Original article

Determination of the anterolateral ligament in the knee in a colombian sample

Determinación del ligamento anterolateral de la rodilla en una muestra colombiana

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ABSTRACT

Introduction: The anterolateral ligament in the knee has a fundamental role in the rotational stability of the joint. Its non-inclusion for the surgical repair of anterior cruciate ligament is a possible cause of postsurgical rotational instability in these patients. This ligament holds global scientific relevance in terms of its morphology and biomechanics. It is encouraged as a subject of research in order to understand and underscore its stabilizing role in locomotion activities.

Objectives: To determine the frequency and anatomical variability of the anterolateral ligament in cadaveric knees.

Methods: Nineteen knees from embalmed cadavers were included in the study. The anterolateral ligament was identified using the dissection technique and morphometric measurements and their anatomical characteristics were taken.

Results: After a plane dissection, the ligament was visualized in 68.4 % of the samples, with a mean length of 20.5 mm. and a thickness of 0.43 mm. Its

insertion at the level of the femoral condyle registered a greater amplitude than that of the distal, which was found close to the head of the fibula.

Conclusions: The anterolateral ligament was found as an independent structure, and their fibers presented an anteroinferior orientation from the lateral epicondyle of the femur, closely related to the articular capsule.

Keywords: ligaments; knee joint; joint instability; anterior cruciate ligament.

RESUMEN

Introducción: El ligamento anterolateral de la rodilla tiene un papel fundamental en la estabilidad rotacional de la articulación. Su no inclusión en la reparación quirúrgica del ligamento cruzado anterior es una posible causa de inestabilidad rotacional posquirúrgica en estos pacientes. Este ligamento tiene relevancia científica mundial por su morfología y biomecánica. Se fomenta como objeto de investigación para comprender y subrayar su papel estabilizador en las actividades de locomoción.

Objetivos: Determinar la frecuencia y variabilidad anatómica del ligamento anterolateral en rodillas cadavéricas.

Métodos: Se incluyeron en el estudio 19 rodillas de cadáveres embalsamados. Se identificó el ligamento anterolateral mediante la técnica de disección y se tomaron medidas morfométricas y sus características anatómicas.

Resultados: Tras una disección plana, el ligamento se visualizó en el 68,4 % de las muestras, con una longitud media de 20,5 mm y un grosor de 0,43 mm. Su inserción a nivel del cóndilo femoral registró una amplitud mayor que la distal, que se encontró próxima a la cabeza del peroné.

Conclusiones: El ligamento anterolateral se encontró como una estructura independiente, y sus fibras presentaron una orientación anteroinferior desde el epicóndilo lateral del fémur, en estrecha relación con la cápsula articular.

Palabras clave: ligamentos; articulación de la rodilla; inestabilidad articular; ligamento cruzado anterior.

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Introduction

The anterolateral region of the knee contains two extra-articular structures important for its rotational stability: the iliotibial tract (ITT) and the anterolateral ligament (ALL), a structure identified by Segond (1879) as a pearly fibrous band associated with avulsion fractures of the lateral condyle of the tibia under rotational mechanisms.

Due to its location and distribution, it presents connections with the femoral insertion of the lateral collateral ligament (LCL), an interposition with the ITT, and with the popliteal muscle tendon, relationships that make it difficult to identify the ligament as an independent structure.[1,2]

In 2007, *Vieira* et al[3] assigned it its current name, motivating greater interest in its investigation.

In 2014 it was identified that the ALL increased the tension between 30 and 60° of flexion and medial rotation of the knee.[2] Other studies defends the use of combined reconstructions; Mostacedo et al. defined the values in degrees of medial knee rotation under conditions of injury and reconstruction, demonstrating that the use of the combined ACL and ALL reconstruction results in similar levels of stability to that of an injury-free knee.[4]

In the United States, more than 400,000 ACL reconstructions are performed each year with 75 % to 97 % recorded as achieving excellent long-term results. However, some patients present evident rotational instability 12 months after the procedure. Reoperation rates can be as high as 10-15 %. If this dysfunction is not treated, there is an increased risk of disability associated with degenerative changes such as early osteoarthritis in 31.3 % and meniscal injury in 71.2 %.[5]

For many investigators, residual instability is due to the chosen surgical technique, due to isolated ACL reconstruction without considering ALL.[6] Possibly this is due to the lack of clarity for the identification and anatomical configuration of ALL, generating an incomplete understanding of the functional mechanics of the knee and the exclusion of ALL in the evaluation and surgical protocols for all susceptible components.[5,7]

The objective of this study was to determine the frequency and anatomical variability of the ALL in a sample of cadaveric specimens.

Methods

This investigation included 40 knee joints from 20 embalmed cadavers of the Universidad del Valle. This investigation has been approved by the Institutional Ethics Committee (009-017) of the Universidad del Valle.

As inclusion criteria; knees with integrity of the structures were taken into account and that responded positively to the restoration process. The final sample obtained was 19 knees, two female, 17 male. It was not possible to obtain data pertaining to age as this was not registered on the death certificates. Each was identified with an alphanumeric code.

Dissection in order to visualize the ALL was performed by examining the layers of the lateral region of the knee including the capsule. Dissection began with the release of the superficial layer of the ITT, through two cuts, one lateral parapatellar and one horizontal supracondylar of 6 cm.

Subsequently, the deep layer of the ITT was identified and freed from nearby muscle structures to be folded distally. The anterolateral layers of the articular capsule were then separated in the anteroposterior direction until the inferolateral geniculate vessels and the LCL were identified. ALL was released from its origin to insertion in order to identify the superficial fibers in the oblique direction of the ALL, extending from the prominence of the lateral epicondyle of the femur (LEF) to the anterolateral region of the tibia.

The anatomical characteristics analyzed were: a) ligament shape; b) insertions: number and location; c) location of the proximal insertion in relation to the LEF. To record this latter variable, the classification proposed by *Daggett* et al,[8] in 2016 with the following options was taken as a reference:

1. Immediately over the LEF; 2. slightly posterior and proximal to the LEF and 3. completely posterior and proximal to the LEF.[8]

The measurements of the morphometric variables analyzed were: A) length of the ligament; B) distance between the ligament and the anterolateral tubercle (ALL-ALT); C) distance between the head of the fibula and the ligament (FH-ALL); D) width at the distal insertion (DI width); E) width at the proximal insertion (PI width); F) width at the central portion (Central Width) (fig. 1). The measurements were made with a digital caliper and squared wire of orthodontic use.

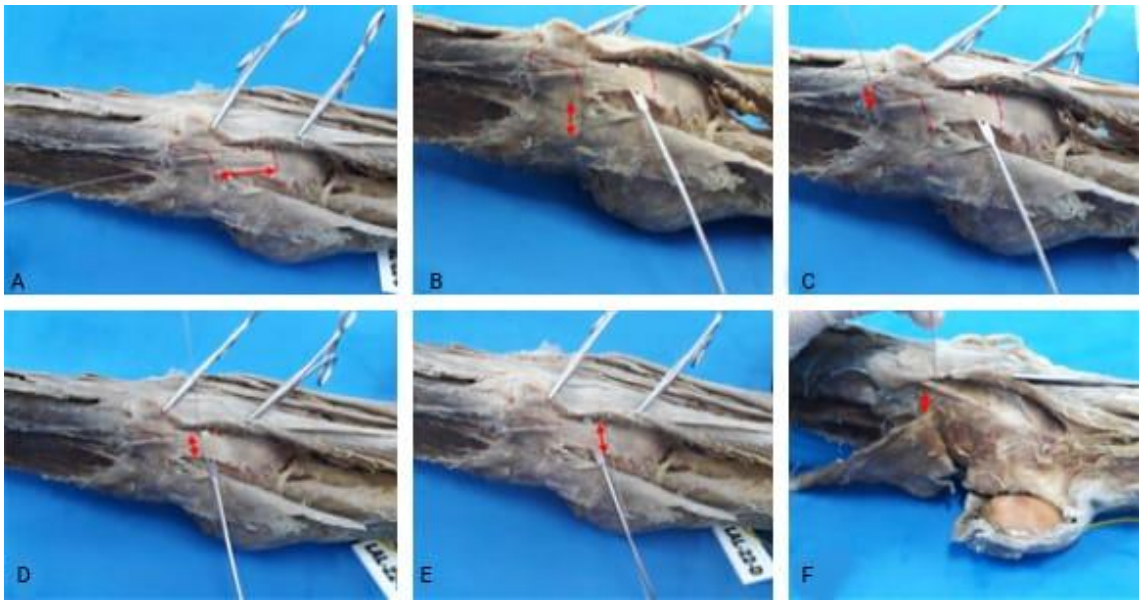

Fig. 1 - Measurement of variables for the anterolateral ligament.

A) Anterolateral ligament length (ALL)

B) Distance between ligament and anterolateral tubercle (ALL-ALT)

C) Distance between the head of the fibula and the ligament (HF-ALL)

D) Width at distal insertion (Width DI)

E) Width at proximal insertion (Width IP)

F) Width in the center portion (Width Center)

G) Digital caliper depth gauge with which the thickness of the LAL was taken

Results

Of the 19 knees included in the study, the ALL was identified in 13, a presentation frequency of 68.4 %. The ligament was found flat in 100 % of the specimens, with its fibers oriented obliquely and superficially in the antero-inferior direction between the femur and the tibia.

Close relationships with the joint capsule and inferolateral geniculate vessels were visualized in all samples. In addition, reinforcement of this area was evidenced by other anatomical structures: posteriorly with the biceps femoris

tendon; anterolaterally the ITT; medially the LCL, and, on a deeper plane, with the origin of the popliteal tendon. Its relationship to the LCL was found oblique and superficial to the proximal third of it.

The proximal insertion was located directly on the LEF in 100 % of cases, as was the tibial portion of the distal end of the ligaments (fig. 2).

Fig. 2 - Lateral view of a right knee.

Legend: (B) Back, (P) Previous, (D) Distal, (Pr) Proximal, (*) Anterolateral ligament.

For the standardization of the morphometry protocol, inter and intra-observer tests were performed on the results of four pieces included in the pilot test. ALL morphometry table shows the minimum, maximum and mean values of each of the morphometric variables considered in this study.

Differences were found in the width of the proximal insertion (PI width) compared to the distal insertion (DI width). However, the distal insertion was found closer to the fibular head (FH-ALL distance) than to the anterolateral tubercle of the tibia (ALL-ALT distance).

Table - Measurements obtained by LAL morphometry

Variable	Minimum value (mm)	Maximum value (mm)	Average (mm)

Tibial length	11,47	30,75	20,5
Width DI	7,19	16,52	11,5
Width PI	7,47	17,49	12,29
Central width	7,54	13,47	10,5
Distance HF-ALL	5,55	26,31	13,34
Distance ALL-ALT	7,62	23,87	14,79
Thickness	0,15	0,72	0,43

Legend: Width DI: width at distal insertion; Width PI: width at proximal insertion; Distance HF-ALL: distance between the head of the fibula and the ligament; Distance ALL-ALT: Distance between ligament and anterolateral tubercle.

Discussion

Since the first report by Segond in 1879, studies on its incidence have presented diverse results.[9,10] In the present study, an incidence of 68.4 % was found, a value which differs from the obtained by other authors, who each reported an incidence of 100 % in Belgium and Canada respectively.[11,12]

The findings from this study are more comparable with European studies, where ALL identification ranged from 45 % in Austria,[13] to 97 % in Belgium.[1] The lowest incidences of ALL have been recorded in Japan (37.2 %) and Korea (42.5 %).[14,15]

One of the factors related to variability in incidence is dissection considered the method most frequently used to identify ALL, however, there is no consensus on the best dissection technique or approach.[16] In some of the protocols described, processes are detailed that include rupture of the periarticular support structures as tenotomies and arthrotomies.[1,13,17]

In our study, a conservative technique was used, in which only two cuts to the ITT were made, one lateral parapatellar and one horizontal, with the preservation of both ends.

De Lima et al,[16] put forward a dissection protocol for fresh cadaveric material. They propose, as proposed in this present study, to obtain access from the ITT, maintaining the knee in a flexed position between 30° and 60°.

Herbst et al[9] and *De Lima* et al[16] recommend working with fresh specimens as they consider tissues subjected to embalming are dehydrated and retracted; particularly in the conditions of the ITT and the articular capsule, the anatomical components closely related to the ALL considered highly susceptible to tears to the degree that confusion is generated both in the identification and in the morphometric values obtained from the ligament.

The narrow width of the ALL and its intimate relationship with the layers of the articular capsule in its anterolateral region create a cross-linking of fibers from both structures.

Morphometry becomes a valuable tool to objectively assess its shape, variability and to carry out analysis on the different population groups. The anatomical reference points used were in accordance with those proposed by *Dagget* et al.[8]

Regarding the anatomical characteristics of the ALL, few authors consider that the shape of the ligament is tubular.[1,11] Our findings found a band shape in 100 % of the specimens examined, results similar by *Watanabe* et al.[14] Our study agrees with these researchers in the fact that the flat shape of the ligament is another factor making it difficult to differentiate ligament fibers from the layers of the joint capsule, and they can tear during dissection.

To define the ALL insertion points, various authors agree that its proximal insertion is closely related to the proximal LCL insertion in the LEF and to use these two structures as reference points for their classification with a broad range for the exact point of its union with the bone.[8]

In all samples, the proximal ALL insertion was found superimposed on the proximal LCL insertion, a description similar to that reported by *Daggett* et al.[8]

Regarding the distal insertion, different authors describe it equidistant between the HF-ALT.[11,18] However, in this study, a lower value was found from the insertion of the ligament towards the FH, corresponding to 13.34 mm compared to the 14.79 mm separating it from the ALT, values similar to those found by *Claes* et al[12] and *Dodds* et al[2] reported that the ligament was closer to the ALT.[11]

This anchorage point is considered biomechanically as a minor lever arm in the tibia following its oblique path from the femur, where it is considered as performing a functional role of secondary stabilizer in medial knee rotation.[19]

For the length of the ALL, the free edge of the ALL was determined as a reference point. The mean length found (20.5 mm) corresponds to the lowest dates reported. Values as high as 59.0 mm in Canada[11] and 40.3 mm in London[2] are reported, while in Brazil an average length of 33.2 mm[17] and 37.3 mm were recorded.[20] The difference between the data obtained compared to other populations may be due to the established measurement protocol, where the measurement was made from the free ends of the ligament and not from its bone insertions to avoid the error that enlargements could generate.

This measurement protocol was used by *Stijak* et al,[17] where a first measurement was made without standardization of reference points and a mean of 41.4 mm was obtained. In the second measurement, the length of the free edge of the ALL was taken and the measurement obtained was 25.0 +/- 4, close to that obtained in this study.

The width of the ligament is an important variable as its extension is involved in the strengthening of the anterolateral region of the knee. When observing its conformation, this measurement was classified into three regions; proximal, central and distal. A greater extension of the proximal insertion was found (12.29 mm) than the distal extension at the level of the tibia (11.5 mm), producing similar results to those of *Dodds* et al[2] which indicated that the attachment of the ALL to the LEF expanded in the form of a fan tightly attached to the capsule. In contrast, the reports by *Claes* et al[1] and *Caterine* et al[11] reported lower measurements and a wider distal insertion. In the central portion the measurement was 10.5 mm, data which approximates that reported by *Claes* et al,[1] from Belgium (11.3 mm).

This discrepancy can be associated with the expertise of the anatomist. As indicated by *Stijak* et al,[17] there is no clear delimitation between the capsule and the ligament. However, *Redler* et al,[21] found that, although the ALL did not present a parallel distribution as organized as the LCL, its structure was ligamentous and could therefore be distinguished from the joint capsule.

When determining the average thickness in the selected samples, a value of 0.43 mm was obtained, a lower value than those reported in studies where this variable was considered.[17] This is associated with the tissue conditions of the cadaveric sample.[13,17]

To improve methods for ALL recognition and its anatomical characteristics, it is necessary to complement the dissection technique with other examination tools such as diagnostic images and increase data to support reconstruction.[22] Such tools make it possible to report ALL presence in a living population and also contribute to establishing clinical identification protocols. As *Hartigan* et al[23] mention, inter-institutional protocols are variable and radiologists do not have ALL assessment included in their routinesand suspect injury when ACL, TIT, and LCM damage are present.[24,25]

Claes et al[1] recommend magnetic resonance imaging as an effective method to complement the identification of the ALL performed by dissection, to obtain measurements and compare data on the position of its insertions.

Such studies favor the understanding of biomechanics, with information useful by specialists to generate assessment alternatives, develop surgical interventions with standardized protocols for combined reconstruction involving the ACL and ALL, to protect against injuries generated by movements which compromise rotational control of the knee, and to reduce the rate of recidivism and post-surgery complications.[26,27]

Advances in ALL research will enable more detailed exploration of the anatomical details of this ligament, it is an area where further research is required because its variability, position supported by a number of other researchers.[28,29,30]

Among the limitations presented in this study are: the low sample number, the underrepresentation of female specimens, and the absence of specimen age data.

Conclusions

The dissection parameters and reference points described allow determining that the anterolateral ligament is an independent structure present in the knee with an incidence of 68.4 %, however, the variability of the reported data may be associated with anatomical characteristics of the knee, joint capsule and the methods used for its identification

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Conflict of interest

The authors have no conflicts of interest.

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