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In vivo kinematics of guided motion total knee arthroplasty

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Introduction

In the normal knee, the femur rolls posteriorly and rotates externally during flexion [1]. Knee simulation studies have indicated that guided motion (GM) total knee arthroplasty (TKA) (bi-cruciate stabilized, asymmetric posterior spine-cam mechanism, and anatomical surface geometry of the tibial plateaus surfaces) which enables for controlled rotation and rollback during flexion may permit more physiological motion at the replaced knee [1] (**Figure 1**). The purpose of this study was to determine whether GM-TKA replicates normal knee kinematics and kinetics in vivo by using mono-planar video-fluoroscopy and standard gait analysis.

Materials and methods

Fifteen patients affected by primary OA were operated by a posterior stabilized rotationally unconstrained fixed bearing GM-TKA (JOURNEY BCS, Smith & Nephew, London-England). All patients were assessed clinically and biomechanically at 1 year follow-up. Clinical assessment was quantified using the IKS 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 activities [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 (**Figure 2**). 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.



Figure 1: JOURNEY BCS Femoral Asymmetric Cam and Tibial (M/L) Anatomical Surfaces

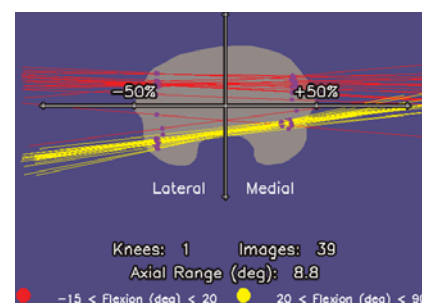


Figure 2: Contact Line Rotations

Results

A consistent medial pivoting pattern was observed in all motor tasks. Particularly, the average contact-line rotation during chair rising, stair climbing and step-up and down activities were respectively $13.0^{\circ} \pm 5.2^{\circ}$ (range: 8.7° - 21.7°), $10.5^{\circ} \pm 2.8^{\circ}$ (range: 6.4° - 14.0°), and $15.9^{\circ} \pm 5.2^{\circ}$ (range: 9.7° - 22.2°) (Figure 3). In these motor tasks, the mean antero-posterior translation (in Figures 5 & 6, during chair rising) was respectively 7.4 ± 2.7 , 8.6 ± 3.5 , 4.2 ± 2.9 mm on the medial compartment, and 15.9 ± 2.6 , 16.7 ± 4.0 , 17.0 ± 4.5 mm on the lateral compartment (Figure 4). Gait analysis demonstrated in all patient symmetric kinematics and kinetics patterns. Knee joint rotations and frontal plane knee moment were close to normal. Two different sagittal knee moment patterns were found: a normal extension and flexion moment pattern associated with normal quadriceps and hamstring muscle activity (80% of the patients) and a permanent flexion knee moment associated with mild co-contraction of the quadriceps and hamstrings. Antero-posterior translation of medial and lateral contact points along knee flexion for chair rising.

Discussion

Our findings are consistent with previous fluoroscopic studies which indicate that TKA design influence considerably knee kinematics. Our results also suggest that design features which enhance femoral external rotation and roll back during flexion such as an asymmetric cam post mechanism and anatomical shaped tibial plateaus are associated with a relatively normal pattern of motion after GM-TKA. Recovery of normal muscle activity of extensor and flexor muscle groups at the knee is likely accounted for the restoration of more physiological knee mechanics even in the absence of the cruciate ligaments.

References

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2. Fantozzi S, Benedetti MG, Leardini A, Banks SA, Cappello A, Assirelli D, Catani F. Fluoroscopic and gait analysis of the functional performance in stair ascent of two total knee replacement designs. Gait Posture. 2003 Jun;17(3):225-34.
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Activities	Avg. Contact Line Rotation	Range
Chair Rising	$13.0^{\circ} (+/-5.2^{\circ})$	$8.7^{\circ} - 21.7^{\circ}$
Stair Climbing	$10.5^{\circ} (+/-2.8^{\circ})$	$6.4^{\circ} - 14.0^{\circ}$
Step Up Step Down	$15.9^{\circ} (+/-5.2^{\circ})$	$9.7^{\circ} - 22.2^{\circ}$

Figure 3: Average Contact Line Rotation

Activities	Medial Compartment	Lateral Compartment
Chair Rising	$7.4 (+/-2.7 \text{ mm})$	$15.9 (+/-2.6 \text{ mm})$
Stair Climbing	$8.6 (+/-3.5 \text{ mm})$	$16.7 (+/-4.0 \text{ mm})$
Step Up Step Down	$4.2 (+/-2.9 \text{ mm})$	$17.0 (+/-4.5 \text{ mm})$

Figure 4: Mean antero-posterior translation

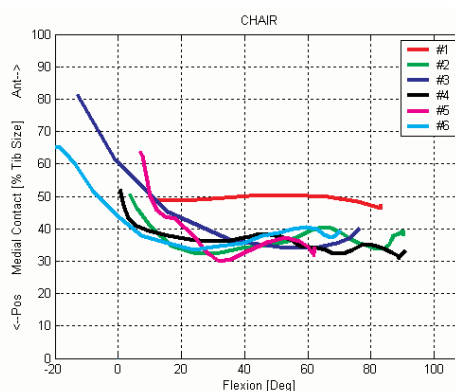


Figure 5: JOURNEY BCS medial contact points through chair rise

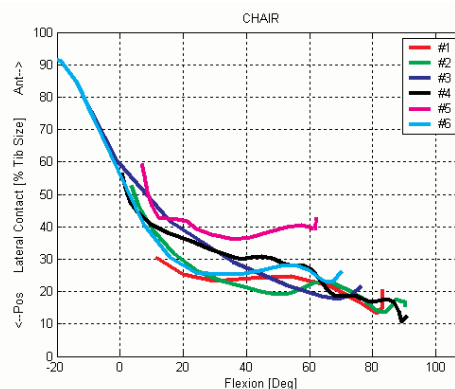


Figure 6: JOURNEY BCS lateral contact points through chair rise

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