Effects of Impaction Assembly Forces on Micromotion and Electrochemical Performance of Taper Junctions

David Pierre, Viswanathan Swaminathan, Laura Scholl, Philip Williams, Kevor TenHuisen.
Stryker Orthopaedics, Mahwah, NJ, USA.

Disclosures: D. Pierre: 3A; Stryker Orthopaedics. V. Swaminathan: 3A; Stryker Orthopaedics. 4; Stryker Orthopaedics. L. Scholl: 3A; Stryker Orthopaedics. 4; Stryker Orthopaedics. P. Williams: 3A; Stryker Orthopaedics. 4; Stryker Orthopaedics. K. TenHuisen: 3A; Stryker Orthopaedics. 4; Stryker Orthopaedics.

Introduction: Mechanically assisted crevice corrosion (MACC) continues to be a major concern in total joint replacements. Significant levels of corrosion continue to be seen in a wide variety of implant designs and recent clinical studies have reported an increase in corrosion-related adverse local tissue reactions. Current bench-top MACC test methods for taper junctions in conventional hip implants are limited in their ability to assess how impaction of the head onto the taper junction may affect the interactions between the materials which may lead to corrosion and fretting motions. We present a method where impaction of the head and initial seating are acquired before electrochemical and micromotion data are concurrently captured during incremental, short-term cyclic fretting corrosion testing of hip stems. The goals of this study are to describe a method of initially impacting each group of generic 12/14 taper couples at various loads and determine the effects on micromotion and fretting corrosion.

Methods: A generic Ti6Al4V stem with a 12/14 taper coupled with a CoCrMo head were investigated (n ≥5) using three different assembly conditions: G1) was not impacted but was pushed down manually with minimal force, G2) was impacted with a 6kN force, and G3) was impacted with a 14kN force. The samples were impacted with a drop tower setup (Instron), during impaction the samples were oriented axially at 90° and impacted 3 times at the predetermined load. Seating displacement was captured and measured through imaging (ARAMIS). The femoral stems were then mounted in a non-conductive ceramic epoxy (ITW Devcon) at 10° valgus/9° flexion. The potted stems were then fixed in an environment chamber in which phosphate buffered saline (PBS, Room T) was placed just above the level of the taper junction. Delrin fixturing containing 3 eddy current sensors was mounted to the head and stem and used to collect pistoning (in z-axis along the length of the taper) and rocking (about the x-axis, or in the medial-lateral plane; and the y-axis, or the anterior-posterior plane) micromotion data about the stem-head taper junction (Fig. 1a). The three eddy current sensors were offset from each other by 120 degrees with one located in the stem’s medial region and the other two located in the anterolateral and posterolateral regions. (Fig. 1b).

Incremental cyclic fatigue loading (R=0.1, 3Hz, 3 min intervals) was applied and loads, motions, and potentiostatic (-50 mV vs Ag/AgCl) fretting corrosion currents were measured. The incremental cyclic fatigue tests were applied in 100 N increments from 100 to 1000 N and then 200 N increments up to 4000 N. Cyclic load-corrosion-micromotion data were continuously captured and subsequently analyzed. Elastic deformation-based motions were accounted for by stiffness measurements of the system after testing and the elastic portions of the motion were subtracted from the total motion to obtain the rigid body subsidence of the head on the neck as well as the rigid-body micromotion for each
cycle. Correlations between fretting currents and cyclic motions were obtained. Fretting corrosion onset loads, currents at max loads, and micromotion data were analyzed statistically with ANOVA (P<0.05 is significant).

**Results:** Onset loads for fretting corrosion were statistically different for G3 in comparison to G1 and G2 (Fig. 2b). Currents at 4000 N (Fig. 2a) were not significantly different between the groups (P>0.05). The head-neck interface exhibited both rigid body micromotion as well as subsidence during cyclic loading (Fig. 3). The micromotion as well as the current at 4000 N both displayed a trend of less micromotion and less current at the end of cyclic loading with the higher impaction forces, but were not statistically significant (P>0.05). The total subsidence for the groups also shows a trend of less subsidence with higher impaction with no statistical difference.

**Discussion:** These tests are short term and performed to determine the effects of impaction force on micromotion and fretting corrosion. Displacements reported in this study are described in reference to the center of the femoral head. These tests are not meant for assessment of the long-term performance of the material components or taper junction but can assess mechanical factors such as stiffness, micromotion and subsidence with fretting currents of components. One G2 individual sample may have been an outlier which skewed the standard deviations from the above reported averages, further analysis is planned.

A short term micromotion and fretting corrosion test method incorporating impaction forces which assess the correlation between assembly and performance has been developed. In this study, Ti6Al4V 12/14 trunnions coupled with CoCrMo heads impacted with different loads had similar results throughout testing though G3 has statistically different onset loads. G3 also showed trends of less micromotion and current at 4000 N.

**Significance:** This test provides a comprehensive method to correlate mechanical (pistoning, rocking, and subsidence) micromotion and electrochemical fretting corrosion results in order to the effect of impaction force at the head-stem taper junction in an in vitro analysis.
Fig. 2: a) Fretting currents at 4000 N (n=5) b) Average onset loads.

Fig. 3: a) Average subsidence b) Average rigid micromotion at 4000 N.