In Vivo Kinematic Evaluation Of Cementless Total Hip Arthroplasty During Step-up Activity

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Introduction: Stair climbing is a physically demanding task and a common limitation for patients suffering from end-stage osteoarthritis. Although Total Hip Arthroplasty (THA) is the treatment of choice for severe osteoarthritis, it is not well understood whether THA restores hip kinematics during daily activities. The purpose of this study was to investigate the effect of THA in the 6 degrees of freedom of the hip joint during stair up activity and compare them to the contralateral native hip.

Methods: Twelve patients with well-functioning, cementless, unilateral THA and mean follow-up period of 13.5 ± 7 months participated in this study. All patients received CT scan of the pelvis and proximal femur for 3D model reconstruction. Dual fluoroscopic imaging system was employed to determine in vivo kinematics of both THA and native hip, while subjects performed stair up activity [1] (Figure 1). The process was repeated for 0.5 second before and 0.5 second after full hip extension. Both femoral and pelvic 3D translational (anterior - posterior, medial - lateral, superior - inferior) and rotational kinematics (flexion - extension, abduction - adduction, internal - external rotation) gathered for analysis. The CT-based 3D models were used to identify potential differences between native anatomy and THA components orientation. A two way repeated measure ANOVA was used to compare the kinematics between THA and native hip. Multiple linear regression was used to evaluate the presence of correlation between differences in kinematics and components orientation.

Results: Significant difference in rotational motion was observed in the transverse plane (Internal - external rotation). The THA hip demonstrated on average 3.8° more internal rotation (range: 2.8° to 5.4°) compared to the contralateral native hip during the entire step up movement. Nine patients (75%) exhibited more than 5 difference in internal rotation at some point in the entire step-up activity (range: -8.7° to 13.1°). No significant femoral head sliding was observed in either group (less than 1 mm in all translational axes). The average difference in internal rotation was correlated with the difference in femoral anteversion and anterior-posterior cup (hip joint center) translation between THA and native hips (r²=0.877, p=0.002)

Discussion: Patients with THA tend to perform the step up activity with their hip significantly more internally rotated than the contralateral native hip. The high degree of correlation between increased internal rotation in THA side with femoral anteversion and cup translation suggests that there is a ‘compensatory’ hip internal rotation during stair up activity. This compensatory alteration may account for the smaller moments around the hip joint observed in previous studies [2] and highlights the importance of THA component orientation in restoring hip kinematics during daily activities.

Significance: There was significant difference in the transverse plane (Internal - external rotation) between THA and native hip during step-up activity. The high correlation between gait difference and
implants orientation suggests that optimal component positioning during THA is essential for restoring normal kinematics.
Figure 3. Subject specific internal – external rotation difference between THA and native hip during the step-up activity.