

Metallosis and Pseudotumor After Failed ORIF of a Humeral Fracture

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Abstract

Metallosis following open reduction and internal fixation (ORIF) for fracture, usually presenting as a soft tissue mass, is barely discussed in the literature. In this case report, the imaging and pathological findings of metallosis after ORIF for a humeral fracture are presented and comprehensively discussed.

Metallosis is a well described entity, most commonly occurring after arthroplasty of the hip, knee, and shoulder.¹⁻³ The etiology of metallosis is considered to be abnormal contact between metallic surfaces that results in the shedding of metallic particles.^{2,4} These metallic fragments become engulfed by histiocytes that then release inflammatory mediators, which, in turn, activate osteoclasts, resulting in bone resorption.^{1,5} We report the radiological and pathological findings in a case of metallosis after open reduction and internal fixation (ORIF) of a humeral fracture.

Case Report

A 70-year-old female presented with a 6-month history of an enlarging, painful mass and swelling in the right arm, occurring 7-years post-ORIF for a benign posttraumatic humeral fracture; she denied recent trauma or fever. Radiographs demonstrated a hardware failure with atrophic nonunion and displacement of the fracture margins. Both linear as well as focal mass-like osteolysis was present. Fixation screws were displaced, and there was backing-out of the

fixation plate (Fig. 1). Magnetic resonance imaging (MRI) displayed a well-circumscribed 13.9 x 8.6 x 9.8 cm mass in the lateral mid-arm. T1 spin-echo sequences demonstrated homogeneous signal, hypointense to isointense relative to muscle, and T2 spin-echo sequences demonstrated heterogeneous signal, with marked hyperintense T2 signal and large confluent, nodular moderate-to-marked hypointense signal, similar to muscle signal. Post-contrast T1 spin-echo sequences revealed predominantly mild linear peripheral enhancement and mild linear septal enhancement. The mass extended to the bone surface (Fig. 2). Excision was performed to rule out sarcoma.

At surgical exploration, a soft friable mass was encountered; notably, it was not stained black. Pathological evaluation revealed grey-tan, soft, partially necrotic tissue, weighing 52 gm and measuring 6 x 6 x 2 cm. Histological evaluation demonstrated granulation tissue with focal necrosis and dystrophic calcification, multinucleated giant cells, old hemorrhagic products, reactive histiocytosis at the periphery, and rare black angulated metallic fragments (Fig. 3). There was no evidence of neoplasm, and special stains for acid fast bacilli and fungi were negative.

Discussion

The most common radiographic finding in metallosis is osteolysis, which our case demonstrated.² The “bubble sign” and “metal line” sign are less common findings. The bubble sign is visualization of metal outlining the joint.⁶ This sign was not observed in our case, since no joint space was involved. The metal line sign, which is a radiopacity secondary to direct visualization of the metallic debris,⁷ also was not seen in our case.

To our knowledge, this is the first report of MRI findings in metallosis after ORIF. The MRI findings in metallosis after arthroplasty are varied in a few reported cases. One report describes osteolysis after total hip arthroplasty (THA), with

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Figure 1 Oblique radiograph demonstrating nonunion (short, thick white arrow), mass-like osteolysis (long, thin black arrows), and displacement of screws (short, thick black arrows).

a mass-like lesion in the iliopsoas pseudobursa, consisting of a fluid-like signal that is hypointense on T1 and hyperintense on T2 imaging, with thick low-signal septations, similar to our case.⁸ However, the investigators describe susceptibility artifact in the periphery of the lesion, as well as within the septa, on T2 spin-echo imaging, corresponding to metallic debris seen on computed tomography (CT); this was not seen in our case. Minimal peripheral enhancement was seen in their case, as in ours. An additional article reported two cases of a cystic groin mass without the radiological sign of loosening.⁹ In one of these cases, T1 imaging showed a heterogeneous appearance, moderately hyperintense relative to muscle, and T2 imaging demonstrated a lamellated appearance, with high signal intensity at the periphery; in the second case, T1 imaging demonstrated moderate hyperintensity relative to muscle centrally and comparative increased signal peripherally; T2 imaging demonstrated hyperintense signal. No significant contrast enhancement was seen. Our case differed in T1 and T2 signal characteristics. In another published series of 20 patients who developed pseudotumors, status post-arthroplasty, only one demonstrated metallosis. The investigators reported isointense T1 signal in 19 of 20

patients and hyperintense T2 signal, with a low T2 signal periphery, in 18 of 20 patients.¹⁰ Of note is that the hypointense T2 signal in their series was confined to the periphery, while hypointense T2 signal was seen throughout the lesion in our case, which may be a helpful feature to distinguish metallosis from other pseudotumors. Gradient echo imaging was not reported in the previous studies. In our case, T2* gradient echo sequence demonstrated several small hypointense foci without corresponding T2 hypointensity, presumably representing blooming due to metallic or calcific debris; however, this was not a prominent feature. Also of note is that in 18 of the 20 patients, the lesions were closely associated with the femoral prosthesis, similar to our case, so this sign, in isolation, is not a differentiating feature of metallosis from other pseudotumors.

Histological findings are varied with metallosis. In a study of 31 cases of metallosis occurring after arthroplasty, published by Chang and colleagues,² histology demonstrated an intense and diffuse histiocytic reaction throughout the joint capsule, on both the femoral and acetabular articular surfaces. In a case of metallosis within the iliopsoas bursa, a histiocytic infiltration of thickened synovium was seen, with abundant intracellular metallic debris present.⁸ In two cases of cystic masses that were secondary to metallosis, histology revealed diffuse or sometimes nodular dense lymphocyte infiltration, mostly around small venous blood vessels, rare plasma cells, and many macrophages with phagocytosed metal particles.⁹ They reported that the tissue displayed a “cystic appearance, an irregular surface, and deep crypts,” as well as that “parts of the surface were covered with fibrinoid-necrotic masses, the necrosis and lymphocyte infiltration in some areas reached the neighboring fatty and muscle tissue, [and] the wall of the cyst was thickened and fibrotic,” and, finally, that the tissue demonstrated “numerous mast cells and hypertrophic endothelial cells of the small vessels.” In another case of metallosis after knee arthroplasty with metal-on-metal impingement in a substitutive long-stemmed knee prosthesis, histology demonstrated numerous histiocytes with a large amount of dark pigment, multinucleated giant cells, abundant fibrosis and fibroblastic reaction, abundant metallic debris, and necrosis,¹¹ which is strikingly similar to our case. The article reported that every histiocyte contained visible particles, which was not seen in our case; MRI findings were not available in this case report. In another study of 15 patients undergoing revision arthroplasty after demonstrating soft tissue abnormalities on MRI, all patients demonstrated fibrinous tissue, 12 displayed necrosis, five showed perivascular lymphocytes, and three had granulomas; however, only one patient demonstrated metallosis.¹⁰ Dystrophic calcifications seen in our case has not, to our knowledge, been reported with metallosis.

The development of metallosis with mass-like osteolysis, as well as nonunion, after ORIF is unusual. There is one report of metallosis associated with humeral hypertrophic nonunion after titanium flexible intramedullary nail insertion.¹²

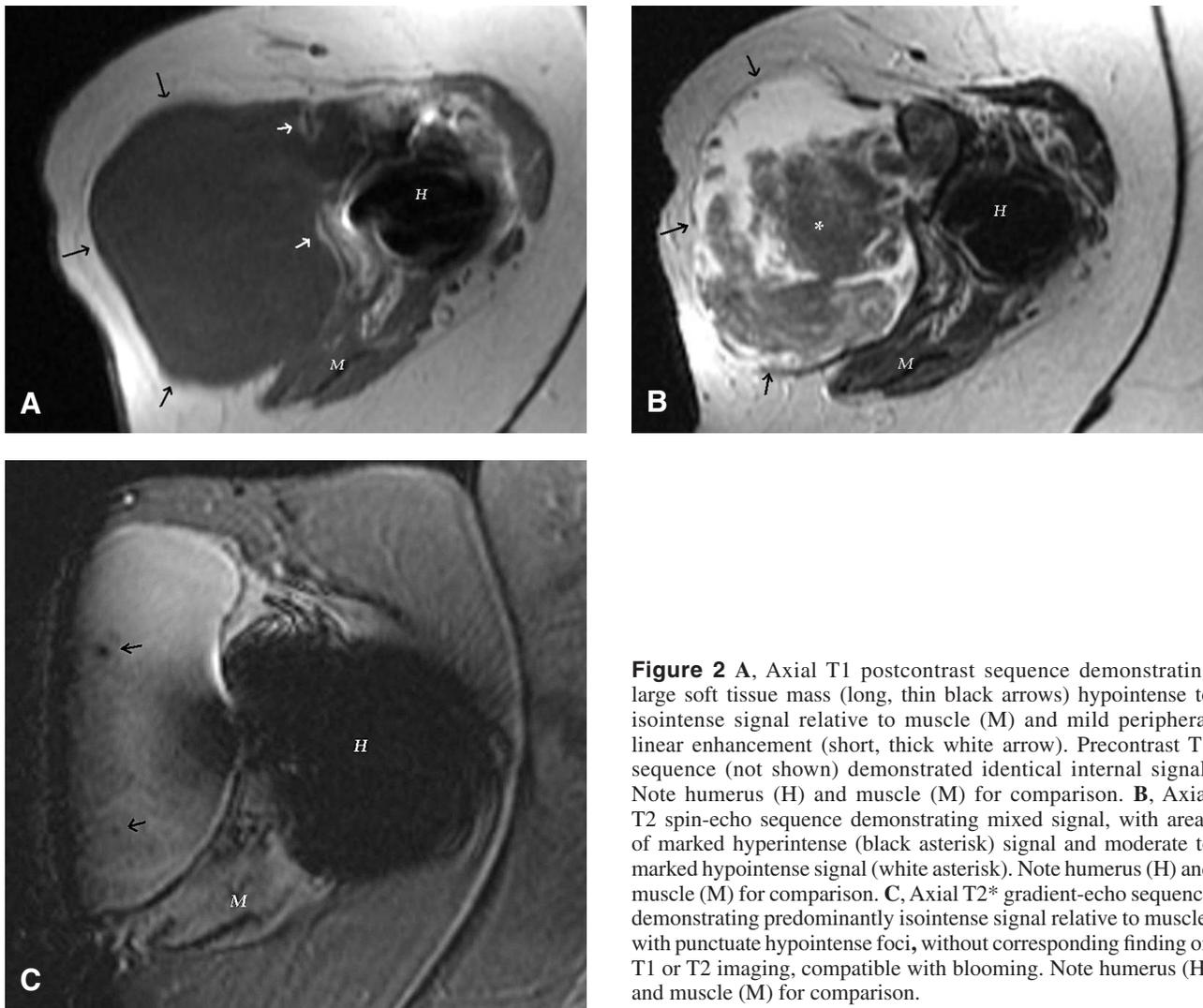


Figure 2 **A**, Axial T1 postcontrast sequence demonstrating large soft tissue mass (long, thin black arrows) hypointense to isointense signal relative to muscle (M) and mild peripheral linear enhancement (short, thick white arrow). Precontrast T1 sequence (not shown) demonstrated identical internal signal. Note humerus (H) and muscle (M) for comparison. **B**, Axial T2 spin-echo sequence demonstrating mixed signal, with areas of marked hyperintense (black asterisk) signal and moderate to marked hypointense signal (white asterisk). Note humerus (H) and muscle (M) for comparison. **C**, Axial T2* gradient-echo sequence demonstrating predominantly isointense signal relative to muscle, with punctuate hypointense foci, without corresponding finding on T1 or T2 imaging, compatible with blooming. Note humerus (H) and muscle (M) for comparison.

In this case, there was extensive loss of the anodization at the level of the nonunion and wear of several consecutive segmental articulations at the same level, with a crack extending into one of the segments. Unlike in our case, there was no focal mass-like osteolysis at the fracture site, and there was no soft tissue mass. There is a single study in the literature of 27 patients, status post-ORIF, with a three-piece stainless-steel modular femoral intramedullary nail, who developed metallosis associated with focal osteolysis as large as 5 mm at the taper junctions.¹³ In this series, there was no report of nonunion and no soft tissue mass. Kang and Stern question the chronology of events in metallosis and nonunion:¹² Does motion lead to particulate debris, which is responsible for metallosis and also osteolysis, that subsequently results in nonunion, or does nonunion allow persistent motion, which leads to the generation of particulate debris that causes the metallosis [and osteolysis]? From the last mentioned two reports, it would seem that either mechanism can occur.

It is interesting to note that in the series by Jones and coworkers,¹³ they posit that the junctions between plates

and screws are small, extracortical, and away from the bone, and are, therefore, unlikely to result in corrosion products in large enough quantity to cause extensive osteolysis. The Kang and Stern case, as well as our case, demonstrate otherwise, although their theory may explain why osteolysis is significantly less common after ORIF than after arthroplasty. It is also interesting to note that in a series of 31 patients with metallosis after arthroplasty, one of the cases was reportedly due to the screw used for femoral stem fixation. The mechanism for metallic debris in this patient was not discussed in the report but is presumably due to motion, similar to our case.²

The association of a soft tissue mass with osteolysis after arthroplasty has been previously reported in a study of 30 patients.¹⁴ Several of the cases demonstrated a soft tissue mass as an extramedullary extension of intramedullary osteolysis, which displaced surrounding structures. However, in this study, metallosis was observed in only eight of the cases, and investigators did not specify whether any of the cases with metallosis also demonstrated a soft tissue

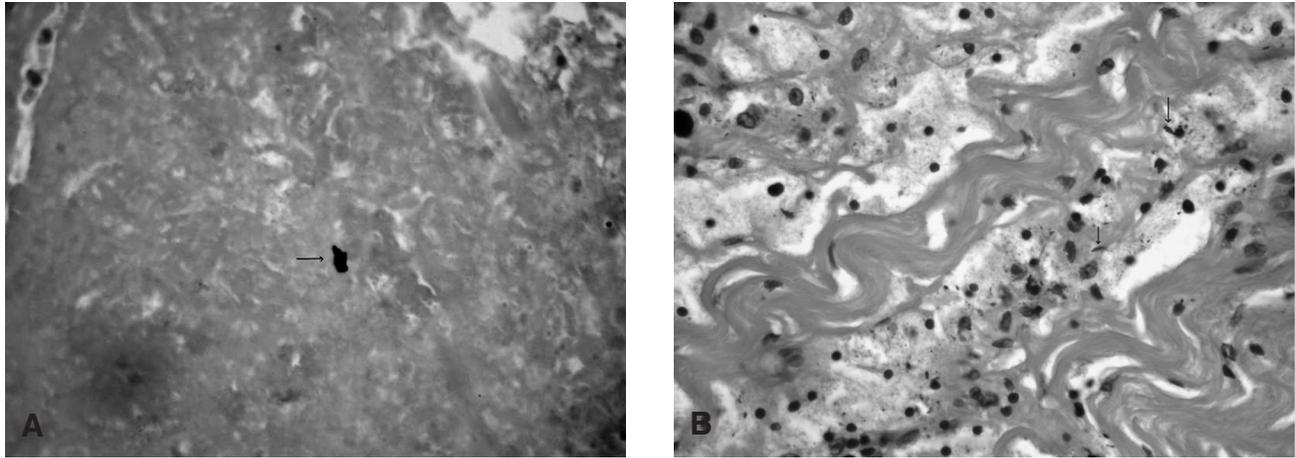


Figure 3 **A**, Photomicrograph (hematoxylin and eosin, X600 magnification) of the resected specimen shows necrotic tissue with black angulated metal fragment (black arrow). **B**, Photomicrograph (hematoxylin and eosin, X400 magnification) of the resected specimen shows infiltration of foamy macrophages with intracellular black metallic debris (black arrows).

mass. MR imaging was not performed in this series.

Conclusion

We present this unique case to emphasize the association of metallosis with a failed ORIF procedure and the development of a pseudotumor. While MRI features of the pseudotumor mass can vary, metallosis should be considered in the differential diagnosis when the following imaging findings are present: 1. mixed, marked hyperintense and extensive moderate to marked hypointense T2 signal, similar to muscle; 2. thin peripheral or septal enhancement; and 3. extension of the mass to the surface of the involved bone.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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