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Case report

Adverse tissue reaction to corrosion at the neck-stem junction after modular primary total hip arthroplasty



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ABSTRACT

Complications related to the neck-stem junction of modular stems used for total hip arthroplasty (THA) are generating increasing concern. A 74-year-old male had increasing pain and a cutaneous reaction around the scar 1 year after THA with a modular neck-stem. Imaging revealed osteolysis of the calcar and a pseudo-tumour adjacent to the neck-stem junction. Serum cobalt levels were elevated. Revision surgery to exchange the stem and liner and to resect the pseudo-tumour was performed. Analysis of the stem by scanning electron microscopy and by energy dispersive X-ray and white light interferometry showed fretting corrosion at the neck-stem junction contrasting with minimal changes at the head-neck junction. Thus, despite dry assembly of the neck and stem on the back table at primary THA, full neck-stem contact was not achieved, and the resulting micromotion at the interface led to fretting corrosion. This case highlights the mechanism of fretting corrosion at the neck-stem interface responsible for adverse local tissue reactions. Clinical and radiological follow-up is mandatory in patients with dual-modular stems.

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1. Introduction

Modularity at the neck-stem junction was introduced in total hip prostheses to improve joint reconstruction accuracy without requiring a major increase in the stock of implants. However, reports of complications at the neck-stem junction are generating increasing concern [1–6]. In addition, registry data indicate higher revision rates compared to standard implants without neck-stem modularity [7]. Adverse tissue reactions due to corrosion at the modular neck-stem junction have been reported with a variety of alloys. Cooper et al. [4,8] provided detailed descriptions of corrosion with elevated serum ion levels after the implantation of prostheses having a modular chrome-cobalt neck and a titanium stem.

Here, we report a case of fretting corrosion at the modular neck-stem junction with a large pseudo-tumour and osteolysis requiring revision surgery 1 year after THA. This case illustrates the contribution of fretting corrosion at the neck-stem junction to adverse local

tissue reactions and cutaneous hypersensitivity reactions. These reactions resolved fully upon implant removal.

2. Case report

A 74-year-old male underwent THA for primary osteoarthritis. The procedure was planned using 3D computed tomography (CT) and HIP-PLAN software (Symbios, Yverdon-les-Bains, Switzerland) [9]. A direct anterior approach was used. Preoperative evaluation of stem size and neck geometry allowed dry assembly of the neck and stem on the back table. The implants consisted of an anatomic uncemented stem (Ti6Al4V; SPS, Symbios), modular neck (varus/long/retroverted; cobalt-chromium alloy), ceramic head (BioloX Delta 28 mm/+4 mm), and press-fit cup with a polyethylene liner (Hilock, Symbios). Full weight bearing was started immediately after surgery.

The patient reported gradually worsening hip pain 1 year later. The scar showed no signs of infection but was surrounded by dry eczema lesions typical for hypersensitivity (Fig. 1). Plain radiographs showed osteolysis of the calcar adjacent to the neck-stem junction (Fig. 2). Serum C-reactive protein was 56 mg/L, without leucocytosis. Cobalt and chromium levels were 7.72 µg/L and 1.61 µg/L, respectively. Milky fluid was aspirated from the joint and

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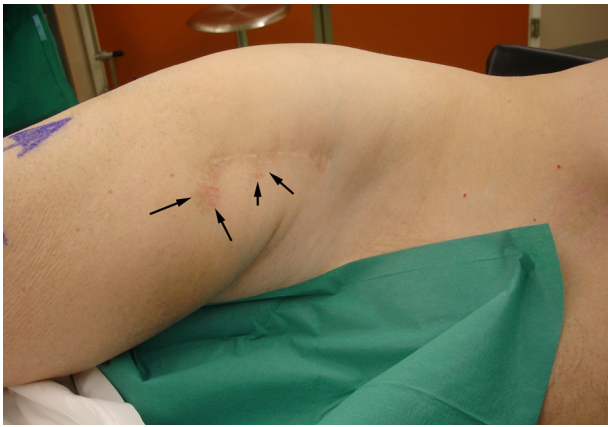


Fig. 1. Eczema at revision surgery, located around the scar left by the direct anterior approach used for the primary procedure.

showed no growth upon culturing. A pseudo-tumour was visible around the prosthesis by both CT and magnetic resonance imaging (MRI) (Figs. 3 and 4).

Revision arthroplasty with exchange of the stem, head, and liner was performed. An extensive periprosthetic cystic lesion surrounded by a thick fibrous capsule (Fig. 5) and filled with milky fluid was drained and excised. Reconstruction was with an all-titanium modular revision stem (Lima Corporate, Udine, Italy) and ceramic head. The postoperative course was uneventful. Weight bearing was protected for 6 weeks. Serum cobalt and chromium ion levels were 4.83 $\mu\text{g/L}$ and 1.87 $\mu\text{g/L}$, respectively, after 6 weeks.

Histological analysis of the resected tissues was consistent with aseptic lymphocytic vasculitis and associated lesions (ALVAL). Disassembly of the retrieved implant (Fig. 6) required the use of a pneumatic press. Gross damage to the interface was visible (Fig. 7). Scanning electron microscopy and energy dispersive X-ray analysis (EDX) detected evidence of fretting corrosion at the cone of the neck-stem junction (Figs. 8 and 9) with deposits measuring several micrometres in thickness and composed of oxidised chromium, molybdenum, and titanium. The presence of titanium indicated transfer of material from the stem onto the cobalt-chromium neck during fretting. Changes were minimal at the neck-ceramic head interface.

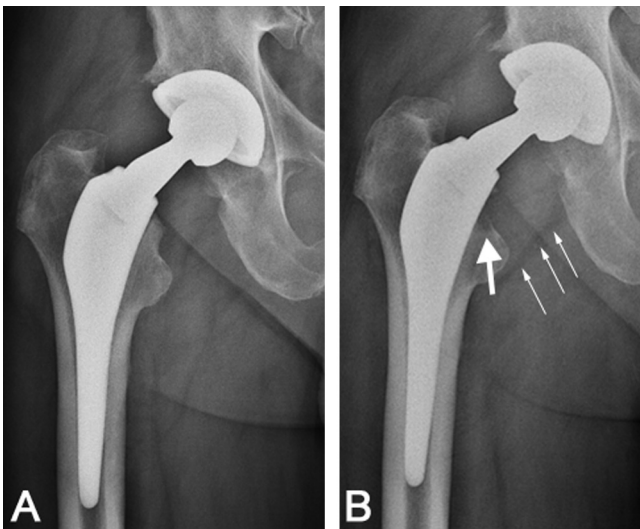


Fig. 2. Radiographs obtained immediately after total hip arthroplasty (A) and 1 year later (B): note the osteolysis of the calcar (bold arrow) and the periarticular soft-tissue lesion (small arrows).

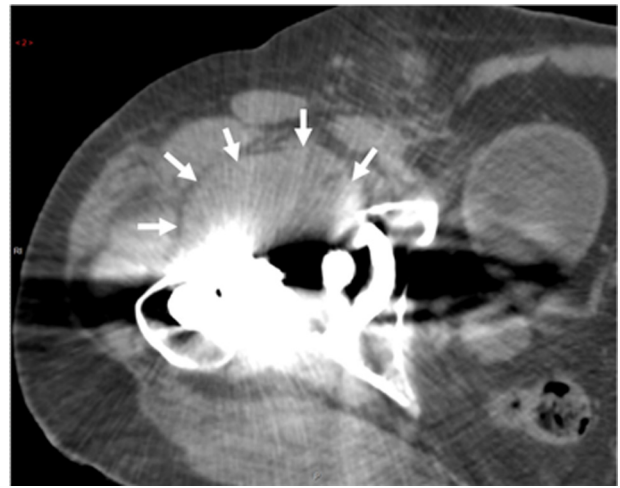


Fig. 3. Axial computed tomography image with multiplanar reconstruction along the axis of the prosthesis neck, showing a periarticular lesion of tissue-density (white arrows) in contact with the anterior aspect of the prosthesis neck.

3. Discussion

This case illustrates both the full range of adverse reactions to metal debris (ARMD) and their mechanism involving micromotion and fretting corrosion at the neck-stem junction but not at the head-neck junction. Thus, osteolysis, ALVAL with a large pseudo-tumour, and a cutaneous metal-hypersensitivity reaction were combined in our patient.

All metal-on-metal interfaces in biological systems are subject to corrosion and therefore shed metal ions or debris [1,2,4,8,10,11]. Recently, attention has been drawn to corrosion-related complications of dual-modular femoral stems, with several reports of adverse clinical outcomes [1,2,4,7]. Cooper et al. [4] recently studied 12 patients with adverse tissue reactions around the neck-stem junction. Particularly, long varus necks have been associated with high failure rates due to unfavourable mechanical-load distribution at the interface [12–14]. In our patient, a long varus neck with retro-angulation was combined with a long head, which further increased the mechanical stress to the neck-stem junction [14].

The eczema observed before revision surgery was not further evaluated. However, metal-induced cutaneous hypersensitivity reactions have been reported after arthroplasty [15]. The resolution of the skin lesions after implant removal in our patient suggests metal-induced eczema.

Analysis of the retrieved implant indicated fretting corrosion [4]. Thus, the morphological assessment of the cone at the neck-stem junction revealed corrosion-related deposits alternating with areas of unchanged machined surface. This pattern indicated incomplete contact between the cone and taper, allowing micromotion and promoting corrosion. The microscopic pattern of the deposits smeared on the taper further supported micromotion. Although the neck-stem junction was too strong to allow manual disassembly, micromotion occurred. Of note, it is our practice to take great care with dry assembly of the neck-stem junction on the back table [16]. We selected the best neck option based on preoperative 3D CT findings [9].

The deposits on the neck taper were composed of oxides of cobalt, chromium, and titanium. As the neck was made of cobalt-chromium alloy, the presence of titanium indicated transfer of titanium from the stem onto the neck. Interestingly, the deposits contained more chromium than cobalt. This finding, together with the high serum cobalt levels, was consistent with the marked solubility of cobalt ions and strong tendency of

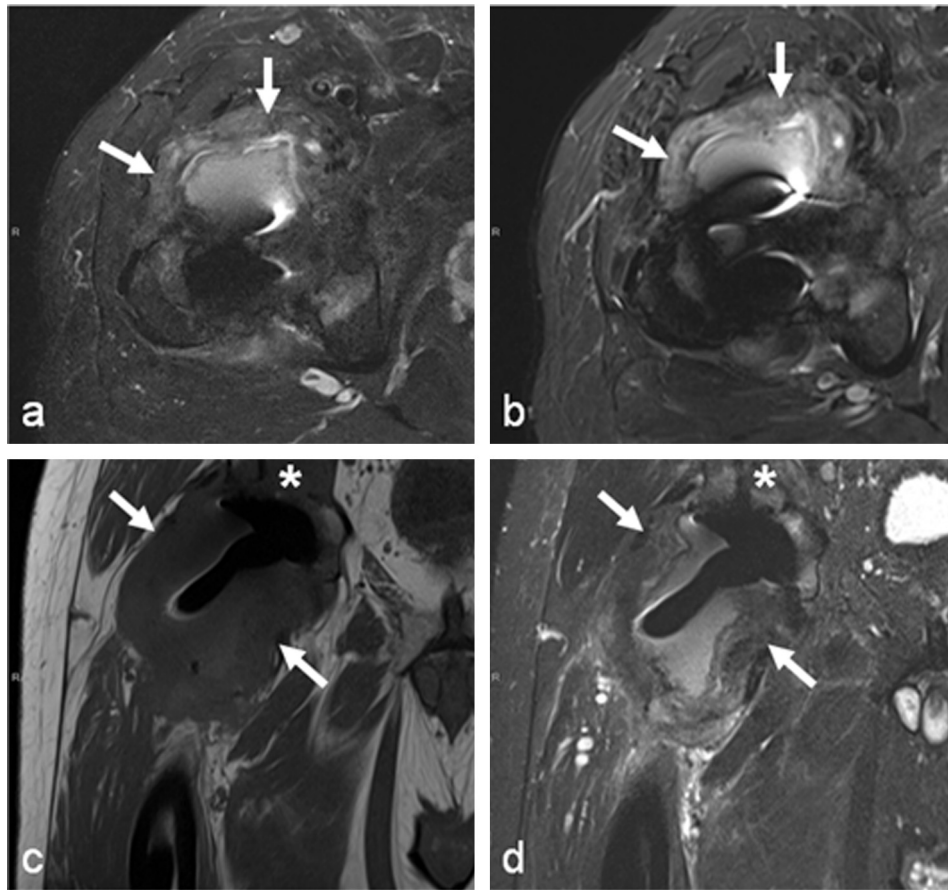


Fig. 4. Axial (a and b) and coronal (c and d) magnetic resonance images (MRI), processed using metal-artefact reduction software (MARS): note the periarticular lesion ($8 \times 9 \times 10$ cm) generating hyperintense signal (arrows) on fat-suppressed proton density (FSE, a) and STIR (d) images and hypointense signal on T1 FSE images (c), with a thick enhancing rim but no nodular enhancement (b). The iliac muscle is involved (asterisk).

chromium ions to precipitate as oxide in neutral pH environments.

The stem was replaced by a revision stem, which was also of modular design. However, all revision stem components were made of titanium, and consequently, no recurrence of metal-related adverse reactions was expected. We are not aware of reports of metal-related pseudo-tumours due to titanium alloys.

Ceramic heads are associated with a significantly lower risk of corrosion at the head-neck taper compared to metallic heads [17].

Based on this case and other reports [4,7], we no longer use modular necks for primary THA. Corrosion should be considered in patients reporting persistent pain after the implantation of dual-modular stems [5].

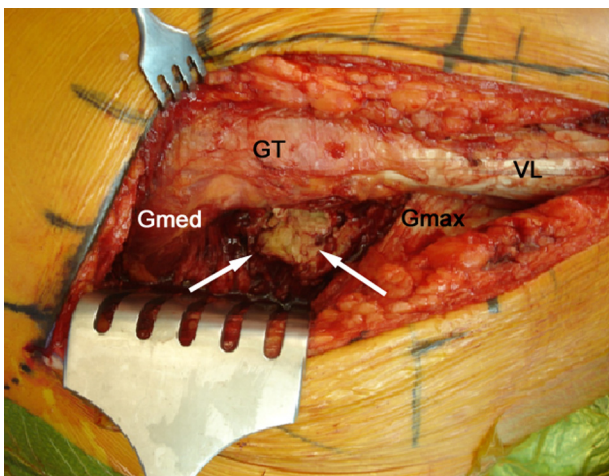


Fig. 5. Pseudo-tumour (arrow) at revision surgery. GT: greater trochanter; VL: vastus lateralis; Gmed: gluteus medius; Gmax: gluteus maximus attachment site.

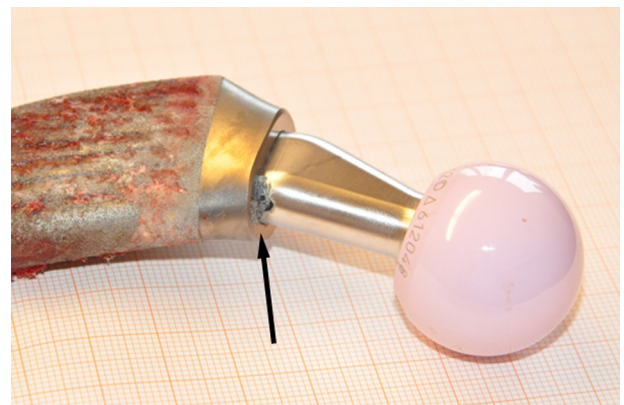


Fig. 6. Explanted stem showing signs of corrosion at the neck-stem junction (arrow). Of note, the junction could not be disassembled manually.



Fig. 7. Significant damage to the surface of the retrieved cone (right) compared to an unused cone (left).

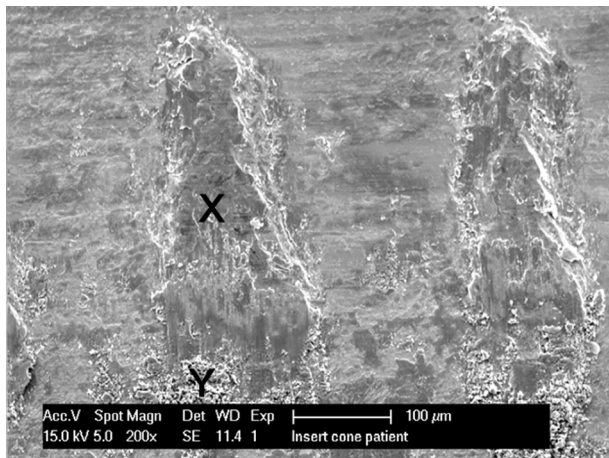


Fig. 8. Scanning electron microscopy of the cone at the neck-stem junction: note the smeared deposits (X) of compacted metal debris (Y) shed during micromotion.

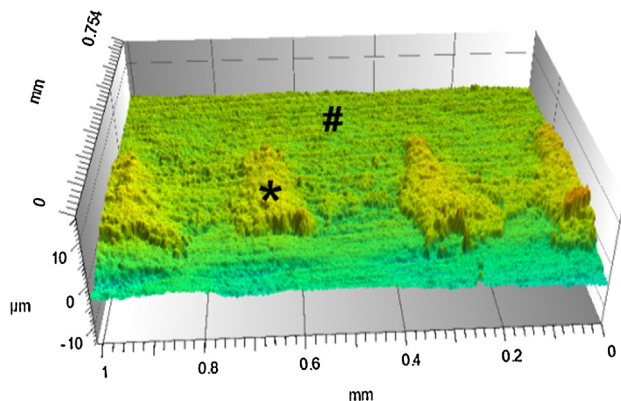


Fig. 9. White light interferometry of the cone: deposits about $4\ \mu\text{m}$ in thickness (*) surrounded by zones of unaltered machined surface (#). This pattern indicates incomplete contact between the neck and stem.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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