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Severe Periprosthetic Metallosis and Polyethylene Liner Failure Complicating Total Hip Replacement: The Cloud Sign

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We present a case of an 85-year-old woman with extensive metallosis of the left hip joint secondary to prosthetic polyethelene liner dislocation and wear. Radiographs demonstrated amorphous cloudy radiodensities surrounding the prosthesis, a feature we have called the "cloud sign." The presence of amorphous cloudy radiodensities as a radiographic sign of metallosis has not been previously described to our knowledge.

Introduction

Metallosis is a rare complication of total hip replacement failures. Pre-operative plain radiography is conventionally used in symptomatic patients suspected to have implant malfunction and may seldom show other atypical underlying complications, such as metallosis.

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Abbreviations: CT, computed tomography

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Case Report

A moderately active 85-year-old woman initially presented to an outpatient clinic with complaints of joint pain in the left hip and thigh region. The patient had a history of undergoing bilateral total hip replacement (THR) approximately 14 years prior to presentation. At that time, two Harris-Galante II (Zimmer, Warsaw, IN) prostheses, each consisting of a cementless acetabular head with a standard Longevity cross-linked high-density polyethylene liner and an Orthomet titanium-based alloy femoral stem, were implanted bilaterally. The trabecular acetabular component was hinged with two bone screws each measuring 40mm in length. After 14 years of doing well with the THR, she started to develop increasing and persistent left hip pain and subsequent disuse over the span of several months. She also complained of a grating sensation with pain and has had difficulty with activities of daily living. She denied any significant accident or history of trauma. Physical examination demonstrated a slightly shorter left leg, minimally antalgic gait pattern, and unrestricted range of motion of the left hip joint with negligible pain. Radiographs of the pelvis obtained at the initial visit showed no

gross anatomical abnormalities. Subsequently, a bone scintigraphy study showed increased radiotracer uptake in the left hip periarticular region, suggesting active hyperemia and chronic inflammatory change, which were considered non-specific findings (Fig. 1).

The patient opted for medical management at the time but, because of no significant improvement, was re-evaluated 6 months later. This time, pelvic radiographs showed eccentric position of the prosthetic femoral head within an otherwise intact left THR acetabular component (Fig. 2). The rapidity of this change suggested displacement or other catastrophic failure of the polyethylene liner rather than simply mechanical wear. This complication prompted immediate surgical management. During THR revision surgery, an anteriorly disengaged acetabular polyethylene liner with obvious full-thickness wear and resultant scuffing of the femoral head was noted. Also, remarkably abundant titanium metallosis extending throughout the entire joint with a large extension into both the iliopsoas and trochanteric bursa was observed. An extremely large amount of inflammatory tissue and metallosis was removed and a complete synovectomy with removal of bursae was carried out intra-operatively. The acetabular socket was also exchanged with retention of the femoral component. Post-operative pelvic radiographs demonstrated a well-positioned, well-fixed left THR with no signs of residual metallosis (Fig. 3).

At a follow-up visit four months later, the patient claimed to be doing very well without any specific complaints about her revised left hip implant. She stated that she walked 4 to 5 miles per day and noticed improvement while working with physical therapy. The left leg had reached its original length and the only abnormal findings on physical examination included a slightly stiff-legged gait and a slightly diminished range of motion.

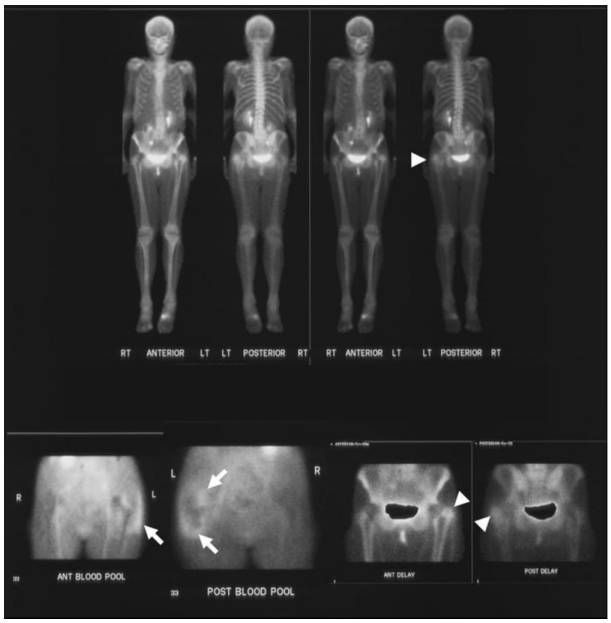

Figure 1. 85-year-old female with metallosis of left total hip replacement. Anterior and posterior projections of a bone scintigraphy study using 30mCi IV technetium-99m-labeled methylene diphosphonate (Tc-MDP) in the 15-minute blood pooling and 3.0-hour delay phases were obtained. This scan demonstrates presence of bilateral THRs with significant increased uptake of Tc-MDP in the periprosthetic bony and soft tissues of the left hip joint in the blood pooling phase (arrows). Delayed phase scans also show mild Tc-MDP uptake in the left hip joint soft tissues (arrowheads). No abnormalities are visualized in the region of the right hip joint.

Discussion

Metallosis is a clinical term used to define chronic infiltration of metallic wear debris with reactive, chronic inflammatory change within the periprosthetic bony and soft tissues [1]. This pathologic phenomenon can happen as a rare complication of failed arthroplasties due to articulation and wear of nonbearing surfaces. Copious accumulation of metallic particulate debris and generation of foreign body granulomas can permeate beyond the joint capsule into the surrounding soft tissues. Pelvic lymph nodes draining these areas may also become involved by undergoing reactive histiocytic change [2]. Osteolysis of the periprosthetic osseous matter is also a common phenomenon that can occur as a result of severe metallosis [1, 3-5].

Hip joint metallosis occurs in the setting of failed THRs due to chronic metal to metal abrasion of the femoral stem component and the acetabular shell [1, 4, 6,-12]. In a study by Chang et al., the overall incidence of metallosis as a result of THR failures was approximately 5.3% [1]. This type of abrasion is prevalent in patients with failed metal-on-metal implants, where both the metallic femoral and acetabular components are primary bearing surfaces [3,13]. It can also occur in THRs that are constructed with acetabular polyethylene liners. If there has been previous eccentric displacement, fracture, or linear full-thickness wear of the polyethylene liner, the titanium femoral stem can easily impinge the underlying acetabular non-articulating, metallic surface and, thereby, generate metallic particulate debris in the joint capsule [1, 5, 10, 11].

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The first (I) and second (II) generation cementless Harris-Galante implants, which are constructed with acetabular polyethylene liners, are especially prone to these complications [1, 10]. First introduced in 1984, the Harris-Galante cup design is particularly susceptible to liner disengagement and wear because of an inadequate modular acetabular locking mechanism [10]. Our patient was also subject to this defect and presented with both eccentric dissociation and chronic wear of the polyethylene liner of her left Harris-Galante II prosthesis, resulting in severe wide-spread metallosis over time. According to the intra-operative grading system used for qualitative measurement of the gross extent of metallosis, as established by Chang et al., we classified this patient as having severe metallosis (Grade III) [1]. In this grading system, mild metallosis (Grade I) is characterized by black spotting in the soft tissues as observed at surgery, moderate metallosis (Grade II) is characterized by geographically patterned black stain in the soft tissues, and severe metallosis (Grade III) is characterized by black staining throughout both soft tissues and bone [1].

Pre-operative radiography of THRs is conventionally used in symptomatic patients suspected to have implant malfunction and may seldom show other atypical underlying complications, such as liner dislocation and metallosis. One of the major findings in the radiographic study of this patient included the eccentric positioning of the femoral stem in the acetabular cup in the left hip implant (Fig. 2A). Asymmetric alignment of the prosthetic femoral head within the acetabular cup on radiography is indicative of a complication involving the polyethylene liner, often excessive mechanical wear, but occasionally catastrophic displacement or fracture [5]. In such cases, where the polyethylene liner is anatomically dissociated, immobilization and careful monitoring is warranted for the patient and revision surgery should be performed urgently [1, 10].

Radiographs of our patient's left hip also demonstrated the presence of the bubble sign, as described by Su et al (Fig. 2B-C) [4]. These bubble-like hyperdensities represent deposited metallic debris outlining the joint space. Other abnormal amorphous cloudy radiodensities in the periprosthetic region are also visualized in this study, a feature we have called the "cloud sign." These radiographic signs both indicate the presence of extreme metallosis in the joint space and are consistent with the grade III classification of metallosis in this patient. Importantly, these signs are not detected in the post-revision radiograph (Fig. 3). This finding suggests that no residual metallosis remained in the joint capsule and the periarticular tissues after surgical debridement.

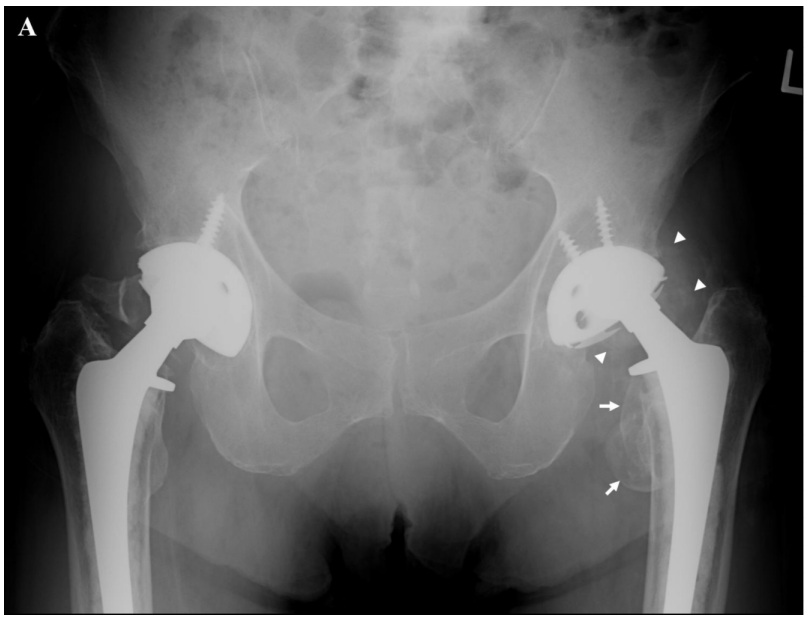

Figure 2A. AP Radiograph of the pelvis shows eccentric position of femoral head within acetabular cup of left total hip replacement. The bubble sign (arrows) and cloud sign (arrowheads) are present in the periprosthetic region of the left hip joint. The right total hip replacement is intact, with incidental heterotopic ossification.

Former studies using energy-dispersive x-ray analysis (EDXA) have shown that the metal particles deposited in the setting of Harris-Galante prosthesis failure are solely composed of titanium [1]. However, such metallic debris can be intermixed with the eroded microscopic polyethylene particles deposited in the periarticular area overtime [1, 14]. Individual polyethylene particles cannot be independently distinguished on radiographs, but their interaction with metallic particulate matter can influence the tissue response that is visualized radiographically. When polyethylene particles are intermixed with metallic debris, they can synergize the inflammatory, granulomatous

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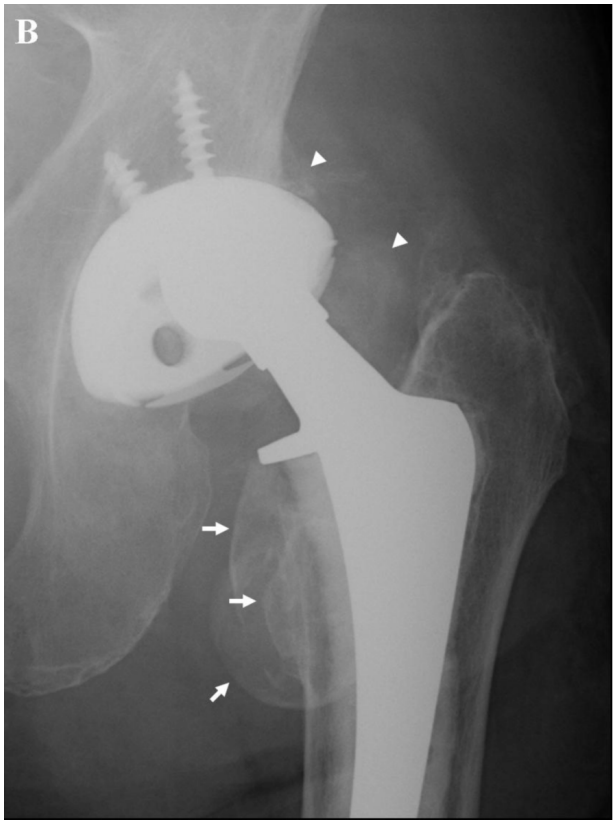

Figure 2B. AP radiograph of the right hip shows eccentric position of the femoral head within the acetabular cup. The bubble sign (arrows) and cloud sign (arrowheads) are present in the periprosthetic region of the left hip joint.

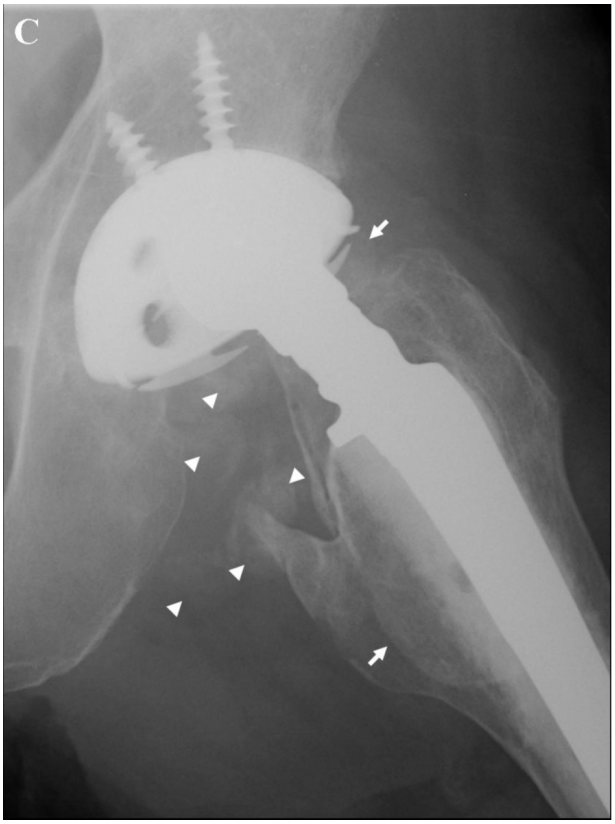

Figure 2C. Frog-lateral radiograph of the right hip shows eccentric position of the femoral head within the acetabular cup. The bubble sign (arrows) and cloud sign (arrowheads) are present in the periprosthetic region of the left hip joint.

response in the periprosthetic soft tissues [1]. So, aggregation of polyethylene wear particles along with titanium debris, which most likely also occurred in our patient, may contribute to the formation of the bubble sign and the cloud sign.

Macroscopic metal particles were not observed radiographically in this study. However, metallosis can present with shedding of gross metallic particulate matter that can be detected radiographically as hyperdense fragments in the peri-articular soft tissues [1]. Macroscopic metal fragments may even be seen more frequently on radiographs than the bubble sign in some cases of Harris-Galante implant failures [1].

Osteolysis is another major radiographic manifestation of THR metallosis [1,3-5]. According to our findings, no metallosis-induced osteolysis is evident in the periprosthetic bony structures of our patient's left hip. However, presence of secondary osteolysis cannot be completely ruled out based on radiographic analysis alone. It is possible that the presence of indiscriminate radiopacities due to metallosis may mask any underlying osteolysis in the same superimposed plane on the radiograph [15]. Likewise, polyethylene debris infiltration into the periprosthetic bony tissues, in the absence of metallosis, can independently induce pure osteolysis [15]. It may also be difficult to distinguish other unrelated causes of decreased cortical bone density, such as disuse osteopenia, from metallosis-induced osteolysis solely based on radiography. Therefore, radiography may not have the best diagnostic sensitivity and specificity for the detection of osteolysis in the setting of metallosis.

Previous investigations by Chang et al. have shown that in 54.8% of 31 cases of hip metallosis studied, neither the bubble sign nor macroscopic metal particulate matter could be identified on pre-operative radiographs [1]. Therefore, although these radiographic signs are specific for

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Figure 3. Frontal radiograph of the pelvis obtained after revision THR of the left hip joint demonstrates a well-positioned new implant. The femoral stem of the left prosthesis is now symmetrically fixed with anatomic alignment of the polyethylene liner within the medullary space of a new acetabular cup. No sign of residual metallosis is suggested.

presence of metallosis, they are not sensitive. Also, eccentric displacement, fracture, or scuffing due to chronic wear of the acetabular polyethylene liner do not always accompany the presence of metallosis or may not be displayed radiographically. Moreover, as described above, other concomitant phenomena, such as masking by metallosis, polyethylene particle infiltration, or disuse osteopenia can affect the interpretation of metallosis-induced osteolysis by radiography, thereby affecting its diagnostic accuracy. In this case study, the radiographs obtained at initial presentation did not show any radiographic sign of metallosis or anatomical defect of the acetabular cup, although polyethylene liner wear or metallosis may have already been in progress. Osteolysis was also never detected on any pre-operative radiographic studies. Accordingly, radiologists and orthopaedic surgeons should not fully depend on the presence of these findings on radiographs in order to suspect polyethylene liner malfunction or metallosis. Regardless of the presence of radiographic signs found on radiographs (liner dissociation, bubble sign, macroscopic metal particles, cloud sign, secondary osteolysis), the possibility of metallosis should be highly considered if clinical suspicion arises. A role for other imaging studies, such as bone scintigraphy, CT, and MRI should be considered in the pre-operative diagnosis of metallosis as a complication of THR failure [16-17].

References

1. Chang JD, Lee SS, Hur M, Seo EM, Chung YK, Lee CJ. Revision total hip arthroplasty in hip joints with metallosis: a single-center experience with 31 cases. J Arthroplasty. 2005 Aug;20(5):568-73. [PubMed]

2. Cerilli LA. Images in pathology. Histiocytic lymphadenopathy secondary to metallosis following hip replacement. Int J Surg Pathol. 2006 Oct;14(4):329-30. [PubMed]

3. Korovessis P, Petsinis G, Repanti M, Repantis T. Metallosis after contemporary metal-on-metal total hip arthroplasty. Five to nine-year follow-up. J Bone Joint Surg Am. 2006 Jun;88(6):1183-91. [PubMed]

4. Su EP, Callander PW, Salvati EA. The Bubble Sign: A New Radiographic Sign in Total Hip Arthroplasty. J Arthroplasty. 2003 Jan;18(1):110-2. [PubMed]

5. Berry DJ, Barnes CL, Scott RD, Cabanela ME, Poss R. Catastrophic failure of the polyethylene liner of uncemented acetabular components. J Bone Joint Surg Br. 1994 Jul;76(4):575-8. [PubMed]

6. Milosev L, Antolic V, Minovic A, Cor A, Herman S, Pavlovcic V, Campbell P. Extensive metallosis and necrosis in failed prostheses with cemented titanium-alloy stems and ceramic heads. J Bone Joint Surg Br. 2000 Apr;82(3):352-7. [PubMed]

7. Grose A, González Della Valle A, Bullough P, Lyman S, Tomek I, Pellicci P. High failure rate of a modern, proximally roughened, cemented stem for total hip arthroplasty. Int Orthop. 2006 Aug;30(4):243-7. Epub 2006 Apr 29. [PubMed]

 DOI: 10.2484/rcr.2007.v2i4.115

8. Rokkum M, Brandt M, Bye K, Hetland KR, Waage S, Reigstad A. Polyethylene wear, osteolysis and acetabular loosening with an HA-coated hip prosthesis. A follow-up of 94 consecutive arthroplasties. J Bone Joint Surg Br. 1999 Jul;81(4):582-9. [PubMed]

9. Steens W, Loehr JF, von Foerster G, Katzer A. Chronic cobalt poisoning in endoprosthetic replacement. Orthopade. 2006 Aug;35(8):860-4. [PubMed]

10. Gonzalez della Valle A, Ruzo PS, Li S, Pellicci P, Sculco TP, Salvati EA. Dislodgment of polyethylene liners in first and second-generation Harris-Galante acetabular components. A report of eighteen cases. J Bone Joint Surg Am. 2001 Apr;83-A(4):553-9. [PubMed]

11. Gambera D, Carta S, Crainz E, Fortina M, Maniscalco P, Ferrata P. Metallosis due to impingement between the socket and the femoral head in a total hip prosthesis. A case report. Acta Biomed. 2002;73(5-6):85-91. [PubMed]

12. Black J, Sherk H, Bonini J, Rostoker WR, Schajowicz F, Galante JO. Metallosis associated with a stable titanium-alloy femoral component in total hip replacement. A case report. J Bone Joint Surg Am. 1990 Jan;72(1):126-30. [PubMed]

13. Iida H, Kaneda E, Takada H, Uchida K, Kawanabe K, Nakamura T. Metallosis due to impingement between the socket and the femoral neck in a metal-on-metal bearing total hip prosthesis. A case report. J Bone Joint Surg Am. 1999 Mar;81(3):400-3. [PubMed]

14. Nasser S, Campbell PA, Kilgus D, Kossovsky N, Amstutz HC. Cementless total joint arthroplasty prostheses with titanium-alloy articular surfaces. A human retrieval analysis. Clin Orthop Relat Res. 1990 Dec;(261):171-85. [PubMed]

15. Hernigou P, Poignard A, Nogier A, Manicom O. Osteolysis in revision total knee arthroplasty: a comparative study of osteolysis with and without metallosis. Rev Chir Orthop Reparatrice Appar Mot. 2005 Feb;91(1):51-7. [PubMed]

16. Weiland DE, Walde TA, Leung SB, Sychterz CJ, Ho S, Engh CA, Potter HG. Magnetic resonance imaging in the evaluation of periprosthetic acetabular osteolysis: a cadaveric study. J Orthop Res. 2005 Jul;23(4):713-9. [PubMed]

17. Claus AM, Totterman SM, Sychterz CJ, Tamez-Peña JG, Looney RJ, Engh CA Sr. Computed tomography to assess pelvic lysis after total hip replacement. Clin Orthop Relat Res. 2004 May;(422):167-74. [PubMed]

 DOI: 10.2484/rcr.2007.v2i4.115