FEMORO-TIBIAL 3D KINEMATICS IN PATIENTS WITH POSTERIOR CRUCIATE LIGAMENT DEFICIENCY

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Introduction: The posterior cruciate ligament (PCL) plays an important role in maintaining normal knee kinematics and function [1]. In the long run PCL-insufficiency leads to the development of knee joint osteoarthritis (OA) by excessive displacement between tibia and femur [2,3]. Nevertheless, there is hardly any quantitative data regarding knee joint kinematics in patients with PCL insufficiency. By applying our MR-based imaging and postprocessing technique it is possible to determine 3D femoro-tibial kinematics from full extension to high flexion angles under muscle activity [4]. Therefore the aim of this study was to investigate the femoro-tibial kinematics in patients with PCL deficiency compared to healthy volunteers.

Materials and Methods: We investigated the knee joints of 12 patients with isolated insufficiency of the PCL (8 men, 4 woman; age 32 ± 6 years; 7-12 month after trauma) prior to single bundle PCL reconstruction. All patients had clinical symptoms of posterior instability. None of the patients had radiological signs of OA or suffered from load-dependent knee pain. As a control, 20 healthy volunteers (11 men, 9 woman; age 27.6 ± 5.1 years) were assessed without any history of knee pain, trauma or surgery.

MR Image acquisition

A low-resolution open MR-scanner (0.2 Tesla) was used applying a 3D GRE sequence (LR-flash: TR 18; TE 5ms; FA 30°; FoV 220x220; matrix 128x256, acquisition time 4,26). The patients and volunteers were placed on their side and the knees were positioned in three different flexion angles (0°, 30°, 90°). In all three positions a weight of 3 kg was applied to the lower third of the shank in a flexing direction. Thus isometric extending muscle activity was produced.

Image analysis

After segmentation and trilinear interpolation, all anatomic structures were reconstructed in three dimensions. The center of mass of the tibia plateau was computed and based on its spatial orientation a 3D coordinate system was determined, with its origin in the center of mass of the tibia plateau (Fig. 1). Then femoral reference points were defined by using the epicondylar axis. Therefore the posterior part of the femoral condyles (medial and lateral) were approximated as part of a cylinder and the centerpoints of the medial and lateral cylinders were connected and the transepicondylar line defined. Finally, the position of the three femoral reference points were projected in the tibia-based coordinate system (Fig. 1), determining both femoro-tibial translation and femoro-tibial rotation [4].

Discussion: This study describes the in vivo kinematics of the PCL deficient knee dependent on extending muscle activity and joint position compared to the healthy knee. The most obvious result is, that the femur in the PCL deficient knee is positioned by far more anterior than in the healthy knee, that the femur is rotated externally in extension (no screw home mechanism), whereas the healthy femur is rotated internally, and that there is paradoxical anterior translation of the femur from 30° to 90° of flexion.

Results: In healthy knees there was typical femoral rollback during flexion, lateral more than medial, leading to an additional external femoral rotation in high flexion, i.e. internal femoral rotation in extension (screw home mechanism). Extending muscle activity led to a significant (P < 0.05) dorsal translation of the lateral condyle and center of femur and thus to increasing external rotation.

In PCL-deficient knees there was also significant dorsal translation of the femur up to 30°, but limited compared to the healthy knees. However, from 30° to 90° of flexion there was significant anterior movement of the femur in PCL deficient knees affecting the medial and lateral condyle, thus creating a paradoxical anterior translation. Furthermore the position of the femoral condyles was significantly more anterior together with significantly more external rotation in PCL deficient knees, obvious in all flexion angles. Finally extending muscle activity had significantly less influence on the translation of the lateral condyle and on rotation in PCL deficient knees in 0° and 30°, whereas it had more influence on the translation of the medial condyle. In high flexion muscle activity even increased the paradoxical anterior translation of the femur.