



Case report

Delayed diagnosis of catastrophic ceramic liner failure with resultant pelvic discontinuity and massive metallosis

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ABSTRACT

With newer-generation ceramic components used in total hip arthroplasty, component fracture is a rare complication. However rare, when ceramic component fracture does occur, prompt identification and revision is necessary as delay can lead to dramatic failure with resultant metallosis as the extremely hard ceramic debris abrades remaining components. We present a case of a 70-year-old woman with ceramic liner fracture and an estimated 10-year delay in intervention with failure resulting in pelvic discontinuity and massive metallosis with associated cutaneous manifestation. She was treated with a complex revision and reconstruction and is 2 years postrevision without major complication.

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Introduction

Ceramic liner fracture, although rare, is a described complication of ceramic-on-ceramic (CoC) total hip arthroplasty. Prompt identification and treatment of ceramic liner fracture is imperative as delay can lead to rapid and dramatic consequences. The CoC bearing couple exhibits the best wear properties of all total joint bearing surfaces with reported ceramic head wear rate of 0.1 mm³ per year and ceramic liner wear rate of 0.04 mm³ per year [1]. Additionally, it has the lowest coefficient of friction of all bearing surfaces used in total joint arthroplasty [2–4]. Furthermore, the wear particles are inert and therefore do not pose an increased carcinogenic risk [5,6]. Unfortunately, CoC systems exhibit low toughness and are highly brittle. Beyond those disadvantages, CoC systems are more expensive than metal-polyethylene couples [7] and some carry a risk of squeaking (<0.5%–11%) [8–12].

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Early endeavors in the United States into the CoC bearings in the 1970s and 1980s yielded unsatisfactory clinical results with overall 10-year survivorship of between 75% and 84% [13,14] due to increased risk of aseptic loosening and ceramic component fracture. The rate of fracture for these ceramic components was reported to be between 3% and 5% and was attributed to large grain size, the presence of inclusions and grain boundaries, and poor taper tolerances. Advances in ceramic materials have largely addressed these issues to maintain superior wear characteristics while improving mechanical properties [15].

Ceramic component fracture is considered a major complication and universally requires early revision [3,15]. If not identified and revised early, a fractured ceramic component can lead to catastrophic material deterioration and massive destruction of bone and tissues due to metal debris from abrasive effects of alumina particles on the metal stem, neck, or socket [3]. We present a case of ceramic liner fracture with an estimated 10-year delay in intervention with catastrophic failure resulting in pelvic discontinuity and metallosis. To the authors' knowledge, there is only one other reported similar case which represented a 1-year delay in diagnosis and less severe manifestations [16]. Additionally, the authors believe that although skin discoloration attributable to metallosis is a rare but reported entity, this represents the first described cutaneous manifestation of metallosis in a CoC bearing couple [17–19].



Figure 1. Cutaneous manifestation of severe metallosis.

Case history

In the case we report here, the patient had a fractured ceramic liner a decade before presentation to our clinic. In June 2014, the patient, a 70-year-old woman, presented to our clinic for evaluation. She had undergone primary total hip arthroplasty 11 years before presentation with a Wright Medical (Arlington, TN) CoC bearing with Conserve acetabular and Profemur modular femoral components. She reported that 1 year after her primary surgery, she

began experiencing pain and grinding sensations as well as hearing crunching noises, she denied any specific traumatic event that lead to this. As a result of her pain and significantly decreased range of motion, she was a wheelchair ambulator for several years before presentation. She was not seen by her operating surgeon and no workup was done until her presentation to our clinic. There was large ecchymotic-type discoloration of the skin overlying the lateral hip (Fig. 1) which represents the cutaneous manifestation of particulate metal debris. Radiographic evaluation on the day of presentation (Figs. 2 and 3) demonstrated catastrophic failure of the prosthesis with significant periacetabular bone loss and the femoral head was shown to have worn through the acetabular shell and was in an intrapelvic position. The liner was not visualized radiographically. Preoperative infectious workup showed no elevation in erythrocyte sedimentation rate or C-reactive protein. Intraoperative frozen section showed less than 5 neutrophils per high power field and cultures showed no growth. Preoperative cobalt and chromium blood levels were also obtained and found to be within normal limits.

Intraoperatively, upon incising through the skin and into subcutaneous tissue there was immediate and obvious infiltration of gray-black discoloration consistent with microscopic metal debris which extended through the fascia and became more intense as the hip was approached. The gluteus medius muscle fibers were completely infiltrated with metallosis debris and there were large sections of the muscle belly and tendon that were frankly necrotic. There was a massive amount of similar friable black-stained tissue lining the joint with pockets extending posteriorly in proximity to the sciatic nerve and into the sciatic notch. There was a significant amount of lysis superior to the cup in the ilium and pockets extending inferiorly into the obturator foramen and anteriorly into the psoas gutter. There was a lytic lesion extending in a transverse pattern up into the sciatic notch. The medial wall was not intact with an approximately 8 × 6 cm elliptical defect centrally. There was a pelvic discontinuity with the ischium and pubis freely mobile. There was an ectatic defect extending off the ilium, but with the superior rim somewhat intact. An extensive and thorough debridement was undertaken although given that the infiltration extended within the pelvis, complete debridement was not safely possible.

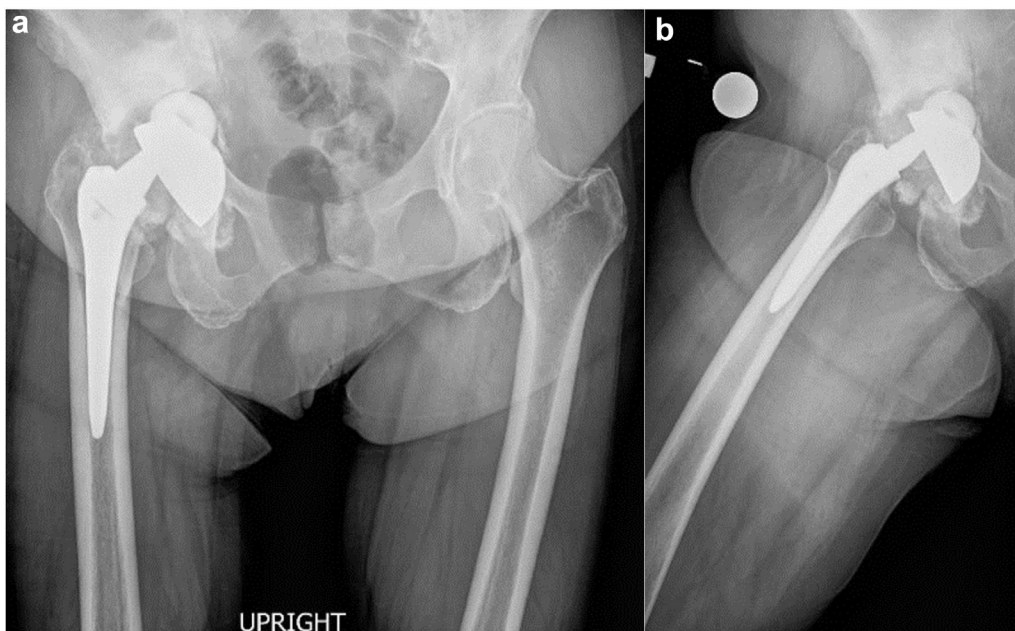


Figure 2. Anteroposterior (AP) pelvis (a) and (b) lateral radiographs at presentation.

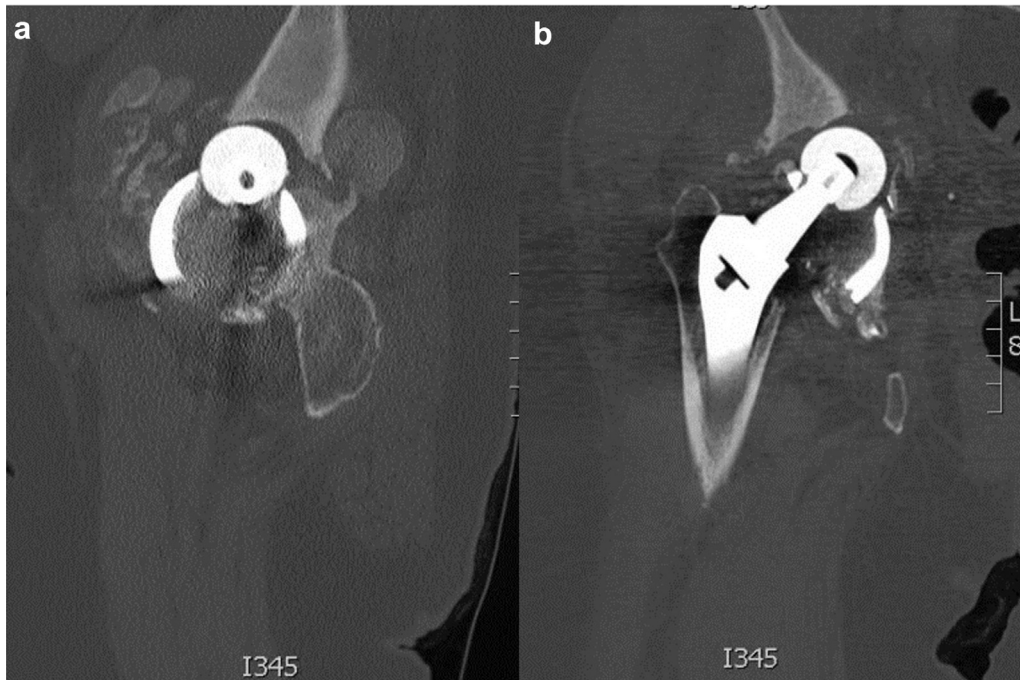


Figure 3. Select images (a) and (b) from computed tomography scan at presentation.

The femoral stem was found to be fixed, but with extensive bone loss and gray-black material surrounding the prosthesis and extending into the substance of the bone throughout the entire proximal femur. There was no noted corrosion on the neck-stem taper. The Wright Medical Profemur modular femoral component has a dual modular neck, which was titanium until 2009, when the company changed the neck composition to cobalt-chromium (CoCr). There was no visible corrosion at this junction.

The bone loss extended into the trochanteric region and the extremely thin remaining greater trochanter was noted to be fractured, this was later secured with a cerclage cable. The head of the femoral prosthesis was found to be intact (although with significant strike wear) and completely worn through the backside of the cup (Fig. 4) and located within the pelvis. There was minimal evidence of the previous ceramic liner which had been pulverized into nearly microscopic size pieces; there were few visible pieces, the largest of which measured approximately $4 \times 3 \times 3$ mm. The remainder of the liner was contained within a gray necrotic paste. The extent of titanium particulate debris was such that Bovie electrocautery would arc to the gray-stained tissues and therefore could not be effectively used.

A 64-mm Zimmer (Warsaw, IN) trabecular metal revision shell allowed contact with the pubic root, the ischium, and the rim on the ilium superiorly and fixation was achieved with 3 screws into the posterior-superior quadrant. Screws into the pubis were attempted, but could not be safely secured. There was a single screw into the ischium inferiorly that provided further fixation. A window was made into the ischium to allow placement of the cage for the Zimmer cup cage system and the inferior flange was driven into the ischium and the superior flange placed superiorly onto the ilium. Superior fixation was achieved with 4 screws. EquivaBone (ETEX, Cambridge, MA) was used to fill in the ectatic defect in the ilium through screw holes in the revision shell and was also used in an attempt to reconstitute some of the posterior wall and column. The definitive highly cross-linked polyethylene liner was cemented into the cage. The construct was felt to hold the ilium in place and bridge the discontinuity. The femur was revised to avoid

complications associated with a modular titanium/CoCr junction such as mechanically assisted crevice corrosion and was instrumented with a Zimmer ZMR revision taper fluted stem with

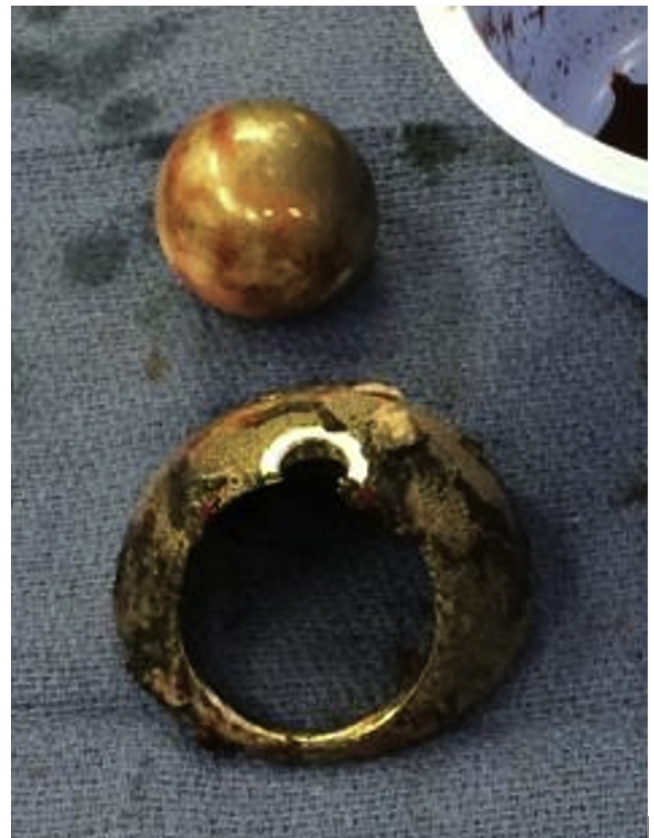


Figure 4. Retrieved intact ceramic head and acetabular cup with circular wear defect.

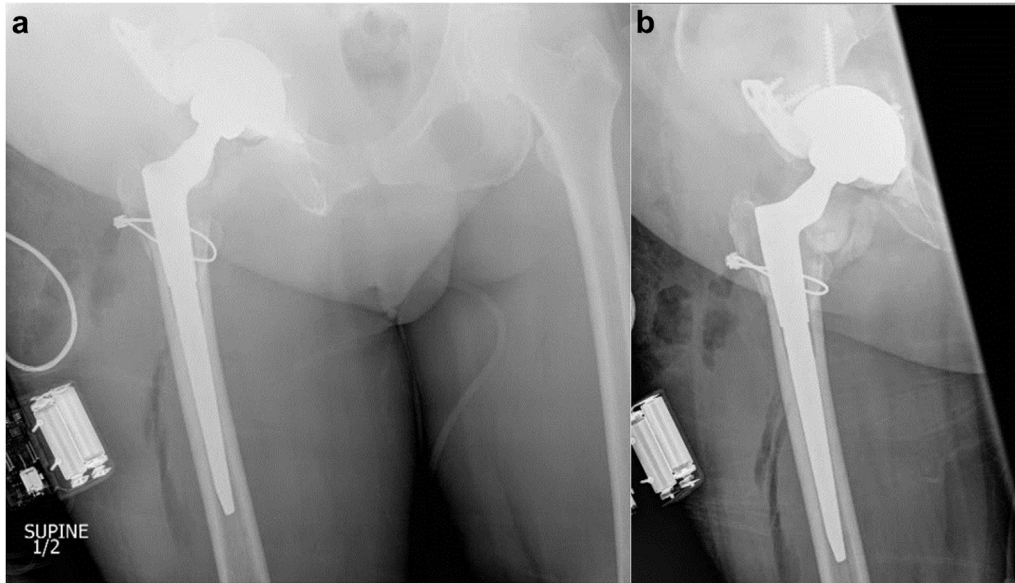


Figure 5. Immediate postoperative oblique radiographs (a) and (b).

standard offset body and a Biolox delta femoral head. With all components in place, the hip was felt to be stable within the construct and the leg lengths were felt to be appropriately matched. No intraoperative complications were appreciated. Postoperative imaging is shown in [Figure 5](#). The patient did experience an early dislocation event on postoperative day 5 which was reduced in the operating room uneventfully. She has had no further dislocation events and is now 2 years out from revision. At her 6 month follow-up, she was noted to be ambulating with a walker and no longer using her wheelchair. Her last imaging was 1 year and 9 months postoperatively ([Fig. 6](#)) which showed no evidence of complication.

Discussion

Despite the vast improvements in ceramic materials used in total hip arthroplasty over the past 40 years, the risk of fracture remains. Overall fracture rates for new generations of ceramic components in total hip arthroplasty have been estimated to be between 0.02% and 0.1% [3,20]. In a study group of 1,382 CoC hips, there was only 1 fracture of an acetabular insert (0.07%) [4,15,21,22]. The authors of that study estimated the risk of fracture over the lifetime of these implants to be closer to 1 in 2000-3000

for femoral heads (0.05%-0.03%) and 1 in 6000-8000 for the acetabular insert (0.017%-0.013%). The introduction of alumina matrix composite materials (ie, Biolox delta introduced for widespread use in Europe in 2004) is expected to decrease these risks further [15]. In a 2016 published long-term study of 1131 third-generation CoC total hips by Kim et al [23], they found no cases of aseptic loosening, osteolysis, or ceramic component fracture at a minimum of 15-year follow-up. Fractures of ceramic components tend to occur within the first few years after implantation. Data collected by Biolox manufacturer, CeramTec AG, on nearly 2 million implants indicated that 50% of ceramic component fractures occur within the first 12 months, 70% within 24 months, and 83% within 36 months [15,24].

Once identified, ceramic component fractures universally require prompt intervention as unidentified failures can lead to material deterioration and extensive destruction of bone and tissues due to metal debris as ceramic particles abrade the metal stem, neck, or socket [3]. This case vividly demonstrates the consequence of long delay in intervention for a fractured ceramic liner. In this case, it is unclear why the patient had not presented for workup earlier and therefore early diagnosis and revision was not possible. Clearly, more prompt diagnosis and revision could have circumnavigated this extremely complex

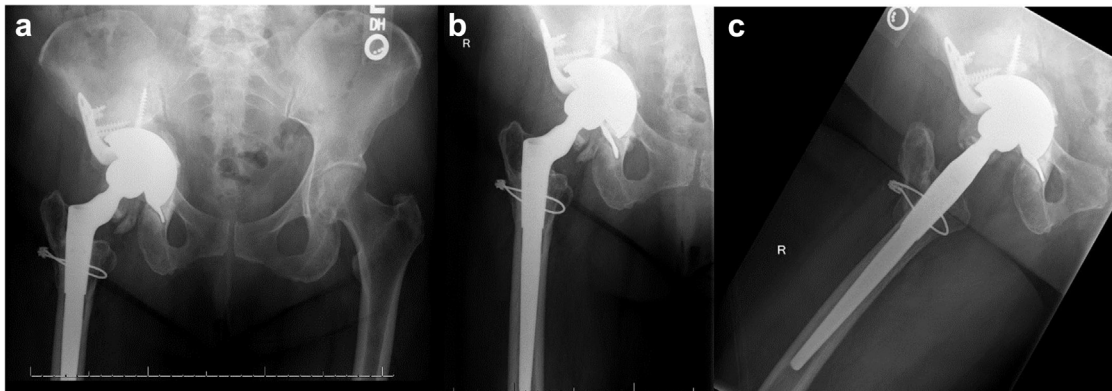


Figure 6. AP pelvis (a), AP right hip (b), and Lowenstein lateral (c) radiographs at follow-up.

situation. Identification of ceramic liner fracture can be challenging. Frank grinding or crunching sensations are highly concerning; however, other clinical signs such as audible sounds must also be investigated. A creaking or squeaking sound is suggestive of articular malposition and initial failure whereas a duller clicking sound has been suggested to indicate rupture [25,26]. Any audible sounds can represent a major complication; Malem [27] et al in 2013 report a case in which a patient with a CoC total hip presented with a squeaking hip 5 years post-operatively and was found to have catastrophic failure at revision. Other less specific symptoms include limited range of motion and hip pain [26]. Radiographic analysis can also prove challenging. Small cracks in the ceramic liner can be difficult to identify with conventional radiology, and the assessment of joint fluid to investigate the presence of ceramic particles has been suggested [28]. Additionally, the use of 3-dimensional computed tomography reconstruction has been suggested to be more sensitive (maybe add the sensitivity number from the study) for identification of ceramic liner failure [26]. Even with early identification and intervention, revision arthroplasty for fractured ceramic component is complex and carries a significant risk of failure as ceramic debris and fragments are sharp and extremely hard. If not thoroughly debrided, the debris acts as an abrasive paste and can lead to rapid wear and catastrophic failure [29].

Revision surgery for fractured ceramic component should be performed urgently in order to reduce the risk of damage to the components from ceramic particles [29,30] and surgery should always include an extensive synovectomy and thorough irrigation; complete elimination of ceramic debris has been shown to increase the survivorship of the new articulation [30,31]. There remains significant debate as to the most appropriate bearing couple for revision after fractured ceramic component. Although there are concerns about accelerated polyethylene wear in such a revision, both CoC and ceramic on polyethylene couples are considered reasonable selections as the use of ceramic heads exhibit increased scratch resistance and could reduce the risk of third-body wear [29,30]. However, in cases where the femoral component is retained, concern has been raised regarding placement of ceramic head on an existing taper due to concern-unrecognized taper damage increasing the risk of ceramic head fracture [32]. In these cases, a titanium sleeve adapter and ceramic head system, the Biolox Option, propose a potential solution to allow for retention of the femoral component without the increased risk of fracture. Furthermore, cobalt toxicity has been reported after revision to a metal-on-polyethylene hip for fracture of ceramic acetabular component [33]. The authors are aware of a single similar case report published in 2013 out of Istanbul, Turkey, in which they present the case of a patient with a CoC total hip who suffered a presumed ceramic liner failure 1 month postsurgery which was not diagnosed until 14 months postsurgery with resultant metallosis and intrapelvic protrusion of the ceramic head [16]. This case was treated with revision to metal-on-polyethylene bearing surface and reported patient's return to full activity at 15-month follow-up. Further data need to be collected to establish the most appropriate components for revision in cases with ceramic component fractures.

Summary

Ceramic component fracture is a complex problem which can be difficult to diagnose. In the case reported here, the patient was exhibiting multiple concerning symptoms for many years that would have prompted a thorough workup had she presented earlier for evaluation. To the authors' knowledge, this is

the first case reported of such a significant delay in diagnosis and highlights the devastating consequences and destructive potential of leaving a failed ceramic component unrevised as well as the first report of cutaneous manifestations of metallosis in a CoC bearing couple. This case also demonstrates the successful treatment of such a dramatic failure with favorable short-term results.

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