor function and, conversely, that their loss leads to dysfunction.[5] A study has reported that knee proprioception, rather than clinically satisfactory mechanical restoration, is more closely related to both the

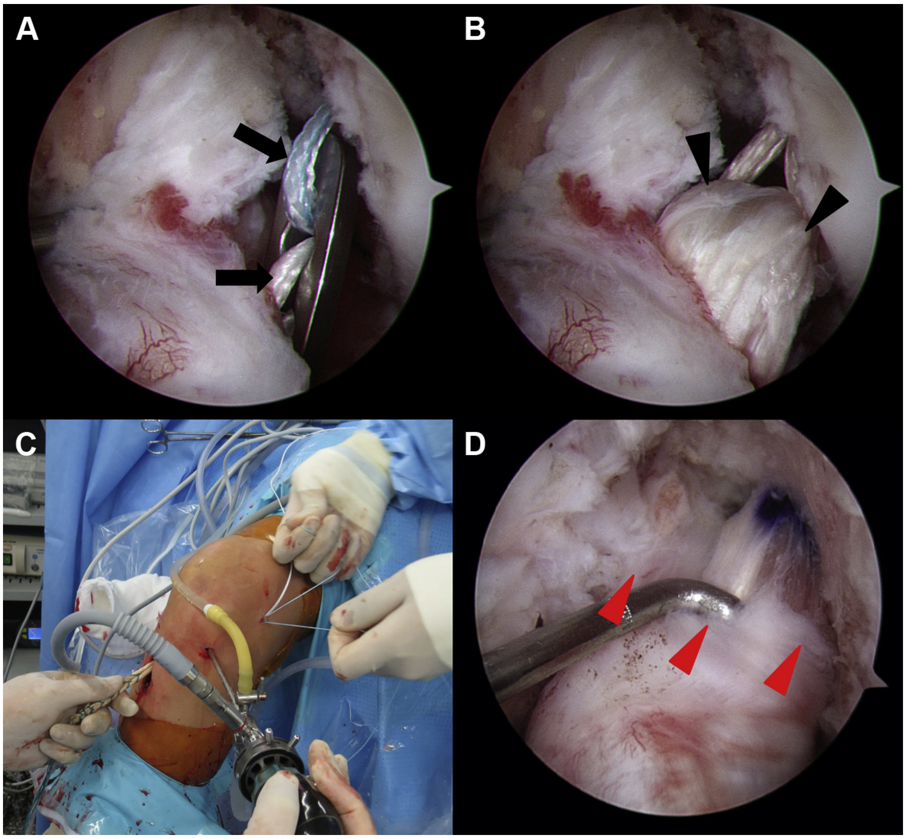

Fig 3. Passage of graft and fixation. (A) The graft is passed from the tibial tunnel to the femoral tunnel using 2 leading sutures (arrows). (B) Hamstring graft (arrowheads) routed through tibial remnant. (C) Tension is applied back and forth on each free end of the femoral pull suture, tensioning the graft up into the socket until the graft reaches the socket orifice. (D) Final arthroscopic view with graft covered by synovial sleeve of tibial remnant (arrowheads).

functional outcome and patient satisfaction after ACL reconstruction.[6] Preservation of the ACL remnant as a biological sleeve for the graft is an important issue from the viewpoints of acceleration of revascularization and ligamentization, preservation of the proprioceptive nerve fibers, enhancement of the biological environment for healing, and maintenance of the anchor point at the native tibial attachment, in addition to yielding a lower incidence of tibial bone tunnel enlargement.[6] Therefore it may seem reasonable to preserve the remnant stump of the injured ACL during reconstruction. Some authors have shown better results with augmentation of the ACL and preservation of the remnant stump.[6,7]

In conclusion, the devised surgical procedure based on a combination of anatomic SB ACL reconstruction and remnant preservation using an outside-in technique is a suitable reconstruction method for patients who have ACL insufficiency.

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