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The anterolateral ligament of the knee: A dissection study ☆,☆☆

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ABSTRACT

Background: Recent studies have described the presence of the anterolateral ligament (ALL). However, there is still no consensus regarding the anatomy of this structure with the topic controversially discussed. The aim of this study was to provide an anatomical description of the ligamentous structures on the anterolateral side of the knee with special emphasis on the ALL.
Methods: Forty-four human cadaveric knees were dissected to reveal the ALL and other significant structures in the anterolateral compartment of the knee joint. The ALL was defined as a firm structure running in an oblique direction from the lateral femoral epicondyle to a bony insertion at the anterolateral tibia.
Results: The ALL was identified in 45.5% (n = 20) of the dissected knee joints. The structure originates together with the fibular collateral ligament (45%) or just posterior and proximal to it (55%). The ligament has an extra-capsular, anteroinferior, oblique course to the anterolateral tibia with a bony insertion between Gerdy's tubercle and the fibular head. The ALL had its greatest extend at 60° of knee flexion and maximal internal rotation.
Conclusion: The ALL is a firm ligamentous structure in the anterolateral part of the knee present in 45.5% of the cases. Given the course and characteristics of this structure, a function in providing rotational stability by preventing internal rotation of the knee is likely.
Clinical relevance: The ALL might be an important stabilizer in the knee and may play a significant role in preventing excessive internal tibial rotation and subluxation of the knee joint.

1. Introduction

Despite anterior cruciate ligament (ACL) injury being one of the most frequent orthopedic procedures performed, reconstruction surgery still yields problems postoperatively, especially in controlling rotational stability [1–3]. A positive "pivot-shift" test following ACL reconstruction is observed in up to 30% of cases after ACL surgery and is responsible for secondary meniscal and cartilaginous problems [4–6]. Believing other stabilizing structures may exist in the lateral aspect of the knee [4,7–14], some surgeons tend to add different techniques of extra-articular tenodesis to intra-articular ACL reconstruction in order to address the problem of rotational instability and to restore the complex system of intra- and extra-articular stabilizers, which are acting statically and dynamically on the tibiofemoral articulation [9,15]. However, the anatomy and biomechanics of the lateral and anterolateral knee compartments are still not fully elucidated and remain controversially discussed.

The Ségond fracture, located at the proximal anterolateral tibia, is a pathognomonic sign for ACL tears. This bony avulsion fracture is caused by excessive internal rotation in combination with varus stress [7,9–11]. In 1879, Ségond described a "pearly, resistant, fibrous band" linking the lateral femoral epicondyle to the anterolateral part of the tibia [16]. Throughout the time different authors used various names such as "midlateral capsular ligament", "lateral capsular ligament", "midthird lateral capsular ligament", "anterior oblique band" or "retrograde tract fibers" [7,9,10,17–20]. Furthermore the detailed qualitative description of these structures vary and lacked in illustrations, leaving it open whether the names refer to the same anatomical structure. This has led to much confusion about the real anatomy and function of this structure.

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☆☆ Ethical Review Committee Statement: In this study no ethical review committee statement or IRB was required since all bodies were donated by individuals who, prior to death, had given informed consent for their use for scientific and educational purposes.

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More recent studies have attempted to reassess the soft-tissue anatomy of the anterolateral knee compartment, introducing the name "anterolateral ligament (ALL)". However, despite using the same name, the described anatomical structures appear to be different with frequencies varying from 50–100% [8,12–15,21–24]. While the tibial attachment is described constantly throughout the investigations to be approximately midway between Gerdy tubercle and the fibular head, anatomical inconsistencies can be found especially in the description of the femoral attachment sites of the ALL. Some authors reported the femoral origin to be anterior and distal to the origin of the fibular collateral ligament (FCL) [8,13,21,23], other anatomical studies reported it to be proximal and posterior of the FCL origin [25]. Two studies described both variants [22,26]. Terry et al. [14] and Vieira et al. [12] described the capsule–osseous layer (COL), the third and deep layer of the iliotibial-band (ITB), which has an anteroinferior course and was said to "act as a true anterolateral ligament". However, in contrast to the above mentioned articles, no bony femoral origin was described of the COL.

Regarding the fact, that there is still no clear consensus about the qualitative and quantitative characteristics of the ALL, the primary aim of this study was to provide a closer look to the anterolateral compartment of the knee using a large sample size. Taking into consideration the current knowledge of this controversially discussed structure, special emphasis was led to the femoral and tibial attachments and length change patterns of the ALL.

2. Methods

Fifty embalmed human cadavers, 28 females and 22 males, with a mean age of 78.1 years (range 61–94) at the time of death were obtained from the body donation program of the Division of Clinical and Functional Anatomy, Medical University of Innsbruck/Austria. The bodies were donated by individuals who, prior to death, had given informed consent for their use for scientific and educational purposes [27,28].

All cadavers were preserved using an arterial injection of a formaldehyde–phenol solution and immersion in phenolic acid in water for one to three months [29]. As for representativeness, a recent analysis has revealed that bodies donated to the DCFA-MUI are a representative sample of the general Austrian population at the age of death [30].

Six knees were excluded from the study because of visible knee pathologies or severe macroscopic degeneration, resulting in an overall number of 44.

The dissection was performed according to the protocol established by Claes et al. [8]. For the standardized approach and measurements, the femoral shaft was fixed at 60° of knee flexion in a mounting tower. For training reasons prior to dissection of the 44 cadaveric knees, each of the four dissectors practiced on at least five cadaveric knees, which were not included in the study. All dissectors are members of the Division of Clinical and Functional Anatomy, Medical University of Innsbruck/Austria.

After removing the skin and subcutaneous adipose tissue of the lateral knee compartment, the iliotibial band (ITB) was identified and transversely cut approximately 25 cm proximal to its insertion at Gerdy's tubercle (GT). The ITB was then sharply detached from the intermuscular septum, and the lateral retinaculum and the fibers were reflected until their insertion at GT. An effort was made to identify the capsular–osseous layer (COL) described by Terry et al. [14] and Vieira et al. [12]. Subsequently, tenotomy of the biceps femoris was performed. After palpating the fibular collateral ligament (FCL) in a slight varus position of the knee, the lateral inferior genicular artery (LIGA) was revealed postero-dorsally and antero-ventrally. With the knee flexed at 60° and the tibia maximally internally rotated, firm fibers running from the lateral epicondyle of the femur to the anterolateral portion of the tibia were unveiled.

Because of the complex anatomy of the lateral knee compartment, a clear definition of the ALL was provided. The lowest common denominator of the most recent publications [8,13,21,25] was used to define the ALL as a ligamentous structure at the anterolateral side of the knee, with a bony origin at the lateral epicondylar region and an oblique course to a bony insertion at the anterolateral proximal tibia. Care was taken not to confound the ALL with the capsular–osseous layer of the ITB, of which the proximal origin is described to be continuous with the fascia of the plantaris and lateral gastrocnemius muscles and having no bony femoral attachment [14].

To ensure that all fibers were visualized throughout their full length, the posterolateral aspect of the knee was carefully dissected, uncovering the popliteus tendon, FCL, lateral gastrocnemius origin and lateral meniscus.

Characterization of the ALL involved determining the location of the tibial insertion in relation to both GT and the fibular head; identifying the femoral origin; revealing any interconnecting fibers with the FCL, the popliteus tendon or the proximal lateral gastrocnemius tendon as well as any connection of the ALL to the lateral meniscus. Furthermore the length changes of the ALL in 0°, 60° and 90° of knee flexion were studied.

Using a digital caliper (Lidl, Neckarsulm, Germany) with an accuracy of 0.02 mm, the quantitative characteristics (mean ± SD) of the structure were determined (Table 1). To determine the length changes within the ALL guiding pins were positioned at the origin and the insertion sides of the structure. The angle between the longitudinal axis of the FCL and the ALL was assessed by an analog goniometer at a knee flexion of 60°.

2.1. Statistical analysis

Quantitative characteristics were described using mean and standard deviation. To assess the length changes within the ALL at specific angles of knee flexion, the paired-t-test with a 95% confidence interval (CI) and the p-level set to 0.05 was used.

3. Results

After removing the superficial, deep and capsular–osseous layer of the ITB, the ALL could be clearly identified in 45.5% (n = 20) of the dissected knees according to our definition. The bony, fan-shaped origin of the structure was located at the lateral femoral epicondyle (LFE) at either the identical position of the origin of the fibular collateral ligament (FCL) (45.0%) or just posterior and proximal to it (55.0%). Fibers originating posteriorly to the FCL origin passed superficially to the proximal third of the FCL and ran in an oblique fashion, well distant from the capsule, to the anterolateral tibia overpassing the LIGA (Fig. 1). The mean enclosed angle between the ALL and the FCL in neutral rotation of the knee was 19.5 ± 4.5°. Fibers deriving from the intermuscular septum, the gastrocnemius fascia or the plantaris fascia were described as the capsular–osseous layer of the ITB and not counted as the ALL. In the majority of the cases, a connection between the posterior border of the proximal third of the ALL and the anterior fibers of the FCL was present.

The tibial bony insertion of the ALL was located proximally, midway between the tip of the fibular head and GT and with a mean distance to the rim of the cartilaginous edge of the tibial plateau (T) of 8.9 ± 2.3 mm. The average distance from the posterior border of the ALL at its insertion to the tip of the fibular head was 15.2 ± 3.4 mm, while the anterior border of the structure was located 18.6 ± 3.9 mm posterior to the center of GT. In 30.0% (n = 6) of the cases, superficial fibers of the ALL continued over the tibial insertion and

Table 1
Anatomical characteristics measured.

- ALL length at 0° flexion and neutral knee rotation
- ALL length at 60° and maximal internal rotation
- ALL length at 90° and maximal internal rotation
- Width at the femoral origin, joint line and tibial insertion
- Thickness at the joint line
- Distance to the tibial plateau
- Distance to Gerdy's tubercle (from the insertion of the anterior border of the ALL)
- Distance to the tip of the fibular head (from the insertion of the posterior border of the ALL)
- Angle between the ALL and the FCL at 60° knee flexion
- Length of the FCL
- Width of the FCL
- Thickness of the FCL