THE LENGTH CHANGE OF THE MEDIAL AND LATERAL COLLATERAL LIGAMENTS DURING IN-VIVO KNEE FLEXION

INTRODUCTION

The collateral ligaments of the knee are important structures for knee stability and may be injured during sports activities. A thorough understanding of collateral ligament function may also be important to knee arthroplasty, where the collateral ligaments may be “balanced” during surgery. However, little data has been reported on the in-vivo function of the collateral ligaments. The objective of this study was to investigate the relative elongation of the medial collateral ligament (MCL), deep fibers of the MCL (DMCL) and the lateral collateral ligament (LCL) during in-vivo knee flexion using a combined dual-fluoroscope and MR imaging technique. Specifically, the relative elongations of the different fiber bundles of the collateral ligaments were compared along the flexion path.

MATERIALS AND METHODS

Five healthy living knees (age 21-41, 4 male, 1 female, average age=27) were scanned using magnetic resonance imaging. Three-dimensional models of the tibia and femur were created from these images. The insertion areas of both collateral ligaments on the femur and tibia were included in the models (Fig. 1). The MCL, DMCL and LCL were divided into three equal portions: the anterior bundle, middle bundle and the posterior bundle.

Each subject performed a single leg lunge while a 3D fluoroscope captured images of the knee from two orthogonal directions at 0, 30, 60, and 90° of flexion. The orthogonal images and the 3D knee model were used to create a virtual dual-orthogonal fluoroscopic imaging system [1]. The knee model position was adjusted in the virtual system until the projections of the tibial and femoral models matched the knee images captured during actual the imaging process. The in-vivo knee position was therefore reproduced using the knee models (Fig. 1). From these knee models, the relative elongations of the different fiber bundles of the collateral ligaments were determined based on their insertions on the tibia and femur. An ANOVA was used to analyze the ligament bundle elongation as a function of flexion.

RESULTS

The length of the anterior bundle of the MCL was relatively constant along the flexion path of the knee (Fig. 2A). The posterior bundle of the MCL consistently shortened with flexion (p<0.05). The bundles of the DMCL and LCL showed deformation patterns similar to each other (Fig. 2B and 2C). The anterior bundles increased in length with flexion and the posterior bundles decreased in length with flexion.

DISCUSSION

This paper reported the in-vivo elongation pattern of the MCL and LCL during a single leg lunge in five living knees. Ligament elongation was quantified by measuring the elongation of three equally sized bundles in each ligament. In the MCL, the length of the anterior bundle was relatively constant, increasing slightly with flexion. However, the middle and posterior bundles were stretched maximally at low flexion angles, indicating that the posterior bundle might be tight in full extension.

The elongation pattern of the bundles of the DMCL and LCL was similar. Their anterior bundles showed a consistent increase in length with flexion. The length of the middle bundle did not change dramatically with flexion, indicating it may be close to the isometric fiber location. However, the posterior bundle was maximally elongated at full extension and reduced by 8% at 30° of flexion. The anterior and posterior bundle showed a reciprocal function with flexion.

These data may provide important insight for surgeries involving collateral ligaments. The treatment of MCL and LCL injuries should be aimed at recreating the function of the ligaments along the flexion path. The data also imply that the different roles of different portions of the collateral ligaments along flexion path should be considered before releasing of the collateral ligaments during knee arthroplasty.

REFERENCES


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