



Third-Generation Alumina-on-Alumina Total Hip Arthroplasty: 14 to 16-Year Follow-Up Study



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ABSTRACT

Ceramic-on-ceramic articulation has the lowest wear with little osteolysis. However, the wear and osteolysis in long-term follow-up are not known. Another concern is ceramic fracture, which might occur after repeated stress during a long period. Ninety hips (76 patients with a mean age of 47 years) that underwent cementless total hip arthroplasty using third-generation ceramic-on-ceramic articulation were followed for 14–16 years. At final follow-up, there was no measurable ceramic wear and no periprosthetic osteolysis was identified. No ceramic fracture occurred during the follow-up. One hip was revised because of late infection. All prostheses were bone-ingrown. Two patients experienced a grinding sensation. However, no patient had squeak. The mean Harris hip score at the final evaluation was 89 points and the survival rate was 98.9%.

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Polyethylene wear and particle-induced osteolysis are known major reasons for failure after total hip arthroplasty (THA). To minimize the wear of bearing surface, more durable articulations; highly crosslinked polyethylene-on-metal, metal-on-metal, and ceramic-on-ceramic (COC) articulations have been introduced [1–3]. However, metal debris-related complications; metallosis and increased blood iron level, have raised concern and decreased the use of metal-on-metal articulation [4–6].

The COC articulation has emerged as an attractive bearing surface in THA because it has the lowest wear rate among the various articulations [7]. Ceramic particles induce less macrophage reaction and decreased cytokine secretion compared with particles of high-density polyethylene [8]. Third-generation COC articulation showed no detectable wear and little periprosthetic osteolysis [9–11]. In midterm follow-up, clinical and radiological results of THA with this articulation were excellent [12].

We have previously published a minimum 5-year follow-up study of COC THA in patients younger than 50 years [10]. There was no osteolysis, ceramic fracture, or any revision. However, the ceramic wear and periprosthetic osteolysis in long-term follow-up after ceramic THA are unknown. Another concern in long-term follow-up is fracture of ceramic parts. Even though these parts were durable until medium

term follow-up, a ceramic fracture might occur due to repeated stress during a long-term use of COC articulation.

Therefore, we performed an extended study, including all age groups, to assess 15-year follow-up results of cementless third-generation alumina-on-alumina THA.

Materials and Methods

Between February 1998 and February 2000, 108 primary THAs were performed at the author's hospital. Among them 104 THAs (89 patients) were performed using a single cementless prosthesis design with alumina-on-alumina articulation. In the remaining 4 patients (4 hips) with small femoral dimensions, that prosthesis could not be used. These 4 patients underwent THA with other prosthesis and were excluded from the study.

Five patients (5 hips) were not followed for a minimum of 14 years. Eight patients (9 hips) died within 14 years after the operation. Thus, the remaining 76 patients (90 hips) were followed for an average of 15.1 (range, 14.2–16.1) years. There were 60 men and 16 women. The mean age of the patients at the index operation was 47 (range, 19–73) years, the mean weight was 63.8 (range, 43–83) kg, and the mean height was 164 (range, 140–182) cm. The primary diagnosis was osteonecrosis in 66 hips, osteoarthritis in 12, fused hip in 4, ankylosing spondylitis in 3, femoral neck fracture in 3 and sequelae of pyogenic infection in 2. The mean preoperative Harris hip score was 36 (range, 13–85) points.

The acetabular components were a hemispherical titanium cup (PLASMACUP SC; AESCULAP AG & Co, Tuttlingen, Germany) with an

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outer pure titanium plasma-sprayed coating (PLASMAPORE, AESCULAP AG & Co) and an alumina acetabular insert (BIOLOX forte; CeramTec AG, Plochingen, Germany). The femoral component was a slightly tapered, rectangular, collarless titanium stem (BiCONTACT; AESCULAP AG & Co). The stem was tapered only in the anteroposterior projection, at an angle of 1.5°. The proximal one-third of the stem was coated with PLASMAPORE. The neck–shaft angle of the stem was 135°. The standard offset was 40 mm, and the offset of the narrow stem ranged from 31.5 to 35 mm. A stem with the standard offset was used in 83 hips and a narrow stem was used in seven. A 28-mm alumina femoral head (BIOLOX forte, CeramTec AG) was used in all hips. A short neck head component was used in 7 hips, a medium neck in 20, and a long neck in 63.

The study was approved by the Institutional Review Board of the hospital. All patients provided informed consent.

All operations were performed by the same surgeon using a posterolateral approach. All of the acetabular and femoral components were inserted in a press-fit manner. Adjunctive acetabular screws were used in 6 (6.7%) hips. Posterior capsules and short external rotators were routinely repaired. A femoral crack occurred in three hips during insertion of the stem, which was fixed with cerclage wire.

Patients were instructed to walk with partial weight-bearing with the aid of crutches for 4 weeks after surgery. Routine follow-up visits were scheduled for 6 weeks, 3, 6, 9, and 12 months, and yearly thereafter. Patients who did not return for regularly scheduled visits were contacted by telephone. Two nurses and a private locator found and visited non-responders.

Clinical evaluation was performed using the Harris hip scoring system [13]. The radiographic evaluation was done by two independent observers who did not participate in the index operations. The 6-week anteroposterior and cross-table lateral radiographs were considered to be the baseline for all comparisons. The abduction and anteversion of the acetabular component were measured on the six-week radiographs. We used the method described by Widmer [14] for the measurement of anteversion. Radiographic evaluation included an assessment of the fixation of the femoral and acetabular components, ceramic components wear, osteolysis, and heterotopic ossification. Vertical migration of the acetabular component was measured along a perpendicular line from the hip center to the inter-teardrop line. Horizontal migration was assessed by measuring the distance from the teardrop to the intersection of the perpendicular line from the hip center and the inter-teardrop line. Acetabular components were considered loose if there was a change in alignment of greater than 4° or ≥ 4 mm of change in position [15]. Femoral components were considered to be unstable when there was progressive subsidence exceeding 3 mm, any change in position, a continuous radiolucent line wider than 2 mm, widening of the femoral canal, or a large pedestal [16]. The wear of articulation was calculated according to the method developed by Livermore et al [17]. Osteolytic lesions were defined according to the criteria of Engh et al [18]. The lesions were recorded according to the three zones described by DeLee and Charnley [19] on the acetabular side and the seven zones described by Gruen et al [20] on the femoral side. Heterotopic ossification was classified according to the system of Brooker et al [21]. We performed Kaplan–Meier survival analysis for all hips with a mean 15-year follow-up with revision of either component as an endpoint [22].

Results

The three femoral fractures, which occurred during insertion of the stem, healed completely, and osseointegration of the prosthesis was achieved. Two hips dislocated after a stumble at postoperative 5 days and 3 weeks, respectively. They were treated successfully with closed reduction and abduction bracing for 3 months, after which, there was no recurrence.

One patient sustained a periprosthetic fracture after falling from a height of 3 m at 9 years postoperatively. The fracture occurred just distal to the stem and was treated with open reduction and internal fixation,

using a locking plate and screws. It subsequently healed completely with no additional procedure.

Periprosthetic infection occurred in one hip at 13 years after the index operation; all prostheses were removed and antibiotic-impregnated cemented spacer was inserted. A second-staged reconstruction was performed using cementless prosthesis 6 weeks after the first stage procedure. There was no clinical and laboratory evidence of recurrent infection until the latest follow-up.

The prevalence of pain in the thigh was 12% (11 hips). In seven hips, the pain disappeared at 1–2 years after the operation. Four patients (4 hips, 5%) had persistent mild intermittent thigh pain at the time of final follow-up. Three patients used some kind of walking support due to knee arthritis. Two patients, who were operated on because of sequelae of pyogenic infections, had mild limps caused by residual discrepancies in leg length.

Six patients (6 hips, 6.7%) experienced an intermittent popping sensation after the operation, which was presumed to be due to the separation of hip bearings. The popping occurred at the initial swing phase of walking or when rising from a sitting or squatting position. In radiographs of these six patients, there was no evidence of separation or ceramic fracture. In four patients, the popping disappeared at 3–6 months after the operation. Two patients (2 hips, 2.2%) had a persistent popping sensation at the time of final follow-up. However, the frequency of popping had decreased. Fluoroscopic examination in these two patients showed no evidence of subluxation during active or passive motion of the hip joint. However, when the operated leg was pulled, the head component was separated from the acetabular component by several millimeters.

Two patients (2 hips, 2.2%) experienced a grinding sensation of the bearing surface while rising from a sitting or squatting position. This phenomenon appeared at postoperative 3 and 7 years, respectively, and persisted until the time of final follow-up. However, it was not audible to others. Otherwise, no squeak was noted in any patient until the latest follow-up.

The mean Harris hip score improved to 89 (range, 37–100) points at the time of final follow-up. Of the 90 hips, 67 had excellent, 18 had good, 2 had fair, and 3 had poor results. The average anteversion and abduction of the acetabular component were 13.9° (range, 8° to 42°) and 43.2° (range, 32° to 50°), respectively. All of the acetabular cups had radiographic evidence of bone ingrown stability at the time of the last follow-up. No femoral stem demonstrated radiographic evidence of subsidence, and all stems had bone ingrown stability. There was no ceramic fracture.

All femora had cortical thinning, which was presumed to be due to cancellation of the cortex, limited to the calcar femorale (zone 7). Thinning was evident at 3 months postoperatively and was not seen to progress on serial radiographs (Fig. 1).

Eleven femora (12%) had cortical hypertrophy in zone 3 or 5 during the follow-up. The cortical hypertrophy normalized in three hips (Fig. 2), while it persisted until the latest follow-up in the remaining eight hips.

No measurable wear and no periprosthetic osteolysis were detected in any of the 90 hips. Reactive radiolucent line formation was found around the uncoated distal tip of the stem in 16 hips at 9–18 months after the operation. It was not associated with the formation of a pedestal and was not progressive.

Heterotopic ossification had developed in 7 (7.8%) hips by the time of the last follow-up. Three hips had grade I ossification, and four had grade II ossification. There were no clinically apparent deep venous thromboses or pulmonary emboli.

Kaplan–Meier survivorship analysis based on 90 hips at risk, with any implant revision for any reason as the end point, revealed a cumulative survival rate of 98.9% (95% CI = 96.7%–100%) at 15.9 years. In the worst-case scenario, assuming that the 14 hips lost to follow-up all and deaths had a revision for any cause, the survival rate was 85.5% (95% CI = 78.6%–92.4%) at 15.9 years. In the best-case scenario,

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