In Vivo Comparison of Minimally Invasive vs. Traditional Total Hip Arthroplasty for Hip Kinematics, Separation and Forces

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Introduction: Minimally invasive surgical approaches (MIS) have been developed to reduce incision length, muscle damage, postoperative scarring, and rehabilitation time. Reduced exposure of anatomical landmarks may result in technical errors and inferior survivorship of total hip arthroplasty (THA). The objective of this study was to determine and compare the in-vivo motions and hip joint contact forces during gait in subjects following THA performed with either MIS or standard surgical approaches.

Materials and Methods: Fifteen subjects were evaluated under weight-bearing in-vivo conditions using fluoroscopy while performing gait on a treadmill. Five subjects were implanted using a MIS anterolateral (AL), five with a MIS posterolateral (PL), and five with a traditional PL THA. Subjects in each group were matched for age, height, weight, body mass index (BMI), diagnosis and femoral head diameter to control for variables possibly having influence on the hip performance and gait kinematics. In-vivo translational and rotational kinematics, obtained using 3D-to-2D image registration technique, were input as temporal functions in a 3D inverse dynamic mathematical model that determines in-vivo soft-tissue and hip bearing surface, articulation forces (Figure 1). The developed mathematical model is based on inverse dynamics model of the lower extremities, which provides the three-dimensional interaction resultant forces and moments. This model was simplified by grouping functionally similar muscles [1,2]. The final derived load profile included contact forces, forces of the rectus femoris muscle, the patella, the patellar ligament and the ligament capsule around the hip during walking. The forces of the hip capsular ligaments were calculated based on the length change, which was obtained from the relative position of the bodies using position vectors. A comparison between the traditional as a control group and the AL and PL MIS patients was performed to determine which group leads to more desirable conditions.

Results: The subjects implanted with both, PL and AL MIS techniques demonstrated significantly less femoral head sliding (separation) than those implanted with the traditional approach (p<0.01). The MIS subjects also experienced lower average maximum peak forces with 3.2 body weight (BW) for the AL-MIS and 2.9 BW for the PL-MIS subjects compared to 3.5 BW for the traditional subjects (p=0.02 and p=0.03, respectively) (Figure 2).

Discussion: This is the first study to compare in-vivo weight-bearing kinematics, separation and kinetics for traditional, AL-MIS and PL-MIS subject groups. Our data indicated in all analyzed parameters differences between the MIS and the traditional groups, with favorable results for the MIS subjects. This may be related, at least in part, to a reduction in stabilizing soft tissues after a MIS procedure, leading to lower bearing surface forces at the femoral head-acetabular cup interface. No differences were observed between the two differing MIS procedures. Our study demonstrates evidence that use of MIS techniques in performing THA may provide short-term advantages as well as implant longevity if the superior mechanics are maintained over longer intervals.