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Does SiN coating of tapers influence the mechanics of modular hip prostheses with respect to micromotions and pull-off strength?

Introduction & Aim: Metal debris released from taper junctions of modular hip arthroplasties caused by tribocorrosion can promote implant failure. Micromotion between the mating taper surfaces is assumed to be a major factor contributing to fretting corrosion. Ceramic heads exhibit less taper corrosion. To bypass metal-on-metal contact, a ceramic coating (SiN) for the male taper surface was proposed. The aim was to clarify whether SiN coated tapers can mitigate micromotion and positively influence the strength of the junction.

Material & Methods: 40 head-neck junctions from two suppliers (either CoCr heads, Aesculap, Germany or Ti6Al4V heads, Peter Brehm, Germany) were combined with coated and uncoated neck adapters made of Ti6Al4V or CoCr (each combination n=5). The components were assembled with 2000 N and consecutive dynamic sinusoidal loading representing loads of daily activities was applied (Fmin=230 N; Fmax1=2300 N, Fmax2=4300 N and Fmax3=5300 N). Relative motion between head and neck was measured. The pull-off force was measured quasi-statically.

Results: Ti6Al4V and CoCr necks exhibited relative motion of 12.5±1.2 µm and 6.4±0.4 µm, respectively (Figure 1) if exposed to 2300 N loading. For 4300 N and 5300 N cyclic loading relative motion of 23.8±2.0 µm and 29.7±2.4 µm (Ti6Al4V) and 12.0±0.8 µm and 14.8±1.1 µm (CoCr) was measured, respectively. Tapers made of Ti6Al4V showed significantly increased relative motion ($p<0.001$). Taper coating had no significant influence regarding relative motion ($p=0.969$). However, pull-off strength was increased for coated tapers ($p=0.018$).

Discussion: Coating did not influence relative motion, though bears the potential to separate the metallic taper surfaces and may inhibit fretting corrosion. The higher pull-off strength might potentially reduce the risk for head loosening.

Recent Publications:

1. Del Balso et al. (2015) Article title. Bone Joint J. 97-B: 911-16.
2. Gilbert et al. (1993) Article title. J Biomed Mater Res. 27: 1533-44.
3. Kocagoz et al. (2016) Article title. Clin Orthop Relat Res. 474: 985-994.
4. Bergmann et al. (2016) Article title. PLoS One. 11 (5): e0155612.
5. Haschke et al. (2016) Article title. Proc Inst Mech Eng H. 230 (7): 690-99.

Biography

A Falkenberg gained his expertise in mechanical engineering and biomechanics in educational institutions (Magdeburg University, Rostock University) and research (TUHH, Hamburg). Currently, he is focused on mechanical testing of modular hip prostheses, specifically determining micromotions within taper junctions, which are assumed to promote implant failure. The presented method helps to improve implant longevity and patient contentment by identifying risk factors in implant design.

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