

Case report

Total hip replacement failure due to adverse local tissue reaction from both ceramic abrasive wear and trunnion corrosion

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ABSTRACT

The most common sources for metal ions after total hip arthroplasty (THA) are the bearing surface in metal-on-metal articulations and trunnion corrosion. Concomitant dual interface failure is an uncommon complication in metal-on-polyethylene THA. We report an unusual case of a 59-year-old woman with ceramic-on-ceramic THA in 2005, who underwent revision to metal-on-polyethylene THA 4 years later after femoral head fracture. Subsequently, she developed substantial adverse local tissue reaction and significant metal ion elevation and the failure was found to be due to both wear at the bearing surface and corrosion at the head neck junction requiring second revision. Findings included massive adverse local tissue reaction, abductor mechanism destruction, osteolysis, and corrosion damage of the trunnion. Abrasive damage of the trunnion was also noted, but prior abrasion from the original ceramic fracture could not be ruled out. Postoperative course at 14 months demonstrates 95% and 64% reduction in cobalt and chromium levels respectively, with symptom resolution.

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Introduction

Metallosis after total hip arthroplasty (THA) is a subject that has been highly researched in recent decades after the association with potential adverse outcomes. Also, trunnionosis [1], defined as wear of the femoral head-neck interface, has recently been acknowledged as a growing cause of THA failure and source of metallosis. Third-body wear affecting exclusively the bearing surface due to previous ceramic fracture had been described before [2,3], and some of these reports have also mentioned metal ion levels leading to patient death due to systemic toxicity [4,5]. However, the extensive local inflammatory response with associated abductor destruction is sparsely highlighted. Furthermore, few studies have highlighted the primary cause of metal ion toxicity due to trunnionosis from corrosion and ceramic abrasive wear, as seen in this

case. Although the rate of ceramic fracture in ceramic-on-ceramic (CoC) bearing surfaces has been reported as less than 1%, the catastrophic outcomes related to the resultant third-body wear must be considered. Risk factors associated with this include higher BMI as well as smaller ceramic heads (ie, 28 mm) [6].

We present a unique case of catastrophic metallosis and early cobaltism due to dual interface failure associated with abrasive third-body wear from prior ceramic fracture at the level of the metal-on-polyethylene (MoP) bearing surface, as well as trunnion corrosion from a prior ceramic head fracture with subsequent revision to a metal femoral head. Although the MoP bearing surface was grossly affected, catastrophic trunnion damage from prior ceramic head fracture likely contributed to marked elevations in metal ion levels, extensive pseudotumor and abductor destruction, and subsequent decrease in ion levels following revision.

Case history

A 59-year-old female presented to our arthroplasty clinic in 2017 as a referral complaining of right hip pain for 4 years. She had originally undergone a right THA in 2005 through a direct anterior approach using a Pinnacle socket, Corail uncemented stem (DePuy Orthopedics Inc., Warsaw, IN), and CoC bearing surfaces. She

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subsequently underwent an acetabular revision 4 years later in 2009 due to a fracture of the ceramic femoral head. Considering the ceramic liner was reportedly impossible to be removed, the revision involved placement of a new uncemented Reflection cup/R3 crosslink polyethylene liner (Smith & Nephew Inc., Memphis, TN) and Articul/eze cobalt-chromium (CoCr) femoral head (DePuy Orthopedics Inc.), again through a direct anterior approach. She reportedly did well until 4 years prior to presentation when she complained of progressive hip weakness, pain, and limping despite nonsteroidal anti-inflammatory drugs and physical therapy. On physical examination she was noted to be weak with right hip abduction strength (2/5), positive Trendelenburg sign, and antalgic gait.

Plain film radiographs of the right hip demonstrated significant osteolysis around both the proximal femur as well as the acetabulum (Fig. 1). Advanced imaging with both magnetic resonance imaging and computed tomography scans demonstrated multiple, complex, fluid collections interposed between the gluteus medius and maximus muscles, with the largest measuring $4.4 \times 6.2 \times 10$ cm (Figs. 2 and 3). The patient underwent a full infectious workup including inflammatory markers all of which returned as normal (C-reactive protein 1.0 mg/L [0–5.0 reference range], erythrocyte sedimentation rate 9 mm/h [0–20 reference range], and white blood cell count 6.0 thou/mm^3 [4–10 reference range]). Furthermore, she underwent synovial fluid aspiration, again with normal results (synovial fluid C-reactive protein $<0.4 \text{ mg/L}$, alpha-defensin negative, total nucleated cell count $555/\mu\text{L}$, 32.3% neutrophils, neutrophil elastase negative, all cultures negative). Given the metal femoral head bearing surface in the setting of prior trunnion damage from ceramic head fracture, metal ion levels were ordered as well, demonstrating significantly elevated Cr and Co levels at 166.6 ppb (≤ 1.4 ppb reference range) and 115.5 ppb (≤ 1.8 ppb reference range), respectively.

Considering these dangerously elevated metal ion levels and reported tremors, seizure history, anxiety, and fatigue, revision surgery was discussed with the patient with the working diagnosis of cobaltism due to metallosis. Pre-operatively, she also underwent electrocardiogram and transesophageal echocardiography due to prior reports of cardiac cobaltism leading to patient death [7], which were reported within normal limits.

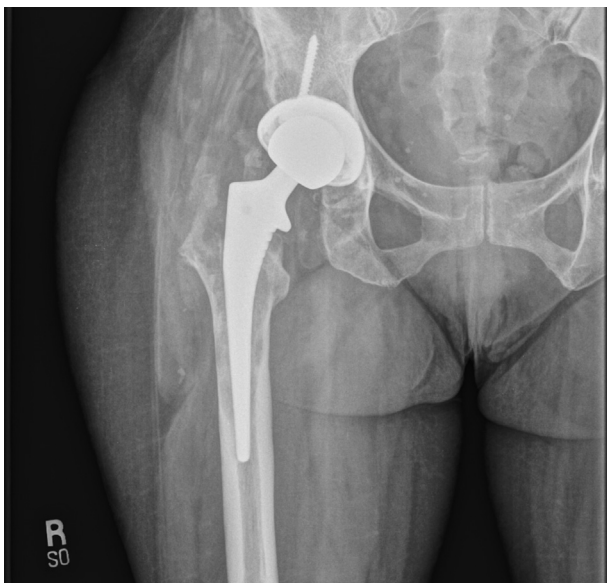


Figure 1. Pre-operative radiograph: anteroposterior radiograph of the right hip on initial presentation with extensive osteolysis around the greater trochanter and acetabulum.



Figure 2. Pre-operative computed tomography: axial computed tomography scan of the pelvis with large rim-enhancing fluid collection involving the abductors representing extensive pseudotumor formation due to metallosis.

After thorough discussion of the surgical options and technical challenges as well as the risks and benefits, the patient elected to proceed with revision surgery. This time an extensile posterolateral approach to the hip was used given the multiple revision history. Immediately upon fascial incision, extensive dark-stained fluid was encountered both subfascial and within the hip joint. There was substantial destruction of the greater trochanter, gluteus medius, gluteus minimus, and short external rotators. The pseudotumor was resected measuring $10 \times 6 \times 4$ cm in size and involving at least half of the gluteus medius posteriorly and near-complete involvement of the short external rotators and posterior capsule (Fig. 4). Tissue was sent for pathologic examination with slides demonstrating significant metallosis (Fig. 5).

Complete synovectomy was performed including anterior, inferior, and superior synovial tissue with meticulous excision of all dark metal-stained tissue.

The femoral component was loose due to extensive osteolysis and easily extracted without additional bone loss or need for

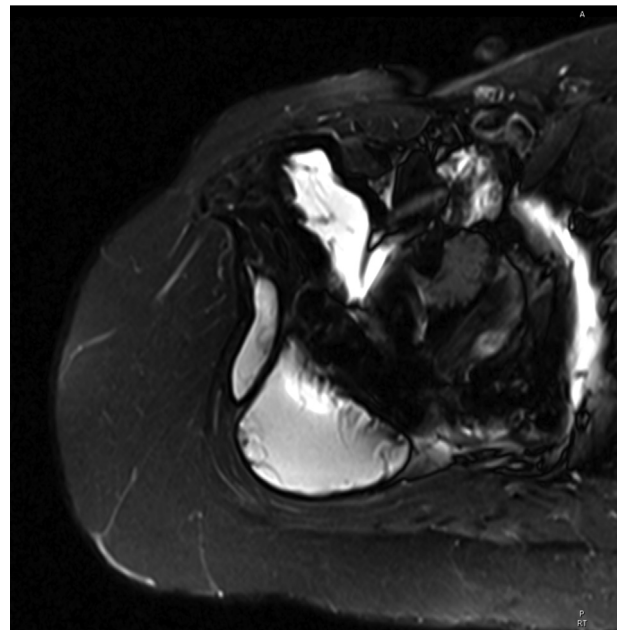


Figure 3. Pre-operative magnetic resonance imaging: axial T2 magnetic resonance imaging with hyperintense, complex, multiloculated, and heterogeneous cystic soft tissue tumor involving the right hip abductors. The pseudotumor measured $4.4 \times 6.2 \times 10$ cm at its largest dimension.

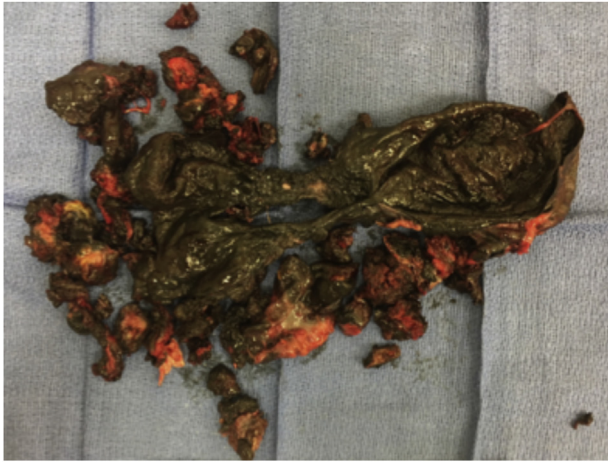


Figure 4. Intra-operative pseudotumor: gross intra-operative findings of extensive pseudotumor and dark stained synovium. Pathology reported as “fibrovascular tissue and fragments of bone with marked metal wear debris.”

extended trochanteric osteotomy. There was severe trunnion damage with corrosion and scratching (Fig. 6).

The femur was revised using an Arcos modular femoral revision hip system (Biomet UK; Waterton Industrial Estate, Bridgend, UK) augmented with cancellous bone chips and demineralized bone matrix putty to fill the osteolytic defects.

The acetabular component was noted to be well fixed and in optimal position, but the accompanying liner was noted to have signs of significant wear, deterioration, and ceramic fragments embedded in to the plastic with the CoCr femoral head

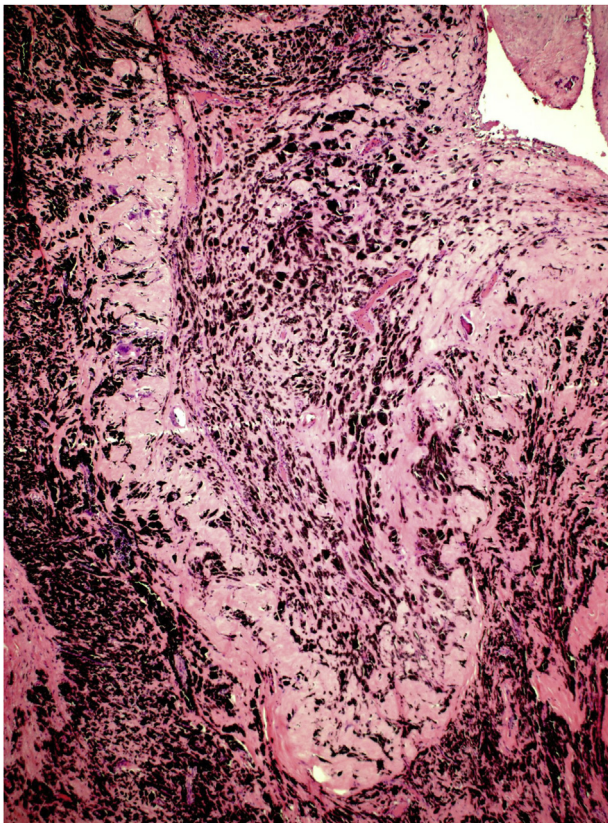


Figure 5. Microscopic pathologic findings of pseudotumor demonstrating significant metallosis.



Figure 6. Intra-operative trunnionosis: intra-operative findings of trunnion corrosion and scratching after femoral stem explant (DePuy Corail).

demonstrating signs of mechanical abrasion (Fig. 7). Upon removal of the liner, it was noted that there was significant backside acetabular osteolysis with dark metal-stained tissue. The decision was made to retain the cup to prevent morbidity associated with extraction of a well-fixed uncemented socket in the setting of severe acetabular bone loss and osteolysis and place a new liner. Similar debridement and irrigation were completed, and osteolytic defects were filled again with cancellous chips and demineralized bone matrix putty. A Biomet Freedom G7 acetabular E1 liner size D × 36 mm inner diameter was cemented into the previous uncemented socket in a similar technique as had been described by Rivkin et al. in 2015 [8]. This technique was utilized in order to retain the well positioned and fixed acetabular Reflection cup with prior studies demonstrating good results at 7-year follow-up in the survivorship studies [9]. The titanium constraint ring was removed from the liner to allow the use of a ceramic head, obtaining a “semi-constrained” mechanism which was indicated considering the complete absence of greater trochanter and abductor mechanism. This off-label technique allowed us to use a ceramic head in the setting of a revision THA for metallosis instead of the metal femoral head compatible with the constrained liner. Furthermore, the use of a ceramic femoral head in the setting of revision THA for metallosis has been shown to be the most effective method for preventing further implant failure [10].

A Biolox delta ceramic femoral head (36 mm + 3 mm) was secured on to the previously cleaned and dried taper trunnion and the hip was reduced. Standard closure was completed approximating the remainder of the abductor sleeve to the femur, deep fascial closure, subcutaneous tissue, and skin. The patient was weight bearing as tolerated immediately post-operatively with both posterior and abductor hip precautions for the first 6 weeks due to intra-operative findings detailed above.

At 1-year follow-up the patient was doing well, walking without ambulatory assist device and returned to normal activities of daily living. She was participating in yoga and experienced no post-operative complications. Her most recent metal ion levels had steadily trended down to Cr and Co of 68.7 and 20.8 ppb (2 months post-operative) to 54.8 and 5.5 ppb (14 months post-operative), respectively. Her Hip disability and Osteoarthritis Outcome Score for Joint Reconstruction had increased from 55.99 pre-operatively to 76.78 at 8 months post-operatively. This greater than 20-point increase in the patient’s Hip disability and Osteoarthritis Outcome Score correlates with a value greater than the minimal clinically important difference of 18 as established by Hung et al. in

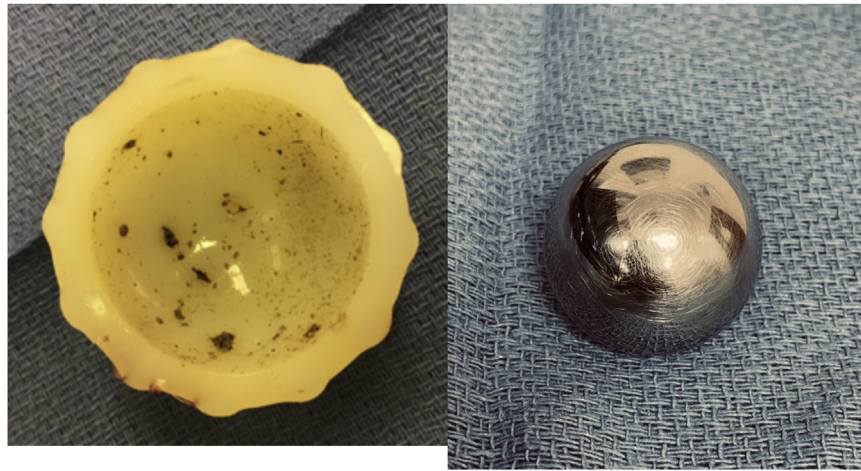


Figure 7. Intra-operative third-body wear: intra-operative findings of polyethylene acetabular liner wear third-body wear with deterioration and embedded ceramic fragments with associated cobalt-chromium femoral head demonstrating mechanical abrasion.

2018 [11]. Fourteen-month plain films demonstrated a well-fixed acetabular component and modular femoral stem with calcar remodeling and metaphyseal cortical thickening (Fig. 8).

Discussion

We describe a case of catastrophic and unusual dual interface third-body abrasive wear at the level of the bearing surface as well as corrosion at the trunnion after index CoC hip arthroplasty followed by MoP revision hip replacement. As is often seen with metallosis due to metal-on-metal (MoM) arthroplasty the patient discussed had near-complete destruction of the abductor mechanism due to the large pseudotumor, as well as early symptoms of systemic cobaltism. Furthermore, our case was a result of dual interface failure both at the bearing surface (MoP with third-body wear due to prior ceramic fracture) as well as severe femoral trunnion damage with trunnionosis due to corrosion, likely related to the first failure with ceramic head fracture, in a stem design with a long-standing track record and no reported issues with the trunnion design (DePuy Corail). In fact, the DePuy Corail is the most commonly used stem in Australia, Norway, England, Wales, Northern Ireland, and the Isle of Man. Furthermore, the National

Joint Registry demonstrated a less than 3% revision rate of the Corail Pinnacle ceramic-on-polyethylene hip construct in a 10-year period [12]. Additional studies with longer term follow-up of 25–30 years have shown excellent long-term survival [13].

Metallosis is a well-described complication of MoM hip arthroplasty with a documented incidence of approximately 5% [14] and trunnionosis specifically approaching 2% [15]. However, elevated ion levels are not commonly reported in the setting of hard-on-soft bearing surfaces such as seen here. Prior case reports have discussed ceramic fracture leading to subsequent metallosis after implantation of metal-on-poly bearing surfaces, and thus, this is not recommended in the revision setting [3,16]. Furthermore, corrosion at the head-neck junction, as seen here, is known to correlate with elevated metal ion level; however, few reports have demonstrated the extensive elevation in metal ion levels, as seen in our case with Cr of 166.6 ppb (≤ 1.4 ppb reference range) and Co of 115.5 ppb (≤ 1.8 ppb reference range), respectively. The levels seen in this case are well above those previously reported in non-fatal cases of metal toxicity [15]. A prior study by Banerjee et al. [17] discussed 5 patients with gross trunnion failure at primary THA all requiring revision. Again, unique to our case, none of the patients reported had the degree of elevation of metal ions or abductor

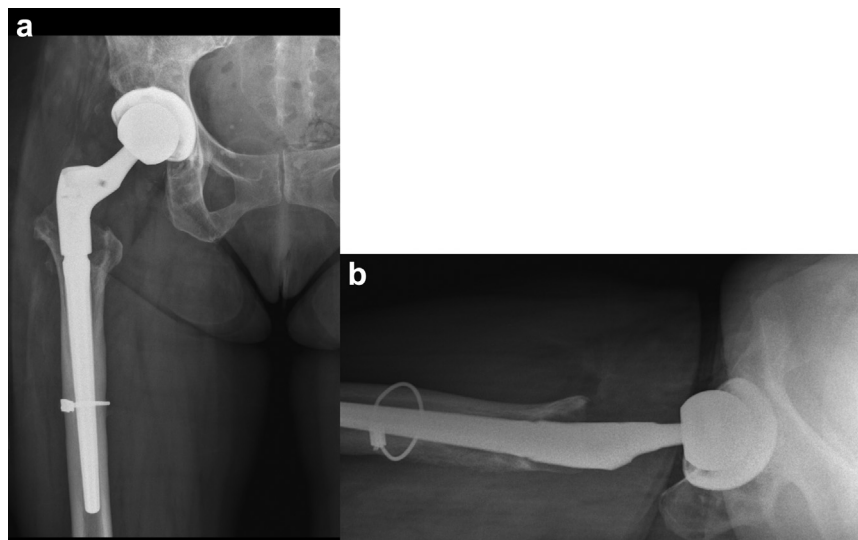


Figure 8. Post-operative radiograph: post-operative anteroposterior (a) and lateral (b) views of the right hip with revision of femoral and acetabular components.

destruction such as seen here. Another study by Plummer et al. [18] also discussed failure due to corrosion at the head-neck junction, again with metal ion levels not approaching those seen here. Finally, previous studies have demonstrated elevated Co levels relative to Cr (average ratio of Co/Cr of 5.6) in cases of severe metallosis; however, this case presented as the opposite [19].

After final revision to a CoP construct the patient did well, with no complications at 14 months postoperatively and excellent results. Metal ion levels were downtrending with most recent levels approximately 14 months after revision operation of Cr 54.8 ppb (≤ 1.4 ppb reference range) and Co of 5.5 ppb (≤ 1.8 ppb reference range), respectively. There is a significant and expected reduction in the metal levels (Co by 95% and Cr by 66%) at 14 months, which is consistent with the literature reporting the Co and Cr half-life is 5 and 27 months, respectively [19].

Summary

We present here a unique case of catastrophic THA failure associated with metal toxicity and adverse local tissue reaction due to dual interface failure at both the head-neck junction from the initial ceramic head fracture, as well as bearing surface due to third-body wear from prior ceramic fracture in MoP articulation. Furthermore, specific details such as prior ceramic fracture with re-implantation of metal components as well as MoM at the head-neck junction in a previously damaged trunnion should alert the surgeon to potential causes of failure. Appropriate workup including metal ion levels and advanced imaging in this setting can prevent catastrophic outcomes.

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