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

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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 a traditional, off-the-shelf (OTS) posterior cruciate retaining TKA while performing both a deep knee bend to maximum knee flexion and chair rise.

METHODS

Twenty subjects with either a CIM (10 patients) (iTotal, ConforMIS, Inc., Bedford, MA) or an OTS (10 patients) (Vanguard, Biomet, Warsaw, IN) TKA implanted by the same surgeon were assessed in this study. Fluoroscopic videos were captured for the patients while they performed both a deep knee bend to maximum knee flexion and a chair rise under mobile fluoroscopic surveillance. Each video was digitized, corrected for distortion, and then analyzed to determine kinematics using a 2D-to-3D image registration technique.

RESULTS

Subjects with a CIM TKA achieved greater axial rotation and more normal-like femorotibial contact patterns. During a deep knee bend, on average, subjects with a CIM TKA experienced 3.5 mm of lateral posterior femoral rollback compared to only 1.3 mm for subjects with an OTS TKA (Figure 1). The average amount of axial rotation was similar for the two groups (CIM = 4.6°, OTS = 4.4°) (Figure 2). However, all subjects with a CIM TKA experienced posterior femoral rollback of their lateral condyle while 50% of the subjects with an OTS TKA experienced an anterior slide of their lateral condyle during flexion, considered paradoxical rollback opposite to the normal knee. During a chair rise, on average, subjects with a CIM TKA experienced 5.3 mm of roll forward for their lateral condyle while this amount was only 2.5 mm for an OTS TKA. Also, subjects with a CIM TKA experienced, on average, 10.6° of normal axial rotation while subjects with an OTS TKA experienced only 6.7°. During a deep knee bend, subjects with a CIM TKA achieved 106° of weight-bearing knee flexion while subjects with an OTS TKA achieved only 103°.

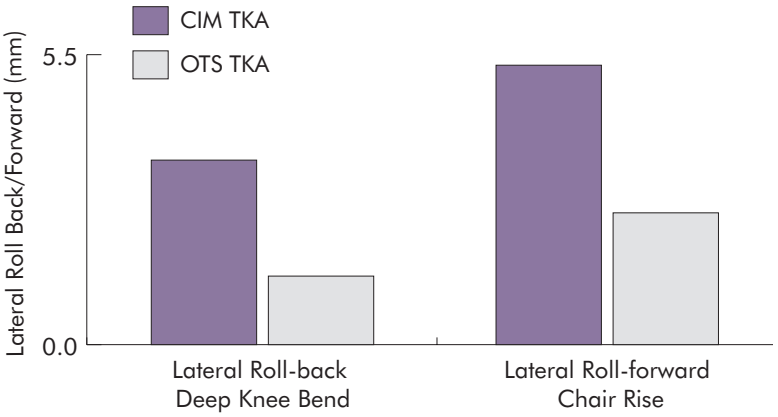

Figure 1: Comparison of average anterior/posterior translation for the CIM and OTS TKAs during Deep Knee Bend and Chair Rise.

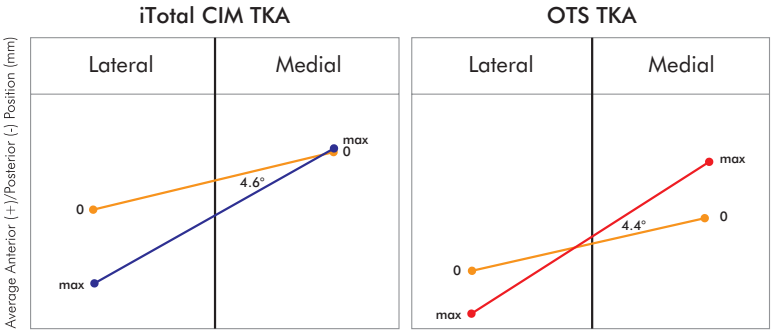

Figure 2: Comparison of average kinematic patterns from full extension to maximum flexion during Deep Knee Bend. Normal knee pattern is large, lateral rollback with no medial anterior sliding.

DISCUSSION

Prior to the introduction of CIM TKA, knee implants were designed based on J-curves that had been derived from anatomic averages in order to fit a majority of the population. More recently, knee implants have been designed based on the anatomical geometry for each individual patient correcting any underlying deformities (flattening, osteophytes, etc.). In this study, patients with a CIM TKA experienced a benefit as they achieved more normal-like kinematic patterns. During both a deep knee bend and a chair-rise, subjects with a CIM TKA achieved more normal motion of their lateral condyle and greater magnitude of axial rotation. Most interesting was the fact that all subjects with a CIM TKA experienced normal motion of their lateral condyle while 50% of the subjects with an OTS TKA experienced an anterior slide of their lateral condyle opposite of the normal knee motion pattern.