Adverse Local Tissue Response in Metal-On-Metal Surface Replacement Compared to Metal-On-Polyethylene Bearings with Corroded Modular Junctions

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Statement of Purpose: An unusual inflammatory local tissue response, unrelated to polyethylene wear debris, has been reported in patients hosting metal-on-polyethylene bearings when there is corrosion of the head-neck modular junction and one or both sides of the junction is made from CoCr alloy(1). The clinical presentation appears similar to the adverse local tissue response associated with metal-on-metal bearings. The purpose of this study was to compare the histological and immunohistochemical patterns of these adverse tissue responses to determine their differences and similarities in patients hosting metal-on-polyethylene bearings compared to those hosting metal-on-metal bearings.

Methods: Periprosthetic tissues were evaluated from 22 patients whose arthroplasty had been revised for adverse local tissue response without clinical or histological evidence of infection. The index diagnosis in all of the patients had been osteoarthritis or avascular necrosis. Twelve of the patients had hosted a cemented CoCr alloy metal-on-metal surface replacement without modular junctions, and the remaining 10 had metal-on-polyethylene bearings with corrosion at the modular head/neck junction. The cases with metal-on-polyethylene bearings had CoCr heads that were mated with CoCr stems in 7 cases and with Ti-alloy stems in 3 cases. Hematoxylin and eosin stained sections of joint capsule, muscle and soft tissue masses were evaluated for the extent and type of necrosis and the extent of inflammatory exudate. A semi-quantitative system was used to score (1 to 4) the overall number of particle-laden macrophages, lymphocytes, lymphoid aggregates, plasma cells, eosinophils, polymorphonuclear leukocytes, and formation of discrete granulomas. Monoclonal antibody-based immunohistochemical methods were utilized to identify B lymphocytes (CD20), T lymphocytes (CD3) and macrophages (CD68). Particulate debris in the tissues was identified using regular and polarized light microscopy and with the use of an energy dispersive x-ray analysis system. The histopathological parameters, including the type and distribution of lymphocytes, were compared between metal-on-polyethylene and metal-on-metal groups using the Mann-Whitney test. The Friedman test was used for within-group comparisons.

Results: In both groups, there was disruption of the synovium, and the surface of the joint pseudocapsules was covered to varying degrees with fibrin exudate. The extent of necrosis of the joint pseudocapsule ranged from minimal to marked, and was greater in the metal-on-polyethylene group compared to the metal-on-metal ($p=0.023$). The primary nature of the inflammatory response was the same in both groups. The cellular infiltrate was dominated by T and B lymphocytes. Immunohistochemical staining revealed that T cells (CD3) predominated over B cells (CD20) for both the metal-on-polyethylene ($p=0.025$) and the metal-on-metal bearings ($p= 0.007$). T cells tended to be distributed both perivascularly and diffusely (Fig. 1), while B cells tended to be concentrated in the perivascular aggregates of lymphocytes (Fig. 2). In some cases in both groups, the lymphocytes were accompanied by plasma cells and degranulating eosinophils. Epithelioid granulomas were observed in 2 of 12 cases with metal-on-metal bearings and 3 of 10 cases with metal-on-polyethylene bearings. No particles were observed within the epithelioid granulomas. In all of the cases, polymorphonuclear leukocytes were rare.

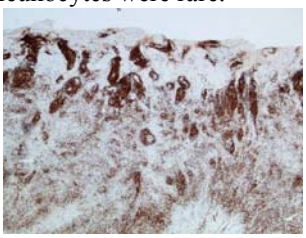

Figure 1. The inflammatory response was dominated by CD3-positive T lymphocytes with a perivascular and diffuse distribution. Metal-on-polyethylene bearing with a corroded CoCr/Ti-alloy head-neck junction. X20.

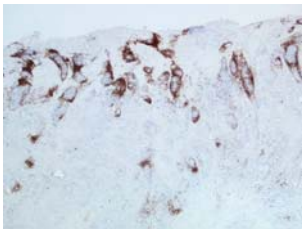

Figure 2. Serial section of the same site as Figure 1. CD20-positive B lymphocytes accompanied the T lymphocytes but were mostly limited to perivascular sites. X20.

CD68-positive macrophages were present in the periprosthetic tissue of both groups. However, macrophages laden with resolvable metal particles were greater in number for the metal-on-metal cases compared to metal-on-polyethylene ($p=0.0002$). The particle-laden macrophages in the metal-on-metal group tended to occur in broad sheets, and the cells contained CoCr wear particles, Cr-rich corrosion products and bone cement. The lesser number of particle-laden macrophages observed in the metal-on-polyethylene cases were associated with particles of chromium phosphate, a corrosion product of cobalt-chromium alloy.

Conclusion: Adverse local tissue response associated with corrosion and metal ion release at head-neck junctions of CoCr-on-polyethylene bearings is similar to the adverse response seen in some patients hosting CoCr metal-on-metal bearings without modular junctions. In both groups, the inflammatory response was comprised of T and B lymphocytes and a lesser number of plasma cells. There was also disruption of the synovial lining, extensive inflammatory exudate and necrosis. A major difference was that many of the metal-on-metal bearings also showed an exuberant foreign-body macrophage response to metallic wear and corrosion particles. This study also suggests that adverse tissue responses in patients hosting a metal-on-metal bearing with head-neck modularity may not be due solely to tribocorrosion at the bearing surface.

Reference: Cooper HJ, JBJS Am.2012; 94(18):1655-61

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