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

P Bills1, L Blunt1, R Racasan1, J Skinner2, A Hart2,3

1EPSRC Centre for Innovative Manufacturing in Advanced Metrology, University of Huddersfield, UK; 2Royal National Orthopaedic Hospital, Brockley Hill, Stanmore, UK; 3London Implant Retrieval Centre, Institute of Orthopaedics and Musculoskeletal Science, University College London, UK.

Background

- Worldwide interest in failure of Metal-on-Metal (MoM) hips.
- Failure rate of 29% reported in some modular Large Head MoM at 6 years [2].
- NUR 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

Discussion

- 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.

Analysis Method

- Software tools allow the calculation of volumetric and linear wear

Data analysis
- Modified Abbott Firestone curve used to remove debris and delineate material loss.
- Form removal

Conclusions

- 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


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http://www.hud.ac.uk/cimam/paul.bills@hud.ac.uk