CORROSION IS THE MAIN MECHANISM OF MATERIAL LOSS AT THE TAPER JUNCTION OF LARGE HEAD METAL ON METAL HIP REPLACEMENTS

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Abstract: Material loss at the head-stem taper junction may contribute to the high early failure rates of stemmed large head metal-on-metal (LH-MOM) hip replacements. We sought to quantify both wear and corrosion and by doing so determine the main mechanism of material loss at the taper. This was a retrospective study of 78 patients having undergone revision of a LH-MOM hip replacement. All relevant clinical data was recorded. Corrosion was assessed using light microscopy and scanning electron microscopy, and graded according to a well-published classification system. We then measured the volumetric wear of the bearing and taper surfaces. Evidence of at least mild taper corrosion was seen in 90% cases, with 46% severely corroded. SEM confirmed the presence of corrosion debris, pits and fretting damage. However, volumetric wear of the taper surfaces was significantly lower than that of the bearing surfaces ($p = 0.015$). Our study supports corrosion as the predominant mechanism of material loss at the taper junction of LH-MOM hip replacements. Although the volume of material loss is low, the ionic products may be more biologically active compared to the particulate debris arising from the bearing surfaces.

Introduction: Material loss from the head-stem taper junction may contribute to the high revision rates of large head metal-on-metal (LH-MOM) hip replacement[1,2]. However, it is unclear whether material is lost due to mechanical wear or corrosion. The purpose of this study was to quantify wear and corrosion at the taper junction and in doing so determine the predominant mechanism of material loss.

Hypothesis: We hypothesised that in LH-MOM retrievals, corrosion of the taper surfaces would be evident in the majority (> 50%) of cases, and volumetric wear at the taper would be greater than that at the bearing surfaces.

Methods: We retrieved 168 components from 78 patients who had undergone revision of a LH-MOM hip. We recorded all relevant clinical variables, including pre-revision blood metal ion levels. The head and stem taper surfaces were examined using light microscopy at 40x magnification. Severity of corrosion was graded using a well-published four-tiered classification[3,4]. Selected components were then sectioned and examined using scanning electron microscopy (SEM). Finally, volumetric wear of the bearing surfaces was measured using a coordinate measuring machine, and of the taper surface using a roundness measuring machine. We used both univariate and multivariate statistical analyses.

Results: 81 out of 90 (90%) retrieved head and stem taper surfaces showed evidence of corrosion. Of these, 14 were classified as mildly corroded, 26 as moderately corroded, and 41 as severely corroded. Microscopy also revealed evidence in all cases that the machined thread of the stem taper had been transferred, or "imprinted" onto the head taper surface. An example of severe corrosion and "imprinting" is shown in Figure 1. SEM confirmed the presence of corrosion debris, pits and fretting damage. Volumetric wear of the taper surfaces was significantly lower than the combined volumetric wear of the bearing surfaces ($p = 0.015$).

Figure 1: Photographs showing a case of severe taper corrosion with imprinting of the stem taper screw thread onto the head taper surface

Discussion and Conclusions: The taper junction contributes significantly less than the bearing surfaces to the total wear volume. Therefore the volume of material alone cannot explain the higher failure rate of LH-MOM when compared to MOM hip resurfacing. However, our results support corrosion as the main mechanism, and it is possible that ionic corrosion products are a more potent inflammatory stimulator than the particulate wear debris originating from the bearing surfaces. The mechanism is likely to involve galvanic and mechanically assisted corrosion. The taper junction provides an ideal crevice and the screw thread facilitates fluid movement to and from the joint. Imprinting of the stem taper surface supports the role of galvanic corrosion, whereby one surface (the head taper) is preferentially corroded.

Clinical Significance: A predominantly galvanic process has important implications for revision surgery, and surgeons can be reassured that the stem taper is likely to be undamaged allowing retention of a well-fixed femoral stem.

Key Refs: [1]Smith et al, 2012, [2]Langton et al, 2012, [3]Goldberg et al, 2002, [4]Kop et al, 2009.