Percutaneous Reconstruction of the Anterolateral Ligament of the Knee With a Polyester Tape

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Abstract: Recent advances in surgeons' understanding of the anatomic, biomechanical, and radiologic features of the anterolateral ligament (ALL) of the knee have led to an increased interest in reconstruction of this structure as part of the management of knee instability. Even without any technical flaws and proper positioning of the bone tunnels, there is a small subset of patients, approximately 7% of all patients, who experience some residual anterolateral rotational instability after anterior cruciate ligament reconstruction. For this reason, some researchers have turned again toward the anterolateral aspect of the knee and specifically the ALL. In this technical note, the surgical steps for percutaneous reconstruction of ALL of the knee using a polyester tape are described.

It is well known that patients diagnosed with complete anterior cruciate ligament (ACL) tears may have different degrees of rotational laxity. ACL reconstruction alone may not entirely restore normal rotatory control leading to residual pathologic laxity.[1] This concept was highlighted by recent research on the function of the ACL bundles and the growing popularity of more anatomic ACL reconstruction.[2] Historically, the first techniques for ACL reconstruction used extra-articular grafts such as the iliotibial band used by MacIntosh in 1980s.[1] Subsequently, intra-articular reconstructions were performed, initially through an arthrotomy and later arthroscopically.[1] Because of limitations of current intra-articular techniques and inability to fully restore normal knee kinematics, insufficient anterolateral structures may play a role in residual knee laxity.[1,3,4]

The role of extra-articular procedures improving knee stability has been a matter of debate, especially with regard to the rotational component (glide), and although authors such as Roth et al.,[5] Strum et al.,[6] and Barrett et al.[7] found no significant improvements with the use of extra-articular plasty, Lerat et al.,[8] Noyes et al.,[9] and Zaffagnini et al.[10] found increased success rates with the addition of an extra-articular procedure.

In 1879, Paul Segond described a fibrous band at the anterolateral aspect of the knee, attached to the eponymous Segond fracture. The origin of the anterolateral ligament (ALL) was situated at the prominence of the lateral femoral epicondyle, slightly anterior and distal to the origin of the lateral collateral ligament. The ALL showed an oblique course with a clear bifurcation to the anterolateral aspect of the proximal tibia, with firm attachments to the lateral meniscus. Its insertion on the anterolateral tibia was grossly located midway between Gerdy tubercle and the tip of the fibular head, definitely separate from the iliotibial band (ITB).[11]

The ligament is isometric from 0° to 60° of flexion of the knee, then slackens when the knee is flexed further to 90° and is lengthened by imposing tibial internal rotation.[12] Parsons et al.[13] found that contribution of the ALL during internal rotation increases significantly with increasing flexion, whereas that of the ACL decreases significantly. At knee flexion angles greater than 30°, the contribution of the ALL exceeds that of the ACL. During anterior drawer, the forces in the ALL are significantly less than the forces in the ACL at all flexion angles.[13]

The various techniques of anatomic ACL reconstruction try to reduce rotatory laxity by placing the graft in the footprint of the original ligament. However, even without any technical flaws and proper positioning of the bone tunnels, a residual anterolateral rotational instability with positive pivot-shift test may be observed in approximately 7% of patients after ACL reconstruction.[14-16] The most common cause of residual

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pathologic laxity is graft failure. Previous and recent studies have revealed the importance of the anterolateral knee structures such as the ITB and ALL in limiting anterolateral rotatory laxity of the knee.[3,17,18] These structures, particularly the ALL may be the key to restoring the normal limits of knee motion.[18,19] In this technical note, the surgical steps for percutaneous reconstruction of ALL using a polyester tape are described.

Surgical Technique

Patient Positioning and Surgical Landmarks

Examination under anesthesia is done with the pivot shift test showing grade 3 in order to confirm the presence of a torn ALL.[18] After applying the tourniquet to the proximal thigh, the patient is positioned supine with the knee flexed on the side of the table and the foot resting on the surgeon's thigh. Routine diagnostic arthroscopy is performed initially to confirm ACL injury and evaluate other knee pathologic conditions. Bony landmarks are identified and marked (Fig 1).

Drilling for the Femoral and Tibial Tunnels

The lateral femoral epicondyle is palpated with 5-mm transverse skin incision made just anterior to it. After this, dissection is made sharply to the bone (Fig 2). Femoral insertion point of the ALL is just anterior and distal to the lateral femoral condyle and can be confirmed under image intensifier with a small curved artery forceps before a 2.7-mm passing pin (Smith & Nephew, Andover, MA) is drilled transversely in a minimal upwards direction through it and out from the medial side (Fig 3). A 4.5-mm cannulated drill pit (Smith & Nephew) is inserted over the passing pin to the medial cortex. After this, both the passing pin and

Fig 1. Bony landmarks are identified and marked, right knee flexed 90° over the side of the table and resting on the surgeon's thigh. (GT, Gerdy tubercle; HF, head of the fibula; LEC, lateral epicondyle.)

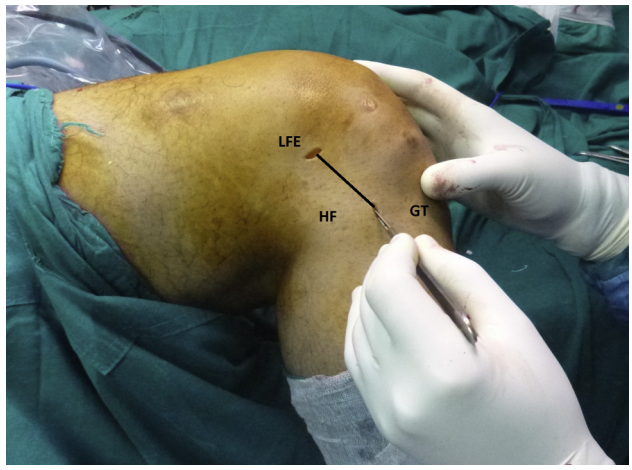

Fig 2. A 5-mm transverse skin incision is made just anterior to the lateral femoral epicondyle (LFE) and 1 cm transverse incision is made in the midpoint between the head of the fibula (HF) and Gerdy tubercle (GT) with sharp dissection to the bone, right knee.

Fig 3. A 2.7-mm passing pin is drilled transversely through the femoral insertion point of the anterolateral ligament and out from the medial side, right knee. (GT, Gerdy tubercle; HF, head of the fibula; LFE, lateral femoral epicondyle; TT, tibial tuberosity.)

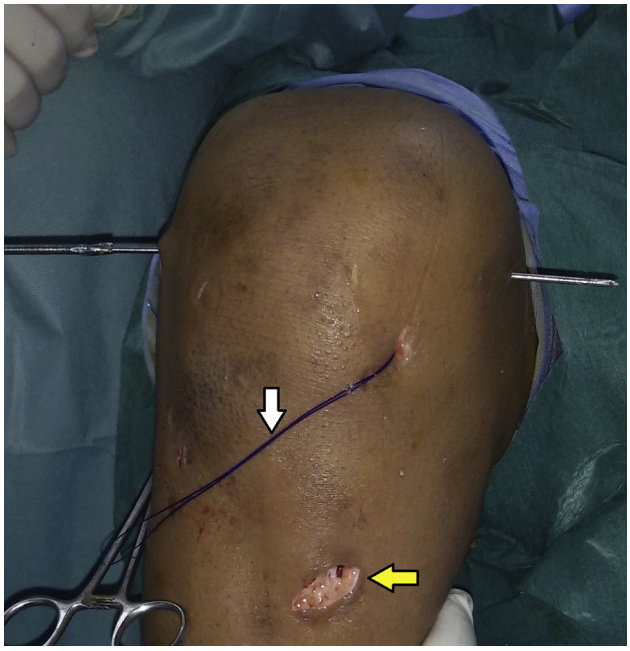

Fig 4. A 4.5-mm cannulated drill pit is inserted over the passing pin to the medial cortex and then both are removed, right knee. Traction sutures for the anterior cruciate ligament graft through femoral tunnel and anteromedial portal (white arrow). Incision for hamstrings graft harvest for anterior cruciate ligament (yellow arrow).

the drill pit are removed (Fig 4). A 5- to 10-mm transverse incision for the tibial insertion point is made just proximal to the midpoint between the head of the fibula and Gerdy tubercle with sharp dissection is made to the bone (Fig 2). The passing pin is drilled transversely across the proximal tibia to the medial side followed by the 4.5-mm cannulated drill pit (Figs 5 and 6). These steps are repeated through the same incision while

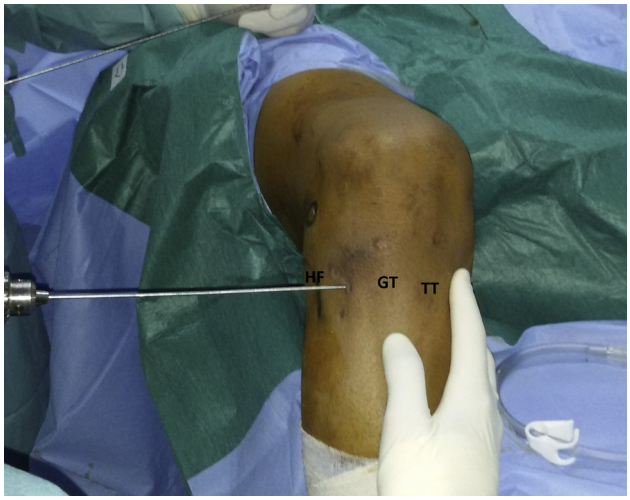

Fig 5. Passing pin is drilled transversely across proximal tibia to the medial side, right knee. (GT, Gerdy tubercle; HF, head of the fibula; TT, tibial tuberosity.)

Fig 6. Passing pin is followed by a 4.5-mm cannulated drill pit, right knee.

leaving 1 cm apart and then both passing pins are removed.

Passage and Fixation of the Tape

After the completion of tunnel drilling for the ACL reconstruction, the passing pin is pulled through the femoral tunnel followed by a No. 1 monofilament suture that will act as a relay suture to pull the sutures of the cortical suspensory fixation button (TightRope; Arthrex, Naples, FL) out from the medial side (Fig 7).

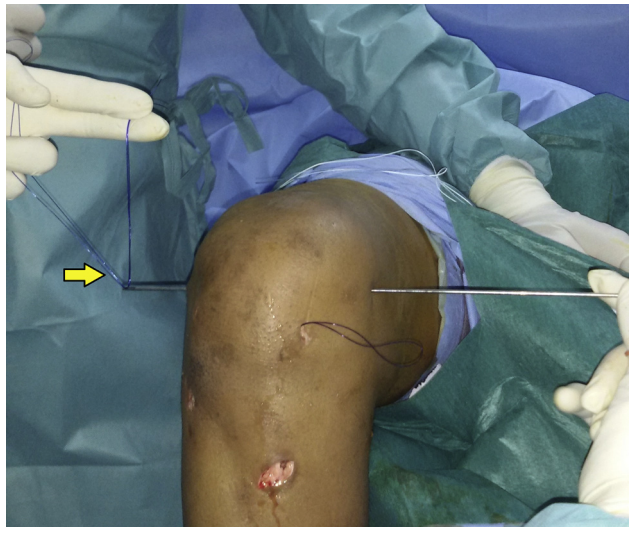

Fig 7. Femoral tunnel passing pin is pulled, followed by a No. 1 monofilament suture (yellow arrow), acting as a relay suture to pull the sutures of the endo-button out from the medial side, right knee.

Fig 8. Cortical fixation button (yellow arrow) with its loop loaded with a polyester tape is pulled medially and flipped over the medial cortex, right knee.

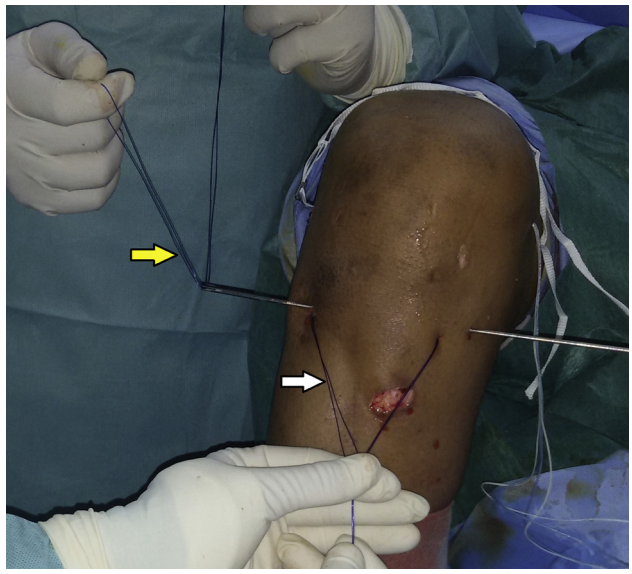

Fig 10. Passing pins of the 2 tibial tunnels are pulled out from the medial side followed by 2 monofilament sutures (white and yellow arrows) that will act as a relay suture.

The button with its loop loaded with a polyester tape of 4 mm diameter and 60 mm length (Ethicon, Somerville, NJ) is pulled medially and flipped over the medial cortex (Fig 8). A curved artery forceps is passed from the tibial incision to the femoral one under the ITB to pull the 2 ends of the polyester tape out from the tibial incision (Fig 9). Two passing pins are passed from the tibial incision through the 2 tunnels out from the medial side followed by 2 monofilament sutures that will act as a relay suture to pull each end of the polyester tape out from the medial cortex after making a 5-mm incision (Figs 10 and 11). Then the 2 ends are tied together after tensioning over the 1 cm bone bridge with the knee in 30° flexion (Fig 12, Video 1). Passage of the ACL graft and fixation is done. Only skin is closed in routine fashion (Fig 13) and light dressing is applied. Knee immobilizer is applied for 2 weeks. Standard ACL rehabilitation program is followed in the postoperative period. Weight bearing and knee flexion are allowed as tolerated. Quadriceps strengthening exercises in the form of quadriceps drill and straight-leg raising are encouraged immediately to maintain full knee extension. Closed-chain exercises are followed for 6 weeks, after which open-chain exercises are allowed.

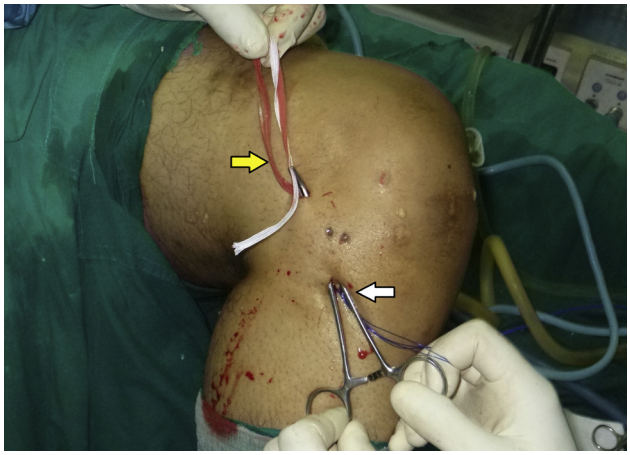

Fig 9. Curved artery forceps (white arrow) is passed from the tibial incision to the femoral one under the iliotibial band to pull the 2 ends of the polyester tape (yellow arrow) out from the tibial incision, right knee.

Discussion

Extra-articular reconstruction techniques for management of ACL injuries were pioneered by Strickler (1937), Lemaire (1960), and MacIntosh (1970s), using a lateral extra-articular tenodesis to control anterolateral tibial subluxation.[20] Although these techniques were shown to control external rotational laxity, they were soon found to stretch out and not control the knee to the desired manner. This then led the way to combined intra- and extra-articular reconstruction. Interestingly, although the combined procedure by and large went out of fashion in the late 1990s, extra-articular tenodesis is making somewhat of a resurgence, with a number of authors using the procedure to aid control of rotational laxity, particularly in revision scenarios.[21]

Current techniques of ACL reconstruction may not achieve normal control of knee rotation.[14,22] The presence of an extra-articular structure responsible for limiting anterolateral rotatory laxity of the knee may explain why isolated intra-articular reconstructions, even when performed correctly, are not always sufficient to restore the rotatory movements of the knee.[19]

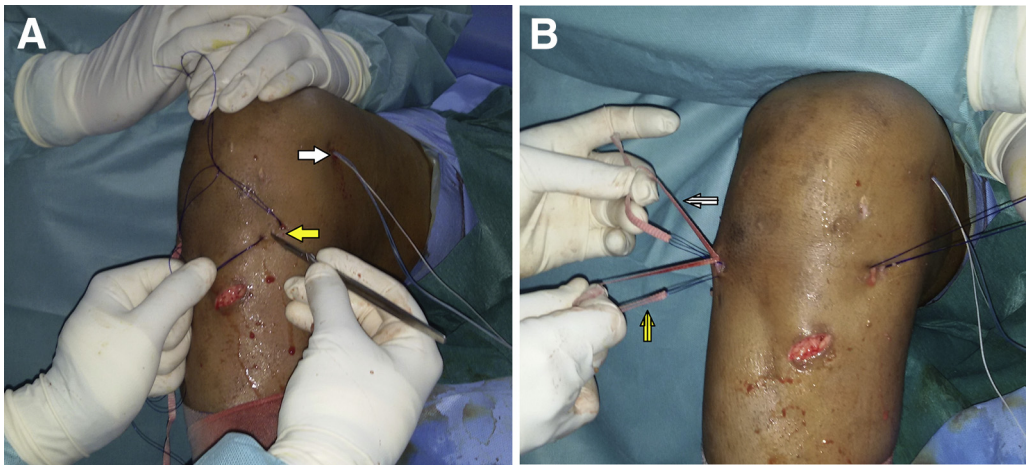

Fig 11. (A) After making a 5-mm incision (yellow arrow) (white arrow, traction sutures for the cortical fixation button), (B) relay sutures are used to pull each end of the polyester tape (striped white and yellow arrows) out from the medial cortex, right knee.

Terry et al.,[23] in 1993, concluded that injuries to the components of the iliotibial tract contributed to the variation in anterior tibial translation and rotation. Samuelson et al.,[24] in 1996, also showed that adding an extra-articular reconstruction to intra-articular ACL reconstruction would improve results if the patient had anterolateral ligamentous injuries. Monaco et al.,[18] in a biomechanical study, showed that sectioning the anterolateral structures increased internal rotation and the pivot-shift grade substantially. Tibial attachment of the ALL may be associated with the Segond fracture and is found in approximately 9% of patients with ACL ruptures.[25]

Placing value on the anterolateral structures for the management of ACL injuries is not a recent trend, but with the evolution of intra-articular reconstructions, it was being left aside.[26,27] Recently, it was shown that performing lateral extra-articular tenodesis in association with intra-articular reconstruction of the ACL using a single bundle might be superior to intra-articular ACL reconstruction with a double bundle, from a rotational point of view, which confirms the importance of these extra-articular structures.[28]

The rationale of combining intra- and extra-articular procedures in ACL reconstruction is to limit the internal rotation of the reconstructed knee, thus providing more knee stability in the rotational axis and preventing excessive stresses on the ACL graft. Many studies have already investigated the role of such extra-articular procedures.[5,6,8-10,29,30] Anderson et al.,[31] as well as Roth et al.,[5] showed no improvement by the addition of an extra-articular procedure. Completely

Fig 12. The 2 ends of the polyester tape are tied together after tensioning over the bone bridge with the knee in 30° flexion, right knee.

Fig 13. Incisions after closure of skin only, right knee. (asterisks).

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
1. Accurate identification of bony landmarks is crucial; image intensifier could be used.	1. Nonanatomic tunnels if landmarks are not well identified.
2. Drilling for the femoral tunnel is done transversely in a minimal upward direction.	2. Without superior inclination, the button will be subcutaneous, causing irritation on the medial side of the knee.
3. Tibial tunnels are drilled while keeping 1-cm bony bridge through both 5-mm incisions on lateral and medial sides.	3. The bone bridge could fail if the distance between the 2 tibial tunnels is less than 1 cm.
4. Keeping monofilament relay sutures in femoral and tibial tunnels while drilling, and passage of ACL graft make it easy to find them again when the tape is passed and fixed.	4. Removing monofilament sutures to drill for ACL tunnels makes it difficult to find the ALL tunnels again.
5. ALL is tensioned first in 30° flexion and then ACL is tensioned in 15°-20°.	

ACL, anterior cruciate ligament; ALL, anterolateral ligament.

different conclusions were shown by Lerat et al.[8] and Noyes et al.,[9] which showed the results of 2 prospective studies with significantly better results in patients with an extra-articular procedure. More recently, Monaco et al.,[28] using a navigator system showed that the addition of a lateral extra-articular tenodesis procedure to a standard single-bundle ACL reconstruction was more effective in reducing the internal rotation of the tibia, when compared with a standard single-bundle ACL reconstruction or with an anatomic double-bundle reconstruction.

The concept of using braided polyester tape has shown positive results, with a low rate of complications for tendon repair in shoulder rotator cuff tendons[32] and tendoachilles injuries[33] as well as in ligament reconstruction for lateral ankle ligaments[34] and coracoclavicular ligament injuries.[35] These results may justify broadening of its clinical applications to ALL reconstruction, with an extra goal of protecting a reconstructed ACL from noncompliant patient activity, secondary injury, or graft elongation and failure during early rehabilitation.[36]

In this technique for percutaneous reconstruction of the ALL, using a synthetic ligament with a polyester tape has many potential advantages, including minimal invasiveness, no additional graft donor morbidity, strength and stiffness with no laxity, secured methods of fixation, minimal precautions needed after surgery, and no joint reaction. However, it is still a synthetic material without true ligament tissue healing, and additional long-term studies with large patient populations are needed for further confirmation of these advantages (Tables 1 and 2).

Table 2. Advantages and Limitations

Advantages
1. Minimally invasive
2. No additional graft donor morbidity
3. Strong and stiff, with no possible laxity
4. Easy and secured methods of fixation
5. Knee does not need usual postoperative protection or precautions
6. Being extra-articular, does not cause any joint reaction
Limitations and disadvantages
1. Still needs long term studies with large patient population
2. Synthetic material without true ligament tissue healing

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