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Metallosis, a Rare Long-Term Complication in a Total Hip Arthroplasty: A Case Report and Literature Review

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Abstract **Case Report**

Metallosis and metal-induced synovitis are well-documented complications associated with metal-backed polyethylene joint prostheses, extensively covered in orthopedic surgery literature. However, the radiological aspects of these complications are less frequently discussed in the literature. There is growing recognition of local and systemic adverse events associated with the release of metal ions and nanoparticles from hip arthroplasty components. Adverse local tissue reactions to metal ion debris can manifest as periprosthetic solid and cystic masses, termed pseudotumors. These pseudotumors can cause pain, swelling, extensive destruction of surrounding hip soft tissues, and compression syndromes affecting neurovascular, gastrointestinal, and genitourinary structures. We present the case of a 50-year-old patient with a history of end-stage chronic renal failure on hemodialysis, who underwent a total left hip arthroplasty 20 years ago. The patient developed a progressively enlarging mass in the left hip, which evolved to include loss of function and increasing inflammatory joint pain. A CT scan and MRI of the left hip were performed, showing radiological signs of metallosis characterized by osteolysis with amorphous increased densities in the periprothetic soft tissues. This case illustrates the importance of radiological findings in the diagnosis and management of rare complications of hip prostheses.

Keywords: Metallosis, Hip prosthesis, Arthroplasty complications, hip CT, hip MRI.

INTRODUCTION

Arthroplasty complications include various pathological conditions, with the most common being infection, periprosthetic fractures, dislocations, osteolysis, and heterotopic ossification [1, 2]. Metallosis is a rare but potentially serious complication of arthroplasty, typically associated with metal-on-metal prosthetic devices, although it has also been reported in non-metallic prostheses [3]. It is characterized by aseptic fibrosis, local necrosis, or device loosening due to metal corrosion and the release of wear debris. This condition arises from metallic erosion and the release of metallic debris, which trigger a significant local release of cytokines from inflammatory cells [4].

Despite overall good outcomes with metal-on-metal hip prostheses, some studies have described periprosthetic fluid collections and soft-tissue masses complicating metal-on-metal prostheses [5]. Many of these lesions correspond to aseptic lymphocytic vasculitis–associated lesions on histology, which are characterized by perivascular or diffuse infiltrates of lymphocytes, often with extensive tissue necrosis [6].

Conventional radiographs of patients with aseptic lymphocytic vasculitis-associated lesions usually appear normal, despite extensive soft-tissue necrosis observed during revision surgery. Ultrasound can detect periprosthetic fluid collections but is limited in identifying deep fluid collections and osseous abnormalities [7, 8]. Consequently, CT and MRI are increasingly recognized as a valuable tool for assessing hip pain in patients with metal-on-metal prostheses. MRI is the most accurate method for detecting and quantifying osteolysis and wear-induced synovitis. Additionally, MRI can evaluate periprosthetic soft-tissue collections or masses that may indicate aseptic lymphocytic vasculitis-associated lesions. Although conventional MRI is limited by susceptibility artifacts from the cobalt-chromium components of the metal-on-metal prosthesis, advanced sequences have demonstrated a reduction in artifacts and improved visualization of the surrounding soft tissues.

To illustrate the importance of radiologic findings in the diagnosis and management of these patients, we present a case of metallosis and metal-induced synovitis complicating a total hip arthroplasty. Specific attention is given to reviewing radiological signs that aid in diagnosis.

Case Report

We present the case of a 50-year-old patient with a history of end-stage chronic renal failure on hemodialysis, who underwent a total left hip arthroplasty 20 years ago. It was indicated due to a poorly treated congenital hip dislocation that was complicated by osteonecrosis of the left femoral head. The patient developed a progressively enlarging mass in the left hip, which evolved to include loss of function and increasing inflammatory joint pain.

A pelvis CT was performed and revealed bone erosions predominantly noted at the sites of capsulo-synovial insertions (the left acetabulum, iliac wing and the ramus of ischium) along with several round, fluid-density periprothetic collections surrounded by a high-density peripheral rims, which are located along the capsule of the left hip joint.

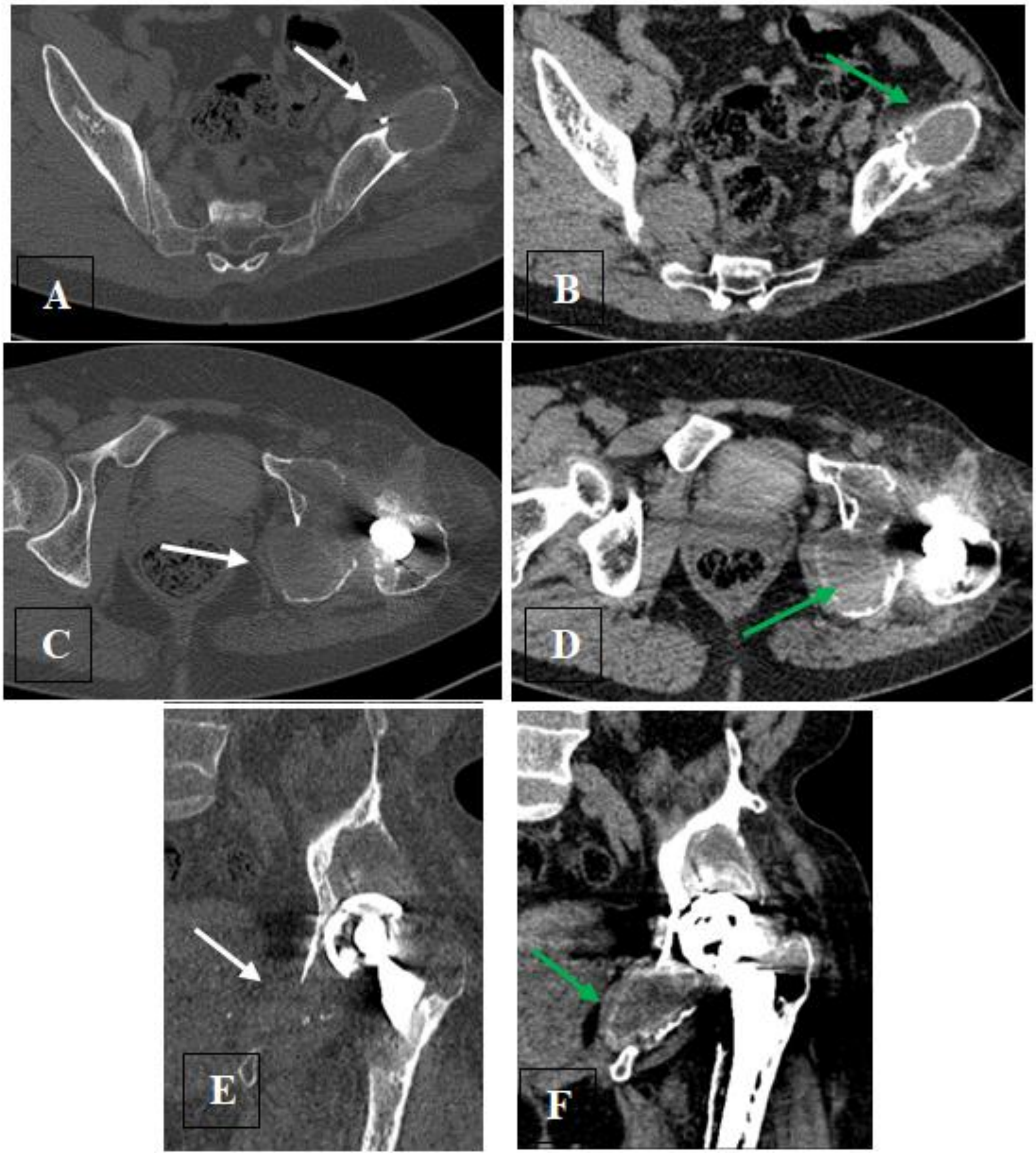

Fig-1: Axial (A,C) and coronal (E) CT images of the left hip in bone window, axial images (B,D) and coronal (F) non contast pelvic CT scan images showing a osteolysis of the left iliac wing (white arrow in A), acetabulum with a completely destroyed medial wall (white arrow in C), and the ramus of ischium (white arrow in E). This bone matrix has been replaced by several round, fluid-filled pelvic periprothetic collections surrounded by a high-density peripheral rims with the typical appearance of the « Bubble sign » (green arrows in B, D and F), which are located along the sites of capsulo-synovial insertions. Artifact from left hip prostheses is also present

A pelvic MRI showed a characteristically low-signal-intensity synovitis with solid appearing pseudotumour located along the capsule of the left hip joint along with osteolysis with susceptibility artifact from the metal debris and surrounding soft-tissu edema.

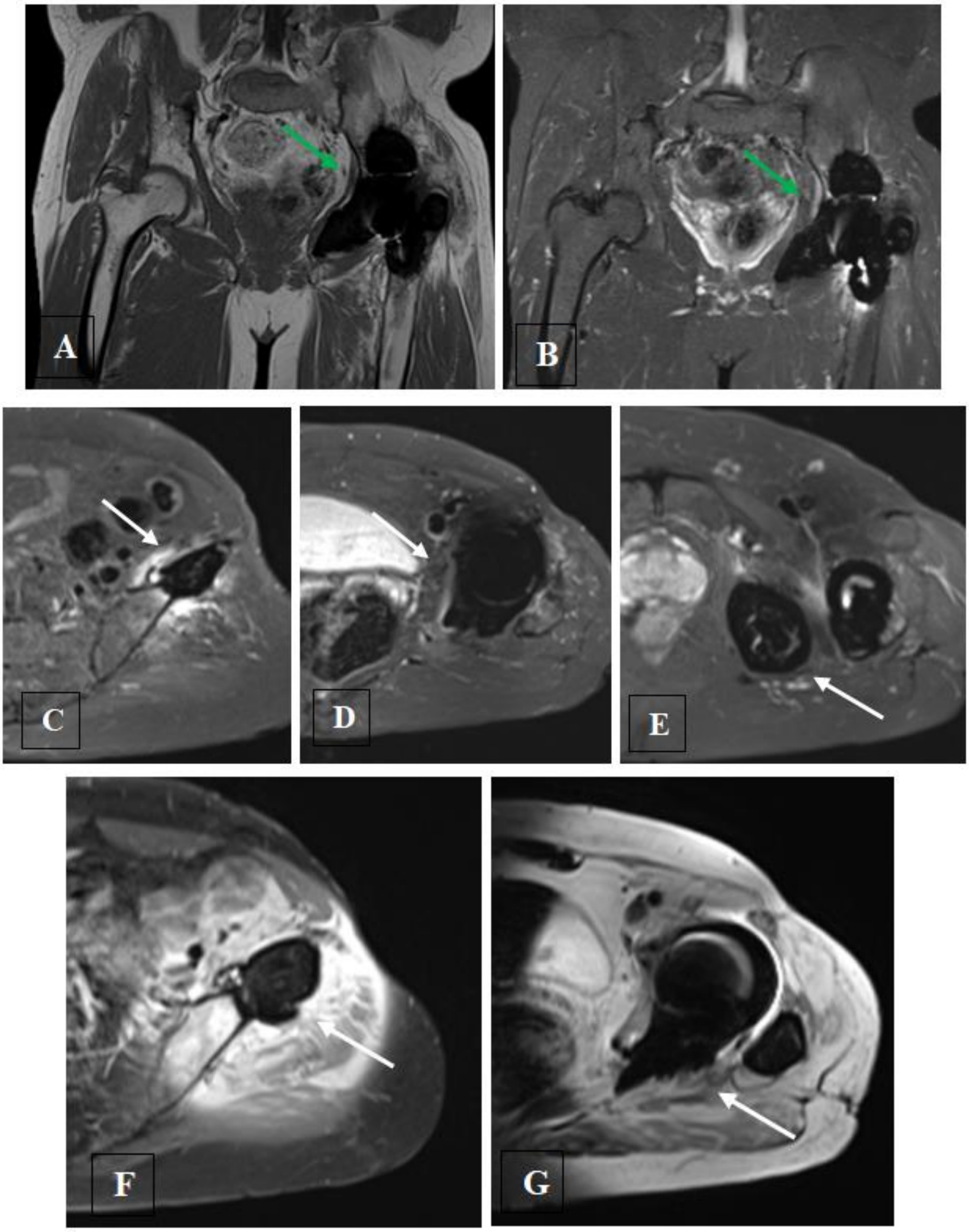

Fig-2: Coronal T1 weighted fast SE (A), coronal (B) and axial (C, D and E) T2W weighted fast SE fat suppressed MR images and axial T1W fat suppressed post-contrast images (F,G) of the left hip arthroplasty system show a low-signal-intensity synovitis with solid appearing pseudotumour (green arrows) located along the capsule of the left hip joint. There is erosion into the left iliac fossa (white arrow in C), the acetabulum (white arrow in D), and the ramus of ischium (white arrow in E) without post-contrast enhancement causing osteolysis with susceptibility artifact from the metal debris and surrounding soft-tissu edema. Artifact from left hip prostheses is also present in the axial T1W fat suppressed post-contrast images.

The diagnosis of metallosis was suspected through imaging. A CT-guided biopsy of the observed lesions was performed, and the anatomopathological study confirmed the diagnosis without any signs of malignancy.

The decision of the multidisciplinary consultation meeting indicated surgery to avoid continuous absorption of the metallic particles. It will consist of a debridement and deep cleaning of the left hip. Along with complete excision of pseudotumor, the THA components will be explanted and a revision THA will be performed. Large contained defects will be filled with cancellous allograft bone.

DISCUSSION

Adverse reactions to metal debris is a broad term encompassing various clinical presentations and histological appearances of reactions to metal-on-metal bearing surfaces. These prostheses are linked with unique adverse features, believed to stem from hypersensitivity to metallic debris, in addition to the general complications seen with other prostheses. Adverse reactions to metal debris may also occur in non metal-on-metal bearing surfaces, including metal-on-polyethylene and metal-on-ceramic, due to the release of cobalt-alloy debris from the head-neck junction or the neck-stem junction of modular systems [9-11].

Severe adverse local reactions are rare but typically become evident soon after surgery. Pseudotumor of the hip refers to a non-neoplastic, non-infected, solid, or cystic mass around the site of total hip arthroplasty (THA), which may be associated with soft tissue necrosis. The histological appearance of hypersensitivity to metal wear particles has been previously described as aseptic lymphocyte-dominated vasculitis-associated lesions. These lesions are reportedly more common in women, with a prevalence of up to 71%, depending on the patient population and specific implant type [12].

Assessment of serum cobalt and chromium ions is usually performed in the initial clinical workup of patients with painful metal-on-metal bearing surfaces. A cutoff value of 4.97 parts per billion for cobalt or chromium in whole blood samples has a reported 63% sensitivity and 86% specificity for predicting a hypersensitivity reaction or clinical failure of the prosthesis and can therefore be a useful adjunct to imaging in some patients [13].

The absence of elevated serum ion levels of cobalt and chromium does not exclude Adverse reactions to metal debris, and imaging is integral to the investigation of the painful metal-on-metal THA. Interestingly, symptoms do not appear to correlate well with the presence or size of pseudotumors, which are often seen in well-functioning prostheses [14]. Instead, the presence of associated marrow edema and tendon tears appears to correlate much more closely with postoperative pain.

Various classification systems for pseudotumors have been described. Classification may be used to distinguish simple (type 1) and complex (type 2) fluid collections from those that appear solid (type 3) as has been shown in this case. Type 1 lesions are flat with a thin wall (<3 mm), appearing of low signal intensity on T1-weighted and high signal intensity on T2-weighted imaging. Type 2a lesions demonstrate a thicker wall, while type 2b lesions additionally demonstrate high signal on T1-weighted imaging. Type 3 lesions are solid throughout and may be of any shape (Table 1). Type 3 lesions are associated with more severe symptoms and higher surgical revision rates, whereas type 1 and 2 lesions are associated with less severe symptoms and a lower revision rate [15, 16].

Table 1: Typical MR Imaging Characteristics of the Different Types of Metallosis

	MRI signal :	Wall thickness
Type 1 (simple)	Cystic lesion : - Low signal intensity on T1-weighted imaging - High signal intensity on T2-weighted imaging	Thin wall < 3mm
Type 2 (complex): Type 2a	Cystic lesion	Thicker wall > 3mm
Type 2b	High signal on T1-weighted imaging	
Type 3 (solid)	- Solid lesion of any shape - Hypointense signal with susceptibility artifacts	

Osteolysis is reportedly found in up to 24% of painful metal-on-metal arthroplasties and, although often visible on MRI, may be more readily demonstrated with CT. Metallosis without a pattern of adverse reaction gives rise to low signal intensity debris within the synovium and may result in intraosseous or soft tissue low signal intensity deposits [17].

Plain radiographs are the primary modality used for the investigation of the painful metal on metal THA, enabling evaluation of hardware integrity, alignment, and positioning. Acetabular cup position is best assessed on AP and cross-table lateral radiographs and should be within a "safe zone" of 40 ± 10 degrees for acetabular inclination and approximately 15 ± 10 degrees for anteversion (18). Beyond this zone of safety, abnormal loading across the bearing surfaces, also termed "edge loading," may result in increased mechanical wear of the prosthesis [19]. Plain films may less commonly demonstrate a radio-dense effusion suggestive of metallosis or a periprosthetic soft tissue mass indicative of adverse reactions to metal debris.

Ultrasound may be useful in excluding pseudotumor formation in asymptomatic subjects, with variable reported sensitivity and specificity, up to 100% and 96%, respectively [20]. In the context of the painful metal-on-metal THA, however, MRI, optimized for metal artifact reduction, appears to be the most sensitive and specific modality and additionally has the ability to demonstrate the majority of adverse features, including osseous abnormalities that would usually be overlooked on ultrasound. In our center, plain radiographs and MRI together form the initial imaging workup of the painful metal on metal THA.

Usually the radiologic findings are consistent with the histologic diagnosis of a mixed adverse local tissue reaction containing elements of hypersensitivity and metallosis. The histologic appearance of an adverse local tissue reaction caused by metal products that has features of hypersensitivity has been described as the aseptic lymphocytic vasculitis–associated lesion. It features a monocytic infiltrate with metal ions, corrosion products, and debris; interstitial or perivascular lymphocytes; occasional plasma cells and eosinophils; and varying degrees of tissue necrosis. Aseptic lymphocytic vasculitis–associated lesion severity is graded on a 10-point scale based on synovial lining appearance, cellular infiltrate type, and tissue organization. Grades of 5 or higher indicate moderate to severe reactions, while grades below 5 indicate low-grade reactions. The host response is influenced by the characteristics and duration of metal debris exposure. Metallosis, associated with high implant wear rates, typically shows a low aseptic lymphocytic vasculitis–associated lesion grade and results from large metallic debris, leading to macrophage activation, synovitis, osteolysis, and eventual implant loosening, similar to polyethylene wear-induced reactions [21, 22].

CONCLUSION

Complications of total hip arthroplasty, such as metallosis, can cause significant pain and require thorough imaging evaluation.

Plain radiographs often identify the cause of a painful THA, and comparison with prior films is crucial for detecting subtle changes in component position or new areas of lucency. Ultrasound is used as a first-line modality in our center for investigating symptoms of soft tissue impingement.

Recent advancements have reduced metal-related artifacts in cross-sectional imaging, and we frequently use MRI to investigate unexplained hip pain, ensuring parameters are optimized for imaging metalwork. CT is reserved for selected cases where high-resolution 3-dimensional osseous assessment is required.

MRI, in particular, proves crucial for detecting pseudotumors and other anomalies. A thorough understanding of radiological signs and appropriate surgical intervention are essential for effectively managing these complications.

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