

Extra-articular Augmentation Scientific Update

Although contemporary ACL reconstruction is generally thought to deliver good results with excellent control of anterior-posterior (AP) laxity, the persistence of some degree of rotational instability characterized by a positive pivot-shift test in some patients is not uncommon. The goal of extra-articular augmentation or reconstruction is to eliminate residual laxity and reduce the risk of ACL graft rupture. Iliotibial band tenodesis or anterolateral ligament reconstruction could play a role in augmenting rotational stability in the ACL reconstructed knee. These procedures are most likely to benefit hyperlax patients, revision cases, pivoting athletes, and those with IKDC grade III pivot shifts. The following document summarizes published studies that describe anatomy, biomechanical data, and clinical outcomes.

Monaco E,
Carrozzo A,
Saithna A,
et al

Clinical Outcome Studies

[Isolated ACL reconstruction versus ACL reconstruction combined with lateral extra-articular tenodesis: a comparative study of clinical outcomes in adolescent patients.](#) *Am J Sports Med.* 2022;50(12):3244-3255. doi:10.1177/03635465221118377

- Level III retrospective comparative cohort study looking at 111 patients undergoing ACL reconstruction (ACLR) with a mean age of 16 years old and mean outcome of 43 months.
- All ACLR performed with quadrupled hamstring tendon autograft and fixated using the TightRope® implant on the femur and biocomposite interference screws in the tibia.
- Patients with a Tegner score greater than 7 and grade $\frac{2}{3}$ pivot shift received an ACLR and lateral extra-articular tenodesis (LET) or a strip of the iliotibial band looped around the fibular collateral ligament, reflected on itself, and sewn in with Vicryl®. Lower-risk patients with a Tegner score less than 6 and a grade 1 or lower pivot received an isolated ACLR.
- Isolated ACL group had a 15% re-tear rate (6/40) with 1 contralateral ACL tear.
- ACL/LET group had 0 re-tears (0/71) including contralateral side.

Cavaignac E,
Mesnier T,
Marot V,
et al

[Effect of lateral extra-articular tenodesis on anterior cruciate ligament graft incorporation.](#) *Orthop J Sports Med.* 2020;8(11):2325967120960097. doi:10.1177/2325967120960097

- ACL grafts showed generally better incorporation and maturation when combined with LET.
- Adding LET to standard ACL reconstruction significantly decreases the loads on the ACL composite graft.
- In this Level 3 cohort study, 62 patients underwent ACL reconstruction using quadrupled semitendinosus autograft.
- At 1-year postoperatively, the MRI appearance of ACL grafts showed generally better incorporation and maturation when combined with LET.

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Sonnery-Cottet B,
Haidar I,
Rayes J,
et al

[Long-term graft rupture rates after combined ACL and anterolateral ligament reconstruction versus isolated ACL reconstruction: a matched-pair analysis from the SANTI Study Group.](#) *Am J Sports Med.* 2021;3635465211028990. doi:10.1177/03635465211028990

- First-ever long-term outcomes study comparing isolated ACL reconstruction with combined ACL and ALL reconstruction using anatomic ALL positioning with fixation in full extension.
- Authors followed 172 patients (86 matched pairs) for a mean of 104 months.
- Findings were in line with previous shorter-term studies, which found patients having undergone combined ACL and ALL reconstruction experienced significantly better ACL graft survivorship (96% vs 82.6%), lower overall rates of reoperation (nongraft-rupture related, secondary meniscectomy, excision of cyclops lesion, arthroscopic lavage) (15.3% vs 32.6%), and lower rates of revision ACL reconstruction (3.5% vs 17.4%).
- Patients undergoing isolated ACL reconstruction were at a >5-fold greater risk of graft rupture, regardless of their preinjury level of activity.

Lau BC,
Rames J,
Belay E,
Riboh JC,
Amendola A,
Lassiter T

[Anterolateral complex reconstruction augmentation of anterior cruciate ligament reconstruction: biomechanics, indications, techniques, and clinical outcomes.](#) *JBJS Rev.* 2019;7(11):e5. doi:10.2106/JBJS.RVW.19.00011

- Authors reviewed the biomechanics and indications for an extra-articular ligament augmentation, typical patient workup, surgical technique, rehabilitation protocol, and clinical outcomes of anterolateral ligament reconstruction and the modified Lemaire procedure.
- Early clinical and biomechanical data suggests that anterolateral complex reconstruction may help increase the rotational stability of an ACL reconstruction.
- Indications are evolving, and new studies are continually being published with encouraging results.
- Authors determined that “Additional studies are necessary to determine the long-term outcomes of these procedures, particularly with respect to restoration of function and reduction of failures following ACL reconstruction.”

Sonnery-Cottet,
Thaunat M,
Freychet B,
Pupim BHB,
Murphy CG,
Claes S

[Outcome of a combined anterior cruciate ligament and anterolateral ligament reconstruction technique with a minimum 2-year follow-up.](#) *Am J Sports Med.* 2015;43(7):1598-1605. doi:10.1177/0363546515571571

- This 2-year follow-up evaluated 83 of 92 patients who underwent a combined ACL and ALL reconstruction.
- IKDC objective scores and pivot-shift evaluation postoperatively were significantly better in anterolateral ligament-reconstructed patients after 2 years.



Anatomy and Biomechanical Studies

Blanke F,
Boljen M,
Lutter C,
Oehler N

[Does the anterolateral ligament protect the anterior cruciate ligament in the most common injury mechanisms? a human knee model study.](#) *Knee.* 2021;29:381-389. doi:10.1016/j.knee.2021.02.026

- Authors used a knee finite element model to evaluate which extra-articular structures supported the ACL in excessive internal and external tibial rotation.
- Initially the model was tested including only the intact ACL, PCL, MCL, LCL, and medial and lateral meniscus, then additional structures—including ALL, POL, popliteal tendon—were added and tested separately then all together. Testing done in 25° of flexion.
- It was determined that the ACL was the most loaded structure in both tibial internal and external rotation and that the ALL was the main stabilizer of the tibia in internal rotation, reducing load on the ACL by 21%.
- 55% of the total load reduction of the ACL in the internal rotation was due to the ALL.

Porter MD,
Shadbolt B,
Pomroy S

[The augmentation of revision anterior cruciate ligament reconstruction with modified iliotibial band tenodesis to correct the pivot shift: a computer navigation study.](#) *Am J Sports Med.* 2018;46(4):839-845. doi:10.1177/0363546517750123

- ITB tenodesis improved laxity, although it did not affect activity levels, when there was a persistent pivot shift after revision ACL reconstruction.

Geeslin AG,
Moatshe G,
Chahla J,
et al

[Anterolateral knee extra-articular stabilizers: a robotic study comparing anterolateral ligament reconstruction and modified Lemaire lateral extra-articular tenodesis.](#) *Am J Sports Med.* 2018;46(3):607-616. doi:10.1177/0363546517745268

- Residual laxity was identified after isolated ACL reconstruction in the setting of ALL and Kaplan fiber deficiency, and the combination of ACL reconstruction in this setting with either ALL reconstruction or the modified Lemaire LET procedure resulted in significant reductions in tibiofemoral motion at most knee flexion angles.
- ALL reconstruction and lateral extra-articular tenodesis have been described in combination with intra-articular ACL reconstruction to address rotational laxity. This study demonstrated that both procedures resulted in significant reductions of tibial internal rotation versus the intact state independent of graft tension or fixation angle, although anterior tibial translation was generally restored to intact values.

Rasmussen MT,
Nitri M,
Williams BT,
et al

[An in vitro robotic assessment of the anterolateral ligament, part 1: secondary role of the anterolateral ligament in the setting of an anterior cruciate ligament injury.](#) *Am J Sports Med.* 2016;44(3):585-592. doi:10.1177/0363546515618387

- This study confirms that the ALL is an important lateral knee structure providing rotatory stability to the knee.
- The ALL was a significant secondary stabilizer throughout flexion during an applied internal rotation torque and simulated pivot-shift test in the context of an ACL-deficient knee.
- Residual internal rotation and a positive pivot shift after ACL reconstruction may be attributed to an ALL injury. For these patients, surgical treatment of an ALL tear may be considered.



Pomajzl R,
Maerz T,
Shams C,
Guettler J,
Bicos J

[A review of the anterolateral ligament of the knee: current knowledge regarding its incidence, anatomy, biomechanics, and surgical dissection.](#) *Arthroscopy*. 2015;31(3):583-591. doi:10.1016/j.arthro.2014.09.010

- The authors systematically reviewed current literature on the anterolateral ligament (ALL) of the knee.
- “The ALL is a distinct ligamentous structure at the anterolateral aspect of the knee, and it is likely involved in tibial internal rotation stability and the Segond fracture.”

Parsons EM,
Gee AO,
Spiekerman C,
Cavanagh PR

[The biomechanical function of the anterolateral ligament of the knee.](#) *Am J Sports Med*. 2015;43(8):NP22. doi:10.1177/0363546515597218

- The ALL is an important stabilizer of internal rotation at flexion angles greater than 35°; however, it is minimally loaded during anterior drawer at all flexion angles.
- The ACL is the primary resister during anterior drawer at all flexion angles and during internal rotation at flexion angles less than 35°.

Helito CP,
Demange MK,
Helito PVP,
et al

[Evaluation of the anterolateral ligament of the knee by means of magnetic resonance examination.](#) *Rev Bras Ortop*. 2015;50(2):214-219. doi:10.1016/j.rboe.2015.03.009

- Using MRI, the ALL was viewed with signal characteristics similar to those of the other ligament structures of the knee.
- The anterolateral ligament of the knee is best viewed in sequences in the coronal plane.

Kennedy MI,
Claes S,
Fuso FA,
et al

[The anterolateral ligament: an anatomic, radiographic, and biomechanical analysis.](#) *Am J Sports Med*. 2015;43(27):1606-1615. doi:10.1177/0363546515578253

- Femoral attachment was located 4.7 mm (95% CI, 3.5 mm to 5.9 mm) posterior and proximal to the fibular collateral ligament attachment.
- Anterolateral tibial attachment was approximately midway between the center of Gerdy's tubercle and the anterior margin of the fibular head.
- ALL originated on the femur 22.3 mm (95% CI, 20.7 mm to 23.9 mm) proximal to the joint line and inserted on the tibia 13.1 mm (95% CI, 12.3 mm to 13.9 mm) distal to the lateral tibial plateau.
- On the lateral view, the femoral attachment was 8.4 mm (95% CI, 6.8 mm to 10.0 mm) posterior and proximal to the lateral epicondyle; the tibial attachment was 19.0 mm (95% CI, 17.1 mm to 20.9 mm) posterior and superior to the center of Gerdy's tubercle.

Rezansoff AJ,
Caterine S,
Spencer L,
Tran MN,
Litchfield RB,
Getgood AM

[Radiographic landmarks for surgical reconstruction of the anterolateral ligament of the knee.](#) *Knee Surg Sports Traumatol Arthrosc*. 2015;23(11):3196-3201. doi:10.1007/s00167-014-3126-y

- Using lateral fluoroscopy, the radiographic landmarks of the ALL origin and insertion were determined.
- ALL was found to be a mean distance of 24.7 mm \pm 4.5 mm from the center of Gerdy's tubercle and 11.5 mm \pm 2.9 mm distal from the lateral tibial plateau.
- The femoral origin of the ALL was found to be a mean of 3.3 mm \pm 1.5 mm anterior-distal from the FCL origin in the first anatomical variant and 5.4 mm \pm 1.4 mm posterior-proximal from the FCL origin in the second anatomical variant.



Caterine S,
Litchfield R,
Johnson M,
Chronik B,
Getgood AM

[A cadaveric study of the anterolateral ligament: reintroducing the lateral capsular ligament.](#) *Knee Surg Sports Traumatol Arthrosc.* 2015;23(11):3186-3195. doi:10.1007/s00167-014-3117-z

- MRI and histological sectioning were used to determine that the ALL is a thickening of the lateral joint capsule and can be referred to as an independent structure.
- Anatomic insertion points on tibia are described, but it is difficult to determine the points on the femur as it fans out and interdigitates with FCL.

Claes S,
Luyckx T,
Verecke E,
Bellemans J

[The Segond fracture: a bony injury of the anterolateral ligament of the knee.](#) *Arthroscopy.* 2014;30(11):1475-1482. doi:10.1016/j.arthro.2014.05.039

- This study confirmed the hypothesis that the ALL inserts in the region on the proximal tibia from where Segond fractures consistently avulse, suggesting that the Segond fracture is actually a bony avulsion of the ALL.
- Although the Segond fracture remains a useful radiographic clue for indirect detection of anterior cruciate ligament injuries, it should be considered a frank ligamentous avulsion itself.

Helito CP,
Demange MK,
Bonadio MB,
et al

[Radiographic landmarks for locating the femoral origin and tibial insertion of the knee anterolateral ligament.](#) *Am J Sports Med.* 2014;42(10):2356-2362. doi:10.1177/0363546514543770

- “The origin of the ALL in the lateral view was found at an average \pm SD of $47.5\% \pm 4.3\%$ from the anterior edge of the femoral condyle and about $3.7 \text{ mm} \pm 1.1 \text{ mm}$ below the Blumensaat line. In the frontal view, the origin was about $15.8 \text{ mm} \pm 1.9 \text{ mm}$ from the distal condyle line. The ALL insertion was an average of $53.2\% \text{ mm} \pm 5.8\%$ from the anterior edge of the lateral tibial plateau in the lateral view and $7.0 \text{ mm} \pm 0.5 \text{ mm}$ below the lateral tibial plateau in the frontal view. In anatomic dissections, the origin of the ALL was $1.9 \text{ mm} \pm 1.4 \text{ mm}$ anterior and $4.1 \text{ mm} \pm 1.1 \text{ mm}$ distal to the lateral collateral ligament, and the insertion was $4.4 \text{ mm} \pm 0.8 \text{ mm}$ below the lateral tibial plateau cartilage.”

Dodds AL,
Halewood C,
Gupte CM,
Williams A,
Amis AA

[The anterolateral ligament: anatomy length changes and association with the Segond fracture.](#) *Bone Joint J.* 2014;96-B(3):325-331. doi:10.1302/0301-620X.96B3.33033

- Detailed anatomic data on the ALL are provided.
- The femoral attachment of the ALL was a mean of 8 mm (2 mm to 12 mm) proximal and 4.3 mm (0 mm to 12 mm) posterior to the most prominent point of the lateral epicondyle.
- The tibial attachment is posterior to Gerdy’s tubercle and anterior to the fibula head.
- Distally, some fibers from the anterior edge of the LCL fanned out to attach to the tibia at the posterior part of the attachment of the ALL.

Claes S,
Verecke E,
Maes M,
Victor J,
Verdonk P,
Bellemans J

[Anatomy of the anterolateral ligament of the knee.](#) *J Anat.* 2013;223(4):321-328. doi:10.1111/joa.12087

- This abstract brings new focus to the ALL as a rotatory stabilizer of the knee.
- History and anatomy of the ALL are discussed.
- Forty-one cadaveric specimens were examined to determine femoral and tibial attachment points of ALL.