WHAT IS REQUIRED TO MEASURE THE WEAR OF EXPLANTED METAL-ON-METAL HIPS?

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Background

- Worldwide interest in failure of Metal-on-Metal (MoM) hips
- 150,000 large diameter MoM hips implanted in UK
- Failure rate of resurfacings is 7,6%, compared to 3% for cemented hips
- Three designs of MoM hips have been removed from the market in past 4 years
- NJR data suggests 43% of hip failures are unexplained
- Wear analysis is vital tool in understanding failure mechanisms
- Edge loaded cups have linear wear rate 7 times greater than non-edge loaded

Our aims:

To assess two of the most commonly used techniques namely roundness measurement and co-ordinate measurement and consider the advantages and disadvantages of both in detail.

Measurement Requirements

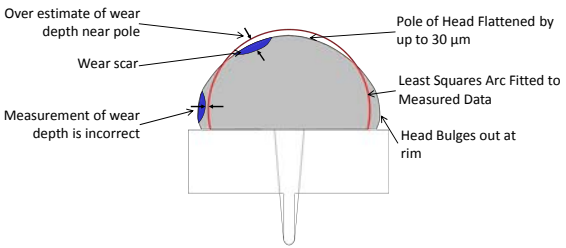
- No British Standard to measure wear of explanted hip joints
- No validated measurement protocol in the literature
- Typical linear wear rates for explanted hips are:

  Cup 0 – 180 µm/year

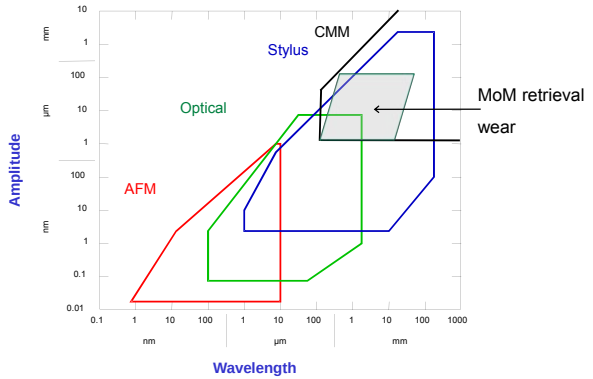
  Head 0 – 750 µm/year
- Accuracy required ~ 1 µm

Wear and Form

- Hip joints are not perfectly spherical as manufactured – the deviations are referred to as "Form"
- The manufactured shape of the components is unknown
- Form errors can be up to 30 µm
- Wear may be smaller than form errors
- Need to be able to separate wear and worn when analysing data



Comparing the Amplitude Wavelength plots for different instrument types[1]



Talyrond

The Talyrond 365 is a stylus based roundness machine.

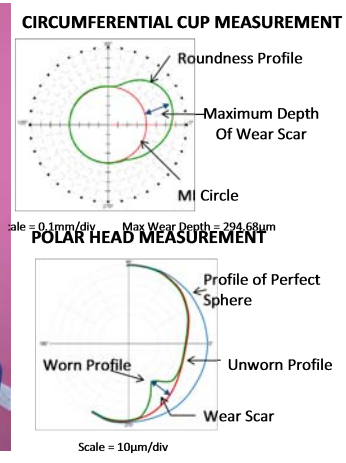
Hip located on a rotating table and the stylus measures the deviation from a perfect circle.

Single profile measured to an accuracy of 30 nm and up to 72,000 data points per rev.

Accuracy: Gauge > 12 nm

Spindle <0.02 µm

Individual roundness profiles can be stitched together to build up 3D maps



Co-ordinate measuring machine (CMM)

The Zeiss PRISMO is a co-ordinate measuring machine.

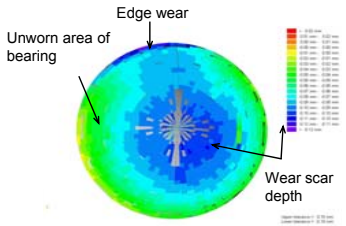
- Hip located in a chuck, probe measures grid of points, scanning whole surface to determine extent of 'unworn area'.
- Unworn area scanned to create a reverse engineered 3D CAD surface which represents the component 'pre-wear' surface.
- Whole surface scanned and deviation is mapped.
- The maximum linear wear and wear volume are then calculated directly.

DIN EN ISO 10360-2

Probing error: 0.7µm

DIN EN ISO 10360-4

Scanning Error: 1.3µm



Comparison of Talyrond & CMM

	CMM	Talyrond
Cost	~£25 - 250k	~£10 - 80k
Resolution	0.02 – 2 µm	1 – 10 nm
Total Uncertainty	Probing 0.7 µm Scanning 1.3 µm U3 ~ 4 µm	Relative 30 nm Absolute 4 µm
No of data points	10, 000 +	Up to 72,000 points per revolution
Time	15-30 minutes per component dependent on point density	Up to 1.5 hrs per component for 3D map. 2D profile in <1 minute
Absolute or Relative Measurement	Traceable Calibration	Calibrated from traceable standard

Conclusion

- The CMM and Talyrond are both instruments suited to measuring wear of explanted hips.
- Development of robust measurement protocol and standard required including;
  - Comprehensive study of good practice.
  - Verifiable uncertainty statements.

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1 Stedman, M, 1987 basis for comparing the performance of surface measuring machines. *Prec. Eng.* **9**, 149-152