The Local Effects of Metal Corrosion in Total Hip Arthroplasty

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KEYWORDS

• Adverse local tissue reaction • Corrosion • Metal debris • Modularity • Total hip arthroplasty

KEY POINTS

- Corrosion can occur at any modular junction in total hip arthroplasty (THA), with the potential for release of metal debris and ions into the surrounding local environment.
- The potential for corrosion at a particular modular junction is multifactorial and can depend on factors such as taper geometry, constituent materials, forces applied to the junction, femoral head size, component offset, and method of assembly.
- Local effects of metal corrosion include adverse local tissue reactions (ALTR), component fracture or failure, instability, and osteolysis and loosening.
- Taper corrosion should be considered in the differential diagnosis of hip pain following THA, and appropriate testing should include serum metal levels and cross-sectional imaging such as magnetic resonance imaging to evaluate the surrounding soft tissues.
- Treatment consists of exchange of the modular part responsible for the ALTR when possible, versus revision of the entire component when not possible.

INTRODUCTION

Metal corrosion in total hip arthroplasty (THA) has long been recognized as a theoretical concern that accompanied the introduction of modularity[1] and soon thereafter was documented in numerous retrieval studies of early modular hip components.[2–13] Although there were rare reports of poor clinical outcomes associated with corrosion,[3,11,13,14] any connections between adverse local effects and corrosion were not firmly established at that time.

As design and manufacturing of modular junctions improved through the 1990s and 2000s, most early concerns surrounding corrosion largely disappeared from the literature. However, there has recently been a renewed concern surrounding corrosion in THA, as many groups have reported adverse local tissue reactions (ALTR) and other local complications in association with modular hip components.[15–26] As complications arising from corrosion are being recognized with increasing frequency, it is important for the orthopedic surgeons who perform these procedures and manage these patients postoperatively to understand this process.

This article reviews the important points concluded from retrieval analyses, and explores the multifactorial etiology of corrosion. Local effects of corrosion are reviewed, and diagnostic evaluation and treatment options for patients with metal corrosion discussed.

CORROSION AT MODULAR INTERFACES IN THA

Modularity offers numerous advantages in modern THA. Modular heads and necks offer increased

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Orthop Clin N Am 45 (2014) 9–18
http://dx.doi.org/10.1016/j.ocl.2013.08.003
0030-5898/14/$ – see front matter

intraoperative flexibility to better match native anatomy, leg length, and offset,[27–29] all of which affect stability. Modularity also allows numerous options for head size and choice of bearing surface without requiring a substantial increase in implant inventory. Head-neck modularity further allows the head to be removed at the time of future surgery, either for exposure or to change head size or neck length. In addition, certain implants with modular proximal-stem and mid-stem junctions offer advantages in addressing difficult primary or revision cases. However, as already noted, the addition of these modular junctions does not come without a cost.

Historical Retrieval Analyses

Soon after the introduction of head-neck modularity in THA, numerous retrieval analyses began to report fretting and corrosion at the head-neck junction.[2–13] Early retrievals documented concerns of increased corrosion associated with mixed-metal junctions, resulting from galvanic acceleration between a titanium (Ti) alloy stem and a cobalt-chromium (CoCr) alloy head[2–6]; however, this was challenged in later studies.[7,8,12] Prevalence of corrosion among retrieved specimens ranged from 0% to 57% at 0.5 to 5.5 years,[2–6,8] but was found to be significantly dependent on device and design.[2–8]

Corrosion in Metal-on-Metal THA

Release of metal wear debris from the metal-on-metal (MoM) bearing surface was originally thought to be the major cause in the development of ALTR after large-head MoM THA, as this was the cause for ALTR following hip-resurfacing arthroplasty. However, recent work from multiple investigators has implicated corrosion at the modular head-neck taper interface to be a major contributing factor.[30–41] Given these findings, there is growing concern that the modular taper junction plays a significant role in the failure of large-head MoM THA, although the clinical significance of metal loss from this junction remains somewhat unclear.[30] This additional modular junction may be responsible for the greater elevations in serum metal levels[38] and higher failure rates of large-head MoM THA when compared with hip-resurfacing arthroplasties bearing the same design.[32]

Corrosion in Metal-on-Polyethylene THA

As orthopedic surgeons became more accustomed to seeing adverse reactions to metal debris associated with MoM devices, similar reactions were noted in patients with metal-on-polyethylene bearing surfaces.[15,17–20] Given that the potential for corrosion at this modular head-neck junction had been well established from the retrieval analyses of metal-on-polyethylene THAs discussed previously, these reactions provided clear evidence of a similar mechanism of metal release from modular head-neck junctions (Fig. 1), regardless of the bearing surface.

Corrosion at Neck-Body Junctions

Numerous designs of modular neck-body stems, also known as dual-taper stems, have been introduced. Similar to modular head-neck junctions, concerns over corrosion at modular neck-body junctions (Fig. 2) were raised soon after these devices were introduced.[42,43] Corrosion at this junction has subsequently been documented in retrieval analyses,[21,22,44] cases of modular neck fracture,[45–47] and reports of ALTR.[16,24] Furthermore, multiple stem designs featuring modular neck junctions from several different manufacturers have been either modified, recalled, or removed from the market after these concerns were noted.

Corrosion at Other Modular Junctions

Concerns over corrosion at stem-sleeve or mid-stem modular junctions were also expressed soon after these devices were introduced.[48] Stem-sleeve devices made from Ti alloy have good mid-term and long-term outcomes reported in both primary and revision settings, although recent reports have raised concerns for fretting and corrosion found at retrieval,[22,49,50] found in association with stem fracture,[50,51] and encountered in junctions with impaired intraoperative disengagement at the time of revision surgery.[52]

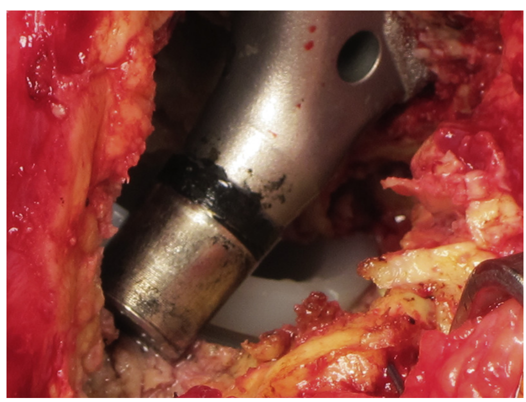

Fig. 1. Corrosion of the femoral trunnion in a 65-year-old woman 3 years following metal-on-polyethylene total hip arthroplasty (THA), seen at the time of revision for adverse local tissue reactions (ALTR).