CURRENT CONCEPTS REVIEW

Truly Existing or Hyped up? Unravelling the Current Knowledge Regarding the Anatomy, Radiology, Histology and Biomechanics of the Enigmatic Anterolateral Ligament of the Knee Joint

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Abstract

Ever since its description, anterolateral ligament (ALL) of the knee joint remains as the hotspot of controversies. Though it has been described under various descriptions, the structure gained its limelight when it was christened as anterolateral ligament by Claes in 2013. The main reason for the controversies around it is the lack of concrete evidences regarding its attachments, morphology, biomechanical aspects and radiological appearance. Similarly the role of ALL in pivot shift phenomenon also remains as a point of debate. The advocates of ALL suggest that because of its ability to modulate internal rotation and attachment to the lateral meniscus, ALL contributes to the pivot shift phenomenon. Similarly, the orientation of ALL stands as the reason for varied documentation with respect to imaging techniques. With the growing body of evidence, it is imperative to fix our stand regarding the structure because, if found to be morphologically persistent, it can be used for concomitant anterolateral stabilization along with anterior cruciate ligament reinforcement surgeries. The present review tries to systematically review the anatomy, variations in classifications, descriptions, histology, radiology and biomechanical features of ALL. At the end of the review, we would like to find the answer for the question: Is ALL a distinct ligamentous structure located at the anterolateral aspect of the knee? What is the contribution of it to the tibial internal rotation stability?

Level of evidence: II

Keywords: Anterolateral ligament, Anatomy, Arthroscopy, Biomechanics, Knee joint, Lateral capsule

Introduction

The ligamentous stabilizers of the knee joint has been a point of interest for numerous studies, owing to the fact that knee is the most commonly injured joint in the body, especially among athletes. A prospective study, after following up the recreational male and female exercisers over a period of 7 years, had reported 15-50% of the injuries in 12 different sports involve knee joint (1). Also, knee injuries accounted for the highest proportion of costs in the medical treatment of sports injuries (1). Knee joint is a complex modified hinge joint which undergoes flexion / extension in sagittal plane along with internal /external rotation in a perpendicular plane. Mechanism of locking at the terminal stages of flexion includes medial femoral rotation on tibia and unlocking of knee at the initial stages of extension includes lateral rotation of femur, both happening in a transverse plane. Anterior Cruciate Ligament (ACL) is the frequent structure to be injured

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and it's also the commonest ligament to be reconstructed in the body. The increasing number of failures in the ACL reconstruction have always kept the researchers in the hunt for discovery of new ligaments in the knee. It was always debated that since ACL and Posterior Cruciate Ligament (PCL) are centrally located structures they do not provide much of a rotational stability. In spite of its perceived role in secondary instabilities following injuries, the anterolateral structures are said to be a major contributors to the rotational stability of knee joint but their anatomy and function have not been concretely perceived.

Along with cruciate ligaments, playing prime roles as passive stabilizers of the knee joint, anterolateral ligament (ALL), also contributes to certain degree. Higher incidence of post-operative rotational instabilities after isolated ACL reconstruction and significant pivot shift results were mainly associated with injuries to lateral ligamentous structure (2, 3). These roused great interest of orthopaedic surgeons to review the anatomy, histology, biomechanics, radiological imaging and arthroscopic visualisation of the osseo-ligamentous complex present in the lateral aspect of knee joint.

Paul Ferdinand Segond, a French surgeon, while describing an avulsion fracture involving upper anterolateral region of tibia in 1879, also had mentioned about the existence of 'a pearly, resistant, fibrous band which got extremely tensed during forced internal rotation of the knee'(4). This structure faced a serious controversy in its nomenclature in the subsequent years. *Irvine* named it "anterior band of the lateral collateral ligament", few authors named it as "mid-third lateral capsular ligament" and *Campos* named it as "anterior oblique band" (5-8). In addition to the nomenclature, the attachments were also variably described in the literature. *Hughston et al.* initially had described the "technically strong" zone of the lateral capsule they met, as extending from the lateral femoral epicondyle to tibia and postulated that they might act as major non-dynamic support to the lateral aspect of knee joint at around 30 degrees of flexion (6). *Terry et al.* had reported that a part of iliotibial tract, getting attached to capsule and bone, acts as anterolateral ligament of knee and it forms an inverted U structure with the ACL in the lateral aspect of femoral condyle (9).

Vieira EL et al. in 2007, had described ALL as a distinct entity extending from lateral femoral condyle to the mid-portion of upper tibia (10). *Claes et al.* rejuvenated the spirit after describing the anterolateral ligament as, "a well-defined ligamentous structure, clearly distinguishable from the anterolateral joint capsule" in 40 out of 41 specimens (11). Since then, the structure which had a varied nomenclature and anatomical description was cast into the spotlight of research.

Anatomy of anterolateral ligament

One review involving 19 studies claims that ALL is present in 96 % of studied knees (12). 13 out of 19 studies had described the course extending from lateral femoral epicondyle, passing anteriorly and downwards to the upper tibia across the knee in an oblique fashion. *Vincent et al.* described ALL originated distal and anterior to the origin of fibular collateral ligament (4). The femoral attachment is high variable in and around the proximal attachment of fibular collateral ligament [Figure 1] (4, 11, 13-15). ALL then overlaps the proximal portion of fibular

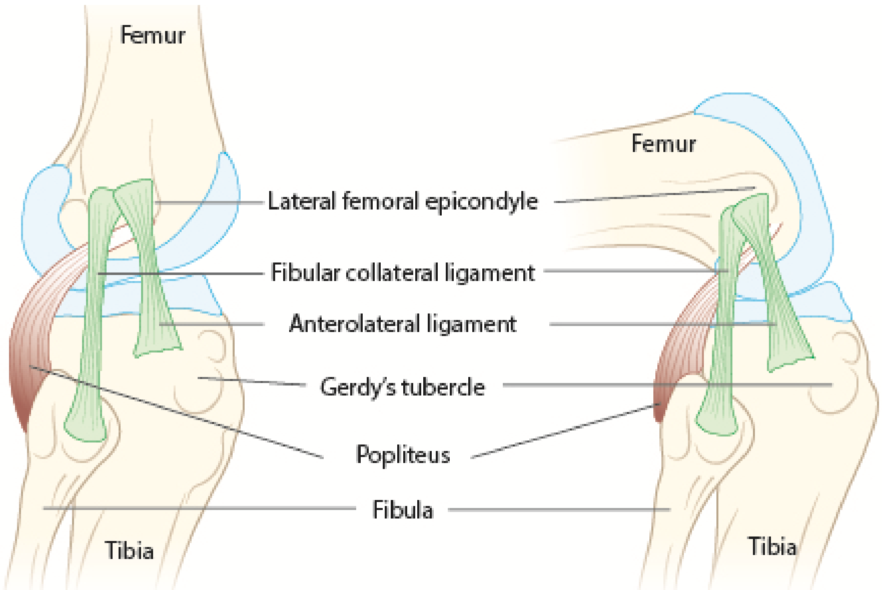

Figure 1. Schematic representation of the anterolateral ligament arising from the lateral epicondyle and getting inserted into the lateral surface of medial condyle of tibia a) knee in extension b) knee in flexion.

collateral ligament (11). A portion of ligament is attached to the lateral meniscus and the lateral capsule; rest of the ligament continue downwards, spread like a fan and get inserted into upper tibia just behind Gerdy tubercle (16, 17). *Macchi et al.* documented that ALL gets inserted on the mid 1/3 of the lateral meniscus in 46% of cases and in rest of the cases gets inserted on the lower 1/3 (18). *Helito et al*. documented the bifurcated appearance of ALL, terminating in 2 ligament attachments to the lateral meniscus, with lower attachment to the tibia between the Gerdy tubercle and the head of fibula (16). *Lutz et al.* postulated that ALL constitutes the "triangular capsular ligament complex" along with the Lateral Collateral Ligament and also delineated the presence of Kaplan fibres, which attaches ALL to Iliotibial tract (17).

We made a preliminary quantitative observation in 30 cadaveric limbs [Table 1]. Combining the dissection methods proposed by *Claes et al.* and *Daggett et al.*, exposition of ALL was done by reflecting the Iliotibial tract and biceps femoris from ALL and defining the margins with internal rotation torque placed on tibia (9, 11). In 24 out of 30 specimens the femoral attachment was origin was always posterior to the attachment of the fibular collateral ligament which was in concordance to the findings of *Kennedy et al.* (14). The location of inferior lateral geniculate vessels in relation to ALL was used an important anatomical landmark to identify it (11). In contrast to the specimens dissected by *Claes et al.* (11) showing the ALL to be chordoid and cylindrical structure, most ALL in our specimens were flat, laminar and less precise in concordance with *Daggett et al.* (19). The variability across different studies reflect the challenges associated with defining the margins and attachments of ALL with precision and measuring its length (4, 8, 10, 11, 16, 20-29, 30). The differences in description of femoral attachment is largely due to the variability of dissection techniques followed by corresponding authors. The key observations which have been made by different authors have been summarized in Table 2.

As described by *Pomazjl et al.*, "these inconsistencies

Table 1. Descriptive statistics of Anterolateral ligament in 30 adult knees

Measurements	Mean (in mm) and range
Antero-lateral ligament length	39.7 (34.5 – 44.7)
Distance between Gerdy's tubercle to tibial attachment of Antero-lateral ligament	19.6 (15.8 – 23.4)
Width of ALL	5.6 (4.8 - 6.4)
Distance from ALL tibial attachment to most prominent point of fibula	35.5 (32.5 – 38)

Table 2. Brief summary of the previous studies documenting the Quantitative anatomy of Anterolateral ligament

Author & year	Type of specimens	Number of specimens	Population and prevalence	Mean length (in mm)	Observation of the study
Campos et al. (2001) (8)	Cadaveric	6	American; 100%	Not available	Thick band between iliotibial tract and lateral collateral ligament stabilizing the knee joint from lateral side and may contribute to the pathogenesis of Segond's fracture.
Vieira et al. (2007) (10)	Cadaveric	10	Brazilian Not stated	Not available	ALL, a part of iliotibial tract is a well-defined functional structure.
Vincent et al. (2012) (4)	Cadaveric	10	French; 100%	34.1 ± 3.4	ALL is a distinct collagenous structure with definite attachments.
Claes et al. (2013) (11)	Cadaveric	41	Belgian; 98%	38.5 ± 6.1	1. ALL is a distinct ligamentous structure controlling pivot-shift 2. Bony avulsion of ALL shall lead to Segond's fracture.
Helito et al. (2013) (16)	Cadaveric	20	Brazilian; 100%	37.3 ± 4	1. ALL is present anterior and distal to LCL. 2. A part of it attaches to lateral meniscus and rest attaches to the area between Gerdy tubercle and head of fibula.
Dodds et al. (2014) (15)	Cadaveric	40	British; 82.5%	59.0 ± 4.0	1. ALL provide rotational stability and influence the pivot shift phenomenon. 2.It is an extra-capsular ligamentous structure

Table 2 Continued.

Potu BK et al. (2016) (20)	Cadaveric	24	Caucasian; 4.16%	34.23	1. ALL is found in one out of 24 knees. 2. Extends from lateral femoral condyle to lateral tibial plateau, with an extension to lateral meniscus.
Caterine et al. (2014) (21)	Cadaveric	19	Caucasian, 100%	40.3 ± 6.2	1. ALL is a ligamentous thickening of the lateral joint capsule that can be referred to as an independent structure, synonymous with the lateral capsular ligament. 2. It tensions under internal rotation and varus stress. Might have a role in controlling anterolateral rotatory stability.
Stijak et al. (2015) (22)	Cadaveric	14	Serbian 50%	41 ± 3	1. ALL is a thickening of the knee joint capsule located in the third layer of the lateral region of the knee (Seebacher classification) 2. It is not always clearly morphologically differentiated from the remainder of the joint capsule
Kennedy et al. (2015) (14)	Cadaveric	15	100%	36.8 ± 4.5	1. The ALL was consistently found in all knees with defined attachments 2. Failure mechanisms of the ALL includes bony avulsions of its tibial attachment (Segond's fracture)
Kosy et al. (2015) (23)	Cadaveric	11	NA 90.9%	40.1 ± 5.53	1. ALL is a capsular thickening with meniscal attachment. 2. Limiting the "pivot-shift", by reconstructing the ALL, might prevent residual instability following intra-articular ACL reconstruction.
Runer et al. (2016) (24)	Cadaveric	44	Austrian 45.50%	42.2 ± 6.2	1. ALL is an inconstant, distinct oblique, extra-capsular structure in the anterolateral compartment of the knee, present in almost half of cases. 2. This structure should not be confused with the capsular–osseous layer of the Iliotibial tract, which has a different origin. 3. provides rotational ability and likely prevents internal rotation
Zens et al. (2015) (25)	Cadaveric	6	Germanian 100%	Static length - NA	1. ALL is a non-isometric structure that tensions with flexion of knee and internal rotation of tibia 2. ALL stabilizes against internal tibial rotation, especially at deep flexion angles. 3. Tensioning and fixation of the ALL graft should be performed near 90° of flexion
Lutz et al. (2015) (17)	Cadaveric	9	French 100%	39.11 ±3.4	1. Demonstrated two distinct anterolateral tissue planes: a superficial plane represented by the iliotibial tract and the Kaplan fibres and a deep plane represented by a triangular capsular ligament complex within which can be found anterolateral ligament and anterolateral capsule recruitment. 2. They get tightened during the internal rotation of tibia.
Watanabe et al (2016) (26)	Cadaveric	94	Japanese 37%	NA	1.Classified the lateral fibrous tissue into two types: ligamentous structure- type I (ALL) Thin aponeurotic- type II (ALLT). 2. The prevalence of the ALL in Japanese people was lower than western population. (type I ALL was approximately 20%, which was related to the Segond fracture; type II was the thin aponeurotic tissue that was not enough strength to cause fracture)

Table 2 Continued.

Parker et al., (2018) (27)	Cadaveric	53	American 96%	38.39±4.3	1. Identified a novel technique for assessing whether the anterolateral ligament is absent in embalmed specimens or has been obliterated or overlooked, using the lateral inferior genicular vasculature. 2. Confirmed the presence in 96% cases and documented few variations in position and course.
Fardin et al. (2017) (28)	Cadaveric	15	Brazilian 0%	ALL is absent in all cases	Mesoscopic analysis of transverse sections along knee joints reveals that ALL would not necessarily be an individualized ligament. Data obtained so far are not sufficient to morphologically characterize the ALL as a ligament.
Farhan PHS et al. (2017) (29)	Cadaveric	26	Indian 100%	39.21±7.2	1. ALL was found to be a distinct anatomical structure on the anterolateral aspect of knee. 2. ALL lesions in ACL injuries might cause high-grade pivot-shift. 3. The reconstruction of ALL along with that of ACL could lead to a decrease in the re-injury rates.
Our observation (unpublished data)	Cadaveric	30	Indian 80%	39.7 ± 5.9	1. ALL was found in 80% kness with defined attachments. 2. In rest 20% knees, ALL was indistinct from the adjacent joint capsule.
Olewnik L et al., 2018 (30)	Cadaveric	111	Poland 63%	37.97 ± 6.9 (males) 32.7 ± 6.78 (females)	1.ALL is morphologically variable 2. It can be classified into four types: a) type 1: single band travelling parallel to the fibular collateral ligament b) type 2: band crossing fibular collateral ligament type 2b: ligaments that bifurcated c) type 3: resembling the capsule d) type 4: double ALL e) type 5: ALL starting from fibular collateral ligament directly.

may be attributed to inter-digitation of soft tissue structures and the difficulty of defining interfaces between anatomic structures in light of varying dissection tools and techniques (31)”. For example, *Vincent et al.*, visualized the anterolateral ligament, as a thickening of the lateral capsule by placing the Hohmann Retractor between the femur and the tibia (4). The structure was delineated from the internal aspect i.e. synovial side. This would have resulted in the documentation of increased ALL width. Another point of dispute is related to the classification be *Seebacher JR et al.*, which stratifies the lateral aspect of knee into three layers with first layer comprising of oblique iliotibial tract fibres and deep part of third layer comprising of joint capsule (32). *Claes et al.* had described a bundle of fibres arising from the lateral femoral condyle in the third layer of the ligament (11). To avoid further conflicts in interpretation, *Stijak et al.*, proposed the transverse laminar arrangement in the lateral region of the knee which would consist of four layers (22). They also presumed that this arrangement of fibre bundles is the resultant of different directions of force impact in the capsule of knee joint capsule. Thus, it can be postulated that knees that have been exposed to force of impact (as in most cadaveric studies) such as internal rotation of tibia have a strengthened part and thus making ALL distinct from the rest of the capsule.

Also, ALL was identified in only one out of 8 paediatric specimens suggesting that it might develop when physiological loads as a result of walking are exerted to the knee joint capsule, in later life (33). Another study involving 21 unpaired foetal limbs of gestational age between 18-22 weeks, could not demonstrate presence of a distinct extra-capsular ligamentous structure in the anterolateral aspect of capsule (34). In contrast, a study involving 20 foetal specimens of mean gestational age 28.64 ± 3.20 weeks demonstrated ALL in all specimens (35). The explanation for this can be hypothesized that, ALL can be visualized prominently after 20 years of life when the fibrous tissue of the lateral capsular area of knee progressively differentiates as an individual ligamentous structure probably due to an increase of the collagen content in ligamentous core (18). Two studies have also described the decreased length of ALL in the female specimens (24, 36). Presumably, in pivot-shift-type injuries, forces passing through ALL in females are either greater than the ligamentous strength or circumvent the core of ligament as a result of increased laxity. This manifests as increased propensity for ACL injuries in female athletes (36).

Histology of anterolateral ligament

The initial histological study by *Vincent et al.* demonstrated that ALL is a wavy core of connective tissue enclosed in loose synovial sheath (4). Approximately, 20% of core of the structure was made up of dense fibrous tissue, especially in sections taken above the level of lateral meniscus. Wavy collagenous fibres in the core was observed in longitudinal sections, suggestive of ligamentous or tendinous structure and some collagen fibres got inserted to lateral meniscus itself [Figure 2]. *Helito et al.*, by virtue of identifying densely arranged connective tissue confirmed it as a true ligament and differentiated it from a mere capsular thickening which is mostly loosely organized with sparse amount of cells (16). *Zens et al.* investigated histological cuts using polarization microscopy and had demonstrated the unique crimping pattern which proved the ligamentous nature of ALL (37). *Macchi et al.*, after a detailed histotopographic study showed that ALL is situated in the 3rd layer (Seebacher's classification) and was separated from lateral inferior geniculate vessel only by little adipose tissue (18). The wavy fibrils was predominantly type I collagen (90%) with minor proportions of type II & III collagen (5%), elastic fibres (<1%) and the core was formed by type VI collagen (3%). S-100 stain demonstrated type I mechanoreceptors suggesting a potential proprioceptive role. *Caterine et al.* found that the body of ALL had the collagen pattern organized as discrete 'bundles', and thereby postulated that it is a stacking of multiple thickenings of the lateral joint capsule in contrast to homogenous morphology of structures such as ACL (21).

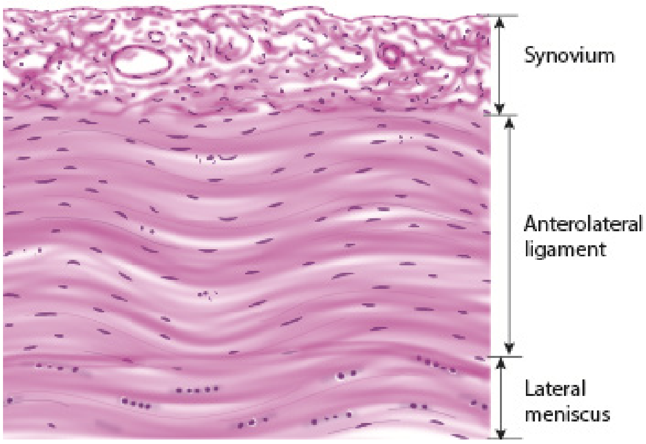

Figure 2. Schematic representation of the section of ALL stained with haematoxylin and eosin and viewed under X 100 magnification. ALL has wavy organization of fibres and lesser cellularity compared to fibular collateral ligament. It is bordered by synovial tissue on the external surface and attachment to the lateral meniscus is marked by the zone of transition.

The femoral attachment of ALL showed a transition from ligamentous structure to mineralized cartilage. Similarly, immunohistochemistry revealed a conglomeration of free nerve endings and mechanoreceptors within the ALL. *Helito et al.* classified ALL into a superficial and deep parts, based on anatomical disposition and found that number of fibroblasts per mm2 was identical in both regions and slightly lower than the number of fibroblasts in ACL (38). *Helito et al.*, also studied the histologic sections of ALL in 20 foetal specimens and found that they are made up of dense, well-organized collagenous fibres (predominantly type I) and an increased concentration of elongated fibroblasts per mm2 (35).

Dombrowski et al., observed a distinct transition from loose connective tissue of the capsule to well organized structure resembling ligament in lateral capsular thickening (39). However, the organization was irregular compared to regular arrangement of Lateral Collateral ligament. Histologic analysis revealed that anterolateral capsule is a loose and hypocellular connective tissue (i.e. absence of ligamentous tissue) with less organized collagen fibres compared to FCL which had dense and well-organized collagen fibres. Thus, it can be understood that ALL is an obvious capsular thickening in the lateral side of knee and ligamentous features (by aligning as parallel bundles) are obtained in adult life, when the joint is exposed to mechanical loads. In addition, the presence of mechanoreceptors suggests its potential proprioceptive property.

Radiology of anterolateral ligament

To optimise the reconstruction procedures related to ALL, the knowledge regarding the radiographic appearance of ALL and its surrounding structures became a topic of pertinence. In plain lateral radiograph of the knee joint (cadaveric specimens), *Helito et al.* used Blumensaat's line (drawn along the roof of inter-condylar notch of femur, which is used to indicate the relative positioning of patella) as a reference point for identifying the femoral attachment (40). *Rezansoff et al.*, used fluoroscopy and documented that mean ALL origin approximately lies on the lateral femoral epicondyle (41). They found that FCL and ALL shared a common origin in some cases and this finding was similar to that of *Claes et al.* who had proposed the anatomical description, "lateral collateral ligament complex" (11). This fact is of significance during surgeries which utilize bone tunnels in terms of graft choice and fixation. *Kennedy et al.* had used stacked reference lines for mapping the quadrants of femur and documented the femoral origin to be proximal and posterior to the midpoint of lateral epicondyle (14). The tibial landmark was indicated to be slightly anterior or posterior to the centre of tibial plateau (14, 39, 42). Avulsion of tibial attachment of ALL causes a bony fragment of upper tibial plateau (Segond's fracture) and it usually occurs along with ACL injuries. Variability between post-operative anterolateral stability of the patients might be explained by an associated ALL injury, which requires its reconstruction.

With ultrasound imaging, ALL was visualized by *Oshima et al.* using the fact that the ligament is sandwiched between lateral inferior genicular artery below and iliotibial tract above (43). *Cavaignac et al*., initially used ultrasonography to locate the structure (corresponding to ALL) in anterolateral aspect of 18 cadaveric knees and documented its length and relations with bony landmarks (44). They then validated the readings by dissection and found that ultrasonography has 100% sensitivity in identifying ALL. Considering the number of ALL injuries involving either attachments, ultrasonography might be a useful for the diagnosis of injuries in these portions along with its dynamic motions (45). In addition, Doppler ultrasonography would help in assessing vascularity during the restoration process and help in comparing with the opposite side (43). Dissimilar to the above mentioned studies, *Capo et al*., found ultrasound to be ineffective for locating the attachment points of the ALL and the ability to delineate it from both deep part of iliotibial tract and adjacent part of joint capsule (46).

La Prade et al. investigated the posterior & lateral corner of the knee and found defined a structure namely "mid-third of capsular ligament" in all 20 knees and then confirmed it by dissection (47). Several studies have assessed the ability of MRI to identify ALL in the normal knee and the detection rates ranges between 72% and 93% (23, 48, 49). ALL can be identified on coronal sections by means of T2-weighted sequences and fat-suppressed evaluation. *Helito et al.* found that part of ALL attached to menisci was the easiest to identify (94.8 %) (49). The other parts of ALL such as femoral part (89.7 %) and tibial part (79.4 %) can be identified with lesser precision. In a case series of ACL injuries, *Claes et al*. could identify ALL in 76.0 % of patients and in cases with ALL injuries the incidence of concomitant anterolateral instabilities was higher (50). *Taneja et al*., observed ALL in 51 % of the knees and the tibial insertion site was well characterized in all images (51). *Kosy et al.* were able to visualize part of ALL in 94 % of the scans and complete ALL in 57 % of the MRI scans and invariably in all cases ALL were attached to the lateral meniscus (52). *Porrino et al.* noted that the ALL and FCL could not be distinctly separated at the origin and no reliable plane could be made out from adjacent joint capsule (53). Another significant feature in MRI, indicating ALL injury, is visualization of oedema in the bone marrow of lateral femoral condyle and posterior tibial plateau following violent pivot-shift trauma (54).

Biomechanics and reconstruction of anterolateral ligament

Monaco et al. severed ALL and studied the changes in degree of movement in fresh frozen knees (55). They observed an increase in anterior translation at 60° and increase in internal rotation at 30°, 45° and 60°. Also, when ACL and ALL were absent *in vitro* models, grade III pivot shift was seen (56). Studies have shown that ALL, owing to its biomechanical properties permit increased degree of internal rotation after 30º of flexion (57, 58). A MRI based study have shown that abnormalities in anterolateral capsule can be evidenced in 20, 40 and 73% of patients respectively, with grade I, grade II and grade III pivot-shift (59). Also, ALL reconstruction along with ACL repair may decrease rotational knee laxity by acting as a secondary stabiliser during internal rotation torque (57). *Parsons et al.* assessed the cadaveric specimens *in situ* and reported that ALL could contribute significantly towards stabilizing internal rotation when knee is flexed > 35 º but had minimal role in anterior tibial translational stability in any degrees of flexion (60). According to *Kennedy et al.*, the failure load of the ALL was 175 N, with a stiffness of 20 N/mm, and failure mechanisms result in either tearing at the femoral origin or tears in the substance or bony avulsions of distal attachment (Segond's fracture) (14). *Zens et al.* stated that the most common point of tear of ALL is its upper 1/3 of ALL near to the femoral origin (25). ALL can be considered as a non-isometric structure which changes its length during flexion between 0ºto 90º and thereby provides maximum stabilizing ability at full flexion (61). In addition, *Dodds et al.*, measured the isometric nature of ALL upon movements and documented that ALL was "close to being isometric" during 0 to 60° of knee flexion and ALL length got reduced in deeper flexion (15). This feature might stabilize during internal rotation of tibia when the knee is getting increasingly flexed. Thus, the role of ALL as a secondary stabilizer of knee in the setting of ACL tear might be the reason for residual positive pivot shift and graft failure in some cases even after reconstructing ACL (62). Knowledge regarding the tensile properties of ALL is of paramount importance in identifying biomechanically comparable graft for its reconstruction.

On other hand, *Guenther et al.* hypothesized that anterolateral capsule is not effective in longitudinally transmitting the forces across tibia and femur compared to a ligament (63). Rather, it functions as fibrous layer and dissipates the force to adjacent structures. *Araujo PH et al.* measured the robotically simulated pivot-shift and showed that anterolateral capsule has only negligible contribution in stabilizing the knee joint (64). They had postulated that an additional anterolateral structure might further restrict the degree of movement by virtue of increasing the external rotation of knee joint. *Schon et al*. showed that reconstruction of ALL, irrespective of its graft fixation angle, cannot completely restore the rotary instability of knee without implying over-constraints (65).

Many surgeons world-wide have started to reconstruct the ALL along with ACL. The current recommendations for ALL reconstruction are ACL tear along with Segond fractures, chronic ACL injuries, grade III pivot-shift and high-level athletes or those who practice sports requiring significant rotation of the knee (66). A recent study by *Zhang et al* which, compared isolated ACL reconstruction and combined ACL and ALL reconstruction, concluded that the latter group fared better owing to better rotatory stability (67). *Neri T et al.*, the outcome of anatomical reconstruction depends on favorable isometry (68). They recommended that placement of ALL femoral graft posterior and slightly proximal to the epicondyle and with a tension between 0-30 degrees of flexion would allow good rotational stability without implying any stiffness. There have been a lot of controversies regarding placement of graft during ALL reconstructions and not to forget even the degree of knee flexion at which graft has to be tensioned and fixed (69). A non-comparative study by *Sonnery-Cottet et al.* assessing the movement post ACL-ALL reconstruction showed a 92% reduction in pivot shift after 2 years of surgery (62). Another study by *Helito et al*, where ALL reconstructions were done as an add on much after ACL reconstructions due to persistent knee instability, they have tried to prove that ALL reconstructions are superior to other extra-articular reconstructions in correcting rotatory instability (70). This made them postulate that performing extra-articular procedure at the time of the index surgery reduces the time taken to return to the pre-injury level in athletes. *Ferretti et al.* reported that nearly half of patients with isolated ACL reconstruction had grade 2 Kellgren-Lawrence or higher arthritis at 10-year follow-up, when compared to 14% of patients who underwent combination of ACL reconstruction and lateral extra-articular tenodesis (71). These studies show that even after much debate on ALL its reconstruction has a good clinical outcome.

Anterolateral ligament, despite facing whirls of controversies in the arena of clinical and biomedical research, is believed to have its effect on regulating internal rotation of knee. This comprehensive review tries to envisage ALL from different perspectives and tabulate the prevailing inconsistencies in attachments and imaging. With the increase in the number of ACL reconstruction surgeries across world, this might be of use to the clinicians to understand the anatomical structure which got popularized recently. We acknowledge our limitations in this systematic review, largely owing to the heterogeneity of the data stemming from various biomechanical studies, which were beyond the scope of this basic review. Nevertheless, we emphasize that all patients with ACL injuires and higher grade of pivot shifts should be thoroughly examined for associated anterolateral rotatory instability and ALL reconstruction might be considered for those cases. Future clinical and biomechanical studies will have to clarify the effectiveness of these procedures.

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