SUBSPECIALTY PROCEDURES

COMBINED ACL AND ANTEROLATERAL LIGAMENT RECONSTRUCTION

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Abstract

Background: Clinical results of combined anterior cruciate ligament (ACL) and anterolateral ligament (ALL) reconstruction have demonstrated a significant reduction in ACL graft rupture rates and improved rates of return to sports compared with isolated ACL reconstruction¹. This finding is supported by laboratory studies that have demonstrated that combined ACL reconstruction and lateral extra-articular tenodesis procedures protect the ACL graft by load-sharing with it and by more reliably restoring normal knee kinematics compared with isolated ACL reconstruction.

Description: The ACL graft is formed from a tripled semitendinosus tendon and a single strand of gracilis tendon. The femoral tunnel is drilled to provide an anatomic location intra-articularly and to exit the femur just posterior and proximal to the lateral epicondyle. The additional length of gracilis therefore exits the femoral tunnel at the anatomic origin of the ALL and is then routed (under the iliotibial band [ITB]) through a tibial tunnel, and back to the femoral origin, to reconstruct the ALL.

Alternatives: Many different types of nonanatomic lateral extra-articular tenodesis procedures have been reported. The most frequently performed were the Lemaire and MacIntosh procedures; however, these, and others, were widely abandoned after poor results were reported in the 1980s.

Rationale: ALL reconstruction differs from other lateral extra-articular tenodesis-type procedures because the procedure is anatomically based and can be percutaneously performed. Nonanatomic procedures (typically with a strand of ITB passed under the lateral collateral ligament [LCL]) have been reported to be associated with overconstraint, early arthritis, and an increased risk of infection²⁻⁵. In contrast, ALL reconstruction has been shown to restore normal knee kinematics and to avoid overconstraint when correctly fixed in full extension and neutral rotation⁶. The main concern with any type of lateral extra-articular tenodesis is based on historical reports of poor outcomes^{2,3}. However, a recent study has demonstrated that combined ACL and ALL reconstruction is associated with a reoperation rate that is comparable with the

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rate seen after isolated ACL reconstruction, and it has a very low rate of complications⁷. This makes a compelling argument for anatomic ALL and ACL reconstruction being the procedure of choice when considering an extra-articular procedure. This is further supported by the fact that, even though previous studies have demonstrated a trend toward reduced ACL graft rupture with nonanatomic lateral extra-articular tenodesis procedures, they have not shown a significant improvement in outcomes⁸. Combined ACL and ALL reconstruction is currently the only type of lateral extra-articular procedure that has been demonstrated to significantly reduce the risk of ACL graft rupture and improve the rate of return to sports¹.

Introductory Statement

Combined anterior cruciate ligament (ACL) and anterolateral ligament (ALL) reconstruction is associated with a significant reduction in ACL graft rupture rates, no increase in the risk of reoperation, and a very low rate of complications.

Indications & Contraindications

Indications

Our main indication for ALL reconstruction is patients undergoing ACL reconstruction who have specific risk factors that predispose them to an increased risk of ACL graft rupture. These factors include the following:

- Young age (<20 years old).
- Participation in pivoting sports or a high-demand athlete.
- Evidence of a high-grade pivot shift on examination.
- Evidence of a lateral femoral notch sign on preoperative imaging.
- A Segond fracture.
- Revision ACL reconstruction.
- Chronic (>12 months) ACL injury.

Contraindications to This Specific Technique

- Tripled or quadrupled semitendinosus and gracilis graft diameter of <7 mm. It is recognized that graft diameters of <7 mm increase the risk of ACL graft failure.
- Lateral compartment arthritis. Although there is no clinical evidence to suggest that this technique can overconstrain the knee, long-term investigations specifically studying radiographic evidence of osteoarthritis are currently lacking for ALL reconstruction. However, clinical studies of ACL reconstruction with lateral extra-articular tenodesis have not shown increased rates of osteoarthritis with long-term follow-up⁹. We consider established lateral compartment arthritis as a relative contraindication to ALL reconstruction.
- Lack of surgeon knowledge about extra-articular procedures and ALL anatomy. It is essential to have a good knowledge of ALL anatomy and structures around the lateral epicondyle to perform this procedure safely and with good outcomes.

Step-by-Step Description of Procedure

Although combined ACL and ALL reconstruction has been previously described, the present article expands substantially on our previous publication¹⁰. Specifically, we provide tips and tricks for surgeons who are new to this procedure and for those who wish to continue using their standard ACL reconstruction technique and perform concomitant ALL reconstruction with an independent graft. In addition, we also provide detailed instruction on how to precisely identify the correct femoral tunnel location and avoid graft malposition.

The technique is described with the use of 3 videos. Video 1 demonstrates combined ACL and ALL reconstruction. The combined graft is formed from a tripled semitendinosus tendon and a gracilis tendon. The ACL graft therefore consists of 3 parts semitendinosus tendon and 1 part gracilis tendon, and the additional length of gracilis forms the ALL graft. Video 2 describes the use of a gracilis autograft or allograft for an ALL reconstruction that is performed independently of the ACL reconstruction. Video 3 describes technical tips for ensuring that the precise femoral location for ALL reconstruction is correctly identified.

Video 1 Surgical technique for combined ACL and ALL reconstruction.

Video 2 Surgical technique for ALL reconstruction if the surgeon prefers to use his or her standard technique for ACL reconstruction, rather than a combined ACL-ALL graft. The graft is fixed on the femoral side with a 5.5-mm closed eyelet SwiveLock Anchor (Arthrex).

Video 3 Understanding normal ALL non-isometry and the consequences of femoral tunnel malposition.

Step 1: Patient Positioning

Position the patient supine on the operating table in the standard arthroscopy position.

- Place a lateral post just proximal to the knee, at the level of the padded tourniquet.
- Use a foot roll. This helps to prevent the hip from externally rotating and allows free range of motion, or maintenance of the knee at 90° of flexion, when required.

Step 2: Identify and Mark Landmarks and Make Stab Incisions

Identify and mark osseous landmarks and locations of stab incisions for ALL reconstruction (Fig. 1).

- Mark the head of the fibula, Gerdy's tubercle, and the lateral epicondyle.
- Mark 3 stab incisions for the ALL reconstruction.
 - Mark the femoral incision just proximal and posterior to the lateral epicondyle.
 - Mark the tibial incisions 1 cm distal to the joint line. Place 1 incision just anterior to the fibular head and the other just posterior to Gerdy's tubercle. They should be separated by approximately 2 cm.

Fig. 1

Fig. 1 Intraoperative photograph of the lateral aspect of the right knee. The image shows the key osseous landmarks and incisions required for ALL reconstruction. (Reproduced, with modification, from: Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaumat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. Arthrosc Tech. 2016 Dec;5[6]:e1253-9. Copyright 2016, with permission from Elsevier.)

Step 3: ALL Tibial Drilling and Verification of Normal ALL Non-Isometry

Create the ALL tibial tunnel and confirm the correct location of the entry point for outside-in drilling of the femoral tunnel.

- Place guidewires into the tibial incisions. This can be performed using a drill guide (Arthrex) as seen in Video 1, or using a freehand technique as seen in Video 2.
- Use a 4.5-mm cannulated drill-bit to overream the guidewires and create two 15-mm sockets (Fig. 2). Use a circular motion to slightly increase the socket apertures to facilitate subsequent graft passage.
- Connect the osseous sockets using a right-angled clamp.
- Create a suture loop by passing a number-2 Ethibond suture (Ethicon) in a retrograde fashion from the anterior aperture of the tunnel to its posterior aperture. This will later be used to facilitate graft passage; however, in the next steps, it is used to confirm that the femoral tunnel position has been correctly identified in order to achieve the normal non-isometry of the anterolateral structures of the knee.
- Insert the femoral guidewire into the stab incision just proximal and posterior to the lateral epicondyle.
- Loop the Ethibond suture around all 3 guidewires, place the knee in full extension (and by default neutral rotation), apply tension to the suture, and then clamp it with a hemostat.
- Take the knee through a full range of motion to ensure that the subsequently placed ALL graft will be non-isometric. The suture (representing the graft that will be placed later) should be tight in extension and slack in flexion, allowing physiological internal rotation, if the tunnels are placed correctly.
- This technique is demonstrated in Video 1 and further explained in Video 3, which focuses on how errors in femoral tunnel positioning can affect the biomechanics of the reconstruction.

Fig. 2

Fig. 2 Intraoperative photograph of the lateral aspect of the right knee. The image shows overreaming of the previously positioned tibial guidewires through percutaneous stab incisions using a 4.5-mm drill.

Step 4: Graft Harvest and Preparation

Harvest the semitendinosus and gracilis tendons and prepare them into a combined ACL and ALL graft.

- Make a standard hamstring harvest oblique or vertical incision medial to the tibial tubercle.
- Retrieve the hamstring tendons and carefully dissect any bands that may divert the tendon stripper and result in premature graft truncation.
- Harvest the semitendinosus and gracilis tendons using an open-ended tendon stripper, ensuring that they are not detached from the tibia at this stage.
- Whipstitch the free end of the gracilis tendon.
- Measure the semitendinosus tendon from its insertion and mark it using a pen at 4 and 10 cm for a female patient and at 5 and 11 cm for a male patient. (Specific tunnel length can be precisely identified at the time of surgery, with arthroscopic rulers if required).
- Detach the gracilis from its tibial insertion.
- Suture the gracilis onto the semitendinosus, beginning at the proximal mark and finishing at the distal mark, using multiple number-1 Ethibond sutures (Fig. 3).
- Place a number-2 FiberWire (Arthrex) onto the semitendinosus at the distal mark, and then fold it back onto itself. Tag it with a number-1 Ethibond suture at the proximal mark.
- Then triple the semitendinosus graft and tag it again with number-1 Ethibond suture to tubularize the graft. This results in an ACL graft that is 3 parts semitendinosus and 1 part gracilis. The ALL graft is therefore the continuation of the gracilis distal to the ACL graft (Fig. 3).
- Measure the graft diameter using a graft sizer.

Fig. 3

Fig. 3 Illustration demonstrating the final graft construct for combined ACL and ALL reconstruction in a right knee. The tibial attachment of the semitendinosus is preserved after harvesting, but the gracilis is detached after the free end is whipstitched. The semitendinosus tendon is doubled and tagged with sutures (at 4 and 10 cm for a female patient and at 5 and 11 cm for a male patient) and the gracilis is sutured to it. The semitendinosus is then finally tripled, and further sutures are placed to tubularize and secure the graft. The final graft is therefore composed of a tripled semitendinosus tendon (ST) with its tibial attachment preserved, and a single strand of gracilis. (Reproduced, with modification, from: Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaumat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech*. 2016 Dec;5[6]:e1253-9. Copyright 2016, with permission from Elsevier.)

Step 5: Drilling of the Femoral ACL-ALL Tunnel

Drill an outside-in femoral tunnel that starts on the lateral aspect of the femur at the anatomic origin of the ALL (Figs. 4 and 5).

- Place the arthroscope in a high lateral portal.
- Insert the femoral outside-in ACL guide (Arthrex) into the knee via the anteromedial portal.
- Place the tip of the guide at the femoral origin of the ACL (Fig. 4).
- Place the bullet-tip sleeve of the femoral guide into the previously made (and confirmed to be in a correct non-isometric position) femoral stab incision just proximal and posterior to the lateral epicondyle. Although this procedure is typically performed in a percutaneous manner, for surgeons learning ALL reconstruction, it is recommended that a small longitudinal incision is made on the femur instead of a stab incision. This allows the lateral collateral ligament (LCL) to be identified and safely avoided (Fig. 5).
- Insert a guidewire in an outside-in manner and overream with a correctly sized drill (based on graft diameter).

Fig. 4

Fig. 5

Fig. 4 Intraoperative arthroscopic view (from the high anterolateral portal) of the right knee. The femoral guide is inserted into the knee via the anteromedial portal. The guide is positioned so that the guidewire will exit in the middle of the ACL femoral footprint.

Fig. 5 Intraoperative photograph of the lateral aspect of the right knee. Although the procedure is typically performed percutaneously, it is recommended that surgeons learning the technique make a small longitudinal incision in order to safely identify the LCL (highlighted with blue surgical marking pen for demonstration purposes) and avoid iatrogenic injury to it when drilling.

Step 6: Drilling of the Tibial ACL Tunnel

Drill the tibial tunnel; this can be performed using the surgeon's preferred technique, but we advocate a remnant-sparing approach¹¹.

- Do not excise the tibial ACL remnant.
- Set the tibial guide to 55°.
- Insert the guide into the knee via the anteromedial portal while viewing from the high anterolateral portal.
- Position the guide so that a subsequently inserted guidewire will enter the middle of the base of the stump.
- Insert a 6-mm reamer, taking care to just breach the tibial cortex and avoid damaging the remnant.
- Sequentially ream, using the same careful technique, with larger-diameter drills until the correct diameter tunnel (equivalent to the graft diameter) is achieved.
- Insert a shaver into the tibial tunnel and into the remnant. Ensure that the suction is switched off, and create a channel within the remnant for graft passage.

Step 7: ACL-ALL Graft Passage and Fixation

Use suture-passing techniques to shuttle the graft through the tibial tunnel and through the remnant to the femoral tunnel, and then appropriately tension and fix the combined ACL and ALL graft.

- Place a TigerStick (Arthrex) into the femoral tunnel and use a grasper to take it through the remnant and out through the tibial tunnel.
- Use the suture from the TigerStick to shuttle the ACL-ALL graft through the tibial tunnel, into the ACL remnant, and then through the femoral tunnel, bringing it out through the femoral stab incision (Fig. 6).
- Insert a nitinol wire into the tibial ACL tunnel adjacent to the graft.
- With tension on the graft as it exits the femoral tunnel, place an interference screw of the same diameter as the ACL graft into the tibial tunnel, over the guidewire.
- Insert the nitinol guidewire into the femoral tunnel via the femoral stab incision.
- Place the knee at 30° of flexion, tension the graft, and insert the femoral interference screw (same diameter as the ACL graft).
- Do not truncate the additional length of gracilis because this forms the ALL graft (Fig. 6).

Fig. 6

Fig. 6 Illustration demonstrating how the graft construct shown in **Figure 3** results in an intra-articular ACL graft composed of a tripled semitendinosus tendon (ST) and a single strand of gracilis, the additional length of which then goes on to exit the knee from the femoral tunnel to form the ALL graft. (Reproduced, with modification, from: Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaumat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech*. 2016 Dec;5(6):e1253-9. Copyright 2016, with permission from Elsevier.)

Step 8: Passage and Fixation of the ALL Graft

Pass the ALL graft from the anatomic ALL origin to the tibial tunnel and back on itself (under the iliotibial band [ITB]) (Figs. 7 and 8).

- Place a grasper underneath the ITB from the posterior tibial stab incision (just anterior to the fibular head) and use it to retrieve the suture tails from the whipstitched end of the gracilis tendon.
- Place these sutures into the previously created Ethibond loop and pull the graft through the ALL tibial tunnel (Fig. 7).
- Insert the grasper (with the retrieved gracilis sutures) under the ITB again, from the anterior tibial stab incision (just posterior to Gerdy's tubercle), and bring it out through the femoral stab incision.
- Place tension on the ALL graft and pass the Ethibond sutures that were placed in the ACL graft during its preparation around the ALL graft, as they exit the femoral tunnel, and tie them with the knee in full extension and neutral rotation.
- Confirm that the knee has full range of motion and that the Lachman and pivot-shift tests are negative.
- Truncate any excess suture and graft to complete the reconstruction. Figure 8 illustrates the final combined ACL and ALL reconstruction.

Fig. 7

Fig. 8

Fig. 7 Illustration showing passage of the ALL graft for combined ACL and ALL reconstruction in a right knee. After fixation of the ACL graft on the femur, the sutured gracilis graft is passed deep to the iliotibial band to the posterior tibial stab incision. The whipstitched suture ends and graft are then passed through the ALL tibial bone tunnel and back proximally under the iliotibial band and out through the lateral femoral tunnel incision. (Reproduced, with modification, from: Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaunat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech*. 2016 Dec;5[6]:e1253-9. Copyright 2016, with permission from Elsevier.)

Fig. 8 Illustration showing the key features of the final reconstruction. This includes a preserved tibial attachment of the semitendinosus, a preserved ACL remnant, an ACL graft comprised of a tripled semitendinosus and single strand of gracilis, and an ALL graft formed with the additional length of gracilis that passes from the femoral tunnel, under the ITB, through a tibial tunnel, and back to the femoral origin underneath the ITB. (Reproduced, with modification, from: Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaunat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech*. 2016 Dec;5[6]:e1253-9. Copyright 2016, with permission from Elsevier.)

Step 9: Rehabilitation

Follow a standard ACL rehabilitation program; no specific differences are required for combined ACL and ALL reconstruction.

- Our routine ACL rehabilitation program is instituted, entailing brace-free, immediate, full weight-bearing after the procedure and progressive range-of-motion exercises. Early rehabilitation is focused on obtaining full extension and quadriceps activation. A gradual return to sports activities is allowed, starting at 4 months for patients who participate in nonpivoting sports, at 6 months for those who participate in pivoting noncontact sports, and at 8 to 9 months for those who participate in pivoting collision sports.

Results

A large prospective comparative series of 502 ACL reconstructions performed with 1 of 3 different surgical techniques, and a minimum follow-up of 2 years, demonstrated significantly reduced rates of ACL graft rupture in a high-risk population (young patients participating in pivoting sports) after combined ACL and ALL reconstruction compared with a matched cohort undergoing isolated ACL reconstruction¹. The graft rupture rates were 10.77% (range, 6.60% to 17.32%) for hamstring tendon grafts in isolated ACL reconstruction, 16.77% (range, 9.99% to 27.40%) for bone-patellar tendon-bone (B-PT-B) grafts, and 4.13% (range, 2.17% to 7.80%) for combined ACL and ALL reconstruction (hamstring) grafts at a mean follow-up of 38.4 months. Multivariate analysis was performed to account for demographic differences between groups. This demonstrated that the rate of graft failure with combined ACL and ALL reconstruction grafts was 2.5 times less than that with isolated B-PT-B grafts (hazard ratio [HR], 0.393; 95% confidence interval [CI], 0.153 to 0.953) and 3.1 times less than that with hamstring tendon grafts in isolated ACL reconstruction (HR, 0.327; 95% CI, 0.130 to 0.758) at the time of the final follow-up¹.

The combined ACL and ALL reconstruction graft was also associated with significantly higher odds of patients returning to their preinjury level of sport than isolated hamstring tendon ACL reconstruction grafts (odds ratio [OR], 1.938; 95% CI, 1.174 to 3.224) but not compared with the B-PT-B graft (odds ratio [OR], 1.460; 95% CI, 0.813 to 2.613)¹.

A separate, multicenter study evaluated the risk of reoperation and complications after 548 combined ACL and ALL reconstructions⁷. Seventy-two patients (13.1%) underwent ipsilateral reoperation at a mean follow-up (and standard deviation) of 35.5 ± 8.0 months (range, 24 to 54 months). This comprised a total of 77 procedures. Graft revision occurred in 14 knees (2.6%) at a mean of 18.3 ± 7.4 months after the index procedure. There were 63 reoperations for indications not related to graft rupture in the ipsilateral limb (30 were related to the meniscus; 22, to arthrofibrosis; 4, to removal of hardware; 4, to arthroscopic lavage without infection; and 3, to deep infection). The only complications specifically related to the ALL procedure ($n = 3$) involved femoral hardware that required removal. It was concluded that the reoperation rate after combined ACL and ALL reconstruction was broadly comparable with the reoperation rate previously reported after isolated ACL reconstruction. Furthermore, the high rates of knee stiffness and reoperation reported in historical series of nonanatomic, lateral extra-articular tenodesis were not observed⁷.

Pitfalls & Challenges

- Graft harvest. When harvesting the semitendinosus tendon, use a right-angled clamp or tendon hook to pull the tendon out of the wound and cut all of the expansions under direct vision before using the stripper. This is particularly important because, if an insufficient length of semitendinosus is harvested, it may not be enough to ensure an adequate ACL and ALL graft diameter.
- Avoid iatrogenic injury to the graft when drilling the ACL tibial tunnel. Because the tibial attachment of the semitendinosus is preserved, there is a risk of injury to it during drilling. The graft should be stored within the wound during drilling, and a small swab can then be inserted to further retract and protect it.
- Drilling of the tibial ALL tunnels. If using a freehand technique, be careful to avoid drilling the sockets too close together or too far apart because this can hinder the subsequent development of bone tunnels with a

right-angled clamp and can make it difficult to pass the needle. An approximate distance of 2 cm is typical. However, if further reassurance is required, place the number-2 Ethibond suture needle on the skin prior to making stab incisions to confirm that they are appropriately distanced to match the size of the needle. An alternative option is to use the Arthrex jig demonstrated in Video 1.

- Locating the femoral tunnel. Incorrect placement of the femoral tunnel can potentially result in overconstraint of the knee or a graft that is too loose. Use the described technique to ensure the tunnel is correctly positioned. Video 3 specifically focuses on how to identify the correct femoral tunnel location and how to recognize and avoid malposition.
- Avoid iatrogenic injury to the LCL. This procedure is intended to be performed in a percutaneous manner. However, surgeons who are learning the procedure may wish to make a small longitudinal femoral incision rather than a stab incision, to confirm with direct visualization that they will not injure the LCL. Making a small longitudinal incision allows the surgeon to mark the LCL and ensure that the femoral tunnel will not encroach on it (Fig. 5).
- Avoid femoral tunnel blowout. Palpate posterior to the femoral guide before drilling to ensure adequate placement on bone.
- Fixing the ACL graft. Be careful when inserting the femoral screw to avoid injury to the additional length of gracilis that will form the ALL graft.
- Avoid femoral screw prominence. Be aware that the femoral tunnel is likely to be more horizontal and shorter than the typical tunnel for isolated ACL reconstruction. The femoral tunnel length can be measured to avoid screw prominence, and arthroscopy can be used to confirm that the screw is not prominent intra-articularly. The typical screw length is 20 to 23 mm.
- Avoid overconstraint. If the ALL graft is secured in non-neutral rotation, or with knee flexion, a gait disturbance or overconstraint may be possible. Avoid overconstraint, by fixing the knee in full extension (which also ensures neutral rotation).
- Surgeon use of his or her preferred ACL reconstruction technique. If the preferred technique for ACL reconstruction is used, but the surgeon wants to perform ALL reconstruction, he or she should do so by performing the ALL reconstruction independently of the ACL surgery. This is demonstrated in Video 2. Graft options include gracilis autograft or allograft.
- Measure tunnel lengths accurately, when required. The technique of marking the semitendinosus at 4 and 10 cm for female patients, and 5 and 11 cm for male patients, is a reliable and time-saving method of ensuring adequate graft in the tibial and femoral tunnels. However, many different techniques can be used to more accurately measure graft length, and these should be employed by surgeons learning the technique or when patients are very tall or short.

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