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

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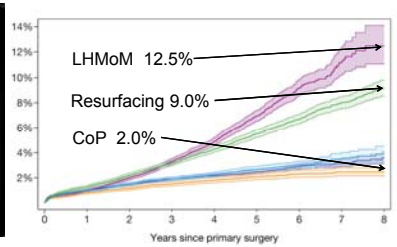
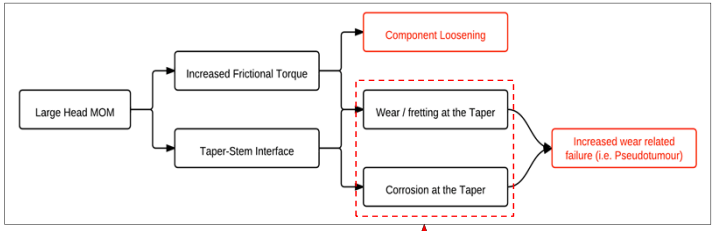
Background

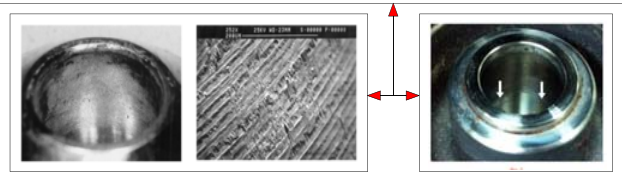
- Worldwide interest in failure of Metal-on-Metal (MoM) hips.
- 31,171 modular MoM implanted in UK 2003-2011 **[1]**.
- Failure rate of 29% reported in some modular Large Head MoM at 6 years **[2]**.
- NJR data suggests 43% of hip failures are unexplained
- Disparity between wear of modular LHMoM hips & 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.

LHMoM Failure Mechanism





Goldberg et al, 2002 **[3]**

Langton et al, 2012 **[4]**

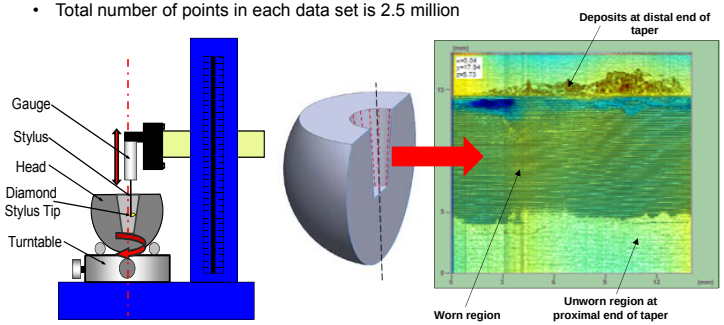
Measurement method

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:

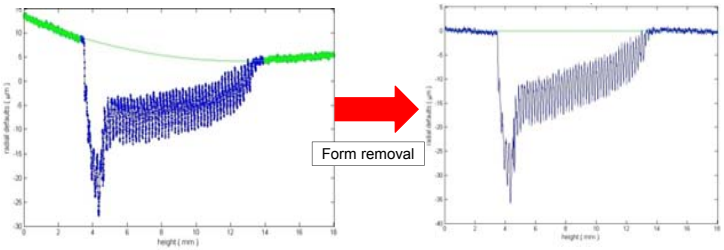
- The surface map consists of 360 vertical profiles, angular spacing of 1°, max linear spacing of 120 µm.
- Each profile contains 7000 points with spacing of 2 µm
- Total number of points in each data set is 2.5 million



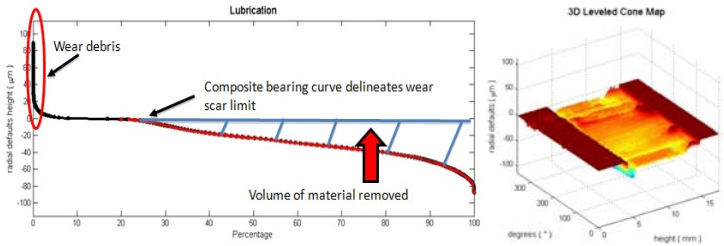
Analysis Method

Data analysis

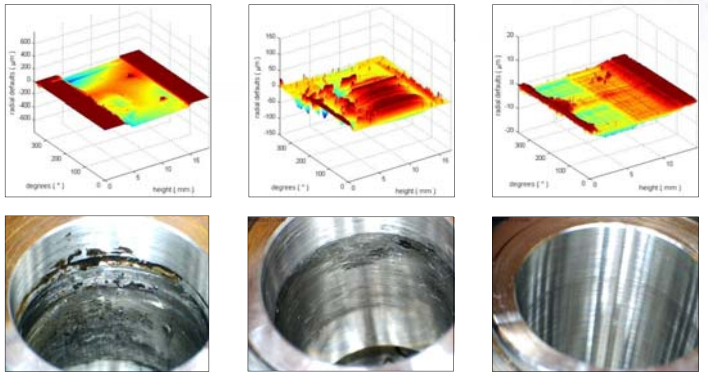
- Software tools allow the calculation of volumetric and linear wear
- Isolation of reference surface - linear/quadratic removal of form.



- Modified Abbott Firestone curve used to remove debris and delineate material loss.



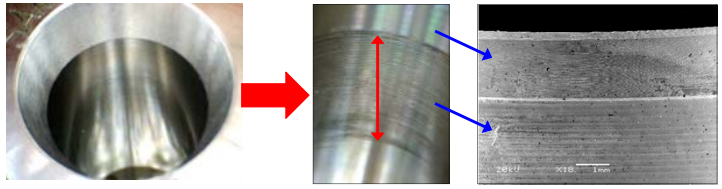
Wear measurement results



Goldberg score: 4 Very Severe Corrosion Material lost: 25.19mm³	Goldberg score: 3 Severe Corrosion Material lost: 6.21mm³	Goldberg score: 2 Mild Corrosion Material lost: 1.06mm³

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.



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

[1] Smith AJ et al. *Lancet* 2012; 379: 1199-1204.
[2] National Joint Registry for England and Wales, 8th Annual Report 2011.
[3] Goldberg JR et al. *Clin. Orthop Related Res* 2002; 401: 149-161.
[4] Langton DJ et al. *Bone Joint Res* 2012; 1: 56-63.

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