Alumina-on-Alumina Total Hip Arthroplasty. A Five-Year Minimum Follow-up Study

Jeong Joon Yoo, Young-Min Kim, Kang Sup Yoon, Kyung-Hoi Koo, Won Seok Song and Hee Joong Kim
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Alumina-on-Alumina Total Hip Arthroplasty

A Five-Year Minimum Follow-up Study

By Jeong Joon Yoo, MD, Young-Min Kim, MD, Kang Sup Yoon, MD, Kyung-Hoi Koo, MD, Won Seok Song, MD, and Hee Joong Kim, MD

Investigation performed at the Department of Orthopaedic Surgery, Seoul National University College of Medicine, Seoul, Korea

Background: Ceramic-on-ceramic couplings are attractive alternative bearing surfaces that have been reported to eliminate or reduce problems related to polyethylene wear debris. Disappointing experiences with alumina ceramic bearings in the past have led to many improvements in the manufacture and design of ceramic implants. The purpose of the present study was to report the results of contemporary alumina-on-alumina total hip arthroplasties with regard to wear, osteolysis, and fracture of the ceramic after a minimum duration of follow-up of five years.

Methods: We evaluated the results of a consecutive series of 100 primary alumina-on-alumina total hip arthroplasties that had been performed with use of a metal-backed socket and a cementless stem in eighty-four patients. All of the patients were sixty-five years of age or younger (mean age, forty-one years), and a single surgeon performed all of the procedures. After a minimum duration of follow-up of sixty months, one patient (one hip) had died and four patients (six hips) had been lost to follow-up, leaving a total of seventy-nine patients (ninety-three hips) available for study. All of these patients were evaluated clinically and radiographically with special attention to wear, periprosthetic osteolysis, and ceramic failure.

Results: The mean Harris hip score was 97 points at the time of the latest follow-up evaluation. All prostheses demonstrated radiographic evidence of bone ingrowth. No implant was loose radiographically, and no implant was revised. Ceramic wear was not detectable in the thirty-seven hips in which the femoral head could be differentiated from the cup on radiographs. Periprosthetic osteolysis was not observed in any hip. A fracture of the alumina femoral head and a peripheral chip fracture of the alumina insert occurred in one hip following a motor-vehicle accident.

Conclusions: The results of contemporary alumina-on-alumina total hip arthroplasty with a metal-backed socket and a cementless stem were encouraging after a minimum duration of follow-up of five years. We believe that these improved alumina-on-alumina bearing implants offer a promising option for younger, active patients.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Ceramic-on-ceramic couplings are attractive alternative bearing surfaces that have been reported to eliminate or reduce problems related to polyethylene wear debris following total hip arthroplasty[1-6]. However, previous experiences with alumina ceramic bearings have been disappointing because of increased rates of acetabular component loosening, ceramic component fracture, and isolated examples of accelerated bearing surface wear[7,8]. Over the last decade, many improvements have been made in the manufacture and design of ceramic implants[6,9]. Hot isostatic pressing, laser marking, and nondestructive proof-testing have been introduced to improve the strength and microstructure of these devices. Contemporary alumina-on-alumina total hip systems incorporate a surface-treated metal-backed socket to overcome the high rates of cup loosening associated with the original component. The short and intermediate-term results associated with these systems have been encouraging[10-12]. Nevertheless, problems related to wear and osteolysis in vivo, and the possibility of ceramic fracture during activities of daily living, are still major concerns associated with ceramic bearings.

A cementless alumina-on-alumina bearing implant has been used at our institution since November 1997. In the present study, we evaluated the results of a consecutive series of contemporary primary alumina-on-alumina total hip arthroplasties with regard to wear, osteolysis, and ceramic fracture after a minimum duration of follow-up of five years.

Materials and Methods

Alumina-on-alumina total hip arthroplasty was performed only for patients who were sixty-five years of age or younger. The first 100 primary alumina-on-alumina total hip arthroplasties at our institution, performed in eighty-four patients between November 1997 and April 1998, were included in the present study. During the same period, no other bearing surfaces were used for primary total hip arthroplasty in patients sixty-five years of age or younger. One patient (one hip) died with the prosthesis in situ as the result of an unrelated medical condition within three years, and four patients (six hips) were lost to follow-up. The remaining seventy-nine patients (ninety-three hips) were evaluated after a minimum duration of follow-up of five years (average, sixty-eight months; range, sixty to seventy-eight months). The study group included forty-nine men and thirty women.

The mean age of the patients at the time of the index arthroplasty was forty-one years (range, eighteen to sixty-five years), and sixty-one patients (73%) with seventy-five hips were less than fifty years old. The mean body weight (and standard deviation) was 63.7 ± 11.4 kg (range, 41 to 98 kg), and the mean body mass index was 23.7 ± 3.7 (range, 16.5 to 34.3). The most common diagnosis, recorded for fifty-three hips (53%), was osteonecrosis of the femoral head (Table I).

TABLE I Initial Indications for Hip Replacement

Indication for Hip Replacement	Number of Hips (N = 100)
Osteonecrosis of the femoral head	53
Primary coxarthrosis or coxarthrosis after hip dysplasia	16
Sequelae of hip-joint infection	10
Sequelae of Legg-Perthes disease	8
Ankylosis of hip joint	5
Rheumatoid arthritis	2
Miscellaneous conditions	6

Fig. 1
Photograph showing the alumina-on-alumina PLASMACUP SC-BiCONTACT hip system. The PLASMACUP acetabular component is a titanium-alloy cup that is coated with Plasmapore with use of a plasma-spray technique. The BiCONTACT femoral component is a straight, tapered, rectangular, collarless titanium alloy stem, the proximal one-third of which is also coated with Plasmapore with use of a plasma-spray technique.

The senior author (Y.-M.K.) performed all of the procedures. The total hip arthroplasty was performed through a lateral approach with a trochanteric osteotomy in eighteen hips, through a lateral approach without a trochanteric osteotomy in nine, and through a posterolateral approach in seventy-three. An alumina-on-alumina combination (BIOLOX forte; CeramTec, Plochingen, Germany) was used in all patients. The acetabular component was a hemispherical titanium cup (PLASMACUP SC; Aesculap, Tuttlingen, Germany) with an outer coating of plasma-sprayed pure titanium (Plasmapore; Aesculap). The uncemented femoral component was a slightly tapered, rectangular, collarless titanium-alloy implant (BiCONTACT; Aesculap). The proximal one-third of the stem was also coated with Plasmapore. The 28-mm modular femoral head was secured with a Morse taper, and the acetabular insert was secured by means of a self-securing conical fit (Fig. 1). Partial weight-bearing was allowed after six days, and full weight-bearing was allowed after eight to ten weeks.

The clinical evaluation consisted of a physical examination, calculation of the Harris hip score[13], and the administration of a questionnaire that included items on pain (including thigh pain) and functional capabilities. Serial radiographs were examined with regard to component stability[14], evidence of stress-shielding[15] or migration of the component, and loosening. Wear was measured according to the method of Livermore et al.[16] for the thirty-seven hips in which the femoral head could be differentiated from the cup on radiographs. Periprosthetic cystic or scalloped lesions with a diameter of >2 mm that had not been present on the immediate postoperative radiograph were defined as periprosthetic osteolysis[17,18].

Results

The mean preoperative Harris hip score for the entire series was 59.3 ± 12.7 points (range, 30 to 84 points), and the mean postoperative score for the seventy-nine patients who

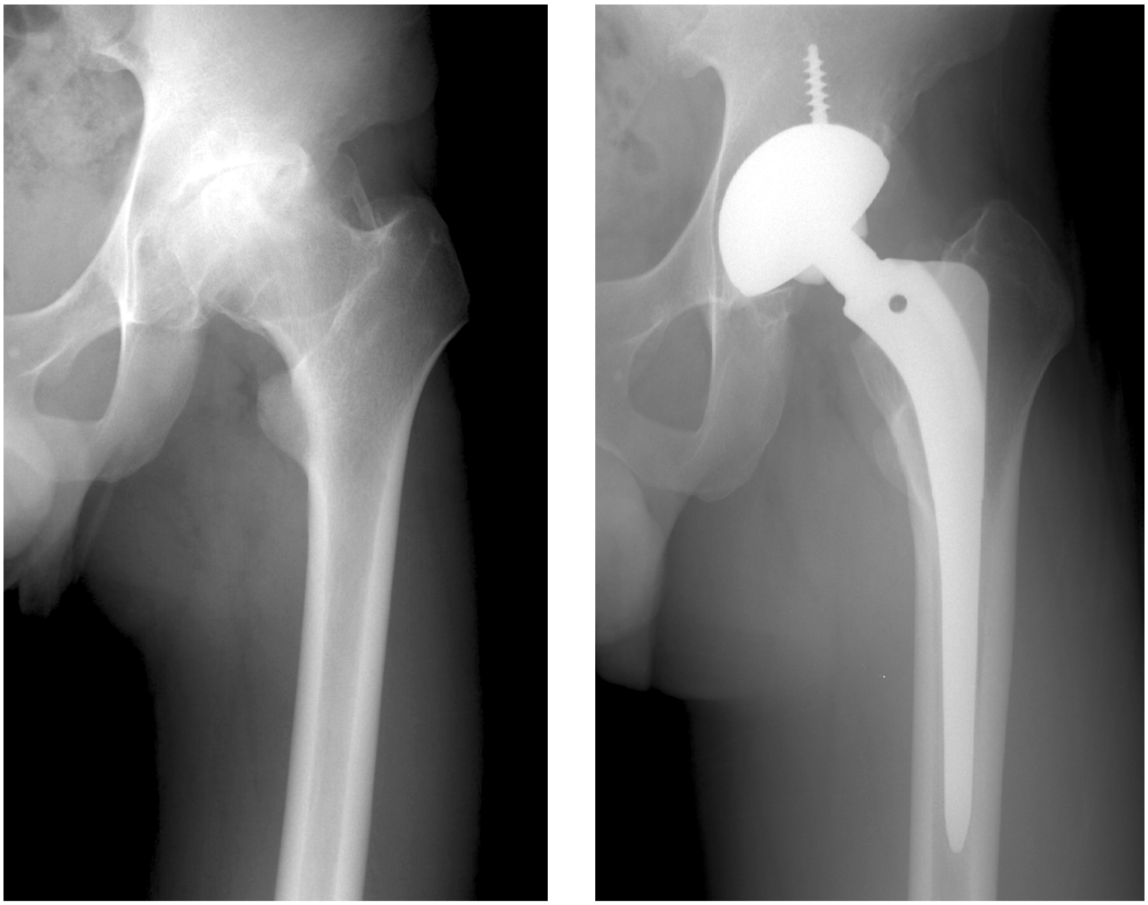

Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Radiographs of the left hip of a twenty-five-year-old man who underwent a total hip arthroplasty with use of the alumina-on-alumina PLASMACUP SC-BiCONTACT hip system. **Fig. 2-A** Preoperative radiograph showing the sequelae of hip-joint infection. **Fig. 2-B** Radiograph, made five years postoperatively, showing no evidence of osteolysis or loosening.

were followed for at least five years was 97.0 ± 3.2 points (range, 83 to 100 points). Three patients (three hips) had mild thigh pain that was not associated with loosening, but the pain did not limit activity. Four patients (four hips) had a mild limp that was caused by abductor muscle weakness. No patient required any kind of walking support at the time of the latest follow-up, and seventy-four patients (94%) could sit in the so-called tailor's position at the time of the latest follow-up.

According to the criteria for bone ingrowth described by Engh et al.[14], all ninety-three hips had radiographic evidence of a bone-ingrown prosthesis at the time of the most recent follow-up. Ten hips (11%) had a radiolucent line in zone 3, 4, or 5 according to the method of Gruen et al.[19], but no hip had a radiolucent line in the proximal anchoring area (zone 1 or 7). None of the radiolucent lines measured >2 mm in width. Mild rounding-off of the calcar was observed in forty-eight hips (52%). Radiographic evidence of mild stress-shielding (second-degree stress-shielding according to the system of Engh et al.[15]) with bone hypotrophy in the proximal femoral region was observed in fifteen hips (16%). Severe stress-shielding with atrophy of the proximal femoral region was not detected in any hip. No hip demonstrated a change of >2° in the cup inclination angle and no hip demonstrated >2 mm of vertical or horizontal migration of the cup.

Periprosthetic osteolysis was not detected around any cup or stem, and there was no radiographic evidence of ceramic wear in the thirty-seven hips that could be so evaluated (Figs. 2-A and 2-B).

One patient sustained a fracture of the alumina femoral head and a peripheral chip fracture on the posterosuperior portion of the alumina acetabular insert following a major motor-vehicle accident that occurred four years and two months postoperatively. Intraoperative examination showed that the inferior portion of the summit of the Morse taper of the well-fixed stem was damaged (Figs. 3-A and 3-B). So-called stripe wear (a long, narrow area of damage on ceramic bearing surfaces caused by edge loading of the bearing[20]) was not observed on the fractured ceramic head. After extensive débridement and synovectomy to remove as much of the ceramic debris as possible, a new cobalt-chromium femoral head and a polyethylene insert were implanted. The stem and the cup were left in place.

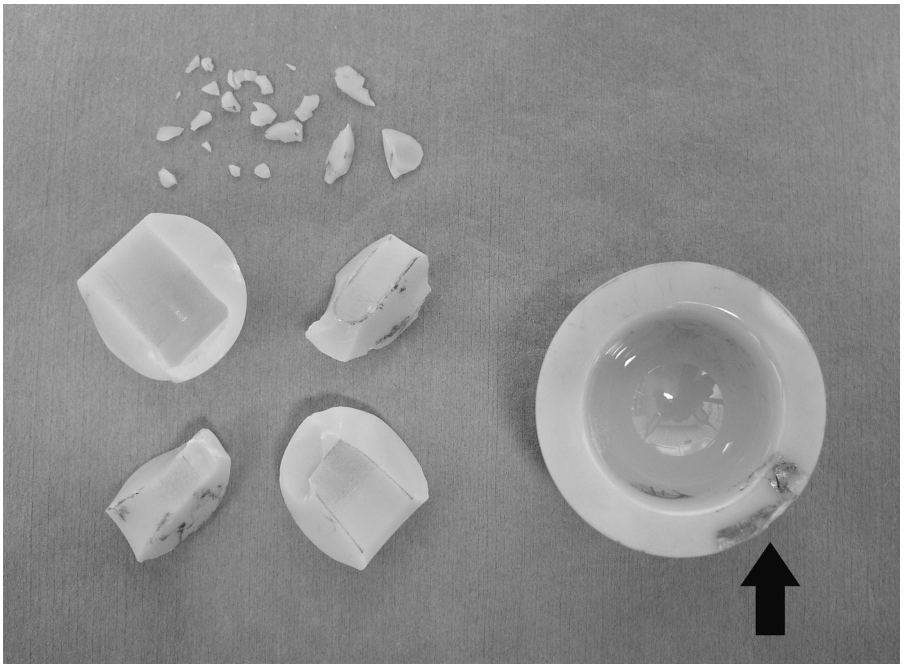

Fig. 3-A

Figs. 3-A and 3-B Photographs showing fractures of alumina bearings and damage to the Morse taper. **Fig. 3-A** Photograph showing the fractured alumina femoral head as well as the peripheral chip fracture and discoloration of the posterosuperior portion of the alumina acetabular insert (black arrow).

A femoral fracture occurred in thirteen hips (13%) during stem implantation, and circumferential wiring was required in nine hips. An acetabular rim fracture occurred in three hips during cup insertion, but no specific treatment was provided. All of these intraoperative fractures healed without problems. A periprosthetic femoral fracture occurred around a well-fixed stem in one patient at eleven months postoperatively. Although an abrupt subsidence of the stem occurred, the fracture healed with nonoperative treatment and no further subsidence was detected.

During the follow-up period, no hip demonstrated radiographic signs of component loosening and no hip dislocated. With the exception of the one reoperation in the patient who had a ceramic fracture, no additional reoperations were required and no revisions were performed.

Discussion

The findings of the present study suggest that contemporary alumina-on-alumina hip arthroplasties performed with use of a metal-backed socket and a cementless stem are associated with excellent clinical results and implant stability at five years. In addition, no wear or osteolysis was observed. The absence of osteolysis in this series after five years of follow-up contrasts with the results of other studies of conventional metal-on-polyethylene bearing surfaces with similar follow-up periods[21,22].

The difficulty of measuring the wear of alumina components with use of standard radiographs has been reported[8,11]. In the present study, alumina wear could not be measured in the majority of hips because of an inability to differentiate the femoral head from the cup on radiographs. In the thirty-seven hips in which such differentiation was possible, wear was undetectable. Considering the relatively young age of the patients in this series (mean age, forty-one years), these wear responses are encouraging.

Fig. 3-B

Photograph showing damage to the inferior portion of the summit of the Morse taper of a well-fixed stem (white arrow).

A ceramic fracture occurred in one hip in this series following a major motor-vehicle accident. However, no ceramic fractures occurred under ordinary conditions during the follow-up period. The treatment of a ceramic implant fracture remains controversial[9,23-27]. Although several studies have demonstrated that ceramic particles produce third-body wear if the fractured bearing is replaced with a cobalt chromium-on-polyethylene bearing[23], we implanted a new cobalt-chromium femoral head and a polyethylene insert and left the stem and cup in place after thorough débridement and synovectomy. Placing a ceramic head on a used and damaged Morse taper is not recommended because of a probable mismatch between the bore of the head and the metal taper, stress concentrations, and a high risk of ceramic head refracture[9,24,25]. Therefore, we believe that the stem should be revised when another ceramic bearing is used. However, removal of a well-fixed stem can be a very complex surgical procedure that can cause damage to the bone stock. Recently, Allain et al. reported that revision with a cobalt-chromium head provided satisfactory clinical results in cases of ceramic femoral head fracture[26].

Several technical aspects should be considered at the time of implantation of ceramic bearings in order to minimize potential complications. In the present study, no peripheral chip fractures of the ceramic insert occurred during the operation. Technical problems involving inadequate placement of the ceramic insert and a difficult intraoperative reduction due to high soft-tissue tension can cause a chip fracture of the ceramic insert[12,28,29]. Repetitive impacts of the head on the rim of the liner following recurrent dislocation or subluxation are other possible causes of chip fracture[27]. Ceramic fragments from the insert may cause excessive wear, and the localized damage of a ceramic insert may increase the possibility of its fracture.

Ceramic bearings are associated with a disadvantage with respect to the restoration of the femoral offset and limb length. Because current ceramic heads are available in a very limited range of neck sizes and so-called skirted heads are not available, a conservative neck cut is recommended to restore proper limb length or stability[28].

A fracture of the femur during the final seating of the stem into the medullary canal occurred in 13% of the hips in this series. High rates of femoral fracture are not uncommon in association with the BiCONTACT stems used in the present study. Grzegorzewski et al. reported that an intraoperative femoral fracture had occurred in 15% of seventy-two hips that they had treated with a BiCONTACT stem during their learning period[30]. These high rates of fracture seem to be associated with the prosthetic design and a lack of surgical experience with the technically demanding stem-implantation technique. In our experience, the fracture rate has decreased during subsequent procedures.

To our knowledge, we are the first to report the minimum five-year results of alumina-on-alumina hip replacements performed with use of a metal-backed socket and a cementless stem. Bizot et al. reported the results associated with an alumina bearing and a press-fit metal-backed wire-mesh socket[10,11]. However, all of the procedures involved the use of a cemented stem and a 32-mm alumina femoral head. D'Antonio et al.[12] reported the results of contemporary cementless alumina-on-alumina total hip arthroplasties, but the mean duration of follow-up was only 35.2 months (range, twenty-four to forty-eight months).

In the current study, alumina-on-alumina hip replacements were performed by one surgeon at one institution with use of a single design of cementless prosthesis in relatively young patients. From the viewpoints of wear, osteolysis, and the possibility of ceramic fracture under ordinary conditions, the results of contemporary alumina-on-alumina total hip arthroplasties performed with use of a metal-backed socket and a cementless stem were encouraging after a minimum duration of follow-up of five years. We believe that there has been a substantial improvement in the fixation of the implant due to the metal-backed socket. We believe that any conclusions regarding wear and osteolysis are premature after a follow-up period of less than ten years. However, we also believe that these improved alumina-on-alumina bearing implants offer a promising option for younger, active patients. ■

Jeong Joon Yoo, MD
Won Seok Song, MD
Hee Joong Kim, MD
Department of Orthopaedic Surgery, Seoul National University Hospital, 28 Yongondong, Chongnogu, 110-744, Seoul, Korea. E-mail address for H.J. Kim: oskim@snu.ac.kr

Young-Min Kim, MD
Kyung-Hoi Koo, MD
Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, 300 Gumidong, Bundanggu, 463-707, Seongnam, Korea

Kang Sup Yoon, MD
Department of Orthopaedic Surgery, Seoul Municipal Boramae Hospital, 395 Shindaebangdong, Dongjackgu, 156-707, Seoul, Korea

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