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Anatomic reconstruction of the lateral capsular ligament ("one-loop plasty") for anterolateral rotatory instability. A cadaveric study

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Abstract The aim of this study was to devise a method for lateral plasty to correct anterolateral rotatory instability (ALRI) responsible for the symptomatology elicited by the McIntosh pivot-shift test. We focused on the anatomy and function of the lateral capsular ligament (LCL). Using 50 cadaveric knees, we cut the LCL and the anterior cruciate ligament (obtaining a positive pivot-shift test result) and made a simple reconstruction of the LCL by looping a portion of fascia lata through a tunnel in the femur under

the fibular collateral ligament, and inside a cortico-cancellous groove just medial to Gerdy's tuberculum on the tibia. The anatomic study let us understand the right points of fixation for a transplant both on the femur and on the tibia with a good isometry. After reconstruction, the pivot-shift test was negative. We think that this "loop–plasty" is a good solution for ALRI.

Key words Knee anterolateral rotatory instability • Lateral capsular ligament • Knee lateral reconstruction

Introduction

The lateral capsule ligament (LCL) is an anatomic structure that reinforces the lateral portion of the knee capsule. It lies under the fibular collateral ligament (FCL) and was described by Hughston [1] as the mid-third capsular ligament. We studied the anatomic insertion of this ligament with the aim of devising an anatomic lateral plasty.

Materials and methods

We examined 50 cadaveric knees. An anterolateral incision was made on each of them to observe, after the fascia lata was removed, the capsular portion under the FCL Then we localized the anatomic insertions of the LCL and the distances of these insertions from fixed anatomic areas. These areas were the posterosuperior portion of the lateral femoral condyle called "over the top" and Gerdy's tuberculum.

We made these observations on each of the cadaveric specimens but in 3 of them we removed the LCL with its osseus insertion on the lateral femoral condyle and on the lateral tibial plateau, obtaining a good model for the study of the tension of each bundle of the LCL in correlation to the rolling of the lateral femoral condyle and the rotation of the lateral tibial plateau.

Anatomic reconstruction

With an anteromedial incision we sectioned the anterior cruciate ligament (ACL) and the LCL from inside, obtaining a positive jerk-test. Then with the knee flexed at 90° , an anterolateral incision was made ("hockey-stick incision"). A transplant of fascia lata $2.0{\text -}2.5$ cm wide and 20 cm long was dissected from the lateral capsule. Two perforations were made on the lateral femoral condyle: the first was on the proximal insertion of the superficial bundle and the second was on the proximal insertion on the deep bundle. The fascia lata was looped inside the tunnel previously prepared between the two holes and inside the capsule. This transplant, with the knee flexed at 90° , was fixed on the inferior portion of the femoral lineae asperae with a metallic staple and inside a

cortico-cancellous groove on the tibia with a suture anchor. This groove was prepared with the knee in extension and then closed with a metallic staple (Fig. 1).

Results

The lateral capsule ligament (LCL) is composed of two bundles: a deep one and a superficial one (Fig. 2). The superficial

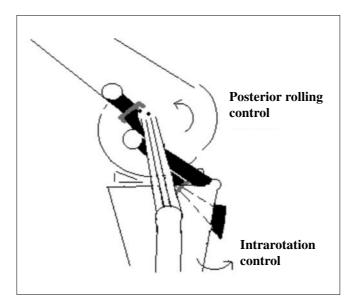


Fig. 1 LCL reconstruction: the *arrows* show the control of the latera femoral condile rolling (deep bundle) and the control of the lateral tibial plateau intrarotation (superficial bundle) during flexion

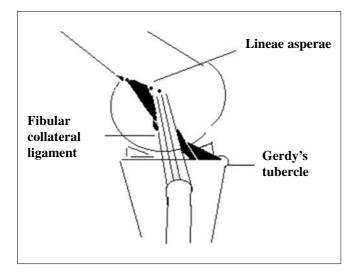


Fig. 2 LCL anatomy: the picture shows, in *black*, the osseus insertion of the two bundles (see text for details)

one takes its proximal insertion 1.5 cm anterior and superior to the "over the top" along the inferior portion of the lineae asperae and, at the level of the lateral epicondyle, under the FCL, changes its direction to insert 1.5 cm posteriorly to Gerdy's tuberculum on the lateral plateau articular edge.

The deep bundle takes its proximal insertion 1.5 cm anterior and inferior to the "over the top" and its distal insertion on Gerdy's tuberculum. We observed that the superficial bundle controls the rolling of the femoral lateral condyle and ties especially in flexion, whereas the deep bundle controls the rotation of the lateral tibial plateau, especially the internal rotation. There is also a vertical bundle of the LCL [2] but we believe that this one has an important mechanical role for the varo-valgus instability.

The result of the reconstruction was to obtain a negative pivot-shift test.

Discussion

This is the first study applied to an anatomical reconstruction of the LCL. Previously, many authors described lateral plasties to control or correct the internal rotation of the lateral tibial plateau [3] or the anterior subluxation of the lateral tibial plateau [4] in case of ACL insufficiency. We observed that, to control anterolateral rotatory instability (ALRI), it is important to correct the rolling of the lateral femoral condyle and the rotation of the lateral tibial plateau. This is essential to eliminate the symptoms related to ALRI elicited by the pivot shift. In fact, the strong superficial bundle of the LCL [5], probably because of its position, controls the rolling of the lateral femoral condyle, especially the posterior traverse of its axis (flexion axis) [6] on a vertical plane around the axis of instantaneous rotation [7]. The deep bundle, instead, controls the rotation of the lateral tibial plateau and in particular the internal traverse of its axis (rotation axis) on a horizontal plane around the axis of instantaneous rotation [7]. The McIntosh pivot-shift test, in fact, starts from a position of internal rotation and extension of the knee; then, during flexion of the joint, the lateral femoral condyle rolls posteriorly and causes the "jerk" in case of ALRI. Therefore, the loop plasty we performed, controlling the intrarotation of the lateral tibial plateau and the posterior rolling of the lateral femoral condyle, can eliminate the McIntosh pivot-shift sign and can control the lateral rotatory stability. This control is also performed by the ACL with its osseous insertions. The LCL controls the lateral rotatory instability and the ACL controls the anteroposterior instability [8], but each of them also controls both the instabilities.

The risk of a lateral plasty is a varus instability. This risk is eliminated by not dissecting the FCL from the capsule but

by looping the transplant directly inside the capsular tissue. The inferior third of the fascia lata represents its strongest mechanical portion [3]. Moreover the maximal failure load [9] of each single band of a 2.0–2.5 cm wide transplant is almost 55% of the patellar tendon failure load; therefore, the plasty is sufficiently resistent after the loop.

This is an anatomic and obviously isometric reconstruction, but our anatomic study of the insertion points led us to conclude that the insertions of the superficial bundle correspond approximately to Kurosawa's isometric points (F5-T2) [10] and that the insertions of the deep bundle correspond approximately to Krackow's isometric points (F8-T3) [11]. The position of the holes causes, during flexion-extension of the knee, a twisting of the transplant that enhances load sharing among the single fibers of the transplant and its overall strength [12].

We observed that when performing the pivot-shift test after section of the LCL and ACL, more than a valgus stress, it is important to apply a soft pressure on the lateral tibial plateau in anteroposterior direction to obtain a complete extension of the knee [13], and therefore the real physiologic valgus of the knee, before flexing it.

We conclude that:

- The LCL is a definite anatomic structure that lies under the FCL.
- 2. The LCL controls the lateral rotatory stability of the knee.
- 3. The loop-plasty we performed in the cadaveric study liminates the positivity of the pivot-shift test in a knee with a complete experimental lesion of ACL and LCL.

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