New Test Protocol to Correlate Micromotions and Fretting Corrosion in Modular Tapers

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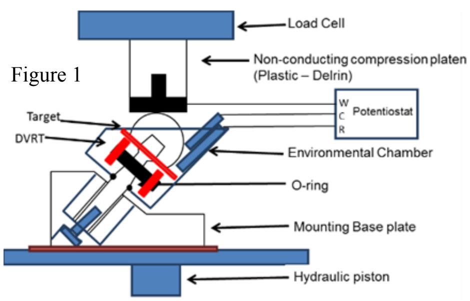
Statement of Purpose: Mechanically-assisted corrosion including fretting corrosion and fretting-initiated crevice corrosion is present in modular devices with metal-on-metal tapered interfaces. Modularity has gained popularity during past two decades in orthopedic surgeries owing to the benefits of providing intra-operative flexibility, simplified revisions, and ability to increase hip stability and range of motion. Fretting corrosion in the presence of crevices accelerates corrosion processes and in some instances may lead to failure of the implant. To date, there has been no device test method developed which can systematically assess and correlate micromotions and corrosion processes at modular interfaces. Hence, the goal of this study is to develop a short-term test protocol to evaluate performance of modular tapers in terms of mechanical (micromotions) and electrochemical (corrosion currents) response.

Methods: Head-neck modular tapers custom fabricated from Ti6Al4V or CoCrMo alloys were used in this study, where neck was made from a simplified circular cylindrical sample onto which the head can be attached. Figure 1 shows the custom-built test fixtures used for the study. The test set-up consists of a mounting base plate (made of aluminum) into which the neck sample can be placed. The environmental chamber is made from polycarbonate and is designed to fit over the mounting base through an O-ring which keeps a water-tight seal around the stem sample. Loads are applied vertically through the head components. The **electrochemical set-up** consists of sample as working electrode, reference electrode (Ag/AgCl) and a counter (carbon) electrode, all immersed in phosphate buffered saline (PBS) at room temperature. For **mechanical assessment**, two submersible non-contact DVRT's (Differential variable reluctance transducers) are mounted to the neck component (superior and inferior head-neck junction regions) by a circular clamp and the sensors are positioned closely to the head component to detect any micro motions that may arise during loading. The test set-is mounted on a servo hydraulic Instron system for application of cyclic loads (starting from 100 N up to 4000N in systematic increments). Currents are measured by holding the potential of the test sample (with a potentiostat) at -50 mV vs Ag/AgCl. Loads, currents and DVRT outputs from both sensors are captured synchronously for the duration of the tests. At the end of the test, a static stiffness calibration test was performed to determine the stiffness for each DVRT.



Micromotion and Elastic Deformation Analysis: The DVRT measurements obtained during the test are comprised of both rigid body and elastic motion (due to compression and bending). Elastic displacement is calculated using stiffness measurements from a static calibration of the sample. This displacement is subtracted from the total motion measured to obtain both subsidence and rigid body motion (Fig. 2).

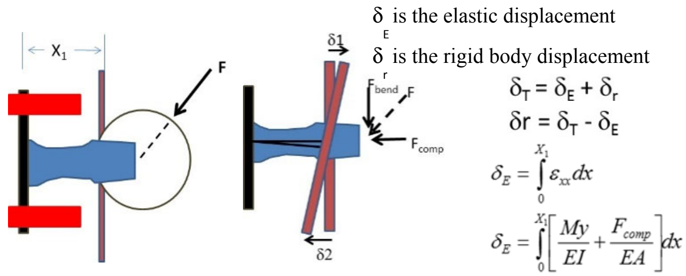


Figure 2: Schematic of DVRT set up and the source of elastic-based motions

Results:

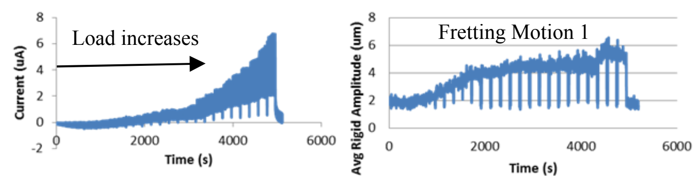


Figure 3: Plot showing fretting currents, rigid body micromotion for a test

Figure 3 summarizes the fretting currents and the rigid-body micromotion data for one DVRT. Fretting currents and micromotion both increase with increasing load. Note that the current and micro-motion plot follow a similar pattern and start at the same time. This indicates a direct link between the two.

Conclusions: The test method developed can measure both fretting corrosion currents and micromotions at head-neck junction. DVRT measurements allows for determination of the relative motions (pistoning versus toggling) that occurs at these taper interfaces. This test method can be used to evaluate performance of modular implants with different taper geometries, materials and other conditions to assess relative effects on fretting corrosion.

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References: S.Y. Jauch, G. Huber, K. Sellenschloh, H. Haschke, M. Baxmann, T.M. Grupp, M.M. Morlock, Journal of Orthopedic Research. 31(8), 2013, 1165-71.

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