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Metallosis with pseudotumour formation: Long-term complication following cementless total hip replacement in a dog

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Summary

Case description—A 10-year-old female Belgian Teruven dog was presented to our clinic for total hip revision following a diagnosis of implant (cup) failure with metallosis and abdominal pseudotumour formation. The patient had a cementless metal-on-polyethylene total hip replacement performed nine years prior to presentation.

Clinical findings—The clinical findings, including pseudotumour formation locally and at sites distant from the implant and pain associated with the joint replacement, were similar to those described in human patients with this condition. Histopathological, surgical, and radiographic findings additionally supported the diagnosis of metallosis and pseudotumour formation.

Treatment and outcome—Distant site pseudo tumours were surgically removed and the total hip replacement was explanted due to poor bone quality. The patient recovered uneventfully and has since resumed normal activity.

Conclusion—In veterinary patients with metal-on-polyethylene total hip implants, cup failure leading to metallosis and pseudotumour formation should be considered as a potential cause of ipsilateral hindlimb lameness, intra-pelvic abdominal tumours, or a combination of both. These clinical findings may occur years after total hip replacement surgery.

Keywords

Total hip replacement; metallosis; pseudo - tumour; canine orthopaedics

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Conflict of interest

There are no conflicts of interest to declare.

Introduction

Metallosis is a well-described condition in the human medical literature that occurs in association with the use of metal-on-metal and metal-on-polyethylene (MoP) orthopaedic joint implants. The condition has been described after total hip replacement (THR), total shoulder replacement, and total knee replacement as well as in cases of uni-compartmental knee arthroplasties (1–6). Metallosis refers to the chronic inflammatory response resulting from infiltration of the peri-prosthetic soft tissue and bone by biologically reactive metallic wear debris. This local pro-inflammatory environment promotes bone resorption and subsequent implant loosening (6). The term pseudotumour was first coined by Pandit and colleagues to describe the features of a non-infectious and non-malignant soft tissue mass associated with hip arthroplasty (7).

Total hip replacement is a commonly performed procedure in the canine patient to relieve pain from coxofemoral osteo-arthritis or for management of physeal fractures. Metal-on-polyethylene refers to the elements of the implant, which consists of a metal femoral head and femoral stem components and an interposed polyethylene acetabular component. Metal-on-polyethylene THR implants used in veterinary patients are most commonly made from titanium or cobalt-chromium alloys.

Symptoms of metallosis described in human patients vary, depending on the location of the inflammatory response. Signs associated with a local tissue reaction arise from chronic synovitis and implant loosening, and include pain, joint swelling and local pseudotumour formation (7–9). A diagnosis of metallosis is made by radiographic, clinical, and histopathological findings. Three distinct radiographic findings in humans are described and include: 1) the “cloud” sign, consisting of amorphous fluffy densities in the peri-prosthetic soft tissues, 2) the “bubble” sign, consisting of a curvilinear, bubble-like, radiodensity outlining the joint space, and 3) the “metal line” sign, consisting of a thin rim of increased density outlining a portion of the joint capsule (10–12).

Typically, pseudotumours develop in the vicinity of the metal implant, and can communicate with the joint (9). At the time of revision surgery, gross metal staining of the peri-prosthetic tissues can usually be seen (6, 13). Distant pseudotumour formation is considered a rare complication following THR in people (9, 14). Pseudotumour formation in intra- and extrapelvic regions have been described in human patients with THR (14–20). Histopathological findings of pseudotumours include features consistent with metal wear reactions and metal hypersensitivity, such as macrophages containing metal particles, necrosis, lymphocytic aggregates and granulomas (20, 21).

This case report describes the clinical and pathological aspects of a case of canine metallosis with intrapelvic pseudotumour formation following the use of a cementless MoP THR system. This is, to the author’s knowledge, the first described case of metallosis with distant pseudotumour formation in a canine patient.

Case report

A one-year-old, 20 kg female Belgian Teruven dog was initially presented to our hospital (The University of Wisconsin Veterinary Care) in 2005 with a five-month history of insidious right hindlimb lameness after slipping on ice. On physical examination the patient showed signs of pain on right hip extension and had decreased extension of the right coxofemoral joint. Radiographs obtained at this time were consistent with avascular necrosis of the right femoral head, although histopathology was not undertaken to confirm this diagnosis (Figure 1A). A total hip replacement was subsequently performed without complication using a cementless implant^a, including a cobalt-chromium femoral head and stem and a titanium acetabular shell with polyethylene insert (Figure 1B, C).

The patient made an uneventful recovery from surgery, and follow-up radiographs performed six months later showed stable implants with no evidence of sub-sidence. The patient, an active agility dog, was reported to return to normal activity with no clinical lameness for the next seven years.

At eight years of age, seven years after THR surgery, the patient was presented to its primary care veterinarian for progressive right hindlimb lameness. Evaluation at this time did not reveal lameness at a walk or trot, although the dog was noted to preferentially stand on the left hindlimb. Radiographs were obtained, and at the time were interpreted as being normal, but subsequent evaluation indicated acetabular cup wear (Figure 2). No further investigation was undertaken.

At 10 years of age, nine years after the initial presentation, the patient was presented to an emergency clinic for an acute onset of vomiting and lethargy. An abdominal ultrasound was performed which showed the presence of a large (7 cm × 5 cm) thick-walled cystic structure in the caudal abdomen. The patient was anaesthetized for exploratory abdominal surgery. A cystic mass was identified within the right intrapelvic abdominal cavity. The mass did not appear to be arising from a specific organ or structure. Fluid was collected from the cystic mass for aerobic culture and sensitivity. The tissues removed were submitted for histopathological evaluation.

Histopathological evaluation of the cystic mass revealed a region of central necrotic debris with abundant black, crystalline pigment that was non-refractive when viewed with polarized light. Despite serial, multidirectional sectioning of the tissue, no birefringent material, consistent with polyethylene wear debris, was identified in the lesion. The morphologic and tinctorial properties of this pigment were inconsistent with endogenous pigments such as melanin, iron and hemosiderin. The material was surrounded by fibroplasia, macrophages which contain similar pigment, plasma cells, lymphocytes and associated skeletal muscle (Figure 3). The culture results were negative for aerobic growth. The findings were consistent with the histological features of a 'pseudotumour' associated with THR in human beings.

^aBFX®: BioMedtrix Inc., Boonton, NJ, USA

Three weeks following the abdominal exploration, the patient was presented to the emergency clinic because of the development of acute non-weight bearing lameness of the right hindlimb. On examination, the dog was noted to resist extension of the right coxofemoral joint. Radiographs were obtained, and although continued acetabular wear was evident, they were deemed unremarkable (Figure 4). The patient was re-presented to the emergency clinic a few days later due to continued progression of lameness. On examination, the patient was pyrexia. Examination of the right hindlimb revealed mild thickening of the tissue on the lateral aspect of the proximal femur in the region of the greater trochanter, and oedema of the distal regions of the right hindlimb. A focal ultrasound was performed which revealed a fluid filled pocket (0.9 cm × 5.7 cm) caudal to the right femur under the fascia and between muscle bellies. A sample of the fluid was aspirated and submitted for cytology, and culture and sensitivity.

Fluid cytology revealed black, mucoid, cloudy pigmented fluid, containing numerous mixed inflammatory cells on a streaming mucinous background with necrotic cell debris. Poorly preserved and degenerate neutrophils comprised approximately 75% of all nucleated cells. The remaining cells consisted of macrophages containing moderate amounts of irregular dark brown to black pigmented material. Though of undetermined origin, this pigment was noted to appear similar to that from the intrapelvic cyst removed two weeks prior. On cytological evaluation, low but consistent numbers of intra- and extracellular long, individualized and chaining bacterial rods with pigment of undetermined origin and necrosis were noted. Aerobic culture was negative for microbial growth.

The patient was referred to our hospital for further evaluation. On examination the patient was non-febrile with mild muscle wasting of the right thigh musculature compared to the left, no evidence of distal limb oedema or swelling, and a decreased range of motion of the right coxofemoral joint. Radiographs were obtained of the coxofemoral joints and pelvis, which revealed excessive wear of the acetabular cup (Figure 5). A pelvic computed tomography (CT) study revealed multiple ill-defined heterogeneous hypo- and hyperattenuating masses in the region of the right coxofemoral joint. A heterogeneously enhancing mass was present in the region of the medial gluteal muscle, lateral to the caudal aspect of the body of the ilium and cranial to the acetabulum (Figure 6). The right medial iliac lymph node and the right lateral sacral lymph node were enlarged and contrast enhancing. These findings were consistent with the diagnosis of metallosis secondary to excessive wear of the THR implants causing metal-on-metal contact with associated metal debris and together with fasciitis and myositis surrounding the right coxofemoral joint and extending to the right pubic region.

A complete blood count, serum biochemical analysis, and urinalysis culture and sensitivity were obtained. Urine was also submitted to a commercial testing company^b for analysis of cobalt and chromium levels. Results of the haematology were unremarkable. The urinalysis was within normal limits, and the urine culture was negative. Results of the serum biochemical analyses showed mild hyperglobulinemia 3.8 g/dl (reference range [rr]: 2.2–3.5), and increased alkaline phosphatase (ALP) 464 U/L (rr: 20–157). Chromium levels

^bMedTox, St. Paul, MN, USA

were within normal limits (rr: <1.0 ng/ml), and cobalt levels were slightly elevated 1.3 ng/ml (rr: <1.0 ng/ml).

Revision surgery was undertaken. The patient was pre-medicated with dexmedetomidine (3.75 mcg/kg IV) and hydromorphone (0.1 mg/kg IV) and induced with propofol (3.5 mg/kg). An epidural injection was administered using morphine (0.2 mg/kg) and bupivacaine (1 mg/kg). The patient was maintained under general anaesthesia using isoflurane. A standard dorsal surgical approach to the coxofemoral joint was made. Muscle bellies and fascial tissue surrounding the hip joint were dark green to black (Figure 7). This tissue was collected and submitted for histopathological evaluation and culture. Upon disarticulation of the femoral head, the polyethylene and titanium cup components were noted to have full thickness wear (Figure 8). The acetabular cup was separated from the underlying pelvic bone and removed without complication. The remaining acetabular bone was dark green to black. Bone re-sorption was present on the dorsal cranial aspect of the acetabulum, correlating with the region of full-thickness acetabular cup wear. Due to concern regarding the integrity of the remaining acetabulum, a cup replacement was deemed inappropriate and a femoral head and neck ostectomy was pursued. The femoral head and stem prostheses were intact, although a moderate amount of bone resorption was present at the proximal femoral bone-implant interface. As the femoral head was removed with a femoral head extractor, a femoral fracture occurred at the level of the greater trochanter. The femoral stem was removed; additional bone did not need to be excised to complete the femoral head and neck ostectomy. The origin of the vastus lateralis was elevated to gain additional exposure to the femur. The femoral fracture was stabilized with two double-looped 0.8 mm cerclage wires and a 10-hole 3.5 mm limited contact-dynamic compression plate^c. Multiple amikacin-impregnated plaster of Paris beads^d were placed around the proximal femur (Figure 9A). Wound closure was routine.

In the immediate postoperative period, the patient received hydromorphone (0.05 mg/kg, intramuscular (IM), every 6 hours) and a single dose of carprofen (4.4 mg/kg, subcutaneous). A 75 mcg fentanyl transdermal patch was applied. Once the patient was eating, treatment with tramadol (3 mg/kg PO every 8 hours for 3 days), carprofen (2.2 mg/kg PO BID for 10 days), amoxicillin-clavulanic acid (19.5 mg/kg PO BID for 7 days), and enrofloxacin (7 mg/kg PO SID for 7 days) were administered pending culture results. The patient made an uneventful recovery and was discharged to the owners four days later.

Histopathological evaluation of the tissue surrounding the THR implants revealed marked multifocal granulomatous myositis and cellulitis with metallosis, which was characterized by black, crystalline, intra-lesional foreign material. Birefringence was noted with polarized light. The tissue was further characterized by necrosis and myofiber atrophy, degeneration, loss and regeneration. The tissue culture revealed a minimal growth of *Clostridium subterminale*. Further antibiotic therapy was not instigated, as the organism was susceptible to the previously prescribed antibiotic medications.

^cDePuy Synthes Vet, West Chester, PA, USA

^d289 mg amikacin: Fort Dodge Animal Health, Kansas City, KS, USA

Follow-up examination was performed nine weeks after surgery. The patient was ambulatory with a grade III/V right hind-limb lameness observed at a walk. There was moderate muscle atrophy of the right thigh muscles compared to the left, and resistance to extension of the right hip. Radiographs of the right proximal femur indicated complete healing of the right proximal femoral fracture with stable surgical implants (Figure 9B).

Follow-up communication with the owner occurred seven months after revision surgery, at which point the patient had returned to complete athletic agility function.

Discussion

Metallosis and pseudotumour formation in human patients with joint arthroplasty is well described in the literature (1–9, 13–28). The generation of particulate wear debris derived from the components of joint prosthesis was initially a complication recognized to occur with implants having metal-on-metal articulation. A recent study following 626 human THR recipients indicated that 25–66% of patients developed pseudotumours after metal-on-metal THR, with the incidence increasing over time (9). In human patients with pseudotumour formation after THR, the strongest predicting factor for pseudotumour presence is pain, although pseudotumours are recognized in asymptomatic patients (9, 22, 24). Metallosis and pseudotumour formation has also been recognized to arise in human patients after polyethylene-liner wear results in metal-on-metal contact in THR, as was reported in the present case study (26).

While local metallosis resulting from metal and polyethylene wear debris has been reported in association with loosening of MoP THR in a dog, the prevalence of this condition in dogs with MoP THR is unknown (27). The development of cement granuloma associated with cemented total hip replacement has also been previously reported in dogs (29). The prevalence of pseudotumour formation in dogs with THR is also unknown; to the author's knowledge, this is the first report of metallosis with pseudotumour formation in the veterinary literature. In human THR patients, pseudotumour formation more commonly occurs in close proximity to the associated implant, while distant pseudotumour formation is considered rare (15). Similar to the case described in this report, intrapelvic pseudotumour formation in humans results from wear of the acetabular component of the total hip replacement system with defects in the medial wall of the acetabulum. In human patients, the pseudotumour generally extends to the pelvic cavity in association with the iliopsoas fascia, eventually forming a caudal abdominal mass within the pelvic cavity (12–15, 28, 30–31). The path of debris resulting in the pseudotumour described in the present case is not known, as computed tomography was not performed prior to pseudotumour removal. Due to the finding of a cyst-like structure between the muscle bellies surrounding the total hip arthroplasty, the authors suspect that the pseudotumour extended into the abdominal cavity in a similar manner to that described in the human literature.

Radiographs obtained prior to presentation to our teaching hospital indicated a severe degree of implant wear, although this abnormality was initially unappreciated. This lack of recognition highlights the need for careful assessment of the surgical implant configuration in addition to surgical implant stability, particularly in cases of dogs that are presented with

lameness of a limb that have previously undergone THR. Two view 90-degree oblique radiographs should be obtained and carefully assessed for any evidence of implant wear such as thinning of the polyethylene acetabular cup.

Interestingly, histopathology of the pseudotumour recovered from this patient did not exhibit birefringent debris, indicative of polyethylene wear. In contrast, the tissue samples collected from around the implant at the time of explant surgery did display birefringent debris. The authors suspect that this discrepancy is reflective of the nearer implant proximity from which tissue displaying birefringence was collected. It is also possible that birefringent material was present in the pseudotumour but not seen on histopathologic evaluation, despite the evaluation of serial, multidirectional tissue sections.

Colbalt and chromium blood ion levels do not appear to associate with the presence of pseudotumour formation in human patients (9). However, health risks are related to chronically elevated blood cobalt concentrations in human beings, including hypothyroidism, polyneuropathy, and cardiomyopathy (32). Measurement of cobalt and chromium levels should be considered in dogs with THR that develop the aforementioned conditions. Serum and urine titanium levels were not obtained in this case, but should be considered for dogs with suspected metallosis associated with titanium-containing implants.

In conclusion, metallosis and pseudotumour formation should be considered as a differential for hip pain in dogs with a THR implant, particularly in cases with radiographic evidence of severe implant wear, resulting in metal-on-metal contact. Additionally, the authors suggest that in cases of dogs with a history of THR presenting with a caudal abdominal mass, evaluation of implants should be undertaken.

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Figure 1.

Pre- and postoperative radiographs of the right coxofemoral joint. **A)** A cranial-caudal extended leg view of the pelvis and coxofemoral joints prior to total hip replacement (THR). The patient was diagnosed with avascular necrosis of the femoral head affecting the right coxofemoral joint. **B)** A lateral and **C)** ventral dorsal frog-leg view immediately after THR using the cementless BFX implants^a. The femoral head is appropriately seated within the acetabular cup. Note the uniform halo resulting from the polyethylene insert surrounding the metallic head.

Figure 2.

A ventral-dorsal radiograph of the pelvis obtained seven years after total hip replacement surgery, illustrating acetabular implant wear, reflected by slight asymmetry of the relationship between the femoral head prosthesis within the acetabular cup. Black lines have been placed in the inserted magnified view of the acetabular implant to highlight this asymmetry.

Figure 3.

Histopathology of abdominal pseudotumor with metallic debris. **A)** Abundant, black, crystalline, non-melanin, non-haemosiderin pigment that is non-birefringent when viewed with polarized light can be appreciated. The material was surrounded by fibroplasia, macrophages which contained similar pigment, plasma cells, lymphocytes and associated skeletal muscle. **B)** A magnified view highlighting metallic debris (arrows). Scale bars = 50 μm.

Figure 4.

Re-examination radiographs of the right coxofemoral implant obtained nine years after total hip replacement. **A)** The ventral dorsal projection reveals slight asymmetry in the position of the femoral head prosthesis within the acetabular cup. Black lines have been placed in the inserted magnified view of the acetabular implant to highlight this asymmetry. **B)** The lateral projection reveals severe thinning of the acetabular cup, as highlighted by the black arrow.

Figure 5.

Radiographs of the pelvis obtained prior to implant removal, nine years after total hip replacement. **A)** Ventral dorsal and **B)** lateral radiographic projections illustrate the severe acetabular implant wear. The radiographic halo normally present around the metal component of the acetabular implant, reflective of the polyethylene liner, is no longer present on the medial and cranial portions of the acetabular cup, resulting in the femoral head component being in direct contact with the metallic portion of the acetabular cup.

Figure 6.

Transverse computer tomography images illustrating implant debris in the region of the implants prior to removal. **A)** A transverse section through the pelvis illustrating a focal ill-defined heterogeneous region (star) cranial to the right acetabulum. Streaking artefact from the coxofemoral implants can be seen. **B)** A transverse plane of the pelvis showing a similar focal ill-defined heterogeneous region (star) directly lateral to the caudal aspect of the right ilium.

Figure 7.

An intra-operative view of a discrete tract of metallic debris found interposed between the middle and deep gluteal muscles extended from the dorsal aspect of the acetabulum into the pelvic canal. *Deep gluteal muscle belly. Cranial is to the right, caudal is to the left.

Figure 8.

Images of the acetabular components and femoral head after implant removal illustrate the severity of implant wear, including erosion of the metallic portion of the acetabular cup. **A)** The complete full-thickness wear of the medial aspect of the acetabular polyethylene and metal portions of the cup is shown. The femoral head is also shown to illustrate a lack of wear on the femoral component of the implant. **B)** The polyethylene cup component was completely eroded on the dorsal and medial aspect. The femoral head is shown seated within the remaining polyethylene cup. **C)** A view of the metallic portion of the acetabular component. The erosion of the implant resulting from contact with the femoral head is seen on the medial and dorsal aspect of the cup. Inserted is the medial aspect of a new acetabular cup with non-eroded polyethylene lining. *Denotes dorsal aspect of the implant.

Figure 9.

Ventral dorsal radiographs of the pelvis obtained **A)** immediately after surgery for explant removal and **B)** nine weeks postoperatively. A femoral fracture occurred at the time of femoral explantation, which was stabilized with a 10-hole limited contact dynamic compression plate and two cerclage wires. Amikacin-impregnated plaster of Paris beads were placed in the surgical site prior to closure.