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IMAGING DIAGNOSIS

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Radiographic and CT features of metallosis in a lame dog after total hip replacement: the cloud sign

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Abstract

A 2-year-old female American Akita was referred for CT of the pelvis and hindlimbs due to a left hindlimb lameness after a left total hip replacement. Referral radiographs and CT images demonstrated amorphous soft-tissue and mineral opacities surrounding the proximal femur and the prosthetic stem, consistent with the "cloud sign" reported as a characteristic of metallosis in humans. Dorsomedial displacement of the prosthetic head, multiple foci of geographic osteolysis alongside the "cloud sign", presumed pseudotumor lesions, and medial iliac lymphadenopathy were also identified with CT. Metallosis was confirmed based on ultrasound-guided cytology, revision surgery, and histopathology.

KEYWORDS
bubble sign, hip dysplasia, postoperative complication

1 | SIGNALMENT, HISTORY, AND CLINICAL FINDINGS

A 2-year-old female, American Akita, weighing 28,3 kg, was referred to the Small Animal Veterinary Hospital of the University of Milan for CT of the hindlimbs due to a chronic, grade-3 left hindlimb lameness. The patient presented with a history of right double pelvic osteotomy, a left cementless total hip replacement (THR), and a left tibial plateau leveling osteotomy (TPLO) performed in another Institution a year before. Biochemistry showed a mild increase of the alanine aminotransferase, whereas hematology analyses were within normal limits. Radiographic views of the pelvis were performed by the referring surgeon (ventrodorsal extended and frog-leg, mediolateral view of the left femur). The radiographic examination showed irregular periosteal reaction and osteolysis of the left greater trochanter with displacement of the corresponding head, indicative of a failure of the implant (Figure 1A).[1] Amorphous soft-tissue and mineral opacities surrounding the proximal femur and the prosthetic stem were also detected, resembling the "cloud sign" compatible with metallosis in human medicine (Figure 1B, C).[2] Based on clinical findings and radiography, the primary differential diagnoses were osteomyelitis, implant failure, and metallosis. Implant-associated neoplasia was considered less likely. The CT examination was requested to confirm the radiographic findings and further assess the stability of the prosthetic implant.

2 | IMAGING FINDINGS, DIAGNOSIS, AND OUTCOMES

Computed tomography of the pelvis and hindlimbs was performed with the patient in sternal recumbency and the hips neutrally positioned, using a multidetector 16-slice CT scanner (Lightspeed, GE

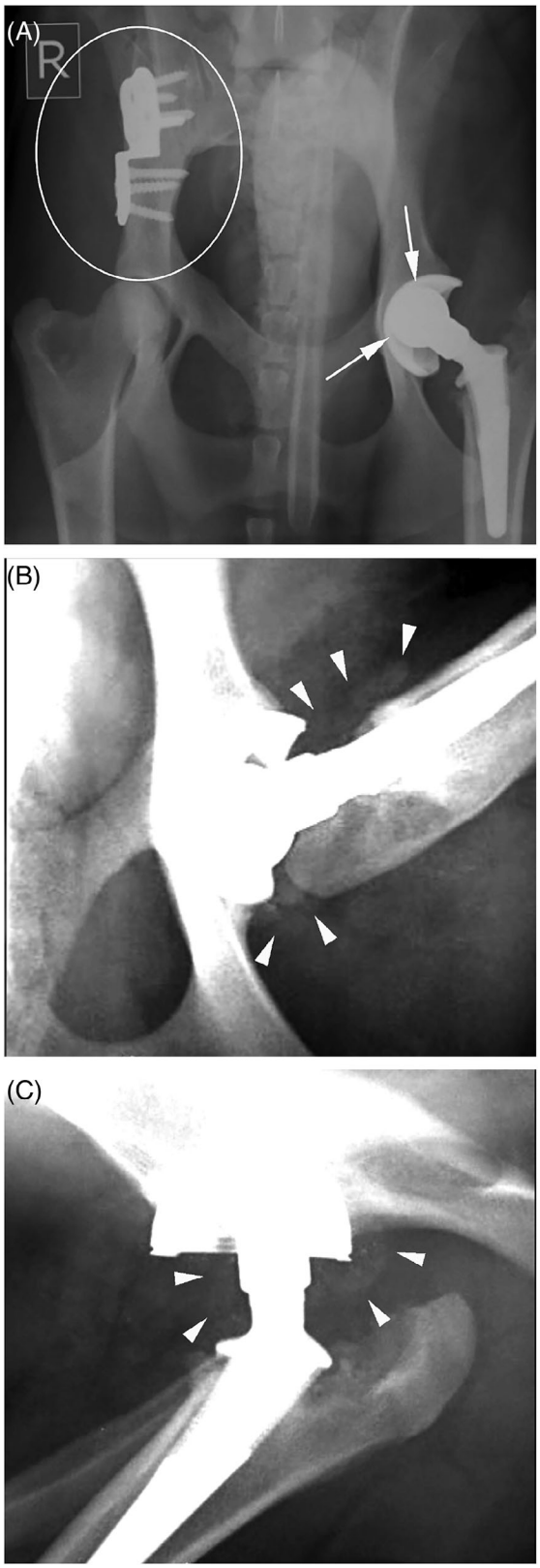

FIGURE 1 Radiographic images of the pelvis. A, Ventrodorsal extended view shows DPO (double pelvic osteotomy) plates (white circle) on the right ilium, asymmetrical position of the femoral head prosthesis within the acetabular cup (long arrows). B, C, Ventrodorsal frog-leg and mediolateral views magnified on the left hip joint showing the amorphous mineral opacities surrounding the prosthetic implant and hip joint, consistent with the "cloud sign" (white arrowheads).

Healthcare), on helical scan mode (parameters: pitch of 1, 120 kVp, 200 mAs, 1.25 mm slice thickness). Postcontrast CT was performed 45 s after administration of 600 mg Iodine/kg of Iodixanol (Visipaque 320 mg/mL, GE Healthcare) through a cephalic venous angio-catheter, using a power injector (Medrad Mark V Plus, Bayer). Precontrast images were reconstructed using soft tissue and bone algorithms and postcontrast images were reconstructed using a soft tissue algorithm.

The CT study confirmed moderate luxation of the prosthetic head (Figure 2A) concurrent with multiple foci of geographic osteolysis (Figure 2B) and irregular periosteal reaction of the greater trochanter. Multiple amorphous mineral-to-metal attenuating foci (821 HU mean) consistent with "the cloud sign" were diffusely distributed in the peri-prosthetic soft tissues (Figure 2C, D).[3] A tubular-shaped, poorly marginated, mixed soft-tissue/fluid attenuating mass containing multiple foci of amorphous mineralization was observed extending in a caudolateral direction between the biceps femoris and adductor muscles (Figure 3A). The medial iliac lymph nodes were homogeneously hyperattenuating (212 HU mean; Figure 3B). Differential diagnoses based on CT findings were osteomyelitis, implant failure, pseudotumor lesions, medial iliac lymphadenopathy, and metallosis.[4–6]

After CT examination, ultrasound-guided fine-needle aspiration of the presumed pseudotumor lesion was performed with a microconvex electronic probe at 8 MHz on B-Mode with a transducer perpendicular to the lesion in a longitudinal plane (CA123, MyLabAlpha, Esaote) and a 22G-1½ inch long needle. The patient was positioned in sternal recumbency with the hindlegs extended caudally, the region of the biceps femoris muscle was shaved and prepared with alcohol and coupling gel. The material collected appeared macroscopically as black fluid, odorless, and with low viscosity. Cytologic findings included abundant black granular material with poor cellularity, rare well-preserved neutrophils, and macrophages, compatible with granulomatous "pseudotumor" inflammation.[7,8] These findings were interpreted to be consistent with metallosis.[9,10]

The patient underwent surgical revision and findings confirmed the presence of metallic debris within the soft tissue surrounding the implant (Figure 4A). The titanium cup appeared perforated by the cobalt-chrome head with the complete destruction of the highly cross-linked polyethylene insert (Figure 4B). A left hind prosthetic implant replacement was performed and bone, articular, and periarticular tissue samples were submitted for histopathology. Histopathologic diagnoses were granulomatous inflammation along with abundant presence of black amorphous material consistent with metal deposits, indicative of metallosis.[9,10]

At 1-month postoperatively, the implant appeared securely positioned and well-integrated. However, soft tissue swelling caudal to the proximal femur was still present and appeared larger compared with the preoperative exam. At the 20-months follow-up, the limb function was considered poor despite the normal appearance of the implant. The swelling of the proximal femur appeared progressively larger and therefore revision surgery was performed to remove the proliferative soft tissue. Chronic granulomatous inflammation from exogenous foreign body material, still consistent with metallosis, was

FIGURE 2 Transverse precontrast CT images of the pelvis and hindlimbs with bone algorithm (A, B), soft tissue algorithm (C), and B/W inverse color lookup table postprocessing (D). Display settings were A, B: WL 600, WW 3000; C, D: WL 158, WW 357. A, Dorsomedial displacement of the femoral head prosthesis (white arrows). B, Geographic osteolysis (white arrows) at the level of the left greater trochanter. C, D, "Cloud sign" surrounding the prosthetic head (white arrowheads).

confirmed on histopathology.[9,10] At 1-year follow-up, the limb function was markedly improved with intermittent grade-1 lameness.

3 | DISCUSSION

This case report described radiographic and CT characteristics consistent with a "cloud sign" in a dog with confirmed THR prosthetic implant failure and metallosis. Based on the authors' review of the literature, only a few case reports about metallosis were found and none of them provided specific imaging features.[9–11] Metallosis represents the accumulation of metallic debris within the peri-prosthetic tissues and can be responsible for pain and joint effusion.[9–12] Several factors have been concurrent with the presence of metallosis: (1) using undersized implants, (2) increased hindlimb bearing due to disease affecting the contralateral limb, and (3) oxidation of the polyethylene.[11] In human medicine, a diagnostic imaging workup is considered to be crucial for detecting and planning treatment for implant-related diseases, particularly in hip arthroplasty cases.[11] This evaluation commonly includes postsurgical radiographs to assess implant positioning, bone alignment, and opacity.[13] In the current case, the "cloud sign" most likely resulted from the fusion of polyethylene wear particles and titanium debris within the reactive soft tissue.[2]

The CT finding of medial iliac lymph node hyperattenuation was likely due to lymphatic migration of metallic debris from the implant elements, as previously reported.[14] Computed tomography was also useful for the detection of the left thigh intermuscular mass adjacent to the prosthetic implant. In human medicine, this lesion is often described as a "pseudotumor", that is, a benign granulomatous or cystic complication concurrent with metallosis after total hip replacement and commonly incidental.[7,8,12] Malignant masses in the periprosthetic region are extremely rare, whereas benign lesions concurrent with hip replacement are common and compatible with seroma or hematoma formation.[4] A hematoma usually appears as a heterogeneous, multilocular lesion; with or without fluid level patterns. A seroma usually appears as a homogenous, fluid-attenuating collection. Neither hematoma nor seroma usually show extensive areas of mineralization or contrast enhancement. Pseudotumors usually show heterogeneous soft tissue attenuation, hypoattenuating center, multiple amorphous mineral attenuating areas (erratic internal metal

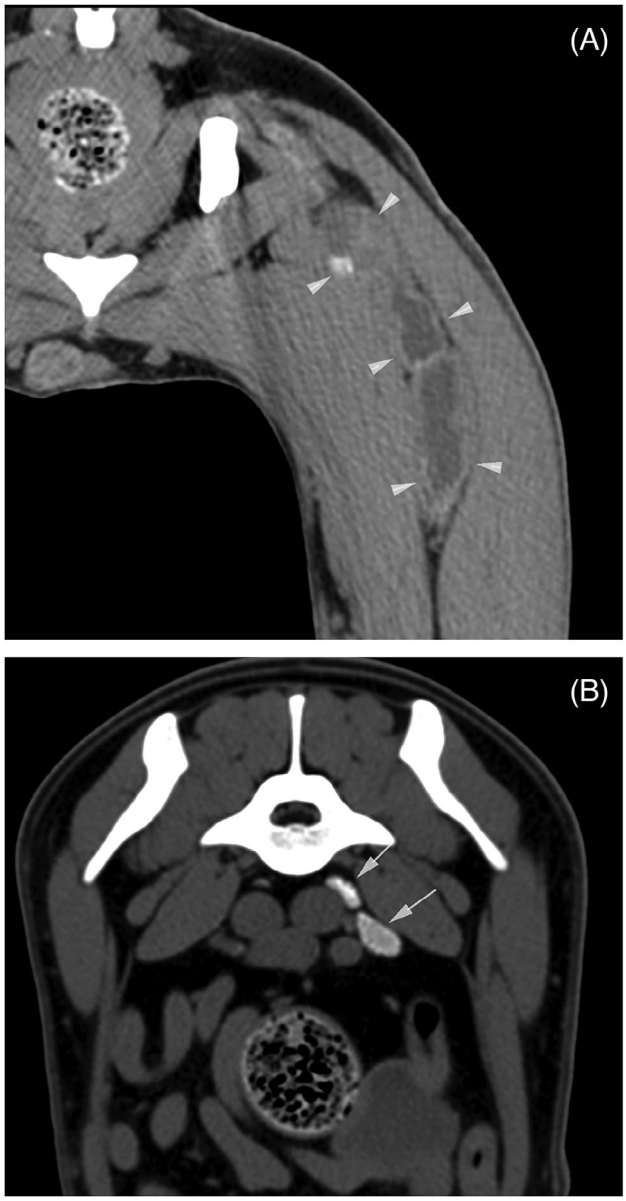

FIGURE 3 Transverse precontrast CT images with soft tissue algorithm of the pelvis and hindlimbs (A: WL 40, WW 350; B: WL 224, WW 747). A, Tubular shaped, mixed soft tissue/fluid attenuating and partially mineralized mass between biceps femoris and adductor muscles (white arrow), consistent with "pseudotumor". B, Homogenous hyperattenuation of the left medial iliac lymph nodes (white arrowheads).

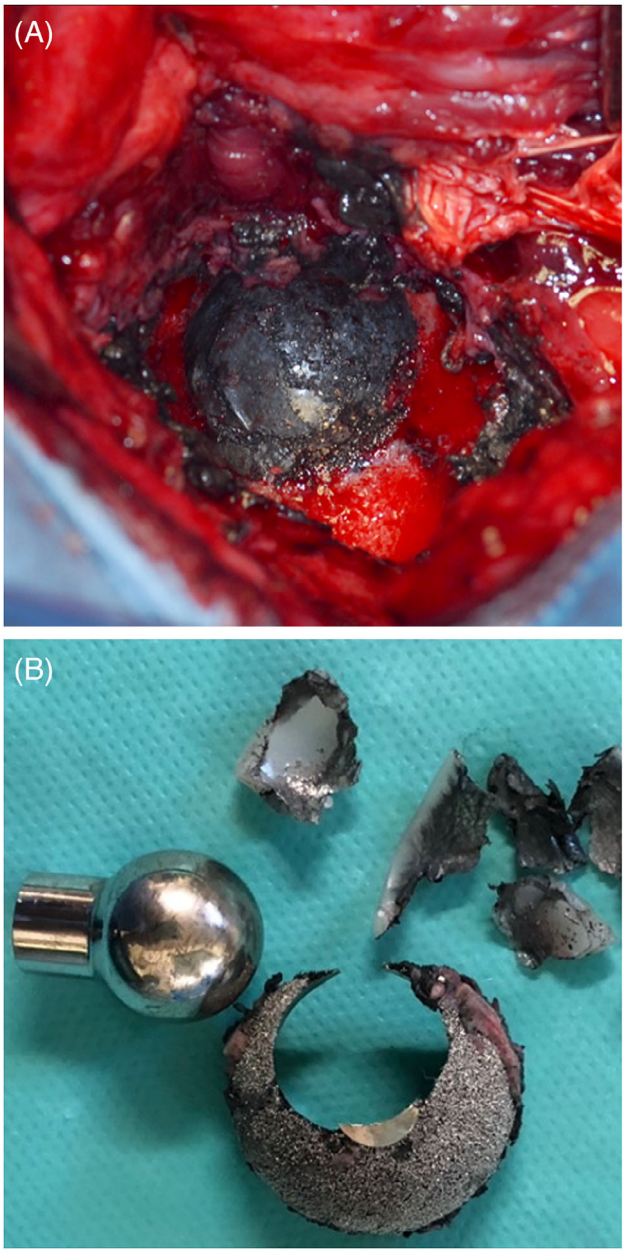

FIGURE 4 Intraoperative and postsurgical photographs. A, Black material and fibrous tissue around the acetabulum. B, Broken acetabular cup after removal.

fragments), and paucity of contrast enhancement (as in the present case).[5,6]

Considering the presence of osteolysis primarily visible at the greater trochanter, other less likely differential diagnoses were also considered. Osteosarcoma, one of the most common primary bone tumors in dogs, can occur anywhere in the skeletal system.[15,16] In a reported case of a dog with osteosarcoma after THR,[17] the femoral findings were more aggressive, with marked medullary/cortical osteolysis and aggressive periosteal reaction. Conversely, no histopathological features of implant-related neoplasia were detected in our patient. As in human literature, some reports describe the presence of osteolytic changes concurrent with metallosis, which induces a foreign-body inflammatory reaction leading to chronic synovitis and osteoclastic bone resorption, causing progressive periprosthetic osteolysis.[18,19] The authors speculate that the long-term and incomplete final recovery from left hindlimb lameness in this patient may have been due to multiple factors, such as the previously performed TPLO, the implant failure of the THR, and the metallosis. Indeed, metallosis was considered the major cause of the lameness based on the clinical improvement after revision surgery.

In conclusion, "cloud sign" and "pseudotumor" CT characteristics previously reported in humans with metallosis were identified and

described in this report of a dog with histologically confirmed metallosis secondary to THR implant failure.

LIST OF AUTHOR CONTRIBUTIONS

Category 1

(a) Conception and design: Lucaci, Battiato, Bassi, Longo

(b) Acquisition of data: Lucaci, Battiato, Bassi, Longo

(c) Analysis and interpretation of data: Lucaci, Battiato, Bassi, Zani, De Zani, Vezzoni, Stranieri, Longo

Category 2

(a) Drafting the article: Lucaci, Battiato, Bassi, Longo

(b) Revising article for intellectual content: Lucaci, Battiato, Bassi, Zani, De Zani, Vezzoni, Stranieri, Longo

Category 3

(a) Final approval of the completed article: Lucaci, Battiato, Bassi, Zani, De Zani, Vezzoni, Stranieri, Longo

Category 4

(a) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Lucaci, Battiato, Bassi, Zani, De Zani, Vezzoni, Stranieri, Longo

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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