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Does the Use of Ceramic Femoral Head Versus Metal Femoral Head Improve the Outcome of Primary Total Hip Arthroplasty?

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Does The Use of Ceramic Femoral Head Versus Metal Femoral Head Improve the Outcome of Primary Total Hip Arthroplasty?

Response/Recommendation: The use of fourth-generation ceramic femoral heads with highly cross-linked polyethylene may be associated with decreased linear wear rates and improved patient-reported outcomes when compared to other bearing surfaces. Ceramic femoral heads may reduce adverse local tissue reaction when compared to metal heads.

Level of Evidence: Strong.

Expert Vote: Strong.

Rationale

Total hip arthroplasty (THA) is a highly successful and cost-effective procedure for the treatment of end-stage osteoarthritis of the hip. However, long-term implant survivorship may be limited by polyethylene wear, osteolysis, and adverse local tissue reactions (ALTRs), contributing to the corresponding increase in revision THA procedures worldwide [1–3]. Highly cross-linked polyethylene (XLPE) acetabular liners were first introduced in the 1990s [4]. Given its superior resistance to wear, XLPE liners have now largely replaced conventional polyethylene liners in patients undergoing primary THA [5]. Ceramic femoral heads demonstrate improved wettability, improved smoothness, and greater resistance to third-body wear [2,5]. These attributes may promise lower risks of polyethylene wear and possibly improved patient-reported outcomes. Numerous studies have shown reduced polyethylene wear with ceramic compared to metal heads using in vitro studies. Hip simulator studies have demonstrated reduced wear rates with ceramic heads over metal heads by as much as 40% [2,6]. Ceramic femoral heads have gained traction following promising reports on their long-term (10 to 16 years) survivorship and decreased risk of postoperative periprosthetic joint infections, despite the possibility of component fracture [7–12]. There has been no consensus on the optimal material for use in femoral heads.

Several studies have shown no difference in wear rates between metal-on-polyethylene (MoP) and ceramic-on-polyethylene (CoP) [13–15]. Orthopaedic surgeons have cited cost and personal experience as factors influencing their implant selection [16]. In recent years, an increasing number of studies have attempted to clarify if there are differences in implant survivorships, patient-reported outcomes, and reoperation rates between MoP and CoP bearings [17–20].

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Despite numerous studies on the survivorship and outcomes of MoP and CoP bearings in primary THA, it is important to note that there is a paucity of high-quality data comparing fourth-generation ceramic and metal femoral heads on XLPE acetabular liners [19]. In a meta-analysis of six studies, Gosling et al. found no significant difference in revision rates, linear wear, or volumetric wear when comparing MoP to CoP bearings [17]. However, their analysis only included randomized controlled trials. In addition, all patients received non-XLPE liners, and there was substantial variability in the generation of ceramic heads used in the different studies [17]. In another study, Mertz et al. performed a meta-analysis and found that fourth-generation ceramic heads had decreased linear wear rates when compared to cobalt-chromium (CoCr) femoral heads [19]. It is also important to note that Mertz et al. included both comparative and noncomparative studies that used fourth-generation ceramic and CoCr femoral heads with XLPE acetabular liners, increasing the generalizability and reproducibility of their findings [19]. On weighted analysis of 36 studies and 2,316 patients, CoCr femoral heads demonstrated significantly increased rates of annual wear (0.063 mm/year ±0.061, confidence interval: 0.049 to 0.077) when compared to ceramic femoral heads (0.047 mm/year ±0.057, confidence interval: 0.033 to 0.062, $P < 0.01$) [19]. Additionally, three of the four comparative studies included in the meta-analysis found decreased wear rates with ceramic versus CoCr femoral heads, although none of these associations reached statistical significance [3,20–22]. The results of Mertz et al. are limited by the lack of measurement type homogeneity, with each method of measurement demonstrating various amounts of wear [19].

The differences between a metal head versus a ceramic head on the trunnion must also be addressed. The articulation of THA has been the focus of study, including metal on metal, MoP, and CoP. It is noted that ALTR and mechanically assisted crevice corrosion have been identified at the head and trunnion junction. Evidence exists that this is a lesser concern with the use of ceramic heads [23]. Ceramic head trunnions demonstrated a lower median fretting and corrosion score at the base zone ($P < 0.001$), middle zone ($P < 0.001$), and the combined score ($P < 0.001$). It should be noted that this applied only to ceramic, not oxinium heads [24]. In another study, cobalt and chromium levels were found to be significantly higher with metal heads compared to ceramic heads ($P < 0.01$) [25].

Database studies have supported the improved performance of ceramic heads over metal heads. A Medicare claims database revealed that CoCr femoral heads had higher rates of readmissions and mortality compared to oxidized zirconia OxZi or ceramic. Both morbidity and mortality were statistically significantly improved with ceramic and OxZi heads [7]. Other databases, including Australian, New Zealand, and NJR (UK, Wales, Northern Ireland, and Isle of Man) all report higher revision rates in MoP as compared to CoP [2].

As the number of primary THA procedures performed annually continues to increase [26], it is important to identify implant-specific risk factors that may be associated with a higher risk of revision. The success rate and longevity of modern THA are excellent. We should attempt to identify implant materials that can both prolong the time to revision THA as well as reduce the risk of complications associated with implant wear, osteolysis, and ALTRs. Based on the available literature, it appears that the use of fourth-generation ceramic femoral heads with XLPE may be associated with decreased linear wear and improved outcomes when compared to conventional CoCr femoral heads.

CRediT authorship contribution statement

Terry A. Clyburn: Writing – review & editing, Methodology, Conceptualization. **Elizabeth A. Abe:** Writing – original draft. **Koos Jordaan:** Writing – review & editing, Methodology, Conceptualization. **Eoin C. Sheehan:** Writing – review & editing, Methodology, Conceptualization. **Dragan Radoičić:** Writing – review & editing, Methodology, Conceptualization. **Yihe Hu:** Writing – review & editing, Methodology, Conceptualization. **Paul M. Courtney:** Writing – review & editing, Methodology, Conceptualization. **Javad Parvizi:** Writing – review & editing, Methodology, Conceptualization. **Graham S. Goh:** Writing – review & editing, Methodology, Conceptualization.

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