Stress and Strain in the Trunnion with Big Heads: Tribocorrosion Turbocharged

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Introduction: The use of large heads has increased 10 fold since the introduction of highly cross-linked polyethylene and metal-on-metal bearing surfaces. Cobalt-chromium (Co-Cr) has approximately twice the modulus of elasticity of titanium (Ti) alloys. Most stems used in the USA today are made out of Ti alloys. Our objective was to investigate the effect of large Co-Cr heads on the resulting stresses and strains in the trunnion.

Methods: A 3D model was constructed of a standard 12/14 trunnion using Simulia's ABAQUS 6.12-3.5 head sizes were modeled. The model had 130.6k nodes and 93.2k elements. To better capture the surface stress, first order membrane elements were overlaid on tetrahedron elements. The trunnion was assigned the material properties of Ti alloys and the heads of Co-Cr. A pressure load of 2.1 MPa was applied to simulate a 2.6 body-weight force at the hip.

Results: The area underneath the head had a significant increase in stresses and strains as the heads increased from 28mm to 40mm. For a 28mm diameter ball the maximum principal stress was 20.3 MPa, for a 32mm ball it was 36.0 MPa, and for a 40mm ball it was 43.8 MPa. Our data shows a 2X increase across the ball diameters studied.

Discussion and Conclusions: Our model suggests that increase in head size significantly augments the stresses and strains at the trunnion-head junction. This increase in motion and stresses at the trunnion head junction can significantly contribute to tribocorrosion and metal ion release. This effect can be magnified if an additional interface exists as in a double modular trunnion.