The Knee xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

The Knee

The anterolateral ligament: Anatomic implications for its reconstruction

Neri Thomas [a,b,*], Palpacuer Fabien [b], Testa Rodolphe [b], Bergandi Florian [c], Boyer Bertrand [a], Farizon Frederic [a,b], Philippot Remi [a,b]

[a] Department of Orthopaedic Surgery, University Hospital of Saint Etienne, Saint-Etienne, France
[b] Univ Lyon - UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Science, EA 7424, F-42023, Saint-Etienne, France
[c] Laboratory of Human Anatomy, Faculty of Medicine, University Hospital of Saint-Etienne, University of Saint-Etienne, Saint-Etienne, France

ARTICLE INFO

Article history:
Received 4 May 2017
Accepted 5 July 2017
Available online xxxx

Keywords:
Anatomy
Anterolateral ligament
Anterolateral ligament (ALL) reconstruction
Laxity
Rotatory instability

ABSTRACT

Background: The purpose of this study was to define the best anatomic parameters with which to perform an accurate anterolateral ligament (ALL) reconstruction. These parameters were anatomical insertions, allowing favorable isometry, length variation during flexion, and anthropometric predictors of ALL lengths.
Methods: A total of 84 fresh-frozen cadaver knees were dissected to analyze the ALL, focusing on its femoral insertion. The ALL length was measured in different degrees of flexion (extension, 30°, 60°, and 90° of flexion) and rotation (neutral, internal or external rotation). The ALL width and thickness were measured. A correlation between ALL length, the general knee size and individual characteristics was investigated.
Results: The ALL was present in 80 specimens (95%). The femoral footprint was always posterior (5.52 ± 0.93 mm, range 3.83–6.94) and slightly proximal (1.51 ± 0.75 mm, range 0.63–2.37) to the lateral femoral epicondyle. The mean ALL length increased with internal rotation and decreased with external rotation ($P < 0.05$). The maximum ALL length was found at 30° of flexion, and the minimum at 90°. There was a significant correlation between the ALL length and height, sex, and proximal femur dimensions.
Conclusion: In order to get an anatomical reconstruction with favorable isometry, it is recommended that the ALL femoral graft is implanted posterior and slightly proximal to the epicondyle. It is also suggested that the tension be adjusted by fixing the graft between 0 and 30° of flexion, being tighter near extension. This will allow good rotational stability without implying any stiffness.

1. Introduction

It has been debated for many years whether there is a ligament or tissue structure between the femur and tibia that participates in rotational stability of the knee. Claes et al., based on the initial description of the Segond fracture, showed the existence of an extra-articular ligamentous structure, which was named the anterolateral ligament (ALL) [1–4].

Recently, some ALL anatomical reconstructions have been performed to control residual pivot shift after anterior cruciate ligament (ACL) reconstruction [5]. Several techniques are available for ALL reconstruction; however, none of them have proved optimal, and many questions remain as to the positioning of the graft and optimal graft tension.

* Corresponding author at: Department of Orthopaedic Surgery, University Hospital of Saint Etienne, France.
E-mail address: thomas.neri@chu-st-etienne.fr (N. Thomas).

http://dx.doi.org/10.1016/j.knee.2017.07.001
0968-0160/

In order to perform an effective reconstruction of the ALL in terms of rotational stability and to maintain favorable isometric behavior during knee flexion, it is essential to precisely define its anatomical insertions; this will determine the proper knee flexion angle at which ALL graft fixation should occur. Estimating ALL length, according to individual characteristics, makes it possible to anticipate preparation of the graft during reconstruction [6].

Concerning the positioning, all studies have defined its tibial insertion as equidistance between Gerdy's tubercle and the fibula head. However, conflicting findings have been reported regarding its femoral origin relative to the lateral epicondyle of the femur. Some authors have described it as anterior and distal to the lateral epicondyle [1,7,8], whereas others have described it posterior and proximal to the lateral epicondyle [9–11]. Other studies, such as Daggett et al., have even described a variability of the ALL femoral origin [12–14].

While all authors have agreed that the length of the ALL increases with internal rotation, no consensus has been reached with regard to its length variation during knee motion. Several of the authors believed that ALL is progressively increased in length to be maximum at 90° knee flexion, and that fixation of ALL reconstruction must be performed at 60–90° flexion [15–17]. Others have thought that the maximum length is reached between 30 and 60° flexion [5,9,18–20]. Therefore, the question of which angle of flexion is the best suited to fix the graft remains unclear.

There is a paucity of literature related to length differences in the ALL. Few studies have attempted to determine correlations between individual characteristics and ALL length variations [1,11,21]. This parameter remains crucial to estimate the length of the graft necessary for the anatomic reconstruction.

The purpose of the present study was to define, through a significant anatomical series, the best anatomical parameters with which to achieve accurate reconstruction of the ALL. These parameters were anatomical insertions, which allowed favorable isometry and length variation during motion, and anthropometric predictors of ALL length.

2. Materials and methods

The characteristics of the ALL were investigated in 84 fresh-frozen cadaver knees of 42 specimens (24 men and 18 women). The mean age was 79 ± 11 years (mean ± standard deviation) (range 57–102) at the time of the death. The mean height was 173 ± 9 cm (range 157–191). Knees with evidence of ACL injury, ACL reconstruction, prior knee surgery, gross deformities, or severe arthritis were excluded from the analysis.

The dissection was realized following the protocol defined by Claes et al. [1]. As the fascia lata is involved in internal rotatory control of the knee, the iliotibial band was not removed during the study. With the knee flexed at 60°, internal rotation was applied to the foot in order to reveal the fibers of the ALL and to better allow their individualization. Dissection of its femoral insertion was carefully performed to study the relations with adjacent structures (Figure 1A). The respective centers of the dissected structured insertions were then spotted in situ using small metal pins in order to make the measurements more reproducible (Figure 1B).

For each specimen, height, weight, age and sex were recorded. Using an electronic digital caliper (Mit500 196-20; Mitutoyo, Japan®) with a precision of 0.01 mm, the quantitative characteristics (length, width, thickness, relation) of ALLs were determined. The ALL length was measured in different conditions of flexion (extension, and 30°, 60°, and 90° flexion) and rotation (neutral, internal or external rotation). For flexion, an analogic goniometer with the center placed at the lateral epicondyle was used to determine all the angulations. The neutral rotation (NR) was defined with unconstrained tibial rotation: the foot placed in neutral rotation and the tibia in its reduced position with respect to the femur. The internal rotation (IR) and external rotation (ER) were performed with a rotation torque applied to the tibia, which was provided by a dynamometric torque wrench placed at the tibiofibular mortise, triggering at five Newton meters.

The ALL width was measured in three positions: tibial insertion, joint line and femoral insertion. Its thickness was estimated on the joint line. The distances of ALL with adjacent anatomical structures were also studied. Anatomic bone measurements were performed to investigate a correlation between ALL length and the general knee size: epicondylar femoral width (measured as the distance from the tip of the medial epicondyle to the tip of the lateral femoral epicondyle), femoral intercondylar notch width, and mediolateral and anteroposterior widths of the proximal tibia.

2.1. Statistical analysis

Results were noted as mean ± standard deviation (range of minimum–maximum).

Changes in the ALL length caused by flexion or rotation of the knee were examined using analysis of variance (ANOVA) with Bonferroni, Student–Newman–Keuls and Tukey adjustments. The dependent variable was the length of the ALL. P-values <0.05 were considered statistically significant. Correlations for statistically different morphometric variables were determined with the Pearson correlation test. Parametric variables (height, sex and age) were analyzed using an unpaired Student t-test, while the Mann–Whitney test was used to analyze nonparametric variables (ALL thickness, length and width, and bone measurements). The position of the knee (extension, flexion, NR, IR, and ER) did not change at all the correlations values and the level of significance.

3. Results

3.1. Anatomic description

The ALL was present in 80 specimens (95%). For all the knees, the femoral insertion was posterior (5.52 ± 0.93 mm, range 3.83–6.94) and slightly proximal (1.51 ± 0.75 mm, range 0.63–2.37) to the epicondyle femoral, and also posterior and proximal

Please cite this article as: Thomas N, et al, The anterolateral ligament: Anatomic implications for its reconstruction, Knee (2017), http://dx.doi.org/10.1016/j.knee.2017.07.001