Abstract ID-61

COMPARISON OF MICROMOTIONS IN HEAD-STEM AND NECK-STEM TAPER JUNCTIONS

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Keywords: hip, corrosion, taper junction, micromotion

Summary: Metal debris released from taper junctions of modular hip arthroplasties caused by tribocorrosion can promote implant failure. Considerably high taper wear rates due to corrosion were observed in bi-modular implant designs. Less frequent corrosion-related failure is stated for head-stem taper junctions. Micromotion between the taper surfaces is assumed to be a notable factor contributing to fretting and crevice corrosion.

The aim was to predict whether the differences in susceptibility to wear can be attributed to distinct differences in micromotion between the two types of taper junctions.

Finite element models (Abaqus 6.14, DassaultSystemes, France) of a neck-stem junction of a bi-modular THA prosthesis (Rejuvenate, Stryker, USA) and a head-stem taper junction (Metha, Aesculap, Germany) were generated, incorporating specific taper parameters (angle, diameter) obtained from tactile measurements (BHN 805, Mitutoyo, Japan). Micromotions and changing contact areas were investigated for loads of daily activities. Model validation was performed based on optical micromotion measurements. Small windows (< 2.5 mm²) were cut through the female tapers to expose the male taper surface for microscopic topographic measurements (Infinite Focus Microscope, Alicona Imaging, Austria). Feature matching (Matlab 2016b, MathWorks Inc., USA) was applied to the images, determining the local micromotion.

Neck-stem micromotion exceeded 30 µm at the medial taper face. Initial loading revealed a permanent tilt of the neck adapter, which shifted taper engagement from distal to diagonal contact. Furthermore, a rocking motion of the neck adapter within the junction was observed, changing the taper contact conditions during cyclic loading. Micromotion within the head-stem junction was substantially lower (2 µm). Nevertheless, head toggling was also revealed. Results from finite element analyses underestimated experimentally measured micromotion by about 10 %.

Continuous changes in contact area may cause the repetitive disruption of the passivation layer of the metals, making them susceptible for fretting corrosion. The higher micromotion at the neck-stem taper is presumably owed to the larger lever arm (20-fold) between load application and taper engagement. These findings might also apply for prostheses with large head lengths, which showed higher failure rates in-vivo.

Acknowledgements. Funding from the European Union's Seventh Framework Program (FP7/2007-2013) under grant agreement GA-310477 (Life-Long Joints).