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Clinical Outcomes and Bearing-Specific Complications Following Fourth-Generation Alumina Ceramic-on-Ceramic Total Hip Arthroplasty: A Single-Surgeon Series of 749 Hips at a Minimum of 5-Year Follow-Up

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ABSTRACT

Background: The purpose of this study is to evaluate the minimum 5-year outcomes and bearing-specific complications in a single surgeon series of fourth-generation alumina ceramic-on-ceramic total hip arthroplasties (THAs).

Methods: We retrospectively analyzed 667 patients (749 hips) who underwent primary THAs by a single surgeon using fourth-generation alumina ceramic bearings. There were 315 men and 352 women with a mean age of 54.2 years. The surgeon used cementless prostheses with an identical design and BIOLOX Delta ceramics in all hips, using a 36-mm head in 472 hips (63%) and a 32-mm head in 227. The mean follow-up duration was 6.5 years (range, 5 to 8 years).

Results: The mean Harris hip score improved from 45.6 points preoperatively to 91.3 points at final follow-up. All but 1 acetabular cup and all femoral stems were well fixed. No radiographic evidence of osteolysis was identified at final follow-up. There were 2 (0.3%) ceramic liner fractures and no ceramic head fractures. A total of 48 hips (6.4%) exhibited audible noise (29 clickings and 19 squeakings), but no patient required revision. Other complications were 1 dislocation, 1 deep infection, 3 iliopsoas tendonitis, and 6 periprosthetic femoral fractures. Kaplan-Meier survivorship for revision for any reason was 98.6% (95% confidence interval, 97.7-99.5) at 6.5 years.

Conclusion: Delta ceramic-on-ceramic THAs had a high rate of survivorship without radiographic evidence of osteolysis at 6.5-year follow-up. However, we found 0.3% ceramic liner fractures and 6.4% audible noises associated with the use of Delta ceramics.

Although total hip arthroplasty (THA) has been considered a successful solution for disabling hip conditions in recent decades, a major limitation affecting THA survivorship has been polyethylene (PE) wear and particle-induced osteolysis resulting in aseptic loosening and late failure of the prosthesis [1]. Alternative bearing options including highly cross-linked PE, metal-on-metal, and ceramic-on-ceramic have been developed in attempts to reduce wear and osteolysis and provide improved THA longevity [2,3].

Although previous studies of third-generation alumina ceramics have shown encouraging survivorship with little or no osteolysis, concerns still remain including ceramic head and, more significantly, liner fracture and squeaking and other noises [4–9]. Fourth-generation alumina ceramic (BIOLOX Delta, CeramTec, Plochingen, Germany) that incorporated zirconia into the alumina matrix was developed in the early 2000s in an attempt to reduce such complications [10]. Delta ceramic showed improved fracture toughness in the laboratory setting and thus allowed the use of larger-diameter femoral heads combined with thinner acetabular liners [11,12]. Although several studies of Delta ceramic-on-ceramic

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THAs have been published, these are limited by small numbers of patients or relatively short-term follow-up [13–18].

The purpose of this study is to evaluate clinical outcomes and bearing-specific complications in a single-surgeon series of 749 Delta ceramic-on-ceramic THAs with a minimum follow-up of 5 years.

Materials and Methods

After our institutional review board approval, we identified 831 consecutive Delta ceramic-on-ceramic THAs performed in 739 patients between May 2009 and April 2012. Of these, 28 patients (30 hips) died because of problems unrelated to the surgery, and 44 patients (52 hips) were lost to follow-up before the minimum of 5 years. None of the 28 deceased patients or 44 lost patients underwent a revision or a reoperation through the last follow-up (mean, 15 months; range, 0-28 months). The remaining 667 patients (749 hips) constituted the study cohort. There were 315 men and 352 women with a mean age (standard deviation) of 54.2 (14.7) years (range, 16-88 years) at the index operation. The mean body mass index (BMI) (standard deviation) was 24.2 (3.2) kg/m^2 (range, 15.4-37.7 kg/m^2). Etiology included osteonecrosis of the femoral head (369 hips, 49%), osteoarthritis (325, 43%), inflammatory arthritis (20, 3%), and hip fracture and others (35, 5%). The mean follow-up was 6.5 years (range, 5-8 years) (Table 1).

All operations were performed by the single senior surgeon in a lateral position through an anterolateral approach. The surgeon implanted prostheses with an identical design and used Delta ceramic-on-ceramic bearings in all hips (Fig. 1). The acetabular component was a cementless Bencox cup (Corentec, Cheon-An, Korea). It was a hemispheric titanium alloy cup with a plasma-sprayed coating using microporous pure titanium. The femoral component was a cementless Bencox stem (Corentec) made of titanium alloy. It was designed as a grit-blasted, tapered, double-wedged stem with a rectangular cross-section. The neck-shaft angle was determined to be 135°, and the neck was made of 12- to 14-mm taper with a circular cross-section. The surgeon used a 32-mm-diameter Delta ceramic head in 277 hips (37%) with a cup size of <52 mm and a 36-mm-diameter Delta ceramic head in 472 (63%) with a cup size of ≥52 mm.

Patients were encouraged and assisted to commence walking on the second postoperative day. Routine follow-up visits were scheduled for 6 weeks, 3, 6, and 12 months, and then annually thereafter. We assessed the clinical outcome using the Harris hip scoring system [19] at each visit. We defined an Harris hip score of 90 points or more as excellent; 80-89 points, good; 70-79 points, fair; and less than 70 points, poor. At each visit, patients were asked whether any noise had occurred since the time of the operation by a questionnaire (Appendix). If there was, the patients were asked the first presentation time, type (clicking, squeaking, or other noise), reproducibility, position or related activities, and any pain associated with the noise. We excluded noises that felt more like sensations and that were not audible. We identified postoperative complications including ceramic fracture, dislocation, infection, iliopsoas tendonitis, and periprosthetic fracture and also recorded reoperations.

Table 1
Demographic Data.

Number of patients (hips)	667 (749)
Mean age (range, SD), y	54.2 (16-88, 14.7)
Gender (male:female)	315:352
Mean BMI (range, SD), kg/m^2	24.2 (15.4-37.7, 3.2)
Etiology, n (%)	
Osteonecrosis of the femoral head	369 (49)
Osteoarthritis	325 (43)
Inflammatory arthritis	20 (3)
Hip fracture and others	35 (5)
Mean follow-up (range), y	6.5 (5-8)

SD, standard deviation; BMI, body mass index.

Fig. 1. A hemispheric titanium alloy cup with plasma-sprayed coating (Bencox; Corentec, Cheon-An, Korea) and a grit-blasted, tapered, double-wedged, titanium alloy stem (Bencox; Corentec) with a fourth-generation ceramic-on-ceramic bearing (BIOLOX Delta; CeramTec, Plochingen, Germany).

Radiographic outcomes were determined by 2 independent investigators who did not participate in the index surgeries. We considered standard anteroposterior and cross-table lateral radiographs (obtained at postoperative 5 days) to represent the baseline for all comparisons. We measured inclination and anteversion of the acetabular cup on plain radiographs [20]. We also evaluated radiolucency and osteolysis around the acetabular cups using the DeLee and Charnley zonal classification [21] and around the femoral components using the zonal classification devised by Gruen et al [22]. We defined periprosthetic osteolysis as the radiographic appearance of a focal area of bone resorption as evidenced by a cystic or scalloped nonlinear lesion of width ≥5 mm [23]. We assessed femoral component migration by measuring the vertical distance from the lower edge of the stem to the tip of the greater trochanter or by measuring the varus or valgus stem angles formed between the stem and neutral axes of the femoral canal. We considered femoral stem loosening to be present when femoral subsidence exceeded 4 mm, the varus angle changed by more than 2°, or we observed a complete radiolucent line [24].

Statistical Analysis

We performed statistical analysis using SAS version 9.4 (SAS Institute, Cary, NC). To compare the noise and silent hip groups, we performed 1-to-3 matching using propensity scoring [25]; the variables included for the propensity score matching were age,