

THE ANTEROLATERAL LIGAMENT OF THE KNEE

ALL OR NOTHING

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“There is nothing new except what has been forgotten.”

– Marie Antoinette

Since the time of Alcmaeon and Hippocrates in the 5th century BCE, through Herophilos and Erastratus (300 BCE), Galen (200 CE) and Vesalius (1540 CE), man has had a keen interest in the study of how the body is structured and functions. Indeed over the centuries, the anatomy and function of the soft-tissue structures about the knee have been thoroughly studied and carefully memorialised in artists’ drawings and refereed journals. Therefore in 2013, it took the medical community by surprise when the world press reported that Claes and colleagues’ had ‘discovered’ a new and important knee ligament called the anterolateral ligament. In more careful review of their manuscript, one will quickly realise that the authors have not only

given appropriate reference to historical accomplishments but, more importantly, delved more deeply into the origins, attachments and unique facets of this structure. The seminal work of Claes et al’ has triggered a revival of interest regarding the importance, function and potential need to reconstruct the anterolateral ligament of the knee when injured.

“The important thing is to never stop questioning.”

– Albert Einstein

Most students of knee anatomy credit the original discovery of an extra-articular structure now called the anterolateral ligament (ALL) to Paul Segond in 1879^{2,3}. Segond described the structure as “a pearly, resistant, fibrous band which invariably showed extreme amounts of tension during forced internal rotation of the knee” at

the anterolateral aspect. Further, Segond correlated the injury with a common radiograph of an avulsion fracture from the proximal-lateral aspect of the tibia. This ‘Segond fracture’ or ‘Segond sign’ has been considered by some as pathognomonic of an anterior cruciate ligament (ACL) rupture, while others consider it evidence of a more severe rotational injury of the knee⁴⁻⁶.

For the next century, clinicians used the Segond sign as an indicator of ACL injury but little research focused on the soft tissue component. In the 1970s, Jack Hughston and colleagues re-evaluated the origin, insertion and function of the “middle third lateral capsular ligament”. The ligament was considered to be a major lateral static support of the knee at 30 degrees of flexion⁷. In the same time frame, Woods et al⁸ described the “lateral capsular sign” as a radiographic clue to significant knee injury. In 1987, Irvine et al⁹ chose to call the structure

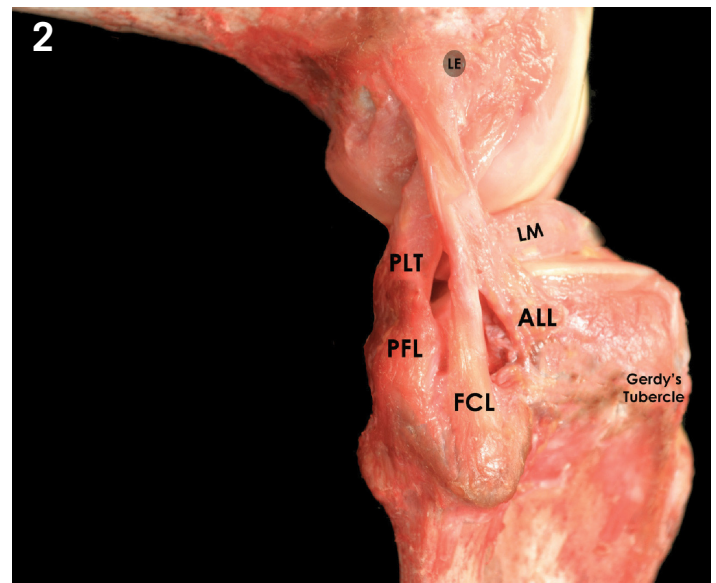
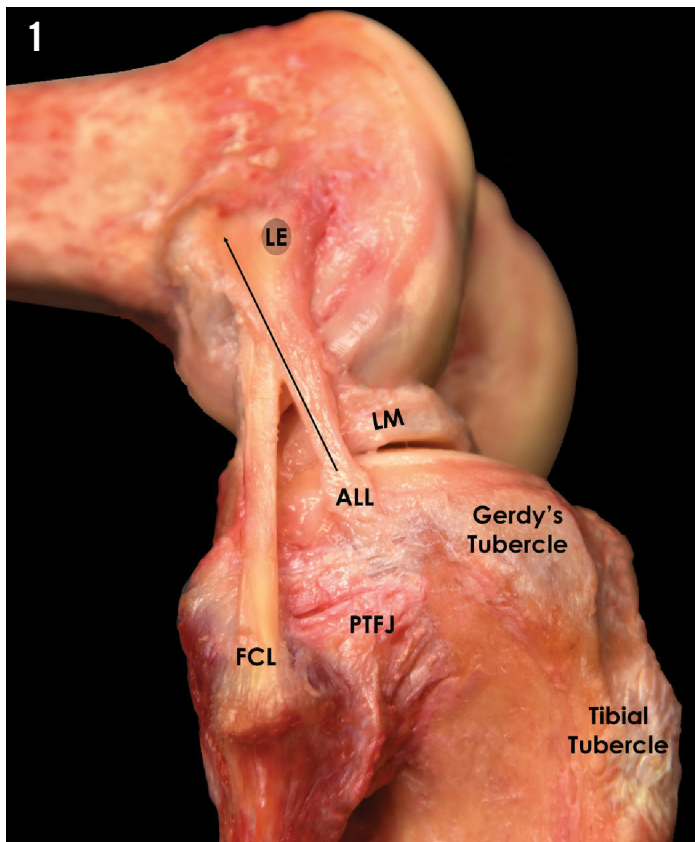


Figure 1: Lateral view of cadaveric specimen. LE=lateral epicondyle, LM=lateral meniscus, ALL=anterolateral ligament, FCL=fibula collateral ligament. Courtesy RF LaPrade, Steadman Philippon Research Institute.

Figure 2: Lateral view of cadaveric specimen. LE=lateral epicondyle, LM=lateral meniscus, ALL=anterolateral ligament, FCL=fibular collateral ligament, PLT=popliteus, PFL=popliteal fibula ligament. Courtesy RF LaPrade, Steadman Philippon Research Institute

the “anterior band of the lateral collateral ligament”. In 2001, Campos et al¹⁰ used the term “anterior oblique band”. Subsequent authors used each of the terms relatively interchangeably but without formal documentation of anatomic orientation, insertion origination or images that could be used to easily reproduce or compare their findings in other studies.

Credit for coining the term ‘anterolateral ligament’ (ALL) of the knee is given to Viera et al¹¹ in their 2007 study which focused on the iliotibial tract. Subsequently, the first paper targeting the ALL was authored by Vincent et al¹² in 2012. They identified the ALL in ten cadaveric specimens, noting the proximal origin was described in close relation to the popliteus tendon in the lateral femoral condyle. The course of the ALL ran just anterior to the popliteus tendon insertion and passed distally near the junction of the anterior and middle thirds of the lateral meniscus. The distal insertion was identified on the proximal anterolateral tibia, posterior to Gerdy’s tubercle and close to the joint line¹².

“Surgical anatomy is, to the student of medicine and surgery, the most essential branch of science,”

– Henry Gray (author of *Gray’s Anatomy*)

In 2013, Claes and colleagues¹ published their influential paper in the *Journal of Anatomy*. Their study provided qualitative and quantitative anatomic characterisation of the ALL using 41 cadaveric specimens. The study found the ALL in 97% (40/41) of the cadaveric specimens as a distinguishable structure from the anterolateral joint capsule. The major origin was located on the lateral femoral epicondyle close to the lateral collateral ligament, and posterior and proximal to the insertion of the popliteus tendon. The superficial fibres of the ALL continued over the lateral aspect of the distal femur in the direction of the lateral inter-muscular septum of the thigh. The ligament continued distally in an oblique course to the proximal tibia attaching posterior to Gerdy’s tubercle in the middle of a line connecting the tip of the fibular head with Gerdy’s tubercle. A strong connection between the ALL and the middle third of the lateral meniscus was seen in most of the specimens. The ALL had a mean width of 8.3 mm and mean length of 38.5 mm. This can be compared to the mean length of 34.1 mm suggested by Vincent¹², or the range of 34.1 to 41.5 mm in length, 5.1 to 8.3 mm in width above the lateral meniscus and 8.9 to 11.2 mm in width below the meniscus, based on pooled meta-analysis of 449 knees¹³.

Subsequent to the Claes publication, the literature has exploded with manuscripts targeting the ALL. A Google Scholar and PubMed literature search from 2013 to present using keywords “anterolateral ligament of the knee” revealed between 75 and 90 manuscripts addressing anatomy, biomechanics, imaging, function and reconstruction of the ALL. Anatomic and morphometric descriptions of the ALL have been published in classic and recent articles but vary considerably^{2,10-14}. Most of the authors have concluded that it is an extra-articular structure independent from the iliotibial band, with a reported incidence of ranging from 83 to 100%^{13,15,16}. Its distal attachment has been consistently described in the middle area between the Gerdy’s tubercle and the fibular head. Specific discrepancies exist regarding the location and conformation of its proximal insertion. Daggett et al¹⁷ showed a broad variation of femoral attachments with 23% being directly at the lateral epicondyle, slightly posterior and proximal in 58%, and completely posterior and proximal in 19%. This variation will raise significant challenges to those attempting to perform an anatomic reconstruction of an injured ligament. Further concern regarding the consistency and reliability of the anatomy

of the ALL has been challenged in studies evaluating the ligament in paediatric and Asian knees^{18,19}. Subsequent to Claes' original work, the most thorough and descriptive work on ALL anatomy was presented by Kennedy, Claes, LaPrade et al²⁰ (Figures 1 to 3). They described the femoral insertion point to be 3.5 to 5.3 mm proximal and posterior to the lateral collateral insertion and traversing anterior and distally to a point half way between Gerdy's tubercle and the anterior aspect of the fibula. Ultimately they concluded that there were reproducible anatomic and radiographic landmarks that could guide an anatomic reconstruction of an injured ALL.

In addition to anatomic dissections, since 2013, the literature has blossomed with manuscripts assessing the ability of radiographic, ultrasonographic and magnetic resonance imaging to assess intact and pathologic anatomy of the ALL. Radiographically, the goal would be to define landmarks that might assist percutaneous guide pin placement – similar to Schottle's point for medial patellofemoral ligament reconstruction. Unfortunately, direct comparison of studies has not presented a reproducible description that all clinicians can agree on. For example Rezansoff et al²¹ placed the tibial insertion 24.7 mm posterior to Gerdy's tubercle and 11.5 mm distal to the tibial plateau, while Helito et al²² noted the insertion was 53% (+/- 6%) from the anterior border of the tibia and 7 mm below the tibial plateau.

Regarding ultrasound and MRI, while most studies support the ability to visualise the ALL with ultrasound, Capo et al²³ found it to be unreliable, suggesting that either other imaging techniques may better visualise the ALL or the ultrasonographer needs to better understand the anatomy and advance their skills when using this tool. Similarly, the accuracy of MRI to completely visualise the ALL has been questioned. Helito²⁴ noted that while they could visualise at least a part of the ALL in 97% of knees, only 72% of the time could they visualise femoral, meniscal and tibial components of the ligament. Taneja and colleagues²⁵ had even worse success with only 51% of ALLs being partially visualised and just 11% completely visualised. Be that as it may, abnormalities on MRI scan

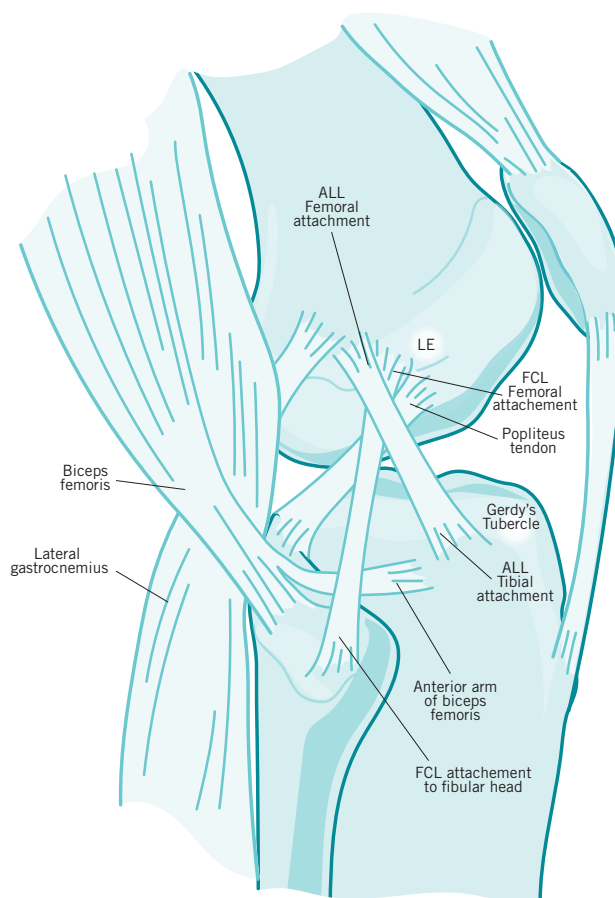


Figure 3: Anatomic drawing of lateral aspect of knee. Courtesy RF LaPrade, Steadman Philippon Research Institute (recreated from).

should alert the clinician to the potential of associated injury of the ALL with ACL injuries. Helito and colleagues²⁶ reported that 33% of ACL-injured patients had associated injuries of the ALL visualised on MRI. Claes and colleagues²⁷ investigated further by carefully evaluating MRI scans of 206 ACL-injured knees. Seventy-nine percent had abnormal findings along the path of the ALL, with 78% of those involving the distal aspect of the ligament.

“As to diseases, make a habit of two things — to help or at least to do no harm.”

—Hippocrates

Understanding normal and pathologic anatomy and biomechanics is foundational to the potential impact of various treatment options including surgical intervention. Ideally, the goal would be to recreate anatomy with similar strength and function without causing additional problems or complications. Indeed, there are numerous techniques that have been described to reconstruct the ALL, with a distinction between anatomic

and functional reconstructions. Extra-articular augmentation and functional reconstructions are more thoroughly covered by Dr Phillippe Landreau elsewhere in this issue of the *Aspetar Sports Medicine Journal*. The conceptual stepwise technique for anatomic ALL reconstruction is presented below:

1. Harvest and prepare appropriate graft with a minimum length of 12 cm.
2. Identify the anatomic femoral origin proximal and posterior to the lateral epicondyle.
3. Identify the tibial insertion point halfway between Gerdy's tubercle and the anterior aspect of fibular head (22 to 24 mm posterior to the tubercle, 10 cm distal to the joint line).
4. Place guide pins and check isometry.
5. Over-drill the femoral pin and place the graft, with anchor, fully flush with the condyle.
6. Over-drill the tibia and the pass graft from femur to tibia using a haemostat.
7. Fix the femoral side.
8. Fix the tibial side.
9. Check for range of motion and isometry.

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In support of routinely performing ALL reconstruction when the ALL is injured, most biomechanical studies have reported that the ALL provides stability in internal rotation of the tibia and improves rotational stability with associated ACL reconstruction²⁸⁻³¹. Closer evaluation has shown that this constraint occurs at flexion angles greater than 35 degrees. At angles less than that, the ACL – and not the ALL – prevents internal rotation of the tibia³². Given the role that the ALL appears to play in rotatory stability of the knee in biomechanical studies, outcome studies have been supportive but not conclusive that some patients require surgical reconstruction of the ALL^{32,33}. In a case series, Sonnery-Cottet et al³⁴ found increased stability at 2-year follow-up in patients that underwent concurrent a ACL and ALL reconstruction. The study compared preoperative versus postoperative pivot shift to define stability. Although this was not a randomised trial, the number of grade one pivot shifts went from 41 to 7 and the number of negative pivot shifts rose from 0 to 76 ($p < 0.0001$). Therefore, the authors concluded that concurrent repair helps to improve stability. Nonetheless, no study to date has evaluated comparative functional outcomes, comparative satisfaction or comparative return to play in a randomised blinded fashion between patients with documented ALL injuries but treated only with ACL reconstruction versus those treated with ACL and ALL reconstruction.

In contrast, several articles have reported potential complications associated with ALL reconstruction, which would suggest a more cautious approach to routine performance. While apparently straightforward, there are challenges to whether anatomic anterolateral reconstructions can be safely and functionally designed. Two studies

concluded that the ALL shows no isometric behaviour during the range of motion of the knee^{35,36}. Helito et al³⁷ showed that an anatomic femoral tunnel for reconstruction was so close to the insertions of the popliteus and LCL that iatrogenic injury to those structures during tunnel placement was possible.

Others have raised concerns that routine repair of the ALL may over-constrain the knee. Katukura et al³⁸ reported tension changes in the reconstructed ALL dependent on various femoral tunnel positions. A study on cadaveric knees by Schon et al³⁹ revealed that ALL reconstruction limited internal rotation of the tibia at all angles of flexion from 30 degrees to 60 degrees. There was no change in anterior drawer, pivot shift or internal rotation stability tests. The authors concluded that repair of the ALL results in an over-constrained knee at all flexion angles which could risk increased articular loads and may limit motion and function³⁹.

“Only those who will risk going too far can possibly find out how far one can go.”

– T.S. Elliott

Ultimately, there is still much debate regarding whether or not the ALL should be reconstructed concurrently with the ACL. As of 2017, the answer regarding routine repair/reconstruction is still not an all or none response. There are no clinical studies to support the conclusion that reconstruction is required for return to play in elite level athletes. Biomechanical studies appear to show a prominent role that the ligament plays in rotatory stability of the knee at flexion angles greater than 30 degrees; however, the risk of over-constraint with current reconstructive techniques should introduce a sense of caution when

recommending reconstruction for all patients. Residual rotatory instability via pivot shift testing despite ACL reconstruction either postoperatively or immediately after intraoperative fixation may be reasonable and conservative indications for ALL reconstruction; however, routine use of ALL reconstruction must be carefully considered based on high-quality outcomes assessment and the risk of complications. As of 2017, reconstruction/repair of the ALL should be individualised to the patient and should not be an ‘ALL or NOTHING’ determination.

References available at
www.aspetar.com/journal

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