Effect of Axial Loading on In Situ Forces in the PCL and Knee Joint Kinematics

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Introduction: Gravity and hamstrings forces have been shown to increase forces in the posterior cruciate ligament (PCL) graft.1,3 As a result, PCL reconstruction surgery has traditionally been conservative (knee locked in full extension for 4 weeks). Previous biomechanical studies have shown that axial compressive loads can increase joint stability.2 The objective of this study was 1) To determine the effect of axial compressive loads on knee kinematics in the intact and PCL-deficient knee and 2) To evaluate the effects of axial compressive loading on the in situ forces in the posterior cruciate ligament (PCL).

Materials and Methods: Ten fresh frozen human cadaveric knees were tested using a robotic/universal force-moment sensor testing system. After determining the passive path, the knees were tested under two external loading conditions at 0°, 30°, 60°, and 90° of knee flexion: 1) 134N AP tibial load and 2) 134N AP load plus 200N axial compression. The posterior tibial load simulates the clinical posterior drawer exam, while the 200N axial compression represents a partial weight-bearing condition. For each loading condition the resulting 5DOF knee kinematics were recorded in the intact and the PCL-deficient state.

Results: In the intact knee the addition of an axial compressive load did not significantly affect the total AP tibial translation (p>0.05). However, anterior tibial translation increased significantly at all flexion angles from 2.2±1.3mm to 1.0±1.4mm at 30° and 120°, while the corresponding posterior tibial translation decreased significantly (0°, 30°, 60°) from 3.5±3.2mm to 1.8±3.9mm at 30° and 60° (p<0.05). The in situ forces in the PCL under the combined posterior tibial load plus the axial compressive load were reduced significantly at 30°, 60°, 90°, and 120° with 60% at 30° and 35% at 90° (p<0.05) (Figure 1). With axial compressive loading, anterior tibial translation in the PCL-deficient knee increased significantly at all flexion angles from 1.8±1.5mm to 1.0±1.1mm at 30° and 90° respectively (p<0.05). Similarly to the intact knee, axial loading in the PCL-deficient knee significantly reduced posterior tibial translation at 0°, 30°, 60°, 90° of knee flexion (p<0.05) (Figure 2). This reduction in posterior tibial translation ranged from 43% at 30° to 13% at 90° (p<0.05).

Discussion: This study indicates that the addition of a 200N axial compressive load significantly reduces posterior tibial translation in the intact and PCL-deficient knee. The in situ forces in the PCL were also significantly reduced when axial compressive loading and AP tibial loads were applied to the knee. By engaging the natural slope of the tibia through axial loading, the tibia is shifted anteriorly. These data are consistent with previous studies evaluating the effects of increasing tibial slope through high tibial osteotomy.1,2 In this study, the reductions in both posterior tibial translation and in situ forces in the PCL suggest that weight bearing may be protective to the PCL and contribute to posterior knee stability.


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Figure 1: In situ force in the PCL with and without axial loading.

Figure 2: Posterior tibial translation in the PCL deficient knee with and without axial loading.