In Vivo Kinematics for Customized, Individually Made vs. Off-the-Shelf TKA During a Deep Knee Bend and Chair Rise

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Summary from the ICJR Pan Pacific Congress 2015 Presentation

INTRODUCTION

Previous fluoroscopic studies were conducted using a stationary fluoroscopy unit that was not able to track the full movement of a patient. More recently, a mobile fluoroscopy unit was developed that can capture subjects performing unconstrained motions that more accurately replicate the everyday demands that patients place on their operated knees. The objective of this study was to determine the in vivo kinematics of subjects having either a Customized Individually Made (CIM) posterior cruciate retaining Total Knee Arthroplasty (TKA) or one of two traditional, Off-the-Shelf (OTS) posterior cruciate retaining TKAs.

METHODS

Sixty-three subjects with either a CIM (15 patients) (iTotal, ConforMIS, Inc., Bedford, MA), OTS 1 (24 patients) (Vanguard, Biomet, Warsaw, IN), or OTS 2 (25 patients) (Triathlon, Stryker, Kalamazoo, MI) TKA implanted by the same surgeon were assessed in this study. Fluoroscopic videos were captured of the patients while they performed both a deep knee bend to maximum knee flexion and a chair rise. Each video was digitized, corrected for distortion, and then analyzed to determine kinematics using a 2D-to-3D image registration technique.

RESULTS

During a deep knee bend, on average, subjects with a CIM TKA experienced 4 mm of lateral posterior femoral rollback compared to 2.6 mm for subjects with an OTS 1 TKA and only 0.4 mm for subjects with an OTS 2 TKA (Figure 1). Additionally, only 7% of subjects with a CIM TKA experienced an anterior slide of their lateral condyle during flexion—considered paradoxical rollback opposite to the normal knee—compared with 24% for OTS 1 and 48% for OTS 2. The average amount of axial rotation for the three groups was 5.1°, 4.7°, and 4.1°, respectively. Subjects with a CIM TKA achieved higher average weight-bearing flexion (104°) compared with OTS 1 TKA (101°) and OTS 2 TKA (99.5°). More importantly, 100% of subjects with a CIM TKA achieved at least 90° of weight-bearing knee flexion, as compared to 75% and 76% of subjects with an OTS 1 TKA and OTS 2 TKA, respectively. During a chair rise, on average, subjects with a CIM TKA experienced 4.6 mm of roll forward for their lateral condyle, a motion pattern consistent with normal kinematics, while this amount was less for subjects with an OTS TKA (3.5 mm for OTS 1 TKA and 1.5 mm for OTS 2). The average amount of axial rotation for the three groups was 7.4°, 6.8°, and 7.4°, respectively.

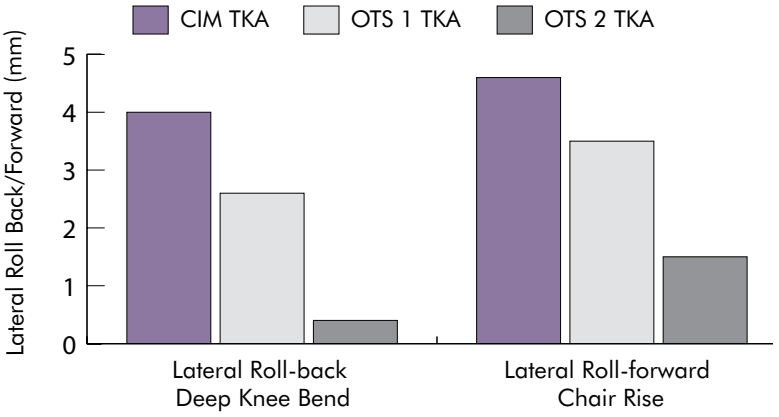

Figure 1: Comparison of average anterior/posterior translation for the CIM and OTS TKAs during Deep Knee Bend and Chair Rise.

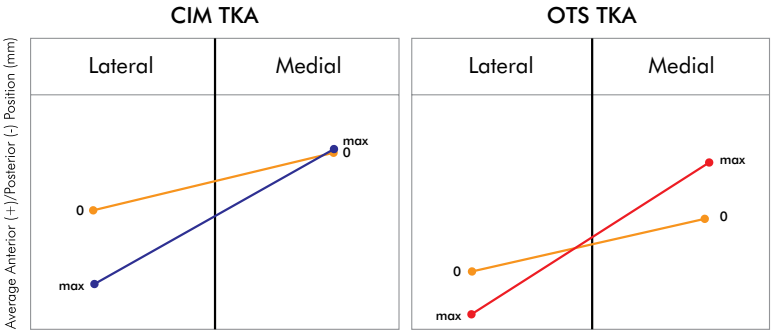

Figure 2: Representation of average kinematic patterns from full extension to maximum flexion during Deep Knee Bend. Normal knee pattern is large, lateral rollback with no medial anterior sliding.

DISCUSSION

In this study, patients implanted with the CIM TKA experienced the greatest amount of lateral condyle rollback during deep knee bend and roll forward during chair rise when compared to both the OTS TKA groups, patterns consistent with normal knee motion. Additionally, both OTS groups frequently exhibited an anterior slide motion, opposite to the normal knee, when compared to the CIM TKA. Axial rotation between the three groups was similar. However, normal rotation patterns were obtained by the CIM TKA patients due to a screwhome mechanism, while the OTS TKA patients experienced rotation due to a rollback of their lateral condyle in combination with an abnormal anterior slide of the medial condyle (Figure 2). Patients with the CIM TKAs also experienced the highest weightbearing flexion during deep knee bend. Lastly, CIM implants performed comparably to, or more normal like than, OTS implants in both activities, however, normal knees may obtain greater magnitudes of motion.

MK-03009-AA 08/15