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Case report

Osteosarcoma Around a Ceramic-on-Ceramic Total Hip Arthroplasty

Jordan J. Levett [a], Robert E. Turcotte, MD, FRCSC [b], Sungmi Jung, MD [c], John Antoniou, MD, PhD, FRCSC [d], Olga L. Huk, MD, MSc, FRCSC [d, *]

[a] Faculty of Medicine, University of Montreal, Montreal, Quebec, Canada
[b] Department of Orthopaedic Surgery, McGill University Health Centre, Montreal, Canada
[c] Department of Pathology, McGill University Health Centre, Montreal, Quebec, Canada
[d] Department of Orthopaedic Surgery, McGill University, Jewish General Hospital, Montreal, Quebec, Canada

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ABSTRACT

Sarcoma arising at the site of a total hip arthroplasty (THA) is uncommon. We present a case report of a patient diagnosed with an osteosarcoma around a ceramic-on-ceramic THA and a narrative literature review of sarcomas around THA. A search of PubMed MEDLINE was performed from inception. Our case report was included in the analysis. A total of 13 studies were included in the review. We report the first case of a sarcoma around a ceramic-on-ceramic hip implant. All cases in the literature reported poor outcomes with an average time from index THA to diagnosis of 9.3 ± 8.2 years. Sarcomas around THA are extremely rare. Despite the rarity of the diagnosis, osteosarcoma must be considered in the differential diagnosis when investigating a periprosthetic mass.

Introduction

Over 400,000 primary and revision total hip arthroplasties (THAs) are performed yearly in the United States alone [1]. Despite the excellent prognosis for patients undergoing THA [2], the main reasons for a revision surgery are infection and instability [3]. Prosthetic wear debris can lead to aseptic loosening and periprosthetic masses. Cobalt and chromium ions released from metal-on-metal (MoM) articulating interfaces and trunnionosis can lead to periprosthetic soft-tissue masses [4]. Incidence of such lesions around joints is typically described using the umbrella term an adverse reaction to metal debris and more specifically as pseudotumors or lymphocytic vasculitis-associated lesions [5]. The use of ceramic-on-ceramic (CoC) articulating interfaces reduces the risk of adverse reaction to metal debris and is reported to improve wear resistance and biocompatibility [6,7]. There is minimal evidence in the literature suggesting that ceramic debris is associated with periprosthetic tumors. Ceramic is a nonconductive material, whereas metals introduce conductive ions that can interfere with cellular polarity and induce oxidative stress or DNA damage [8].

Sarcomas develop in bone or soft tissue and can metastasize to distant organs. It is a rare cancer, and its risk factors are poorly understood [9]. Examples of sarcomas include osteosarcoma, chondrosarcoma, fibrosarcoma, angiosarcoma, and others. Osteosarcoma is a bone tumor where cancer cells produce malignant osteoid and invade through the bone and can extend to adjacent soft tissues. Current treatment options depend on the grading of the tumor and can include a combination of neoadjuvant and adjuvant chemotherapy, radiation therapy, and surgery [10]. Despite the adverse reactions associated with hip implants, certain limb-salvaging techniques leverage orthopedic implants to replace neoplastic long bones and to optimize patient's function.

Periprosthetic masses can remain benign or be associated with malignancy. The etiology of sarcomas is unknown but can include radiation exposure, chronic lymphedema, chemical or viral exposure, and hereditary diseases [11]. The occurrence of sarcomas in proximity to orthopedic implants is rare, but incidence of such cases should be reported [12]. We present a case report of a patient diagnosed with a high-grade osteosarcoma 11 years after THA and a narrative literature review of published studies in English related to sarcomas at the site of THA.

* Corresponding author. Department of Orthopaedic Surgery, McGill University, Jewish General Hospital, 3755 Chemin de la Côte-Sainte-Catherine, Montréal, QC H3T 1E2, Canada. Tel.: +1 514 983 0297.
E-mail address: olgahuk@gmail.com

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Case history

Patient history

At the age of 24, the patient sustained a pathologic left-hip fracture while training for the army in September of 2009, which was treated with a dynamic hip screw. The following day, there was failure of fixation, and the hardware was removed. A biopsy of the femoral neck revealed a unicameral bone cyst. The patient was placed in transfemoral traction and transferred to another hospital where he underwent a cementless hemiarthroplasty. An intraoperative femoral shaft fracture occurred at the time of the hemiarthroplasty that required cerclage wiring. In January of 2010, 4 months after the operation, the patient presented to our institution with increasing pain in the left hip area. Aspiration of the left hip revealed isolates of coagulase-negative staphylococci. The patient then underwent a stage I prosthesis with antibiotic-loaded acrylic cement (PROSTALAC, DePuy, Warsaw, IN) procedure and received 3 months of intravenous antibiotic therapy. The second-stage conversion to a THA was performed 6 months later. The conversion consisted of a cementless acetabular component (PINNACLE; DePuy, Warsaw, IN), a ceramic acetabular liner (BIOLOX Delta; CeramTec GmbH, Plochingen, Germany), a fully porous long-stem femoral component (Solution; DePuy), and a ceramic head (BIOLOX Delta; CeramTec GmbH) (Fig. 1). He had no postoperative complication and had routine annual follow-up.

Osteosarcoma diagnosis and follow-up

In July of 2021, a 35-year-old male construction worker presented for his routine yearly follow-up 11 years after THA. He complained about 3 months of left buttock and greater trochanteric pain that he attributed to excess exercise. On physical examination, he had full and pain-free range of motion of the left hip and pain on palpation of the posterior buttock and greater trochanter. There was no palpable mass. The anteroposterior pelvis and anteroposterior and lateral radiographs of the left THA were unremarkable and unchanged compared to July 2020. A diagnosis of greater trochanteric bursitis was likely, and cortisone infiltration was administered. Several weeks after the infiltration, he reported a 50% improvement in pain.

In September of 2021, he presented to the clinic complaining of persistence of buttock pain and sensations of electric shocks down his left leg. On physical examination, he had decreased and painful range of motion of the left hip and persistence of pain on palpation of the greater trochanter. A radiograph of the lumbosacral spine and an infectious workup was ordered. Even though the patient had a CoC articulation, a metal artifact reduction sequence (MARS) magnetic resonance imaging (MRI) was also ordered. The radiograph of the lumbar spine was normal.

The MARS MRI revealed a left periprosthetic mass measuring 9 × 8 × 10 cm without bony involvement and no bone marrow edema (Fig. 1). Erythrocyte sedimentation rate (22 mm/h, range: 2-28 mm/h) was normal, and C-reactive protein level (14.4 mg/L, range <10.0 mg/L) was elevated. Serum alkaline phosphatase level (318 IU/L, range 40-125 IU/L) was elevated, suggesting high osteoblastic activity. A hip aspirate was performed, and the automated cell count was 10,750 white cells/μL. Three specimens (aerobic and anaerobic culture bottles and a sterile specimen cup) were sent for culture and sensitivity test, and all cultures were negative for growth. Chromium and cobalt levels were normal, 0.21 μg/L and 0.24 μg/L, respectively. A diagnosis of periprosthetic pseudotumor was made on the basis of adverse local tissue response seen on imaging (Fig. 1) and the assumption of corrosion between the cobalt chrome trunnion and the ceramic head. The patient was scheduled for surgery.

In October of 2021, 1 month after being scheduled for surgery, the patient presented to the clinic with increasing pain. On physical examination, he now had a firm, palpable mass posterior to his greater trochanter. A radiograph was repeated and compared to the radiograph performed 3 months prior, and there was extensive proximal femoral lysis. A repeat MARS MRI revealed a substantial

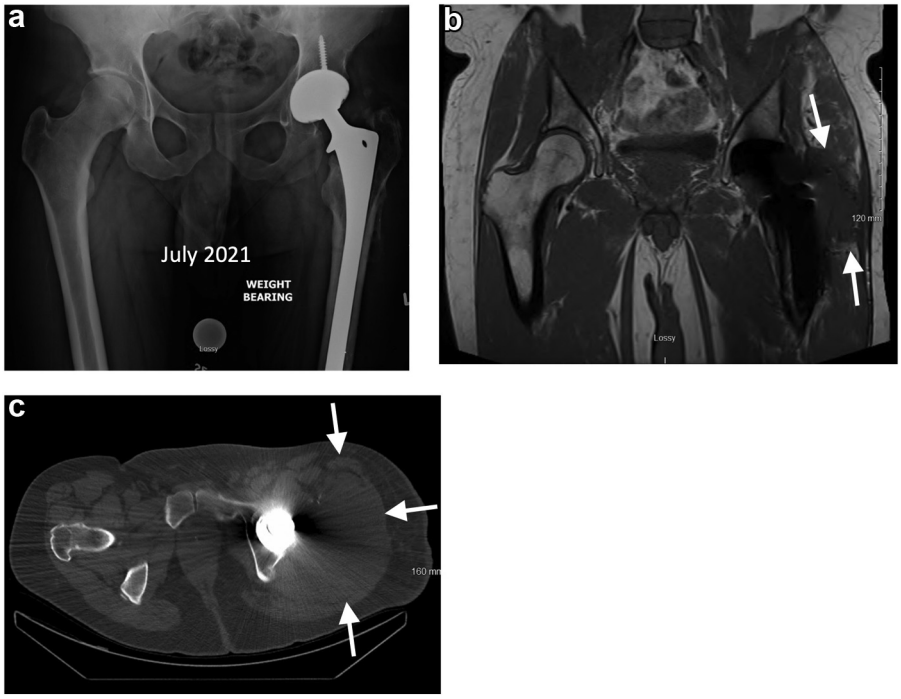

Figure 1. (a) Anteroposterior radiograph of pelvis and left CoC THA at 11 years postoperatively. (b) T1 weighted coronal MRI of pelvis and hip initially suggesting of left-sided periprosthetic pseudotumor forming inflammatory changes. (c) Axial MRI of pelvis displaying a mass of size 9 × 8 × 10 cm in left hip, as depicted by the arrows (July 2021).

increase in volume compared to the imaging performed 7 weeks prior. The mass now measured 12 × 11 × 16 cm circumferentially, involving the medullary cavity and left femoral diaphysis (Fig. 2). It encircled the sciatic nerve. There was associated local lymphadenopathy.

The rapid and aggressive progression of the lesion was no longer compatible with a pseudotumor, and the patient was immediately referred to an orthopedic oncology surgeon. A positron emission tomography combined with computed tomography supported malignancy with hypermetabolism of the mass. The biopsy concluded to osteosarcoma. The patient underwent preoperative chemotherapy. Due to the tumor size, its location, and the involvement of the sciatic nerve, the limb was not salvageable, and an external hemipelvectomy was performed. The final pathology confirmed high-grade giant cell-rich osteosarcoma. At 7 months postoperatively, the patient unfortunately developed lung metastases.

Informed consent was received from the patient to report the case and to publish relevant images.

Discussion

A narrative literature review of PubMed MEDLINE was conducted to determine the incidence of sarcomas in proximity to a hip arthroplasty. A keyword search of the English literature consisting of “hip replacement”, “hip arthroplasty”, and “sarcoma” was queried from inception to April 2022. A total of 12 relevant case reports were included, and metadata from each patient were collected. Our case report was added to the review, totaling to 13 included studies. The median age of the patients was 65 years (range 35 to 84 years). There were 6 (46.2%) male patients and 7 (53.8%) female patients. The average length of follow-up from THA to sarcoma diagnosis was 9.3 ± 8.2 years (mean ± standard deviation). Patients were diagnosed with osteosarcoma in 6 (46.2%) cases, angiosarcoma in 3 (23.1%) cases, chondrosarcoma in 1 (7.7%) case, liposarcoma in 1 (7.7%) case, spindle cell sarcoma in 1 (7.7%) case, and the type of sarcoma was not specified in 1 (7.7%) case. Table 1 outlines the patient characteristics of the included studies.

Sarcomas around THA

Sarcoma after THA is a rare condition that initially presents as a periprosthetic mass with the potential to metastasize. Since the increase in the use of MoM articulating interfaces, such periprosthetic masses have more commonly been pseudotumors secondary to the release of metal ions. Metal ion release causing a pseudotumor can originate from several sources, including the articular MoM interface, trunnionosis at the trunnion-femoral head junction, and release from modular stem-neck junctions. Pseudotumors have a reported prevalence of 26%-61% in well-functioning hips [25,26]. Adverse local tissue reactions (ALTRs) have been described as growth of fibrotic masses from the synovial membrane of patients with hip implants [27]. ALTR due to metal ions typically lead to mitochondrial exhaustion and subsequently intracellular hypoxia. It is also believed that ALTR can be a manifestation of delayed-type hypersensitivity reactions to metal wear products and ions. In response, inflammatory cytokine reaction induces mass growth in proximity to the implant [28,29]. Certain implant materials have benefits and drawbacks compared to others. The innate properties of the implants can have varied ALTRs in a patient population. MoM implants using cobalt-chromium-molybdenum had a wear rate of 0.60 ± 0.18 mm^3/Mc [30], whereas a ceramic-on-metal implant had a wear rate of 0.87 mm^3/Mc [31], and a ceramic-on-polyethylene (alumina-polyethylene) implant had a wear rate of 34 mm^3/Mc [32]. CoC implants reported to have the lowest wear rates at 0.1 mm^3/Mc [33].

All cases of reported pseudotumors have been benign periprosthetic masses or inflammatory responses. Campbell et al. present a case of a pseudotumor around a CoC implant and suggest that ceramic debris can cause local tissue reaction [34]. In the latter

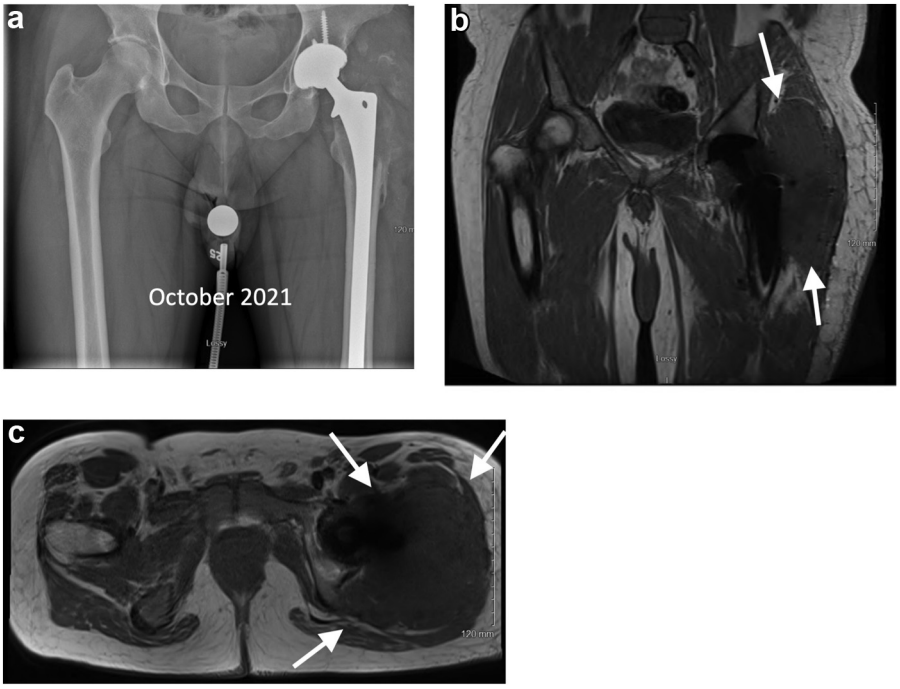

Figure 2. (a) Anteroposterior radiograph of pelvis and left hip showing extensive lytic erosion involving the left greater trochanter and proximal diaphysis. (b) Coronal and (c) axial views of MARS MRI showing marked interval size increase of the left periprosthetic mass to 12 × 11 × 16 cm. There is circumferential involvement of the medullary cavity of the left proximal femur with associated posterolateral cortical disruption. There is extension to the left gluteal, ischiofemoral, and anterior-proximal thigh compartments, as depicted by the arrows(October 2021).

Table 1
Narrative literature review of case reports involving THAs and sarcomas.

Author year	Age (year)/sex	Side of sarcoma	Hip implant	Stem-head alloy; acetabular cup; fixation	Sarcoma diagnosis	Time elapsed from THA to sarcoma diagnosis (years)	Treatment	Clinical outcomes
Ryu, 1987 [13]	41/M	NR	Uncemented THA	CoCr; NR; cemented	NR	1.25	NR	Death 10 mo after diagnosis
Martin, 1988 [14]	66/F	Right	Charnley-Müller	CoCr; polyethylene; cemented	Osteosarcoma	NR	Disarticulation of limb, chemotherapy	Death 8 mo after diagnosis
Brien, 1990 [15]	60/F	Left	Charnley-Müller	Stainless steel; polyethylene; cemented	Osteosarcoma	8	Preoperative chemotherapy, proximal femur excision (replaced with cemented implant)	NR
Stephensen, 1999 [16]	57/M	Left	Protasul (femoral component), Harris-Galante (acetabular component)	Titanium-aluminum-niobium stem with a CoCr-molybdenum head; titanium; cemented (only femoral component)	Liposarcoma	6	Surgical resection of tumor	Death 3 mo after surgery from bronchopneumonia (unrelated)
Rana, 2001 [17]	79/F	NR	Howse I	Stainless steel; polyethylene; cemented	Spindle cell sarcoma	13	Internal fixation, radiotherapy	Death 7 mo after radiotherapy
Prasad, 2002 [18]	70/M	Right	Howse II	TiAlV; polyethylene/titanium; uncemented	Osteosarcoma	6.5	THA revision	Death 7 wks after revision surgery
Adams, 2003 [20]	62/M	Left	Harrise-Galante	Titanium stem, CoCr modular head; titanium shell with polyethylene liner; uncemented	Osteosarcoma	3	NR	NR
Mallick, 2009 [19]	84/F	Right	Müller (femoral component), Burch-Schneider reinforcement cage (acetabular component)	Titanium; titanium; cemented	Angiosarcoma	30	Radiotherapy	Palliative care
Liska, 2015 [21]	38/F	Left	NR	NR	Chondrosarcoma	8	Revision surgery with wide resection of proximal femur	NR
Kavalar, 2016 [22]	65/M	Left	Anatomic modular (femoral component), press-fit cup (acetabular component)	TiAlV stem with alumina ceramic head; TiAlV shell with alumina ceramic liner; uncemented	Osteosarcoma	15	Chemotherapy	NR
Sánchez-García, 2019 [23]	64/F	Left	Charnley-Kerboull	NR; polyethylene; uncemented	Angiosarcoma	Diagnosis at death	Hemipelvectomy and discharge colostomy	Death
Lee, 2021 [24]	69/F	Left	NR	Metal; polyethylene; NR	Angiosarcoma	0.67	Radiotherapy	Death 40 d after diagnosis
Levett, 2023	35/M	Left	Solution DePuy (femoral component), Biolox CeramTec (acetabular component)	CoCr stem with alumina ceramic head; TiAlV shell with alumina ceramic liner; uncemented	Osteosarcoma	11	Chemotherapy and hemipelvectomy	Developed lung metastases. Routinely followed at 7 mo after operatively

NR, not reported; CoCr, cobalt-chromium; TiAlV, titanium-aluminum-vanadium.

case, a higher wear rate of the CoC interface could have been caused by an excessively vertical cup with an abduction angle of 52°-55° [34]. Another case of a CoC hip implant reported atypical ALTR due to liner fragmentation and a screw causing wear [35]. The periprosthetic mass found in these cases was benign and not cancerous in nature. The pathophysiology of ALTR induced by ceramic debris is poorly understood, and future studies should explore such mechanisms.

The causes of osteosarcoma are multifactorial including DNA alterations, epigenetic changes, cytokine secretion, and the deregulation of differentiation of mesenchymal stem cells [36]. Inflammatory response to a foreign entity such as a hip implant can therefore trigger tumor cell proliferation. Our narrative review of the literature revealed only 1 case where a soft-tissue sarcoma was associated with a CoC THA [13]. However, this case used an aluminum ceramic and CoCr stem. Given the rarity of this case and ours, it remains uncertain if the findings of an osteosarcoma around a CoC THA are coincidental. Nonetheless, these cases remind physicians to include sarcoma in the differential diagnosis for patients presenting with gluteal or thigh pain after THA.

Treatment for patients in the included studies involved chemotherapy, radiation therapy, and surgery. Most studies followed bimodality therapy involving surgery (resection, internal fixation, or THA revision) and chemotherapy or radiation therapy [14–18,21,23], including our case. Other studies used unimodal therapy with either chemotherapy or radiation therapy to treat the sarcoma [19,22,24]. The prognosis for the patients in this literature review is poor with survival being less than 1 year after diagnosis in 92.3% of patients. The time from index THA to diagnosis of sarcoma was 9.3 ± 8.2 years (mean ± standard deviation). Poor outcomes can be partially attributed to late staging and aggressiveness of the osteosarcoma. In our patient, the volume of the mass almost tripled within 7 weeks (720 cm^3 to 2112 cm^3).

Considerations and future directions

Routine clinical and radiographic monitoring after THA is essential. When the etiology of a suspected soft-tissue reaction around a prosthesis is unclear based on routine laboratory and imaging workup, providers are urged to consider an oncologic origin. The patient presented in this case was followed up annually at our institution and was treated before metastasis to distant organs. Through our narrative literature review, we demonstrate the importance of early detection and diagnosis of sarcoma around a prosthetic implant to optimize the prognosis for patients undergoing THA.

Summary

To the best of our knowledge, this is the first reported case of a sarcoma around a CoC THA. This occurred in a patient diagnosed with a high-grade osteosarcoma. The pathogenesis of sarcoma in proximity to implants remains obscure, and future studies should elaborate on such mechanisms. This case report and narrative literature review remind physicians to include sarcoma in the differential diagnosis upon presentation of hip pain after THA.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.101094.

Informed patient consent

The author(s) confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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