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Original Article

Long-Term Results of Third-Generation Ceramic-on-Ceramic Bearing Cementless Total Hip Arthroplasty in Young Patients

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ABSTRACT

Background: The results of third-generation of alumina-on-alumina ceramic bearing in a large number of patient cohorts are limited. The purpose of this study was to determine clinical and radiologic outcome, prevalence of osteolysis detected with radiographs and computerized tomographic scan, and survivorship of a cementless total hip arthroplasty using a third-generation of alumina-on-alumina ceramic bearing in a large number of active patients aged younger than 65 years.
Methods: We reviewed the cases of 871 patients (1131 hips) who underwent a cementless total hip arthroplasty when they were aged 65 years or younger at the time of surgery. The most common diagnoses were osteonecrosis (53%) and osteoarthritis (20%). Harris hip score, Western Ontario and McMaster Universities Osteoarthritis Index, and University of California, Los Angeles activity scores were recorded. Radiographic and computerized tomographic evaluations were used to evaluate implant fixation and osteolysis. The mean follow-up interval was 18.8 years (range, 15-20 years).
Results: At the time of final follow-up, the mean Harris hip score, Western Ontario and McMaster Universities Osteoarthritis Index score, and University of California, Los Angeles activity score were 90 points, 15 points, and 8 points, respectively. All the femoral stem and acetabular components were well-fixed at the time of final follow-up. No hip had aseptic loosening or osteolysis or fracture of ceramic material at the time of the final follow-up.
Conclusion: The current results with the use of the third-generation of alumina-on-alumina ceramic bearings in young patients suggest that cementless acetabular and femoral components provide outstanding long-term fixation and provide a high rate of survivorship without evidence of osteolysis.

Secure fixation of the components in cemented and cementless total hip arthroplasty (THA) is achieved in most patients [1-3], but polyethylene wear and osteolysis are known as major reasons for failure after THA. Therefore, there have been efforts to develop alternate bearing surfaces to eliminate or reduce complications related to polyethylene wear debris. An alumina-on-alumina ceramic combination was introduced as an attractive alternative in the early 1970s. In recent years, several studies have investigated the prevalence of osteolysis after using an old and third-generation alumina-on-alumina ceramic bearing [4-11]. However, these studies had only looked at the results of a small number of patient cohorts.

The purpose of this study was to determine: (1) long-term clinical and radiologic outcome, (2) how many lesions of osteolysis could be detected with radiographs and computerized tomographic (CT) scan, and (3) survivorship of a cementless THA using a third-generation alumina-on-alumina ceramic bearing in 871 active patients aged younger than 65 years.

Materials and Methods

From March 1995 to March 2000, the senior author performed consecutive 1152 primary THAs using a cementless total hip systems with a third-generation alumina-on-alumina ceramic bearing in 892 patients aged younger than 65 years. Five patients died, and 16 patients were lost to follow-up in the interim and so 871 patients (1131 hips) were available for clinical and radiographic evaluation with a mean follow-up of 18.8 years (range, 15-20 years). The indication for THA was diseases that were severe enough to warrant THA after an adequate trial of nonoperative therapy.

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The diagnosis was osteonecrosis of femoral head in 464 patients (53%), osteoarthritis in 177 (20%), osteoarthritis secondary to developmental dysplasia in 116 (13%), osteoarthritis secondary to childhood pyogenie arthritis in 62 (7%), ankylosing spondylitis in 25 (3%), traumatic arthritis in 19 (2%), and multiple epiphyseal dysplasia in 9 (1%). Patients were excluded if they were older than 65 years, if they had inflammatory arthritis, if they had a foot or ankle disorder that limited walking, or if the follow-up was less than 15 years. The study protocol, including consent forms, was approved by the institutional review board at our institution. A detailed informed consent form was signed by each patient. There were 561 men and 310 women with a mean age (and standard deviation) of 52.9 (11) years (range, 20-64 years) at the time of surgery. The mean body weight (and standard deviation) was 81 (9) kg (range, 66-120 kg), and the mean height (and standard deviation) was 167 (11) cm (range, 155-186 cm). The mean body mass index (and standard deviation) was 29 (6) kg/m^2 (range, 27-38 kg/m^2) (Table 1).

All procedures were performed by the senior author (Y.H.K.) through a posterolateral approach. A cementless Duraloc acetabular component (DePuy, Warsaw, IN) was used in all hips with a 28-mm alumina ceramic liner (Biolox-forte; CeramTec, Plochingen, Germany). These components were press-fitted after the acetabulum had been under reamed by 1 mm. One or 2 screws were used for additional fixation in 102 hips (9%); the remainder did not require any screw fixation. The size of the acetabular components ranged from 48 mm to 62 mm. All patients received an immediate postoperative stability (IPS; DePuy, Leeds, United Kingdom) anatomic femoral component with a 28-mm alumina ceramic femoral head (Biolox-forte, Plochingen, Germany). The proximal femur was prepared with broaches; reamers were never used. The size of the femoral component that matched the size of the largest broach used was selected. The size of the femoral component was selected not by a canal fit and fill, but the torsional stability of the stem dictated by bone quality.

Patients were mobilized on the second postoperative day and progressed to full-weight-bearing with a walking frame or crutches as comfort permitted; they were advised to use a walking aid for 6 weeks.

The patients were reviewed at 3 months, 1 year, and yearly thereafter. The Harris hip score [12] was recorded at each visit, as was the Western Ontario and McMaster Universities Osteoarthritis score [13]. Thigh pain was recorded on a 10-point Visual Analog Scale where 0 represented no pain and 10 severe pain, and activity level was assessed using the University of California, Los Angeles activity score [14]. In addition, the patient's satisfaction was assessed. All the data were obtained by one observer who was not part of the surgical team (D.R.K.). Any clicking or squeaking sound from the ceramic-on-ceramic bearing was recorded.

Table 1
Demographic Data of Patients.

Number of patients (hips)	871 (1131)
Male:female	561:310
Mean age, y, range (standard deviation)	52.9 (20-64.11)
Mean weight, kg, range (standard deviation)	81 (66-120.9)
Mean height, cm, range (standard deviation)	167 (155-186.11)
Mean body mass index, kg/m^2, range (standard deviation)	29 (27-38.6)
Diagnosis (patients), n (%)	
Osteonecrosis	464 (53)
Ethanol associated	264 (57)
Idiopathic	144 (31)
Steroid use	55 (12)
Osteoarthritis	177 (20)
Osteoarthritis secondary to developmental dysplasia	116 (13)
Osteoarthritis secondary to childhood pyogenic arthritis	62 (7)
Ankylosing spondylitis	25 (3)
Traumatic arthritis	19 (2)
Multiple epiphyseal dysplasia	9 (1)
Duration of follow-up (y)	18.8 (15-20)

Anteroposterior, cross-table lateral and iliac oblique radiographs at each patient had been made before the index arthroplasty and undertaken at 3 months and 1 year postoperatively, and every 2 or 3 years thereafter. The femoral morphology was determined preoperatively using Dorr's system of classification [15]. Anteversion and inclination of the acetabular component was measured by the method of Engh et al [16]. Definite loosening of the femoral component was defined when there was progressive axial subsidence of >3mm or a >3° varus of valgus shift [16]. The stability of the stem was classified as osseointegrated, fibrous stable, or unstable [16]. Stress shielding was graded in the radiographs at the final follow-up according to the classification of Engh and Bobyn [17]. The senior author (Y.H.K.) examined all the plain radiographs for evidence of periacetabular osteolysis. Osteolysis was defined as a sharply demarcated lucent area adjacent to the acetabular component that was not evident on the immediate postoperative radiograph [18].

At the final follow-up, all patients underwent CT scans after institutional review board approval because of radiation exposure to detect osteolysis using a multislice scanner (General Electric Light Plus; GE Medical Systems, Milwaukee, WI) as reported by Kim et al [19]. CT images were acquired with 1-mm collimation, a pitch of 1.5, and a 14-cm to 22-cm field of view. The raw data were reconstructed for 1-mm slices. The area within 5 cm from the prosthesis–bone interface in all directions was evaluated. The presence of osteolytic lesions and their volumes and the presence of medial wall perforations were assessed on the CT scans [20].

Radiographs and CT scans were analyzed by a research associate (D.R.K.) with no knowledge of the patient's name. The intraobserver error in all the radiographic and CT measurements was determined by the intraclass correlation coefficient after repeated measurements for 3 times at 3-day intervals. This was 0.97 (0.95-1.00), indicating excellent reproducibility.

Statistical Analysis

The changes in Harris hip score were evaluated using the 2-tailed Student's *t*-test. The chi-square test with Yate's correction was used to analyze complication rates and the radiologic data. Kaplan–Meier survival analysis [21] was used to estimate the probability of retention of the THA in relation to revision for any reason and included the entire cohort. Ninety-five percent CIs were calculated. All statistical analyses were performed using the Statistical Package Social Science software, version 14.0 (SPSS Inc, Chicago, IL), and statistical significance was set at a P value of <.05.

Results

The mean Harris hip score increased from 40 ± 13.1 points (range, 11-51 points) before surgery to 95 ± 2.9 points (range, 73-100 points) at 1 year after surgery, 93 ± 5.9 points (range, 70-100 points) at 5 years, 92 ± 6.8 points (range, 70-100 points) at 10 years, 91 ± 11.1 points (range, 70-100 points) at 15 years, and 90 ± 9.9 points (range, 65-100 points) at 20 years. No patient had thigh pain at the final follow-up. Western Ontario and McMaster Universities Osteoarthritis score was 69 points (range, 41-89 points) preoperatively and 15 points (range, 5-35 points) at the time of the final follow-up (Table 2).

Dependence on walking aids and limping had decreased substantially by the time of the final follow-up. At the final follow-up,