

# Length changes of the medial patellofemoral ligament during in vivo knee motion: an evaluation using dynamic computed tomography.

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**INTRODUCTION:** The medial patellofemoral ligament (MPFL) is a critical stabilizer preventing lateral patellar dislocation.<sup>2</sup> The ligament nearly always ruptures when the patella dislocates, impeding its function and increasing the risk of reoccurrence to 30%.<sup>4</sup> MPFL reconstruction is the primary surgical intervention for patients with recurrent patellofemoral instability. However, despite undergoing surgery, approximately 26% of patients experience complications such as pain and instability.<sup>6</sup> These complications are often caused by graft overloading and laxity due to inaccuracies in graft positioning.<sup>5</sup> Obtaining a deeper insight into the elongation patterns of the MPFL and the impact of variations in graft placement may help improving clinical outcomes. Hence, the objective of this study was to evaluate length changes of the MPFL along the superomedial border of the patella during knee flexion.

**METHODS:** This study was approved by the local Institutional Review Board and subjects provided written informed consent for secondary use of their data. A dataset was utilized comprising static and dynamic CT scans from 100 healthy subjects aged 18 to 35 years, of which 115 knees of 63 healthy subjects were included.<sup>3</sup> Static CT scans were obtained in supine position and dynamic CT scans were obtained while subjects performed a flexion-extension-flexion movement between 90° and full extension within 10 seconds, with both knees simultaneously. Using the CT data, 3D surface meshes of the femur, patella and tibia were created per angle of flexion. MPFL length was measured from Schöttle's point on the femur to three insertion points on the superomedial border of the patella (proximal, central, and distal) based on anatomical studies (Figure 1).<sup>1</sup> The shortest wrapping path over the bony surface of the femoral condyle was chosen for each fiber to calculate the MPFL length changes between 0 and 90° flexion. The MPFL length changes were expressed as percentual length changes relative to the length in full extension to account for initial differences in MPFL length due to anatomical variation.

**RESULTS SECTION:** MPFL length changed during knee flexion, with variations observed across different fibers and between individuals (Figure 2). The median proximal fiber length was the longest in full extension and shortened during knee flexion to -6.0% (IQR, -9.4 to -2.6%) at 90°. The median central fiber length decreased during initial flexion, returned to full extension length at 50°, and then decreased to -2.7% (IQR, -6.2 to 1.1%) at 90° flexion. The median distal fiber length initially decreased by 1.8% during the first 10° and then increased, reaching a maximum of 4.6% (IQR, -0.7 to 9.4%) at 60° of flexion. The median maximal length change between 0 and 90° was 4.6 mm (IQR, 3.2 to 6.0 mm), 4.7 mm (3.3 to 6.0 mm) and 5.7 mm (3.6 to 8.1 mm) for the proximal, central, and distal fiber.

**DISCUSSION:** The median MPFL length changed by approximately 5 mm between 0 and 90° of flexion. Proximally the length continuously decreased, indicating slackening behavior. Distally the length increased at deeper flexion angles, indicating tightening behavior. A major strength of this study was its large sample size. Automated extraction of the MPFL length changes facilitated the incorporation of a substantial sample size of 115 healthy knees. A major limitation of this study was the lack of subject-specific knowledge on the MPFL attachment sites. The selected MPFL attachments were based on anatomic studies which might differ from native MPFL attachment sites, resulting in MPFL length changes that do not fully represent clinical practice. Also, MPFL length changes were assessed during a non-weight-bearing open-chain active flexion-extension-flexion movement which might not be representative for different activities during daily life.

**SIGNIFICANCE/CLINICAL RELEVANCE:** Distal patellar insertion should be avoided in MPFL reconstruction techniques utilizing the Schöttle's point to establish the femoral insertion, as that causes elongation of the ligament which may increase the risk for complications due to overloading.

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## IMAGES AND TABLES:

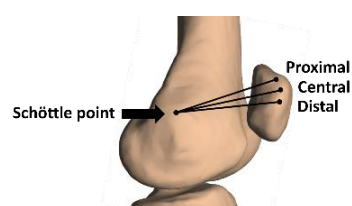


Figure 1. 3D bone surface model of the knee in full extension showing the three MPFL fibers.

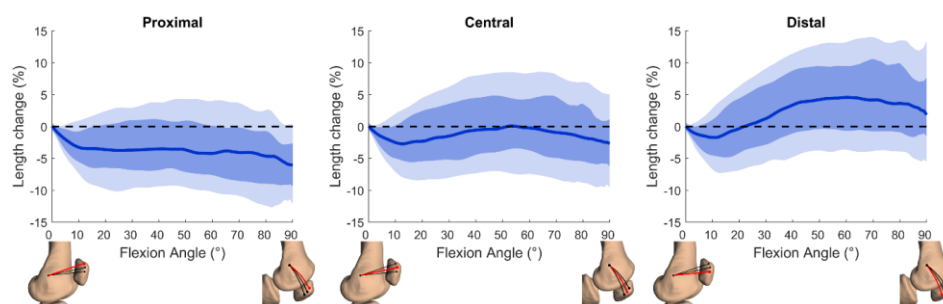


Figure 2. Percentual MPFL length changes relative to full extension between 0 and 90° of knee flexion for the proximal, central, and distal patellar attachment. Solid lines represent inter-subject medians, dark shadings represent  $\pm 1.5$  IQR (12.5 - 87.5%), light shadings represent  $\pm 1.5$  IQR (12.5 - 87.5%).