# ANATOMY OF ANTEROLATERAL LIGAMENT OF HUMAN KNEE JOINT: A CADAVERIC STUDY AT A MEDICAL COLLEGE IN KATHMANDU, NEPAL

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## ABSTRACT

Knee joint is a bicondylar variety of synovial joint formed by articulations among lower end of femur, upper end of tibia and patella. It is stabilized by numbers of ligaments, anterolateral ligament (ALL) being one of them. Recently, ALL is gaining researcher's attention because of its discovery as a new ligament of knee joint which has a potential role in the anterolateral rotational stability. However, there is still persistence of different anatomical description of the ALL, including its prevalence, femoral origin, and tibial insertion. This study aimed to determine prevalence and detail anatomy of ALL in human knee joint. The study included 30 cadaveric lower limb of both side with intact knee joint available in Nepal Medical College, Department of Human Anatomy. ALL was identified in 26 knee joint (86.7%) where mean length of the ALL measured at extension and 90º flexion was 31.12± 8.06 mm and 32.59±7.71 mm respectively. The femoral attachment of ALL was variable; the most common one 42.31% being attached just posteroinferior to the lateral femoral epicondyle (LFE) followed by 38.46% attached to posterosuperior aspect of LFE and 19.23% of ALL attached just anteroinferior to LFE. The attachment of ALL on tibia was quantified relative to bony landmark; Gerdy's tubercle (GT). The average distance between the GT and ALL attachment was found to be 21.82±4.89 mm. There is a need for detailed understanding of the ALL anatomy to ensure proper diagnosis and treatment of knee joint pathology.

## KEYWORDS

Anterolateral ligament, knee joint, lateral femoral epicondyle, gerdy's tubercle

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## INTRODUCTION

Knee joint is a bicondylar variety of synovial joint formed by articulation among lower end of femur, upper end of tibia and patella. This tibiofemoral articulation is stabilized by numbers of ligaments, anterolateral ligament (ALL) being one of them. Recently, ALL is gaining researchers attention because of its discovery as a new ligament of the joint which has a potential role in the anterolateral rotational stability.[1,2]

Though there was no standard anatomical name for ALL, its earliest description was presented by Segond in 1879 as a pearly, resistant, fibrous band, which invariably showed extreme amounts of tension during forced knee internal rotation.[3] Thereafter, this anatomic structure has been investigated by several researchers and described by different terms such as; Last[4] termed it ‘‘short lateral ligament’’ Terry *et al*[5-7] have referred to this structure as the ‘‘capsulo-osseous layers’’ of the iliotibial band, LaPrade *et al*,[8] Hughston *et al*,[9] and Goldman *et al*[10] have used the term ‘‘mid-third lateral capsular ligament’’, Dietz *et al*,[11] Johnson[12] called it as “Lateral Capsular Ligament” and Campos *et al*[13] coined the term ‘‘Anterior Oblique Band’’. The structure was first named as ‘‘anterolateral ligament’’(ALL) by Vieira *et al*[14] in 2007, Vincent *et al*[15] in 2012. Claes *et al*[16] in 2013 clearly distinguished ALL from the anterolateral joint capsule in human cadaveric knees.

ALL is a relatively consistent structure in the lateral knee linking the lateral femoral condyle, the lateral meniscus, and the lateral tibial plateau. ALL originates slightly proximal and posterior to the lateral epicondyle of the distal femur and has an anteroinferior course toward the tibial insertion between the tip of the fibular head and Gerdy’s tubercle below the lateral tibial plateau.[17] Several cadaveric studies reported that ALL was identified as a distinct ligamentous structure, separate from the anterolateral capsule.

However, there is still persistence of different anatomical description of the ALL, including its prevalence, femoral origin, tibial insertion, and relationship with the surrounding structures.[18] Some studies reported ALL is only a thickening of the articular capsule or a complex of fibrous tissue on the anterolateral capsule. With these inconsistent descriptions, questions regarding the anatomical implications for surgical approach to ALL reconstruction may require detailed and specific understanding.

There is a need for detailed understanding of the ALL anatomy to ensure proper diagnosis and treatment of knee joint pathology. Reconstruction of the anterior cruciate ligament (ACL) is one of the most common procedures in orthopaedic surgery. Even with advances in surgical techniques and implants, some patients still have residual anterolateral rotator laxity after reconstruction. ALL reconstruction can be a solution for residual rotational instability after anterior cruciate ligament reconstruction.[17] As further investigations are necessary to resolve the controversies regarding ALL anatomy and to establish appropriate ALL reconstruction techniques, this study aimed to determine detail anatomy of ALL in human knee joint and present the findings to reconcile these controversies regarding ALL.

## MATERIALS AND METHODS

This descriptive and cross-sectional study was carried out in Nepal Medical College (NMC) Department of Human Anatomy for a period of one year from January 2024 to December 2024, after obtaining ethical approval from the Institutional Review Committee (IRC) of NMC Ref. No.: 46-080/081. Materials for this study were 30 cadaveric lower limb of both side with intact knee joint available in Department of Human Anatomy.

A tenotomy of the Quadriceps tendon was performed at the myotendinous junction. The iliotibial band ITB was carefully separated from its tibial attachment at the Gerdy’s tubercle (GT). The retropatellar pad of fat in the region was removed. The lateral collateral ligament (LCL) and the surrounding biceps femoris tendon were isolated carefully. All soft-tissue structures were incised from the lateral condyle. The tendon of popliteus was identified and cleared. After isolation, ALL was well demarcated from the anterior joint capsule. The following measurements were recorded using a digital vernier calipers –ALL length in flexion and ALL length in extension. The distance between the center of the ALL insertion and GT was also measured. All collected data were analyzed statistically by using SPSS-16.

## RESULTS

Out of 30 dissected knees, a distinct ligamentous structure was identified at the anterolateral side of 26 knee joint (86.7%) which connect femur with the tibia. The mean length of the ALL measured at extension and 90° flexion was 31.12 ± 8.06 mm and 32.59 ± 7.71 mm, respectively. Among the extension length of ALL measured, highest value was 48.95 mm

**Table 1: Table showing descriptive statistic of ALL**

| SN. | ALL Length (mm) Flexion (90) | ALL Length (mm) Extension | Distance between GT and ALL (mm) |
|---|---|---|---|
| Mean | 32.59 | 31.12 | 21.82 |
| Median | 31.88 | 29.84 | 23.08 |
| SD | 7.71 | 8.06 | 4.89 |
| Max | 50.12 | 48.95 | 28.66 |
| Min | 18.81 | 18.04 | 10.34 |
| Presence of ALL = 26 | | | |
| Paired sample test: 2.556, P = 0.017 | | | |

**Table 2: Comparison of ALL length at flexion/extension between Right/ Left Knee Joint**

| Parmeters | Right knee joint | | Left knee joint | |
|---|---|---|---|---|
| | Flexion | Extension | Flexion | Extension |
| Mean | 32.8331 | 29.8969 | 32.3546 | 32.3369 |
| SD | 6.52805 | 6.07841 | 9.01429 | 9.76132 |
| Maximum | 45.91 | 42.24 | 50.12 | 48.95 |
| Minimum | 21.92 | 20.01 | 18.81 | 18.04 |
| Frequency | 13 | 13 | 13 | 13 |
| Two-way ANOVA | Length at flexion vs. side: F=0.024, p= 0.878,<br>Length at extension vs. side: F=0.585, p= 0.452 | | | |

**Table 3: Table showing attachment site of ALL**

| Proximal attachment | | Distal attachment | |
|---|---|---|---|
| **Site of attachment with reference to LCL** | **Frequency** | **Site of attachment with reference to GT and head of fibula** | **Frequency** |
| Posterosuperior | 10 (38.46%) | Between head of fibula and GT | 4 (15.38%) |
| Anteroinferior | 5 (19.23%) | Posterior to GT | 10 (38.46%) |
| Posteroinferior | 11 (42.31%) | Posterosuperior to GT | 5 (19.23%) |
| | | Anterosuperior to head of fibula | 7 (26.92%) |

and lowest being 18.04 mm. Similarly, 90° flexion length of ALL was measured maximum at 50.12 mm and minimum at 18.81 mm. The attachment of ALL on tibia was quantified relative to bony landmark; Gerdy's tubercle. The average distance between the GT and ALL attachment was found to be 21.82 ± 4.89 mm (Table 1).

The paired sample test showed mean difference between flexion and extension to be 1.48 with t-value 2.556 and p-value 0.017 which is statistically significant. Thus, the ALL length during flexion is statistically greater than during extension.

While comparing the mean ALL length on right and left knee joint during flexion and extension, mean flexion length of ALL was slightly longer in right than left knee joint. Comparing mean extension length between sides; it was slightly higher on left than on right knee joint. For both flexion and extension, the side does not have a statistically significant effect on the ALL length. ANOVA test showed no significant difference between flexion and extension length sidewise (Table 2).

The femoral attachment of ALL was variable; the most common one 42.31% being attached just posteroinferior to the lateral femoral epicondyle (LFE) followed by 38.46% attached to posterosuperior aspect of LFE and 19.23% of ALL had proximal attachment just anteroinferior to LFE (Table 3).

The ALL lying superficial, run anteroinferior to proximal half of LCL and was a completely separate structure from LCL. It was also superficial and a distinct structure from capsule of the knee joint.

The tibial attachment in all cases lies behind the GT and anterior to head of fibula. In most of the cases, ALL lies posterior or posterosuperior

**Table 4: Comparison of dimensions of anterolateral ligament with previous studies and present study**

| Authors | Sample | Incidence | ALL Length | Femoral origin | Tibial insertion |
|---|---|---|---|---|---|
| Patel *et al*[19] | 25 knees | 12.0% | N/A | Proximal and posterior to LFE | Between GT and FH |
| Nasu *et al*[20] | 25 knees | 0.0% (Complex of fibrous tissues with a sheet-like structure) | N/A | Proximal and posterior to LFE | Lateroposterior area to the GT |
| Lima *et al*[21] | 53 studies | 100.0% | 40.0 ± 0.4 mm | Proximal and posterior to LFE | Between GT and FH (4.0 mm to 7.0 mm below the tibial plateau) |
| Gon-charov *et al*[22] | 60 knees | 68.0% women, 42.0% men | 38.5 ± 4.4 mm | 65.0% proximal and posterior to LFE, 24.0% anterior to the origin of the LCL, 12.0% popliteus tendon insertion | Between GT and FH |
| Neri *et al*[23] | 84 knees | 95.0% | 50.4 ± 6.6 mm | Proximal and posterior to LFE | Posterior and proximal to GT, anterior and proximal to FH, and distal to ACT |
| Stijak *et al*[24] | 14 cadavers | 50.0% | 41±3 | Anterior to LCL | Midway between the GT and the FH |
| Caterine *et al*[25] | 19 cadavers and 10 MRI | 100.0% | 40.3±6.2 | Proximal and posterior to LCL | 11.1±2.4 mm from joint line 23.4±3.4 mm from GT 23.9±5.5 mm from LCL insertion |
| Daggett *et al*[26] | 52 knees | 100.0% | N/A | Center of LFE, proximal and posterior to LFE | Between GT and FH |
| Kennedy *et al*[27] | 15 knees | 100.0% | 36.8 mm (0°) | Proximal and posterior to LFE | Between GT and FH |
| Dodds *et al*[18] | 40 cadaver | 83.0% | 59±4 | Proximal and posterior to LFE | 11±2 mm from joint line 18±3 mm from GT and 17±3 mm from FH |
| Claes *et al*[16] | 41 cadavers | 97.0% | 38.5±6.1 (extension) 41.5±6.7 (90° flexion) | Anterior to LCL | 6.5±1.4 mm from articular margin 21.6±4.0 mm posterior to GT 23.2±5.7mm anterior to FH |
| Helito *et al* [28] | 20 cadavers | 100.0% | 37.3±4.0 | Anterior and distal to LCL | 4.4±1.1 mm from distal articular margin |
| Vincent *et al*[15] | 10 cadavers | 100.0% | 34.1± 3.4 | Anterior to popliteous tendon | 5 mm from articular margin posterior to GT |
| Present study | 15 cadavers | 86.7% | 31.12±8.06 (extension) 32.59±7.71 (90° flexion) | 42.3% posteroinferior, 38.5% posterosuperior and 19.2% anteroinferior to LFE. | 21.82±4.8 mm posterior to GT |

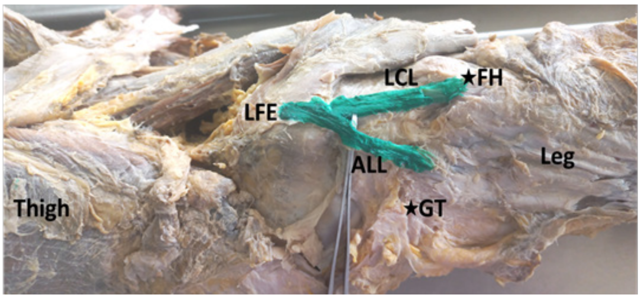


**Fig. 1:** Lateral view of knee joint during dissection where ALL is attached posterosuperior to LCL. ALL- Anterolateral Ligament, LCL- Lateral Collateral Ligament, LFE- Lateral Femoral Epicondyle, FH- Fibular Head, GT- Gerdy Tubercle

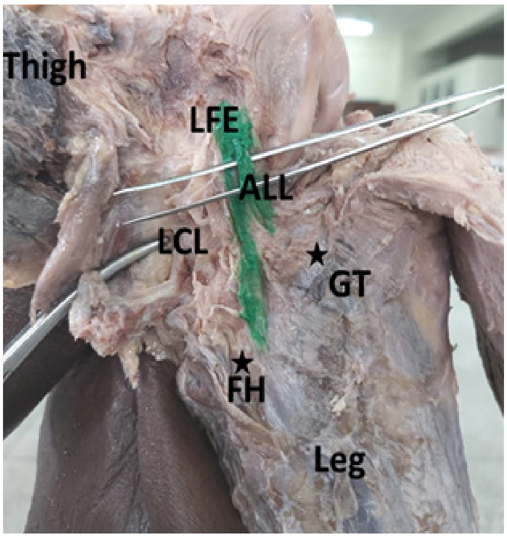


**Fig. 1:** Lateral view of knee joint during dissection where ALL is attached anteroinfeior to LCL. ALL- Anterolateral Ligament, LCL- Lateral Collateral Ligament, LFE- Lateral Femoral Epicondyle, FH- Fibular Head, GT- Gerdy Tubercle

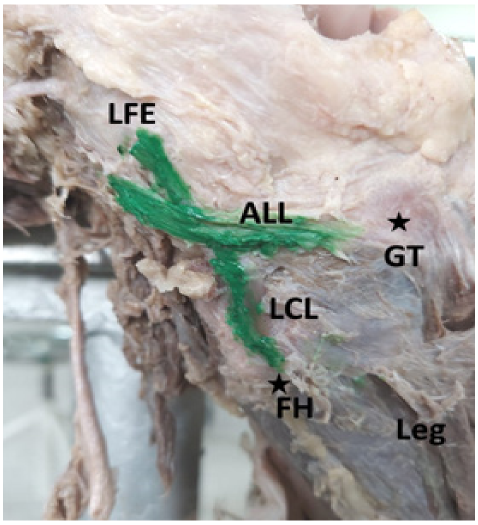


**Fig. 1:** Lateral view of knee joint during dissection where ALL is attached posteroinferior to LCL. ALL- Anterolateral Ligament, LCL- Lateral Collateral Ligament, LFE- Lateral Femoral Epicondyle, FH- Fibular Head, GT- Gerdy Tubercle

to the GT, in some cases it was between GT and head of fibula while in few cases it was more close to head of fibula (anterosuperior). Out of 26 cases, in two speciemen, some fibres from ALL blended with the LCL.

It is a comparision table of anatomical details of ALL with previous and present studies listed in a reverse chronological order.

## DISCUSSION

The most debatable issue regarding ALL is its existence, whether ALL is just a simple capsular thickening or a distinct ligamentous structure. Present study shows 86.7% prevalence of ALL which was similar to the studies by Lima *et al*[21] showing 83.0% and Dodds *et al*[18] showing 83.0%. In past cadaveric studies related to presence of ALL, controversial prevalence were noted ranging from from 0.0% to 100.0%.[19,20,25] In a study reported by Helito *et al*[28] and Caterine *et al*[25], ALL was identified in 100.0% of the cadaveric knees. Thereafter, numerous cadaveric studies reported various prevalence rates; 97.0% by Claes *et al*[16], 83.0% by Dodds *et al*[18] and 50.0% by Stijak *et al.*[24] While some studies insisted that it does not exist as a distinct ligamentous structure Iseki *et al.*[29] Lima *et al*[21] suggested that different dissection preservation methods could affect ALL identification, demonstrating lowest in embalmed cadaveric studies, whereas it was high in fresh-frozen cadavers because clear identification of ALL could be restricted in the embalmed specimen.

The length of ALL reported in previous studies varied from 34.1 mm to 59 mm.[15,18] One of the review article demonstrated that the length of ALL is typically between 33.0 and 42.0 mm in most studies[21] which was very much similar to our study where the mean length of the ALL measured at extension and 90° flexion was 31.12 ± 8.06 mm and 32.59 ± 7.71 mm, respectively. Most of the studies did not mention whether the length of ALL was measured in extension or flexion but Claes *et al*[16] noted it as 38.5±6.1 (extension) 41.5±6.7 (90° flexion) which was higher than our case. The length of ALL increased with knee flexion and tibial internal rotation[28] which were similar in our case as well.

The next controversial issue regarding the anatomy of the ALL is the exact location of its proximal attachment with reference to LCL. Many studies reported various descriptions about the femoral origin of ALL with reference to attachment of LCL at lateral femoral epicondyle. The researchers described the origin of ALL as;

proximal and posterior to the lateral femoral epicondyle,[18-20,22,23,26,27] the center of the lateral epicondyle by Daggett *et al*,[26] anterior to the LCL femoral origin.[16,24,28] The present study observed that the maximum number of cases had femoral attachment posteroinferior to LCL attachment at LFE followed by posterosuperior and then anteroinferior to LCL attachment. Even though there are some variations, the current consensus is that the femoral origin of ALL is typically located proximal and posterior to the lateral femoral epicondyle.[21]

Unlike the controversies regarding the femoral origin of ALL, many authors agree that the distal attachment site is present halfway between Gerdy's tubercle and the tip of the fibular head. This was not the case in present study as only few cases had distal attachment between GT and fibular head but in majority of the cases ALL was attached closer to posterior aspect of GT. While in some cases the tibial attachment was closer to head of fibula.

Although there are some anatomical variations in the anterolateral ligament (ALL), most of the studies agree its existence as a distinct ligamentous structure on the anterolateral aspect of the knee joint. In present study, out of 30 dissected knees, ALL was identified in 26 knee joint (86.7%) which connect femur with the tibia. The mean length of the ALL measured at extension and 90° flexion was 31.12±8.06 mm and 32.59±7.71 mm, respectively.

The femoral attachment of ALL was variable; the most common one 42.31% being attached just posteroinferior to the LFE followed by 38.5% attached to posterosuperior aspect of LFE and 19.2% of ALL had proximal attachment just anteroinferior to LFE. The attachment of ALL on tibia was quantified relative to bony landmark as Gerdy's tubercle. The average distance between the GT and ALL attachment was found to be 21.82 ± 4.89 mm.

Variability in the ligamentous structure of the ALL suggests that it may be more important in some patients than others and reconstruction may need to be performed in selective patients. Hence, the present study is not only to highlight the discussion about the existence of ALL but also to disclose detail anatomy about ALL. Further studies are recommended for better understanding the role of ALL, its indications for reconstructive surgeries and development of biomechanical settings and surgical techniques.

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