EFFECT OF KNEE FLEXION ANGLE AND TIBIAL POSITION DURING GRAFT FIXATION ON THE BIOMECHANICS OF A PCL RECONSTRUCTED KNEE

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Introduction:

The optimal knee flexion angle and anterior-posterior (A-P) position of the tibia at the time of graft fixation for posterior cruciate ligament (PCL) reconstruction remain controversial. While some have advocated fixation of the graft with the knee in flexion to mimic the high tension of the intact PCL [1], others have recommended full extension [2] or lower knee-flexion angles [3] to reduce posterior subluxation of the tibia. The application of an anterior load to the tibia to reduce posterior sag prior to graft fixation has also been suggested [1]. The objective of this study was to quantitatively assess the effect of knee flexion angle and A-P position of the tibia at the time of graft fixation on the biomechanical outcome of a PCL reconstruction. We hypothesized that fixing the graft with the knee in flexion will better restore intact knee kinematics and *in situ* forces in the PCL replacement graft than with the graft fixed at extension. We further hypothesized that the application of an applied anterior tibial load at the time of graft fixation would significantly affect the resulting kinematics and *in situ* forces.

Materials and Methods:

Eight fresh-frozen, human cadaveric knees (36-65 years) were evaluated using a robotic/universal force-moment sensor (UFS) test system [4]. The femur was rigidly fixed relative to the robot base and the tibia was mounted to the end-effector of the robotic manipulator. The UFS allowed measurement of the forces applied to the tibia. Posterior tibial loads of up to 134 N were applied at flexion angles of 0º, 30º, 60º, 90º and 120º and the resulting 5-degree of freedom (DOF) knee kinematics were recorded.

The PCL was arthroscopically transected and the intact knee kinematics were repeated by the robot while resulting forces and moments were measured by the UFS. Using the principle of superposition, the vector difference in forces recorded before and after cutting the PCL represents the *in situ* force in the PCL for the intact knee [4]. An Achilles tendon graft was used to reconstruct the anterolateral bundle of the PCL. The graft was fixed on the femoral side using an interference screw and on the tibia using a jig which enabled the graft to be tensioned and fixed multiple times. The graft was pre-tensioned to 89 N. Five different reconstructions were tested with the replacement graft fixed at: 1) 0º, 2) 60º, 3) 60º with a 134 N applied anterior drawer, 4) 90º, and 5) 90º with an anterior drawer. Each reconstruction was then subjected to the same testing protocol as the intact knee to determine the 5 DOF kinematics and *in situ* forces in the PCL replacement graft.

Because all tests were performed on the same specimen, statistical analysis was performed using a repeated measures analysis of variance followed by multiple contrasts with a significance level of $p < 0.05$.

Results:

Under the 134 N posterior tibial load, posterior tibial translation (PTT) of the intact knee ranged from 6.4 mm at 30º to 5.7 mm at 90º. PTT increased significantly with PCL deficiency at all flexion angles by 2–13 mm ($p<0.05$). Both knee flexion angle and application of an anterior drawer at the time of PCL graft fixation significantly affected the PTT of the reconstructed knee (Figure 1). With regard to flexion angle, graft fixation at 0º significantly reduced PTT to 0.8-3.8 mm less than that of the intact knee ($p<0.05$). Further, the *in situ* forces in the graft were significantly higher than those in the intact PCL at all knee flexion angles for this reconstruction except 30º (Table 1).

For the grafts fixed at 60º and 90º, PTT was not significantly different from that of the intact knee beyond 30° of flexion (Figure 1). However, *in situ* forces in these PCL grafts were significantly lower than in the intact PCL (Table 1).

Application of the 134 N anterior drawer at the time of graft fixation significantly reduced PTT of the reconstructed knee for the graft fixed at 60° ($p<0.05$). However, the anterior drawer did not have this effect for the graft fixed at 90° ($p>0.05$). *In situ* forces in the graft fixed at 90° were significantly lower than in the intact PCL ($p<0.05$). With the additional anterior drawer, however, graft forces did not differ significantly from the intact PCL ($p>0.05$) except at 30° of flexion (Table 1).

Discussion:

These results support our hypotheses that knee flexion angle and the application of an anterior drawer at the time of graft fixation, significantly affect the kinematics of the PCL reconstructed knee and the *in situ* forces in the PCL replacement graft. Our data further suggest that fixing the graft at 0º of knee flexion results in significantly less PTT and increased graft forces when compared with the intact knee, indicating an overconstrained reconstruction. Graft fixation at 90º with an anterior drawer resulted in knee biomechanics that most closely resemble those of the intact knee.

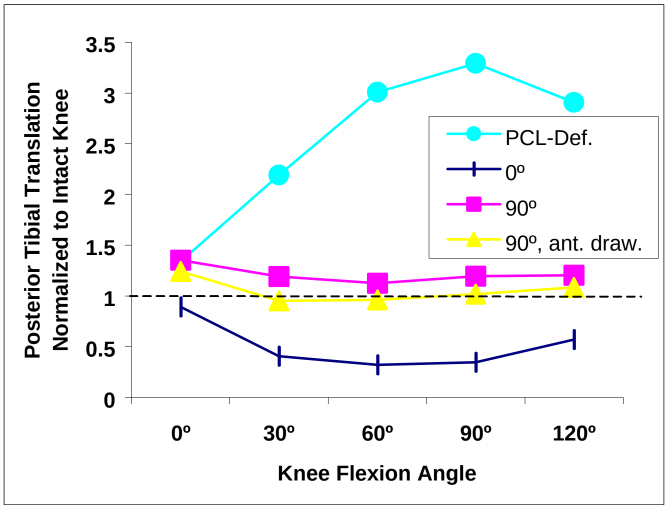

Figure 1. Mean posterior tibial translation relative to the intact knee in response to a 134 N posterior tibial load for graft fixations at selected knee flexion angles and tibial positions.

Flexion Angle	Intact PCL	Fixation @ 0°	Fixation @ 90°	Fixation @ 90° w/ Ant. Draw
0°	31±10	52±33*	17±4*	27.0±10.9
30º	87±24	98±30	67±32*	74±28*
60º	111±30	128±41*	95±38*	102±33
90º	131±19	149±22*	105±41*	119±33

* significantly different from the intact knee, p < 0.05

Table 1. *In situ* force (N, mean ± SD) in the PCL or PCL replacement graft in response to a 134 N posterior tibial load for graft fixation performed at selected positions.

References:

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