MAGNETIC RESONANCE IMAGING COMPARISON OF LATERAL COLLATERAL LIGAMENT AND PATELLAR TENDON LENGTH

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Summary

Introduction. The problem of using patellar tendon auto or allografts for lateral collateral ligament reconstruction results in the occurrence of ligaments mismatch. The length of patellar tendon does not match the lateral collateral ligament. Material and Methods. Out of 151 patients, who formed the study, 102 were men with the mean age of 30 years (18-54) and 49 women, with the mean age of 34 (18-55), and they all underwent magnetic resonance imaging of the knee. Both patellar tendon and lateral collateral ligament were measured using a three-dimensional isovoxel true fast-imaging with steady-state precession sequence with water excitation and secondary multiplanar reformations. In order to visualize the lateral collateral ligament insertions precisely, sagittal images were reformatted according to the anatomical, oblique ligament position, in anteriorly tilted, paracoronal plane. The length of the patellar tendon was measured from the patellar apex to the tibial tuberosity insertion site. Results. The mean patellar tendon length was 52.88±7.56 mm (37-75) with a significant difference between men and women. The mean lateral collateral ligament length was 61.21±5.77 mm (46-80) with a significant difference between genders. The average differences between lateral collateral ligament and patellar tendon length was 8.38±7.23 mm (-9 to 26) without a significant difference between the genders. In 18 (11.92%) patients, the patellar tendon was longer than the lateral collateral ligament; in 7 patients (4.63%) they were equal; and in 126 patients (83.44%) the patellar tendon was shorter than the lateral collateral ligament. Conclusion. The length of patellar tendon does not match the length of lateral collateral ligament. If patellar tendon auto or allograft is used for lateral collateral ligament reconstruction, the lengths of both ligaments must be determined preoperatively in order to avoid intraoperative complications. Key words: Magnetic Resonance Imaging; Patellar Ligament; Bone-Patellar Tendon-Bone Grafting; Collateral Ligaments; Imaging, Three-Dimensional; Male; Female; Adult; Preoperative Care; Intraoperative Complications.

Sažetak

Uvod. Problem korišćenja patelarnih tetive kao autografta ili allografta za rekonstrukciju lateralnog kolateralnog ligamenta dovodi do pojavljivanja nestakljenosti dužine navedenih ligamenta. Dužina patelarnih tetive ne odgovara dužini lateralnog kolateralnog ligamenta. Materijal i metode. Magnezto-rezonantnim imadžingom kolenog zglobova pregledani su 151 pacijent, 102 muškog pola, prosečne starosti 30 godina (18-54), 49 ženskog pola – prosečne starosti 34 godine (18-55). Oba ligamenta, patelarna tetiva i lateralni kolateralni ligament su mereni korišćenjem trodimenzionalne izovokselne sekvence (eng. true fast imaging with steady-state precession with water excitation), napravljene su sekundarne multiplanarne reformacije. Kako bi se precizno vizualiziralo mesto insercije lateralnog kolateralnog ligamenta, sagitalni tomogrami su rekonstruisani prema anatomskom toku vlakana – koja pozicija ligamenta, sa parakoronalnim tilmom ravni. Dužina patelarnih tetive merena je od vrha patele do mesta inercije na tuberozitas tibije. Rezultati. Prosečna dužina patelarnih tetive bila je 52.88±7.56 mm (37-75) sa signifikantnom razlikom između pacijenata muškog i ženskog pola. Prosečna dužina lateralnog kolateralnog ligamenta bila je 61.21±5.77 mm (46-80) sa signifikantnom razlikom između polova. Prosečna razlika u dužini između lateralnog kolateralnog ligamenta i patelarnih tetiva iznosila je 8.38±7.23 mm (-9 to 26) bez signifikantne razlike među polovima. Kod 18 (11.92%) pacijenata patelarna tetiva je bila duža nego lateralni kolateralni ligament; kod 7 (4.63%) dužina je bila jednaka; a kod 126 (83.44%) pacijenata patelarna tetiva je bila kraća nego lateralni kolateralni ligament. Zaključak. Dužina patelarnih tetive ne odgovara dužini lateralnog kolateralnog ligamenta. Ukoliko se kao autograft ili allograft koristi patelarni ligament za rekonstrukciju lateralnog kolateralnog ligamenta, oba ligamenta se preoperativno moraju izmeriti kako bi se izbegle intraoperativne komplikacije. Ključne reči: Magnetna rezonanca; Patelarna tetiva; Kost-tetiva-kost graft; Kolateralni ligament; Trodimenzionalni imadžing; Muško; žensko; Odrašci; Preoperativna priprema; Intraoperativne komplikacije.

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Introduction

The lateral collateral ligament (LCL) is the primary varus stabilizer of the knee [1,2] and its injuries are frequently associated with anterior cruciate ligament (ACL), posterior cruciate ligament (PCL) and posterolateral corner injuries. If these posterolateral injuries remain unrecognized, they may lead to ACL [3] or PCL reconstruction failure. When recognized, in the presence of bony avulsion, the primary repair of posterolateral corner can be successful [4–6]. In the absence of bony avulsion, the primary or secondary reconstruction [6–8] of the LCL and posterolateral corner with a variety of autografts or allografts [9–11] has been recommended with various results.

Noyes and Barber-Westin were the first who described an anatomical graft replacement of the LCL with bone – patellar tendon – bone (BTB) graft together with the reconstruction of the other posterolateral structures [8]. The advantages of using BTB graft for LCL replacement are strong initial fixation, better bony incorporation at the femoral and tibial insertion sites, early knee mobilization which decreases the risk of arthrofibrosis, and the avoidance of prolonged incorporation associated with soft tissue grafts [12]. A potential problem specific to using BTB grafts for LCL reconstructions is the possibility of patellar tendon (PT) graft – LCL mismatch. The goal of this study was to compare and correlate PT and LCL by means of magnetic resonance imaging (MRI). Our hypothesis was that the length of PT graft does not correlate to the length of LCL, and that in the majority of cases is therefore not applicable for LCL reconstruction.

Material and Methods

The study was approved by the Ethical Committee of Institute of Oncology of Vojvodina, which allowed a retrospective review of images and relevant records with waiver of the informed consent. Our sample consisted of 151 patients, 102 men – mean age 30 years (18-54), and 49 women – mean age 34 (18-55), who underwent MRI of the knee at 3-Tesla MR imaging unit (Siemens Trio; Siemens Medical Solutions, Erlangen, Germany) using a dedicated send/receive 8-channel phased-array knee coil. For examination, a three-dimensional (3D) isovoxel true fast imaging with steady-state precession (FISP) sequence with water excitation and secondary multiplanar reformations (MPRs) was performed. The sequence parameters were (TR/TE=9.44/3.45; turbo factor GRAPPA 2; field-of-view 160x160 mm; matrix size 233x256; pixel size 0.6x0.6 mm; slice thickness 0.6 mm). MPRs with a 2-mm partition thickness were acquired.

In order to visualize LCL insertions precisely, the sagittal images were reformatted on the system console (Leonardo; Siemens Medical Solutions) according to the anatomical – oblique ligament position, in anteriorly tilted, paracoronal plane.

In this plane, a mid-reference line was adjusted and placed parallel to LCL in order to enable complete ligament visualization from the lateral femoral epicondyle to the head of the fibula. The calipers were also placed centrally inside the LCL (Figures 1a and 1b). The length of the PT was measured in true sagittal plane, from the patellar apex to the tibial tuberosity insertion site. The calipers were placed centrally inside the tendon fibers, at mid-sagittal image, where the tendon was displayed at its maximal thickness [13–15] (Figure 1c). In case of presence of constitutionally oblique course of the PT, we checked the tendon position on the reformatted images in coronal plane.

Exclusion criteria included the patients under 18 years of age, conspicuous varus or valgus knee deformity, extensor mechanism abnormalities.

Figure 1. Optimal visualization and measurements
a. 3D true FISP MPR sagittal image – according to the plane of ligament (long white line)
b. 3D true FISP MPR coronal image – visualization of complete LCL, LCL insertions (arrows)
c. 3D true FISP sagittal image – complete visualization of PT (white line)
knee fracture, joint effusion, cruciate and collateral ligamentous abnormalities and the patients with a prior knee surgery. All MRI measurements and post-processing were performed by a board-certified musculoskeletal radiologist with 10 years experience.

Statistical analysis was obtained through the software Smart Line agency (NS) and included mean, SD and range for all measurement. The comparison between genders was conducted with an unpaired Student’s t test. Statistical significance was defined as \( p < 0.05 \).

**Results**

The mean PT length in both genders was 52.88 ± 7.56 mm (37-75). The mean PT length was 54.60 ± 7.43 mm (38-75) and 49.31 ± 6.59 mm (37-67) in the men and in the women, respectively. This difference between the men and the women was significant \( p<0.05 \) (Table 1).

The mean LCL length in both genders was 61.21 ± 5.77 mm (46-80). The mean LCL length was 62.81 ± 5.61 mm (51-80) and 57.88 ± 4.59 mm (46-66) mm in the men and in the women, respectively. This difference between genders was significant \( p<0.05 \) (Table 1).

The comparison of the differences between LCL and PT length showed that the average difference was 8.38 ± 7.23 mm (-9 to 26). The mean LCL-PT length difference was 8.22±7.14 mm (-7 to 26) and 8.71±7.49 mm (-9 to 25) in the men and in the women, respectively. This difference between genders was not significant \( p=0.693 \). In 18 (11.92%) patients, PT was longer than the LCL; it was equal in 7 (4.63%) patients, while in 126 (83.44%) patients PT was shorter than the LCL (Graph 1).

**Discussion**

The LCL is the primary varus stabilizer to the knee. When the knee is in extension the fibular head goes backward, pulled by LCL and femoral biceps tendon, so the ligament produces stability in the extended knee [16]. Coobs et al. [1], LaPrade et al. [9] and Buzzi et al. [17] have shown that only an anatomical LCL reconstruction can restore the near normal knee stability after LCL tears. The anatomic LCL insertion has a semicircular-shaped attachment 3-5 mm posterior and 1-2 mm proximal to the lateral epicondyle of the femur [18, 19] and 8-10 mm posterior to the anterior point of the head of the fibula with the well-defined limits.

The mean LCL length reported in the literature is 63.1 mm (55-71) [20, 21]. Our measurements of the length relate to the middle bundle of the ligament, which is relatively constant along the flexion path [22] and measured an average length of LCL is 61 mm (46–80) and it strongly correlated to the patient’s gender.

The average length of the PT in our study was 53 mm (37–75), and there was a significant correlation between the PT length and the patient’s gender. Denti et al. [23] measured the length intraoperatively and reported the mean PT length of 46 mm. Shaffer et al. [24], who also measured the PT length intraoperatively in 34 patients and La Prade [25] who measured PT length in 50 cadavers, both described the mean PT length of 48 mm (40–63). Although MC Alister et al. [26] recommended lateral radiographs to determine the PT length, MRI is the most frequently used method. Yoo et al. [13] measured PT using MRI in 172 knees and showed the mean PT length of 40 mm (31–52). In the study of Goldstein et al. [14] the mean PT length was 46 mm, and there was a correlation between the patient’s height, gender with the PT length. On the other hand, Brown et al. [15] measured the length in 414 knees and reported no correlation between the patient’s height and PT length.

![Graph 1. Differences between PT and LCL length](image)
Anteroposteriorly the mean width of LCL at the level of the articular knee joint space is 8.5 mm (5-12 mm) and the mean thickness is 2-4 mm [20]. Having the width of 9–10 mm and the thickness of 3-5 mm [13, 27], BTB graft seems to be a good candidate for LCL reconstruction, but the problem is its inadequate length. Noyes and Barber-Westin [8] were the first to describe the successful use of BTB autograft or allograft for LCL reconstruction in 16 (76%) of 21 knees. Latimer et al. [10] used a large BTB allograft to replace only the LCL. Nine out of ten patients in this series showed an improvement despite addressing only one component of the corner. The authors felt that a 9 mm wide PT allograft, which is wider than LCL, positioned at the isometric point on the lateral femoral condyle, may substitute adequately for the LCL as well as for the popliteofibular and arcuate ligaments. One of the comments to this article was that an increase of 3-5mm in lateral joint line opening may not be an excellent result, meaning that reconstruction of the LCL together with other posterolateral structures would provide better stability [28]. Clinically, < 2 mm of excursion of the graft through the range of motion is thought to be acceptable [29, 30]. It was much later that Noyes and Barber-Westin [12] proposed the preoperative measuring of the distance between the anatomical femoral and fibular insertion site on the lateral radiograph to avoid mismatch between BTB autograft or allografts and LCL. If fixation with interference screw in the femoral tunnel is impossible due to short BTB graft, they propose an inlay technique with a 4-prong staple for grafts.

The limitation of this study is that the measurement of the PT and LCL on MRI are not compared with a cadaver measurement. Further clinical and cadaver research is needed to confirm the MR measurements.

**Conclusion**

The advantages of using bone - patellar tendon - bone graft for lateral collateral replacement are strong initial fixation, better bony incorporation at the femoral and fibular insertion sites, early knee mobilization which decreases the risk of arthrofibrosis, and the avoidance of prolonged incorporation associated with soft tissue grafts. A potential problem is a mismatch between patellar tendon graft and lateral collateral ligament.

The length of patellar tendon does not match the length of the lateral collateral ligament and, in the majority of cases is therefore not applicable for the lateral collateral ligament reconstruction.

Magnetic resonance imaging is a reliable modality for measurements. It can predict a mismatch and avoid surgery complications.

**References**


