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Effect of Uncertainty on Wear Measurement of Metal-on-metal Total Hip Replacement Components

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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 29% reported in some Large Head MoM at 6 years [1].
- Three designs of MoM hips have been removed from the market in past 4 years
- NJR data suggests 43% of hip failures are unexplained
- Volumetric accuracy not quoted or incorrectly determined.

Measurement Requirements

- Wear analysis is vital in understanding failure mechanisms
- Typical linear wear rates for explanted hips are:
  - <span class="reference" data-query="NJR data suggests 43% of hip failures are unexplained">43%</span>
  - >150,000 large diameter MoM hips implanted in UK.
  - Worldwide interest in failure of Metal-on-Metal (MoM) hips.
  - NJR data suggests 43% of hip failures are unexplained

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Measurement related uncertainty

- Scanning strategy is a visual representation of the path of the stylus across the surface of the component. Minimizing the uncertainty through appropriate point spacing parameters.
- A study has been conducted to assess the impact of scanning strategies and parameters on point spacing distribution, stylus travel and volume difference when compared to a nominal hemisphere volume with a diameter of 50mm (see table).

<table>
<thead>
<tr>
<th>Method</th>
<th>Linear Wear (mm/year)</th>
<th>Volumetric Wear (mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM (under development)</td>
<td>0.318</td>
<td>11.873</td>
</tr>
<tr>
<td>ISO 14242-2:2000</td>
<td>0.215</td>
<td>87.820</td>
</tr>
</tbody>
</table>

Analysis related uncertainty

- The wear patch influences the mean error of the LSO fitting process.
- The LSO fitting determines the centre and radius of the unworn bearing surface.
- The wear area influences the position of the fitted sphere as well as the radius.
- Depending on the magnitude and position of wear patch the fitting process can produce bicuspid result.
- Interactive user selection of the unworn surface is critical in minimizing analysis uncertainty.

Conclusions

- Measurement uncertainty is multi-factorial
- Analysis method must be controlled and understood
- Determination of unworn geometry key factor in accuracy of measurement method and is stable only if done post process.
- Wear area must be isolated from unworn geometry prior to fitting.

References