Combined Anatomic Anterior Cruciate Ligament and Double Bundle Anterolateral Ligament Reconstruction

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Abstract: The results of arthroscopic anterior cruciate ligament (ACL) reconstruction are so far satisfactory and improving over time as a result of the improved understanding of the anatomy and biomechanics of the ACL. Rotational instability confirmed by a positive pivot shift is present in more than 15% of cases who underwent successful ACL reconstruction. Persistent rotational instability interferes with performing pivoting sports, and also may lead to meniscal and chondral injuries, or re-rupture of the reconstructed ACL. Surgeons reconsidered the anatomy and biomechanics of the ACL and introduced the double bundle ACL reconstruction technique aiming to achieve a more rotational control by reconstructing the anteromedial and anterolateral bundles of the ACL. To date, the results of double bundle ACL reconstruction are mixed and inconsistent. The improved understanding of the existence, function, and biomechanical role of the anterolateral ligament (ALL) in controlling the rotational instability of the knee has redirected and refocused attention on a supplemental extra-articular reconstruction of the ALL in conjunction with the intra-articular ACL reconstruction so as to restore normal kinematics of the knee. In this Technical Note, we describe a technique that allows for a combined ACL and double bundle ALL reconstruction using autogenous hamstring graft (semitendinosus and gracilis) tendons. This technique is an extension of our previously described technique of a combined anatomic ACL and single bundle ALL reconstruction. The improved understanding of the anatomy of the ALL makes a double bundle ALL reconstruction more anatomic than single bundle ALL reconstruction, as the native ALL is triangular or inverted Y in shape, with a narrow proximal femoral attachment and a broad distal tibial attachment between Gerdy's tubercle and the head of the fibula.

Anterior cruciate ligament (ACL) reconstruction is a common surgical procedure performed by orthopaedic surgeons, particularly in association with sports-related injuries.[1] ACL injury is one of the most frequent sports injuries, with an incidence of approximately 35/100,000 people per year.[2]

Historically before the advent of arthroscopy, ACL-deficient knees were managed with extra-articular lateral reconstruction. Several techniques have been described for extra-articular lateral reconstruction.[3-6] Rotational instability in ACL-deficient knees was the main concern, and it was thought that controlling rotational instability would ensure knee stability.[7] The results of all these techniques of isolated extra-articular lateral reconstruction were mixed, and some authors have reported high failure rate with recurrent instability.[5,8,9] Also many complications were associated with isolated extra-articular lateral reconstruction, such as secondary degenerative changes in the lateral compartment of the knee due to increased stresses as a result of overtightening of the lateral compartment.[10] Inability to control anterior tibial translation whilst maintaining rotational instability was also reported.[11] Donor site morbidity and cosmetic concerns have also been described.[9,12] Attention was then directed toward intra-articular ACL reconstruction. The results thus far are satisfactory, reliable, and improving over time, but persistence of rotational instability has been confirmed by a positive pivot shift in more than 15% of cases of successfully reconstructed ACL.[13-16] ACL anatomy and biomechanics were reconsidered by surgeons, and this led to the introduction of double bundle ACL

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Table 1. Advantages and Limitations of the Technique

Limitations	Advantages
• Graft too short (<24 cm)	• ACL and ALL reconstruction with autologous graft • No need for knee hyperflexion while working on the femoral ACL footprint. The work can be done in 90° knee flexion with a clear visualization condition and without the need for special instruments (e.g., flexible instruments).The foot rests on the table, so there is no need to carry the limb • Femoral guide pin insertion and femoral tunnel creation are performed using an outside-in technique, so no hazards of injuring the skin, the medial femoral condyle, the medial meniscus, common peroneal nerve, blood vessels, or the lateral collateral ligament • Femoral graft fixation is performed using an outside-in technique, so no fear of loss or breakage of the screw inside the joint. No fear of screw wrapping around the graft or injuring the graft fibers • A U-shaped loop for ACL tibial fixation adds extra length to the graft • ALL reconstruction is performed in an anatomic manner. The double bundle ALL reconstruction is similar to the native ALL anatomy, with a broad tibial attachment to mimic the triangular shape of the ALL • No implant is used for tibial ALL fixation, as the 2 bundles of the ALL are tied on a bony bridge on the medial tibial cortex • A single femoral tunnel and a single femoral fixation implant are used for both the ACL and ALL with little morbidity to the patient and with little cost • The ITB is left intact so no fear of lateral thigh hematoma formation or muscle herniation • This technique is suitable for skeletally immature patients

ACL, anterior cruciate ligament; ALL, anterolateral ligament; ITB, iliotibial band.

reconstruction, aiming to control this persistent rotational instability.[17] Double bundle ACL reconstruction has yielded mixed and inconsistent results to date, besides being a more difficult technique than single bundle ACL reconstruction with double cost and double operative time.[18]

Several studies have been published recently regarding the presence, anatomy, function, arthroscopic and radiographic assessment of the anterolateral ligament (ALL), and also highlighting the biomechanical role of the ALL in controlling knee internal rotation. This has renewed and redirected attention toward combining the anatomic extra-articular reconstruction of the ALL in conjunction with the standard intra-articular anatomic ACL reconstruction so as to prevent persistence of the pivot shift.[19-28]

Some techniques have been recently published addressing a combined anatomic reconstruction of both the ACL and ALL by using either the iliotibial band[29] or hamstring tendons, and by using the semitendinosus tendon for ACL reconstruction and the gracilis tendon for ALL reconstruction.[30-32] We have recently described a technique for a combined ACL and ALL reconstruction by using hamstring tendons in a way that both semitendinosus and gracilis tendons are used for both ACL and ALL reconstruction, but ALL reconstruction is performed in a single bundle manner.[33]

In this Technical Note, we could modify and extend our previously described technique and get benefit of both semitendinosus and gracilis tendons to reconstruct the ALL in a double bundle manner that is more anatomic.

Surgical Technique

This Technical Note describes step-by-step combined ACL and ALL reconstruction using a hamstring graft (Video 1). The ALL is reconstructed in a double bundle manner. The advantages and limitations are summarized in Table 1, and the pearls and pitfalls are summarized in Table 2.

Indications for a combined procedure included 1 or more of the following criteria[32]: grade 3+ pivot shift, chronic ACL lesion, ACL revision, high level of sporting activity and pivoting sports, associated Segond fracture, and lateral femoral notch sign on radiographs.

Patient Position and Surgical Landmarks

After induction of anesthesia, the patient is placed in the supine position. Landmarks for the three arthroscopic portals are performed: a high anterolateral (HAL) portal, a high anteromedial (HAM) portal, and an accessory anteromedial portal (AAM), and also landmarks for the ALL reconstruction are drawn (Fig 1 A and B). The patient is examined under anesthesia. A high thigh nonsterile padded tourniquet is then applied. The patient is then prepped and draped in the usual manner.

Graft Harvesting and Preparation

While the patient is supine, the limb is put in a 90° flexed position. A small incision (2-3 cm) is made at the medial aspect of the proximal tibia. Semitendinosus and gracilis tendons are identified after incising the sartorial fascia. The 2 tendons are harvested with an open-type striper (Arthrex, Naples, FL) (Fig 2 A and B). The 2 tendons are amputated as distal as possible with a sleeve of periosteum so as to gain the maximum length and to improve healing (Table 2). Muscle fibers are removed from the tendons. The length and diameter are determined (Fig 2 C and D). This graft preparation allows us to obtain an ACL graft with a diameter of 8 to 9 mm.

Arthroscopic ACL Reconstruction

Routine knee arthroscopy is performed by viewing through the HAL portal and working through any of the 2 medial portals (Karl-Storz, Tuttlingen, Germany). Any chondral or meniscal pathology is managed.

Table 2. Surgical Steps, Pearls, and Pitfalls

Surgical Steps	Pearls	Pitfalls
• Graft harvest	• Use an open striper to free the graft proximally; then the graft is freed as distal as possible to gain as much length as possible • The graft is harvested distally with a periosteal sleeve to help in healing	• Premature cut of the graft or a too short graft will interfere with this technique
• Tibial guide pin insertion	• It is inserted with the use of an ACL guide with the knee in 70° to 80° flexion for proper visualization	• Knee flexion >80° will draw the ligamentum mucosa and infrapatellar fat pad into the notch making visualization difficult
	• It is inserted before making the femoral tunnel so as to ensure the optimal condition of visualization	• It may be difficult to localize the anatomic ACL tibial point after drilling of the femoral tunnel due to loss of joint distension and because of the bone debris
• Tibial tunnel creation	• It is made after creating the femoral tunnel	• If done before the femoral tunnel, this will lead to loss of fluid and joint distension with bad visualization
• Wire loop passage	• Two wire loops are inserted from outside into the femoral tunnel • A probe is inserted through the AM portal to transport the wire loops from the posteriorly located femoral tunnel aperture to the anteriorly located tibial tunnel aperture (Aperture-to-Aperture transport) where they can be easily retrieved through the tibial tunnel outside the joint • The first wire loop is used to shuttle an Ethibond strand to accurately measure the total required length for ACL and ALL reconstruction. The second wire loop is used to shuttle the traction sutures of the graft	
• ACL tibial fixation	• It is important to ensure that the U-shaped loop rests completely on the tibial cortex without any prominence	• A prominent loop may lead to graft slackening after femoral fixation • A prominent loop causes discomfort and anterior knee pain with further need of removal
• Femoral fixation	• A biodegradable screw of the same graft size with 25 mm length is used • The screw is inserted in the anterior or proximal half of the femoral tunnel	• If a longer screw is used, it may protrude inside the joint causing fritting and tear of the graft • Insertion of the screw into the posterior or distal half of the femoral tunnel will impinge on the remaining part of the graft that will be used for ALL reconstruction, and also will shorten it
	• Final seating of the screw is done while the scope in the knee to ensure graft tension	• If final tightening was done while the scope was not in the knee, the ACL graft might be lax and this would require removal and reinsertion of the screw
• ALL tibial tunnel drilling	• ACL guide is used to direct the 2 ALL tibial tunnels away from the ACL tibial tunnel	• If the ALL tibial tunnels are not well directed, connection with the ACL tibial tunnel may occur with ACL graft injury

ACL, anterior cruciate ligament; ALL, anterolateral ligament; AM, anteromedial; ROM, range of motion.

A tibial guide pin is inserted in the anatomic tibial footprint of the ACL by using a tip aimer ACL tibial guide (Acufex, Smith & Nephew, Andover, MA) that is inserted through the AAM portal with the knee in 70° to 80° flexion; we avoid more flexion than 80° so as to prevent impairment of visualization by the ligamentum mucosa and infrapatellar fat pad (Table 2). The leg hangs off the table, whereas the foot is supported by the surgeon's knee (Fig 3A). The tibial anatomic point lies in the center of the tibial footprint of the ACL, in line with the posterior border of the anterior horn of the lateral meniscus, between the medial and lateral tibial spines (Fig 3 B and C).

The anatomic femoral ACL attachment point is determined by viewing through the HAM portal to have an enface view of the medial wall of the lateral femoral condyle. It is necessary to have a clear view of the medial wall of the lateral femoral condyle up to the distal and posterior femoral condyle cartilage. There is no need for knee hyperflexion; just the knee is flexed 90° and the foot rests on the table (Fig 3D). The femoral ACL anatomic point lies on the medial wall of the lateral femoral condyle (LFC), posterior to the resident's ridge, just proximal to the cruciate ridge and next to the femoral condyle articular cartilage. The anatomic point for the femoral attachment of the ALL is located

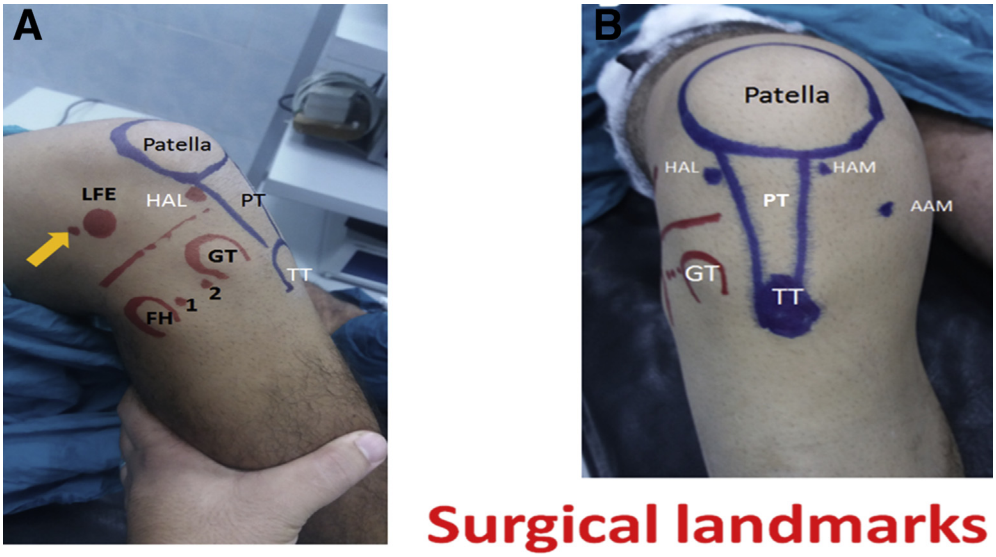

Fig 1. Surgical landmarks. (A) Lateral image of the right knee with the patient supine showing the landmarks for ALL reconstruction. The dotted red line represents the joint line. The red points numbered 1 and 2 represent the sites for the guide pins of each bundle of the ALL. (B) Front image of the right knee with the patient supine showing landmarks for the arthroscopic portals. (AAM, accessory anteromedial portal; ALL, anterolateral ligament; FH, fibular head; GT, Gerdy's tubercle; HAL, high anterolateral; HAM, high anteromedial; LFE, lateral femoral epicondyle; PT, patellar tendon and the patella; TT, tibial tuberosity.)

on the lateral wall of the LFC, just proximal and posterior to the lateral femoral epicondyle. The ALL femoral landmark can be marked with an electric cautery after incising skin and the iliotibial band down to bone. Skin incision is centered over the previously determined skin landmark.

The femoral tunnel creation is performed by the outside-in technique. A standard tip aimer ACL tibial guide is used after adjusting its angulation (Acufex, Smith & Nephew). The ACL guide is inserted through the HAL portal, whereas the scope is in the HAM portal. The tip of the aimer is inside the joint at the previously determined anatomic ACL femoral point on the medial wall of the LFC, whereas the tip of the guide sheath is outside the joint and rests directly on bone on the previously determined anatomic ALL point on the lateral wall of the LFC. A guide pin is drilled from outside in (Fig 3 D-F). The femoral tunnel is created using a drill bit of the same diameter of the graft. A curette is inserted through the AAM portal while drilling the femoral tunnel to protect the medial femoral condyle and the posterior cruciate ligament. The knee is flexed 90° and the foot rests on the table (Fig 4A).

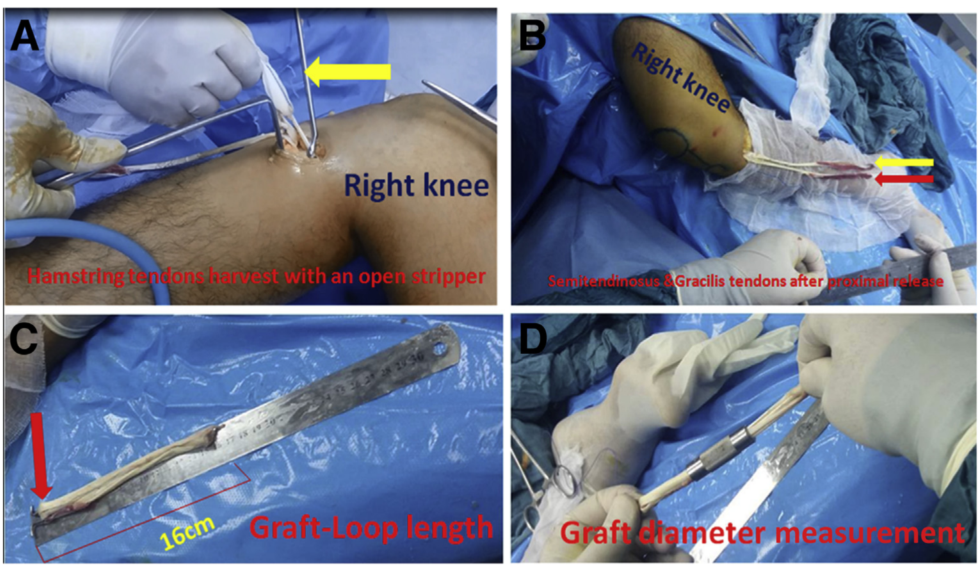

Fig 2. Steps of hamstring graft harvesting and preparation from the right leg; the patient is supine. (A) Semitendinosus and gracilis tendons are identified and harvested with an open striper through a small incision in the proximal tibia. (B) The 2 tendons are released from their proximal attachment. The red arrow points to the semitendinosus and the yellow arrow points to the gracilis tendons. (C) The 2 tendons are doubled over the U-shaped loop (red arrow), and the whole length is measured. (D) The diameter of the doubled tendons is measured.

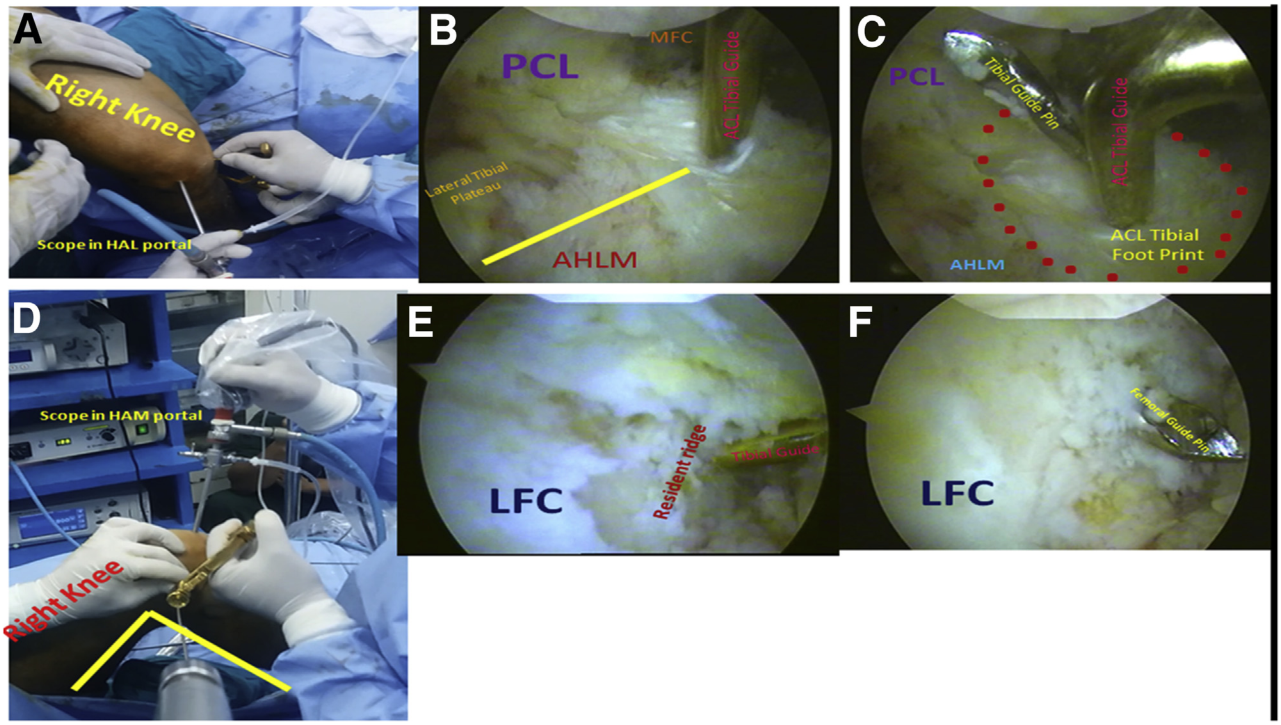

Fig 3. Knee position and arthroscopic landmarks for the femoral and tibial tunnel position. (A) Image of the right knee with the leg hanging off the table and the foot supported by the surgeon's knee. Viewing through the HAL portal with the standard tibial guide in the AAM portal. (B) Arthroscopic view of the right knee showing the tip of the standard ACL tibial guide in the anatomic tibial footprint of the ACL in line with the posterior border of the anterior horn of the lateral meniscus (AHLM) (yellow line), while viewing through the HAL portal. (C) Arthroscopic view of the right knee while viewing through the HAL portal showing the tibial guide and the tibial guide pin in the anatomic tibial footprint of the ACL; the tibial ACL footprint is outlined with a red dotted circle. (D) Image of the right knee on the supine position while the knee is flexed 90° (the 2 yellow lines) and the foot rests on the table while viewing through the HAM portal showing outside-in drilling of the femoral guide pin. (E) Arthroscopic view of the right knee while viewing through the HAM portal showing the medial wall of the lateral femoral condyle and the tip of the standard ACL tibial guide in the anatomic point of the femoral attachment of the ACL on the medial wall of the lateral femoral condyle, posterior to the resident ridge. The guide is introduced through the HAL portal. (F) Arthroscopic view of the right knee while viewing through the HAM portal showing the medial wall of the lateral femoral condyle with the tip of the femoral guide pin in the anatomic femoral attachment of the ACL. (AAM, accessory anteromedial portal; ACL, anterior cruciate ligament; HAL, high anterolateral; HAM, high anteromedial, LFC, lateral femoral condyle; MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

The shaver (Stryker, Kalamazoo, MI) can be inserted through the femoral tunnel from outside to clear the tunnel from bone debris. The integrity of the whole circumference of the tunnel walls is checked (Fig 4B).

The tibial tunnel is performed while viewing through the HAL portal. A curette is inserted through the AAM portal for protection while drilling the tunnel (Fig 4C).

After finishing the femoral and tibial tunnels, 2 wire loops are inserted into the femoral tunnel from outside into the knee joint (Table 2). A probe is inserted from the AAM portal to pull the wire loops from the femoral tunnel intra-articular aperture till the tibial tunnel intra-articular aperture "Aperture-to-Aperture transport" where they can be easily retrieved outside the joint with a grasper or a probe through the tibial tunnel (Video 1) (Table 2). One of the 2 wire loops is used to measure the length of the graft that is required for ACL and ALL reconstruction. This is done by shuttling the free ends of a doubled Ethibond strand, and then marking the length required for the ACL and the length of the 2 bundles of the ALL (Fig 5 A and B). Then the available graft length is evaluated (Fig 5C). In most cases the graft length is sufficient with a minimum of 15 mm length of the graft within the ALL tibial tunnels. If the length of the graft is less than the measured total length for ACL and ALL reconstruction, we can increase the length of the graft by using a longer U-loop or we can slide the 2 tendons over each other for a distance of 2 to 3 cm before being doubled over the U-shaped loop. The graft is then stitched with No. 2 Vicryl (Fig 5D). Ethibond No. 5 is attached to the end of the graft to be used as a traction suture. The second wire loop is used to shuttle the free tails of the Ethibond that is attached to the end of the whole graft (Fig 5E). The graft is passed through the tibial and femoral tunnels by pulling on the Ethibond till the U-shaped loop that is attached

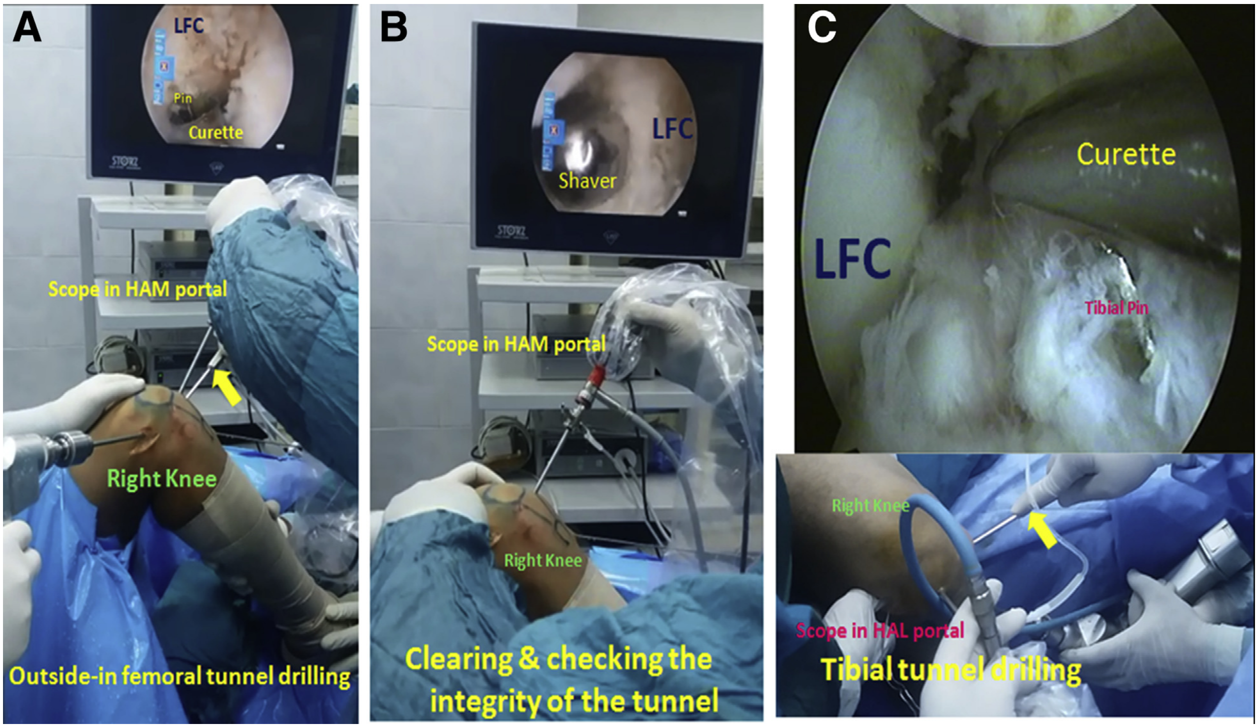

Fig 4. Knee position while creating the femoral and tibial tunnels. (A) Image and arthroscopic view of the right knee with the patient supine and knee flexed 90°; the foot rests on the table, and skin and iliotibial band (ITB) are incised down to bone. Skin incision is centered over the previously determined skin landmark on the lateral femoral epicondyle. The femoral tunnel is created from outside in with a drill bit of the same graft diameter, while viewing through the HAM portal and with a curette inserted through the AAM portal for protection (yellow arrow). (B) Image and arthroscopic view of the right knee with the patient supine and knee flexed 90°; the foot rests on the table, and a shaver blade can be inserted from outside into the femoral tunnel so as to clear the tunnel from bone debris and to check the integrity of its walls. The femoral tunnel is created connecting the anatomic femoral attachment of the ALL on the lateral wall of the lateral femoral condyle, just proximal and posterior to the LFE to the anatomic femoral attachment of the ACL on the medial wall of the lateral femoral condyle. (C) Image and arthroscopic view of the right knee with the patient supine and knee hanging off the table with the foot of the patient being supported by the surgeon's knee. The scope is in the HAL portal; a curette is inserted from the AAM portal for protection (yellow arrow), while drilling the tibial tunnel with a drill bit of the same graft diameter. (AAM, accessory anteromedial portal; ACL, anterior cruciate ligament; ALL, anterolateral ligament; HAL, high anterolateral; HAM, high anteromedial, LFC, lateral femoral condyle; LFE, lateral femoral epicondyle.)

to the other end of the graft that rests on the medial cortex of the tibia (Video 1).

While maintaining traction on the graft, the knee is cycled to tension the graft and then an outside-in biodegradable interference screw of the same graft size (25 mm, Smith & Nephew) is used to fix the graft in the femoral tunnel with the knee in 30° of flexion. Care must be taken to insert the screw in the proximal or anterior half of the femoral tunnel so as not to impinge on the remaining extra-articular part of the graft that will be used for ALL reconstruction, and also to save length (Fig 6A) (Table 2). The screw is fully tightened and the graft tension is assessed with a probe.

Extra-articular ALL Reconstruction

The length of the extra-articular part of the graft is evaluated (Fig 6B); then a small incision is made midway between the head of the fibula and Gerdy's tubercle (Fig 6C). A tip aimer ACL guide (Acufex, Smith & Nephew) is used after adjusting its angulation to pass 2 parallel guide pins anterior and posterior to a point midway between the head of the fibula and Gerdy's tubercle at least 10 mm apart, and at approximately 5 to 10 mm from the joint line to exit the superomedial tibial cortex below the ACL tibial tunnel (Fig 6 D and E). An all-through tunnel is created over each guide pin with a 6-mm cannulated drill bit (Fig 6F). It is important to leave a bone bridge on the medial tibial cortex between the 2 tunnels over which the Ethibond strands attached of the 2 ALL bundles are tied for fixation. An artery forceps is used to pass the 2 limbs of the graft under the ITB (Fig 7A). A wire loop is used to shuttle each bundle of the graft into its corresponding tunnel (Fig 7B). The Ethibond strands of both bundles of the ALL are tied over the bone bridge on the medial tibial cortex with the knee in 30° flexion and the tibia neutrally rotated (Fig 7C).

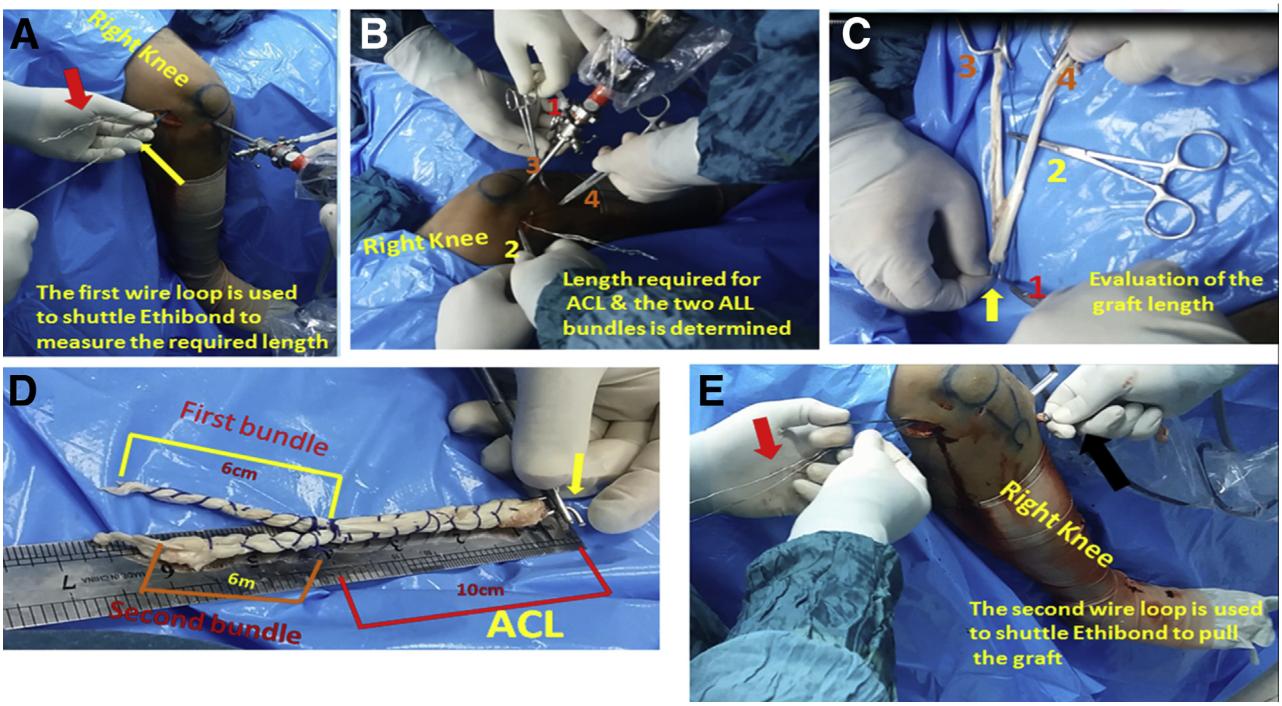

Fig 5. Wire loop passage for the measurement of the required length for ACL and ALL reconstruction and for graft passage. (A) Image of the right knee with the patient supine and the leg hanging off the table. Two wire loops are introduced from outside into the joint through the femoral tunnel; then these 2 wire loops are retrieved outside the joint through the tibial tunnel by a probe or a grasper. The first wire loop (yellow arrow) is used to shuttle the free ends of a doubled Ethibond strand; this Ethibond strand is used to determine the required length for ACL and ALL reconstruction. (B) Image of the right knee with the patient supine and the leg hanging off the table. Four artery forceps are used to determine the length of the ACL and ALL. Artery forceps number 1 at the extra-articular aperture of the tibial tunnel. Artery forceps number 2 at the extra-articular aperture of the femoral tunnel. Artery forceps numbers 3 and 4 at the ends of each bundle of the ALL (midway between Gerdy's tubercle and the head of the fibula). (C) Image of the doubled graft over the U loop (yellow arrow). The length of the graft for the ACL and the 2 bundles of the ALL are compared with that on the Ethibond strand. The distance between artery forceps number 1 and forceps number 2 represents the part of the graft for ACL reconstruction, whereas the distance between artery forceps numbers 2, 3, and 4 represents the length of the graft for each bundle of the ALL. (D) Image of the sutured, doubled graft over the U loop (yellow arrow). The length of the graft for the ACL and the 2 bundles of the ALL are demonstrated. (E) Image of the right knee with the patient supine and the leg hanging off the table. The second wire loops is used to shuttle the traction suture attached to the other end of the graft (black arrow) for graft passage. (ACL, anterior cruciate ligament; ALL, anterolateral ligament.)

A drain is inserted into the joint and into the graft harvest incision for 24 hours. Wounds are closed and an ice bag is applied around the knee.

Discussion

Isolated lateral extra-articular reconstruction in ACL-deficient knees was associated with high failure rate and complications such as instability, lateral compartment overtightening, and degeneration. This may be because historically this procedure was performed without concomitant intra-articular reconstruction with the joint being secured in a sublaxed position and with persistence of anterior translation instability. Lateral extra-articular reconstruction was performed in a nonanatomic manner; this may be another cause for the poor results. Also, prolonged postoperative knee immobilization after such procedure may be another cause for the poor reported results.[5,8,9,34,35]

Focus was directed toward intra-articular ACL reconstruction. Isolated single bundle intra-articular ACL reconstruction was associated with the lack of rotational stability that was confirmed by a positive pivot shift test in 15% to 30% of cases.[13-16] Persistent rotational instability in ACL reconstructed knees caused difficulty in pivoting sports, and also contributed to secondary meniscal and cartilaginous injuries.[32]

Double bundle ACL reconstruction was then introduced aiming to perform a more anatomical ACL reconstruction by reconstructing the 2 bundles of the ACL, namely the anteromedial and posterolateral bundles, with the hypothesis that reconstruction of the posterolateral bundle of the ACL will result in a more rotational control.[17,36] The results are mixed with the technique being technically challenging especially with the less experienced hands, besides the double

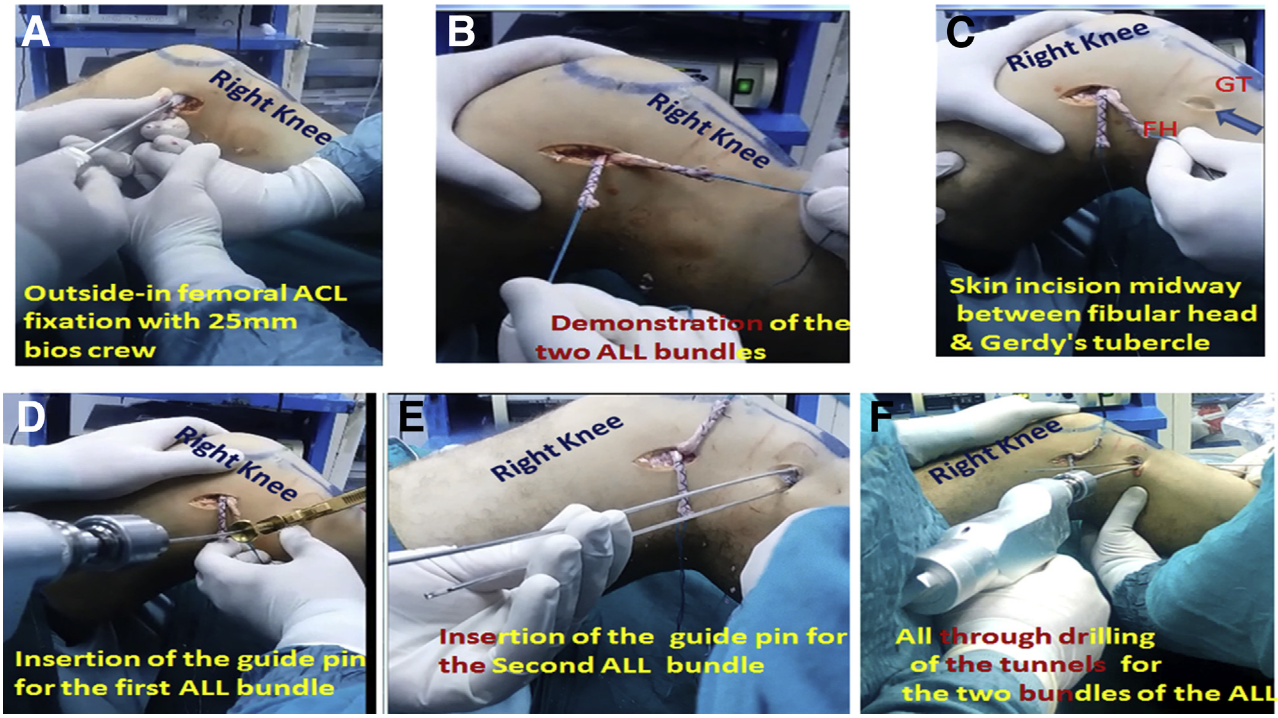

Fig 6. Steps of ACL femoral fixation and ALL reconstruction. (A) Image of the right knee with the patient supine; the foot rests on the table and the knee is flexed 30° showing the outside-in fixation of the ACL with a biodegradable screw of the same tunnel size with a length of 25 mm. The screw is inserted in the proximal or anterior half of the tunnel. (B) Image of the right knee for demonstration and evaluation of the length of the 2 bundles of the ALL. (C) Image of the right knee demonstrating the site of the skin incision midway between Gerdy's tubercle and the head of the fibula. (D) Image of the right knee demonstrating the use of the standard tibial ACL guide for the insertion of the first guide pin for one of the 2 bundles of the ALL from lateral to medial. The guide is used to direct the pin away from the ACL tibial tunnel. (E) Image of the right knee demonstrating the insertion of the second guide pin for the other bundle of the 2 bundles of the ALL from lateral to medial. (F) Image of the right knee while a 6-mm drill bit is used to create the 2 tibial tunnels for the 2 bundles of the ALL while preserving a bone bridge in between the 2 tunnels on the medial tibial cortex. (ACL, anterior cruciate ligament; ALL, anterolateral ligament; FH, fibular head; GT, Gerdy's tubercle.)

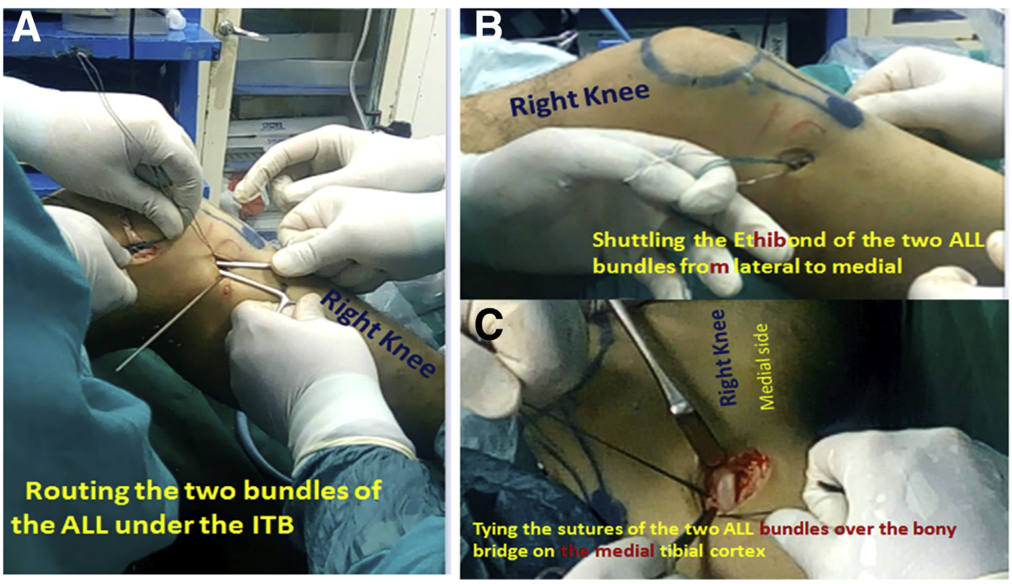

Fig 7. Steps of the double bundle anterolateral ligament (ALL) reconstruction. (A) Image of the right knee with the patient supine; the knee is flexed 90° and the foot rests on the table, routing of the 2 bundles of the ALL under the iliotibial band (ITB). (B) Image of the right knee with the patient supine and knee flexed 90° and the foot resting on the table, shuttling the Ethibond of the 2 bundles of the ALL from lateral to medial. (C) Image of the right knee with the patient supine and knee flexed 30° and the foot resting on the table, tying the sutures of the 2 bundles of the ALL over the bone bridge on the medial tibial cortex.

cost and time needed and the increased incidence of Cyclops syndrome.[18,32,37]

A navigated biomechanical study by Monaco et al.[28] was performed to evaluate the anterior translation and rotational instabilities after ACL tear and its secondary restraints. The results showed that selective cutting of the ACL posterolateral bundle alone did not show any significant increase in anterior tibial translation or internal rotation at any angles of knee flexion. The additional lesion to the anteromedial bundle produced a noticeable increase in anterior translation compared with isolated lesion to the posterolateral bundle, but with an insignificant increase in internal rotation. The addition of an anterolateral structure lesion with a completely cut ACL resulted in a significant increase in both anterior tibial translation and internal rotation.

In addition, other studies showed that injuries to the anterolateral structures of the knee produce a positive pivot-shift sign in knees with intact ACLs.[27,38,39]

Lateral extra-articular tenodesis, which is peripheral to the center of rotation of the knee, provides a better lever arm for controlling internal rotation than double bundle ACL reconstruction.

In this technique we could replicate the anatomy of the ACL and ALL by reconstructing the ALL in a double bundle way. Our concept is that the ACL reconstruction techniques have evolved from nonanatomic to anatomic and individualized techniques so as to maximally reproduce the anatomy of the ACL. Also, we reproduced the anatomy of the ALL by making our reconstruction in a double bundle way.[1,40] Given increasing knowledge about the anatomy of the ALL, double bundle reconstruction of the ALL will reproduce the triangular or the inverted Y shape of the native ALL with its narrow femoral attachment and broad tibial attachment[21,22,25,32] (Fig 8).

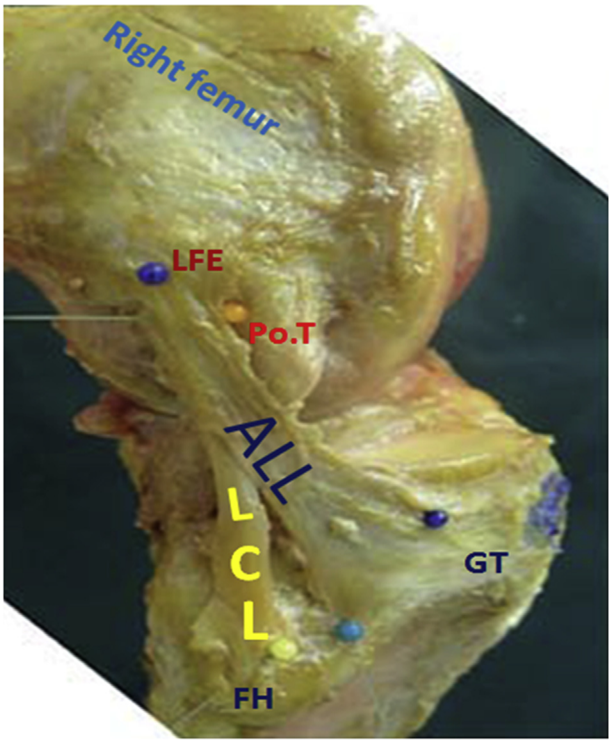

Fig 8. Cadaveric specimen of the right knee showing the anatomy of the ALL with its narrow proximal femoral attachment (proximal and posterior to the lateral femoral epicondyle [LFE]) and its broad distal tibial attachment (midway between Gerdy's tubercle [GT] and fibular head [FH]). The ALL is triangular or inverted Y in shape. In the specimen it is the structure marked with the 3 blue pin heads. The lateral collateral ligament (LCL) is the structure marked with the 2 orange pin heads. (ALL, anterolateral ligament; Po.T, Popliteus tendon.)

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