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Case report

Adverse Soft-Tissue Reaction After Ceramic-On-Ceramic Bearing Fracture Mimicking a Periprosthetic Joint Infection

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ABSTRACT

Prosthetic failure secondary to bearing fracture remains a potential complication in ceramic-on-ceramic total hip arthroplasty. We report the unusual presentation of a ceramic component fracture of a total hip arthroplasty performed 17 years ago that mimicked a periprosthetic joint infection. This case was managed based on the current guidelines and algorithms recommended for periprosthetic joint infection management. Histologic examination of periprosthetic tissue revealed an adverse inflammatory soft-tissue reaction to the ceramic fragments released from the fracture site. Our case highlights a misleading, inflammatory acute response usually associated with an infectious process corresponding to an adverse soft-tissue reaction. High clinical suspicion and a systematic approach are essential to address these deceiving clinical scenarios.

Introduction

Total hip arthroplasty (THA) is among the most clinically successful procedures developed in the last century [1,2]. A surgical intervention initially intended for elder arthritic individuals is currently used among a broad spectrum of patients where an unacceptable compromise in quality of life constitutes a valid indication for surgery [1]. Despite the practical advances in THA, complications could be expected even with an adequate and thorough practice [2,3]. Among the potential sources of complications, wear, fracture, and corrosion have been recognized as significant causes of implant failure [4].

Bearing surface fracture remains a rare but relevant cause of hardware failure leading to a high socioeconomic burden. In 2014, Sadoghi et al. estimated the incidence of this complication at 304 fractures per 100,000 implants, most commonly affecting ceramic-on-ceramic (CoC) bearings [5]. Over the years, the evolution of material sciences in orthopedic arthroplasty has focused on improvements to extend the lifetime of the implants [6,7]. This progress in the design and manufacturing processes has significantly minimized the fracture risk of CoC components [8].

Alumina has been used as a ceramic bearing surface in THA since 1970. However, owing to their high fracture incidence, zirconia femoral heads were introduced in the United States in 1989 as an alternative because of their increased fracture toughness and higher bending strength [9]. Despite their successful use on CoC bearings, both materials had drawbacks. This situation led to the development of zirconia-toughened alumina, combining alumina's hardness with zirconia's toughness to improve structural weakness. This fourth-generation ceramic was introduced in the market around 2000 under the trade name BIOLOX Delta (CeramTec GmbH; Plochingen, Germany) [9].

Nowadays, ceramic components remain an alternative in THA [8]. Their continued use is associated with their desirable tribological properties such as hardness, scratch resistance, wettability, and lubrication that altogether achieve a very low wear rate. In addition, the CoC implants demonstrated higher biocompatibility

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than metal-on-metal components, with significantly less risk of local or systemic adverse reactions [8,10].

Continuous implant wear can generate particles and ionic complexes that have been associated with inflammatory processes leading to adverse soft-tissue reactions. This scenario has been associated with severe osteolysis and implant failure, especially in metal-on-metal THA [11,12]. However, the evidence regarding ceramic bearing fractures and adverse soft-tissue reactions remains limited.

We present the unusual case of a 56-year-old male with bilateral THA that presented signs and symptoms suggestive of left hip periprosthetic joint infection (PJI), and its surgical management and tissue analysis revealed an adverse soft-tissue reaction secondary to a ceramic bearing fracture.

Case history

A 56-year-old morbid obese Hispanic male with a past medical history of type 2 diabetes mellitus, former intravenous drug user, inflammatory bowel disease, and bilateral femoral heads osteonecrosis secondary to chronic steroid use visited the emergency room (ER) because of progressive left hip pain for the past 2 weeks. Prior surgical history was remarkable for simultaneous bilateral THA in 2001 to treat bilateral femoral head avascular necrosis. At the evaluation, the patient described a diffuse pain over his left hip that was worsened with weight-bearing, causing difficulty to ambulate. He denied any recent trauma or injury. No constitutional symptoms such as fever, malaise, or night sweats were reported. Physical examination showed vital signs within normal limits, tenderness to palpation over the anteromedial aspect of his left hip, no warmth, no erythema, no suppuration, or sinus tract formation. Passive and active range of motion were limited because of pain. His neurovascular examination was unremarkable. The initial laboratory workup was not concerning for an acute infectious process. The anteroposterior pelvic radiograph was negative for aseptic loosening, fracture, or dislocation. The ER physician discharged the patient with instructions to avoid weight-bearing for 1 week and visit an orthopedic reconstructive specialist with follow-up labs.

At the reconstructive clinic, the patient reported persistent left hip discomfort for the past 3 weeks. The initial evaluation did not show evidence of fever or any other constitutional symptom. Physical examination revealed left hip anteromedial tenderness with a clicking and snapping sensation elicited on hip rotation. The anteroposterior pelvis radiograph performed at the ER did not reveal femoral or acetabular component loosening or liner wear (Fig. 1). Laboratory values showed a white blood cell count (WBC) of 6.3×10^3 ml, C-reactive protein (CRP) at 34.5 mg/l, and erythrocyte sedimentation rate (ESR) at 36 mm/h. Based on the clinical presentation, imaging studies, and elevated serologic markers, the patient was admitted under the impression of a deep prosthetic infection. A left hip aspiration without preprocedural antibiotics was performed. The aspirate evaluation showed a turbid pink fluid, synovial WBC 26.6×10^3 ml with 98% polymorphonuclear cells (PMN), no crystals, and no organisms on gram stain. In addition, a drug screen was ordered to categorically rule out continuous intravenous drug use as a possible etiology for recurrent infections; this came back negative.

The infectious disease service evaluated the case and recommended avoiding antibiotic therapy until intraoperative tissue cultures were obtained. The patient was oriented about the current findings and the treatment alternatives, including surgical management, to which he agreed and consented. He was scheduled for prosthetic revision and intraoperative tissue cultures.

At the operating room, preoperatory antibiotics were avoided, and time-out was performed. The surgical incision was made using

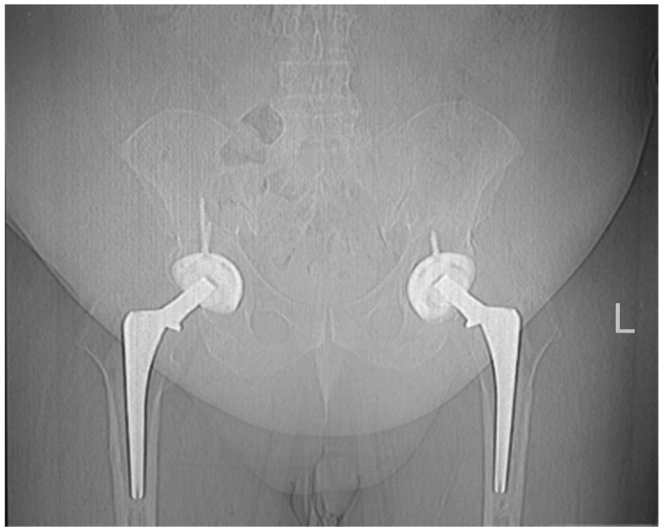

Figure 1. Anteroposterior pelvis radiograph showing eccentric femoral head component and osteolysis around bone screws.

the scar of the prior posterolateral approach. The short rotator tendons were reflected, and a capsulotomy was performed. Around 10 cc of a thick and opaque white fluid was found in the joint. The frozen section yielded less than 1 PMN per high power field. Intraoperative tissue sampling and cultures were made. Then, the acetabular and femoral components were evaluated and found to be well-fixed and aligned (abduction angle 45° and anteversion angle 25°). Gross evaluation of the trunnion showed an adequate neck geometry without abnormal wear, fretting, or corrosion (no black debris in the taper-head junction). However, the ceramic liner on the acetabular part was fractured, and stripe wear was noted on the ceramic femoral head (Fig. 2a and b). Both components consisted of third-generation pure alumina ceramic.

Consequently, the ceramic liner and the femoral head component were replaced. Extensive periarticular tissue debridement and copious irrigation with pulse lavage were performed to reduce the ceramic particle load known to cause third body wear, especially on replacement polyethylene prosthetics. The liner components were no longer in production, requiring minor modifications to the modular components available at our institution to obtain the desired result. The new prosthesis components consisted of a 32-mm, 12/14 taper alumina head with a 32-mm standard polyethylene liner and a 15° elevated rim. The backside of the polyethylene component has been slightly sanded down and cemented into the acetabular component to provide adequate fixation (Fig. 3). The hip was cleansed with normal saline and chlorhexidine solution, hemostasis was achieved, and a layered closure was performed without complication. After a surgical debridement with modular components exchange, the immediate outcome was a stable hip without subluxation throughout the functional range of motion.

After the intervention, the patient was started on broad-spectrum antibiotics with daptomycin and cefepime as per infectious disease recommendations. The aspirate culture was reported negative, and the intraoperative culture report was pending for antibiotic tailoring. The patient reported feeling better, and no signs of infection were noted after the procedure. No organisms were identified by gram stain, and intraoperative hip cultures were negative at 48 hours and 7 days. The tissue evaluation demonstrated dense connective tissue with few foci of acute inflammation (greater than 50 neutrophils per high power field) and foreign refractive material (Fig. 4a and b). The case was discussed with the

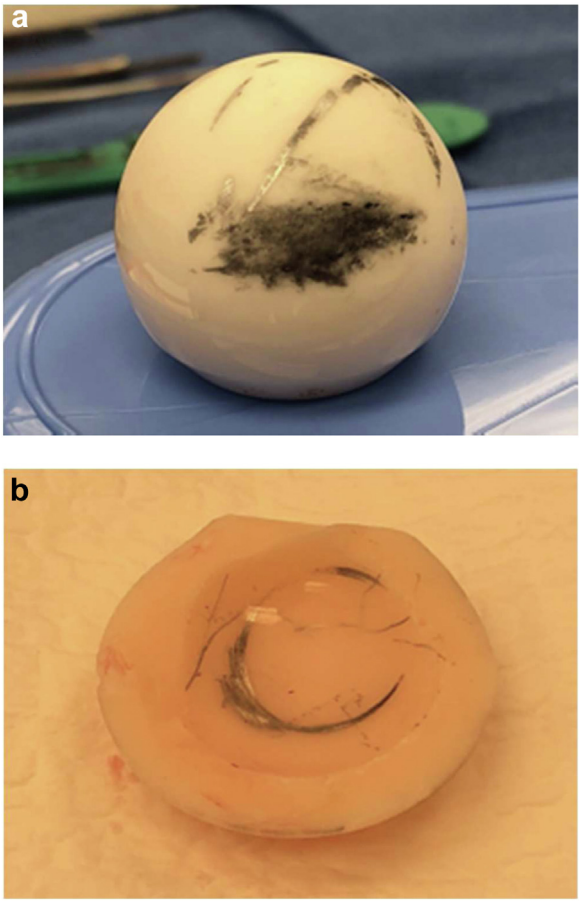

Figure 2. A gross examination of the ceramic components showed (a) an acetabular head showing signs of stripe wear within the alumina and (b) a fracture on the ceramic bearing surface.

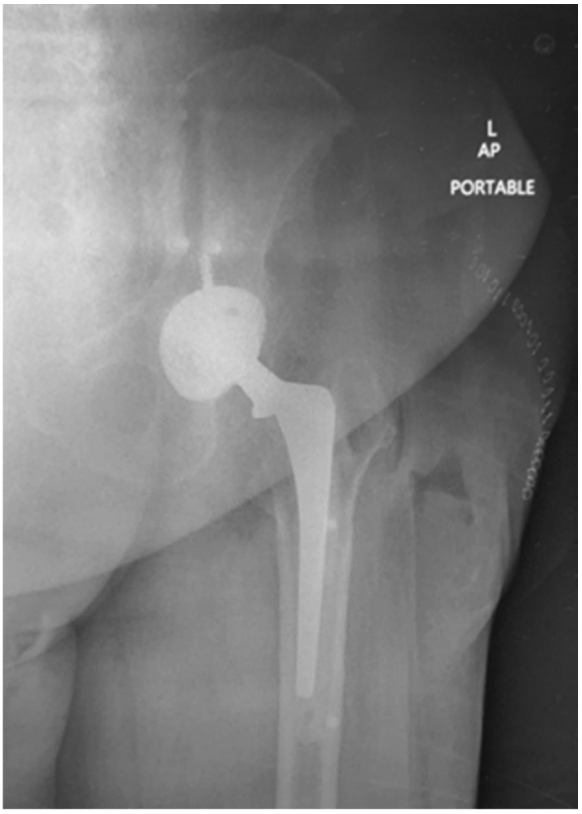

Figure 3. Postoperative left hip anteroposterior radiograph.

pathologist, who indicated that a foreign body reaction was most likely. Based on the pathologic assessment and concurrent negative infectious workup, the antibiotic therapy was discontinued. The patient was discharged from our service and transferred to the Physical Medicine and Rehabilitation ward for postoperative inpatient rehabilitation.

The patient showed complete resolution of the initial symptoms and felt well at the first follow-up visit (Fig. 5). He was ambulating without assistance and tolerating full weight-bearing. Fever, chills, malaise, or any other symptom suggestive of an ongoing infectious process were denied. After 2 years of scheduled follow-up, the patient remained completely functional and without any complication.

Discussion

Implant failure secondary to CoC bearing fracture is a well-documented complication in THA [5,8,10]. However, the atypical presentation of this case represents a diagnostic dilemma as the initial symptoms were highly suggestive of a PJI. First, the history of a patient with multiple comorbidities such as obesity, diabetes, steroid use, former intravenous drug user, bilateral THA due to femoral head avascular necrosis, progressive pain, and elevated serologic markers was consistent with most of the hallmarks established by the American Academy of Orthopedic Surgeons guidelines to suspect PJI [13,14]. In addition, the new scoring definition for PJI proposed by Parvizi et al. provides more evidence to support an infectious diagnosis [15]. The presence of some minor criteria (elevated ESR and CRP; score = 3) suggests possible infection (score 2-5). Consequently, a hip joint aspiration should be performed for further evaluation to determine if the PJI definition is fulfilled (score $\geq$6) [15]. The synovial fluid aspirate, in this case, showed evidence of a significantly elevated WBC count (26,620 ml, 98% PMN) when compared with the minimum parameters for suspected infection (WBC > 3000 cells/ml, 80% PMN) [16]. This additional finding provides enough evidence to decide on a PJI diagnosis based on the validated criteria (elevated ESR, CRP, synovial WBC, and synovial PMN; score = 8) [15]. Therefore, the patient was managed under the current practice guidelines for PJI, including operative tissue culture, before starting antibiotic therapy [13].

In the setting of a PJI, a treatment strategy is established to alleviate pain, restore normal joint function, and eliminate the infection. Among the treatment alternatives, the surgeons usually consider between debridement and retention, one- or two-stage implant replacement, or long-term suppressive therapy based on the patients' characteristics and preferences [14]. Intraoperative tissue examination techniques are often used to diagnose PJI, especially when the diagnosis remains questionable. Frozen sections, gram stain, and cultures could be the definitive diagnostic factor when the preoperative data are inconclusive [16]. However, these tools should be carefully applied and considered within the clinical scenario of each patient as their sole use may not be consistent. However, intraoperative cultures are the most reliable method to identify the infecting organism when proper sampling is executed [16]. On the other hand, a postsurgical periprosthetic tissue examination could represent an asset when facing atypical cases, similar to this one.

In the context of our patient and the acute nature of the symptoms, a surgical debridement with modular components exchange was performed. The decision was based on the

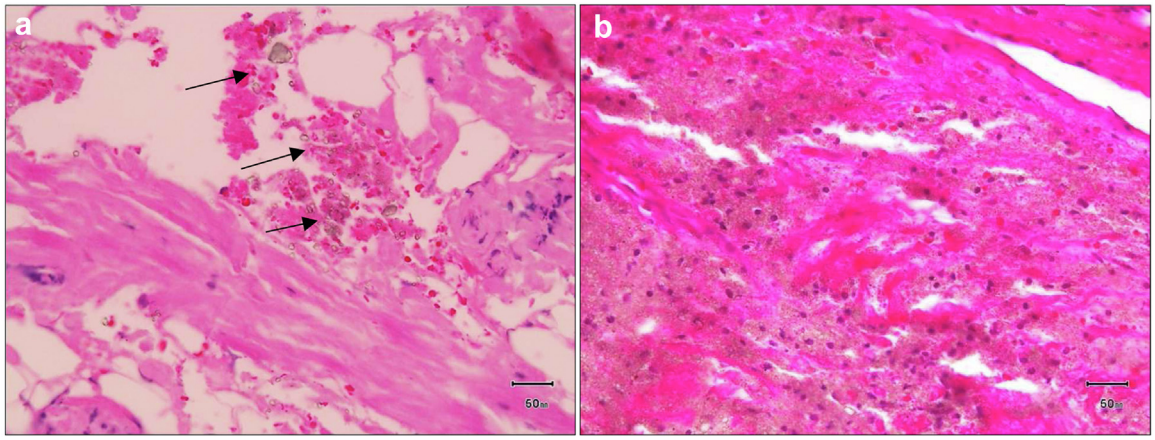

Figure 4. Pathologic slides demonstrating (a) foreign fragments and (b) mild infiltrate of lymphocytes with a foreign body reaction. Arrows indicate ceramic fragments.

intraoperative findings of the CoC THA evaluation, which showed an acetabular component fracture with femoral head wear, requiring modular components exchange. Additional etiologies such as trunnionosis were also ruled out intraoperatively after observing a taper-head junction without macroscopic changes concerning for corrosion or fretting; Goldberg Fretting and Corrosion Score = 1 (no visible findings) [17,18]. We proceeded with the intervention given the patient's recent presentation (less than 4 weeks since symptoms onset), stable prosthesis, good bone condition, lack of sinus tract formation, and the low probability of difficult-to-treat infection caused by an antibiotic-resistant organism. In settings where the prior indications are met, the success of a surgical debridement with prosthesis retention could be greater than 80% [14]. The postsurgical tissue analysis performed by the pathologist revealed an adverse inflammatory reaction to the alumina fragments.

The alumina debris arising from the ceramic component fracture or tribocorrosion could elicit soft-tissue reactions in some patients as these particles behave as foreign bodies. This phenomenon has been documented in some studies, including literature associated with the biological reactions to non-metal-on-metal components [6,7,11,19,20]. The inflammatory response to alumina, the ceramic constituent, could explain the sudden onset of pain and discomfort once enough fragments of ceramic were produced, causing the adverse soft-tissue reaction. Among those patients suffering from these adverse reactions, ipsilateral leg pain, the presence of a mass, and impaired ambulation have been the most commonly reported complaints [11]. Usually, restoring the bearing surfaces and removing the debris from the articulation are enough to allow healing and avoid further reactions [20].

Figure 5. Two-week postoperative pelvis anteroposterior radiograph.

Despite the significant advances in material sciences, fracture of a ceramic component remains a considerable complication attributed to implant failure in THA [8,10]. Similarly, PJI is one of the most challenging and devastating mechanisms of implant failure after THA [16]. Those patients presenting with symptoms concerning for PJI should be carefully evaluated through a systematic approach as suggested by current guidelines. Moreover, the nature of the prosthetic components should be reviewed as part of the evaluation of a suspicious PJI. Orthopedic surgeons should remain aware that an acute inflammatory presentation suggestive of an infectious process could be the debuting appearance of an adverse soft-tissue reaction. Therefore, high clinical suspicion and a comprehensive diagnostic approach are essential when facing acute inflammatory reactions in a hip previously managed with a THA.

Summary

This case demonstrates a deceiving presentation of an adverse soft-tissue reaction secondary to a ceramic component fracture. We recognize that the current guidelines and algorithms to diagnose and manage PJI are essential to standardize an adequate approach in those patients with an infected hip arthroplasty. However, an acute inflammatory reaction suggestive of an acute infectious process is not an exclusive presentation and can be associated with other etiologies, such as an adverse soft-tissue reaction. Orthopedic surgeons should remain aware that signs and symptoms suggestive of an acute PJI could be the debuting scenario of an adverse soft-tissue reaction even when the current criteria to diagnose a periprosthetic infection have been fulfilled.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Informed patient consent

The authors confirm that informed consent has been obtained from the involved patient, and the patient has approved this information to be published in this case report.

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