Adverse Tissue Response to Corrosion and Products of Corrosion in CoCr Dual-Modular Neck Hip Prostheses

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Statement of Purpose: Modularity continues to increase in primary hip arthroplasty with the use of dual-modular necks which have a neck-stem junction in addition to the traditional head-neck modularity. Severe fretting corrosion has been reported at the neck-stem junction of retrieved prostheses in which both the modular neck and stem are made of titanium alloy[1, 2]. Several manufacturers now employ a CoCr modular neck for use with Ti-alloy or CoCr stems. In the present study, retrieved dual-modular CoCr necks were examined to determine whether or not severe fretting corrosion also occurs with these devices, to identify the composition of corrosion products generated, and to characterize the nature of the tissue and cellular response in the periprosthetic soft tissues.

Methods: Fifteen CoCr dual-modular necks from three manufacturers (10 Stryker, 3 Smith & Nephew, 2 Wright Medical) were retrieved after a mean duration of 14 months (range, 1-27 months) under IRB approval. Twelve of the modular necks had been mated with Ti-alloy femoral stems (10 TiMoZrFe, 2 TiAlV) and 3 with CoCr stems. Modular heads were ceramic (8), ceramic with Ti insert (1), or CoCr alloy (6) and ranged in size from 28 to 44 mm in diameter with the majority (8) being 36 mm. All articulated against highly cross-linked polyethylene. Specimens of joint pseudo-capsule and surrounding tissue were collected from 9 patients.

Both the neck-stem and head-neck tapers were examined using a stereo microscope at 8 to 50 X. The tapers were scored for degree of surface damage based on the area of fretting and corrosion using a scale of 1 to 4 (none or minimal = 1, mild = 2, moderate = 3 or marked = 4). The modular junctions were studied using a scanning electron microscope to determine the mechanisms of corrosion. Solid products of corrosion adherent to the device and particulates in the tissues were analyzed using energy dispersive x-ray analysis (EDX). The data were presented as the mean and standard deviation of the scores. Spearman correlations between damage scores and duration in situ were performed.

Results: At the neck-stem junctions, corrosion was observed in a total of 12 devices retrieved after 10 to 27 months (Fig. 1). Corrosion was marked in 11 cases and mild in one. Corrosion scores increased with duration ($r=0.651$, $p=0.009$). The damage included fretting corrosion and fretting corrosion debris. Areas of adhesive transfer from the TiMoZrFe femoral stem to the CoCr modular neck were also observed. Particles isolated from around the opening of the neck-stem junction were identified as chromium phosphate, and, rarely, as cobalt phosphate corrosion products (Fig. 1).

At the head-neck junction, corrosion was observed in 11 of the 15 cases. In these cases, the modular necks had been mated with a ceramic head (7), a ceramic head with Ti insert (1), or a CoCr head (3). The nature of the corrosion in 10 of the 11 cases was severe pitting (Fig. 2). The pitting damage was marked in 7 cases, moderate in one case, and mild in two. Under light microscopy, the pitting corrosion rendered a dulled appearance to the surface of the femoral taper. The pitting was revealed only under higher magnification using scanning electron microscopy. Fretting and/or corrosion at the head-neck junction was absent in the remaining 4 components.

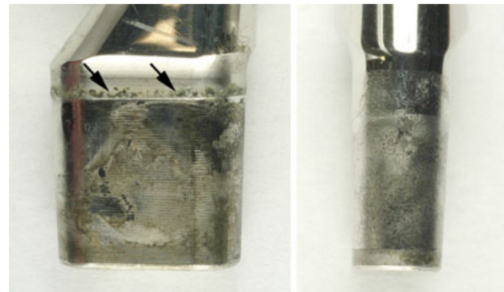

Fig. 1 Severely corroded CoCr-alloy modular neck-stem junction retrieved after 27 months. Arrows indicate chromium phosphate corrosion products deposited at the opening of the junction.

Histologically, an adverse local tissue response was seen in 8 of the patients, all associated with implants that had marked corrosion at the neck-stem junction. Extensive necrosis of the joint pseudocapsule and surface fibrin were observed. In the viable areas, abundant perivascular and diffuse lymphocytes were present. In 4 cases, plasmacytes and eosinophils were also seen. Particles in the periprosthetic tissues were identified as chromium phosphate corrosion product.

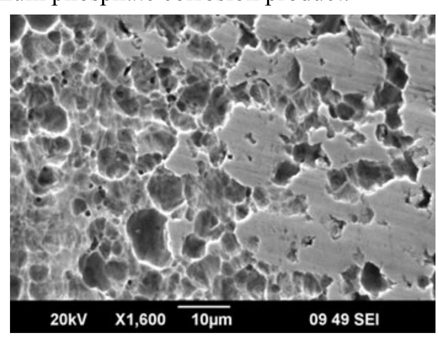

Fig. 2 Severe pitting corrosion of a CoCr modular head-neck mated with a ceramic head and removed for pain after 21 months.

Conclusions: Fretting and corrosion of dual-modular CoCr necks can lead to an adverse local tissue response in some patients, similar to that seen with metal-on-metal bearings. The prevalence of failure is not known overall, or, for specific designs. Dual-modularity clearly presents additional interfaces and increased potential for generation of particulate and soluble products of corrosion, both at the neck-stem and head-neck junctions. Use of a ceramic head on a CoCr neck does not preclude corrosion at the head-neck junction.

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References: 1. Urban RM, AAOS March 2010; 2. Gilbert JL, JBMR 100B, 2012