# Presence of antero lateral ligament in knees with and without anterior cruciate ligament tear

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**Abstract**

**Background:** There is a debate around the existence, anatomy, and role of the so called ―anterolateral ligament (ALL). This study was conducted with a primary aim of finding out and comparing the prevalence of the presence of anterolateral ligament and it's three portions (femoral, meniscal and tibial) in knees with and without ACL tear.

Methodology: This is a cross sectional study conducted in which A total of 96 patients undergoing MRI knee for clinically evident ACL injury or history of chronic knee pain were included in the study. Out of 96 patients included in the study, 48 patients had ACL tear (Group A) and 48 patients did not have an ACL tear (Group B). Demographic data and clinical information were noted for all patients. Descriptive variables were expressed as mean and standard deviation for quantitative variables and frequency and percentages for qualitative variables. The data was analyzed using SPSS® version 21.0. Categorical variables were analyzed using Chi square test and for normally distributed data - t test was used. p value <0.05 was considered as statistically significant.

**Results:** ALL was visualized in 65% of the patients included in the study. Its femoral component was visualized in 56%, tibial component in 63% and meniscal component in 57% of the patients. The three components were viewed together in 30% of the patients. We found a significant association between ACL tear and the presence of ALL (p <0.001), with ALL visualized in around 81%of knees with an ACL tear and only 48% of knees without an ACL tear. Meniscal tears were significantly associated with the presence of ALL as out of the 62 patients in which ALL was visualized, 24 had an associated medial meniscal tear, 7 had lateral and 3 had tear in both the menisci.

**Conclusion:** Our study demonstrated radiological evidence of the existence of the ALL. Furthermore, we found presence of ALL to be significantly associated with ACL injury and meniscal tear. Age, gender, or affected side was not found to be associated with the presence of ALL.

**Keywords:** Anterolateral Ligament, Anterior Cruciate ligament, MRI, Meniscal tear

## Introduction

The knee joint is the largest and most heavily loaded joint of the human body. The knee is a modified hinge joint that permits flexion and extension, and limited varus-valgus and internal-external rotations. Furthermore, some modest translations do occur of which the anterior-medial translation is the largest. There are four main ligaments in the knee joint i.e., two ligaments on either side of the knee, called the lateral collateral ligament (LCL) and medial collateral ligament (MCL) and two other ligaments called anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) that are located in the center of the knee joint.

There is a debate around the existence, anatomy, and role of the so called-anterolateral ligament (ALL) that represents one of the principal sources of controversy among the orthopedic community. Since the landmark study by Claes and colleagues [1] in 2013, which renewed interest in the anterolateral anatomy of the knee, many efforts have been made to try to reconcile historical theories with modern anatomic and biomechanical findings. Despite these extensive research efforts, there is still no consensus on whether or not the ALL exists and what function it serves. A consensus meeting among the ALL experts took place in Lyon, France, in November 2015 where they concluded that the ALL is a distinct ligament of the anterolateral side of the human knee [2]. However, other investigators still refute this statement, denying the presence of a true ligament and citing the importance of other anatomic structures such as the anterolateral capsule and the deep portion of the iliotibial band (ITB) [3].

The most significant debate with regard to the ALL surrounds its anatomy. According to the consensus paper from the ALL Expert Group, the ALL is considered a distinct ligament at the anterolateral side of the human knee, deep to the iliotibial band, with femoral attachment, posterior and proximal to the lateral epicondyle, and a tibial attachment between Gerdy‘s tubercle and the fibular head with a constant attachment to the lateral meniscus [2]. These statements have been supported by many anatomic studies, which have reported the incidence of the ALL to be between 50% and 100% in cadaveric specimens drawn from several populations. According to Daggett and colleagues, the all can be identified reflecting distally from the ITB up to its insertion at the Gerdy tubercle, after a transverse incision is made 6 to 8 cm proximal to the lateral epicondyle. Because the proximal ALL is reported to be closely adhered to the ITB, tissue must be carefully reflected at this point. Applying internal rotation with the knee flexed between 30 degrees and 60 degrees, the oblique fan like fibers of the ALL can be seen running from the epicondylar region to the proximal tibia and attaching between the Gerdy tubercle and the fibular head. On reflecting the biceps femoris insertion on the fibula posteriorly, the lateral collateral ligament (LCL) can be seen and the capsule between the LCL and ALL can be excised by sharp dissection. By also excising the capsule anterior to the ALL it is possible to appreciate the ALL insertion more clearly, including its meniscal attachments [4].

Analysis of the numerous cadaveric studies has revealed a certain amount of variability in structure. The femoral origin of the ALL is typically found just posterior and proximal to the lateral epicondyle of the femur directly adhered to bone. Its course is oblique, overlapping the proximal portion of the LCL, with some fibers attaching to the lateral meniscus and anterolateral capsule as it approaches the joint line. The tibial attachment is reported to be located around 1 cm below the joint line, midway between the fibular head and Gerdy‘s tubercle. The ligament has been reported to be between 34 mm and 59 mm long, of variable thickness (nearly twice as thick in men compared with women), and to tighten with tibial internal rotation.

Ingham *et al.* performed knee dissections on 58 specimens from 24 different animal species and did not find the ALL in any of the specimens [5]. In studies of human specimens, the ALL has been identified as a distinct anatomic structure in 12% to 100% of specimens [6]. Given the results of these studies, there has been a call for a better understanding of the anterolateral knee anatomy [7] with some authors suggesting that through careful dissection with a clear knowledge of the anatomic insertions of the ALL, this ligament can be identified in all human cases.[8] Several studies have tested the biomechanical properties of the ALL, with a mean ultimate load to failure measured between 50 and 205 N, a mean stiffness of 20 to 42 N/mm, and a mean ultimate strain of 36%.[9] Through biomechanical testing, failure of the ALL has been shown to occur by a variety of mechanisms, including ligamentous tear at the femoral or tibial insertions, intrasubstance tears, and complete detachment from the tibia with an associated bony avulsion (Segond fracture).

Although no study has specifically investigated the biomechanical properties of the ALL and/or its contribution to whole knee kinematics, its role as a lateral stabilizer is evident [10]. Given its relatively anterior insertion compared with the LCL, the ALL may contribute to anterior and rotational stability, and Dodds *et al.* have recently implicated this by showing a length increase of the ALL during an applied internal rotation torque of 5 Nm. This length increase, implying the ALL's resistance to internal rotation, varied as a function of knee flexion angle. No length change was observed during external rotation or in neutral rotation across the flexion-extension spectrum. Recently, Claes *et al.* implied the ALL's involvement in tibial rotational stability and concluded that injury to the ALL most prevalently presents at its distal insertion [11]. Furthermore, they indicated a high incidence of ALL injury (78.7%) in patients with ACL-reconstructed knees, but the exact involvement of the ALL in ACL injury has not been shown. Future studies assessing the ALL's contribution to tibiofemoral stability across the flexion-extension spectrum, the kinematic impact of ALL deficiency, and the ALL's role in other soft-tissue injuries are warranted.

Studies have suggested that ALL deficiency results in a higher grade pivot shift compared with an ACL tear alone [12]. However, one study did not find increased IR with pivot shift but rather an increase in acceleration of the lateral tibial compartment, which has been clinically correlated with pivot-shift changes [13]. One study found increased pivot shift in patients with MRI evidence of anterolateral capsule, medial meniscal, and lateral meniscal tears.[1]There are very studies from India which have investigated the presence of ALL [14]. Recent studies have shown that ALL injury correction along with ACL reconstruction provides more rotational stability to the knee joint [15]. Obtaining anatomical knowledge on this ligament will be vital for the orthopedic surgeons in performing functionally effective reconstructive surgeries involving both the ACL and ALL. This study was conducted with a primary aim of finding out and comparing the prevalence of the presence of anterolateral ligament and its three portions (femoral, meniscal and tibial) in knees with and without ACL tear.

## Methodology

This is a cross sectional study conducted in Bhagat Phool Singh Govt. Medical College for Women, Khanpur Kalan, Sonepat. Prior scientific and Ethical Committee approval were taken from the concerned authorities. A total of 96 patients undergoing MRI knee for clinically evident ACL injury or history of chronic knee pain were included in the study. Patients with associated bony fractures of tibial plateau and femur or congenital deformities of lower limb or clinically evident PCL injury. The sample size was calculated based on previous study by C P Helito *et al.* [17] using n Master 2.0 software at expected proportion 33.3% and 95% confidence interval taking 5% precision with a finite population. Out of 96 patients included in the study, 48 patients had ACL tear (Group A) and 48 patients did not have an ACL tear (Group B). The patients were explained about the need and purpose of the study and a prior informed consent were taken from all the participants. All the study participants underwent an MRI of the knee using 1.5T Philips MRI machine.

**MR Imaging protocol**

MR images were performed on GE Signa Horozon LX 1T scanner (GE Medical Systems, US). The following MR sequences were acquired in the knees included in the study.

1. Sagittal T1-weighted fast spin-echo sequences (TR/TE 575/min; section thickness 3 mm; field of view 180 x 135 mm; matrix 384 x 224).
2. Sagittal intermediate-weighted (3600/min full).
3. T2-weighted (3600/102).
4. FSE sequences (section thickness 3 mm; field of view 180 x 135 mm; matrix 512 x 224)
5. Coronal gradient-echo T2 (325/min; flip angle 30; section thickness 3mm; FOV 180 x 135 mm; matric 256 x 192).
6. T2-weighted fat suppressed sequences (12/3700/fatsat, section thickness 3 mm; FOV 180 x 135 mm; matrix 385 x 224).
7. Axial intermediate-weighted FSE sequences (3500/20; section thickness 3 mm; FOV 170 x 127, 5mm; matrix 320 x 256).

**MR Imaging results**

1. The ALL was considered to have been visualized if low-signal-intensity fibers were seen arising from the lateral epicondyle of the distal femur, running slightly oblique to the anterolateral border of the proximal tibia, passing laterally from the lateral inferior geniculate vessels.
2. The ALL was determined to be abnormal in case of complete disruption of the ligament (all fibers discontinuous), if the contour of the ALL was markedly irregular (e.g.-bended out), intra- or peri-ligamentous edema existed or a combination of these MRI features was observed.
3. The ALL was considered as non-visualized if no distinct fibers were identified at the expected location of the ALL in absence of edema.
4. Based on previous anatomic studies the ALL was divided into femoral (from the origin to the bifurcation point), meniscal (from the bifurcation point to the meniscal insertion), and tibial (from the bifurcation to the tibial insertion) parts. Visibility was then interpreted according to these anatomical parts, and the reviewer independently indicated whether the parts were visible. The reviewer also indicated whether the entire ligament was visible. If any part was not seen in both coronal and axial MR imaging planes, it was considered-not visible.
5. Focal or diffuse thickening, high signal intensity in the PDW images, disruption, or an irregular contour of the ligament was accepted as injury of the ALL.
6. ACL rupture was evidenced by thickening of the ligament, increased signal intensity on PDW images, discontinuity of the fibers, and changes in the expected course of the ACL (should be as steep or steeper than the intercondylar roof, with the apex pointing posteriorly and less steep than Blumensaat‘s line).
7. For the determination of ACL injury, these primary signs were then evaluated with secondary signs such as bony contusions of the posterolateral tibial plateau and lateral femoral condyle, Segond fracture, anterior tibial translocation sign, reduced posterior cruciate ligament angle, positive posterior cruciate ligament line, and uncovered posterior horn of the lateral meniscus.

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## Data collection and Statistical analysis

Using a pre-designed, semi-structured patient related data were collected. Demographic data like age, gender and address were noted for all patients. Clinical information like mechanism of injury, comorbid conditions, past surgical history and ambulatory status were noted for all patients. Descriptive variables were expressed as mean and standard deviation for quantitative variables and frequency and percentages for qualitative variables. The data was entered into a Microsoft Excel spreadsheet and analyzed using standard statistical software SPSS® statistical package version 21.0(SPSS Inc, USA). For continuous outcome mean and SD was calculated for quantitative data, proportion and percentage was calculated for qualitative data. Categorical variables were analyzed using Chi square test and for normally distributed data -t test was used. $p$ value <0.05 was considered as statistically significant.

## Results

Mean age of the patients was 29.75 ± 10.17 years, ranging between 11 to 60 years. The most common age group was 21 to 30 years. (Table 1)

**Table 1:** Distribution of patients according to their age

| Age group (in years) | N | % |
|---|---|---|
| Less than 21 | 25 | 26% |
| 21 to 30 | 28 | 29% |
| 30 to 35 | 19 | 20% |
| More than 35 | 24 | 25% |

Females comprised only 19% while males were 81% of the study population in the present study. Right side was affected in 51% of the patients and rest had left side affected. All patients underwent MRI assessment. Reasons for undergoing MRI was road traffic accident in 65% of the patients, sports injury in 29%, chronic knee pain in 5% and fall on ground for one patient. (Table 2)

**Table 2:** Distribution of patients according to the reason for undergoing MRI

| Reasons for MRI | N | % |
|---|---|---|
| Road side accident | 62 | 65% |
| Sports injury | 28 | 29% |
| Chronic knee pain | 5 | 5% |
| Fall on ground | 1 | 1% |

ALL was visualized in 65% of the patients included in the study. Its femoral component was visualized in 56%, tibial component in 63% and meniscal component in 57% of the patients. The three components were viewed together in 30% of the patients. (Table 3). Associated medial meniscal tear was present in 35% of the patients, lateral meniscal tear in 18%, both medial and lateral meniscal tear in 9% of the patients. No meniscal tear was observed in 38% of the patients. (Table 4)

**Table 3:** Distribution of patients according to ALL visualization on MRI

| ALL visualized | N | % |
|---|---|---|
| Any type | 62 | 65% |
| Femoral | 54 | 56% |
| Meniscal | 55 | 57% |
| Tibial | 60 | 63% |

**Table 4:** Distribution of patients according to associated meniscal injuries

| Associated meniscal injury | N | % |
|---|---|---|
| Medial | 34 | 35% |
| Lateral | 17 | 18% |
| Both | 9 | 9% |
| None | 36 | 38% |

ALL was visualized in a total of 62 patients, of which 19 were aged less than 21 years, 18 were aged between 21 to 30 years, 11 were aged between 30 to 35 and 14 were aged above 35 years. We did not find any significant association between age and the presence of ALL (Table 5). The ligament was visualized in a total of 62 patients, of which 10 were females and rest were males. We did not find any significant association between gender and the presence of ALL (Table 6).

**Table 5:** Association of age with the presence of all

| | ALL present | | Total |
|---|---|---|---|
| **Age group (in years)** | No | Yes | |
| Less than 21 | 6 | 19 | 25 |
| 21 to 30 | 10 | 18 | 28 |
| 30 to 35 | 8 | 11 | 19 |
| More than 35 | 10 | 14 | 24 |
| | 34 | 62 | 96 |
| *p* value* 0.53 | | | |

*Using chi-square test

**Table 6:** Association of gender with the presence of ALL

| | ALL present | | Total |
|---|---|---|---|
| **Gender** | No | Yes | |
| Female | 8 | 10 | 18 |
| Male | 26 | 52 | 78 |
| | 34 | 62 | 96 |
| *p* value* 0.34 | | | |

*Using chi-square test

The anterolateral ligament was visualized in a total of 62 patients, of which 23 had an ACL tear and rest did not. We found a significant association between ACL tear and the presence of ALL ($p$ <0.001). Out of 48 without ACL tear patients ALL was found in 39 patients that means almost 81%, this is significant relation between intact ACL and ALL visualization in comparison to 48 patients with ACL tear where ALL visualization was found in only 23 patients that means 48%. (Table 7). Meniscal tears were significantly associated with the presence of ALL as out of the 62 patients in which ALL was visualized, 24 had an associated medial meniscal tear, 7 had lateral and 3 had tear in both the menisci. (Table 8)

**Table 7:** Association between presence of ALL and ACL injury

| | ALL present | | Total |
|---|---|---|---|
| **ACL tear** | No | Yes | |
| Not present | 9 | 39 | 48 |
| Present | 25 | 23 | 48 |
| | 34 | 62 | 96 |
| *p* value* < 0.001 | | | |

*Using chi-square test

**Table 8:** Association of meniscal tear with the presence of ALL

| | **ALL present** | | **Total** |
|---|---|---|---|
| **Meniscal tear** | No | Yes | |
| Both | 6 | 3 | 9 |
| Lateral | 10 | 7 | 17 |
| Medial | 10 | 24 | 34 |
| No | 8 | 28 | 36 |
| | 34 | 62 | 96 |
| *p* value* < 0.01 | | | |

*Using chi-square test

**Following MRI findings were present in our study**

**Fig 1:** All 3 portions (femoral, meniscal and tibial) of ALL are seen

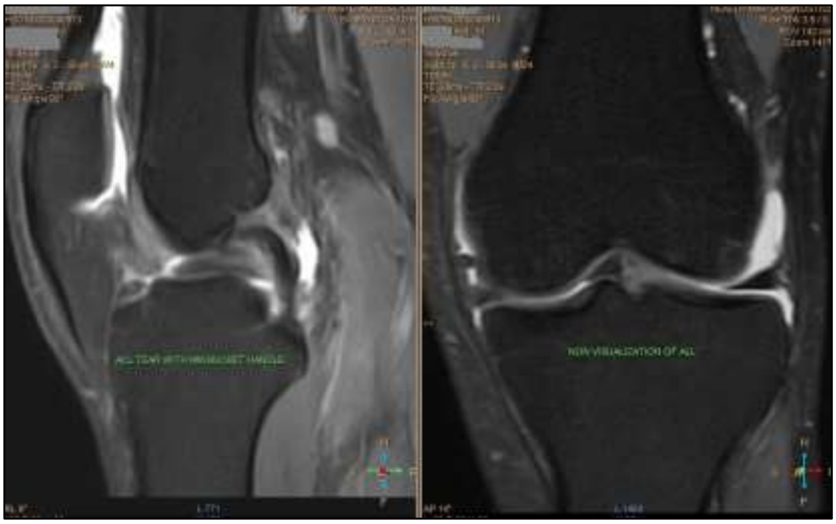

**Fig 2:** ACL and MM tear is present and ALL is not visualized.

**Fig 3:** ACL tear is present and ALL is not visualized

**Fig 4:** ACL tear present and only femoral portion of ALL is visualized

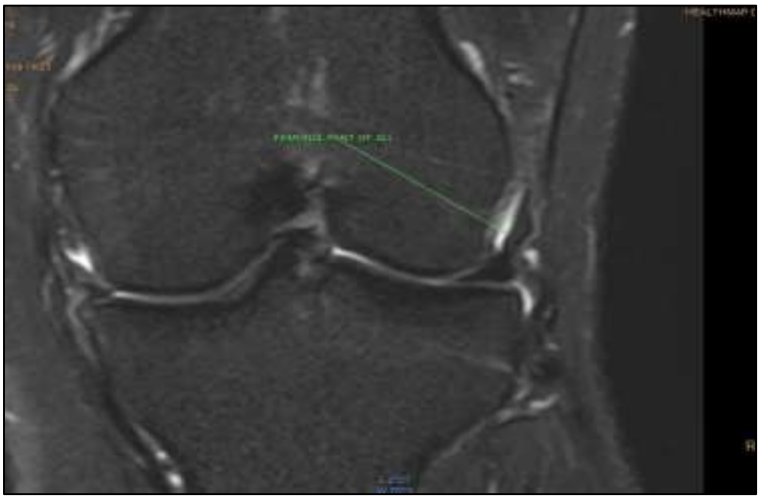

**Fig 5:** Only femoral portion of ALL is visualized

**Fig 6:** Femoral and tibial portions of ALL are visualized

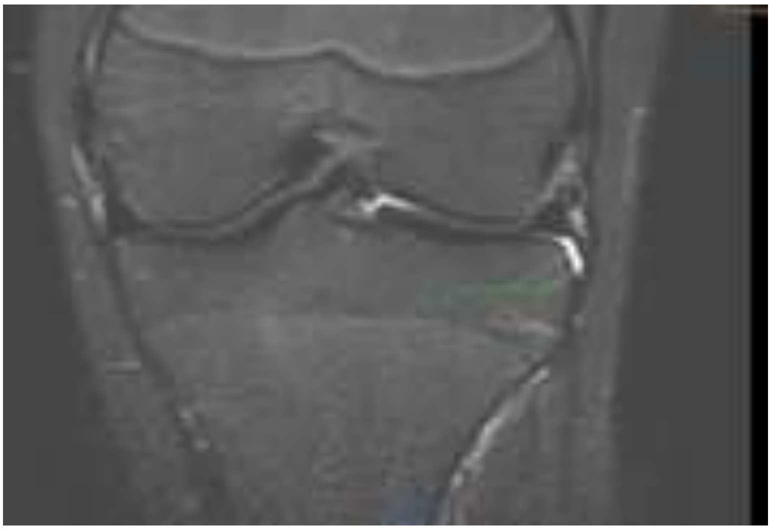

**Fig 7:** Only tibial portion of ALL visualized

## Discussion

The present study was aimed to look for the presence of anterolateral ligament separately for femoral, meniscal and tibial portion in knees with or without ACL tear. The study was conducted on patients presenting with knee injuries and chronic knee pain undergoing MRI of knee in the Department of Orthopedics, BPS Govt. Medical College, Khanpur Kalan, Sonepat, and Haryana during the period of DNB training. This study was approved by institutional ethics committee of BPS Govt. Medical College, Khanpur Kalan, Sonepat. The ALL was first named in 2012 by Vincent *et al..*, [16] despite its initial discovery by Paul Segond in 1879 in association with a Segond fracture. The ALL originates near the lateral epicondyle of the distal femur and inserts on the proximal tibia near Gerdy‘s tubercle. Biomechanical studies have shown that the ALL functions as a secondary stabilizer to the ACL in resisting anterior tibial translation and internal tibial rotation.

In the present study ALL was visualized on MRI, it was seen that some portion of the ligament was viewed clearly in 65% of the patients included in the study. Its femoral component was visualized in 56%, meniscal component in 57% and tibial component in 63% of the patients. The three components were viewed together in 30% of the patients. Out of 48 without ACL tear patients ALL was found in 39 patients that means almost 81%, this is significant relation between intact ACL and ALL visulisation in comparison to 48 patients with ACL tear where ALL visualization was found in only 23 patients that means 48%.

On comparing with the previous study Helito *et al.* (2014) performed a study to evaluate the presence of the anterolateral ligament of the knee in magnetic resonance imaging examinations. Thirty-three MRI examinations on patient‘s knees that were done because of indications unrelated to ligament instability or trauma were evaluated. The ALL was viewed with signal characteristics similar to those of the other ligament structures of the knee, with T2 hypo signal with fat saturation. The main plane in which the ligament was viewed was the coronal plane. From analyzing the MRI, it was seen that some portion of the ligament was viewed clearly in 27 knees (81.8%). The meniscal portion was evident in 25 knees (75.7%), the femoral portion in 23 (69.6%) and the tibial portion in 13 (39.3%). The three portions were viewed together in 11 knees (33.3%). They concluded that the Antero lateral ligament of the knee is best viewed in sequences in the coronal plane. The ligament was completely characterized in 33.3% of the cases. The meniscal portion was the part most easily identified and the tibial portion was the part least encountered [17].

Debate exists as to the presence and prevalence of the ALL, enough that some authors have questioned whether the ALL is fact or fiction [18]. Ingham *et al.* performed knee dissections on 58 specimens from 24 different animal species and did not find the ALL in any of the specimens. In studies of human specimens, the ALL has been identified as a distinct anatomic structure in 12% to 100% of specimens [19, 20]. Vincent *et al.* performed an investigation of the ALL in 30 consecutive patients undergoing primary total knee arthroplasty, and they were able to identify the ALL in all 30 patients [21]. In addition, they performed an anatomic dissection on 10 fresh cadaveric knees, in which the incidence of the ALL was also 100%. Helito *et al.* investigated the anatomy and histology of the ALL with dissections on 21 human cadaveric knees with a mean age of 61.5 years and ALL was clearly identified and defined in each of the 20 specimens [18]. In a more recent study by the same group, Helito *et al.* performed radiography and dissection on 10 unpaired cadaveric knees (mean age, 62.8 years) and stated that the ALL was clearly visualized in all 10 specimens [22]. The difference in the incidence of ALL can be attributed to the variability in the defined attachment site of the ALL. Previous studies investigating the incidence of the ALL have described it as-an intimate part of the capsule whereas they have defined it as -superficial to the LCL and not attached directly to meniscus. Dodds *et al.* identified the ALL as inserting below the meniscus at the tibial plateau, a distinction not explicitly made in previous studies [23]. This distinction is likely the reason for the lower incidence reported in the article of Dodds *et al.*, (83%). Likewise, variability in the femoral attachment site introduces some discrepancy in the incidence of the ALL reported in their study. Claes *et al.,* [24] described the femoral attachment site as being above the epicondyle, anterior to the LCL attachment site, whereas Dodds *et al.,* Described the femoral attachment site as-variable, but approximately 8 mm proximal to the epicondyle and 4 mm posterior to it.

ACL tear was visualized in half of all patients included in the study and ALL was found to be significantly associated with ACL tear ($p$ <0.001). Associated lesions with ACL injury are known to correlate with trauma mechanism and have been well addressed for acute ACL injury by previous studies [25]. Various mechanisms have been suggested for the ACL injury including both noncontact and contact, and ACL injuries most often result from pivot shift like movement, consisting of combined sudden extreme anterior tibial translation and internal tibial rotation. With extreme internal tibial rotation applied, ACL tears often occur in conjunction with injury to posterolateral corner (i.e., osseous lesions) and tears of the lateral meniscus [26].

In our patient population meniscal tears were significantly associated with the presence of ALL ($p < 0.01$). Associated medial meniscal tear was present in 35% of the patients, lateral meniscal tear in 18%, both medial and lateral meniscal tear in 9% of the patients. No meniscal tear was observed in 38% of the patients. Several biomechanical studies have shown a significant function of the ALL in providing rotatory stability during pivot-shift movement [27]. However, other studies have demonstrated only minor increase or no significant increase in anterior tibial translation and internal tibia rotation (i.e., pivot shift) with further sectioning of ALL in ACL deficient knees [28]. Furthermore, Noyes *et al*., reported that only significant increase in pivot shift was found after concomitant sectioning of ALL and iliotibial band [29] Thus, whether concurrent ALL reconstructive surgery is required for ACL reconstruction as to reduce rotatory instability or to reduce the forces that could be sustained on the graft after ACL reconstruction without reconstruction of secondary restraint (i.e., ALL) is yet controversial.

Spencer *et al*., in a biomechanical cadaveric study found that ALL reconstruction did not significantly improve rotatory instability or anterior tibial translation compared with an ALL deficient state [30] Tavlo *et al.*, in their biomechanical study also found that detaching the ALL had a significant effect on knee instability only in ACL deficient knees and that this significant effect was neutralized after ACL reconstruction [31]. Claes *et al.* noted in a study with 206 patients that when the ALL was identifiable, over 75% had a concomitant ALL injury and that a majority of these injuries occurred in the ligament‘s tibial attachment [11]. Hartigan *et al*., noted that while the ALL was identified in 100% of acutely injured ACL knees, radiologists were unable to reliably classify the ligament as intact or injured when the study was performed on a 1.5T MRI with slice thickness of 4.0 mm [32]. By using a 3.0T magnet with a more standardized approach to image interpretation, and by applying the identification techniques outlined in this article, the surgeon can more readily identify the ALL. The authors believe that proper identification of this ligament and potential pathologies will allow researchers to better determine its clinical significance.

Mean age of the patients was 29.75 ± 10.17 years, ranging between 11 to 60 years and the most common age group was 21 to 30 years. Females comprised only 19% of the study population in the present study. Right side was affected in 51% of the patients and rest had left side affected. ALL was visualized in a total of 62 patients, of which 19 were aged less than 21 years, 18 were aged between 21 to 30 years, 11 were aged between 30 to 35 and 14 were aged above 35 years and we did not find any significant association between age and the presence of ALL ($p = 0.53$).

We did not find any significant association between gender and the presence of ALL ($p = 0.34$). Though not studied in the present study, anatomic measurements of the ALL have been reported to demonstrate a difference between sexes, and the ALL is significantly thicker in males than females. In cadaveric dissections by Daggett *et al*., the authors were able to confirm the existence of the ALL in all 157 dissected knees, confirming its existence as a constant structure at the anterolateral portion of the knee [33]. The authors found a statistically significant difference in length and thickness of the ALL at the level of the lateral meniscus but not for width measurements and the ligament in males was on average 1.04 mm thicker than that in females, over twice as thick in male subjects when compared with females. The authors concluded that female ALLs are on average half the thickness of their male counterparts, which could be a potential reason for the increased propensity for ACL injury in the female knee. Increased rotational laxity has been previously demonstrated in females and is believed to be why there is an increased propensity for females to suffer ACL injuries. When a pivot-shift-type injury occurs, the forces are distributed through the external structures of the knee and then progress through the ACL.

Majority of the cadaveric studies suggest that combined ALL and ACL reconstruction improve rotational stability of the knee compared with ACL reconstruction alone. Nitri *et al*. found improved rotatory stability with combined ALL and ACL reconstruction [34]. While one study found no decrease in internal rotation or improvement in pivot shift after ALL reconstruction in cadaveric knees, the ACL was not concurrently reconstructed in this study. Future studies comparing autograft, allograft, and synthetic reconstruction grafts are needed. Lateral extra-articular tenodesis reconstruction was previously utilized to control rotational stability of the knee as a supplement to ACL reconstruction. However, a major concern was over-constraining the lateral knee, which may lead to decreased range of motion, stiffness, and/or lateral compartment osteoarthritis [35]. This led to it falling out of favor. These concerns remain with ALL reconstruction, regardless of the ALL-graft fixation angle. However, Sonnett used a traction force of 88 N, which may have led to the finding. In addition, the over-constraint was measured as 1° to 2°, which may not be clinically relevant. On the contrary, cadaveric studies are inherently limited by the lack of graft incorporation, soft tissue stretching, and lack of other associated capsule ligamentous and soft tissue injuries seen in ACL tears. Though, a retrospective clinical study of combined ALL and ACL reconstruction did not find limitations in range of motion [36], prospective clinical studies in humans are needed.

Injury to the ALL is most commonly associated with a concomitant tear of the ACL [11]. In a clinical case series of 60 patients undergoing ACL rupture, Ferretti *et al.*, exposed the lateral knee compartment and found various lesion types of the ALL, including macroscopic hemorrhage involving the area of the ALL extending to the anterolateral capsule (32%), macroscopic hemorrhage involving the area of the ALL extending to the posterolateral capsule (27%), complete transverse tear of the ALL near its tibial insertion (22%), and a bony tibial avulsion, that is, Segond fracture (10%).Bony contusions seen on MRI may also lead one to suspect injuries of the ALL and ACL. On the basis of retrospective review of 193 MRIs of patients who underwent ACL rupture, Song *et al*., found that bony contusions of the lateral femoral condyle and lateral tibial plateau (but not the medial femoral condyle or medial tibial plateau) were significantly associated with ALL injury [37]. Ruptures of the ALL are particularly associated with a Segond fracture, or a bony avulsion near the lateral tibial plateau often found in the presence of an ACL tear. Similarly, Porrino *et al*., evaluated 20 knee MRIs with a Segond fracture and found that the ALL was attached to the fracture fragment in all but one case limited by anatomic distortion.

This study has its limitations like there is no reference standard for the characterization and comparison of ALL by MRI images. Although MRI is a method with great potential, lack of standard anatomic and radiological definitions of ALL has led many authors to arbitrarily claim the presence of ALL. Also, Biomechanical studies were not conducted, which would be desirable in an ideal study to understand the physiological role of ALL in greater detail.

Moreover, the sample size of the study is relatively small.

## Conclusion

Our study demonstrated radiological evidence of the existence of the ALL. Some portion of the ligament was viewed clearly in 65% of the patients in this study. Its femoral component was visualized in 56%, meniscal component in 57% and tibial component in 63% of the patients. All 3 components were visualized together in 30% of the patients. Furthermore, we found presence of ALL to be significantly associated with ACL injury and meniscal tear. Age, gender, or affected side was not found to be associated with the presence of ALL.

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