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Case Report

Late Hematogenous Total Hip Infection After Revision for Mechanically Assisted Crevice Corrosion With Adverse Local Tissue Reaction

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ABSTRACT

Mechanically assisted crevice corrosion (MACC) at the trunnion-bore junction of a total hip arthroplasty may cause adverse local tissue reaction (ALTR) with inflammatory reaction and tissue necrosis. Complications, including acute infection, continued pain, and instability, are therefore common after a revision surgery for MACC. We now present 2 cases of late hematogenous bacterial infection years after revision for MACC and ALTR, a previously unreported outcome in this population. We hypothesize that MACC-induced tissue necrosis does not heal over time, and some patients with metal-on-polyethylene total hip arthroplasty treated for ALTR are at long-term risk of hematogenous bacterial infection.

Introduction

Mechanically assisted crevice corrosion (MACC) at the trunnion-bore junction of a metal-on-polyethylene (MoP) total hip arthroplasty (THA) is recognized as a cause of adverse local tissue reactions (ALTRs) including inflammatory reactions and tissue necrosis [1–4]. A revision surgery to remove the cobalt (Co) alloy femoral head is effective at removing ion generation [5,6], but early complication rates have been reported in over 25% of surgeries, most commonly dislocation (22%) and early deep infection (11%) [7].

Prieto et al. reported a high prevalence of late or delayed infection in a group of 124 metal-on-metal (MoM) revisions, where 8 (6.4%) presented with an infection after 3 months with a previously well-functioning revision result [8]. The authors theorized that the "increased prevalence of infection could be due to a combination of particulate debris, molecular (rather than particulate) effects of Co and chromium (Cr) ions on soft tissues, and/or products of corrosion that may change the local environment, predisposing to infection." We agree with this observation and believe it is likewise a risk in cases of MoP revision surgery for tribocorrosion. Furthermore, we hypothesize that the necrotic tissue caused by the original ALTR, when it cannot be completely removed, remains a risk factor for late hematogenous deep infection.

We present for the first time to our knowledge 2 cases of hematogenous bacterial infection years after revision for MACC and ALTR occurring in patients with a MoP THA. Outcomes of revision surgery for this complication were poor, with radical resection in 1 case and chronic infection suppression after the revision surgery (debridement, antibiotics, and implant retention) in the other [9]. Surgeons should be aware of this potential complication when treating patients with MACC after both primary and revision THAs.

Case histories

Case 1

The patient is a 73-year-old male with a history of right MoP THA in 2010 for degenerative arthritis using an anterior-based

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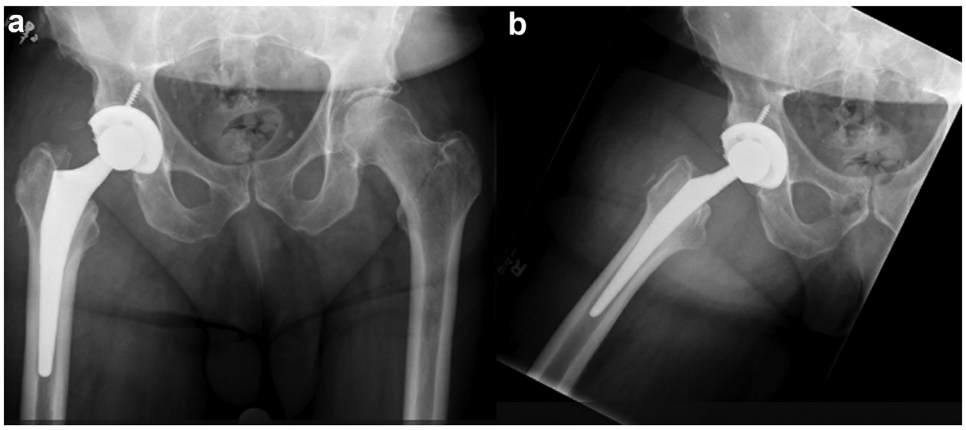

Figure 1. (a) Anteroposterior (AP) and (b) frog lateral radiographs 3 years after metal-on-polyethylene total hip arthroplasty in a 76-year-old man with increasing hip pain.

muscle-sparing approach [10]. Components used were Trilogy acetabulum (with a 58-mm outer diameter and 32-mm inner diameter), an M/L Taper stem (size 12.5 with an extended neck offset), and a 32-mm Co alloy femoral head (Zimmer Biomet, Warsaw, IN). His past medical history was significant for prostate cancer treated with resection and radiation therapy, diabetes mellitus type II, hypertension, chronic kidney disease, and hyperlipidemia. Three years after his index surgery, he presented with persistent hip pain after unsuccessful conservative management of presumed trochanteric pain syndrome. Radiographs showed a well-fixed, well-positioned, noncemented MoP THA (Fig. 1a and b). At that time, he had an elevated sedimentation rate (ESR) of 36 mm/h (normal range, <20 mm/h), C-reactive protein (CRP) of 17.4 mg/L (normal range, <8 mg/L), Co of 8.8 ppb (normal range, <1 ppb), and Cr levels of 1.1 ppb (normal range, <0.3 ppb), supporting a diagnosis of MACC. Aspiration was negative for bacterial growth. Metal artifact reduction sequence magnetic resonance imaging (MRI) revealed rupture of the rectus femoris tendon with retraction, rupture of the gluteus minimus, and partial tear of the gluteus medius tendon, extensive edema, and extraarticular fluid confirming a diagnosis of ALTR (Fig. 2a and b). Hip aspiration to rule out occult infection was suggested, and revision surgery was discussed.

One month later, the patient presented with a nonreducible, nontraumatic posterior right hip dislocation and again was found to have elevated CRP and ESR. The patient was treated urgently with revision THA, using a Biolox Option ceramic femoral head and titanium sleeve (CeramTec, Plochingen, Germany), a Trilogy constrained acetabular component, and a polyethylene liner (Zimmer Biomet, Warsaw, IN); subtotal resection of devitalized tissue; and abductor repair (Fig. 3). Intraoperatively, necrosis of a majority of the abductor muscles, proximal femur, and periacetabular bone was noted (Fig. 4a), consistent with ALTR. The femoral head disimpaction revealed extensive tribocorrosion with accumulation of black debris on the femoral neck and discoloration of trunnion and bore, with associated imprinting (Fig. 4b) [11]. This was changed to a revision-style ceramic head with a titanium sleeve after the trunnion was cleaned and dried. The stem was fixed in a satisfactory position. Devitalized periprosthetic bone and tissue around the femur and acetabulum were partially debrided, and the deep wound was thoroughly irrigated. The hip was then reduced, and range of motion and stability were satisfactory. All cultures were negative for bacterial infection; pathology showed fibrotic, acellular tissue with no evidence of acute inflammation.

Seven months after the revision surgery, the patient sustained a nontraumatic posterior right hip dislocation (Fig. 5a) which was again treated with a revision surgery. The acetabulum was revised to another Trilogy Longevity constrained liner (Zimmer Biomet, Warsaw, IN), and the femur was revised to a Biolox Option ceramic femoral head (Fig. 5b). The aspirated fluid from subcutaneous tissues at the level of the fascia latae, in communication with the hip prosthesis, showed a corrected cell count of 568 leukocytes/cubic millimeter (28% polymorphonuclear leukocytes, 68% lymphocytes, 2% eosinophils, and 2% basophils). Bacterial and fungal cultures were negative for growth. Surveillance follow-up at 1 year demonstrated stable radiographs. The patient described low-grade

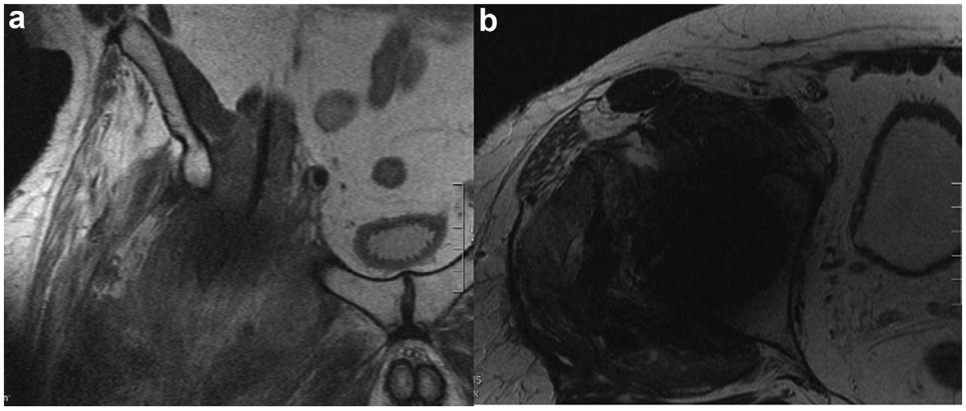

Figure 2. (a) Coronal metal artifact reduction sequence magnetic resonance imaging view showing edema and signal abnormality in the distal iliopsoas muscle. (b) Axial view showing rupture of the rectus femoris tendon with retraction. Extensive edema and extraarticular fluid confirm a diagnosis of adverse local tissue reaction.

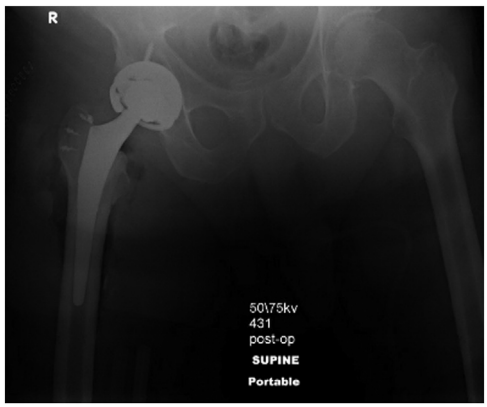

Figure 3. Recovery room AP pelvis radiograph after revision for nonreducible hip dislocation in conjunction with ALTR associated with MACC. A ceramic femoral head and titanium sleeve (Biolox Option; CeramTec, Plochingen, Germany), a Trilogy constrained acetabular component, and a polyethylene liner (Zimmer Biomet, Warsaw, IN) were used in addition to subtotal resection of the devitalized tissue and abductor repair.

pain of 1-2 out of 10 on a visual analog scale, and he walked with a marked Trendelenburg limp.

The patient next presented as an outpatient 2.5 years after the second revision surgery with a continuous limp and an increase in right hip pain and weakness. Examination revealed a positive Trendelenburg sign and Stinchfield test. A month later, the patient presented to the emergency department with increasing hip pain and new-onset nausea, shaking chills, and laboratory tests consistent with acute hematogenous bacterial infection of his hip implant. ESR was 24 mm/h, CRP was 59.2 mg/L, and white blood cell count was 13,200 cells/ul with 85% neutrophils, 6% lymphocytes, and 9% monocytes. Aspiration of the hip demonstrated a cell count of 59,250 leukocytes/cubic millimeter (95% polymorphonuclear leukocytes, 2% lymphocytes, 3% monocytes), suggestive of infection.

An urgent debridement and implant retention (DAIR), with femoral head and liner exchange, was offered, in addition to intravenous (IV) antibiotics. Intraoperatively, there was a large amount (400-500 mL) of cloudy fluid under significant pressure. This fluid appeared to be circumferential around the joint replacement, extending along the iliopsoas tendon sheath and tracking down the femoral shaft. There was avascular bone circumferentially around the acetabulum and proximal femur (Fig. 6). Cultures obtained intraoperatively grew *Staphylococcus lugdunensis*; susceptibility to rifampin and cefazolin was confirmed, and these antibiotics were started. Unfortunately, his symptoms continued. When his septic arthritis continued in conjunction with the implant being supported only by necrotic bone, the patient was transferred to a referral hospital with orthopedic oncology expertise for consideration of radical excision of the necrotic hemipelvis and proximal femur as well as the extensive necrotic and infected muscle.

Radical excision was deferred at the referral institution, and he was transferred back to our institution after resection of the implant but not the necrotic tissue (Fig. 7). A negative-pressure, vacuum-assisted closure (VAC) dressing had been placed in the wound. He continued antibiotics but ultimately required readmission for increased drainage from the wound VAC with elevated CRP of 113.8 mg/L and sedimentation rate of 112 mm/h. Computed tomography of the right hip (Fig. 8a and b) was consistent with chronic osteomyelitis along with fluid collections concerning the ongoing soft-tissue infection. In lieu of amputation or internal hemipelvectomy, the patient was treated for chronic infection with 5 irrigation and drainage surgeries. Three years after his Girdlestone procedure (along with resection of the patient's right proximal femur and a majority of the posterior acetabular wall and lateral pubis), his hip remains stable with an aseptic fluid collection surrounding the remnant of the proximal femur. He is no longer on antibiotics and has a nondraining wound, but he has deferred revision with tumor prosthesis (Fig. 9).

At the age of 82 years, he is able to drive with a modified car. He uses 2 forearm crutches or a rolling walker to ambulate short distances. He avoids stairs if possible but can negotiate steps with 2 arms on the banister. He has difficulty putting on shoes and socks and grades the pain in his hip as 1-2/10.

Written informed consent was obtained prior to submitting this manuscript for publication.

Case 2

The patient is an 80-year-old male with a past medical history of hypertension, subdural hematoma, and chronic inflammatory demyelinating polyneuropathy (CIDP) with lower-extremity weakness treated with immune globulin injections. He presented with end-stage hip arthritis and underwent a right MoP THA in 2007. Components used were Trilogy Trabecular Metal acetabulum (with a 58-mm outer diameter and 32-mm inner diameter), an M/L Taper stem (size 10 with a standard neck offset), and a 32-mm Co alloy femoral head (Zimmer Biomet, Warsaw IN).

Nine years after the 2007 index procedure, the patient developed increased right lower-extremity weakness, thought to be related to his known CIDP. During follow-up examinations, atrophy of the right quadriceps was appreciated although the quadriceps tendon was intact and there was satisfactory range of motion in

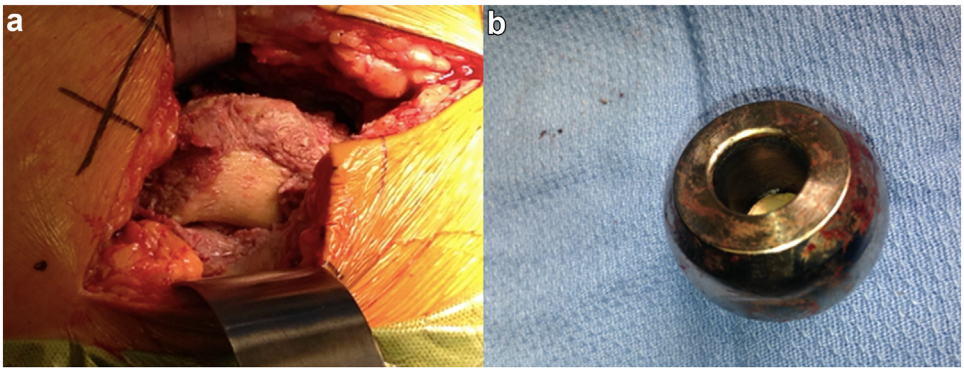

Figure 4. Intraoperative photographs showing (a) necrosis of a majority of the abductor muscles and proximal femoral bone and (b) extensive tribocorrosion with accumulation of black debris and discoloration of the femoral head bore with associated imprinting.

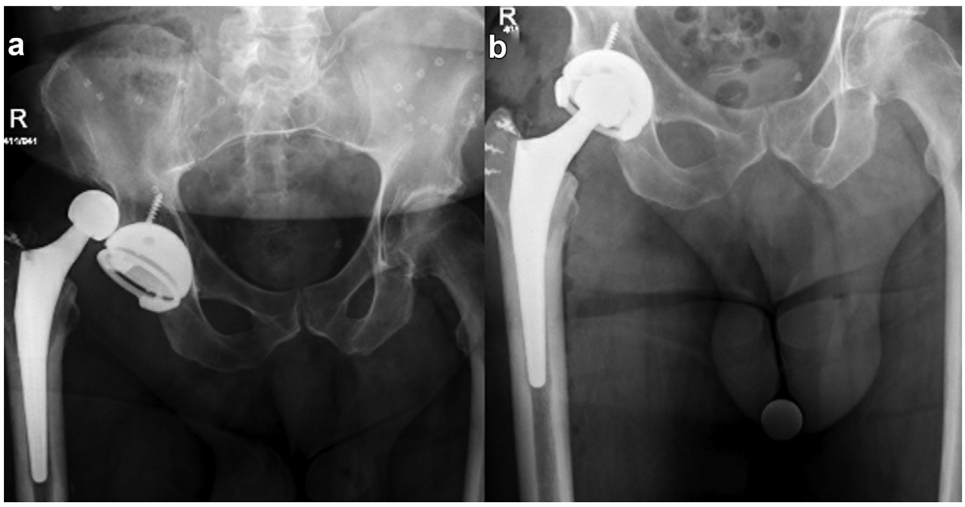

Figure 5. AP pelvis radiographs (a) before and (b) after a second revision surgery. The patient dislocated his constrained THA, and he underwent revision to replace the constrained liner and to re-locate his THA.

both his right hip and right knee. With progressive right lower-extremity weakness and a history of right THA, laboratory studies were obtained which revealed an ESR of 72 mm/h (normal range, <20 mm/h), CRP of 13.3 mg/L (normal range, <8 mg/L), Co of 2.4 ppb (normal range, <1 ppb), and Cr levels of 1.3 ppb (normal range, <0.3 ppb), supporting a diagnosis of MACC. Metal artifact reduction sequence MRI revealed a rupture of the right gluteus medius-myotendinous junction and tendonous insertion at the greater trochanter with significant periprosthetic fluid collection (Fig. 10a and b), strongly supporting a diagnosis of MACC with ALTR. Aspiration of the patient's right hip joint demonstrated no crystals, a white blood cell count of 94 leukocytes/cubic millimeter, an intraarticular Cr level of 335.4 ppb, and an intraarticular Co level of 244.5 ppb. Bacterial cultures were negative.

A posterior revision of the right THA with conversion to a ceramic revision head and liner exchange was performed. The patient was noted to have soft-tissue necrosis consistent with ALTR, abductor detachment, and necrotic bone and soft tissue around the rim of the acetabulum, greater trochanter, calcar region, and proximal vastus lateralis insertion into the femur. Darkened fretting and/or corrosion material was noted in the head bore and also on the trunnion; the trunnion was cleaned prior to femoral head replacement. Subtotal debridement of necrotic and hypertrophic tissues was performed, removing as much tissue as possible without compromising the implant fixation or wound closure. An attempted repair of the gluteus medius was also performed; a constrained bearing surface was used (Fig. 11a and b).

The femoral component was revised to a Biolox Option ceramic femoral head and titanium trunnion sleeve. The acetabulum was revised to a Trilogy Longevity constrained liner. The postoperative course was uncomplicated. At 2-month outpatient follow-up, the patient had an antalgic gait using a cane, with a well-healed wound and negative Stinchfield test. Range of motion was satisfactory and without pain.

Four years after his 2016 revision surgery, the patient presented to the emergency department febrile, tachycardic, and tachypneic with elevated CRP to 354.2 mg/L. The patient was found to have a urinary tract infection, and in addition, computed tomography scans of the abdomen and pelvis revealed a complex fluid collection adjacent to his right hip prosthesis (Fig. 12). Purulent fluid was aspirated from the right hip, and a culture grew pansusceptible *Escherichia coli*. An urgent DAIR with femoral head and liner exchange was offered, in addition to IV antibiotics. Again, a ceramic Biolox Option femoral head and titanium trunnion sleeve were used on the femoral side, and the acetabulum was revised to a

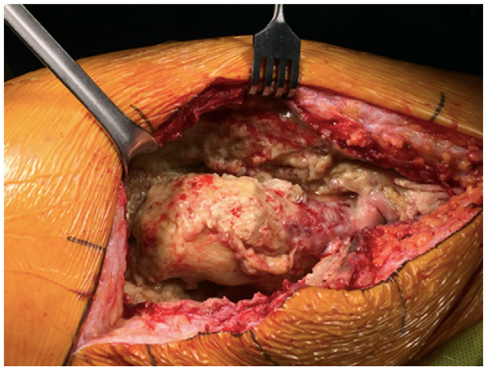

Figure 6. Intraoperative photograph showing purulence, necrosis of femoral bone, and no healing compared with first revision for mechanically assisted crevice corrosion and adverse local tissue reaction 38 months prior. Cultures obtained intraoperatively grew *Staphylococcus lugdunensis*.

Figure 7. AP pelvis radiograph after implant resection for late hematogenous infection after revision for ALTR associated with MACC. Resection of the implant without radical resection of the necrotic tissue with a negative pressure dressing in the wound led to bacterial and fungal colonization, and multiple subsequent surgeries were required.

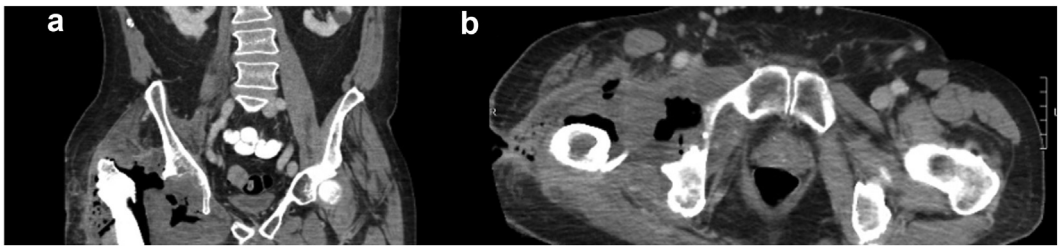

Figure 8. Computed tomography (CT) image of the right hip was consistent with chronic osteomyelitis and fluid collections with ongoing infection. Coronal (a) and axial (b) images show heterogenous rim-enhancing collections of air and fluid centered around the right hip. The collection extends from pubic symphysis medially past the femur where the collection communicates with the open wound.

Triology Longevity constrained liner. Three large pockets of purulent fluid under pressure were appreciated intraoperatively, including possibly 4 tracks along the iliopsoas tendon into the pelvis. Devitalized tissue was debrided, deep wounds were thoroughly irrigated, and a sterile compressive VAC dressing was applied over his closed incision. Postoperatively, the patient received 42 days of ceftriaxone and then oral antibiotic suppression with amoxicillin. Because of leukopenia, he was transitioned to doxycycline and then to cefuroxime for indefinite suppression. The patient received care at the rehabilitation facility and then was transitioned to home health care postoperatively. At the 6-month outpatient follow-up, the patient's incision was well healed again without signs of infection.

At 1 year after the revision, the patient continued to have moderate right hip pain; aspiration again revealed pansusceptible *E. coli* with chronic elevation in ESR and CRP. His hip wound began to weep serous fluid but was without frank sinus formation. The patient was counseled on surgical management options including revision but opted for antibiotic management alone. He was subsequently treated with a 6-week course of IV ceftriaxone, followed by oral suppression with cefuroxime. Radiographs of the right hip at 1 year postoperatively revealed a well-aligned prosthesis without loosening or progressive osteolysis (Fig. 13). He remained on oral antibiotics for suppression, his hip pain resolved, and the wound healed completely.

The patient recently passed away at the age of 80 years, 2 years and 6 months after his initial presentation for prosthetic joint infection, using the Death with Dignity program in Maine (a structured, legal process by which qualified patients may request and receive life-ending medication from their attending physician under specific circumstances). Prior to that, he was mostly bedbound, requiring full assist for any transfers. His case was complicated by the combination of progressive weakness from his CIDP along with the loss of power from his periarticular hip muscle necrosis.

Written informed consent was obtained prior to submitting this manuscript for publication prior to his passing.

Discussion

These 2 cases illustrate the poor outcomes in patients experiencing late hematogenous bacterial infection years after revision of MoP THA for MACC with ALTR. Each patient had confirmed MACC with visible corrosion at the bore-trunnion junction, and both had extensive soft-tissue damage, including rupture of abductor tendons as well as necrotic soft tissue and bone. Furthermore, widespread tissue necrosis made full excision of devitalized tissue impossible without excision of the implant and supporting bone. Ultimately, both patients underwent a repeat surgery for late infection and had poor functional and clinical outcomes. Infection could not be controlled. In 1 case, implant resection with multiple surgeries was required, and in the other, 2 separate courses of IV antibiotics as well as oral suppressive antibiotics were needed to subdue the infection.

The inflammatory process of MACC with ALTR may predispose the local anatomy to infection through an effect of the remaining metal and/or corrosion debris, modulation of the immune system related to MACC, late seeding of necrotic tissue that was impossible to be fully debrided, or a combination of all these factors [1,8,12]. Our patients experienced extensive soft-tissue injury and necrosis due to ALTR and subsequent debridement which may make vulnerable tissues susceptible to hematogenous spread of the bacteria. Molecular (rather than particulate) effects of Co and Cr ions on soft tissues and/or products of corrosion may change the local environment, thereby predisposing tissues to infection. Patients with MACC have been shown to have elevated intraarticular levels of Co [12], which are cytotoxic, leading to necrosis and inflammation in the surrounding tissues [13–15], likely predisposing these patients to infection. We demonstrated high Co and Cr levels in the failed hip of patient two. Hosman et al. [16] proposed that particles from MoM THA changes the periprosthetic environment and, therefore, hamper the immune system, altering bacterial growth patterns and metal resistance selection mechanisms, thereby increasing the infection risk. Corrosion products may ultimately modulate the immune system and bacterial growth patterns, which the authors postulate could lead to increased antibiotic resistance [16,17]. MACC-induced tissue necrosis does not appear to heal over time as demonstrated by the chronic state of necrosis in both our patients, leaving tissue in which bacteria can grow. Notably, 1 ex-vivo study found Co ion levels did not

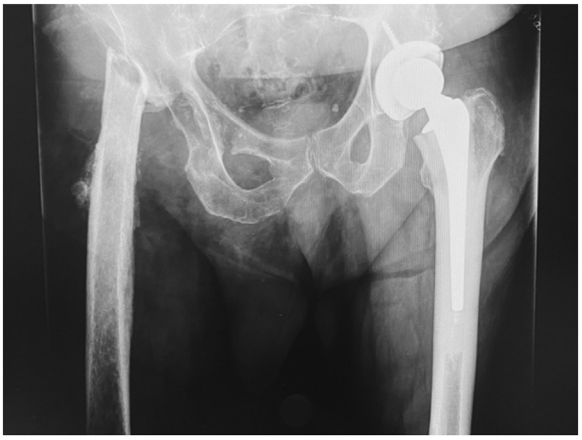

Figure 9. Current AP pelvis radiograph after implant resection for late hematogenous infection after the left THA revision for ALTR associated with MACC. Extensive resection of the necrotic tissue and secondary healing has allowed ultimate healing without obvious ongoing infection.

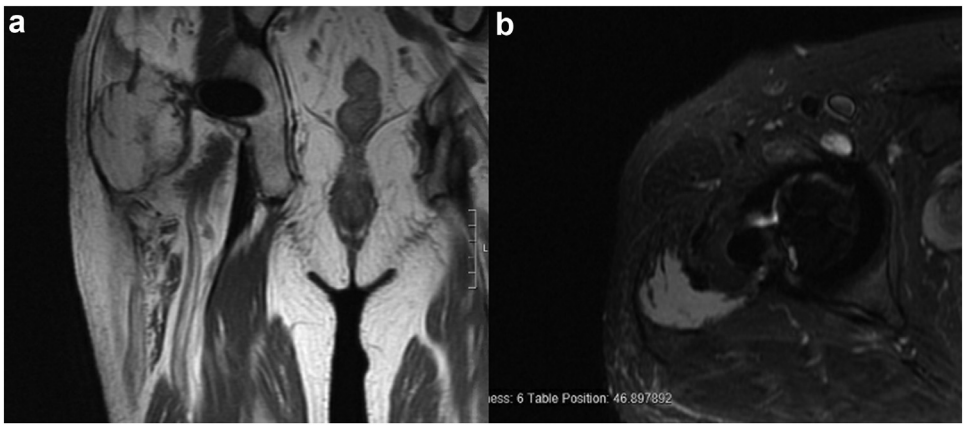

Figure 10. (a) Coronal metal artifact reduction sequence magnetic resonance imaging view showing fluid collection and tear at the gluteus medius-myotendinous junction. (b) Axial view showing bilobed extraarticular fluid surrounding iliopsoas confirming a diagnosis of adverse local tissue reaction.

potentiate or inhibit *Staphylococcus epidermidis* growth in mesenchymal stem cells, favoring the hypothesis that tissue necrosis drives postoperative infection following ALTR rather than Co cytotoxicity [18]. On the other hand, neither of our patients demonstrated primary infection with *S. epidermidis.* Thus, the mechanism by which the inflammatory process from MACC with ALTR causes chronic hematogenous infection is still not fully understood.

Based on our current experience, surgeons may want to consider interventions that diminish late hematogenous infections in patients with MACC and extensive necrosis associated with ALTR. Surgically, transposition or free flap grafting could be considered to fill dead space and offer more healthy blood supply after subtotal debridement [19]. From a nonsurgical approach, extended postoperative oral antibiotics [20] or antibiotic prophylaxis [21] should be utilized when the patient is at risk of bacterial infection.

While *Staphylococcus aureus* and *S. epidermidis* are the most common pathogens involved in acute hematogenous periprosthetic joint infections [22,23], our patients grew *E. coli* and *S. lugdunensis*. These pathogens are uncommon, and outcomes of PJI in patients with these bacteria are not widely reported in the literature. Prieto et al. [8] reported only 1 of 8 patients grew *E. coli* and none grew *S. lugdunensis* from a periprosthetic deep infection following an MoM THA revision. Additionally, our patients were likely at a higher risk of hematogenous infection due to their multiple medical comorbidities including prostate cancer with radiation, neuromuscular disease on immunosuppressive medications, and diabetes. These immune-compromised states may have allowed the spread and growth of atypical pathogens, leading to chronic infection.

Not all patients with MACC (as noted by a serum Co level >1 ppb) have evidence of ALTR on MRI. We do think, however, that when patients have demonstrable ALTR, they should be offered urgent revision surgery to avoid further damage to the abductor musculature and surrounding soft tissue and to minimize progressive tissue necrosis. Both patients in this series underwent a revision surgery to replace the corroding CoCr head with a ceramic head which has shown generally satisfactory results [24]. Still, multiple authors [7,25,26] have demonstrated a high rate of early complications including infection and instability after revision for ALTR-associated head-neck taper corrosion in MoP THA cases. In 252 patients with MoP THAs requiring a revision surgery, Bonner et al. [27] reported early complications in 35% of patients, with 23% of patients requiring a third revision for ALTR and extensive intraoperative tissue necrosis. Of these patients, dislocation and infection were the most common indication for the second and third revisions. Wyles et al. [28] reported patients with a failed MoM THA may be at a higher risk of infection after undergoing a revision surgery. Within their series on aseptic revisions, 2 of 3 patients requiring revision for infection had shown adverse reaction to metal debris from ALTR. Although these authors have demonstrated a high complication rate associated with the revision

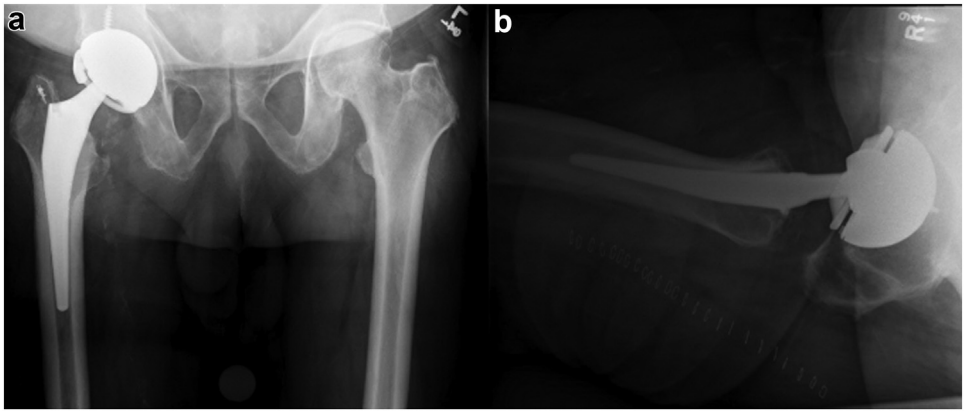

Figure 11. (a) AP pelvis and (b) direct lateral radiographs after revision MoP THA for MACC and ALTR. Note the constrained liner and suture anchor in the trochanter from abductor repair.

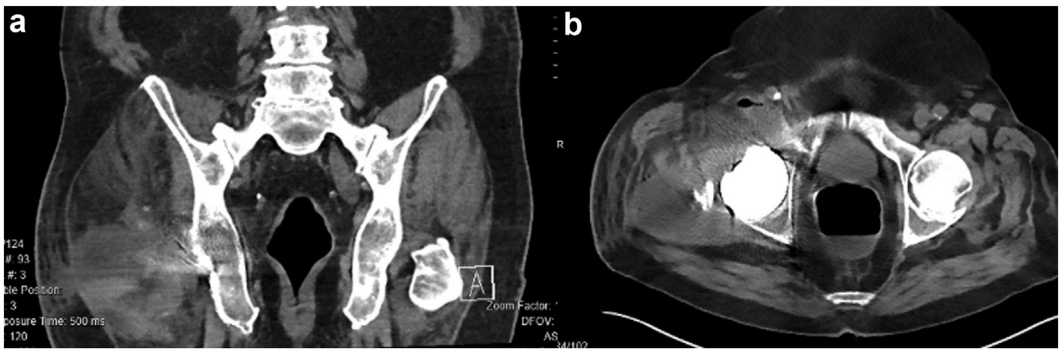

Figure 12. Computed tomography (CT) images of the right hip were consistent with a large periprosthetic complex fluid collection. Coronal (a) and axial (b) images show heterogenous rim-enhancing collections of air and fluid centered around the right hip. There is some gas noted on the axial view.

surgery in this setting, our 2 cases are the first to highlight the risk of late hematogenous infection.

While revision THA is the ideal treatment for MACC with ALTR, in our patient with chronic infection, a modified Girdlestone procedure has been effective in meeting the patient's goals of avoiding a re-revision surgery. Resection arthroplasty may be a good option in patients with chronic infection as healing of infection has been reported at 80%-100% [29,30] although these results are worse in specific subsets of patients. Patients with permanent resection have lower health status and quality of life scores than a normal population [31] as up to 45% of patients will be unable to walk even with assistive devices and 16%-33% of patients complain of severe pain [29]. Thus, definitive Girdlestone is a treatment option to minimize chronic infection following revision for MACC with ALTR; however, it may have a significant impact on a patient's quality of life and functional capabilities.

Summary

Patients with MACC with ALTR may experience significant soft-tissue damage and necrosis, leading to complications including dislocation and infection. We present 2 patients with acute hematogenous infections 2.5 and 4 years after the index revision THA, respectively, for MACC and associated ALTR. Long-term management included multiple surgeries ending in permanent resection arthroplasty for 1 patient and DAIR with chronic antibiotic suppression in the other. Ultimately, definitive management remains a challenge due to the large amounts of tissue necrosis, and these challenges should be considered when treating patients with MACC and ALTR.

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Conflicts of interest

Dr. B. J. McGrory receives royalties from Smith & Nephew Inc. and Innomed Inc.; is in the speakers' bureau of or gave paid presentations for Smith & Nephew Inc.; is a paid consultant for Smith & Nephew Inc.; receives financial or material support from Springer/Nature; is in the editorial or governing board of *Arthroplasty Today*/American Association of Hip and Knee Surgeons; and is a board member for *Arthroplasty Today*/American Association of Hip and Knee Surgeons. Both the other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.10.005.

Informed patient consent

The authors confirm that informed consent has been obtained from the involved patients or, if appropriate, from the parent, guardian, power of attorney of the involved patients and that they have given approval for this information to be published in this article.

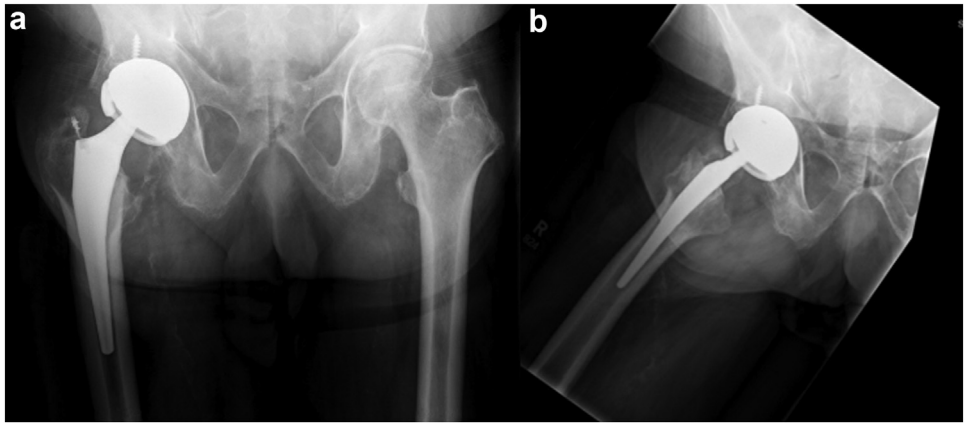

Figure 13. (a) AP pelvis and (b) frog lateral radiographs 1 year after the revision MoP THA for MACC and ALTR. No progressive lytic lesions or implant loosening are noted.

References

[1] Eltit F, Assiri A, Garbuz D, et al. Adverse reactions to metal on polyethylene inplants: highly destructive lesions related to elevated concentrations of cobalt and chromium in synovial fluid. J Biomed Mater Res A 2017;105A:1876–86.

[2] Wang Q, Eltit F, Garbuz D, et al. CoCrMo metal release in metal-on-highly crosslinked polyethylene hip implants. J Biomed Mater Res B Appl Biomater 2019;108:1213–28.

[3] McGrory BJ. High incidence of mechanically assisted crevice corrosion at 10 Years in non-cemented, non-recalled, contemporary total hip arthroplasties. J Arthroplasty 2022;37:S941–6.

[4] Morozov PP, Sana M, McGrory BJ, Farraher SW, Abrahams TG. Comparison of pre-revision magnetic resonance imaging and operative findings in mechanically assisted crevice corrosion in symptomatic metal-on-polyethylene total hip arthroplasties. J Arthroplasty 2017;32:2535–45.

[5] 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 2012;94-A:1655–61.

[6] 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 2013;95:865–72.

[7] McGrory BJ, Jorgensen A. High early major complication rate after revision for mechanically associated crevice corrosion in metal-on-polyethylene total hip arthroplasty. J Arthroplasty 2017;32:3704–10.

[8] Prieto HA, Berbari EF, Sierra RJ. Acute delayed infection: increased risk in failed metal on metal total hip arthroplasty. J Arthroplasty 2014;29:1808–12.

[9] Engesæter LB, Dale H, Schrama JC, Hallan G, Lie SA. Surgical procedures in the treatment of 784 infected THAs reported to the Norwegian Arthroplasty Register: best survival with 2-stage exchange revision, but also good results with debridement and retention of the fixed implant. Acta Orthopaedica 2011;82:530–7.

[10] Rana AJ, Sturgeon CM, McGrory BJ, Frazier MV, Babikian GM. The ABLE anterior-based muscle-sparing approach: a safe and effective option for total hip arthroplasty. Arthroplasty Today 2022;16:264–269.e1.

[11] Bormann T, Müller U, Gibmeier J, Mai PT, Renkawitz T, Kretzer JP. Insights into imprinting: how is the phenomenon of tribocorrosion at head-neck taper interfaces related to corrosion, fretting, and implant design parameters? Clin Orthopaedics Relat Research® 2022;10:1585–600.

[12] McGrory BJ, Payson AM, MacKenzie JA. Elevated intra-articular cobalt and chromium levels in mechanically assisted crevice corrosion in metal-on-polyethylene total hip arthroplasty. J Arthroplasty 2017;32:1654–8.

[13] Gill HS, Grammatopoulos G, Adshead S, Tsialogiannis E, Tsiridis E. Molecular and immune toxicity of CoCr nanoparticles in MoM hip arthroplasty. Trends Molecular Medicine 2012;18:145–55.

[14] Dundon JM, Ramkumar PN, Lajam C. Tribocorrosion in total hip arthroplasty. JBJS Rev 2017;5. https://journals.lww.com/jbjsreviews/Abstract/2017/03000/Tribocorrosion_in_Total_Hip_Arthroplasty.5.aspx.

[15] Garbuz DS, Tanzer M, Greidanus NV, Masri BA, Duncan CP. The John Charnley Award: metal-on-metal hip resurfacing versus large-diameter head metal-on-metal total hip arthroplasty: a randomized clinical trial. Clin Orthopaedics Relat Research® 2010;468:318–25.

[16] Hosman AH, van der Mei HC, Bulstra SK, Busscher HJ, Neut D. Effects of metal-on-metal wear on the host immune system and infection in hip arthroplasty. Acta Orthopaedica 2010;81:526–34.

[17] Ogunwale B, Schmidt-Ott A, Meek R, Brewer JM. Investigating the immunologic effects of CoCr nanoparticles. Clin Orthopaedics Relat Research® 2009;467:3010–6.

[18] Wyles CC, Paradise CR, Masters TL, et al. Cobalt and chromium ion release in metal-on-polyethylene and ceramic-on-polyethylene THA: a simulator study with cellular and microbiological correlations. J Arthroplasty 2020;35:1123–9.

[19] Rovere G, Smakaj A, Calori S, et al. Use of muscular flaps for the treatment of knee prosthetic joint infection: a systematic review. Orthop Rev 2022;14:33943.

[20] Kheir MM, Dilley JE, Ziemba-Davis M, Meneghini RM. The AAHKS Clinical Research Award: extended oral antibiotics prevent periprosthetic joint infection in high-risk cases: 3855 patients with 1-year follow-up. J Arthroplasty 2021;36:S18–25.

[21] Lafaurie GI, Noriega LA, Torres CC, et al. Impact of antibiotic prophylaxis on the incidence, nature, magnitude, and duration of bacteremia associated with dental procedures: a systematic review. J Am Dental Assoc 2019;150:948–959.e4.

[22] Garvin KL, Hanssen AD. Infection after total hip arthroplasty. Past, present, and future. JBJS 1995;77:1576–88.

[23] Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. Clin Orthopaedics Relat Res 2008;466:1710–5.

[24] Plummer DR, Berger RA, Paprosky WG, Sporer SM, Jacobs JJ, Della Valle CJ. 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;31:264–8.

[25] Kwon Y-M, MacAuliffe J, Arauz PG, Peng Y. Sensitivity and specificity of metal ion level in predicting adverse local tissue reactions due to head-neck taper corrosion in primary metal-on-polyethylene total hip arthroplasty. J Arthroplasty 2018;33:3025–9.

[26] Kwon YM, Rossi D, MacAuliffe J, Peng Y, Arauz P. Risk factors associated with early complications of revision surgery for head-neck taper corrosion in metal-on-polyethylene total hip arthroplasty. J Arthroplasty 2018;33:3231–7.

[27] Bonner B, Arauz P, Klemt C, Kwon Y-M. Outcome of Re-revision surgery for adverse local tissue reaction in metal-on-polyethylene and metal-on-metal total hip arthroplasty. J Arthroplasty 2020;35:S284–8.

[28] Wyles CC, Van Demark RE, Sierra RJ, Trousdale RT. High rate of infection after aseptic revision of failed metal-on-metal total hip arthroplasty. Clin Orthopaedics Relat Research® 2014;472:509–16.

[29] Cordero-Ampuero J. Girdlestone procedure: when and why. Hip Int 2012;22:36–9.

[30] Basu I, Howes M, Jowett C, Levack B. Girdlestones excision arthroplasty: current update. Int J Surg 2011;9:310–3.

[31] Vincenten CM, Den Oudsten BL, Bos PK, Bolder SBT, Gosens T. Quality of life and health status after Girdlestone resection arthroplasty in patients with an infected total hip prosthesis. J Bone Jt Infect 2019;4:10–5.