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Original article

Behavior of the anterolateral structures of the knee during internal rotation

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ABSTRACT

Introduction: Since the recent descriptions of the anterolateral ligament (ALL), the role played by the anterolateral peripheral structures in the rotational control of the knee is again being debated. The objective of this study was to identify the structures during internal tibial rotation and then to define their anatomical characteristics. We hypothesized that internal rotation would tighten several anatomical formations, both superficial and deep, with the ALL one part of these structures.
Material and methods: Nine fresh-frozen cadaver knee specimens were studied. The anterolateral structures tightened were identified from superficial to deep at 30° of flexion. Each was selectively dissected, identifying its insertions and orientations, and measuring its size. The length variations of the ALL during internal tibial rotation were measured by applying a 30-N force using a dynamometric torque wrench at the tibiofibular mortise.
Results: The superficial structures tightened were the iliotibial tract and the Kaplan fibers. In internal tibial rotation, the Kaplan fibers held the iliotibial tract against the lateral epicondyle, allowing it to play the role of a stabilizing ligament. The Kaplan fibers were 73.11 ± 19.09 mm long (range, 63–82 mm) and at their femoral insertion they were 12.1 ± 1.61 mm wide (range, 10–15 mm). The deep structures tightened covered a triangular area including the ALL and the anterolateral capsule. The ALL was 39.11 ± 3.4 mm long (range, 35–46 mm) in neutral rotation and 49.88 ± 5.3 mm long (range, 42–58 mm) in internal rotation ($p < 0.005$). Its femoral insertion area was narrow at 5.27 ± 1.06 mm (range, 3.5–7 mm) and was mainly proximal and posterior at the lateral epicondyle. Its tibial insertion zone was wide, with a clearly differentiated anterior limit but a posterior limit confused with the joint capsule. In the vertical plane, this insertion was located 6.44 ± 2.37 mm (range, 2–9) below the joint space.
Discussion: This study demonstrates two distinct anterolateral tissue planes tightened during internal rotation of the tibia: a superficial plane represented by the iliotibial tract and the Kaplan fibers, which acts as a ligament structure, and a deep plane represented by a triangular capsular ligament complex within which the ALL and the anterolateral capsule are recruited.
Level of evidence: Descriptive cadaver study IV.

1. Introduction

Rotational control of the knee is one of the main objectives of anterior cruciate ligament reconstruction. The insufficient control in this area [1–6] has renewed interest in the anterolateral ligament of the knee. Reference to the work of Segond [7] was the starting point for the research conducted by Claes et al. [8] and their description of the anterolateral ligament (ALL). The appeal for this ligament has been confirmed by several articles on its anatomy [9–11], its arthroscopic description [12], and its identification in ultrasound [13] and MRI [14–17]. Nonetheless, its precise anatomy and its possible involvement in rotational control and stability continue to be debated.

The objective of this study was to identify the anterolateral tissue structures tightened by internal tibial rotation and then to define their anatomical characteristics. We hypothesized that internal tibial rotation would tighten several anatomical formations, both superficial and deep, suggesting that understanding

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the peripheral control and rotational stability should include the analysis of all of these structures, with the ALL only one of them.

2. Material and methods

Ten fresh-frozen knee specimens on whole-body cadavers were used for this work: three knees from the Strasbourg Anatomy Laboratory and seven from the Tours Anatomy Laboratory. All the knees were dissected by the same operator. The bodies were placed at room temperature for 24 h before beginning the dissections. One knee presented degenerative lesions and was excluded. The nine remaining knees, from five females and four males, with a mean age of 77.7 years (range, 63–86 years) presented no signs of major osteoarthritis or cutaneous scars. The range of motion in extension, flexion, and internal rotation were within physiological norms.

The condition of the cruciate ligaments was checked by manual testing and direct visualization via anteromedial arthrotomy.

For the dissection, the limbs were installed at 90° knee and hip flexion, maintained by lateral augments and distal support. The insertion points of the anatomical structures were identified using colored needles.

For the measurements, the knees were maintained at 30° flexion, the position verified with a goniometer with the center placed at the lateral epicondyle. This value was obtained to observe the behavior of the anterolateral structures in the pivot shift clinical position and to compare these results with other similar studies [15–17].

Dissection ablated a rectangular flap of skin and subcutaneous adipose tissue to expose the extensor apparatus, the lateral patellar retinaculum, the iliotibial tract, the distal part of the femoral biceps, and the head of the fibula (Fig. 1).

Application of 30 N of force in internal tibial rotation using the dynamometric torque wrench placed at the tibiofibular mortise made it possible to observe the behavior of the iliotibial tract during this movement.

This was then resected transversally 10 cm proximally from the lateral epicondyle and then pulled back distally, exposing the Kaplan fibers for study of their behavior during internal rotation of the knee, measurement of their length between the distal insertion on the subcondylar tubercle and proximally at the femoral metaphyseal-diaphyseal junction and their width. These fibers were then cut and the iliotibial tract folded back to expose the anterolateral capsule.

Internally rotating the knee then allowed tightening the ALL as well as the capsule located between this ligament and the lateral collateral ligament (LCL).

The ALL insertion points were detailed at the femur by the distance at the center of the lateral epicondyle and at the tibia by the distance to the most protuberant part of the subcondylar tubercle and at the summit of the fibular head.

Fig. 1. Exposure of the knee's anterolateral side.

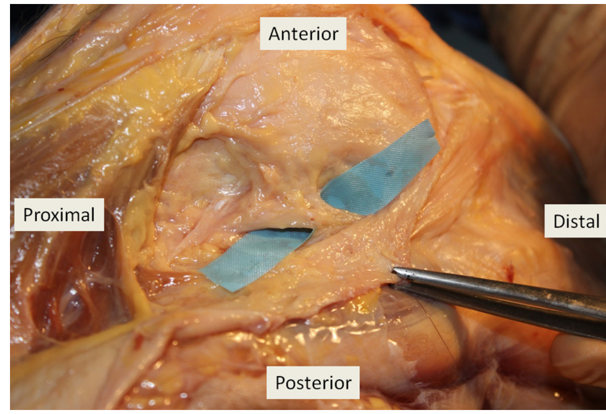

Fig. 2. Femoral insertion of Kaplan fibers.

The variations in ALL length were measured using a caliper in millimeters, with the knee flexed at 30°, based on a position in neutral rotation identified by the femur-tibia-foot alignment in dorsal flexion, to a position of internal tibial rotation by applying a 30-N force using the above-described method.

Statistical analysis: the data were described for each series of values with their mean (± standard deviation) and the range for each series.

ALL lengths were compared using the Student *t*-test for matched series. The correlations were calculated with the Pearson coefficient and are presented with their values and 95% confidence intervals. A *P*-value less than 5% was considered significant.

3. Results

3.1. Iliotibial band and Kaplan fibers

Internal rotation of the knee originated the tension of the iliotibial tract, predominant on the posterior fibers (Table 1).

Once it had been transversally resected proximally, the internal rotating of the knee still showed substantial tension of this fascia in its posterior portion, whereas this resected structure should have released. In the anterior view, this tension was made possible by the action of the Kaplan fibers, which, by holding the iliotibial tract against the lateral epicondyle, allowed its distal portion to act as a ligament and tighten in internal rotation. As soon as the Kaplan fibers were resected at their proximal insertion, the remaining iliotibial tract relaxed, releasing its control over the internal rotation.

The distal insertion of the Kaplan fibers was shared by the superficial part of the iliotibial tract on the subcondylar tubercle. Their ascending trajectory was characterized by a twisting of its fibers going from a sagittal plane distally to a frontal plane proximally. Their proximal insertion is located at the diaphyseal-metaphyseal junction of the femur opposite the linea aspera. Their length was 73.11 ± 19.09 mm (range, 63–82 mm) and their length at the femoral insertion was 12.1 ± 1.61 mm (range, 10–15 cm) (Fig. 2).

3.2. "Triangular capsular ligament complex" and anterolateral ligament

After having folded back the iliotibial tract, the anterolateral capsule was exposed. The ALL was the anterior part of a "triangular anterolateral capsular complex." The posterior, vertical, part of this complex was made up of capsular fibers that inserted onto the LCL, and the base, distal, comprised the insertion of the capsule on the