Antero-Posterior Knee Stability During Stair Descent

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Disclosures:

Introduction: Increasing attention to the functional outcome of total knee replacement (TKR) has demonstrated that many patients experience limitations when attempting to perform demanding activities that are normal for age-matched peers, primarily because of knee symptoms. Episodes of instability following TKR are most commonly reported during activities in which significant transverse or torsional forces are supported by the joint with relatively low joint compression forces, including stair-descent and walking on sloped or uneven surfaces. This study was performed to examine the influence of conformity between the femoral and tibial components on the Antero-Posterior (AP) stability of knee during stair descent.

Methods: Six cadaveric knees were loaded in a six degree-of-freedom joint simulator, with the application of external forces simulating the action of the quadriceps and hamstring muscles and the external loads and moments occurring during stair descent, including the stages of terminal swing phase, weight-acceptance phase (prior to and after quadriceps contraction) and midstance. During these maneuvers, the displacement and rotation of the femur and the tibia were measured with a multi-camera high resolution motion analysis system. Each knee was tested in the intact and ACL deficient condition - and after implantation of total knee prosthesis with Cruciate-Retaining (CR), Cruciate-Sacrificing (CS) and Posterior-Stabilizing tibial inserts.

Results: Loading of the knee during stair descent caused the femur to displace anteriorly by 4.31±1.47mm prior to quadriceps contraction. After TKR, anterior displacement ranged from only 1.11±0.41mm (PS) to 8.19±3.17mm (CS/deficient PCL). Intermediate values were measured with the CS insert with a functioning PCL (1.46±0.42mm) and the CR insert design (3.03±0.94mm). Quadriceps contraction displaced the femur posteriorly by 5.53±1.08mm in the intact knee, compared to 8.22±2.94mm with the CS/deficient PCL 2.32±0.83mm with the CS/functioning PCL, 2.02±0.94mm with the CR design and 1.08±0.38mm with the PS.

Discussion: During stair descent, anterior-posterior knee stability can be restored through selection of a PS insert or a CS insert if the PCL is intact. In the presence of a CR insert, quadriceps forces must exceed those in the intact knee to maintain the normal position of the femur with respect to the tibia during this activity.

Significance: Our study showed that a healthy quadriceps force was able to return the knee to its anatomic alignment. It is reasonable to hypothesize that an increased quadriceps force is needed to stabilize a TKR of the CS design in the absence of the PCL, though further study would be indicated. The results presented here have implications regarding implant designs and function as AP stability of the knee during stair descent varied with prosthetic design.

Acknowledgments:
References:
Figure Legends
Figure 1. Custom built, computer controlled, six degree of freedom knee activity simulator
Figure 2. The phases of stair-descent as simulated during experimental testing.
Figure 3. The 3 designs of tibial inserts used in this study.
Figure 4. AP displacement of the knee in response to pre and post quadriceps contraction with the knee flexed at 15 degrees (“Weight Acceptance”).
Figure 5. Axial rotation of the knee in response to pre and post quadriceps contraction with the knee flexed at 15 degrees (“Weight Acceptance”).