Knee Mechanics In-Vivo In Rotationally Unconstrained Total Knee Arthroplasty

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Introduction: Clinical and biomechanical studies have suggested that normal joint kinematics is not restored in fixed bearing total knee arthroplasty. Non physiological tibio-femoral antero-posterior translation and axial rotation during knee flexion are consistent with the observed reduction of knee range of motion, anterior knee pain and abnormal muscle activity. Published results from in vivo fluoroscopic analyses demonstrated net rotational deflections averaged between 5 to 8 degrees, much less than normal knee (about 16 degrees) [1]. A new rotationally unconstrained fixed bearing posterior stabilized total knee arthroplasty (TKA) claims to coordinate post-cam interaction along the flexion-extension axis of the femoral component to allow the femur to rotate axially (+/- 25°) while maintaining contact stresses below the yield strength of polyethylene even at flexion angles as high as 150 degrees. The purpose of this study was to evaluate the effect of these design features on replaced knees by looking at kinematics, kinetics and muscle activity in vivo.

Materials and Methods: Fifteen patients affected by primary OA received a posterior stabilized rotationally unconstrained fixed bearing TKA (NRG® Knee System - Stryker Orthopaedics, Mahwah, New Jersey, USA). The previous design was modified by moving the post-cam mechanism more posteriorly and the tibial polyethylene insert was machined along a rotational arc to allow up to 25 degrees of axial rotation. All patients were assessed clinically and biomechanically at 1 year follow-up. Clinical assessment was quantified using the IKSS score. Knee kinematics were assessed using shape recognizing lateral mono-planar video-fluoroscopy (DRS, System 1694 D, General Electric CGR, USA) during chair rising, stair climbing and step-up and down [2]. Particularly, the contact-line rotation, defined as the rotation of the line connecting the medial and lateral tibio-femoral contact points with respect to medio-lateral axis on the tibial transverse plane, was measured. The antero-posterior translation of these contact points on the same plane during knee flexion was also calculated.

Standard gait analysis [3] for the same locomotor tasks was performed using a 8-cameras Vicon® motion system (Aurion S.r.l, Milan-Italy) quantifying lower limb kinematics, kinetics, and electromyography.

Results: All knees rotated nearly around the tibial medial compartment close to the spine. Particularly, the average contact-line rotation during chair rising, stair climbing and step-up and down activities were respectively 10.9° +/- 4.2° (range: 4.1° - 16.0°), 9.4° +/- 3.9° (range: 4.0° - 16.3°), and 11.8° +/- 3.6° (range: 6.4° - 16.6°). In these motor tasks, the mean antero-posterior translation (in the figure, during chair rising) was respectively 1.8° +/- 1.9, 3.8° +/- 1.9, 3.4° +/- 1.8 mm on the medial compartment, and 2.1° +/- 1.4, 2.7° +/- 1.6, 1.6° +/- 2.0 mm on the lateral compartment. All patients demonstrated symmetric kinematics and kinetics pattern in gait analysis. Two different sagittal knee moment patterns were found: normal extension and flexion moment pattern associated with normal quadriceps and hamstring muscle activity (70% of the patients) and a permanent flexion knee moment associated with mild co-contraction of the quadriceps and hamstrings.

Discussion: Our results suggest that nearly normal knee kinematics and kinetics can be attained utilizing a fixed bearing posterior stabilized TKA design incorporating improved post-cam mechanics with increased freedom of rotation. Smaller antero-posterior translation of the femur during knee flexion supports the efficacy of the single radius at the femur component geometry and of the spin-cam mechanism designed in fact to obtain a more physiological knee biomechanics. Recovery of normal muscle activity of extensor and flexor muscle groups at the knee, even in the absence of the cruciate ligaments, supports further this conclusion.

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