The Definition of Taper Failure in Metal-On-Metal Modular Total Hip Replacement

Adverse soft-tissue reactions after metal-on-metal modular total hip arthroplasty are associated with increased bearing surface wear. Recent reports suggest the modular junction is a considerable source of corrosion, material loss and metal ions.

Methods

Corrosion was qualitatively assessed for 111 components of three different designs; the ASR XL (DePuy), the BHR (Smith and Nephew) and Durom (Zimmer) devices. A peer-reviewed qualitative grading system was used (adapted from Goldberg et al).

<table>
<thead>
<tr>
<th>Corrosion Severity</th>
<th>Appearance of the taper surface</th>
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<tr>
<td>None (1)</td>
<td>No visible signs of corrosion</td>
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<tr>
<td>Mild (2)</td>
<td>&lt;30% of taper surface discoloured or dull</td>
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<tr>
<td>Moderate (3)</td>
<td>&gt;30% of taper surface discoloured or dull or &lt;10% of taper surface covered in black debris</td>
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<tr>
<td>Severe (4)</td>
<td>10-30% of taper surface covered in black debris</td>
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<tr>
<td>Very Severe (5)</td>
<td>&gt;30% of surface covered in black corrosive debris</td>
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Detailed examination of material loss was performed on 10 ASR XL hips that failed due to debris-induced synovitis but had low bearing surface linear wear rates (<10μm/year combined head/cup). The female taper interface was divided into quadrants and profilometry analysis undertaken using The TESA Rugosurf 90-G Surface Roughness Gauge (Hexagon Metrology, Rhode Island, USA).

Results

86 out of the 89 components experienced corrosion, with at least moderate corrosion observed in 54 (61%). No difference was observed between manufacturers (p=0.52). The median volumetric loss was 3.08 mm³ (range: 0.61-9.44). The maximum wear depth ranged from 14-85 μm, and commonly occurred where the base of the trunnion met the female taper. Profilometry and scanning electron microscopy showed that the ridges on the trunnion had imprinted into the female taper surface. Therefore wear occurred throughout the taper interface.

Discussion

Large diameter femoral heads have increased the mechanical demands at modular junctions, leading to enhanced wear and susceptibility to mechanically-assisted crevice corrosion. Metal debris has been implicated in the formation of soft-tissue reactions and we have shown that material loss at modular junctions can be substantial. We propose hip systems that fail due to debris-induced synovitis with evidence of taper wear in the absence of bearing surface wear be called “taper failures”. Currently there is no other obvious culprit for the high failure rates of ASR XL when compared to ASR resurfacing.

Conclusions and Definition

- Material loss from modular junctions is clinically significant
- Definition of taper failure: hip systems that fail with debris-induced synovitis resulting predominately from material loss at the modular junction.


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Figure 1 – A 9mm/10mm female taper retrieved after 56 months with very severe corrosion
Figure 2 – A 12mm/14mm taper retrieved after 40 months with a the zone of imprinting (red arrow)
Figure 3 – A scanning electron microscopy image showing a femlae taper surface with typical mechanical wear and imprinting, with black corrosion debris between the imprinted grooves.

Figure 4a 4b