**NEXT GENERATION KNEE REPLACEMENTS: A new approach to replicate the function of the ACL**

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**Introduction:** Current total knee replacements (TKRs) are an effective treatment for the arthritic knee, but normal patterns of knee motions are not restored. In addition, paradoxical anterior sliding of the femur occurring in the first half of the flexion range can damage the patello-femoral mechanism. Acquiring anatomical motion is important for daily activities, in restoring stability and function. Our goal was to determine if experimental TKRs with surface-guided design features could restore anatomical knee motion.

**Materials and Methods:** Four types of TKRs were produced:

TCP: Standard total condylar TKR with partially conforming double-dished surfaces, for ACL/PCL resection.

PS: Standard posterior stabilized; same as the TCP but with a central post-cam for femoral rollback after 75° flexion.

EXP1: A modified PS with the medial tibial surface more dished and the lateral surface shallower to promote rotation with flexion, and an antero-medial recess-ramp to prevent paradoxical motion.

EXP2: The same as the PSR but with a central tibial ramp interfacing with a central femoral recess, to replace the cam-post.

A lower extremity test machine was built to replicate a crouching motion. The tibia was free to rotate about its long axis. The hinged ankle joint was attached to the tibia. A stepper motor was used to control the quadriceps tendon. Two extension springs applying up to half the maximum quadriceps force were attached to the hinged ankle joint to simulate the hamstrings. A motion tracker with 0.2mm accuracy was used to track the knee location at 30 Hz (MicronTracker, Canada).

A transverse femoral axis was created with a vector joining the centers of the 23mm posterior radii of lateral and medial condyles; superimposed onto the proximal tibia at each angle to track the motion of the knee.

**Results:** A comparison of the motion paths of the anatomic knee specimens, and the knee replacements was produced. (Fig 1) The motion of the knee joint with a resected ACL showed no internal tibial rotation. Both the PS and CR designs behaved similarly. The two experimental designs, however, followed the medial pivot replicating anatomical knee motion. Paradoxical motion was also prevented by the anterior recess-ramp of the EXP1/EXP2 designs. The resulting axial rotations and the displacements were calculated (Fig 2). The data shows a correlation between the intact knee and the EXP1 and EXP2 designs allowing an average 16° of rotation. There is also a correlation between the ACL resected knee and the TCP and PS designs allowing an average 6° of rotation. There were also significant correlations in the displacements of the lateral/medial sides. These results showed that the two experimental designs were able to restore normal knee motion and evidently provided the function of the ACL.

**Discussion:** In the arthritic knee, the ACL is often damaged, causing abnormal kinematics. Restoration of normal kinematics should be an important goal of knee replacement. Standard design types in widespread use today did not restore normal kinematics in our experiments. In contrast, designs with geometrical features to effectively provide medial stability and rotation did restore close to normal motion. Finally, a medial ramp-recess feature was found to prevent paradoxical motion.