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Does the Type of Femoral Stem and/or Femoral Head Influence the Rate of Adverse Local Tissue Reactions After Primary Total Hip Arthroplasty?

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Does the type of femoral stem and/or femoral head influence the rate of adverse local tissue reactions (ALTR) after primary total hip arthroplasty?

Recommendation: The incidence of adverse local tissue reactions (ALTRs) in primary total hip arthroplasty (THA) is higher with the use of cobalt-chromium alloy femoral heads compared to ceramic femoral heads. It is important to note that other factors also affect the rate of ALTR including metal-on-metal (MOM)−bearing surface, modularity of the femoral stem, femoral head size, and the type of femoral stem.

Strength of Recommendation: Strong.

Delegate Vote: Agree 95.4%, disagree 2.8%, abstain 1.9% (unanimous strongest consensus).

Rationale

Adverse local tissue reaction (ALTR), also known as adverse reaction to metal debris, is a potential complication after primary THA. Although it has various definitions across the literature, it is broadly defined as a local lymphocytic reaction and surrounding tissue necrosis secondary to wear and corrosion at the level of the hip joint or implant modular junctions [1]. Most literature focuses on bearing surface materials as a potential risk factor for ALTR. However, more recently, the term mechanically assisted crevice corrosion (MACC) was introduced to describe the process from which tribocorrosion at the head−neck (or, in the case of modular neck stems, neck−stem) interfaces led to ALTR [2]. Notwithstanding, the role of the femoral component design and materials in the development of this pathology is still a matter of debate. Femoral component characteristics associated with ALTR are: 1) head and bearing surface materials; 2) femoral head size; and 3) head−neck and neck−stem modularity.

Head and Bearing Surface Materials

An ALTR has traditionally been associated with metal-on-metal (MOM)-bearing surfaces, with the reported ALTR-related revision

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rates ranging from 0 to 41.6% [3–22]. While some studies describe low revision rates, the incidence of symptomatic and asymptomatic pseudotumors evidenced in metal artifact reduction sequence magnetic resonance imaging is considerably high [23–25]. Moon et al. found no revisions for ALTR in a MOM THAs cohort with 20 years of mean follow-up [5]. However, the incidence of asymptomatic pseudotumors in this cohort was 28.6%. The ALTR revision procedures are usually performed in a discretionary manner based on the symptom's severity, leading to an underestimation of the true ALTR rates in this patient population.

Metal heads are often coupled with polyethylene liners to minimize the risk of metal debris. There were three retrospective single-cohort studies that investigated the incidence of ALTR in metal-on-polyethylene (MOP) articulations that reported a high rate of ALTR-related revision surgery, namely 4.5, 11.7, and 18.9% [26–28]. Conversely, in a randomized controlled trial performed by Ikeda et al., the incidence of asymptomatic ALTR and revisions was significantly higher in MOM articulations (41.6%) compared to MOP articulations (0%) [29]. While the use of a polyethylene liner in the context of a metal head could mitigate the risk of ALTR, other alternatives, such as the use of ceramic heads, might provide better outcomes [30]. Higgins et al. evaluated a cohort of MOM versus ceramic-on-metal bearings and found a higher revision rate in the MOM group (21.4 versus 19.4%) [31]. However, the number of patients who had a ceramic-on-metal THA in this study is not negligible. The bearing surfaces least linked to revisions for ALTR were ceramic-on-polyethylene and ceramic-on-ceramic [32–37], with only one study reporting two of 26 (7%) patients who had ceramic-on-ceramic articulations undergoing revision surgery in the setting of a symptomatic pseudotumor [6].

Femoral Head Size

Larger-diameter femoral heads are often preferred when performing THA, as they help mitigate the risk of dislocation. Notwithstanding, a larger head diameter might increase the likelihood of volumetric polyethylene wear, increase frictional torque at the bearing surface, and therefore influence the rate of ALTR [38]. De Steiger et al. studied the risk of ALTR revisions in MOP with large ($\geq$ 36 mm) and small-diameter ($\leq$ 32 mm) femoral heads using the data from the Australian Orthopaedic Association National Joint Replacement Registry [39]. They found that larger heads increased the rate of revisions for ALTR compared to smaller heads (hazard ratio 3.2 [95% confidence interval 1.9 to 5.3]; $P < 0.001$). Retrieval studies have shown an association between increased femoral head and taper dimensions and the development of MACC, secondary to increased torque at the head-neck interface [40,41]. However, retrieval studies were out of the scope of this review. A randomized controlled trial performed by Engh et al. assessing the 5-year survivorship of MOM THAs with 36- and 28-mm femoral heads and MOP THAs with 36-mm femoral heads showed slightly higher rates of ALTR in 36-mm heads (3.3 versus 0%) only for the MOM group [42]. There were two studies that described an increased number of symptomatic and asymptomatic pseudotumors in MOP THA with heads $\geq$ 36 mm; however, in the context of modular necks and a high-risk stem, they might act as confounders [43,44]. The current literature suggests that larger-diameter femoral heads exhibit a higher risk of ALTR compared to smaller-diameter heads in both MOP and MOM implants.

Neck–Stem Modularity

Neck modularity is commonly seen at the neck–head (that is, trunnion–bore) interface, but some implants exhibit a modular neck–stem junction to further adjust for neck length, anteversion, and offset. In a prospective cohort study, Nawabi et al. found that a sizable number of patients who had a recalled modular THA system were revised due to ALTR (73 of 199, 33.8%), as opposed to no revisions in the nonmodular stem group (zero of 17) [45]. This aligns with the findings of a prospective cohort described by Vendittoli et al., in which neck–stem modular implants had higher ALTR revision rates compared to implants without such modularity (six of 13 versus five of 32, 15.6%) [46]. Multiple other studies analyzing modular neck–stem implants showed a high prevalence of asymptomatic pseudotumor and elevated metal ions [32,43,44] regardless of the femoral head characteristics. The type of metal used in the modular neck does influence the mechanism of failure. Titanium alloy necks fail predominantly at the head-neck junction, and due to the lower elasticity modulus, this type of neck is more prone to fracture [8,47]. Conversely, cobalt-chrome alloy modular necks are found to fail to corrosion predominantly at the neck-stem junction [48,49].

High-Risk Femoral Stems and Recalled or Discontinued Systems

A few nonrecalled cementless stems have been identified as high-risk for ALTR. In the 10-year follow-up cohort described by McGrory et al., 16 of 163 patients (9.8%) who had an M/L taper style stem demonstrated ALTR by magnetic resonance imaging [26]. Similarly, Grothe et al. describe a high incidence of pseudotumors (27%) in a cohort of two stems with a small-diameter V40 taper. In the study by Grothe et al., both, titanium–molybdenum–zirconium–iron alloy (TMZF) stem and a modular neck stem, which was later recalled, had a high incidence of pseudotumors [50,51]. Using data from the Australian Orthopaedic Association National Joint Replacement Registry, DeSteiger et al. corroborated the high incidence of ALTR-related failures in TMZF and M/L stems [39]. The TMZF would be later replaced by a stem made from a different titanium alloy (Ti6Al4V). A subset of low-friction ion treatment cobalt-chromium heads, used in association with TMZF stems was recalled due to the same concern [27,52,53]. In a large retrospective cohort by Wilson et al., 72 of 621 (11.6%) MOP THA implants with a TMZF stem and low-friction ion treatment femoral head were revised for MACC, and four of them exhibited gross trunnion failure [54]. Of note, ALTR-related failures of TMZF stems were reported in association with polyethylene countersurface and metal heads, but not ceramic. The association of femoral stems and head composition strongly influences ALTR rates [50,54,55].

Other Femoral Component Characteristics

A greater femoral neck offset and length increase the moment arm and the forces transmitted through the taper, which could lead to MACC [56]. Snyder et al. studied the risk factors for ALTR in a cohort of patients who had a recalled THA system. They found that head offsets greater than 4 mm were associated with a higher prevalence of ALTR (53 versus 38%, $P = 0.050$) [52]. Contrastingly, Hussey et al. reported an MACC incidence of 3.2% (43 of 1,352) in a cohort of nonrecalled, noncemented MOP implants. Multivariate regression analysis revealed that a neck length of 0 was an independent risk factor for MACC compared to lengths of +3.5 and −3.5 mm [56].

CRediT authorship contribution statement

Juan D. Lizcano: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Conceptualization. **Sameh Marei:** Writing – review & editing, Writing – original draft, Investigation. **Peter F. Sharkey:** Writing – review & editing, Writing – original draft, Investigation. **Carlos A. Higuera-Rueda:**

Writing – review & editing, Writing – original draft, Investigation. **Joseph T. Moskal:** Writing – review & editing, Writing – original draft, Investigation. **Terry A. Clyburn:** Writing – review & editing, Writing – original draft, Investigation. **Linda I. Suleiman:** Writing – review & editing, Writing – original draft, Investigation. **Brian J. McGrory:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization.

References

[1] Hall DJ, Pourzal R, Jacobs JJ. What surgeons need to know about ALTR in THA. J Arthroplasty 2020;35:S55–9. https://doi.org/10.1016/j.arth.2020.01.016.

[2] McGrory BJ, Jacobs JJ, Kwon Y-M, Fillingham Y. Standardizing terms for tribocorrosion-associated adverse local tissue reaction in total hip arthroplasty. Arthroplasty Today 2020;6:196–200. https://doi.org/10.1016/j.artd.2020.01.008.

[3] Hasegawa M, Naito Y, Yamaguchi T, Miyazaki S, Wakabayashi H, Sudo A. Factors associated with symptomatic pseudotumors following metal-on-metal total hip arthroplasty. BMC Muscoskel Disord 2016;17:456. https://doi.org/10.1186/s12891-016-1317-z.

[4] Palomäki A, Hemmilä M, Matilainen M, Eskelinen A, Haapakoski J, Puhto A-P, et al. No difference in implant survival between 28-mm M2a RingLoc metal-on-metal and metal-on-polyethylene total hip arthroplasty: results from the Finnish Arthroplasty Register. Acta Orthop 2022;93:854–8. https://doi.org/10.2340/17453674.2022.5252.

[5] Moon J-K, Kim Y, Hwang K-T, Yang J-H, Ryu J-A, Kim Y-H. Prevalence and natural course of pseudotumours after small-head metal-on-metal total hip arthroplasty: a minimum 18-year follow-up study of a previous report. Bone Joint J 2019;101-B:317–24. https://doi.org/10.1302/0301-620X.101B3.BJJ-2018-1054.R1.

[6] Zeng Y, Yin S, Liang S, Zeng J, Yang J, Shen B. Clinical outcomes, metal ion levels, lymphocyte profiles, and implant survival following five different bearings of total hip arthroplasty: a mean 10-year follow-up study. J Arthroplasty 2022;37:2053–62. https://doi.org/10.1016/j.arth.2022.04.031.

[7] Cip J, vonStrempel A, Bach C, Luegmair M, Benesch T, Martin A. Implication of femoral stem on performance of articular surface replacement (ASR) XL total hip arthroplasty. J Arthroplasty 2014;29:2127–35. https://doi.org/10.1016/j.arth.2014.06.025.

[8] Levy YD, Ezzet KA. Poor short term outcome with a metal-on-metal total hip arthroplasty. J Arthroplasty 2013;28:1212–7. https://doi.org/10.1016/j.arth.2012.10.005.

[9] Greiner JJ, Callaghan JJ, Bedard NA, Liu SS, Goetz DD, Mahoney CR. Metal-on-Metal total hip arthroplasty at five to twelve years follow-up: a concise follow-up of a previous report. J Arthroplasty 2016;31:1773–8. https://doi.org/10.1016/j.arth.2016.01.058.

[10] Reiner T, Do TD, Klotz MC, Hertzsch F, Seelmann K, Gaida MM, et al. MRI findings in patients after small-head metal-on-metal total hip arthroplasty with a minimum follow-up of 10 years. JBJS 2017;99:1540. https://doi.org/10.2106/JBJS.16.01021.

[11] Holappa E, Kettunen J, Miettinen H, Kröger H, Miettinen S. Long-term survival analysis of cementless large-diameter head metal-on-metal total hip arthroplasty. Arch Orthop Trauma Surg 2023;143:4437–46. https://doi.org/10.1007/s00402-022-04633-9.

[12] Bosker BH, Ettema HB, van Rossum M, Boomsma MF, Kollen BJ, Maas M, et al. Pseudotumor formation and serum ions after large head metal-on-metal stemmed total hip replacement. Risk factors, time course and revisions in 706 hips. Arch Orthop Trauma Surg 2015;135:417–25. https://doi.org/10.1007/s00402-015-2165-2.

[13] Park C-W, Kim J-H, Lim S-J, Moon Y-W, Park Y-S. A minimum of 15-year results of cementless total hip arthroplasty using a 28-mm metal-on-metal articulation. J Arthroplasty 2019;34:1387–94. https://doi.org/10.1016/j.arth.2019.03.010.

[14] Innmann MM, Gotterbarm T, Kretzer JP, Merle C, Ewerbeck V, Weiss S, et al. Minimum ten-year results of a 28-mm metal-on-metal bearing in cementless total hip arthroplasty in patients fifty years of age and younger. Int Orthop 2014;38:929–34. https://doi.org/10.1007/s00264-013-2228-3.

[15] Dhotare SV, Shivarathre DG, Croitoru C, Armstrong C, Kapoor B, Peter VK. Medium-term results following large diameter metal-on-metal total HIP arthroplasty: increasing failure after 6 years. HIP Int 2016;26:226–32. https://doi.org/10.5301/hipint.5000344.

[16] Pietiläinen S, Linnovaara A, Venäläinen MS, Mäntymäki H, Laaksonen I, Lankinen P, et al. Median 10-year whole blood metal ion levels and clinical outcome of ReCap-M2a-Magnum metal-on-metal total hip arthroplasty. Acta Orthop 2022;93:444–50. https://doi.org/10.2340/17453674.2022.2510.

[17] Maliarov A, Huk OL, Epure LM, Bergeron SG, Antoniou J, Zukor DJ. Long-term outcome of small head metal-on-metal total hip arthroplasty: a 15-to-22 Year follow-up. J Arthroplasty 2021;36:3214–20. https://doi.org/10.1016/j.arth.2021.04.011.

[18] Althuizen MNR, Hooff MLv, Erp SHM, Limbeek Jv, Nijhof MW. Early failures in large head metal-on-metal total hip arthroplasty. HIP Int 2012;22:641–7. https://doi.org/10.5301/HIP.2012.10340.

[19] Bozza N, Guindani N, Pezzotta G, Alberto F, Castelli CC. 15-year follow-up of MoM 36-mm THA: clinical, laboratory, and radiological (CT and MRI) prospective assessment. HIP Int 2020;30:42–51. https://doi.org/10.1177/1120700020971662.

[20] Kleeman LT, Goltz D, Seyler TM, Mammarappallil JG, Attarian DE, Wellman SS, et al. Association between pseudotumor formation and patient factors in metal-on-metal total hip arthroplasty population. J Arthroplasty 2018;33:S259–64. https://doi.org/10.1016/j.arth.2018.03.039.

[21] Pearce O, Matharu GS, Bolland BJ. Predictive factors for revision and survivorship analysis of a prevalent 36-mm metal-on-metal total hip replacement system: a large single-center retrospective cohort study. J Arthroplasty 2021;36:1380–7. https://doi.org/10.1016/j.arth.2020.10.028.

[22] Korovessis P, Petsinis G, Repanti M, Repantis T. Metallosis after contemporary metal-on-metal total hip arthroplasty: five to nine-year follow-up. JBJS 2006;88:1183. https://doi.org/10.2106/JBJS.D.02916.

[23] Fehring TK, Odum S, Sproul R, Weathersbee J. High frequency of adverse local tissue reactions in asymptomatic patients with metal-on-metal THA. Clin Orthop Relat Res 2014;472:517–22. https://doi.org/10.1007/s11999-013-3222-1.

[24] Bayley N, Khan H, Grosso P, Hupel T, Stevens D, Snider M, et al. What are the predictors and prevalence of pseudotumor and elevated metal ions after large-diameter metal-on-metal THA? Clin Orthop Relat Res 2015;473:477. https://doi.org/10.1007/s11999-014-3824-2.

[25] Sutphen SA, MacLaughlin LH, Madsen AA, Russell JH, McShane MA. Prevalence of pseudotumor in patients after metal-on-metal hip arthroplasty evaluated with metal ion analysis and MARS-MRI. J Arthroplasty 2016;31:260–3. https://doi.org/10.1016/j.arth.2015.07.011.

[26] McGrory BJ. High incidence of mechanically assisted crevice corrosion at 10 Years in non-cemented, non-recalled, contemporary total hip arthroplasties. J Arthroplasty 2022;37:S941–6. https://doi.org/10.1016/j.arth.2021.11.026.

[27] Weber MA, Snyder MJ, Workman KK, Sims MM, Smith CN, Kumar D, et al. Comparison of asymptomatic and symptomatic adverse local tissue reaction in patients with head-neck taper corrosion. J Arthroplasty 2021;36:S358–62. https://doi.org/10.1016/j.arth.2020.09.014.

[28] Dover C, Kuiper JH, Craig P, Shaylor P. Ten years on: increased metal ion levels in a cohort of patients who underwent uncemented metal-on-polyethylene total hip arthroplasty. Bone Joint J 2020;102-B:832–7. https://doi.org/10.1302/0301-620X.102B7.BJJ-2019-1372.R1.

[29] Ikeda S, Kaku N, Hosoyama T, Tsumura H. Survival rates of different bearing surfaces with the same model of stem in total hip arthroplasty: predictive factors for revision surgery. Arch Orthop Trauma Surg 2023;143:4501–10. https://doi.org/10.1007/s00402-022-04706-9.

[30] White PB, Meftah M, Ranawat AS, Ranawat CS. A comparison of blood metal ions in total hip arthroplasty using metal and ceramic heads. J Arthroplasty 2016;31:2215–20. https://doi.org/10.1016/j.arth.2016.03.024.

[31] Higgins JE, Conn KS, Britton JM, Pesola M, Manninen M, Stranks GJ. Early results of our international, multicenter, multisurgeon, double-blinded, prospective, randomized, controlled trial comparing metal-on-metal with ceramic-on-metal in total hip arthroplasty. J Arthroplasty 2020;35:193–197.e2. https://doi.org/10.1016/j.arth.2019.08.002.

[32] Laurençon J, Augsburger M, Faouzi M, Becce F, Hassani H, Rüdiger HA. Systemic metal ion levels in patients with modular-neck stems: a prospective cohort study. J Arthroplasty 2016;31:1750–5. https://doi.org/10.1016/j.arth.2016.01.030.

[33] Martin JR, Jennings JM, Watters TS, Levy DL, Miner TM, Dennis DA. Midterm prospective comparative analysis of 2 hard-on-hard bearing total hip arthroplasty designs. J Arthroplasty 2018;33:1820–5. https://doi.org/10.1016/j.arth.2018.01.019.

[34] Eichler D, Barry J, Lavigne M, Massé V, Vendittoli P-A. No radiological and biological sign of trunnionosis with large diameter head ceramic bearing total hip arthroplasty after 5 years. J Orthop Traumatol Surg Res 2021;107:102543. https://doi.org/10.1016/j.otsr.2019.12.015.

[35] Persson A, Eisler T, Bodén H, Krupic F, Sköldenberg O, Muren O. Revision for symptomatic pseudotumor after primary metal-on-polyethylene total hip arthroplasty with a standard femoral stem. JBJS 2018;100:942. https://doi.org/10.2106/JBJS.17.00616.

[36] Beauchamp J-E, Vendittoli P-A, Barry J, Pelet S, Belzile EL. Catastrophic failure of femoral stem modular junction when combined with metal-on-metal bearing in comparison to ceramic-on-ceramic: a retrospective cohort study. J Orthop Traumatol Surg Res 2021;107:102749. https://doi.org/10.1016/j.otsr.2020.102749.

[37] Lübbeke A, Gonzalez A, Garavaglia G, Roussos C, Bonvin A, Stern R, et al. A comparative assessment of small-head metal-on-metal and ceramic-on-polyethylene total hip replacement. Bone Joint J 2014;96-B:868–75. https://doi.org/10.1302/0301-620X.96B7.32369.

[38] Tsikandylakis G, Mohaddes M, Cnudde P, Eskelinen A, Kärrholm J, Rolfson O. Head size in primary total hip arthroplasty. EFORT Open Rev 2018;3:225–31. https://doi.org/10.1302/2058-5241.3.170061.

[39] de Steiger RN, Hatton A, Peng Y, Graves S. What is the risk of THA revision for ARMD in patients with non-metal-on-metal bearings? A study from the Australian national joint replacement Registry. Clin Orthop Relat Res 2020;478:1244. https://doi.org/10.1097/CORR.0000000000001277.

[40] Dyrkacz RMR, Brandt J-M, Ojo OA, Turgeon TR, Wyss UP. The influence of head size on corrosion and fretting behaviour at the head-neck interface of artificial hip joints. J Arthroplasty 2013;28:1036–40. https://doi.org/10.1016/j.arth.2012.10.017.

[41] Balso CD, Teeter MG, Tan SC, Howard JL, Lanting BA. Trunnionosis: does head size affect fretting and corrosion in total hip arthroplasty? J Arthroplasty 2016;31:2332–6. https://doi.org/10.1016/j.arth.2016.03.009.
[42] Engh CA, MacDonald SJ, Sritulanondha S, Korczak A, Naudie D, Engh C. Metal ion levels after metal-on-metal total hip arthroplasty: a five-year, prospective randomized trial. JBJS 2014;96:448. https://doi.org/10.2106/JBJS.M.00164.
[43] Mikkelsen RT, Fløjstrup M, Lund C, Kjærsgaard-Andersen P, Skjødt T, Varnum C. Modular neck vs nonmodular femoral stems in total hip arthroplasty—clinical outcome, metal ion levels, and radiologic findings. J Arthroplasty 2017;32:2774–8. https://doi.org/10.1016/j.arth.2017.03.072.
[44] McConnell ZA, Stambough JB, Barnes CL, Wilson BL, Mears SC. Cobalt levels and pseudotumor characteristics vary due to metal ion source: modular femoral neck vs metal-on-metal articulations. J Arthroplasty 2021;36:3490–7. https://doi.org/10.1016/j.arth.2021.05.018.
[45] Nawabi DH, Do HT, Ruel A, Lurie B, Elpers ME, Wright T, et al. Comprehensive analysis of a recalled modular total hip system and recommendations for management. JBJS 2016;98:40. https://doi.org/10.2106/JBJS.N.01121.
[46] Vendittoli P-A, Massé V, Kiss M-O, Lusignan D, Lavigne M. Modular junction may be more problematic than bearing wear in metal-on-metal total hip arthroplasty. HIP Int 2019;29:262–9. https://doi.org/10.1177/1120700018808696.
[47] Pour AE, Borden R, Murayama T, Groll-Brown M, Blaha DJ. High risk of failure with bimodular femoral components in THA. Clini Orthop Relat Res 2016;474:146. https://doi.org/10.1007/s11999-015-4542-0.
[48] Cooper HJ, Urban RM, Wixson RL, Meneghini RM, Jacobs JJ. Adverse local tissue reaction arising from corrosion at the femoral neck-body junction in a dual-taper stem with a cobalt-chromium modular neck. JBJS 2013;95:865. https://doi.org/10.2106/JBJS.L.01042.
[49] Ghanem E, Ward DM, Robbins CE, Nandi S, Bono JV, Talmo CT. Corrosion and adverse local tissue reaction in one type of modular neck stem. J Arthroplasty 2015;30:1787–93. https://doi.org/10.1016/j.arth.2015.04.039.
[50] Grothe T, Günther K-P, Hartmann A, Blum S, Haselhoff R, Goronzy J. The incidence of adverse local tissue reaction due to head taper corrosion after total hip arthroplasty using V40 taper and 36 mm CoCr head. Bone Joint J 2022;104-B:852–8. https://doi.org/10.1302/0301-620X.104B7.BJJ-2021-1769.R1.
[51] Molloy DO, Munir S, Jack CM, Cross MB, Walter WL, Walter WKS. Fretting and corrosion in modular-neck total hip arthroplasty femoral stems. JBJS 2014;96:488. https://doi.org/10.2106/JBJS.L.01625.
[52] Snyder MJ, Weber MA, Kromka JJ, Sims MM, Smith CN, Daji AV, et al. Predictors of adverse local tissue reaction in a high-risk population. Arthroplasty Today 2022;13:125–9. https://doi.org/10.1016/j.artd.2021.12.005.
[53] Urish KL, Hamlin BR, Plakseychuk AY, Levison TJ, Higgs G, Kurtz S, et al. Trunnion failure of the recalled LFIT cobalt chromium alloy femoral head. J Arthroplasty 2017;32:2857–63. https://doi.org/10.1016/j.arth.2017.03.075.
[54] Wilson JM, Broggi MS, Oladeji P, Goel RK, Roberson JR. Outcomes following revision for mechanically assisted crevice corrosion in a single femoral design. J Arthroplasty 2021;36:3966–72. https://doi.org/10.1016/j.arth.2021.08.010.
[55] Matsen Ko L, Chen AF, Deirmengian GK, Hozack WJ, Sharkey PF. Catastrophic femoral head-stem trunnion dissociation secondary to corrosion. JBJS 2016;98:1400. https://doi.org/10.2106/JBJS.15.00914.
[56] Hussey DK, McGrory BJ. Ten-year cross-sectional study of mechanically assisted crevice corrosion in 1352 consecutive patients with metal-on-polyethylene total hip arthroplasty. J Arthroplasty 2017;32:2546–51. https://doi.org/10.1016/j.arth.2017.03.020.