What is required to measure the wear of explanted metal-on-metal hips?

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

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

Presented at
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12 – 13 July, 2010

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

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

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.

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

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.

Cost ~£25 - 250k ~£10 - 80k
Resolution 0.02 – 2 µm 1 – 10 nm
Total Uncertainty Probing 0.7 µm Scanning 1.3 µm
No of data points 10,000 + Up to 72,000 points per revolution
Time 15-30 minutes per component
Up to 1.5 hrs per component for 3D map.
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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Talyrond

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

Wear and Form

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>
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<th>CMM</th>
<th>Talyrond</th>
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<tbody>
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<td>Up to 1.5 hrs per component for 3D map, 2D profile in &lt;1 minute</td>
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<td>Absolute or Relative Measurement</td>
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</tbody>
</table>

Finite Element Analysis (FEA)

- 3D simulation of MoM joint in contact with a femur
- Comparison of different designs with respect to wear and clinical outcome
- Potential to predict long-term performance

References

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

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