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

Lizcano JD MD, Marei S MD, Yuan Z MD, Sharkey P MD, Higuera-Rueda CA MD, Moskal JT MD, Clyburn T MD, Suleiman L MD, McGrory BJ MD

Recommendation:

The incidence of adverse local tissue reactions (ALTR) is higher with the use of cobalt chromium femoral head compared to ceramic femoral head. It is important to note that other factors also affect the rate of ALTR that includes metal-on-metal bearing surface, modularity of femoral stem, femoral head size and the type of femoral stem.

Strength of Recommendation: Strong

Rationale:

Adverse reaction to metal debris (ARMD) also known as adverse local tissue reaction (ALTR) is a potential complication after primary total hip arthroplasty (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 interface 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.) head size and 3.) head-neck modularity.

Head and bearing surface materials

ALTR has traditionally been associated with MOM bearing surfaces, with reported ALTR-related revision rate ranging from 0% to 41.6% [3–22]. While some studies describe low revision rates, the incidence of symptomatic and asymptomatic pseudotumor evidenced in metal artifact

reduction sequence MRI 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%. ALTR revision procedures are usually performed in a discretionary manner based on the symptoms 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. Three retrospective single cohort studies investigating the incidence of ALTR in metal on polyethylene (MOP) articulations 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 offset 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 (COM) bearings and found a higher revision rate in the MOM group (21.4% versus 19.4%) [31]. However, the number of patients with a COM THA in this study is not negligible. The bearing surfaces least linked to revisions for ALTR were ceramic on polyethylene (COP) and ceramic on ceramic (COC) [32–37], with only one study reporting 2/26 (7%) patients with COC 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 for dislocation. Notwithstanding, a larger head diameter might increase the likelihood of volumetric polyethylene wear and influence the rate of ALTR [38]. De Steiger et al. studied the risk of ALTR revisions in MOM with large (≥36mm) and small diameter (≤32mm) femoral heads using the data from the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) [39]. They found that larger heads increased the rate of revisions for ALTR compared to smaller heads (HR 3.2 [95% CI 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. An RCT performed by Engh et al. assessing the 5-year survivorship

of MOM with 36mm and 28mm femoral heads and MOP with 36 mm femoral heads, showed slightly higher rates of ALTR in 36mm heads (3.3% versus 0%) only for the MOM group [42]. Two studies describe an increased number of symptomatic and asymptomatic pseudotumor in MOP THA with heads ≥36mm; however, in the context of modular necks and a high-risk stem which 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 MOM implants.

Neck-Stem modularity

Neck modularity is commonly seen at the neck-head interface, but some implants exhibit a modular neck-stem junction to adjust for neck length and offset. In a prospective cohort study, Nawabi et al found that a sizable number of patients with a recalled modular THA system were revised due to ALTR (73/199, 33.8%), as opposed to no revisions in the monoblock stem group (0/17, 0%) [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 monoblock implants (6/13, 46.2% versus 5/32, 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 necks are more prone to fracture [8,47]. Conversely, cobalt-chrome modular necks are more predominantly corrode at the neck-stem junction [48,49].

Femoral stem and recalled systems

A few non-recalled cementless stems have been identified as high-risk for ALTR. In the cohort described by Mcgrory et al, 30 of 32 ALTR cases secondary to MACC happened in M/L tapered style stems [26]. Similarly, Grothe et al. describe a high incidence of pseudotumors (27%) in a cohort of stems with small diameter V40 taper. In the study by Grothe et al. study, both Accolade 1 titanium–molybdenum–zirconium–iron alloy (TMZF) stem and ABG II stems had a high incidence of pseudotumors [50]. Using data from the AOANJRR, DeSteiger et al. corroborated the high incidence of ALTR-related failures in TMZF and M/L tapered stems [39]. While the Accolade I stem (TMZF) was not recalled, it was replaced by the accolade II system which is made from a

different titanium alloy (Ti6Al4V). Moreover, given the high ALTR rates seen with the ABG II stem and modular neck system, Stryker decided to voluntarily recall this implant in July 2012 [51]. Low-friction ion treatment (LFIT) cobalt-chromium (CoCr) heads, used in association with TMZF stems, were also recalled by Stryker in August 2016 due to the same concern [27,52,53]. In a large retrospective cohort by Wilson et al. head, 72/621 (11.6%) MOP THA implants with a TMZF stem and LFIT femoral were revised for MACC and 4 of them exhibited gross trunnion failure [54]. Of note, ALTR-related failures of Accolade I TMZF stems are reported in association with metal and polyethylene 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 with a recalled THA system. They found that head offsets greater than 4 mm were associated with a higher prevalence of ALTR (53% vs 38%, P = 0.050) [52]. Contrastingly, Hussey et al report a MACC incidence of 3.2% (43/1352) in a cohort of non-cemented MOP implants. Multivariate regression analysis revealed that a neck length of 0 was an independent risk factor for MACC compared to lengths of +3.5mm and -3.5mm [56].

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