Solid Corrosion Products in Metal-Metal Hip Tissues: Implications for Metal Sensitivity?

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Introduction

Cobalt-chromium (CoCr) wear products from metal-metal total hip replacement (MMTHRs) bearings differ substantially from polyethylene (PE) debris and the clinical consequences of these products are the subject of ongoing research. One concern is that some patients can mount a hypersensitivity response that causes pain and can require implant revision. Unlike osteolysis that is induced by PE wear particles, metal hypersensitivity does not appear to depend on the amount of wear debris in the tissue surrounding metal joint prostheses, but rather, it may be triggered by certain particle characteristics or the way in which they change after exposure to the joint milieu.

From the analysis of MM hip periprosthetic tissues, “drop-like” inclusions in macrophages have been associated with hypersensitivity reactions [1]. Currently, their source and composition are unknown. Others have reported the presence of chromium-rich material thought to be a solid corrosion product which may also cause a hypersensitivity response [2]. The purpose of this study was to examine tissues from failed MM hips for these specific features and to correlate their presence with implant type, cellular response, and mode of failure.

Methods and Materials

12 MMTHRs and 10 MM hip resurfacing arthroplasties (HRAs) were studied. For comparison, 6 non-MM were also analyzed; 4 metal-on-PE THRs, 1 metal-on-ceramic THR, and 1 CoCr hemi-resurfacing. Two tissue sites were used per case. The majority of hypersensitivity cases were in HRAs.

Tissues were fixed in formalin, paraffin embedded, sectioned and stained with hematoxylin and eosin (H&E), Giemsa, Periodic-Acid Schiff (PAS), or Perls stain for iron. Analysis was performed using light microscopy at 40x-400x. Slides were examined in a blinded fashion for the presence of corrosion products, “drop-like” inclusions, fibrin, bleeding and metal debris. Serial sections were sputter coated and analyzed with Scanning Electron Microscopy (SEM) and Electron Dispersive X-ray Analysis (EDAX). Corrosion products were defined as yellowish, opaque, sheet-like rectangular material on H&E, showing no birefringence, and having Cr or Ti peaks on EDAX. “Drop-like” inclusions were defined as beige/gold, translucent, intracellular round bodies on H&E, showing no birefringence and staining deep blue with Giemsa, but PAS and Perls stains were negative.

Results

Small amounts of solid corrosion products were found in 4 of 12 MMTHRs, 0 of 10 MMRHAs, and 2 of 6 control tissues. They ranged from 5-400µm and were often found within giant cells and were associated with visible metal debris in surrounding macrophages. There was no apparent immunological or inflammatory response to this material. Titanium and oxygen peaks were identified using EDAX and no chromium rich material was identified. “Drop-like” inclusions ranged from 2-15µm and were found almost exclusively at tissue edges and typically close to adherent fibrin. They were usually abundant but focal, and although they were found in 4 of the cases with metal hypersensitivity, they were also found in cases that failed from component loosening and high wear that showed little evidence of a hypersensitivity reaction on histological evaluation. They were not found in any of the non-metal-metal control tissues. Metal peaks were not identified with EDAX.

Discussion

The solid corrosion products we found occurred in THRs, which is consistent with previous reports of tapered neck wear as the source [2,3]. These were titanium alloy stems with CoCr femoral heads mated to a CoCr or a PE socket. We did not detect chromium rich solid corrosion products and the lack of an immune or inflammatory response likely reflects the high degree of tissue tolerance for titanium debris in small amounts.

“Drop-like” inclusions were included in the features Prof Hans Willert associated with a lymphocyte dominated response to modern MM hips that is now often described as ALVAL [1]. We found it was often difficult to visualize and differentiate these from other intracellular globular material such as haematin, fat and cement voids. It does seem clear, however, that they are not exclusively associated with metal hypersensitivity because of their presence in multiple failure modes, including long-term high wear cases. Because we consistently noted their proximity to fibrin, which is abundant in tissue from metal hypersensitivity and high wear related failures, these inclusions may be related to fibrin breakdown. Whether the fibrin contains nanoparticulates or metal-protein complexes that induce drop-like inclusion formation is the subject of ongoing research.

References