



Case Report

Adverse Local Tissue Reaction Associated With Ceramic-On-Metal Bearing Surface in Primary Total Hip Arthroplasty: Report of Two Cases

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ABSTRACT

Total hip arthroplasty (THA) is one of the most common and successful surgical procedures worldwide. At the same time, it is constantly evolving, and as a consequence, advances in implant technology have led to significant improvements in the different materials of the acetabular and femoral components. The selection of bearing surfaces and their tribology are critical to achieving a successful outcome. Pseudotumors are important, and usually misdiagnosed, complications associated with hard bearing surfaces such as metal-on-metal couples. They belong to a group of reactions called adverse local tissue reaction, which can occur in the vicinity of any THA. We present 2 cases of adverse local tissue reaction associated with the use of ceramic-on-metal bearings surfaces in 2 primary THAs that were treated with modular component exchange during single-stage revision surgery.

Level of Evidence: IV

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Introduction

Total hip arthroplasty (THA) has evolved considerably in recent decades, including improved designs, materials used, and fixation methods. The reduced wear rate of bearing surfaces has become a determinant of long-term implant survival. However, prosthetic wear is one of the most important causes of hip revision surgery [1].

Some alternatives to address this complication include polyethylene improvements and the development of hard friction bearings surfaces. Currently, the most commonly used hard bearing surfaces include metal-on-metal (MoM), ceramic-on-ceramic (CoC), and ceramic-on-metal (CoM). All options have excellent tribological properties, but none are without complications [2]. The pseudotumor is a frequently underdiagnosed complication that can occur with any hip replacement. Its potential causes may be associated with hypersensitivity, reaction to a foreign body, or an increased wear rate [3]. These soft-tissue adverse reactions are a

well-known complication of MoM surfaces used in both hip resurfacing [4,5] and THA [3]. The pseudotumor belongs to a group of reactions called adverse local tissue reaction (ALTR), which can occur in the vicinity of any THA [6].

The presentation of an ALTR when using CoM bearing couples has been rarely reported in the literature, probably because the latter option has had a limited indication and short-term follow-up. For this reason, we present 2 patients who developed an ALTR complication associated with the metallic component of the CoM couple in primary THA. The informed consent of both patients was signed for the purpose of publication of each case.

Case 1

A 44-year-old woman with bilateral hip osteoarthritis underwent cementless right THA through a posterolateral approach. 6 months later, the left THA was performed using the same fixation method using the same approach. The components that were implanted included a 54 mm acetabular cup (PINNACLE cup, DePuy Synthes, Warsaw, IN), a 36-mm cobalt-chrome insert (PINNACLE insert, DePuy Synthes, Warsaw, IN), a 36 + 5-mm ceramic head

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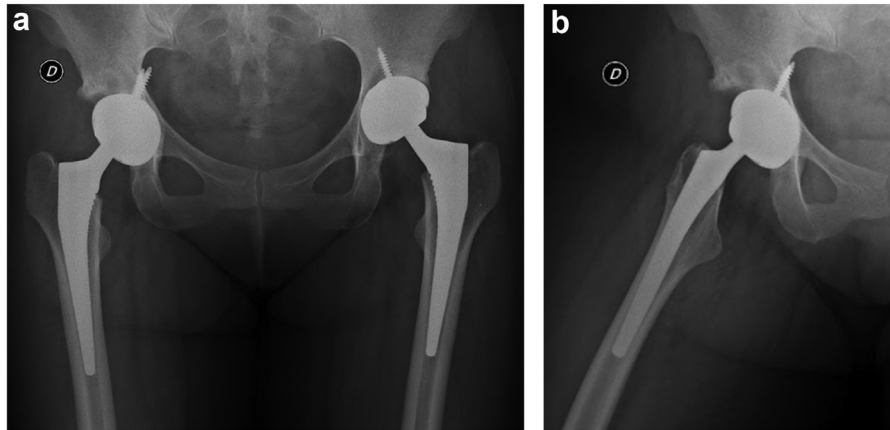


Figure 1. Anteroposterior (AP) (a) and lateral (L) (b) radiographs of the right hip show a well-fixed and well-aligned THA without signs of loosening.

(BIOLOX Delta, Ceramtec AG, Plochingen, Germany), and a fully hydroxyapatite porous-coated cementless stem (CORAIL stem, DePuy Synthes, Warsaw, IN). There were no intraoperative complications, and the patient had an uneventful recovery.

After 3 years, the patient presented with groin pain in her right side, squeaking, and a sensation of instability when sitting. Radiographs showed well-aligned and well-fixed implants (Fig. 1a and b). The triple-phase technetium bone scan showed no signs of hyperactivity around the implants. Laboratory parameters were within normal ranges, with a C-reactive protein (CRP) value of 0.4 mg/L and erythrocyte sedimentation rate of 8 mm/hour. Metal ion levels in blood and urine were below the reported level of toxicity (chromium in urine of 2.00 $\mu\text{g/gC}$; serum chromium $<1 \mu\text{g/L}$; serum cobalt $<1 \mu\text{g/L}$, and cobalt in urine of 3.00 $\mu\text{g/L}$). Metal artifact reduction sequence magnetic resonance imaging (MARS-MRI) did not reveal any pathological findings.

Due to the persistence of pain and instability, revision surgery was indicated. No signs of impingement or loosening were evidenced intraoperatively. However, extensive synovitis, signs of metallosis, and abundant synovial fluid were found (Fig. 2). After confirming the stability and good position of the acetabular cup and the femoral stem, the metal insert and the ceramic femoral head were removed. A highly cross-linked polyethylene insert (ALTRX Polyethylene, DePuy Synthes, Warsaw, IN) was placed for a 36-mm cobalt-chrome femoral head.



Figure 2. Intraoperative photograph evidencing extensive synovitis and signs of metallosis.

One year after the revision surgery, the patient did not refer any pain or instability. The postoperative Harris Hip Score (HHS) was 89 points. The histopathology analysis of the resected soft tissues revealed abundant fibroconnective tissue with extensive necrosis, metal and hemosiderin deposits, lymphocytic infiltrate, histiocytes, and occasional multinucleated giant cells. These findings were consistent with those described for a metallosis reaction. Ten years after the revision surgery, the patient remains asymptomatic, with no restrictions during daily activities and an HHS of 89 at the latest follow-up.

Case 2

A 59-year-old man with bilateral hip osteoarthritis underwent simultaneous bilateral THAs through a posterolateral approach. A 56-mm acetabular cup (PINNACLE cup, DePuy Synthes, Warsaw, IN), a 36-mm cobalt-chrome insert (PINNACLE insert, DePuy Synthes, Warsaw, IN), a 36 + 1.5-mm ceramic head (BIOLOX Delta, Ceramtec AG, Plochingen, Germany), and a fully hydroxyapatite porous-coated cementless stem (CORAIL stem, DePuy Synthes, Warsaw, IN) were used in both hips. There were no intraoperative complications, and the patient had an uneventful recovery.

After 10 years, the patient presented with progressive left groin pain. The radiographs did not show signs of osteolysis or loosening (Fig. 3a and b). The inflammatory parameters were within normal values, with a serum CRP of 2.5 mg/L and an erythrocyte sedimentation rate of 7 mm/hour. Metal ion levels in blood and urine were below the toxicity level (serum chromium $<1 \mu\text{g/L}$; serum cobalt $<1 \mu\text{g/L}$, and urine cobalt of 3.00 $\mu\text{g/L}$). The triple-phase technetium bone scan showed moderate hyperactivity in the left hip around the trochanteric level and the anterior wall of the acetabulum. The MARS-MRI revealed the thickening of the synovium, with a pseudocapsular formation, suggestive of hypersensitivity to metal (Fig. 4a and b).

Revision surgery was performed through the same posterolateral approach. Extensive synovitis, signs of metallosis, and an ALTR were evidenced (Fig. 5a and b). Given that the cup and the stem were well fixed and well aligned, only the metal liner and the ceramic femoral head were removed. A 36-mm highly cross-linked polyethylene insert (ALTRX Polyethylene, DePuy Synthes, Warsaw, IN) and a 36 + 1.5-mm ceramic femoral head (BIOLOX Delta, Ceramtec AG, Plochingen, Germany) were inserted. The aspirated fluid during the surgery was negative for infection, and the intraoperative synovial CRP was within normal values. No intraoperative or postoperative complications were recorded.

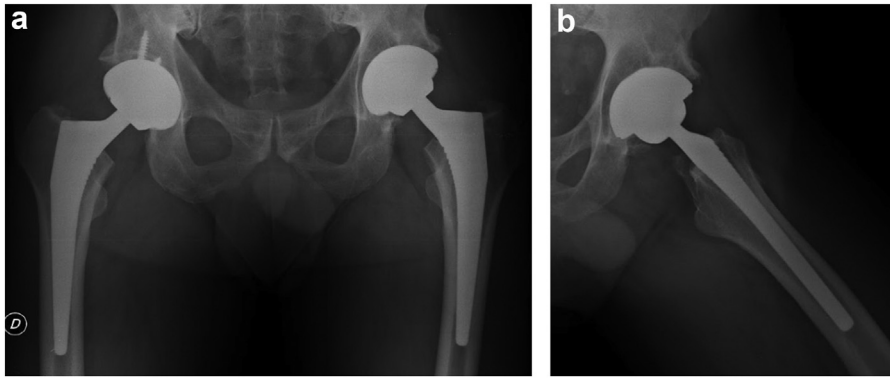


Figure 3. AP (a) and L (b) radiographs of the left hip show a well-fixed and well-aligned THA without signs of loosening.

One year after the revision surgery, the patient referred no pain or instability with an HHS of 90. The histopathology results evidenced signs of metallosis. Three years later, the patient remains asymptomatic, with no restrictions during daily activities and an HHS of 90 at the latest follow-up.

Discussion

THA is constantly evolving, seeking better outcomes by improving implant designs, fixation techniques, and bearing surfaces. The thorough tribological study of these materials is critical for a successful outcome.

MoM bearing couple was one of the most used surfaces in THA history. This surface has been shown to have a lower wear rate than the metal on conventional ultra-high-molecular-weight polyethylene (MoP) bearing surface. However, wear particles are microscopic, and serious complications have been related at the local and systemic levels [7]. The CoC couple has lower wear rates than MoM and MoP, but complications such as “squeaking” and implant fracture remain problematic [8]. In order to reduce the complication rate associated with MoM and CoC surfaces, a new CoM alternative was created, using a ceramic femoral head and an acetabular metal insert. Some of the potential advantages of CoM bearing couples are the lower wear rate and lower serum metal ion levels than the MoM although CoM and CoC alternatives have reported similar wear rates [9].

ALTRs are sometimes underdiagnosed after THA. They are a granulomatous or destructive cystic lesion, neither infective nor

neoplastic. In many cases, these lesions behave like a tumor, affecting the surrounded soft tissues around the THA [3]. They are part of a group of pathological biological reactions, such as muscle or bone necrosis, capsular thickening, cystic lesions, excessive fluid collections, and soft-tissue masses. These lesions were grouped by McGrory et al. [6] under the name of ALTR, with the aim of standardizing their study, analysis, and interpretation.

The incidence of the ALTR is variable. Tallroth et al. reported that 4.6% of patients with MoP THA evidenced ALTRs in radiographic examinations [10]. Moreover, Pandit et al. showed that approximately 1% of patients with MoM hip resurfacing developed an ALTR within 5 years from the surgery [4]. Finally, Young-Min Kwon et al. [5] reported a 4.4% prevalence of asymptomatic ALTRs in patients with MoM hip resurfacing. Despite these differences, most of the literature agrees with the low frequency of this type of complication.

Patients with an ALTR can be asymptomatic or refer groin pain, a palpable mass, and edema [11]. Compression syndromes such as neuropathies or vein thrombosis have also been described [12]. If asymptomatic, they are usually diagnosed by routine imaging studies or due to increasing metal ion levels [5]. MARS-MRI is the most specific tool for studying soft tissue complications following THA. ALTRs can range from cystic lesions to well-defined solid masses. Synovial thickening can also be present in these types of lesions [13]. In one of our cases, MRI showed images suggestive of ALTR, like pseudocapsular formation around THA and synovial thickening. On the other hand, the increase in metal ions levels in MoM bearing surfaces is well known [5]. The literature agrees that

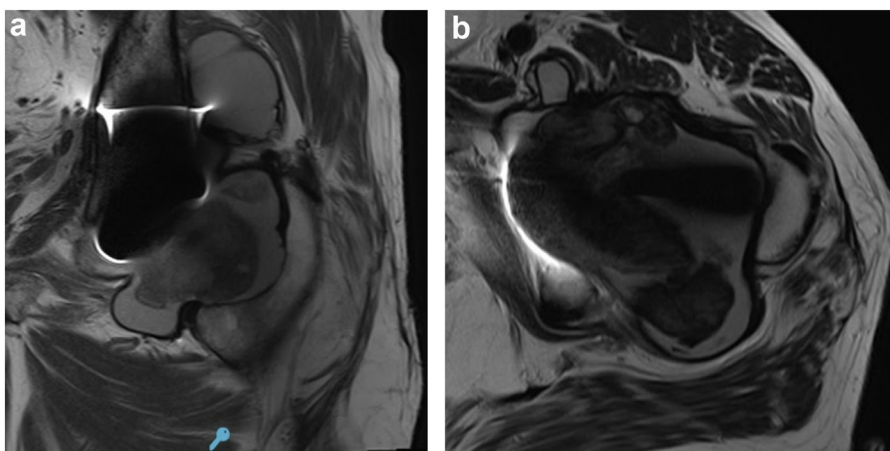


Figure 4. MRI coronal (a) and axial (b) images show extensive synovitis and the ALTR around the left THA.

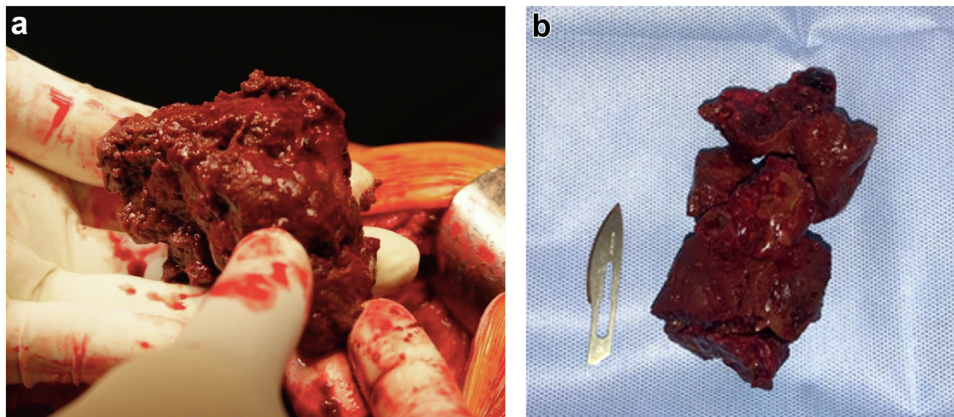


Figure 5. Intraoperative photograph showing the removal of the ALTR (a) and its typical brownish coloration (b).

serum metal ion levels increase and remain constant in THA with MoM surfaces. However, Kim et al. [14] reported that serum chromium and cobalt levels are not constant at 10 years of follow-up. Lastly, no consensus has been reached regarding serum metal ion levels in CoM couples. Similar to our cases, Blau et al. [15] reported a patient with an ALTR after CoM THA and no elevation of serum cobalt and chromium ion levels.

The increased wear rate and the excess of wear particles are associated with the formation of ALTRs. These wear particles can result from the mechanical wear and corrosion surfaces in MoM THA [3]. This debris excess can also be related to the ALTR origin in other bearing couples like MoP [16]. According to these, McGrory et al. [17] reported a prevalence of 1.1% in a series of 1356 MoP hip arthroplasties, with a minimum follow-up of 2 years. The reaction to a foreign body, especially to materials like polyethylene, metal, or methyl methacrylate, can be associated with the formation of ALTRs. In addition, the hypersensitivity reaction to metal was also identified as one of the potential causes of this complication [3]. The position of the components can also influence the wear rate. Some authors claim that a malpositioning of the acetabular cup with an excessive inclination and anteversion can generate posterior impingement, with the consequent increase in the wear rate [11]. Nevertheless, Matthies et al. reported similar incidence of ALTR between patients with well-positioned hips and those with adverse cup position [18]. Finally, Glyn-Jones et al. [19] reported a higher risk of revision surgery due to ALTR in female patients under the age of 40 years and with small components.

CoM surfaces have been shown to decrease wear rates and friction compared to the MoM. This has been attributed to decreased corrosive wear, smoother surfaces, and better lubrication properties [20]. Furthermore, as previously mentioned, another advantage is the lower metal ion levels in blood than in MoM. Despite these advantages, the CoM surface is not without complications. A few cases have been reported in the literature of early failure due to soft tissue adverse reactions associated with CoM. Deshmukh et al. reported a case of a patient who presented groin pain and hip instability in a CoM THA. The revision surgery evidenced a well-fixed and well-aligned THA with extensive synovitis, local inflammatory response, and a metallic stain on the ceramic femoral head [2]. Additionally, Naik et al. [21] reported an ALTR associated with a CoM THA. In this case, the patient referred pain, local edema, and elevated serum chromium and cobalt values. An extensive metallosis and ALTR were evidenced during the revision surgery. In these last 2 examples, acetabular implants were removed with femoral head and liner exchange. On the contrary, both acetabular cups were retained in our cases, and only the

modular components were replaced. Even though both of our cases had well-positioned implants, a possible cause of failure could have been a slightly vertical cup and the consequent edge loading. Although these 2 alternatives have shown promising results and seem suitable for treating this complication, further studies are needed to reach a consensus with more robust recommendations.

Summary

We report 2 patients who developed ALTRs associated with CoM surfaces similar to these last 2 reported cases. We believe it is essential to highlight this complication due to its low frequency and the possibility of underdiagnosis in regular consultations. Local pain and edema, cystic images around the THA evidenced on the MARS-MRI, and elevated serum metal ions levels lead us to think about this potential complication, even with the use of CoM surfaces. No bearing surfaces are exempt from this complication, and misdiagnosis can lead to chronic pain, gait alterations, implant loosening, and episodes of instability. Despite the good outcomes of CoM THA, further prospective studies are needed to determine the true incidence of this complication.

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 paper.

For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2022.04.014>.

Informed patient consent

The author(s) confirm that 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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