

Caveat Emptor: Adverse Inflammatory Soft-Tissue Reactions in Total Hip Arthroplasty with Modular Femoral Neck Implants

A Report of Two Cases

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Modular femoral neck (MFN) implants in total hip arthroplasty facilitate optimizing femoral offset and version while minimizing femoroacetabular impingement¹, but component fracture and dissociation have been reported with titanium-alloy MFN implants²⁻⁶. Cobalt-chromium MFN components have improved strength compared with earlier designs, but the long-term consequences of wear and corrosion at the femoral neck-stem junction are unknown^{3,7}. Inflammatory metal-hypersensitivity reactions have been most frequently reported in cobalt-chromium metal-on-metal articulations used in total hip arthroplasty and hip resurfacing arthroplasty^{8,9}, but to our knowledge, these reactions have not been described in MFN implants with metal-on-polyethylene articulations. We present two patients with MFN implants who developed partially cystic peri-implant soft-tissue masses with histologic features suggestive of metal hypersensitivity requiring revision arthroplasty. Both patients were informed that data concerning their cases would be submitted for publication, and they provided consent.

Case Report

CASE 1. A sixty-three-year-old woman (body mass index, 31.3) with severe osteoarthritis had undergone a left total hip arthroplasty with a 50-mm Trilogy Shell (Zimmer, Warsaw, Indiana), a 36-mm highly crosslinked polyethylene liner (Zimmer), an uncemented titanium-alloy ABG II size-3 modular femoral stem with a 130° cobalt-chromium MFN (Stryker, Mahwah, New Jersey), and a +5-mm 36-mm cobalt-chromium head (Stryker). The patient had an uneventful postoperative course and was discharged on postoperative day three.

Seven months later, the patient presented with progressive pain in the left hip. Radiographs showed satisfactory component

positioning with no osteolysis, aseptic loosening, or periprosthetic fracture. Blood work showed an elevated erythrocyte sedimentation rate (ESR), C-reactive protein level (CRP), and serum

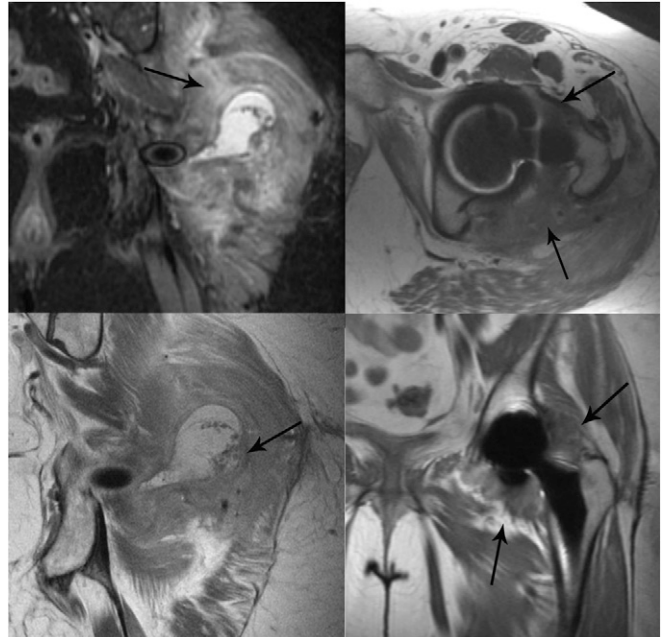


Fig. 1

Metal artifact reduction sequence MRI of the patient in Case 1. The modular total hip arthroplasty was performed eight months previously, and the patient had an elevated erythrocyte sedimentation rate, C-reactive protein level, and metal ion levels. The images show aggressive soft-tissue reaction (arrows). Reproduced, with permission, from H.G. Potter, MD, courtesy of the MRI Department at the Hospital for Special Surgery, New York, NY.

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TABLE I Prerevision and Postrevision Laboratory Values*

	Eight Months After Primary Total Hip Arthroplasty	Prerevision Surgery	One Year After Revision Surgery
Erythrocyte sedimentation rate (<i>mm/h</i>) (normal, <30)			
Case 1	60	52	17
Case 2	43	—	—
C-reactive protein (<i>mg/dL</i>) (normal, <0.80)			
Case 1	23.9	2.6	0.53
Case 2	4.67	—	—
Blood cobalt level (<i>mcg/L</i>) (normal, <1.8)			
Case 1	4.4	—	<0.5
Case 2	6.7	—	—
Blood chromium level (<i>mcg/L</i>) (normal, <1.2)			
Case 1	<0.5	—	<0.5
Case 2	<0.5	—	—
White blood-cell count for initial joint aspiration (<i>cells/μL</i>)			
Case 1	650	—	—
Case 2	28	—	—

*Dashes indicate that laboratory values were not obtained or unable to be obtained.

metal ion levels without leukocytosis (Table I). Computed tomography (CT) of the hip demonstrated a 2.3 × 3-cm fluid collection between the gluteus maximus and medius muscles. Aspiration of the hip yielded 2 mL of orange-tinted fluid with a white blood-cell (WBC) count of 650 cells/ μ L with 96% polymorphonuclear cells. Gram stain, aerobic cultures, and anaerobic cultures were all negative. The patient had improvement of the hip pain after aspiration, but she returned to the clinic with recurrent pain. Metal artifact reduction sequence magnetic resonance imaging (MRI) demonstrated an 11.5-cm (diameter) fluid collection with a thick anterior wall effacing the posterior capsule and dissecting between the posterior soft tissues (Fig. 1). Concern for a metal-hypersensitivity reaction with inflammatory pseudotumor led to revision arthroplasty eight months after the index procedure.

Intraoperative findings demonstrated large necrotic areas surrounding the total hip arthroplasty, including all of the gluteus musculature, the short external rotator muscles, and both the anterior and posterior capsules. The femoral and acetabular components were solidly fixed, and the polyethylene liner showed no substantial wear; however, corrosion was grossly evident at the modular femoral neck-stem junction but not at the femoral head-neck junction (Fig. 2). Revision to a nonmodular Short Citation femoral stem with a ceramic head (Stryker) was completed without complication. The hip was stable on examination.

Analysis of the joint aspirate revealed a WBC count of 1950 cells/ μ L with 43% lymphocytes, and analysis of the bursal fluid found on initial entry into the fascia revealed a WBC count of 1750 cells/ μ L with 97% lymphocytes. All fluid and tissue cultures were negative for microorganisms. Histologic evaluation showed extensive necrosis and marked diffuse chronic inflammation (Fig. 3). There was no acute inflammation, and visible metal particles were very rare.

The patient had an uncomplicated postoperative course and painless gait at the one-year follow-up. Repeat blood work showed a decrease in inflammatory markers and serum metal

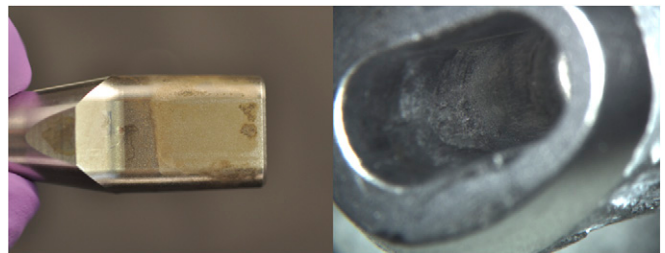


Fig. 2

The male portion of the implant in Case 1 shows corrosion at the modular femoral neck-stem junction (left). The female portion of the implant shows wear and corrosion at the interface of the modular femoral neck-stem junction (right). Reproduced, with permission, from T. Wright, PhD, and M.E. Elpers, Hospital for Special Surgery, New York, NY.

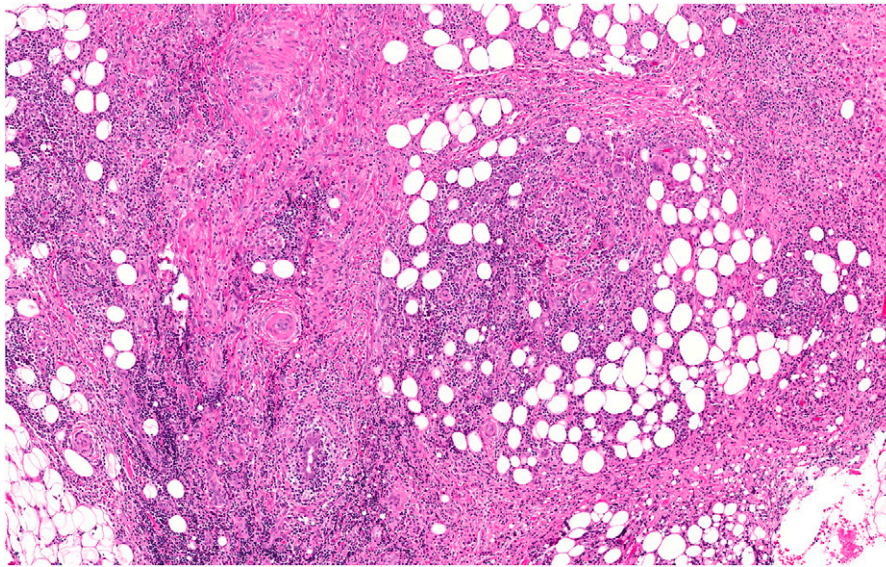


Fig. 3
Marked diffuse and perivascular chronic inflammation composed of lymphocytes and plasma cells in periprosthetic tissues is seen on this specimen from Case 1 (hematoxylin and eosin, 10× magnification).

ion levels (Table I). She experienced two posterior dislocations of the total hip arthroplasty, which were managed with closed reduction and standard hip precautions. Repeat MRI one year after the revision arthroplasty demonstrated continued inflammatory reaction adjacent to the prosthesis; however, the severity of these findings was diminished compared with the MRI obtained prior to the revision arthroplasty (Fig. 4).

CASE 2. An active eighty-year-old woman with primary osteoarthritis had undergone a total hip arthroplasty with a 50-mm Trilogy Shell (Zimmer), a 36-mm highly crosslinked polyethylene liner (Zimmer), an uncemented titanium-alloy ABG II size-4 modular femoral stem with a 130° cobalt-chromium MFN (Stryker), and a +5-mm 36-mm cobalt-chromium head (Stryker). The patient did well initially, but she presented with a limp and persistent pain ten months postoperatively. Radiographs, CT, and peripheral WBC count were unremarkable, and all blood cultures were negative. Joint aspiration yielded turbid fluid with a WBC count of 28 cells/ μ L, a negative Gram stain, and negative cultures. Inflammatory markers and serum cobalt levels were elevated (Table I), and metal artifact reduction sequence MRI imaging showed intermediate signal in the soft tissue surrounding the arthroplasty, suggestive of early inflammatory reaction without frank soft-tissue disruption.

The patient underwent surgical exploration, removal of the femoral implant, and revision to a nonmodular ABG II size-5 femoral component with a ceramic femoral head (Stryker). Intraoperatively, pericapsular necrotic tissue extended inferiorly into the pseudocapsule and superiorly into the abductor and gluteus minimus muscles. Wear and corrosion were appreciated at the modular femoral neck-stem junction. Histology of periprosthetic tissue showed an extensive superficial layer of necrosis with underlying diffuse

chronic inflammation without acute inflammation (Fig. 5). Postoperatively, the patient had good relief of pain and improved function.

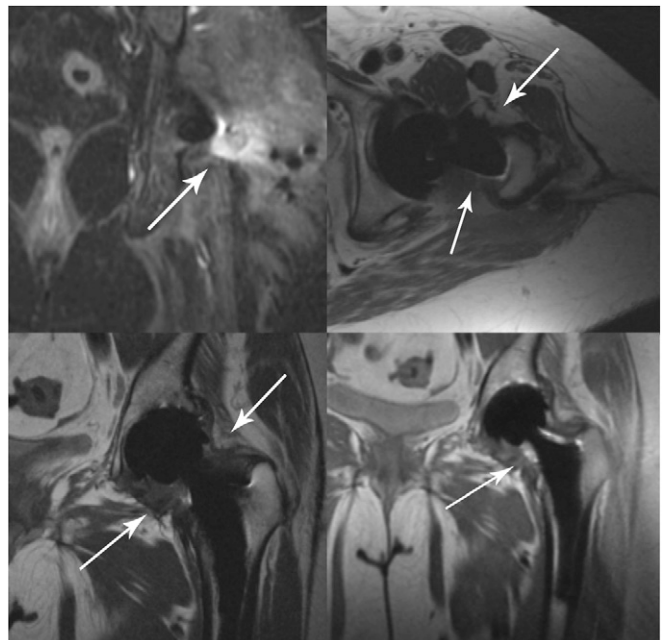


Fig. 4
Metal artifact reduction sequence MRI of the patient in Case 1, which was obtained seven months after revision to the uncemented fixed neck stem. The images show scarred capsule, but there is less inflammatory reaction (arrows) than seen in Figure 1. Reproduced, with permission, from H.G. Potter, MD, courtesy of the MRI Department at the Hospital for Special Surgery, New York, NY.

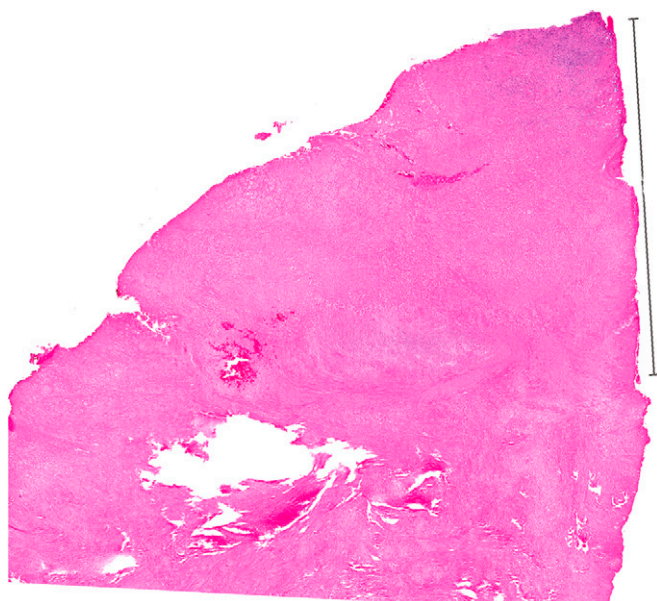


Fig. 5
The surface of the membrane was composed of a thick layer of necrotic tissue and overlying chronic inflammation, as seen on this specimen from Case 2. The necrosis in this field measures approximately 2.75 mm in thickness (measurement bar) (hematoxylin and eosin, 2× magnification).

Discussion

Inflammatory reactions such as metal hypersensitivity have been increasingly described in the setting of metal-on-metal total hip arthroplasty or hip resurfacing arthroplasty⁸⁻¹¹. To the best of our knowledge, the only clear risk factor for metal hypersensitivity is a previous reaction to a metal implant or jewelry¹². Clinical findings include persistent pain, chronic effusion, and soft-tissue necrosis and inflammation without evidence of infection¹⁰. Laboratory values often show elevated serum metal ion levels¹³⁻¹⁷ but rarely show increased inflammatory markers¹⁸⁻²⁰. The etiology of this pathologic response is unknown, but evidence is accumulating that suggests an immune reaction associated with metal debris^{8,10-12,15,21,22}. We describe two patients with MFN implants who developed symptoms and findings suggestive of an immune reaction at the femoral neck-stem junction; they both achieved clinical improvement after revision to nonmodular components.

Initial evaluation of a painful total hip arthroplasty should rule out aseptic loosening, infection, malpositioning, and osteolysis^{23,24}. Elevated inflammatory markers without evidence of infection have been described in the setting of metal hypersensitivity^{18,20}. In our patients, the cobalt levels were elevated beyond those seen in metal-on-polyethylene total hip arthroplasty, but not as high as commonly described in metal-on-metal articulations^{15,16,25}. Aseptic loosening and component malpositioning are common sources of metal wear debris; however, our two patients showed neither on radiographs or CT^{26,27}.

While a CT scan can characterize osteolysis and component positioning, a metal artifact reduction sequence MRI

better evaluates soft-tissue masses, integrity of the posterior soft tissues, muscle necrosis, and potential sciatic nerve compression²⁸⁻³¹. Both metal-induced synovitis and osteolysis present with intermediate intensity signal on MRI; however, a lack of osseous erosion suggests metal hypersensitivity²⁸. Pandit et al.⁹, Mabilieu et al.²², and Mahendra et al.²⁹ have used the term “inflammatory pseudotumor” with reference to cystic or partially cystic masses, often associated with compromised posterior soft tissues^{9,22,29,31}. These descriptions are consistent with the cystic mass seen in the patient described in Case 1 and the periprosthetic tissue reaction seen in the patient in Case 2.

The histologic features thought to represent a metal hypersensitivity were described by Willert et al.¹¹, Hallab et al.¹⁵, and Jacobs et al.³². Features include a thick, superficial layer of necrosis overlying a thickened membrane containing diffuse and perivascular lymphocytes (aseptic lymphocytic vasculitis-associated lesions [ALVALs]). These individual histologic findings are not specific for metal-on-metal articulations, as they can be seen to a lesser extent in failed metal-on-polyethylene implants or during staged revision for infection³³. The combination of extensive necrosis and marked diffuse chronic inflammation in the absence of infection suggests an immune-mediated inflammatory process and is typical of a subset of failed metal-on-metal total hip arthroplasty and hip resurfacing arthroplasty. The term “pseudotumor” is currently not being used in a consistent way, but the term “inflammatory pseudotumor” has been used to describe benign chronic inflammatory lesions in various locations³⁴ and may be appropriate for some soft-tissue masses associated with failed implants. Additional studies are needed to correlate the histologic, radiographic, and clinical features of cystic, partially cystic, and inflammatory masses associated with failed orthopaedic implants.

Wear at a modular neck-stem junction and subsequent catastrophic failures have previously been reported with titanium-alloy MFN implants. Risk factors for failure include obesity, male sex, and components with a femoral neck-shaft angle less than 135°³⁵. Increased bending stresses at the neck-stem junction can lead to micromotion and subsequent corrosion at the neck-stem junction, eventually leading to crack formation and component failure^{3,36}. Next-generation modular cobalt-chromium femoral neck implants decrease micromotion at the modular junction and have improved fatigue strength compared with titanium-alloy designs; however, retrieved components have shown that mixed-metal couplings have greater corrosion than same-metal couplings³⁷⁻³⁹. Goldberg and Gilbert⁴⁰ and Gilbert et al.⁴¹ hypothesize that micromotion at the taper interface leads to fracture of the protective passivation film, a process described as mechanically assisted crevice corrosion⁴⁰. The exposed alloy is then subject to fretting, pitting, and chemical corrosion, which leads to formation of an interfacial debris layer composed of titanium, chromium, and molybdenum⁴¹. This suggests that cobalt is selectively leached away during corrosion, and may explain why our patients had elevated cobalt levels but normal chromium levels.

MFN implants have shown promising results in patients with hip dysplasia or increased femoral anteversion⁴²⁻⁴⁶, but modularity may introduce additional mechanisms of failure, as suggested by the more-than-double cumulative revision rate for MFN stems compared with fixed neck stems (8.9% versus 4.2%)^{47,48}. Our two cases illustrate another potential complication of MFN implants: an inflammatory reaction with features suggestive of metal hypersensitivity. We advocate selective use of modular total hip arthroplasty with appropriate clinical indications^{45,46}, appropriate preoperative screening⁴⁹, and utilization of implants with a proven clinical history^{48,50}. The advantages of component modularity must be carefully weighed against the risks of mechanical wear and subsequent tissue reactions and/or component failure. ■

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