Pseudotumor From Modular Neck Corrosion After Ceramic-on-Polyethylene Total Hip Arthroplasty

Andrew R. Hsu, MD, Christopher E. Gross, MD, and Brett R. Levine, MD

Abstract

Pseudotumor formation after hip arthroplasty is a rare complication that can occur with various head-liner articulation couples. Adverse local tissue reactions and pseudotumors have been shown to present as prosthetic infections or implant failures with a broad array of laboratory and imaging findings. We report a case of pseudotumor formation resulting from modular neck-stem corrosion in a well-fixed ceramic-on-polyethylene total hip arthroplasty. The patient underwent successful revision surgery using an extended trochanteric osteotomy, long-stem revision femoral component, and head-liner exchange. It is critical that surgeons are aware of the potential complications with increased component modularity and the possibility of adverse local tissue reactions resulting from fretting and crevice corrosion at modular junctions.

The growing frequency of primary total hip arthroplasty (THA) in the United States has sparked recent interest in proximal component modularity with the advent of a neck-stem taper junction to provide increased intraoperative versatility. While modular femoral heads have been used for decades, the goal of modular neck-stem tapers is to further micromanage leg length, anteversion, and offset to better replicate native hip biomechanics. This increases component options available, and uncouples the stem body from the neck to afford independent modulation of the femoral head center, in cases where fixed neck geometry devices are suboptimal.[1] Additional advantages of a neck-stem taper include greater adjustment of femoral version, enhanced ability of soft tissue balancing, and easier revision to access the acetabulum in the future.[2] However, complications of these additional junctions include fracture, corrosion, fretting, dissociation, and cold-welding as the increased modularity provides a potential site for failure.[3-8] Kop and colleagues[2] found that cobalt-chromium-molybdenum components had increased crevice corrosion, fretting, and particulate debris at the neck-stem junction with resultant metallosis.

A major concern of modular neck-stem junctions is crevice corrosion that may result in similar metal hypersensitivity reactions as seen with metal-on-metal (MOM) THA.[9-13] Modular neck devices have been found to have elevated serum cobalt and chromium ion levels, compared with hip resurfacing components, due to corrosion at the neck-stem taper.[14] An increasingly reported complication of metallosis after THA is adverse local tissue reactions (ALTRs) and pseudotumors, chronic inflammatory lesions found in periprosthetic tissues.[15,16] The histology of pseudotumors has features of metal hypersensitivity and metal wear reactions with the presence of macrophages, lymphocytes, and cellular necrosis.[17,18] The incidence of ALTRs has been reported to be 1% within 5 years after MOM hip resurfacing arthroplasty, but it is unknown what the prevalence is at long-term follow-up.[16]

ALTRs and pseudotumor formation have also been reported in patients with metal-on-polyethylene THA due to corrosion at the head-neck junction causing local metal wear debris.[19-22] It is currently unknown what the effects of increased neck-stem modularity are on the incidence of metal hypersensitivity reactions after THA.

We report a case of corrosion at the modular neck-stem taper in a well-fixed uncemented ceramic-on-polyethylene THA resulting in pseudotumor formation with extension around the greater trochanteric bursa. The patient provided written informed consent for print and electronic version of this case report.

Case Report

A 64-year-old man who underwent a primary right THA at an outside institution 1 year prior to evaluation at our clinic presented with worsening hip pain and stiffness with difficulty walking over the previous 7 months. The patient had pain at rest localized to the groin and thigh, exacerbated by ambulation. He had tried non-steroidal anti-inflammatory medications, trochanteric bursa steroid injections, and physical therapy with no relief of

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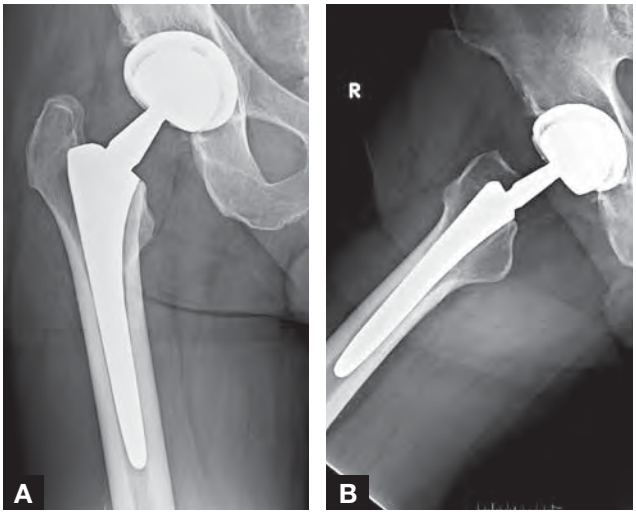

Figure 1. Anteroposterior (A) and lateral (B) radiographs of the right hip prosthesis 1 year after index surgery showed a well-fixed THA in adequate alignment without evidence of eccentric wear or component loosening.

symptoms. A work-up for abductor tendinitis and spinal pathology as possible sources of pain included radiographs, hip metal artifact reduction sequence (MARS) magnetic resonance imaging (MRI), and bone scan, all of which were found to be negative at the outside institution. His past medical history was significant for osteoarthritis, depression, and hypertension, and the initial postoperative course had no complications. On examination, the patient was 1.85 m tall and weighed 91 kg (BMI, 26). He had an antalgic gait over the operative limb, had groin pain with rotational motion, and palpable pain along the greater trochanter. The incision was well healed with no evidence of infection, but there was a fullness on the lateral surrounding soft tissues. Hip range-of-motion was mildly limited with intact motor and sensation throughout the extremity. Preoperative Harris Hip score was 37, indicating hip dysfunction.

Radiographs demonstrated a well-fixed THA in adequate alignment without evidence of wear or loosening (Figure 1). Review of the previous operative record identified components as a cementless ceramic-on-polyethylene THA using a 58 mm acetabular cup, size 9 modular femoral stem with +4 mm head offset, 42 mm modular neck length, and 44 mm diameter ceramic head (Trident/Rejuvenate, Stryker, Mahwah, New Jersey). Re-review of the MARS MRI brought in from the outside institution showed a significant fluid collection extending from the right hip joint to the trochanteric bursa suspicious for a pseudotumor or ALTR (Figure 2). Previous serum inflammatory markers and intra-articular hip aspiration at the outside institution were negative for infection. Given the clinical and imaging findings, combined with the history of significant femoral stem modularity, it was felt that the patient's symptoms were likely due to an ALTR associated with debris from fretting corrosion at the cobalt-chromium modular neck

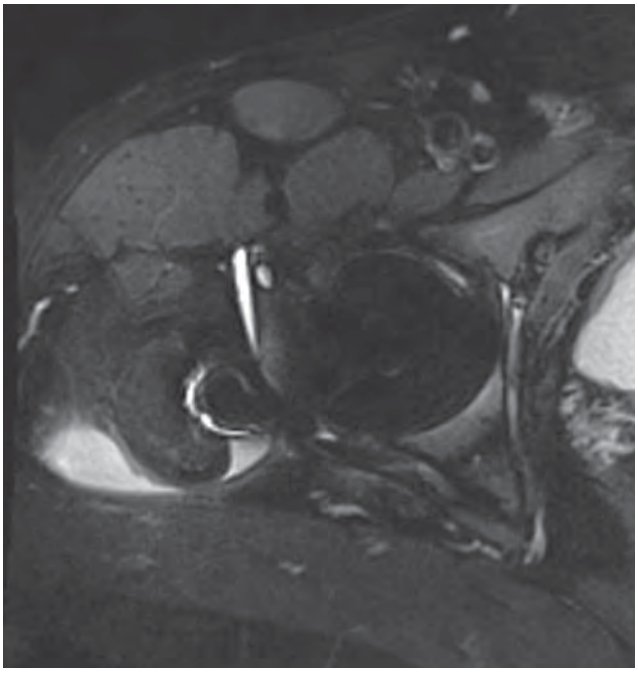

Figure 2. T1-weighted axial MARS MRI image of the right hip demonstrated a significant fluid collection and effusion extending from the right hip joint to the trochanteric bursa consistent with a pseudotumor.

junction. Surgical exploration with revision THA using an extended trochanteric osteotomy was discussed and the patient consented to surgery. Blood samples collected to determine preoperative serum metal ion levels were contaminated and results were not available prior to revision surgery.

The patient underwent a revision THA through his previous incision and using a standard posterior approach to the hip. After incising the deep fascia, a significant amount of fluid erupted from the acetabulum and a large soft tissue membrane sac was visualized (Figure 3). The pseudotumor and surrounding sac were excised, and intraoperative fluid analysis was not consistent with infection: white blood cell count of 225, with 56% polymorphonuclear, 42% lymphocytic, and 2% large mononuclear cells. Operative cultures and gram stain were negative. Intraoperative frozen section of the mass showed synovial necrosis with chronic inflammation. The short external rotators were minimally attached as they had been encapsulated by the pseudotumor.

Once the hip was dislocated, the femoral head and neck were removed and significant corrosion was seen on the neck and stem body (Figure 4). The femoral stem could not be extracted as it was well-fixed along the entire length of the fully coated implant. Therefore, an extended trochanteric osteotomy was performed starting from the tip of the greater trochanter to a point 12 cm distal along the lateral femur. After removing the stem, the medullary canal was debrided and the acetabular component polyethylene liner was removed. A

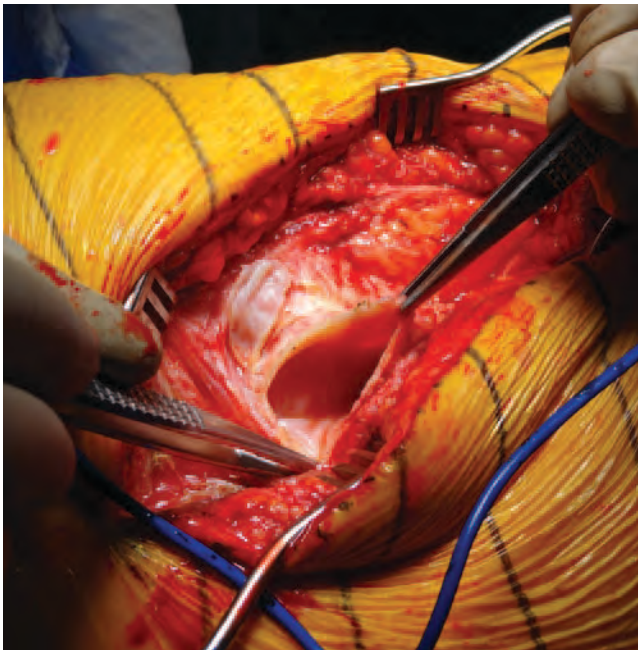

Figure 3. Intraoperative photograph of the incised soft tissue pseudotumor membrane sac seen under the deep fascia.

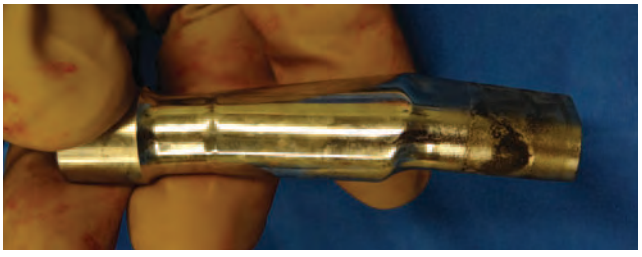

Figure 4. Intraoperative photograph of the corrosion material seen on the neck and femoral stem body junction after excision of the soft tissue mass.

size 15 x 225 mm Wagner Revision Hip Stem (Zimmer, Warsaw, Indiana) was used along with a 36 mm +7 cobalt-chromium head and 36 mm highly cross-linked polyethylene liner. The osteotomy site was reattached using 2 metal cables (Depuy, Warsaw, Indiana) and Grafton demineralized bone matrix putty (Osteotech, Eatontown, New Jersey) was used to fill any bony gaps. The wound was closed and the patient made touch-down weight bearing with no active abduction to protect osteotomy healing for 6 weeks.

At initial follow-up 2 weeks after surgery, the patient had no pain with passive range of motion of the right hip. Radiographs showed good alignment and no evidence of hardware or osteotomy failure (Figure 5). Serum metal ion analysis measured using high-resolution sector field inductively-coupled plasma mass spectrometry (Element2, Thermo-Fisher Scientific GmBH, Bremen, Germany) showed a cobalt level of 1.42 ng/mL, chromium level of 0.27 ng/mL, and titanium level of 4.10 ng/mL. At 6-week follow-up, the patient was made partial weight-bearing with physical therapy increasing

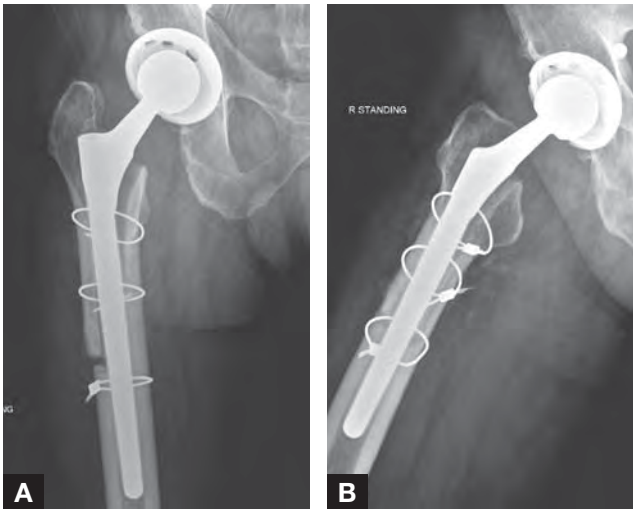

Figure 5. Postoperative anteroposterior (A) and lateral (B) radiographs of the right hip after revision of femoral component with an extended trochanteric osteotomy along with head and liner exchange.

from 30% to full weight-bearing with assistive device and active abduction over a 6 week period. At 5-month follow-up, the patient was doing well with decreased pain and improved range of motion and ambulation. Repeat serum metal ion analysis showed decreases in all ion levels with cobalt, chromium, and titanium levels of 0.71 ng/mL, 0.22 ng/mL, and 3.55 ng/mL, respectively. The patient at recent follow-up is 9 months from revision surgery with continued improvements in function and a Harris Hip Score of 83, compared with 37 preoperatively. Serum levels, at 9-months follow-up, of cobalt, chromium, and titanium have decreased further to 0.62 ng/mL, 0.20 ng/mL, and 2.64 ng/mL, respectively.

Discussion

Modular femoral heads have become a standard part of THA designs as they provide intraoperative adjustment of leg length and offset providing increased joint stability. Component modularity also provides easier exposure when revising the articular surface while retaining a well-fixed femoral stem. Common modes of failure in modular THA systems at the head-neck junction include crevice corrosion and/or fretting corrosion rather than passive dissolution, particularly in devices with a titanium stem and cobalt-chromium head.[3,23,24] Goldberg and colleagues[23] reported that mixed alloy couples and increased flexural neck rigidity predispose implants to corrosion at the head-neck junction and that crevice corrosion continues even after loading has stopped. Increased modularity with a neck-stem junction in a dual modular design is proposed to further improve hip biomechanics and reduce impingement and dislocation, but the reported complications of fracture, corrosion, fretting, and welding have been increasing recently in the literature.[3,5,14] The Rejuvenate (Stryker) THA system described in this report was released in early 2010 and uses femoral stems

made of TMZF alloy (Ti-12Mo-6Zr-2Fe), a proprietary material with a plasma sprayed coating of titanium and hydroxyapatite. The modular neck taper is fabricated from a cobalt-chromium alloy in an effort to improve strength, durability, and reduce the risk of fractures seen with titanium modular neck components.[25] However, the additional modularity at the neck-stem junction in our case underwent corrosion with subsequent ALTR necessitating revision surgery.

In the present case, the index procedure used a 44 mm ceramic head with a 42 mm modular neck and size 9 modular femoral stem with +4 mm head offset. The relatively long neck, combined with a large diameter femoral head, likely caused micromotion at the neck-stem junction due to an increased lever arm and bending moment. This micromotion can predispose components to fretting corrosion and metal debris deposition in periprosthetic tissues by disrupting the protective oxide layer that titanium and cobalt-chromium alloys normally have to resist corrosion.[26,27] Repetitive disruption of the self-passivating layer creates an anaerobic, acidic environment that potentiates component corrosion.[25,28] Furthermore, a large diameter head on a small taper can cause increased eccentric loading and frictional torque than was initially anticipated with these implants. No preoperative serum metal ion levels were available for our patient due to sample contamination, but early postoperative values after revision showed decreasing levels of cobalt, chromium, and titanium towards normal values indicating that the source of metal ions was from corrosion at the modular neck.

Pseudotumors have been given various descriptive terms including cysts, masses, fluid collections, and ALVAL.[29,30] The pathophysiology of these lesions is unclear, but they are thought to be local chronic inflammatory reactions to metal debris causing cellular cytotoxicity and necrosis.[13,15,16,18] Patients with pseudotumors after THA have been shown to have significantly elevated serum cobalt and chromium levels, compared with patients without pseudotumors.[31] However, opposing studies have found no correlation between pseudotumors and metal ion levels.[30,32] Langton and colleagues[33] investigated ALTRs to metal debris, and found that wear rates and serum metal ion concentrations did not correlate with the extent of periprosthetic tissue damage. It was suggested that pseudotumors may represent an advanced stage of the physiologic response to metal wear particles that occurs in all patients with metal implants. Mao and colleagues[34] recently reported a case of pseudotumor formation secondary to corrosion at the head-neck junction with a cobalt-chromium head on a titanium taper. Additional reports exist in the literature describing pseudotumor formation after metal-on-polyethylene THA.[19-22] Kwon and colleagues[31] found pseudotumors in 6.5% of patients with asymptomatic, well-functioning, appropriately positioned MOM implants. While pseudotumors have been increasingly reported with MOM THA, the case presented here is the first report of pseudotumor formation due to corrosion at the modular neck-stem junction in a ceramic-on-polyethylene THA.

ALTRs to metal debris are multifactorial and can result from a number of different causes, including edge loading from malpositioned components, metal hypersensitivity, and corrosion at modular junctions. Individual patient susceptibility to metal wear debris may also play a significant role in the formation of ALTRs. While there are several advantages of increased neck modularity in THA designs, it is critical for surgeons to recognize that there is the potential for increased corrosion at the neck-stem junction. Elevated levels of metal ions may contribute to component failure and have negative long-term local and systemic effects. Overall, pseudotumors remain a rare complication from fretting and crevice corrosion, but should be in the differential diagnosis in any symptomatic patient with a well-fixed THA, regardless of component design or bearing surface. Advanced imaging studies and determination of serum metal ion levels for further work-up of symptomatic patients may assist in diagnosis and preoperative planning should revision surgery become necessary. The use of dual modular components in THA remains controversial with opposing reports of its advantages and disadvantages. Future studies are warranted to determine whether the advantages of increased neck modularity can be obtained without the deleterious effects of implant corrosion and failure.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Dunbar MJ. The proximal modular neck in THA: a bridge too far: affirms. *Orthopedics.* 2010;33(9):640.
2. Kop AM, Keogh C, Swarts E. Proximal Component Modularity in THA-At What Cost?: An Implant Retrieval Study. *Clin Orthop Relat Res.* 2012;470(70):1885-1894.
3. Kop AM, Swarts E. Corrosion of a hip stem with a modular neck taper junction: a retrieval study of 16 cases. *J Arthroplasty*. 2009;24(7):1019-1023.
4. Ellman MB, Levine BR. Fracture of the Modular Femoral Neck Component in Total Hip Arthroplasty. *J Arthroplasty.* 2011; July 26 [Epub ahead of print].
5. Atwood SA, Patten EW, Bozic KJ, Pruitt LA, Ries MD. Corrosion-induced fracture of a double-modular hip prosthesis: a case report. *J Bone Joint Surg Am.* 2010;92(6):1522-1525.
6. Sporer SM, DellaValle C, Jacobs J, Wimmer M. A case of disassociation of a modular femoral neck trunion after total hip arthroplasty. *J Arthroplasty.* 2006;21(6):918-921.
7. Viceconti M, Baleani M, Squarzoni S, Toni A. Fretting wear in a modular neck hip prosthesis. *J Biomed Mater Res.* 1997;35(2):207-216.
8. Fraitzl CR, Moya LE, Castellani L, Wright TM, Buly RL. Corrosion at the stem-sleeve interface of a modular titanium alloy femoral component as a reason for impaired disengagement. *J Arthroplasty.* 2011;26(1):113-119, 119 e1.
9. Biant LC, Bruce WJ, van der Wall H, Walsh WR. Infection or allergy in the painful metal-on-metal total hip arthroplasty? *J Arthroplasty.* 2010;25(2):334. e11-e16. Epub 2009 Feb 24.
10. Earll MD, Earll PG, Rougeux RS. Wound Drainage After Metal-On-Metal Hip Arthroplasty Secondary to Presumed Delayed Hypersensitivity Reaction. *J Arthroplasty.* 2011;26(2)338. e5-e7. Epub 2010 Feb 9.
11. Mikhael MM, Hanssen AD, Sierra RJ. Failure of metal-on-metal total hip arthroplasty mimicking hip infection. A report of two cases. *J Bone Joint*

Surg Am. 2009;91(2):443-446.
12. Perumal V, Alkire M, Swank ML. Unusual presentation of cobalt hypersensitivity in a patient with a metal-on-metal bearing in total hip arthroplasty. *Am J Orthop (Belle Mead NJ).* 2010;39(5):E39-E41.
13. Watters TS, Eward WC, Hallows RK, Dodd LG, Wellman SS, Bolognesi MP. Pseudotumor with superimposed periprosthetic infection following metal-on-metal total hip arthroplasty: a case report. *J Bone Joint Surg Am.* 2010;92(7):1666-1669.
14. Garbuz DS, Tanzer M, Greidanus NV, Masri BA, Duncan CP. The John Charnley Award: Metal-on-metal hip resurfacing versus large-diameter head metal-on-metal total hip arthroplasty: a randomized clinical trial. *Clin Orthop Relat Res.* 2010;468(2):318-325.
15. Campbell P, Ebramzadeh E, Nelson S, Takamura K, De Smet K, Amstutz HC. Histological features of pseudotumor-like tissues from metal-on-metal hips. *Clin Orthop Relat Res.* 2010;468(9):2321-2327.
16. Pandit H, Glyn-Jones S, McLardy-Smith P, et al. Pseudotumours associated with metal-on-metal hip resurfacings. *J Bone Joint Surg Br.* 2008;90(7):847-851.
17. De Haan R, Campbell PA, Su EP, De Smet KA. Revision of metal-on-metal resurfacing arthroplasty of the hip: the influence of malpositioning of the components. *J Bone Joint Surg Br.* 2008;90(9):1158-1163.
18. Mahendra G, Pandit H, Kliskey K, Murray D, Gill HS, Athanasou N. Necrotic and inflammatory changes in metal-on-metal resurfacing hip arthroplasties. *Acta Orthop.* 2009;80(6):653-659.
19. Leigh W, O'Grady P, Lawson EM, Hung NA, Theis JC, Matheson J. Pelvic pseudotumor: an unusual presentation of an extra-articular granuloma in a well-fixed total hip arthroplasty. *J Arthroplasty.* 2008;23(6):934-938.
20. Svensson O, Mathiesen EB, Reinholt FP, Blomgren G. Formation of a fulminant soft-tissue pseudotumor after uncemented hip arthroplasty. A case report. *J Bone Joint Surg Am.* 1988;70(8):1238-1242.
21. Howie DW, Cain CM, Cornish BL. Pseudo-abscess of the psoas bursa in failed double-cup arthroplasty of the hip. *J Bone Joint Surg Br.* 1991;73(1):29-32.
22. Walsh AJ, Nikolaou VS, Antoniou J. Inflammatory pseudotumor complicating metal-on-highly cross-linked polyethylene total hip arthroplasty. *J Arthroplasty.* 2012;27(2):324. e5-e8. Epub 2011 Apr 16.
23. Goldberg JR, Gilbert JL, Jacobs JJ, Bauer TW, Paprosky W, Leurgans S. A multicenter retrieval study of the taper interfaces of modular hip prostheses. *Clin Orthop Relat Res.* 2002;401:149-161.
24. Jacobs JJ, Skipor AK, Patterson LM, et al. Metal release in patients who have had a primary total hip arthroplasty. A prospective, controlled, longitudinal study. *J Bone Joint Surg Am.* 1998;80(10):1447-1158.
25. Grupp TM, Weik T, Bloemer W, Knaebel HP. Modular titanium alloy neck adapter failures in hip replacement--failure mode analysis and influence of implant material. *BMC Musculoskelet Disord.* 2010;11:3.
26. Gilbert JL, Mali S, Urban RM, Silverton CD, Jacobs JJ. In vivo oxide-induced stress corrosion cracking of Ti-6Al-4V in a neck-stem modular taper: Emergent behavior in a new mechanism of in vivo corrosion. *J Biomed Mater Res B Appl Biomater.* 2011; Nov 24. [Epub ahead of print].
27. Srinivasan A, Jung E, Levine BR. Modularity of the femoral component in total hip arthroplasty. *J Am Acad Orthop Surg.* 2012;20(4):214-222.
28. Urban RM, Jacobs JJ, Gilbert JL, Galante JO. Migration of corrosion products from modular hip prostheses. Particle microanalysis and histopathological findings. *J Bone Joint Surg Am.* 1994;76(9):1345-1359.
29. Glyn-Jones S, Pandit H, Kwon YM, Doll H, Gill HS, Murray DW. Risk factors for inflammatory pseudotumour formation following hip resurfacing. *J Bone Joint Surg Br.* 2009;91(12):1566-1574.
30. Matthies AK, Skinner JA, Osmani H, Henckel J, Hart AJ. Pseudotumors Are Common in Well-positioned Low-wearing Metal-on-Metal Hips. *Clin Orthop Relat Res.* 2011;470(7):1895-1906.
31. Kwon YM, Glyn-Jones S, Simpson DJ, et al. Analysis of wear of retrieved metal-on-metal hip resurfacing implants revised due to pseudotumours. *J Bone Joint Surg Br.* 2010;92(3):356-361.
32. Williams DH, Greidanus NV, Masri BA, Duncan CP, Garbuz DS. Prevalence of pseudotumor in asymptomatic patients after metal-on-metal hip arthroplasty. *J Bone Joint Surg Am.* 2011;93(23):2164-2171.
33. Langton DJ, Joyce TJ, Jameson SS, et al. Adverse reaction to metal debris following hip resurfacing: the influence of component type, orientation and volumetric wear. *J Bone Joint Surg Br.* 2011;93(2):164-171.
34. Mao X, Tay GH, Godbolt DB, Crawford RW. Pseudotumor in a Well-Fixed Metal-on-Polyethylene Uncemented Hip Arthroplasty. *J Arthroplasty.* 2012;27(3):493. e13-e17. Epub 2011 Sep 28.