EFFECTS OF STEM CROSS SECTIONAL SHAPE ON TORSIONAL MICROMOTION AND MIGRATION IN AN UNCEMENTED FEMORAL STEM

Introduction: Micromotion and permanent migration of femoral hip components have been associated with thigh pain and inhibition of bone ingrowth or ongrowth at the bone/implant interface. Press-fit uncemented components may offer certain advantages over cemented components if equivalent fixation and stability can be obtained. Geometric differences among implant designs are likely to affect overall fit and stress distribution in the loaded femur, as well as initial implant stability. This study evaluated the hypothesis that axial and rotational micromotion and migration for a tapered wedge trapezoidal shaped femoral prosthesis would be significantly reduced compared to a more anatomic tapered rod shaped femoral prosthesis under combined axial and torsional loads that approximate rising from a chair.

Materials and Methods: Six paired fresh frozen human cadaver femora (mean age 45.3 ± 12.8) were used for testing of two different commercially available femoral stem geometries: one with a tapered wedge trapezoidal cross-section stem and one with a more typical anatomic curved stem with a cylindrical cross section. Radiographs were taken prior to implantation with trials inserted to ensure appropriate fit. A differential variable reluctance transducer (DVRT, MicroStrain, Burlington, VT) with a resolution of 1 µm was attached across the bone/implant interface on the stem at the interface, rotational motion of approximately 1° lateral to the vertical axis in an MTS Bionix system and subjected to a cyclical 0.5 Hz combined axial load of 0-680 N and torsional load of 0-22 N-m for 1000 cycles. In-cycle micromotion and permanent migration were recorded for both motion directions. Statistical analysis for the four motion parameters were performed using a paired t-test with significance set at p< 0.05.

Results: Pre- and post-implanted specimens demonstrated no radiographic fractures or pathology. The micromotion results are summarized in Figure 1 below. Permanent rotational migration was significantly less for the tapered wedge cross-section design stem compared to the cylindrical design (p<0.05). While not statistically significant, a trend towards decreased rotational micromotion was noted for the wedge-shaped cross-section design (p=0.10). No significant differences were found between the devices for axial micromotion or total subsidence.

Discussion: Previous studies on the effect of geometric differences in femoral hip prosthesis designs on initial implant stability have focused primarily on the shape of the stem (straight versus curved), the use of a collar, and cemented versus uncemented. Significant early rotational micromotion (>150 µm) of the femoral stem may preclude bony ingrowth or ongrowth and cause pain. Significant rotational migration may result in a poorly aligned femoral component. Using the geometries of the designs tested and the position of the DVRT on the stem at the interface, rotational motion of approximately 400 µm is equal to 1° of rotation in a retroversion direction. The results of this study demonstrate that an uncemented wedge-shaped prosthesis significantly reduced rotational migration under applied physiological loads compared to an uncemented anatomic design with a cylindrical cross section.

Acknowledgement: This work was supported by Wright Medical Technologies, Inc.

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