Evaluation and Treatment of Painful Total Hip Arthroplasties With Modular Metal Taper Junctions

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Abstract: Modern primary total hip arthroplasty femoral components have evolved to include modular necks. Subsequently, the additional taper junction provides another interface as a potential source for mechanically assisted crevice corrosion, which is a complex process involving fretting and crevice corrosion. Furthermore, it is becoming evident that an adverse local tissue reaction may result in some patients due to the mechanically assisted crevice corrosion. This article details the clinical, radiographic, and laboratory evaluation of patients with these components who present with persistent pain. The relevant surgical strategies and techniques to address this pathology in symptomatic patients are addressed.

Modern primary total hip arthroplasty (THA) femoral components have evolved to include modular necks, which provide the surgeon with more options to reproduce or correct the patient’s anatomy and hip biomechanics. However, with the additional taper junction, the modular neck femoral components provide an additional interface that may be a source of mechanically assisted crevice corrosion, a complex process involving fretting corrosion and crevice corrosion.1,7

Reported to occur at the metal taper junction between cobalt-chromium (CoCr) femoral heads and metal stems, mechanically assisted crevice corrosion can similarly occur at the metal taper junction between the modular neck and stem in such designs. This can occur in titanium–titanium, CoCr–titanium, and CoCr–CoCr taper junctions.1–7

It has been reported that elevated serum metal levels and an adverse local tissue reaction may occur with metal-on-metal bearings, causing premature failure.8–24 For the purposes of this report, adverse local tissue reactions include soft tissue responses, such as aseptic lymphocytic-dominated vasculitis-associated lesions, periprosthetic osteolysis, and pseudotumors. A similar reaction and potentially premature failure of THA has been reported to occur in rare cases of patients with modular-neck femoral components.3

This article discusses the clinical presentation, evaluation, and workup of patients who present with persistent pain after successful THA with a metal taper junction suspected of mechanically assisted crevice corrosion. This will provide clinicians with basic guidelines—but only at our current level of understanding based on the few reported cases—for the potential clinical presentation, evaluation, histopathology, and surgical treatment of such patients.

Clinical Presentation

Patients with a persistently painful THA containing a modular neck primary femoral component (Figure 1) who lack an evident etiology should be considered for a potential adverse local tissue reaction to mechanically assisted crevice corrosion at the modular taper junction. Patients will typically present with pain in the anterior, lateral, or posterior hip. In a severe case of pseudotumor, patients may feel a large mass...
or fluid collection, raising the suspicion for significant local soft tissue destruction. Patients may have pain at rest, but more often have pain with weight bearing. Physical examination may also reveal pain with hip motion and joint loading.

**Evaluation for Infection**

Anecdotal and reported cases document superimposed bacterial infection in the face of clinical adverse local tissue reaction from metal-on-metal articulations. Evidence also exists that alteration of the local pH may create an environment that facilitates metal corrosion, which suggests the pH alteration in occult peri-prosthetic infection may be a precursor to corrosion in metal taper junctions. Further confounding the issue is the reported incidence of patients with an adverse local tissue reaction who present with a clinical picture mimicking infection, including elevated serum inflammatory markers.

The initial workup of a painful THA should be a screening of the erythrocyte sedimentation rate and C-reactive protein; if either or both are elevated, a hip aspiration is essential to rule out infection as the source of pain. In patients with a modular taper junction who do not have evidence for a diagnosis for infection, a workup for the possibility of adverse local tissue reaction from metal junction mechanically assisted crevice corrosion is recommended.

In patients with metal-on-metal bearings and an adverse local tissue reaction, the intra-articular fluid is typically substantial in volume, turbid, and brownish or grey in color. Despite this frequently described appearance, aspiration analysis has not yet been proven to be specific to failed implants due to metal-on-metal bearings or modular taper junctions.

**Serum Metal Levels**

Mechanically assisted crevice corrosion from modular taper junctions may result in adverse local tissue reactions via elevated metal concentrations. Therefore, patients presenting with a painful THA of unknown etiology and a modular taper junction should obtain serum metal studies. It has been reported that chromium ion levels >17 µg/L and cobalt ion levels >19 µg/L were associated with elevated joint fluid ion levels and metallosis.

Recently, Kwon et al reported metal-on-metal resurfacing arthroplasties using ultrasound/magnetic resonance imaging and serum/hip aspirate cobalt and chromium measurements. Pseudotumors found in 7 patients (4%) were associated with higher cobalt and chromium levels. The median serum cobalt and chromium levels in women with bilateral arthroplasty in the pseudotumor group were 9.0 and 12.0 µg/L, respectively, but only 2.9 and 3.2 µg/L, respectively, in similar patients without pseudotumor formation. These data suggest that pseudotumors may be associated with increased wear generated from metal-on-metal articulations.

The Medicines and Healthcare products Regulatory Agency suggested a cutoff blood level of 7 parts per billion, yet this was shown to have a specificity of 89% and sensitivity 52% for pre-operatively detecting an unexplained failed metal-on-metal THA. It was reported the optimal cutoff for the maximum cobalt or chromium level was 4.97 parts per billion and had sensitivity 63% and specificity 86%; it was concluded that blood metal ions have the ability to separate failed and well-functioning hip replacements.

However, interlaboratory variability can exist in metal measurements due to differences in instrumentation, specimen collection protocols, matrix (whole blood or serum), and analytic methodology. In addition, the levels may be confounded by the presence of other implants containing metal and differences in renal function. Although an understanding of metal levels and their correlation with adverse local tissue reactions in THA continues to evolve, the above values are attempts at providing some guidance to the clinician evaluating a patient with a painful THA suspected of an adverse local tissue reaction with modular taper junctions.

**Metal Hypersensitivity**

Speculation exists that a metal allergy may contribute to implant loosening. However, a clear connection is not found between the incidence of metal sensitivity and implant duration, infection,
Successful evaluation of fluid collections and graphs, advanced imaging, and normal plain radiographs are elevated serum metal ion levels, patients with persistent pain, of bony erosion (Figure 1). In normal and show no evidence of ionization or metal-on-metal bearing. Radiographic analysis of fluid collections and persistence imaging detects osseous erosion and complications in the periprosthetic soft tissues, such as wear-induced synovitis, periprosthetic fluid collections, neurovascular compression, and quality of the muscle and tendons. If one is considering an MRI, detailed dialogue with radiologists knowledgeable in the metal artifact reduction techniques is necessary to optimize the information available from these advanced imaging techniques.

**PERIARTICULAR HISTOPATHOLOGY**

Patients with an adverse local tissue reaction to local metal debris from mechanically assisted crevice corrosion may demonstrate similar perivascular pathologic characteristics as those reported in patients with metal-on-metal bearings. Intraoperative hip fluid is typically described as brownish or grey in color. The characteristic histological features typically consist of diffuse and perivascular infiltrates of T and B lymphocytes and plasma cells, high endothelial venules, massive fibrin exudation, accumulation of macrophages with drop-like inclusions, and infiltrates of eosinophilic granulocytes and necrosis (Figure 2). Also, metal particles are uncommon and are not a requisite for the diagnosis of an adverse local tissue reaction.

**RECOMMENDED SURGICAL TREATMENT**

Although no specific clinical data exist to guide surgeons in the surgical treatment of patients who have a painful THA with modular taper junctions, mechanically assisted crevice corrosion at the head–neck or modular neck–stem junction, certain tenets and strategies should be used. First, although difficult and stressful for the surgeon and patient, it is not recommended that observation without surgical intervention be used for any significant time. Adverse local tissue reactions have been reported in patients with mechanically assisted crevice corrosion of metal taper junctions.

In severe cases, these adverse local tissue reactions can render abductors completely absent or via mass effect cause neurovascular compromise of surrounding nerves or vessels. Therefore, surgical intervention should be strongly considered once the diagnosis of an adverse local tissue reaction from mechanically assisted crevice corrosion has been confirmed. As always, this is done after a detailed discussion with the patients explaining the risks of observation versus operative intervention.

Once the decision to surgically intervene has been made, the method of revision reconstruction should use the principle of minimizing any modular...
metal taper junctions because the presumption is either that the patient’s immune system played a role in the development of an adverse local tissue reaction via hypersensitivity or that the patient’s local biology created an environment supportive of mechanically assisted crevice corrosion for reasons that are yet unclear. Therefore, acetabular components can typically be retained if well-fixed and in acceptable position. The acetabular liner should be composed of highly cross-linked polyethylene, although ceramic liners may be used as well.

If a femoral component with a modular neck was used, then consideration should be given to removal and replacement with a femoral component that does not use a modular neck. If mechanically assisted crevice corrosion damage is limited to the male portion of the taper, one may consider retaining a well-fixed stem and exchanging the damaged modular neck; however, data are not yet available to determine the likelihood or incidence of mechanically assisted crevice corrosion recurring at this interface. Therefore, the surgeon should weigh the risks associated with removal of a well-fixed femoral component with the uncertainty associated with a modular neck exchange. However, if visible damage is observed to the femoral stem portion of the taper junction, strong consideration should be given to removal of the femoral component.

In further support of minimizing metal modular interfaces in patients who have adverse local tissue reactions, if a metal femoral head was used in the original reconstruction, consideration should be given to replacement with a modern ceramic femoral head. It has been shown that ceramic-on-metal modular junctions have less mechanically assisted crevice corrosion than metal-on-metal modular junctions. However, if damage exists to an existing metal taper, it is recommended to use a ceramic head with a metal sleeve insert to minimize the chance of ceramic head fracture. Fortunately, the majority of studies that report surgical treatment of adverse local tissue reaction due to metal-on-metal bearings by conversion to an alternative bearing such as ceramic-on-ceramic or metal-on-polyethylene have reported resolution of pain and symptoms in the majority of patients (Figure 3).

**INTRAOPERATIVE FINDINGS**

Evidence of mechanically assisted crevice corrosion of the modular taper junction (either at the neck–head or neck–stem junction) is visualized by irregular black material on the surface of the metal contained within the junction (Figure 4). Furthermore, the black material is typically associated with and near surface irregularities on the metal taper surface in contact with the opposite metal surface, consistent with crevice corrosion. Adverse local tissue reactions may also create a substantial amount of intra-articular joint fluid, as is typically seen preoperatively on MRI, and is reported to be a brownish or grey color with a turbid consistency.

Although this has been described, to the authors’ knowledge the intra-articular fluid characteristics have not been consistently characterized macroscopically or with respect to laboratory analysis and cell count at the time of this publication. Local soft tissue necrosis has been seen in advance local tissue reaction from metal debris and can be extensive to include the pseudocapsule, the abductor musculature, and tendinous insertion onto the greater trochanter (Figure 5), with necrotic bone observed to the femoral stem up to the level of the modular neck; however, the extent of local tissue damage is limited to the area of the modular neck exchange.

**REFERENCES**


