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Significantly Lower Wear of Ceramic-on-Ceramic Bearings Than Metal-on-Highly Cross-Linked Polyethylene Bearings: A 10- to 14-Year Follow-Up Study

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ABSTRACT

Background: This study aimed to retrospectively compare clinical and radiographic results between consecutive total hip arthroplasties (THAs) using ceramic on ceramic (CoC) and metal-on-highly cross-linked polyethylene (MoP), with >10 years of follow-up.

Methods: Sixty-seven patients (52 women and 15 men) underwent CoC THA, whereas 81 (67 women and 14 men) underwent MoP THA. The average patient age at the time of surgery was 54.0 years in the CoC group and 54.2 years in the MoP group.

Results: The mean postoperative Harris Hip Scores were 88.9 and 86.4 in the CoC and MoP groups, respectively ($P = .063$), and the mean annual liner rates of wear were 0.0043 and 0.0163 mm/year, respectively ($P < .001$). Osteolysis was observed on the femoral side of 1 joint (1.5%) in the CoC group and in 1 (1.2%) acetabular and femoral (1.2%) joint each in the MoP group. Three joints (3.7%) in the MoP group showed aseptic cup loosening, one of which (1.2%) required revision THA because of progression of the loosening. Revision THA was also required in 1 joint (1.5%) in the CoC group because of ceramic fracture. The Kaplan–Meier survival rate at 10 years with implant loosening or revision THA as the end point was 98.5% for CoC and 96.3% for MoP ($P = .416$).

Conclusion: The wear rate of CoC implants was significantly lower than that of MoP implants. Kaplan–Meier survival at 10 years with implant loosening and revision THA as end points did not differ significantly between these implants.

Total hip arthroplasty (THA) has become a common treatment for osteoarthritis of the hip [1,2]. However, despite improved implant designs and surgical techniques, bearing surface wear and the resultant wear-induced osteolysis continue to be major limitations to long-term prosthesis survival [1–6].

Metal-on-polyethylene bearing surfaces were once considered the gold standard for THA and have shown good long-term results in elderly patients [5,7]. However, in recent decades, the debris generated from polyethylene liner wear with time was found to be associated with the occurrence of osteolysis, which subsequently leads to implant loosening and failure. The osteolysis rate of metal-on-polyethylene bearings has been reported to be as high as 26%, and the aseptic loosening rate was found to be 3% after 10 years of follow-up in a previous study [1]. To avoid problems caused by wear debris, different bearing surfaces have been developed, such as metal-on-highly cross-linked polyethylene (MoP), which shows lower linear and volumetric wear than conventional polyethylene [3,4,8]. Similarly, hard bearing surfaces such as ceramic on ceramic (CoC) have also been developed to address the problem of osteolysis [6].

The aim of the present study was to compare the clinical and radiographic results, especially the wear rate, of consecutive CoC bearings to those of MoP bearings obtained in a 10-year follow-up period.

Materials and Methods

Patient Selection

Between April 2000 and December 2004, we performed consecutive CoC THAs at 1 institution and MoP THAs at another to

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minimize the risk of selection bias. A total of 187 patients (193 THAs) who completed a minimum follow-up period of 10 years were eligible for the study. The exclusion criteria included death from causes unrelated to surgery (5 patients; 5 joints), patient inaccessibility (8 patients moved abroad; 8 joints), Crowe group III/IV hips (3 patients; 3 joints), and revision THA (29 patients; 29 joints).

Informed consent was obtained from all patients, and the study was approved by the ethics committee of our hospital. Demographic data are given in Table 1. All operations were performed by a single senior surgeon or a junior surgeon who was supervised by the senior surgeon. The posterolateral approach was used for surgery, with the patients in the lateral decubitus position. The socket was fixed in the acetabulum using an acetabular alignment guide.[7]

Acetabular and Femoral Components

Three titanium alloy acetabular components were used in this study: Trident PSL, TriAD, and Securfit AD, with a hydroxyapatite arc deposited titanium surface (Stryker Orthopaedics, Mahwah, NJ). Although the ceramic material in all 3 implants was the same, the ceramic liners of Trident PSL and TriAD were recessed within a metal-backed titanium sleeve, whereas those of Securfit AD were not.

Three titanium alloy femoral components with the same metal constituents as the acetabular components were also used: Securfit, Super Securfit, and C-stem (Stryker Orthopaedics; Table 2). In all cases, the highly cross-linked polyethylene liner used was Crossfire Polyethylene Insert (Stryker Orthopaedics), whereas the ceramic liner and head were BIOLOX forte (CeramTec, Plochingen, Germany). The diameter of the cobalt chrome head was 26 mm for 81 joints (100%). The diameter of the ceramic head was 28 mm for 36 joints (53.7%) and 32 mm for 31 joints (46.3%; Table 3).

Data Collection

The patients' clinical data including the Harris Hip Score were prospectively recorded by a senior surgeon 1 month before THA, 6 months and 1 year after THA, and then annually and at the final follow-up after THA. These data were then retrospectively investigated from the patients' medical records.

Radiographs of the hips in the standard anteroposterior (AP) view and Lauenstein view with the patient in the supine position were recorded 3 months postoperatively and then annually. AP radiographs with both hips in neutral rotation and 0° abduction and Lauenstein-view (frog position) radiographs with the hips in 45° abduction were collected for each patient [9,10].

Table 1
Patient Demographics.

Parameters	CoC Group (n = 67)	MoP Group (n = 81)	*P* Values
Age (range), y	54.0 (28-70)	54.2 (24-79)	.788
Gender (female/male)	52/15	67/14	.534
BMI (range), kg/m^2	23.9 (17.7-32)	22.5 (16.8-31.8)	.639
Follow-up (range), y	11.0 (10-13)	11.3 (10-14)	.185
Diagnosis, n (%)			.571
Osteoarthritis	56 (83.6)	64 (79.0)	
Avascular necrosis	11 (16.4)	16 (19.8)	
Post-traumatic osteoarthritis	0	1 (1.2)	

CoC, ceramic on ceramic; MoP, metal-on-highly cross-linked polyethylene; BMI, body mass index.

Table 2
Characteristics of Implants.

	CoC Group (n = 67)	MoP Group (n = 81)
Cementless cup		
Trident PSL	30 (44.8%)	64 (79.0%)
TriAD HA	10 (14.9%)	17 (21.0%)
Securfit AD	27 (40.3%)	0
Cementless stem		
Securfit	31 (46.3%)	50 (61.7%)
Super Securfit	36 (53.7%)	6 (7.3%)
Cemented stem		
C-stem	NA	25 (30.9%)

CoC, ceramic on ceramic; MoP, metal-on-highly cross-linked polyethylene; NA, not available.

Radiographic evaluations with images magnified to 400% were independently performed by 2 surgeons using the Neochart computer system (Fujitsu Co, Tokyo, Japan).

Definite loosening of the femoral component was defined as progressive axial subsidence of >3 mm or a varus or valgus shift [9]. Definite loosening of the acetabular component was diagnosed if the position of the component changed (over 2 mm vertically and/or medially or laterally) or if a continuous radiolucent line wider than 2 mm was seen on both AP- and Lauenstein-view radiographs [10]. Osteolysis was defined as areas of endosteal, intracortical, or cancellous destruction of the bone that were not linear, exceeded 2 mm in width, and were progressive [11]. Acetabular inclination was measured using the transischial line as reference, and anteversion was investigated using the method of Lewinnek et al [12-14].

Using the methods of Dorr et al [15], 2 surgeons examined femoral head penetration into the liners from digitized AP- and Lauenstein-view radiographs by using the computer-digitizer facilities of the Roman V1.70 software (Institute of Orthopaedics, Oswestry, UK) [3,16,17]. The size of the implanted femoral head (26, 28, or 32 mm) was used as an internal reference (Fig. 1).

Femoral head penetration was investigated at annual intervals to calculate the wear, true wear, and creep rates. Wear rate was calculated by dividing total femoral head penetration by the time of the last follow-up in years. Linear regression was conducted for the mean femoral head penetration over time, and the creep and true wear rates were ascertained as the y-intercept and the slope of linear regression, respectively [16].

Intraclass correlation coefficients were calculated and used to determine interobserver reliability regarding the measurement of femoral head penetration.

Statistical Analysis

Statistical analyses included Fisher exact test, Student *t* test, and Kaplan–Meier survival analysis. All analyses were performed using SPSS, version 21 (IBM Corp, Armonk, NY). A *P* value <.05 was considered statistically significant.

Table 3
Femoral Head Diameter.

Diameter	Ceramic Head, n (%)	Cobalt Chrome Head, n (%)
26 mm	NA	81 (100)
28 mm	36 (53.7)	0
32 mm	31 (46.3)	0

NA, not available.