NEW INSIGHTS INTO FEMORAL ROLLBACK DURING STAIR CLIMBING AND POSTERIOR CRUCIATE LIGAMENT FUNCTION

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Introduction: Femoral rollback has been reported to be necessary for normal stair climbing since it increases the lever arm of the quadriceps mechanism at a phase of the stair climbing where maximum demand is placed on the quadriceps muscles (1). Abnormal rollback was one explanation for the reduced quadriceps moment associated with posterior cruciate ligament (PCL) sacrifice, since reduced roll back would shorten the lever arm of the quadriceps muscle. However, there has not been a direct measure of femoral roll back during natural stair climbing conditions. Previously reported fluoroscopic studies do not include the entire stair climbing cycle (2).

The purpose of this study was to test the hypothesis that femoral roll-back occurs during stair climbing and that the characteristics of the anterior-posterior (AP) movement of the femur are dependent on the function of the posterior cruciate ligament.

Materials and Methods: Fifteen patients and 10 age matched normal subjects were tested during stair climbing (20 cm. height) following total knee replacement. All patients had implants from the same implant system and were selected on the basis of a good or excellent clinical result (> 85 H. S. S. rating). Ten knees were cruciate retaining and 7 were posterior stabilized. The implants had nearly identical tibial-femoral and patellofemoral geometry. All subjects were IRB approved and received informed consent

A point cluster method was used to determine the six degree of freedom motion of the femur with respect to the tibia (3). The origin of the femoral coordinate system, located at the midpoint of the transepicondylar axis, was used to quantify AP translation of the femur with respect to the tibial coordinate system (4). Differences in motion were tested using a one-way ANOVA with a Bonferroni correction at a significance level of $\alpha < .05$.

Results: Femoral roll back with flexion was dependent on the phase of the stair climbing cycle. There was an offset between the swing phase position of the femur and the stance phase position (Figure 1) at identical angles of knee flexion.

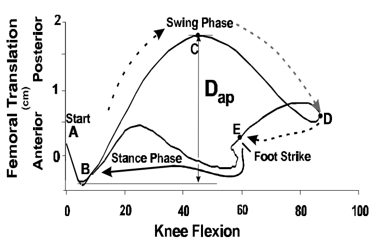

Figure 1. The AP displacement of the femur as a function of knee flexion angle for normal stair climbing.

The maximum AP translation (Dap) for the normal population had an average value of 1.9 cm $\pm$ 0.6 cm. This value was significantly less than either group of patients following total knee replacement. The cruciate retaining group was 2.9 cm $\pm$ 0.6 cm while the posterior stabilized group was 3.3 cm $\pm$ 0.8 cm. The posterior stabilized group reached the greatest anterior position at approximately 65 degrees of knee flexion. The cruciate retaining group reached a maximum anterior position at approximately 55 degrees of knee flexion while the normal group reached a maximum anterior position at approximately 45 degrees of knee flexion (Figure 2).

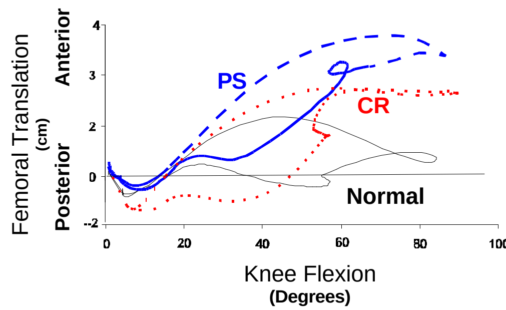

Figure 2. A comparison of normal, cruciate retaining(CR) and sacrificing (PS) knees.

Discussion: Femoral roll back was dependent on the phase of the stair climbing cycle. During the early swing phase, the femur moves forward with flexion, as a result of the hamstring producing knee flexion. The femur begins moving posterior at approximately 45 degrees of flexion, probably as tension in the PCL increases. The posterior stabilized design had the largest anterior displacement of the femur, since the cam did not engage until approximately 70 degrees of flexion, which is likely too late in flexion to replicate normal PCL function. The cruciate retaining design also demonstrated increased anterior displacement of the femur, suggesting tensioning of the PCL near 45 degrees might be an important consideration.

References: **(1)** Andriacchi, T.P., et al., J Bone Joint Surg, 62A:749-757, 1980. **(2)** Banks, S.A. and Hodge, W.A., *IEEE Trans Biomed Eng* 43(6), 638-649. **(3)** Andriacchi, T.P., et al., Trans. 41st ORS 20:128, 1995 **(4)** Dyrby, C. et al., 5th Biannual 3D Human Movement Symposium, 1998.

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