In Vivo Kinematics for Subjects Implanted With Either a Traditional or a Customized, Individually Made TKA

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Introduction: Until recently, knee implants were designed using average patient demographics. More recently, patient specific posterior cruciate retaining (PCR) total knee arthroplasty (TKA) have been individually made based on the patient’s anatomy using a CT scan pre-operatively. The objective of this study was to use a state-of-the-art mobile fluoroscopy unit to determine the in vivo kinematics for subjects having a either a traditional, off-the-shelf (OTS) knee implant vs. subjects having a customized, individually made (CIM) knee implant that replicates their own femoral and tibial geometries.

Methods: In vivo kinematics for 36 subjects, 23 of which having the CIM PCR TKA and 13 having a standard, OTS PCR TKA were assessed. A mobile fluoroscopic system was used while subjects performed a weight-bearing deep knee bend, rising from a chair (Figure 1) and normal gait under fluoroscopic observation. All the subjects were implanted by a single surgeon and each patient was deemed clinically successful (HSS Score >90) without any laxity or pain. Comparison of kinematics between the two designs focused on range of motion, posterior femoral roll back, axial rotation and condylar lift-off.

Results: During a deep knee bend, subjects having a CIM PCR implant experienced 2.1 mm of posterior femoral rollback as compared to 0.1 mm for the OTS TKA. Additionally, the implants experienced 4.2 and 2.9 degrees of axial rotation for the CIM PCR TKA and the OTS PCRTKA respectively. During the deep knee bend 56% of patients in the OTS TKA group experienced condylar lift-off >1.0mm compared to 0% of patients in the CIM TKA group. During a chair-rise, subjects having an OTS PCR TKA experienced 0.9 degrees of axial rotation, while subjects having a CIM TKA experienced 5.3 degrees. On average, subjects having a CIM PCR TKA experienced 112 degrees of weight-bearing flexion, compared to only 102 degrees for subjects with a traditional PCR TKA.

Discussion: Differences in overall motion and pattern were evident between the two groups. During a deep knee bend, subjects having a CIM PCR implant experienced more posterior femoral rollback of their lateral condyle and greater axial rotation than subjects having a standard OTS PCR TKA. Also, 44.4% of the subjects having a standard OTS PCR experienced an anterior slide of their lateral condyle and a reverse axial rotation pattern, compared to only 9.0% of the subjects having a CIM PCR TKA (one patient). During the chair-rise activity, subjects having an OTS PCR TKA experience a posterior slide of their lateral condyle opposite to the normal knee, while subjects having a CIM PCR TKA experienced a roll forward motion typical in pattern for a normal knee, but less in magnitude. Interestingly, subjects having an OTS PCR TKA experienced high magnitudes of femoral external rotation throughout the activity (opposite the normal knee), whereas the CIM subjects experienced a change from external to internal rotation of the femur throughout the activity (similar to a normal knee in pattern) (Figure 2).
Significance: This is the first study to utilize mobile fluoroscopy to assess chair-rise and gait for subjects having two distinctly different TKA types. Subjects having a CIM PCR TKA demonstrate more normal kinematics patterns that more closely approach that of the normal knee. Subjects having a standard OTS PCR TKA show greater variability in their kinematic patterns, differing from the normal knee.