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ANATOMICAL, HISTOLOGICAL AND BIOMECHANICS ANALYSIS OF THE ANTEROLATERAL LIGAMENT

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Abstract: The present work focuses on carrying out a bibliographical research on the anterolateral ligament of the knee, with the main objective of incorporating the results obtained from the articles analyzed, in relation to anatomy, histology and ligament biomechanics. The literature search was through the MEDLINE database via PubMed® and SciElo®, focusing on articles that contained the objectives proposed by the research. The anterolateral ligament does not have a constant incidence, due to the different forms of dissection used by studies, it is worth highlighting that the distal to proximal method was more successful in identifying the ligament. Therefore, studies seek to understand the anatomy of the anterolateral ligament, which is covered by fibrous connective tissue and originates from the lateral epicondyle of the femur, varying proximally, distally, anteriorly and posteriorly in relation to the lateral collateral ligament. It has an anterodistal trajectory towards the tibia, where it is inserted between the head of the fibula and Gerdy's tubercle, and in the meniscus between the anterior horn and the body of the meniscus. Regarding biomechanics, studies converge on the explanation that the ligament has the function of stabilizing the knee.
Keywords: Anterolateral ligament. Histology. Biomechanics. Knee.

INTRODUCTION

Based on studies by doctors Dr. Steven Claes and Dr. Johan Bellemans in their article: "Anatomy of the anterolateral ligament of the knee" published in 2013 (1), the anterolateral ligament (LAL) began to be studied in depth and thus Thus, its importance in the knee ligament complex has been exposed.

The anterolateral ligament is inserted into the proximal-distal axis of the femur, and in the tibia there are several variations regarding its attachment, which may be in the lateral meniscus or between Gerdy's tubercle and the head of the fibula. Recent studies on the ligament reveal its importance in knee stability. It must be noted that, in knee dissections with the aim of exposing the ligament, in many cases its existence has not been confirmed, therefore, there are still techniques and theories being developed to perform the dissection and also explanations about these variations. In this context, this article focuses on exposing the most recent data contained in the medical literature about the anterolateral ligament of the knee through a bibliographical research. Morphological, anatomical and biomechanical aspects will be analyzed, as well as the importance of reconstitution for patients with anterior cruciate ligament injuries.

THEORETICAL FOUNDATION

HISTOLOGY

To prove that it was a ligament structure and not just some extension of another structure in the anterolateral region of the knee, several articles sought to investigate the histology of the tissue studied (2, 3, 4, 5, 6). Laboratory analyzes proved that the structure was a ligament, as the identified tissue is part of the dense connective tissue, characteristic of ligament structures. In the anterolateral ligament (ALL), well-organized fibers composed of type 1 collagen were found, which were oriented parallel and arranged slightly wavy (Figure 1), predominant in ligaments and tendons, with the aim of providing greater resistance to adjacent structures (2, 3, 4, 5, 6). Vascular tissue was also found in the ALL (7).

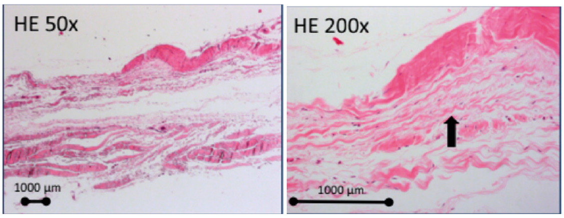

Figure 1. Histology: Anterolateral ligament (ALL) (HE = hematoxylin-eosin stain). Note the densely organized collagen fibers of this thin ligamentous structure and the parallel orientation of the fibers, which are arranged slightly in a wave shape (arrow).

Source: Adapted from Brockmeyer et. al., 2019.

Helito, in 2017 (4), obtained images that histologically represented the anterolateral ligament with its origin in the right femoral epicondyle and with insertion in the lateral meniscus (Figure 2), which corroborates the dissection studies of the structure (5, 2, 1, 6, 8).

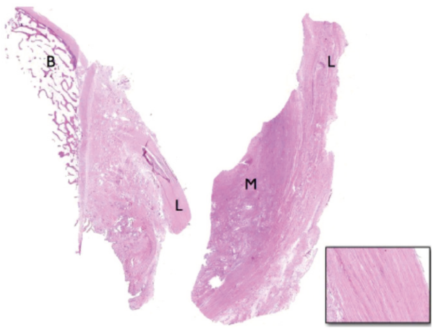

Figure 2. Histological analysis of the anterolateral region of the knee exposes the origin in the lateral epicondyle (B) of the anterolateral ligament (L) – where dense connective tissue is observed – with its insertion in the lateral meniscus (M).

Source: Helito, 2017.

ANATOMY OF THE ANTEROLATERAL LIGAMENT

Among the knee ligament complex (Figure 3), the anterolateral ligament is one of the current focuses, being officially confirmed and named in 2013. We must emphasize that, in knee dissections with the aim of exposing the ligament, in many cases there was no its existence confirmed.

In this context, there are variations in the incidence of LAL between 4.16% and 100% in the studies evaluated (Table 1).

The origin of the LCL varies in the bibliographies studied, being correlated with the lateral collateral ligament, and may be anterior, anterodistal, anteroproximal, distal, posterodistal and presenting the same origin as the LCL. In Helito (2017) (4), the ligament was found most frequently (65.7%) in the anterodistal region to the LCL. (6, 8, 2, 1, 9, 10, 11, 3, 12, 5).

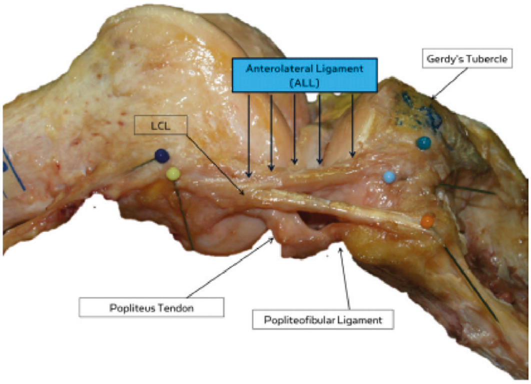

Figure 3. Photograph of the right knee after dissection. ALL: anterolateral ligament; LCL: lateral collateral ligament; Gerdy Tubercle – Gerdy's tubercle; Popliteofibular ligament: popliteo-fibular ligament; Popliteus Tendon: popliteal tendon.

Source: Claes et al., 2013.

The trajectory followed by the ligament until insertion into the tibia is related to an oblique and anterodistal trajectory for insertion into the meniscus and tibia. (1, 2, 11, 12, 4, 9, 5, 8). The location of the insertion in the meniscus converged in the studies (Figure 4), with the exception of Brockmeyer et al., 2019 (5) in which the insertion was located in the lateral meniscus. In most studies, it was located between the anterior horn and the body of the lateral meniscus (1, 2, 6, 4, 14, 8, 5). In Helito et al., 2016 (14), meniscal insertion was

	Year	Knees dissected	Incidence of LAL
Brockmeyer et al.	2019	23	100%
Rustagi et al.	2019	20	95%
Cho e Kwak	2019	120	42,5%
Helito	2017	105	100%
Potu et al.	2016	24	4,16%
Stijak et al.	2016	14	50%
Kennedy et al.	2015	15	100%
Dodds et al.	2014	40	83 %
Helito et al.	2013	6	100%
Claes et al.	2013	41	97%

Table 1. Incidence of the anterolateral ligament in several studies

	Year	Length (Average)	Width (Average)	Thickness (Average)
Brockmeyer et al.	2019	0°- 39,13 mm	Femoral origin - 10.2 mm Joint line- 8.99 mm Tibial insertion- 9.91 mm	Linha articular – 2,06 mm
Rustagi et al.	2019	0°- 40,38 mm 90°- 43,35 mm	Origin - 6,98 mm Insertion – 9,36 mm	(nothing)
Stijak et al.	2019	41 mm	4 mm	1 mm
Cho e Kwak	2019	32,4 mm	5,2 mm	1,3 mm
Helito	2017	0°- 37,88 mm 90°- 40,94 mm	Joint line – 7.32 mm	1,87 mm
Potu et al.	2016	0°- 34,23 mm 90°- 30,41 mm	Femoral origin - 4.83 mm Joint line- 4.04 mm Tibial insertion- 6.06 mm	Joint line- 1.78mm
Kennedy et al.	2015	0°- 36,8 mm 90°- 41,6 mm	(nothing)	(nothing)
Dodds et al.	2014	59 mm	6 mm	(nothing)
Helito et al.	2013	35,1 mm	6,8 mm	2,6 mm
Claes et al.	2013	0°- 38,5mm 90°- 41,5 mm	Femoral origin - 8.3 mm Joint line- 6.7 mm Tibial insertion- 11.2 mm	(nothing)

Table 2. Anterolateral ligament measurements

	Method	Incidence
Claes et al., 2013	Distal-proximal	97%
Helito et al., 2013	Distal-proximal	100%
Potu et al., 2016	It Doesn't make it specific	4,16%
Helito, 2017	Distal-proximal	100%
Cho e Kwak, 2019	Proximal-distal	42,5%
Brockmeyer et al., 2019	Distal-proximal	100%

Table 3. Method of dissection of the ALL and the results obtained regarding visualization of the ligament.

found in 100% of dissected knees, whereas in Brockmeyer et al., 2019 (5), it was found in only 65% of cases. Furthermore, there was difficulty in visualizing the separation of the meniscal fibers and the insertion of the anterolateral ligament (2). The insertion on the tibial plateau was constant (Figure 5) between the head of the fibula (FH) and Gerdy's tubercle (GT), and can also be found posterior to the GT (1, 2, 11, 12, 6, 4, 8, 9, 10, 5).

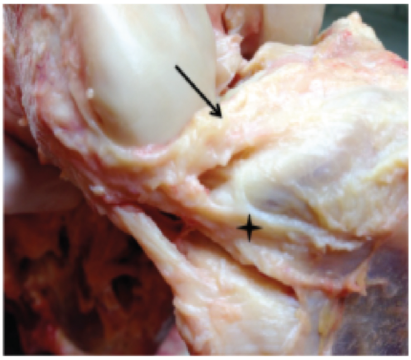

Figure 4. Insertion of the anterolateral ligament into the lateral meniscus (arrow) and Gerdy's tubercle (asterisk).

Source: Helito et al., 2013.

The anatomical measurements of the LAL follow a standard. Width and thickness are close in most studies, although these measurements vary within a wide margin. The length is greater when it is flexed, with the exception of Potu et al., 2016 (6) (Table 2). The presence of more than one band in the LAL structure has been reported. A study with dissection of 13 knees observed the presence of two bands in 12 of the 13 knees analyzed. The surface band of the ALL had a posterior and proximal origin to the center of the lateral epicondyle, and its length increases when the knee is extended, and without insertion into the lateral meniscus. The deep band originated in the center of the lateral epicondyle and its length increased with the knee in flexion. Both structures had a similar tibial insertion site, and the deep band was situated slightly more posteriorly (13). There is little data described on the innervation of the LAL. Recent studies have detected circular structures that can be defined as small peripheral nerves or mechanoreceptors involved in the innervation of the ligament (13).

LAL BIOMECHANICS

Non-consensually, some authors defend the idea that the LAL has significant relevance during anterolateral tibial rotation, acting as a secondary stabilizer in internal rotation.

Combined anterior cruciate ligament (ACL) and ALL injuries with reconstruction of the ACL alone tend to evolve with residual rotational laxity, not reestablishing the expected kinematics.

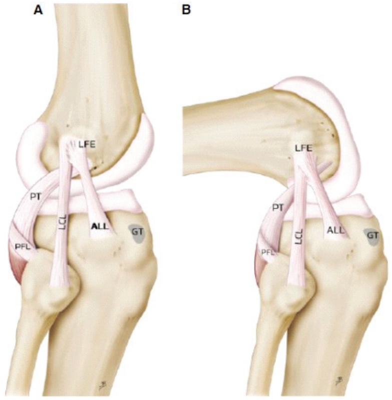

Figure 6. Anatomical drawing considering the LAL and its relationship with known anatomical landmarks on the lateral aspect of the human knee. (A) Knee in full extension. (B) Knee in 90° flexion. ALL: anterolateral ligament; LCL: lateral collateral ligament; GT: Gerdy's tubercle; LFE: lateral femoral epicondyle; PT: popliteal tendon; PFL: popliteofibular ligament.

Source: Claes et al., 2013

METHODOLOGY

A search was carried out through the Scielo® and MedLine databases via PubMed®. The search strategy used the following MeSH terms as basic keywords: *The anterolateral ligament anatomy; The anterolateral ligament*

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anatomy; Biomechanical of the anterolateral ligament. Os autores, de maneira independente, examinaram os títulos e resumos dos artigos na electronic database to exclude articles not relevant to the study. After this, the articles retrieved through the search key were analyzed in full and their references analyzed with the aim of finding more articles that met the study's inclusion criteria. After a first reading of the texts, a re-reading began with the aim of noting aspects that would comprise this research and to compare theoretical data on the subject.

DISCUSSION

The striking aspect that can justify the different incidences of the anterolateral ligament in different studies is the way in which its dissection is carried out. There are two preponderant methods used to visualize the structures of the anterolateral region, dissection starting proximally or distally. Studies that opt for dissection from proximal to distal are more likely to damage the more superficial tissues that pass through the origin of the LCL, thereby potentially removing some of the LAL's structure. Regarding dissections from distal to proximal, these tend not to visualize the deep tissues, thus compromising the correct visualization of the ALL (4). Therefore, it is clear that each methodology has disadvantages, however dissection from distal to proximal has greater results in relation to the incidence of the ligament (Table 3).

Below is a knee dissected from distal to proximal (Figure 7)

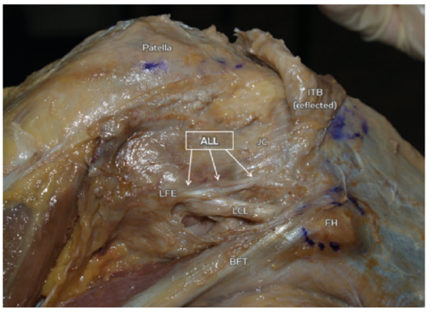

Figure 7. Typical view of a right knee during dissection. ITB (reflected): reflected iliotibial tract; ALL: anterolateral ligament; LCL: lateral collateral ligament; Patella: patella; FH: head of the fibula; JC: joint capsule; LFE: lateral epicondyle of the femur; BFT: biceps femoris tendon.

Source: Claes et al. 2013

FINAL CONSIDERATIONS

The article focused on providing an analysis of the existing bibliography about the anterolateral ligament, to provide the reader with relevant information regarding publications in recent years on the histology, anatomy and biomechanics of this ligament.

Regarding histology, the present work brought the focus of several articles that argued that the structure present in the anterolateral region of the knee is in fact a ligament, such that it is made up of dense connective tissue. In anatomy, not all articles researched found the ligament in 100% of the dissected knees, which may be related to different dissection techniques, with those starting from distal to proximal obtaining a better incidence of the ligament. There are also disagreements regarding the origin of the ligament on the lateral epicondyle of the femur. The path and insertion are constant in studies, following an oblique and anterodistal trajectory, and inserting between Gerdy's tubercle and the head of the fibula in the tibial insertion and between the anterior horn and the body of the lateral meniscus. In relation to biomechanics, the published articles propose the approach of LAL acting as a stabilizer of the integral units.

REFERENCES

• Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J. Anatomy of the anterolateral ligament of the knee. Journal of Anatomy. 2013 Aug 1;223(4):321–8.

• Helito CP, Miyahara H de S, Bonadio MB, Tirico LEP, Gobbi RG, Demange MK, et al. Estudo anatômico do ligamento anterolateral do joelho. Revista Brasileira de Ortopedia. 2013 Jul;48(4):368–73.

• Helito CP, Demange MK, Bonadio MB, Tírico LEP, Gobbi RG, Pécora JR, et al. Anatomy and Histology of the Knee Anterolateral Ligament. Orthopaedic Journal of Sports Medicine. 2013 Dec 1;1(7):232596711351354.

• Camilo Partezani Helito. O ligamento anterolateral do joelho: estudo anatômico, histológico e por ressonância magnética. Tese de Doutorado em Ortopedia e Traumatologia - Universidade de São Paulo . 2017 Jul 17;

• Brockmeyer M, Orth P, Höfer D, Seil R, Paulsen F, Menger MD, et al. The anatomy of the anterolateral structures of the knee — A histologic and macroscopic approach. The Knee. 2019 Jun;26(3):636–46.

• Bhagath Kumar Potu, Abdel Halim Salem, Abu-Hijleh MF. Morphology of Anterolateral Ligament of the Knee: A Cadaveric Observation with Clinical Insight. Advances in Medicine. 2016 Oct 25;2016.

• Parker M, Smith HF. Anatomical variation in the anterolateral ligament of the knee and a new dissection technique for embalmed cadaveric specimens. Anatomical Science International. 2016 Dec 18;93(2):177–87.

• Cho HJ, Kwak DS. Anatomical Consideration of the Anterolateral Ligament of the Knee. BioMed Research International. 2019 [cited 2021 Oct 15];2019:5740473.

• Gopal P, Rustagi S, Ahuja M, Arora N, Sood N. The anterolateral ligament of the knee: Descriptive anatomy and clinical correlation. Indian Journal of Orthopaedics. 2019;53(1):89.

• Lazar Stijak, Marko Bumbasirevic, Vidosava Radonjić, Marko Kadija, Puskas L, Milovanovic D, et al. Anatomic description of the anterolateral ligament of the knee. Knee Surgery, Sports Traumatology, Arthroscopy. 2016 Jul 1;24(7):2083–8.

• Kennedy MI, Claes S, Fuso FAF, Williams BT, Goldsmith MT, Turnbull TL, et al. The Anterolateral Ligament. The American Journal of Sports Medicine. 2015 Apr 17;43(7):1606–15.

• Dodds AL, Halewood C, Gupte CM, Williams A, Amis AA. The anterolateral ligament. The Bone & Joint Journal. 2014 Mar;96-B(3):325–31.

• Ariel de Lima D, Helito CP, Lacerda de Lima L, de Castro Silva D, Costa Cavalcante ML, Dias Leite JA. Anatomy of the Anterolateral Ligament of the Knee: A Systematic Review. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2019 Feb;35(2):670–81.

• Helito CP, Bonadio MB, Rozas JS, Wey JMP, Pereira CAM, Cardoso TP, et al. Biomechanical study of strength and stiffness of the knee anterolateral ligament. BMC Musculoskeletal Disorders. 2016 Apr 30;17(1).