Clin Orthop Relat Res (2013) 471:4082–4086
DOI 10.1007/s11999-013-3133-1

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

CASE REPORT

Adverse Local Tissue Reaction Associated With a Modular Hip Hemiarthroplasty

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Received: 25 February 2013 / Accepted: 19 June 2013 / Published online: 29 June 2013

Abstract

Background The local and systemic effects of wear debris and corrosion products remain a concern in arthroplasty and reaction to corrosion or wear products from modular junctions has been reported in primary and revision total joint arthroplasties. These effects have not been reported previously for unipolar hemiarthroplasties where there is no prosthetic bearing surface to contribute to the phenomenon. This may have implications for clinical surveillance and implant design.

Case Description We report the case of a 72-year-old man who had symptomatic pseudotumor formation, confirmed by pathologic examination of the excised pseudotumor, with a large-head modular hip hemiarthroplasty. Metallosis and corrosion of the modular head/neck taper junction were noted at the time of revision surgery.

Literature Review To our knowledge, this is the first report of pseudotumor formation where the corrosion or wear products arose from the modular junction of the implant with no bearing couple present to contribute wear debris that may influence the formation of the pseudotumor.

Purposes and Clinical Relevance Adverse tissue reactions to wear debris generated at prosthetic articulating surfaces and corrosion and wear products from nonarticulating prosthetic junctions have been reported. The problem has been reported to be higher in metal-on-metal bearing

One of the authors certifies that he (MRW), or a member of his or her immediate family, has or may receive payments or benefits, during the study period, an amount of less than USD 10,000 from the British Orthopaedic Association funded by a commercial entity (Zimmer Inc, Warsaw, IN, USA; traveling fellowship).
One of the authors certifies that he (BAM), or a member of his or her immediate family, has or may receive payments or benefits, during the study period, an amount of USD 10,000–USD 100,000 from a commercial entity, Zimmer Inc. The institution of the authors (BAM, MRW) has received funding from Zimmer Inc, DePuy Synthes Canada Ltd, Johnson & Johnson (Canada) Inc (Markham, Ontario, Canada), Stryker Canada (Hamilton, Ontario, Canada), and Bayer Inc (Toronto, Ontario, Canada).
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Each author certifies that his or her institution approved or waived approval for the reporting of this case and that all investigations were conducted in conformity with ethical principles of research.

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couples and in large-diameter hip arthroplasties. Mixed-alloy junctions appear to be more susceptible to corrosion. We believe that corrosion should be considered a possible diagnostic entity when investigating persistent symptoms after hemiarthroplasty and may be avoided with the use of monoblock components.

Introduction

The local and systemic effects of wear debris and corrosion products remain a concern in arthroplasty [4, 14, 15] and local adverse reactions to wear debris have been documented for various bearing couples [2, 20]. Reaction to wear or corrosion products from modular junctions is not a new phenomenon [3], but the relative contribution of each of these to the observed reactions is not clear. The local adverse reactions that occur may be symptomatic or asymptomatic [20].

We present a case of symptomatic pseudotumor formation secondary to corrosion at the modular head/neck junction of a hemiarthroplasty in which there was no prosthetic bearing couple; the reconstruction used a cobalt-chrome unipolar prosthesis with modularity limited to the head-neck junction. To our knowledge, this is the first case report of local tissue adverse reaction in the absence of a prosthetic bearing surface, leaving the modular head-neck junction as the only source of metal debris.

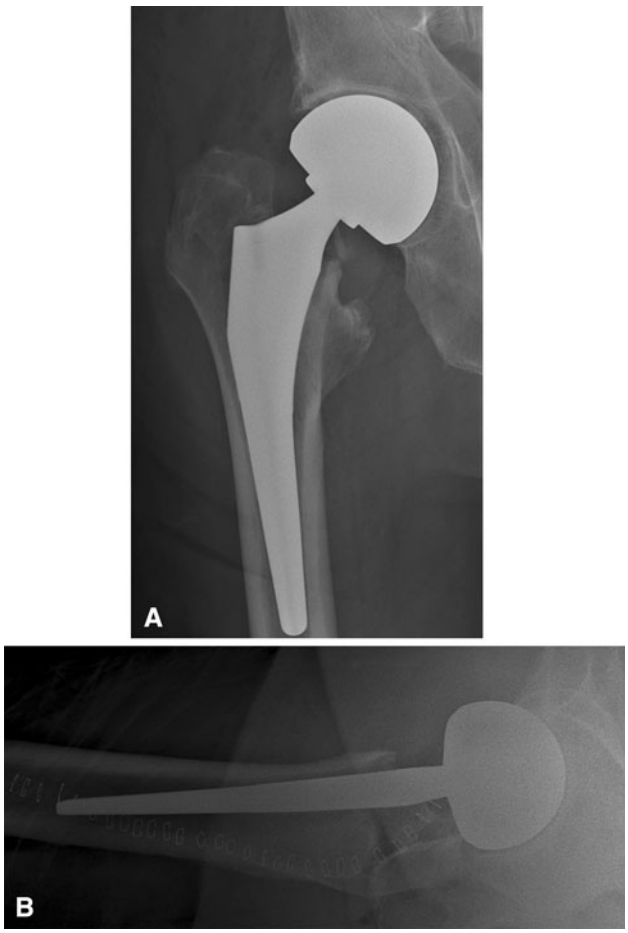

Fig. 1A–B One-day postoperative (**A**) AP and (**B**) lateral view radiographs show the uncemented modular implant.

Case Report

A 72-year-old man underwent an uncemented unipolar right hip hemiarthroplasty for a displaced intracapsular fractured neck of the femur in 2007. He previously had been an elite athlete, having competed in the Olympic Games many years earlier. The fracture was sustained in a fall from greater than standing height with no preexisting hip symptoms. His initial recovery was uneventful. Eighteen months after treatment, he sought the opinion of his initial surgeon because his range of motion (ROM) was becoming increasingly limited and this was restricting his activities of daily living, although he no longer was participating in sports at an elite level. He described pain at the extremes of his arc of ROM. Conservative management was advised. Twenty-four months after his hemiarthroplasty he sought referral to our unit for persistent pain and stiffness.

Clinical assessment revealed the right (surgical) leg was 2 cm shorter than the left. He had stiffness in several planes, with ROM limited to 5° to 90° flexion and a fixed external rotation contracture of 15°; he had adduction to 15° and abduction to 30°. Pain was provoked by flexion to 90°, adduction, and attempted internal rotation. Radiographs confirmed the limb length discrepancy and Brooker Grade III heterotopic ossification [1], and further showed the cementless stem to be well-fixed. Initial postoperative radiographs showed the stem was in 1.5° valgus alignment and 9° anterior to posterior alignment (Fig. 1). Alignment was unchanged on followup radiographs and there was no detectable subsidence. Initial management included conservative measures, including analgesia and physiotherapy, as the patient felt his symptoms were not severe enough to justify revision surgery.

His restricted ROM persisted and his pain increased, and he presented for reevaluation. The degree of shortening was stable and therefore although this could have created impingement leading to reduced ROM and pain, this would not have explained the increase in his pain. However, he had significant heterotopic ossification which led to significant reduction in ROM, which would have decreased the risk of impingement. At that time, the patient was afebrile and preoperative investigations revealed a white blood cell count of $7.8 \times 10^3/\mu L$ (neutrophils, $6.1 \times 10^3/\mu L$) and a C-reactive protein of 7.7 mg/L. Accordingly, a

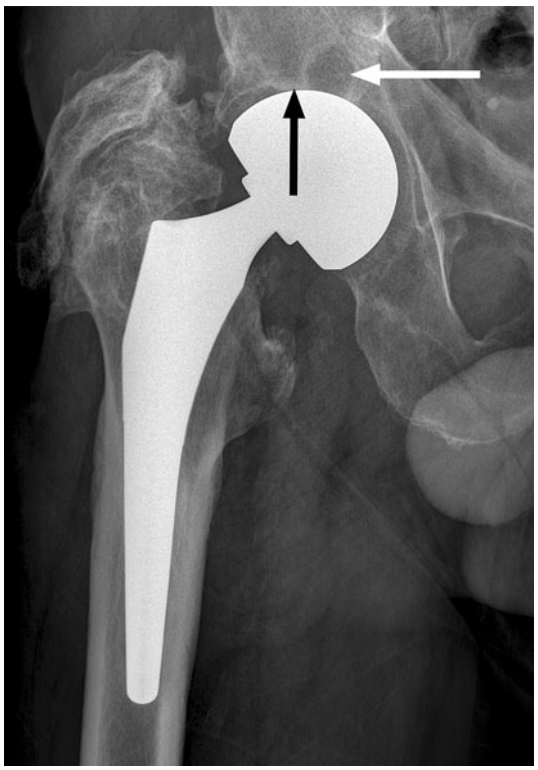

Fig. 2 Acetabular erosion (black arrow), cyst formation in the sourcil (white arrow), and heterotopic ossification were seen 53 months after surgery.

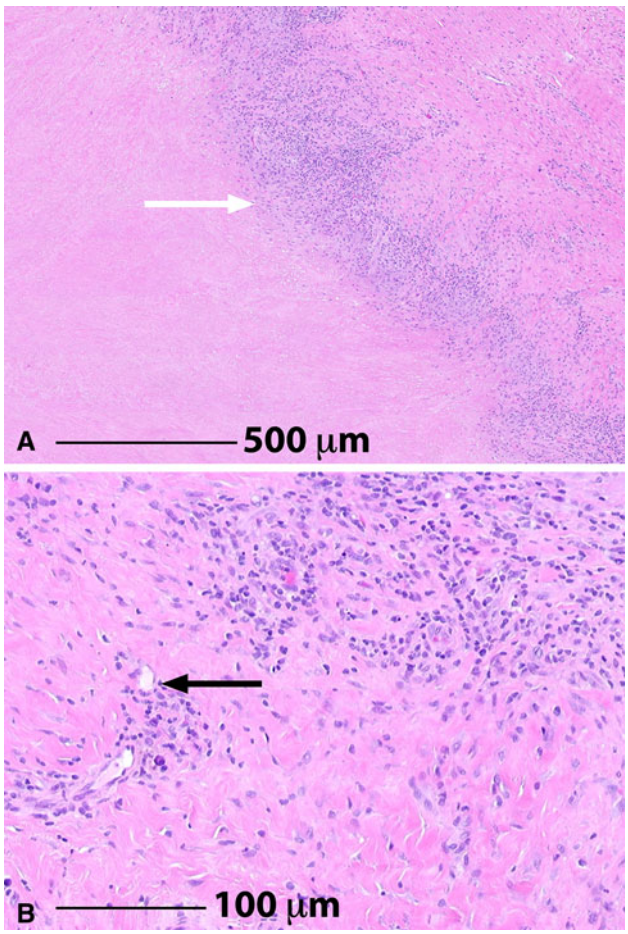

Fig. 3A–B (**A**) Extensive necrotic hyalinized tissue (left) is garlanded by a lymphohistiocytic inflammatory reaction (white arrow) (Stain, hematoxylin and eosin; original magnification, ×20). (**B**) Inflammatory cells are composed mainly of lymphoplasmacytes with perivascular aggregates (black arrow) (Stain, hematoxylin and eosin; original magnification, ×100).

decision was made to perform revision surgery 53 months after the index operation. Radiographs obtained before revision surgery showed a substantial cavitary focal acetabular erosive lesion (maximum dimension, 1.5 × 1.3 cm). The femoral head rested on subchondral bone; there was complete chondrolysis but no evidence of acetabular erosion beyond the subchondral bone with the exception of the cavitary lesion in the sourcil region (Fig. 2).

Implant labels from the primary operation confirmed the implants used were an FDA-approved Accolade TMZF Plus stem (Howmedica/Osteonics, Mahwah, NJ, USA) (a beta titanium alloy (Ti-12Mo-6Zr-2Fe), size 3.5;) with a Unitrax v40 standard sleeve (Howmedica/Osteonics) (vitallium alloy, Co-Cr-Mo) and a unipolar Unitrax 54-mm outer diameter endoprosthetic head (vitallium alloy, Co-Cr-Mo). The only modular junctions with this construct are between the stem and sleeve, and between the sleeve and the head.

Revision surgery was performed 60 months after the index operation. Preoperative radiotherapy (one cycle of 700 cGy) was performed 1 day before surgery to reduce the risk of recurrence of the heterotopic ossification. At the time of revision surgery, extensive heterotopic ossification was observed and excised. Metallosis was observed with black corrosion products seen on the trunnion; the metal surface was thoroughly cleaned. Necrotic material was seen in the socket, which was pale and bland. Thorough débridement was performed. Because the stem was well fixed, it was elected to keep the stem and implant at 36-mm diameter +10 mm neck length head. The acetabulum was sequentially reamed and the cavitary lesion débrided and packed with bone graft harvested from the reamings. A 60-mm outer diameter Continuum cup (Zimmer, Warsaw, IN, USA) was implanted with a 15° elevated liner, achieving satisfactory ROM, stability, and partial leg length correction. A cobalt-chrome head was used because the presence of adverse reaction to metal debris was not suspected preoperatively.

Pathologic examination of the excised tissue showed large areas of bland necrosis surrounded by a rim of dense lymphohistiocytic (granulomatous) inflammation (Fig. 3A). Inflammatory cells were composed predominantly of lymphoplasmacytes showing perivascular aggregates followed by macrophages and eosinophils (Fig. 3B). Occasional perivascular neutrophils also were seen, albeit in

a lower range than expected for an infectious etiology. In addition, visible metal particles with foreign body reaction and ossification were seen in the specimens. These pathologic features are entirely consistent with a necrotic granulomatous pseudotumor, as described in the literature most commonly in the context of metal-on-metal resurfacing cobalt-chromium implants [13]. At followup, the patient's pain and stiffness had resolved, although he still had some abductor weakness and is continuing physiotherapy. He is scheduled for annual followup in the event that further corrosion of the trunnion should lead to deleterious effects.

Discussion

To our knowledge, this is the first report of pseudotumor formation where the corrosion or wear products arose from the modular junction of the implant with no bearing couple present to contribute wear debris that may influence the formation of the pseudotumour. We believe this is an important finding because it emphasizes the importance of this differential diagnosis to orthopaedic surgeons who may not have an arthroplasty subspecialty interest. It further raises the question of modularity in arthroplasty and in hemiarthroplasties performed for trauma. Although modularity has the advantage of reducing the inventory required and increases the surgeon's intraoperative options for restoration of offset and leg lengths, it does introduce a potential interface for failure [3]. In particular, the large modular heads used for trauma applications may exert high torques and result in the potential for corrosion at the head-neck junction as was seen in our patient.

Given the evidence of high failure rates in large-diameter metal-on-metal implants in THAs [17], the diameter of the prosthetic head is likely to be important in this case. Corrosion at the modular interface between the head and neck of the implant is potentiated by the mechanical environment with cyclic loading leading to disruption of the passive oxide layer in a restricted crevice environment [6]. Although our patient previously had competed in sports at an elite level and remained active, he no longer participated in competitive sports but it is likely that his activity levels were greater than those of an average patient of his age. This may have been an exacerbating factor in the observed process. The effect is observed in mixed and similar metal couples, although the effect appears to be exaggerated in mixed couples [8]. An increased diameter bearing increases the lever arm and rotational torque on the modular interface of the head and neck, which may exacerbate disruption of the passive oxide layer and lead to formation of further corrosion products. The degree of corrosion present is related to the local and systemic distribution of corrosion products including chromium and cobalt [9]. The presence of corrosion at the head-neck interface in THA has been associated with ongoing hip pain and adverse tissue reactions requiring revision surgery in a small number of cases [4, 11, 18, 19]. The introduction of further modularity may be associated with increased blood metal ion levels and pseudotumour formation [7]. Differential elevation of serum cobalt and chromium levels has been attributed to wear or corrosion at the modular junction in metal-on-metal THA [5, 10] and in metal-on-polyethylene THA [4]. In this case, corrosion may occur at the interface between the stem and sleeve (titanium on cobalt-chrome) or at the interface between the sleeve and head (cobalt-chrome on cobalt-chrome). Macroscopically, corrosion was observed on the trunnion and inner surface of the sleeve. The sleeve was not disengaged from inside the prosthetic head to permit examination of that interface. We did not suspect this diagnosis preoperatively therefore serum metal ions were not obtained and as the levels would not have altered our ongoing followup and treatment of the patient, they were not obtained postoperatively.

The stem used at primary surgery in this case was a titanium alloy (Ti-12Mo-6Zr-2Fe) with a vitallium (cobalt-chrome-molybdenum) alloy sleeve and a vitallium (cobalt-chrome-molybdenum) unipolar head. This combination increases the risk of galvanic corrosion; however, the reported coupled corrosion potentials generated are low with small observed corrosion rates in an in vitro direct coupling study [12]. The stem used in the primary surgery in this case was reported in a case of adverse reaction to metal debris in a metal-on-polyethylene THA [11]. The reduced contact area of the v40 taper, narrow neck design of the stem design used here, and low rigidity of the stem neck have been identified as potential risk factors for corrosion [11, 16].

We think the corrosion in this case was the result of crevice corrosion which was exacerbated by the mechanical environment created by the large-diameter head and narrow neck and taper shape. As there was no macroscopic damage to the trunnion after cleaning, the stem was retained to avoid the morbidity associated with revision of a well-fixed uncemented stem. This is consistent with common practice in cases of trunnion corrosion in THA [4]. If we had known that the final disease was a necrotic granulomatous pseudotumor, we would have used a ceramic head with a titanium sleeve instead of a cobalt-chrome head, as is our practice when revising metal-on-metal hip replacements for this diagnosis. Although this is the first case of pseudotumor formation reported with the use of a modular hemiarthroplasty implant, we think the diagnosis is important and worth highlighting. Given the population of patients in whom hemiarthroplasty is performed and the relatively low demand of this patient group compared with

a population undergoing elective THA for degenerative disease, it is possible that this is an underrecognized and underreported phenomenon.

Acknowledgments We thank Torsten Nielsen MD, PhD, FRCPC of the Department of Pathology, University of British Columbia, for assistance in the sample analysis and preparation of this work.

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