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AAHKS Symposium: Corrosion at the Head-Neck Junction: Why is this Happening Now?

Diagnosis and Treatment of Adverse Local Tissue Reactions at the Head-Neck Junction

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ABSTRACT

Modular junctions in total hip arthroplasty are susceptible to mechanically assisted crevice corrosion, leading to the release of metal wear debris. Adverse local tissue reactions result from an immune-mediated biological reaction to this debris and can have a profound effect on the surrounding periarticular soft tissue envelope. Patients often present with pain or muscle weakness and demonstrate elevated serum cobalt and chromium levels. Serum inflammatory markers and synovial fluid tests help distinguish these reactions from deep infection in the majority of cases; however, the presence of amorphous material or fragmented cells can lead to difficulty in some cases. Advanced cross-sectional imaging is essential in establishing the diagnosis. Early revision surgery is generally the treatment of choice for symptomatic adverse local tissue reaction from corrosion at the modular head-neck junction. The existing stem is retained, and a new ceramic head is placed on the existing trunnion whenever possible. This strategy generally leads to short-term improvement of symptoms with reliable clinical outcomes; however, longer term results are presently lacking.

Modular junctions in total hip arthroplasty (THA) have been known to be susceptible to corrosion after this finding was documented in retrieval studies in the 1980s and early 1990s. Corrosion at this junction occurs through a combination of fretting and crevice corrosion, also known as mechanically assisted crevice corrosion (MACC), and can lead to the release metal wear debris into the tissues around the prosthesis. Adverse local tissue reactions (ALTRs) after THA result from an immune-mediated biological reaction to this metal wear debris and can have a profound effect on the surrounding periarticular soft tissue envelope. These local tissue reactions are clinically and histologically similar to those seen after metal-on-metal hip arthroplasty that were described in the mid 2000s, and the resultant inflammatory response can lead to synovitis, metallosis, and degradation of the capsule, soft tissues, and bone around the hip joint. This sequence of events can often result in pain, instability, and dysfunction of the THA.

The prevalence of ALTR appears to be increasing after metal-on-polyethylene (MoP) THA; however, this may be multifactorial and may represent in part an increased awareness rather than a true increase in prevalence [1]. Orthopedic surgeons treating patients with modular hip arthroplasty should be familiar with the clinical presentation and management of this condition, as it is a part of the differential diagnosis of pain after THA. The purpose of this article is to review the current literature regarding diagnosis and treatment of ALTR resulting from corrosion at the modular head-neck junction after THA.

Diagnosis of Head-Neck Corrosion

The prevalence of corrosion at the modular head-neck junction is not yet well understood, as there have been little cross-sectional or longitudinal data published to date. To date, there are fewer than 100 reported cases of failure related to corrosion at the head-neck junction in the literature. Accordingly, it remains unclear how strongly this diagnosis should be considered in the evaluation of a painful hip arthroplasty. Because the condition appears to be multifactorial in nature (with influences from factors such as stem design, trunnion geometry, trunnion finish, head size, neck length, among others), the prevalence of corrosion and ALTR may vary widely depending on specific implant combinations.

In the largest cross-sectional study published to date, McGrory et al [2] describe a 1.1% prevalence of MACC (defined as new-onset clinical symptoms and elevated serum cobalt levels) at short-term

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to midterm follow-up among a cohort of 1356 consecutive noncemented femoral components from a single manufacturer. In a separate study, Cooper et al [3] report a 1.8% revision burden for modular head-neck corrosion as the primary diagnosis at a single tertiary referral institution, making it far less common than periprosthetic joint infection (PJI), instability, and aseptic loosening as a cause for failure. Although not common, this condition does occur with enough frequency to merit consideration in the differential diagnosis of hip pain after modular THA. Furthermore, it may also occur at the modular head-neck junction after unipolar or bipolar hemiarthroplasty [4,5]; however, the prevalence in this patient population is not presently known.

Clinical Presentation

Patients can present with symptoms of ALTR within the first year after the index procedure or can have a delayed presentation of several decades [6]. In the largest cohort studies published to date, the mean time to presentation ranged from 3.7 to 4.3 years after the index THA [2,3,6,7]. Patients may present with a variety of clinical symptoms, most commonly pain in or around the groin, buttock, thigh, or peritrochanteric region [3]. Some patients present with swelling or fluid collections around the hip, whereas others demonstrate objective muscle weakness and a limp [3]. Furthermore, a minority of patients with ATLR may present with symptoms of recurrent hip instability in the absence of baseline pain [8,9]. Accordingly, trunnion corrosion with resultant ALTR should be considered as a part of the differential diagnosis of patients with recurrent instability without an otherwise obvious cause. Serum metal levels typically demonstrate elevations of both cobalt and chromium above reference levels, with a greater degree of elevation in serum cobalt over chromium (Table 1).

ALTR vs Infection

PJI and ALTR share many similarities and can present with similar symptoms of worsening pain, soft tissue destruction, fluid collections on advanced imaging, and elevated inflammatory markers. Distinguishing between these 2 entities, or ruling out PJI before revision for ALTR, can often be difficult for the treating surgeon, particularly as the presence of metal debris, clumped cells, and foreign material can appear as purulence and lead to inaccurate cell counts.

Yi et al [10] described differences in serologic and synovial tests between septic and aseptic patients undergoing revision with metal-on-metal bearings, metallosis, and trunnion corrosion. Using a cohort of 150 patients undergoing revision THA, the authors were able to calculate optimal cutoff values to distinguish infected vs noninfected hips of 32.0 mm/h for erythrocyte sedimentation rate (area under the curve [AUC] of 88% on a receiver operator characteristic curve) and 10.0 mg/L for C-reactive protein (AUC 85%). This demonstrated that even though serum inflammatory markers can be elevated in approximately half of the cases with ALTR [3], fairly typical cutoff values still remain valid in differentiating between septic and aseptic failure.

Synovial fluid analysis in these cases can be misleading, as the presence of amorphous material, fragmented cells, or clots can prevent an accurate cell count from being obtained. Automated machine analysis of these samples can either fail to yield a cell count, or can lead to a spuriously inflated cell count and a potential false positive result [10]. In the study by Yi et al [10], 33% of their samples available were deemed “inadequate,” but a minority of samples were able to be salvaged with a manual cell count or repeat aspiration. When these inadequate samples were excluded, the authors found optimal cutoff values for the synovial fluid white blood cell count (WBC) of 4350 WBC/μL (AUC 98%) and for the differential of 85% polymorphonucleocytes (AUC 90%), demonstrating excellent diagnostic utility of these tests even in the setting of metal debris. However, given that nearly 1 in 3 synovial fluid samples may be inadequate for analysis, there may be a role for protein-based technologies, immunoassays for biomarkers, and protein or nucleic acid-based identification of bacteria in the future [11].

Imaging Findings

Plain radiographs are a critical part of evaluating a painful or failed hip arthroplasty, as they often reveal findings such as component loosening, failure of osteointegration, bearing surface wear, osteolysis, periprosthetic fracture, implant failure, or gross component malpositioning. However, ALTR often fails to demonstrate findings on x-ray, particularly in less-advanced cases. Plummer et al [6] documented radiographic osteolysis of the proximal femur in 7 of the 27 MoP hips (26%) with ALTR, generally seen at the calcar or base of the greater trochanter.

When ALTR is suspected, advanced imaging modalities that allow for cross-sectional imaging should be obtained. Ultrasound, computed tomography, and magnetic resonance imaging using a metal-artifact reduction sequencing protocol each offers select advantages and disadvantages relative to each other (Table 2), and each of these 3 tests merits consideration under certain circumstances [12]. Yet in most centers where it is available, metal-artifact reduction sequencing magnetic resonance imaging is the imaging modality of choice given its high sensitivity and correlation with degree of tissue damage.

Treatment of Head-Neck Corrosion

At the time this article was written, routine surveillance for trunnion corrosion and metal release in patients with MoP hip arthroplasties is not recommended as a standard practice.

Table 1
Multiple Studies Demonstrating Serum Cobalt Levels Differentially Elevated Over Serum Chromium Levels in Patients With ALTR and Trunnion Corrosion at the Modular Head-Neck Junction.

Reference	Cobalt (ppb)	Chromium (ppb)
Cooper (2012) [3]	10.3 (0.1-49.8)	2.2 (0.2-9.8)
McGrory (2015) [2]	5.4 (1.6-8.8)	0.75 (0.2-1.5)
Plummer (2016) [6]	11.2 (1.1-49.8)	2.2 (0.2-9.8)

Values are presented as mean (range).
ALTR, adverse local tissue reaction.

Table 2
Relative Advantages and Disadvantages of Imaging Modalities to Diagnose Adverse Local Tissue Reaction After Total Hip Arthroplasty.

Modality	Advantages	Disadvantages
Ultrasound	• Accessible • Inexpensive • No metal artifact • No radiation • Excellent screening technique	• Has not been correlated to severity of ALTR • Technique and operator dependent
Computed tomography	• Highly sensitive • Provides accurate information on component positioning	• Ionizing radiation • Limited enhanced soft tissue contrast
Magnetic resonance imaging	• Highly sensitive • No radiation • Predicts severity of ALTR • Correlates with degree of tissue necrosis	• Expensive • Technique dependent

ALTR, adverse local tissue reaction.