In Vivo Kinematics for Customized, Patient Specific Vs. Two Generations of Traditional TKA During Various Activities

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Presented at BASK 2016

INTRODUCTION

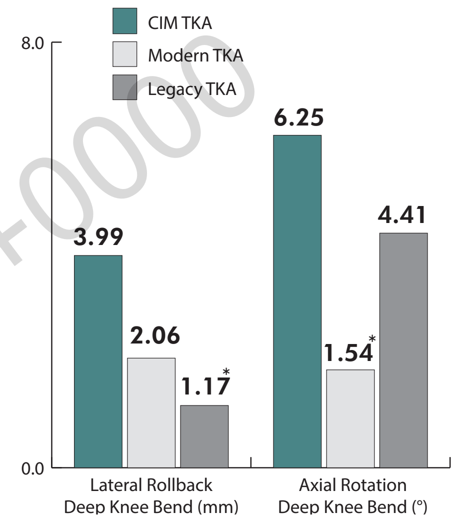
Until recently, knee implants were designed using average patient geometry. Advances in technology have allowed for patient specific posterior cruciate retaining (PCR) total knee arthroplasty (TKA) to be individually made based on the patient's anatomy, using a CT scan pre-operatively while correcting any acquired deformities. 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 one of two generations of traditional, off-the-shelf (OTS) knee implant versus subjects having a customized, individually made (CIM) TKA.

METHODS

Fifty-nine subjects, having either a CIM or one of two generations of OTS CR TKA were assessed. Both OTS designs are currently on the market, and they represent a legacy design and a more recently developed modern design by the same manufacturer. All the subjects were implanted by one of two surgeons and each patient was deemed clinically successful (HSS Score >90) without any laxity or pain. Twenty-five CIM TKAs, 15 legacy OTS TKAs, and 19 modern OTS TKAs were evaluated. Fluoroscopic videos were captured while patients performed the deep knee bend (DKB) and chair-rise under mobile fluoroscopic surveillance. Each video was digitized, corrected for distortion, and analyzed to determine kinematics using 2D to 3D image registration. Comparison of kinematics between the designs focused on range of motion, posterior femoral roll back, and axial rotation.

RESULTS

During the DKB, subjects with a CIM TKA experienced 3.99mm of lateral femoral rollback compared to 1.17mm ($p=0.05$ vs. CIM) and 2.06mm ($p=0.129$) for the legacy and modern design OTS subjects respectively (Figure 1). There were minimal differences with respect to differences in medial condyle translation (Figure 1). The CIM TKA patients demonstrated 6.25° of axial rotation compared to 4.41° ($p=0.35$) and 1.54° ($p=0.005$) for the legacy and modern design OTS PCR TKAs (Figure 2). During chair-rise, all subjects having a CIM TKA experienced a normal roll forward pattern of lateral condyle motion, while subjects having a both the legacy and modern OTS TKA experienced incidences of posterior sliding of their lateral condyle, opposite to the normal knee but consistent with most OTS PCR TKAs. On average, CIM subjects experienced similar weight-bearing flexion to the modern design OTS TKA (103° vs 105°), compared to 95° for legacy design OTS TKA subjects. Some of these kinematic differences may be due to the manner in which OTS knee implants are designed based on J-curves derived from anatomic averages. These statistically derived geometries cannot consistently match the natural J-curves of the individual patient or their natural condylar offsets.



* Represents statistical significance with respect to CIM TKR

Figure 1: Comparison of average anterior/posterior translation for the CIM and OTS TKAs during Deep Knee Bend and Chair Rise.

DISCUSSION

During DKB, CIM subjects experienced greater lateral condyle femoral rollback and axial rotation. The legacy OTS subjects, and to a lesser magnitude the modern OTS groups, experienced entirely external femoral orientation, different from normal knee motion. CIM subjects experienced a change from internal to external rotation during the DKB, consistent with normal knee motion. In this study, patients with both OTS implant designs exhibited larger magnitudes of paradoxical anterior slide of the lateral condyle during DKB. In general, patients having CIM CR TKA achieve more normal-like kinematic patterns of medial and lateral condyles for both a deep knee bend and a chair rise with a rotation pattern similar to a normal, healthy knee.

MK-02958-AB