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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

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.

Comparison of Talyrond & CMM

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

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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http://www1.imperial.ac.uk/medicine/hipcentre

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