



Case report

Corrosion and adverse tissue reaction after modular unipolar hip hemiarthroplasty

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ABSTRACT

Modern unipolar hip hemiarthroplasty, commonly used for displaced femoral neck fracture, is now modular, with both a variable length cobalt-chromium adapter-sleeve and large femoral head. Patients with these modular components may develop symptomatic trunnion corrosion, with elevated serum metal levels. We report the case of an 82-year-old woman, 5.5 years after a modular unipolar hip hemiarthroplasty, who presented with a 4-month history of hip pain and limp. Evaluation showed elevated serum cobalt and chromium levels and an acetabular cyst. At revision, fluid, tissue, and gross inspection were consistent with trunnion corrosion. The hip was revised with a ceramic head and dual mobility acetabular component, with a good result at 1 year. The designs of commercially available, modern unipolar hip hemiarthroplasty prostheses are reviewed.

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Introduction

Adverse local tissue reaction (ALTR) has been described after metal-on-metal resurfacing and total hip arthroplasty (THA) [1]. Metal debris and ions were originally assumed to be generated only from the articular surfaces. Pain due to ALTR, with elevated cobalt (Co) and chromium (Cr) levels, has also been reported after metal-on-polyethylene THA, with a single taper [2] or dual taper modular femoral component [3,4]. Metal ions, fretting, and corrosion debris in these cases are caused by mechanically assisted crevice corrosion [5]. Displaced femoral neck fractures are commonly treated with a cemented or uncemented unipolar hemiarthroplasty. Historically, these have been monoblock components. However, most femoral hemiarthroplasties are now modular, with some type of neck adapter-sleeve between the stem and the large head, for intraoperative adjustment of leg lengths. As these patients are generally

elderly patients with low demands, there has been little concern about possible fretting corrosion at the stem-sleeve or sleeve-large head interfaces.

To our knowledge, there have been 2 published reports of ALTR, based on pathological intraoperative specimens, with modular “unipolar” hip hemiarthroplasty (Table 1). However, in one case, the diagnosis was not suspected preoperatively and no metal levels were obtained [6]. In the second case, the metal levels were not characteristic of the disorder. In both cases, a 36-mm cobalt chromium head was placed onto the retained femoral component [7]. No follow-up was reported in the first case, and there was recurrent dislocation which required revision in the second case [6,7]. This study reports a patient with a modular unipolar hip hemiarthroplasty, painful ALTR, and elevated metal levels, and suggests a treatment. The patient was informed that her clinical information would be submitted for publication and provided consent.

Case history

The patient is an 82-year-old woman, with a 4-month history of left hip pain. She fell at home and sustained a displaced left femoral neck fracture 5 and a half years, previously. She was healthy, independent, and did not have dementia. The surgeon performed an uncemented, press-fit, modular unipolar hip hemiarthroplasty (Unitrax unipolar 48 mm, +5 mm sleeve, both CoCr alloy, and

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Table 1
Reported cases of unipolar corrosion.

Cases of trunnion corrosion	Gender	Age at the time of hemiarthroplasty	Time in vivo until reoperation, mo	Symptoms	Radiographic findings	CRP, mg/L	ESR	Cobalt level	Chromium level	Location of corrosion	Treatment	Outcome
Whitehouse et al. [6]	Male	72	53 (onset symptoms)	Stiffness, hip pain	Heterotopic ossification; acetabular erosion; 1.5 × 1.3 cm cyst	7.7	ns	np	np	Stem and sleeve junction	Tantalum acetabular component; CoCr head	Hip abductor weakness, but follow-up time not stated
Khair et al. [7]	Male	ns	Between 36 and 48	Low back pain, groin pain	Superior-medial migration of hemiarthroplasty	ns	ns	1.8 ppb	2.4 ppb	Stem trunnion and sleeve junction	Acetabular bone grafting, and cage; cemented PE liner, 36-mm CoCr head	Failed, due to recurrent anterior dislocation at 12 mo; acetabular revision with plating and 74-mm titanium acetabular component, constrained PE liner, 32-mm ceramic head
Current case	Female	77	66	Lateral hip and groin pain	Loss of acetabular cartilage; 1 × 1 cm superolateral cyst	2.63	16	9.3 ug/m/mL	5.2 ug/m/mL	Sleeve, head junction	Tritanium acetabular component, dual-mobility liner, 28-mm ceramic head with titanium sleeve	No complications

np, not performed; ns, not stated; PE, polyethylene; CRP, C reactive protein; ESR, erythrocyte sedimentation rate.

titanium alloy Omnifit FX femoral component, Stryker, Mahwah, NJ) through a posterolateral approach, with repair of the capsule and short external rotators. She had no complications and returned home, ambulating independently with a cane. At 5 and a half years after surgery, she developed left lateral hip and groin pain. She was evaluated by an orthopaedic surgeon, who diagnosed trochanteric bursitis, and advised medication and exercises. However, this did not help, and she presented to this surgeon for consultation. The patient complained of groin and lateral hip pain exacerbated by walking and range of motion. She lived independently at home, used a cane full-time, walked short distances outdoors, and had difficulty placing on her left sock and shoe. Examination showed a moderate limp, shortening of 1 cm, and painful limited range of motion of the left hip. There was no palpable hip mass. Radiographs (Fig. 1a and b) showed a well-fixed uncemented, modular unipolar hip hemiarthroplasty. The acetabulum showed no cartilage and a superolateral cyst. Laboratory studies showed C reactive protein 2.63 mg/L (normal: 0–4.9), erythrocyte sedimentation rate 16 mm/h (normal 0–20), cobalt 9.3 ppb, and chromium 5.2 ppb. The diagnosis of trunnion corrosion of the left hip modular hemiarthroplasty was made. Aspiration of the hip was not performed and a magnetic resonance imaging scan was not performed, as a revision was requested by the patient.

At revision, through the posterolateral approach, the hip was aspirated of cloudy yellow fluid, and automated cell count of 38,547 nucleated cells, 85% neutrophils, but the laboratory would not perform a manual cell count. Histologic examination of synovium and acetabular membrane showed necrosis and long-term inflammation. The synovium and hollow interior of the 48-mm femoral head was full of yellow necrotic material (Fig. 2a and b). The femoral component was well-fixed, but the taper showed black discoloration and mild damage. The femoral head sleeve could not be removed from the large head. The acetabulum had a membrane and a 1 cm anterosuperior cyst filled with metal-stained yellow tissue. The abductor muscles and tendons were intact. Because of the higher risk of dislocation of a THA revised from a large head hemiarthroplasty, a dual mobility component with a ceramic head and titanium sleeve, was implanted. The well-fixed femoral component taper was cleaned with multiple lap sponges. The patient had no complications and complete relief of pain at 1 year. Metal levels were only obtained at 3 months, and showed cobalt 1.4 ppb and chromium 1.0 ppb.

Discussion

Displaced femoral neck fractures in patients over the age of 60 years have been generally treated with femoral head arthroplasty rather than fixation. Although THA has been performed for some patients, the most common procedure has been a unipolar hemiarthroplasty, with either a cemented or press-fit uncemented femoral component. Historically, these implants have been one-piece components, such as the Austin-Moore, Thompson, and Cathcart prostheses. This is an acceptable and valuable method of treatment, especially in patients who have low functional demands and a short life expectancy. In a study of 162 modular, cemented unipolar hip hemiarthroplasty performed in women over 70 years of age, the patient survival rate was 73% at 1 year, 23% at 5 years, and only 6% at 10 years [8]. Three of 18 prostheses (16%) had acetabular protrusion, and overall, 5 hips were revised at a mean of 1.3 years. Degeneration of acetabular cartilage articulating with a metal head has been described with both monoblock unipolar and bipolar hip hemiarthroplasty. Using biopsy specimens, Dalldorf et al. [9] reported degeneration of acetabular cartilage in 12 elderly patients with monoblock hemiarthroplasties, with complete loss of cartilage in all 6 patients in whom the implant had been in situ for

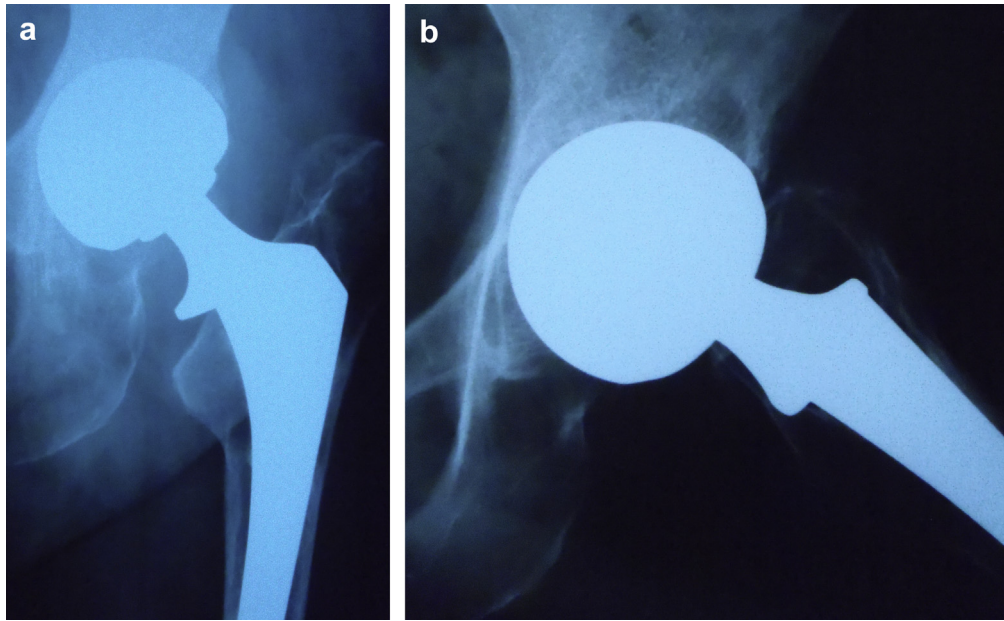


Figure 1. (a and b) Preoperative anteroposterior and frog lateral radiographs of modular unipolar hemiarthroplasty, showing an acetabular cyst.

more than 5 years. This study concluded that symptoms in a patient with a well-fixed hip hemiarthroplasty 5 years after implantation are probably due to wear of acetabular cartilage.

However, over the past several years, many unipolar hip hemiarthroplasty components have been fabricated as modular prostheses, with a large cobalt-chromium alloy femoral head, an adapter-sleeve (also cobalt-chromium alloy) to facilitate intraoperative adjustment of leg length and offset, and the femoral component (either titanium or cobalt-chromium alloy). There are a wide variety of designs of modern modular unipolar hip hemiarthroplasties, and to our knowledge, there is only one company that fabricates a monoblock unipolar with varying neck lengths (Table 2). The designs vary based on whether the large femoral head is solid or “hollow,” taper design, and number and lengths of the adapter-sleeves. There are additional options of using an oxinium head or a ceramic head, with a bipolar prosthesis. All companies have femoral components for press-fit insertion (titanium alloy) or for cement fixation (cobalt-chromium alloy). Although the design features that may contribute to trunnion corrosion of a hip hemiarthroplasty are not known, all 3 case reports had implants

from one manufacturer with one specific taper. ALTR has been reported with metal-on-polyethylene THAs and related to mechanically assisted crevice corrosion of the femoral component trunnion [2,4,5]. The cause of this corrosion is likely multifactorial, but incompletely understood [10,11]. These patients present with either groin or diffuse hip pain, swelling around the hip, or late instability. Elevated serum metal levels, particularly a differential elevation of serum Co levels with serum Cr levels, are very helpful in establishing this diagnosis. This has been described with both cobalt-chromium alloy and titanium alloy uncemented femoral components with a modular cobalt-chromium alloy femoral head. The treatment recommended has included debridement of the intra-articular inflammatory tissue or pseudotumors, liner exchange, and placement of a ceramic head-titanium sleeve on a manually cleaned trunnion [12]. A constrained liner has also been recommended in these cases if there is compromise or necrosis of the abductor muscles [1,11].

The patient in this report had both groin and lateral hip pain that was ascribed to trochanteric bursitis. Radiographs showed a well-fixed, modular, hip hemiarthroplasty femoral component, but

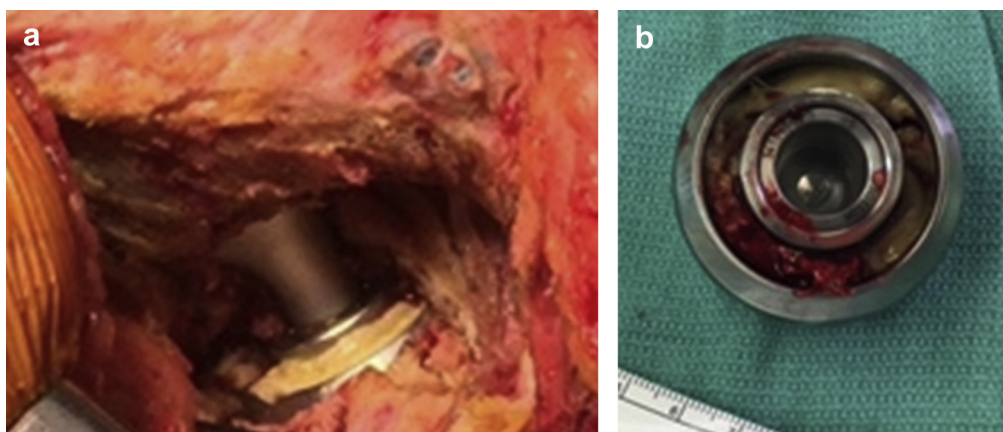


Figure 2. (a) Intraoperative photograph of modular unipolar head filled with necrotic tissue. (b) Unipolar head, filled with necrotic material, was not removed from adapter.

Table 2
Unipolar hip prostheses available in the United States.

Company	Head material	Solid or hollow femoral head	Head sizes, ranges, mm	Cobalt-chromium sleeve lengths	Taper	Femoral component ("low-demand" fracture stem)
Stryker	Cobalt-chromium	Hollow	41-72	V40: -4, 0, +4, +8, +12 C-taper: 0, +5, +10	V40 and C-taper	Ti
Zimmer Biomet	Cobalt-chromium	Solid	38-60	-4, 0, +4, +8 mm	12/14 taper	Ti
DePuy Synthes	Cobalt-chromium	Solid	41-60	-3, 0, +5, +10	12/14 articular/EZE	Ti (uncemented) Co-Cr (cemented)
Smith & Nephew	Cobalt-chromium or oxinium	Solid	40-61 40-55	-3- +12 mm	12/14	Ti Co-Cr
Exactech	Cobalt-chromium	Hollow	42-55	-3.5, 0, +3.5, +7, +1-	12/14	Ti
DJO Global	Cobalt-chromium	Hollow	40-64	-3.5, 0, +3.5, +7, +10.5	12/14	Ti and Co-Cr
MicroPort	Cobalt-chromium	Hollow	36-56	-3.5, 0, +3.5, +7	12/14 "SLT"	Ti (uncemented) Co-Cr (cemented)
Stelkast	Cobalt-chromium	Solid	41-61 (-5, 0, +7 mm neck length)	No sleeve	12/14	Ti (uncemented) Co-Cr (cemented)

Ti, titanium alloy; Co-Cr, cobalt-chromium alloy.

early acetabular protrusion with an acetabular cyst. Trunnion corrosion was also suspected, and confirmed by elevated serum metal levels. A metal artifact reduction magnetic resonance imaging scan was not performed. The choice of components, to relieve pain and prevent postoperative complications, for revision of modular hip hemiarthroplasty is somewhat controversial. Sah and Estok [13] have reported a dislocation rate of 22% after conversion of a hip hemiarthroplasty to THA. This high rate is likely related to the reduction of the size of the femoral head unique to conversion arthroplasty. One of the case reports of ALTR after hip hemiarthroplasty had recurrent dislocation and cup loosening, which required re-revision to a constrained component. For the patient in this report, a dual-mobility component with a ceramic femoral head was performed, rather than a constrained liner, to reduce the chance of postoperative dislocation, as the abductor muscles appeared to be viable. This dual mobility component does have a cobalt-chromium alloy liner, impacted into a titanium acetabular shell, with which the large polyethylene ball articulates. Although Matsen Ko et al. [14] reported elevated serum Co and Cr alloy levels in 4% of 100 consecutive primary THAs using modular dual-mobility components with a cobalt-chromium alloy head, possibly showing corrosion at the liner-acetabular junction, this finding has not been corroborated, and the elevated Co and Cr ions could have been from the metal alloy heads used in this cohort.

Summary

This is the third reported case of ALTR associated with trunnion corrosion in a patient with a modular unipolar hip hemiarthroplasty. We suspect that this complication may occur more frequently, either in isolation or with associated acetabular protrusion. Cyst formation may be a sign of ALTR and was seen in this patient and one of the other reported cases. Surgeons should consider this diagnosis when such a patient presents with diffuse hip pain. We recommend obtaining serum Co and Cr levels in

patients with a painful modular hip hemiarthroplasty. The choice of revision prosthesis is controversial, but should include a ceramic head-titanium sleeve for the retained femoral component trunnion.

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