



## Case report

## Corrosion and adverse local tissue reaction after total hip arthroplasty with a modular titanium alloy femoral neck

Colin D. Canham, MD, Pavel I. Muradov, MD, Jordan B. Simpson, MD, Stephen J. Incavo, MD\*

Houston Methodist Orthopedics &amp; Sports Medicine, Outpatient Center, Houston, TX, USA

## ARTICLE INFO

## Article history:

Received 27 January 2017

Received in revised form

7 March 2017

Accepted 8 March 2017

Available online 15 April 2017

## Keywords:

Total hip replacement

Trunnionosis

Modular titanium alloy femoral neck

Pseudotumor

Metallosis

Bi-modular femoral stem

## ABSTRACT

This report describes a case of mechanically assisted crevice corrosion and secondary adverse local tissue reaction in a patient following a total hip arthroplasty, utilizing a modular neck (bi-modular) femoral component. Radiographic evaluation demonstrated a well-positioned, stable, cementless arthroplasty. Upon further evaluation, the patient had elevated serum cobalt and chromium levels, and magnetic resonance imaging demonstrated a periprosthetic pseudotumor. Corrosion of both the neck-stem and head-neck junctions was suspected. At the time of surgery, the neck-body junction was pristine; however, the head-neck junction of the implant demonstrated severe corrosive wear, a problem that has been reported only once previously with this particular bi-modular implant. This serves as a reminder that any modular junction may be susceptible to corrosion and not all bi-modular designs behave similarly.

© 2017 Houston Methodist Orthopedics & Sports Medicine. Published by Elsevier Inc. on behalf of The American Association of Hip and Knee Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Modular neck femoral stem designs, which have modular connection at both the proximal and distal aspects of the neck, are referred to as “bi-modular.” These designs provide additional intraoperative versatility to independently fine-tune ante-version, leg length and offset [1]. Unfortunately, early failures have been documented in cases of some bi-modular neck designs secondary to mechanically assisted crevice corrosion (MACC) at the neck-stem junction [2–6]. MACC resulted in recalls of Rejuvenate, ABG II (both Stryker Orthopedics, Mahwah, NJ), and some Profemur (MicroPort Orthopedics, Memphis, TN) implants [2,3,7,8].

Adverse local tissue reaction (ALTR) associated with MACC has involved only modular junctions in which at least one of the 2 members is fabricated from a cobalt chromium alloy [9]. Titanium

fretting corrosion has been demonstrated in retrieval studies of failed bi-modular stems with titanium necks, and elevated serum titanium levels have been found in patients with titanium femoral stems [10]. However, titanium corrosion has not been associated with ALTR [11].

We report on a patient who after undergoing routine total hip replacement presented with elevated cobalt and chromium levels and a periprosthetic pseudotumor. The implant was of a bi-modular design with a titanium neck that does not generally fail at the neck-body junction and has not been recalled. The patient was informed that data concerning the case would be submitted for publication, and patient consent was obtained.

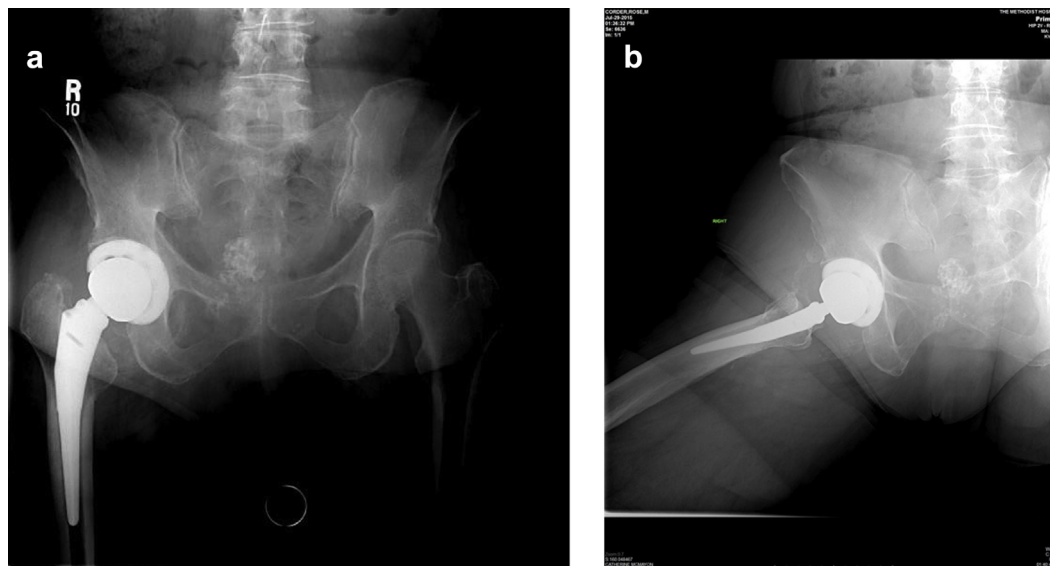
## Case history

A 78-year-old female with a body mass index of 34 kg/m<sup>2</sup> presented to our office with worsening groin pain and a limp. The symptoms began 2 years after an uncomplicated cementless total hip arthroplasty (THA) for end-stage osteoarthritis. The prosthesis used was a bi-modular Zimmer M/L Taper size 9 stem with a Kinectiv Technology modular neck made of titanium alloy (Ti6Al4V) with a 12/14 taper modular head-neck junction [12]. The shell was a size 60 Zimmer Continuum with a Longevity highly

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to <http://dx.doi.org/10.1016/j.artd.2017.03.003>.

\* Corresponding author: 6445 Main St., Suite 2500, Houston, TX 77030, USA. Tel.: +1 713 441 3569.

E-mail address: [sjincavo@houstonmethodist.org](mailto:sjincavo@houstonmethodist.org)



**Figure 1.** Anteroposterior (AP) pelvis (a) and lateral right hip (b) radiographs demonstrating a well-positioned right total hip arthroplasty with a bi-modular stem and a metal-on-polyethylene articulation.

cross-linked polyethylene liner; the head was a size 40 made of cobalt chrome alloy (Zimmer Biomet, Inc., Warsaw, IN).

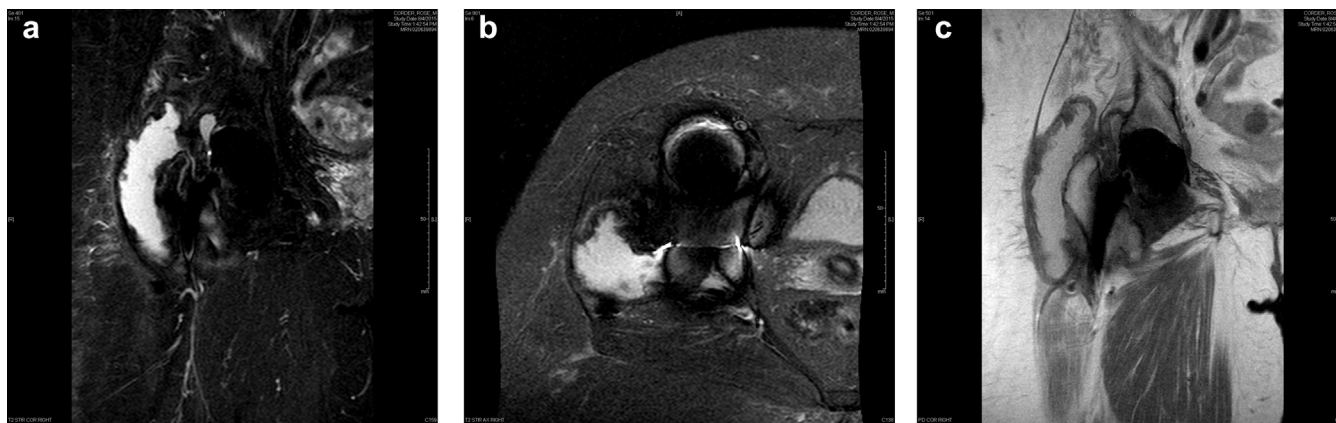
The radiographs showed well-positioned implants without significant osteolysis (Fig. 1). A metal artifact reduction sequence magnetic resonance imaging scan at the time of workup revealed a characteristic periprosthetic pseudotumor formation consistent with ALTR (Fig. 2).

Preoperative laboratory studies were significant for elevated serum cobalt of 12.3 ppb and chromium of 1.8 ppb. C-reactive protein and erythrocyte sedimentation rate were elevated at 2.8 mg/dL (ref 0.0–0.5) and 52 mm/h (ref 0–20), respectively. A fluoroscopically assisted hip joint aspiration performed prior to surgery was negative for infection. Gram stain and culture of fluid and tissue samples taken at the time of surgery were also negative for infection.

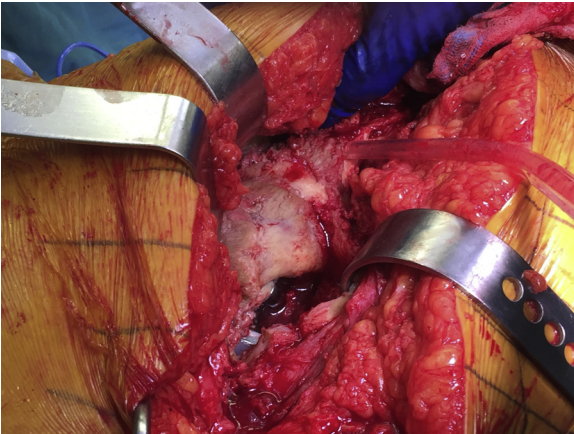
At the time of revision, the fascia was opened and a pressurized cavity that communicated with the joint was encountered. The large cyst contained a chalky fluid, consistent with ALTR. The abductor musculotendinous insertion was necrotic and only the anterior one-third of the fibers remained intact (Fig. 3). After

dislocation and head removal, inspection of the trunnion demonstrated severe damage and circumferential corrosion involving the head and trunnion. This was in contrast to the seemingly pristine neck-stem junction (Fig. 4). In order to minimize the risk of future implant-related complications, the decision was made to remove the femoral stem and replace it with a monolithic stem. Therefore, an extended trochanteric osteotomy was performed and the femoral component was revised to a nonmodular cementless Biomet Mallory-Head stem (Zimmer Biomet, Inc.). Due to the degree of abductor muscle destruction, the decision was made to use a constrained liner. The cup was gently tapped with a mallet and tamp to assess its stability and noted to be loose. Therefore, it was revised to a cementless Biomet G7 revision shell (Zimmer Biomet, Inc.) and fixed with multiple screws and a constrained liner was inserted. A one-piece ceramic head was used to minimize the risk of recurrent MACC at the head-neck junction.

At last follow-up, the patient was 10 months after surgery. She was experiencing occasional pain 2/10 in severity. She was ambulating without difficulty but used a cane and had a slight trendelenburg gait. Abductor strength was 4/5. Radiographs



**Figure 2.** Coronal T2 (a), axial T2 (b), and coronal T1-weighted (c) metal artifact reduction sequence magnetic resonance imaging demonstrating a periarticular fluid-filled cyst consistent with a pseudotumor.



**Figure 3.** Intraoperative image of the large cyst containing a chalky fluid, consistent with a pseudotumor.

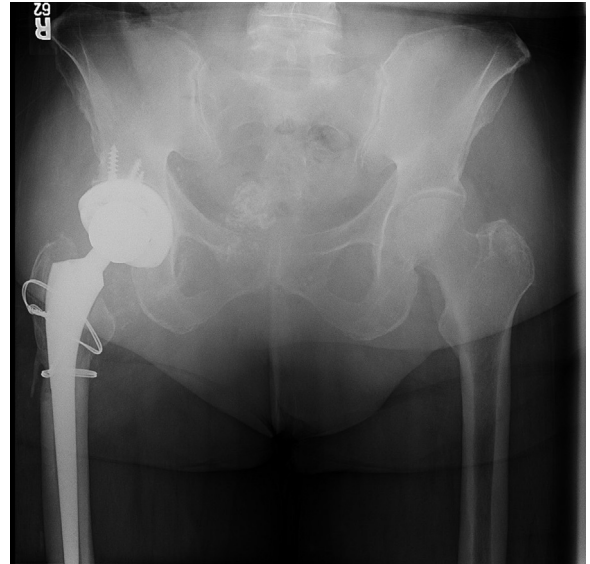
demonstrated stable position of components with healing of the extended trochanteric osteotomy (Fig. 5).

The implant failure outlined in this manuscript was not reported to the US Food & Drug Administration (FDA) MedWatch program, as the senior author chose not to report it.

## Discussion

Failure of bi-modular stems with cobalt chrome necks and titanium bodies has been widely reported [2,5,13,14]. The failure mechanism of these implants is typically MACC of the neck at the neck-stem junction, resulting in elevated cobalt and chromium levels and associated ALTR. However, the subject of this case report had a bi-modular implant with a titanium neck on a titanium stem and a cobalt chromium head. In light of this, the only potential source of the elevated serum cobalt and chromium was the head-neck junction. Although gross mechanical failure of Ti-Ti bi-modular stems has been widely reported [8,15–19], the authors are familiar with only one other case of failure of this type of bi-modular stem due to head-neck corrosion [20]. However, this taper (Zimmer 12/14; Zimmer Biomet, Inc.) has been found to have a relatively high prevalence of MACC [21]. This serves as a reminder that any modular junction is a potential site of failure and that not all bi-modular designs behave similarly.

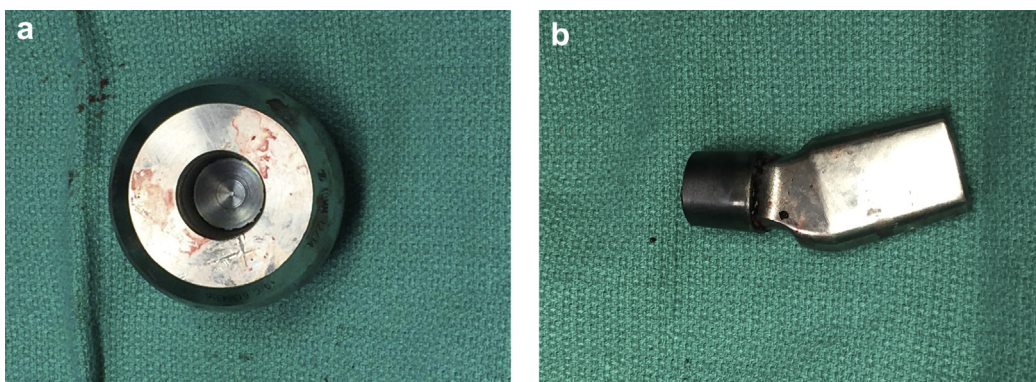
Taper breakdown at the modular head-neck junction is an increasingly recognized mode of failure in THA [4,9,22,23]. In implants with cobalt chrome alloy heads, corrosion of the trunnion results in elevated cobalt and chromium levels that have been



**Figure 5.** Follow-up anteroposterior pelvis radiograph of the patient's 10-month status after revision surgery.

associated with ALTR [24]. Increased taper wear may be associated with rougher taper surfaces, increased femoral offset, and mixed alloy combinations [4]. The patient in this case report did have a large, 40-mm diameter femoral head; it has been suggested that large head size contributes to taper wear, but this has recently come into question [25]. In a retrieval study of metal-on-metal implants, devices with neck modularity demonstrated increased damage at the head-neck taper compared to those without neck modularity [26]. However, it is unclear what factors specific to bi-modular femoral components may contribute to taper wear.

In contrast to bi-modular stems with cobalt chrome necks, those with titanium necks have not been associated with failure due to MACC of the neck-stem junction. Several authors have reported gross mechanical failure of modular Ti-Ti neck-stem junctions [8,15–17,19], including the same Zimmer Kinectiv implant use with our patient [18]. Additionally, high failure rates of the Ti-Ti bi-modular Profemur implant have been reported due to aseptic loosening [8]. Corrosion of the neck-stem junction in bi-modular implants with titanium necks may contribute to mechanical failure. Elevated serum titanium levels secondary to titanium corrosion have been reported, but there has not been an association with ALTR [11]. The clinical effects of elevated serum titanium levels associated with titanium taper corrosion remain unknown.



**Figure 4.** Photographs of the retrieved modular head (a) and neck with a black staining at the trunnion (b) consistent with corrosion.



We chose to remove the entire stem in this patient in order to replace it with a monolithic stem that would not have the potential for further complications related to the modular neck-stem junction. A simpler option in this patient's case would have been to replace the cobalt chrome head with a ceramic head and place a new modular titanium neck. This would likely eliminate the problem of MACC at the head-neck junction, but the modular neck-stem junction would remain as a potential site of failure. Even though the Zimmer Kinectiv modular necks have not had the degree of problems other bi-modular stems have had, given reports of neck fracture with this implant and its uncertain long-term performance, we chose to revise it in favor of a monolithic stem in order to minimize the risk of future complications in this patient who had already suffered considerable morbidity from a failed implant. A third option would be to retain the modular neck, clean it thoroughly, and place a revision ceramic head with a titanium sleeve on it. Given that replacement modular necks exist for the Kinectiv implant, retaining the neck in our case is likely ill-advised, but it would be an option in a case where no replacement neck is available.

### Summary

Bi-modular femoral stems used for THA have demonstrated multiple modes of failure, which depend in part on the composition of the neck component. Those with cobalt chromium necks tend to fail due to corrosion at the neck-stem junction and associated ALTR. Those with titanium necks tend to fail due to neck fracture and stem loosening. In this case, we observed ALTR due to MACC at the head-neck junction of a bi-modular femoral component with a titanium neck, without evidence of corrosion at the neck-stem junction. This serves as a reminder that any modular junction may be susceptible to corrosion and not all bi-modular designs behave similarly.

### References

- [1] Duwelius PJ, Hartzband MA, Burkhart R, et al. Clinical results of a modular neck hip system: hitting the "bull's-eye" more accurately. *Am J Orthop (Belle Mead, NJ)* 2010;39(10 Suppl):2.
- [2] Meftah M, Haleem AM, Burn MB, Smith KM, Incavo SJ. Early corrosion-related failure of the rejuvenate modular total hip replacement. *J Bone Joint Surg Am* 2014;96(6):481.
- [3] Molloy DO, Munir S, Jack CM, et al. Fretting and corrosion in modular-neck total hip arthroplasty femoral stems. *J Bone Joint Surg Am* 2014;96(6):488.
- [4] Esposito CI, Wright TM, Goodman SB, Berry DJ. Clinical, Biological and Bioengineering Study Groups from Carl T. Brighton Workshop. What is the trouble with trunnions? *Clin Orthop Relat Res* 2014;472(12):3652.
- [5] Atwood SA, Patten EW, Bozic KJ, Pruitt LA, Ries MD. Corrosion-induced fracture of a double-modular hip prosthesis: a case report. *J Bone Joint Surg Am* 2010;92(6):1522.
- [6] Rajpura A, Board TN. The evolution of the trunnion. *Hip Int* 2015;25(1):2.
- [7] Kop AM, Swarts E. Corrosion of a hip stem with a modular neck taper junction: a retrieval study of 16 cases. *J Arthroplasty* 2009;24(7):1019.
- [8] Pour AE, Borden R, Murayama T, Groll-Brown M, Blaha JD. High risk of failure with bimodular femoral components in THA. *Clin Orthop Relat Res* 2016;474(1):146.
- [9] Jacobs JJ, Cooper HJ, Urban RM, Wixson RL, Della Valle CJ. What do we know about taper corrosion in total hip arthroplasty? *J Arthroplasty* 2014;29(4):668.
- [10] Grupp TM, Weik T, Bloemer W, Knaebel HP. Modular titanium alloy neck adapter failures in hip replacement—failure mode analysis and influence of implant material. *BMC Musculoskelet Disord* 2010;11:3.
- [11] Nam D, Keeney JA, Nunley RM, et al. Metal ion concentrations in young, active patients following total hip arthroplasty with the use of modern bearing couples. *J Arthroplasty* 2015;30(12):2227.
- [12] Hertzler JS, Johnson TS, Meulink SL. Performance evaluation of Kinectiv® technology. [http://prod-www.web.zimmer.com/content/pdf/en-GB/ML\\_Taper\\_with\\_Kinectiv\\_White\\_Paper\\_\(97-7713-010-00\)\\_2010.pdf](http://prod-www.web.zimmer.com/content/pdf/en-GB/ML_Taper_with_Kinectiv_White_Paper_(97-7713-010-00)_2010.pdf) (97-7713-010-00 Rev. 1 0905-H07 2.5ML Printed in USA ©2008, 2009, 2010 Zimmer, Inc.) Updated 20092017. Accessed January 2017.
- [13] Cooper HJ, Urban RM, Wixson RL, Meneghini RM, Jacobs JJ. Adverse local tissue reaction arising from corrosion at the femoral neck-body junction in a dual-taper stem with a cobalt-chromium modular neck. *J Bone Joint Surg Am* 2013;95(10):865.
- [14] De Martino I, Assini JB, Elpers ME, Wright TM, Westrich GH. Corrosion and fretting of a modular hip system: a retrieval analysis of 60 rejuvenate stems. *J Arthroplasty* 2015;30(8):1470.
- [15] Wright G, Sporer S, Urban R, Jacobs J. Fracture of a modular femoral neck after total hip arthroplasty: a case report. *J Bone Joint Surg Am* 2010;92(6):1518.
- [16] Hernandez A, Gargallo-Margarit A, Barro V, Gallardo-Calero I, Sallent A. Fracture of the modular neck in total hip arthroplasty. *Case Rep Orthop* 2015;2015:591509.
- [17] Ellman MB, Levine BR. Fracture of the modular femoral neck component in total hip arthroplasty. *J Arthroplasty* 2013;28(1):196.e1.
- [18] Sotereanos NG, Sauber TJ, Tupis TT. Modular femoral neck fracture after primary total hip arthroplasty. *J Arthroplasty* 2013;28(1):196.e7.
- [19] Wodecki P, Sabbah D, Kermarrec G, Semaan I. New type of hip arthroplasty failure related to modular femoral components: breakage at the neck-stem junction. *Orthop Traumatol Surg Res* 2013;99(6):741.
- [20] Plummer DR, Berger RA, Paprosky WG, et al. Diagnosis and management of adverse local tissue reactions secondary to corrosion at the head-neck junction in patients with metal on polyethylene bearings. *J Arthroplasty* 2016;31(1):264.
- [21] McGrory BJ, MacKenzie J, Babikian G. A high prevalence of corrosion at the head-neck taper with contemporary Zimmer non-cemented femoral hip components. *J Arthroplasty* 2015;30(7):1265.
- [22] Cooper HJ, Della Valle CJ, Berger RA, et al. Corrosion at the head-neck taper as a cause for adverse local tissue reactions after total hip arthroplasty. *J Bone Joint Surg Am* 2012;94(18):1655.
- [23] Shulman RM, Zywiell MG, Gandhi R, Davey JR, Salonen DC. Trunnionosis: the latest culprit in adverse reactions to metal debris following hip arthroplasty. *Skeletal Radiol* 2015;44(3):433.
- [24] Scully WF, Teeny SM. Pseudotumor associated with metal-on-polyethylene total hip arthroplasty. *Orthopedics* 2013;36(5):e666.
- [25] Triantafyllopoulos GK, Elpers ME, Burket JC, et al. Otto Aufranc Award: large heads do not increase damage at the head-neck taper of metal-on-polyethylene total hip arthroplasties. *Clin Orthop Relat Res* 2016;474(2):330.
- [26] Higgs GB, Hanzlik JA, MacDonald DW, et al. Is increased modularity associated with increased fretting and corrosion damage in metal-on-metal total hip arthroplasty devices? A retrieval study. *J Arthroplasty* 2013;28(8 Suppl):2.