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Accurate determination of material loss at the taper interface of retrieved metal-on-metal hip replacements

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Background

• Worldwide interest in failure of Metal-on-Metal (MoM) hips.
• 31,171 modular MoM implanted in UK 2003-2011 [1].
• Failure rate of 29% reported in some modular Large Head MoM at 6 years [2].
• NJR data suggests 43% of hip failures are unexplained
• Disparity between wear of modular LHMoM hips & observed blood ion levels could be due to taper wear/corrosion.

• Quantification of material loss is vital tool in understanding failure mechanisms
• Accuracy required ~ 1 µm.

Equipment and setup:
• Taylor Hobson Talyrond 365 Roundness Measurement Machine
• Head/stem mounted on rotating table, stylus measures deviations in profile.
• Series of vertical straightness profiles combined into cylinder maps.
• Gauge resolution 30 nm, spindle run out 20 nm.

Strategy:
• The surface map consists of 360 vertical profiles, angular spacing of 1°, max linear spacing of 120 µm.
• Each profile contains 7000 points with spacing of 2 µm
• Total number of points in each data set is 2.5 million

Data analysis
• Software tools allow the calculation of volumetric and linear wear
• Isolation of reference surface - linear/quadratic removal of form.
• Modified Abbott Firestone curve used to remove debris and delineate material loss.
• Is material lost as a result of corrosion or wear?
• Presence of imprinting – evidence supporting galvanic corrosion.
• Corrosion and wear seem to be coupled and interacting.
• Goldberg scores are indicative of the amount of material loss when compared to measurement results.
• Deposits and maximum linear wear values located mostly at the distal end of taper
• One sided material loss of head taper indicative of toggling effects of micromotion and components form tolerance.

Wear measurement results

Analysis Method

• Female head taper surface exhibits imprint of the male stem taper surface suggesting evidence of galvanic corrosion.
• Roundness machine ideal for taper measurement due to high resolution and low observed wear volumes
• Unworn region identification and removal of deposits important for setting the baseline.
• Fitting algorithm takes into account possible 'barrelling' or 'hogging' of the component due to manufacturing errors.

References