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

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Background and Aims

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).

Corrosion Severity	Appearance of the taper surface
None (1)	No visible signs of corrosion
Mild (2)	<30% of taper surface discoloured or dull
Moderate (3)	>30% of taper surface discoloured or dull or <10% of taper surface covered in black debris
Severe (4)	10-30% of taper surface covered in black debris
Very Severe (5)	>30% of surface covered in black corrosive debris

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).

Figure 1

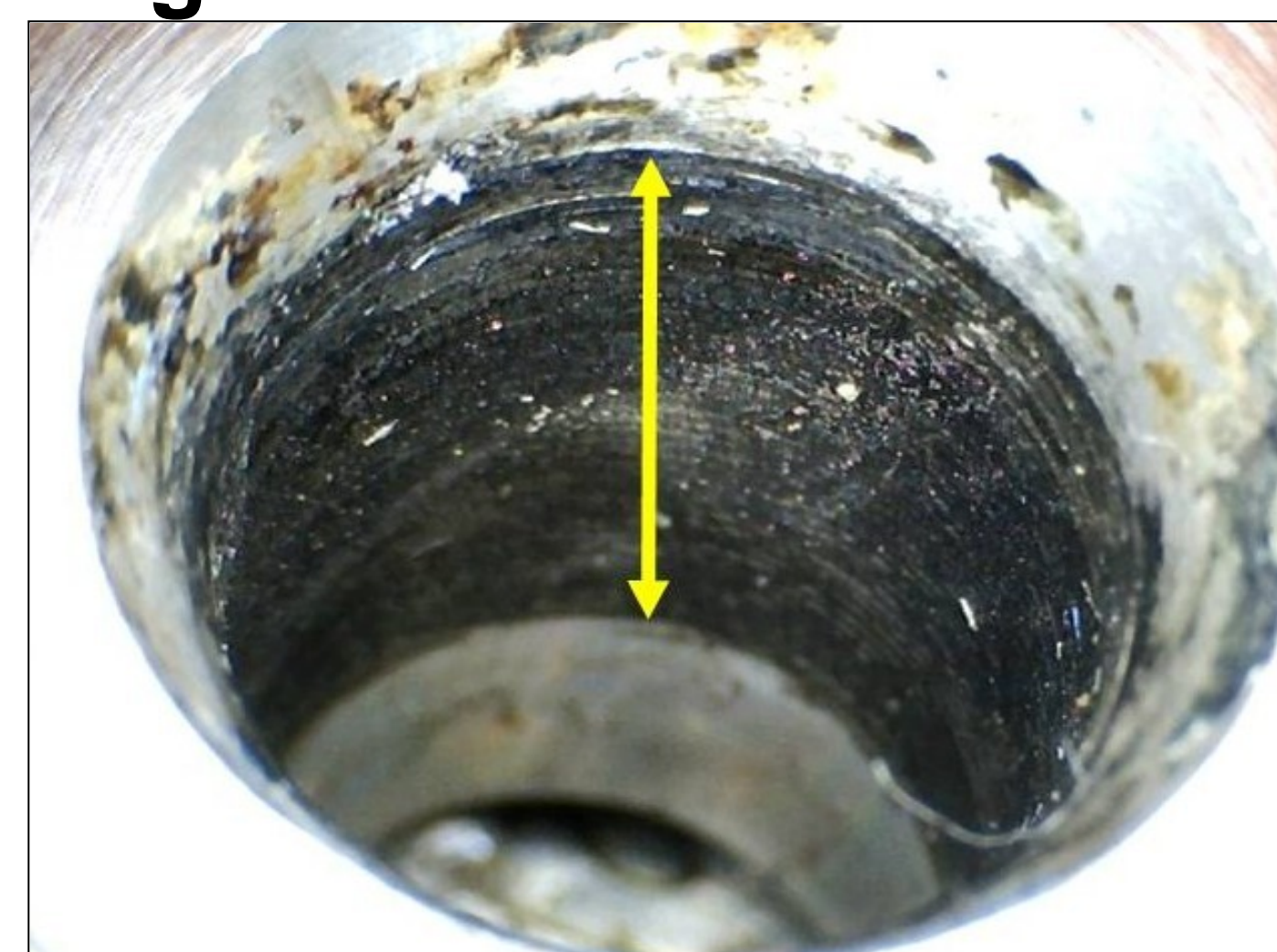


Figure 2

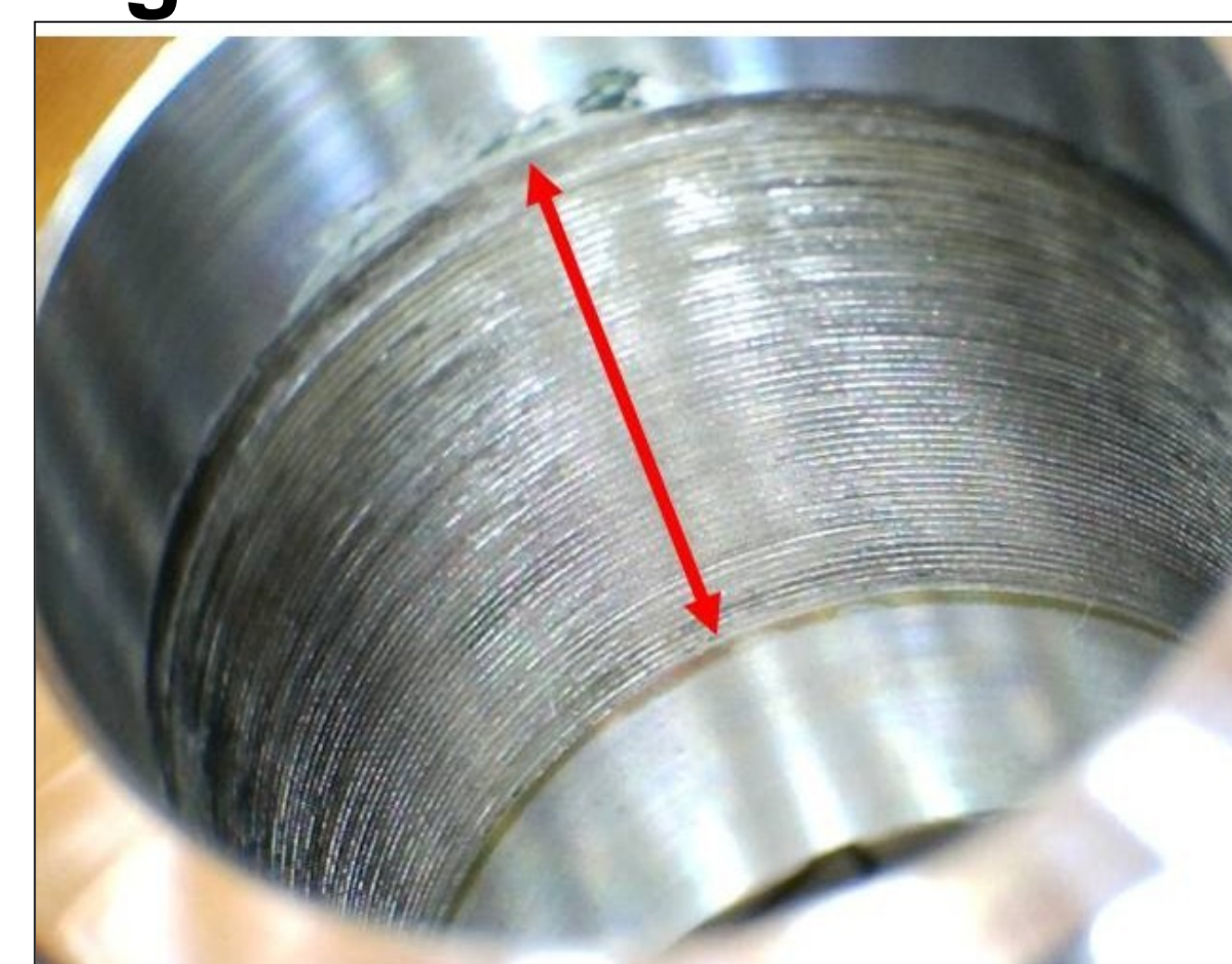


Figure 3

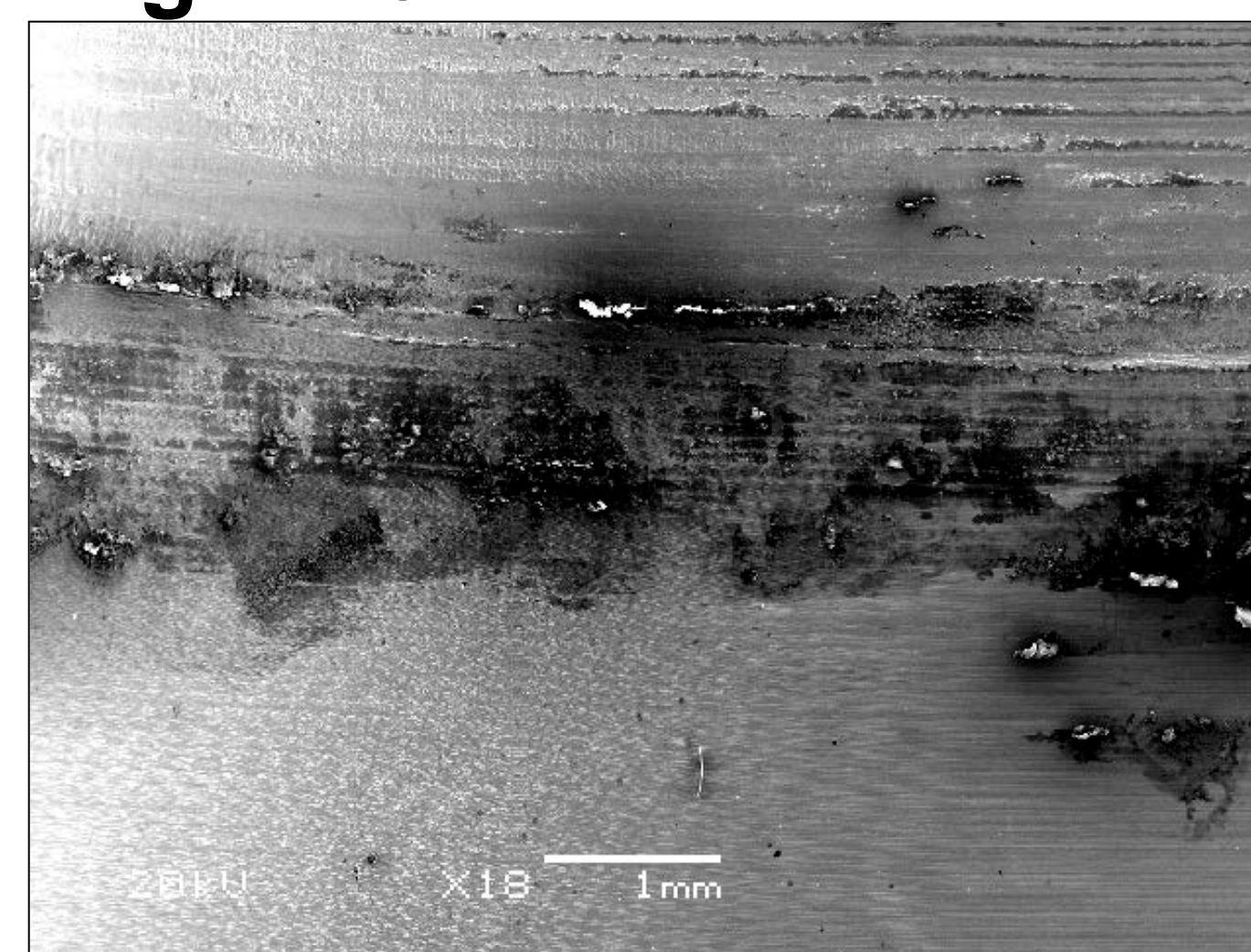
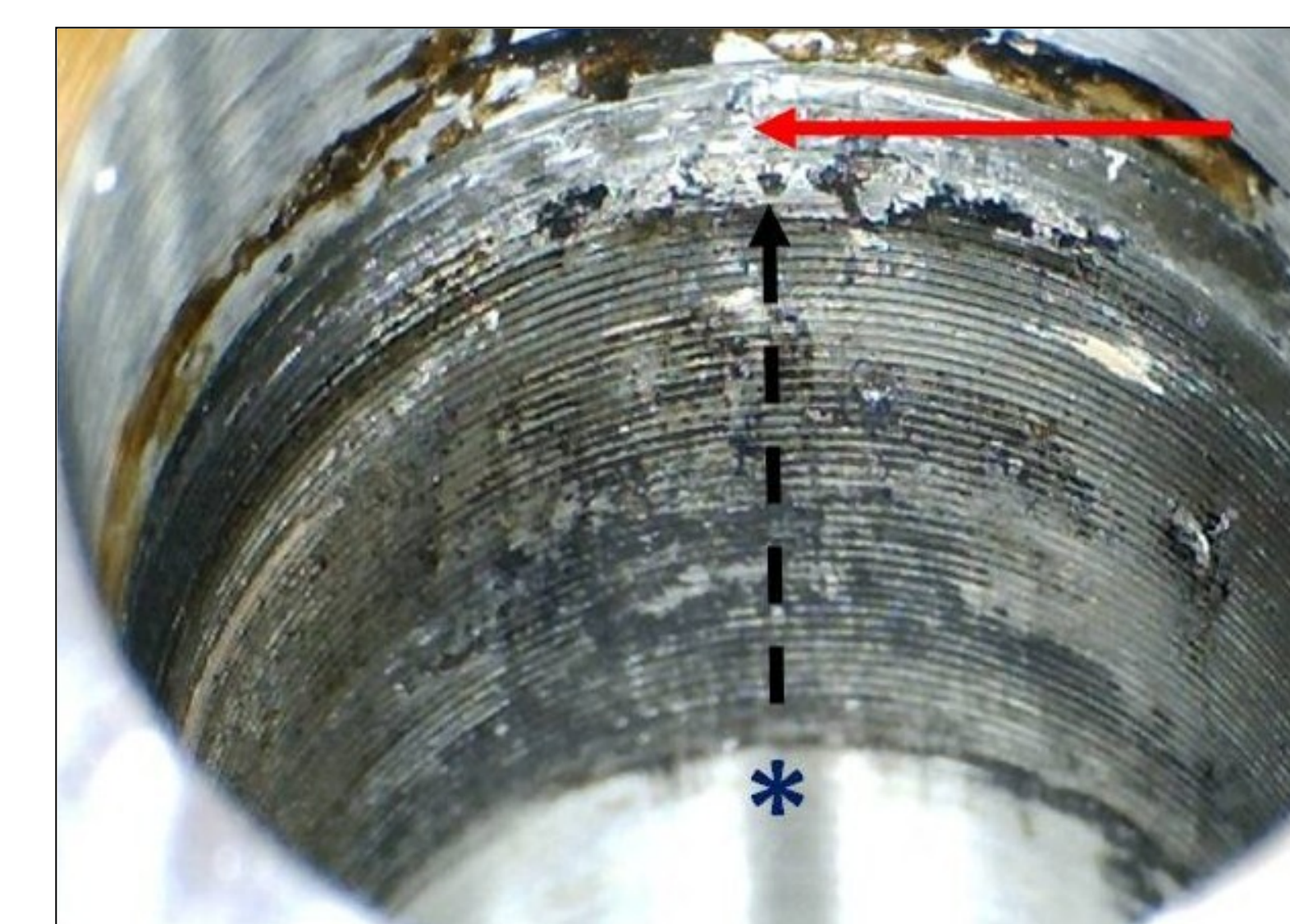


Figure 1 – A 9mm/10mm female taper retrieved after 56 months with very severe corrosion
 Figure 2 – A 12mm/14mm taper retrieved after 40 months with a the zone of imprinting (red arrow)
 Figure 3 – A scanning electron microscopy image showing a femlae taper surface with typical mechanical wear and imprinting,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

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.

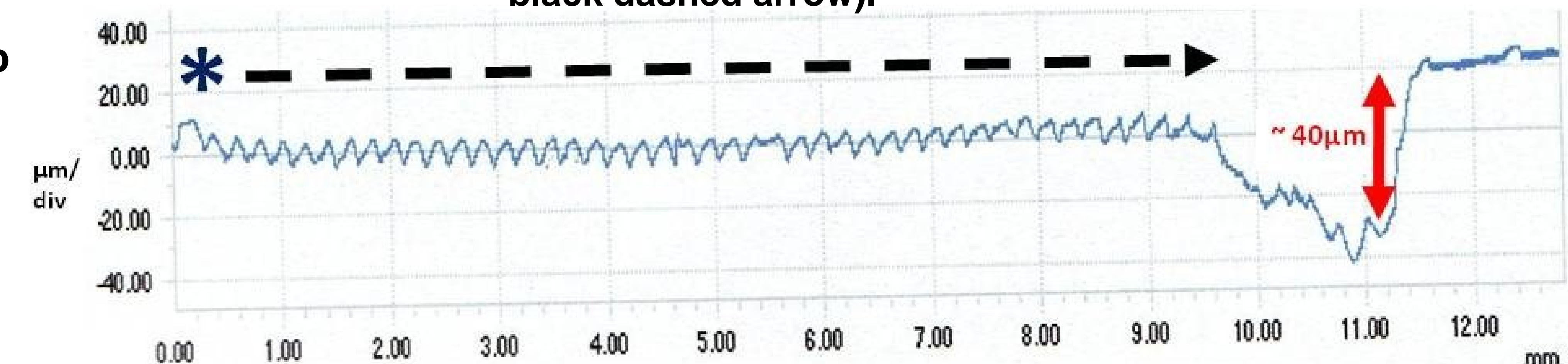
Figure 4a



4a) A photograph of a female taper surface with severe corrosion. A wear scar is visible at the superficial margin where the base of the trunnion was in contact (red arrow).

4b) A profilometry tracing of the same female taper surface. The trace at 0.00mm indicates the surface profile at the base of the bore (shown by asterisk) and the profile at 12mm corresponds to a location near the rim of the bore. The red arrow shows material loss to a depth of approximately 40µm. The ridged pattern can be seen over a distance of between 9-10 mm leading up to the wear scar (shown by the black dashed arrow).

Figure 4b



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.**

Reference: Goldberg JR et al. A multicenter retrieval study of the taper interfaces of modular hip prostheses. *Clinical orthopaedics and related research* 2002;401: pp. 149-161.