Comparison of Ten-Year Survivorship of Hip Prostheses with Use of Conventional Polyethylene, Metal-on-Metal, or Ceramic-on-Ceramic Bearings

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Background: To improve the long-term performance of hip prostheses, alternative bearings with metal-on-metal (MoM) and ceramic-on-ceramic (CoC) couples have been introduced. Although currently the results from the use of these bearings are in the midterm stage, there have been few comparative studies of these different bearings.

Methods: From 2000 to 2002, 487 total hip replacements were performed with use of a BICON-PLUS acetabular cup and an SL-PLUS femoral stem (Plus Orthopedics, Rotkreuz, Switzerland, now Smith & Nephew Orthopaedics). The patients were divided into three groups according to the type of bearing that was used: an MoM group (sixty-nine prostheses), a metal-on-polyethylene (MoP) group (200 prostheses), and a CoC group (218 prostheses). Patient demographic data and data with regard to revision operations were evaluated from the hospital computer database. The mean follow-up period was 8.5 years (range, 6.9 to 10.5 years). Patient activity was assessed with use of the University of California at Los Angeles activity scale.

Results: The mean patient age was sixty years at the time of the index arthroplasty in the MoM and CoC groups, and seventy-one years in the MoP group. Based on a scale of ten, the mean postoperative activity level was six in the CoC group, five in the MoM group, and four in the MoP group. Survival at ten years with regard to revision for any reason was 0.984, 0.956, and 0.879 for the MoP, CoC, and MoM groups, respectively. When revision for any reason was considered as the end point, survival of the MoM bearings was significantly worse than that of the MoP bearings (p = 0.005). Survival at ten years with regard to revision for aseptic loosening was 0.995, 0.990, and 0.894 for the MoP, CoC, and MoM groups, respectively. When revision for aseptic loosening was considered as the end point, survival of the MoM group was significantly worse than that of either the MoP group (p = 0.001) or the CoC group (p = 0.003).

Conclusions: When comparing two groups of patients of similar mean age and mean activity level undergoing total hip arthroplasty with the use of alternative bearings, CoC bearings had better survival than did MoM bearings at the ten-year follow-up; the difference was significant when revision for aseptic loosening was defined as a failure. However, neither the CoC nor the MoM alternative bearings provided improved midterm results when compared with the results of the conventional MoP bearings. For older, less active patients, traditional metal-on-polyethylene bearings are the appropriate choice.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.
The main reason for failure of metal-on-polyethylene (MoP) hips that are made with conventional (i.e., not highly cross-linked) polyethylene is aseptic implant loosening. To overcome this problem, third-generation metal-on-metal (MoM) bearings and ceramic-on-ceramic (CoC) bearings were introduced in the field of hip arthroplasty in the early 1990s for use in total hip replacement (THR). These so-called alternative bearings were developed to reduce wear and, consequently, to reduce the production of wear-debris particles that are believed to be the main cause of osteolysis and related aseptic loosening. Furthermore, the very low in vitro wear of these materials was extrapolated to be mirrored in comparatively low wear in vivo. Clinical assessment of both MoM and CoC alternative bearings is currently in the midterm phase (i.e., five to thirteen years of follow-up).

The cobalt-chromium-molybdenum (CoCrMo) alloy used in the MoM bearings in the 1960s and 1970s was a cast alloy containing 0.2% carbon by total weight. In the third generation of MoM bearings, a high-carbon alloy (>0.2% carbon by total weight) and a low-carbon alloy (<0.07% carbon by total weight) are used. A variety of production procedures, including cast forging, heat treatment, and annealing, have been adopted by manufacturers to achieve the desired distribution of carbides within the alloy. MoM couples of the previous generations usually achieved good clinical results and showed low wear. Midterm results for third-generation bearings have indicated as much as 100% survival at ten years when revision arthroplasty was used as the end point.

Compared with the alumina used in first-generation and second-generation CoC bearings, the third-generation alumina (Biolox forte; CeramTec, Plochingen, Germany) has an increased density (3.98 g/cm³) and a grain size smaller than 2 μm, achieved with use of hot isostatic pressing subsequent to sintering. Results for the third-generation CoC bearings are promising, with the reported survival reaching 99% at ten years when revision of the prosthesis for any reason is used as the end point.

Despite the great optimism following the introduction of alternative bearings, there is a relative lack of comparative studies among the different types of alternative bearings and, furthermore, between alternative and conventional MoP bearings. To compare the survivorship of different types of bearings, we evaluated a consecutive series of patients who received the same type of acetabular and femoral components but different types of bearings (i.e., MoM, MoP, or CoC).

Materials and Methods

Patient Demographics

From January 2000 to December 2002, 487 primary consecutive THRIs were performed on 469 patients at our institution with use of a BICON-PLUS acetabular cup and an SL-PLUS femoral stem (Plus Orthopedics, Roetkreuz, Switzerland, now Smith & Nephew Orthopaedics). The selection of the type of bearing surface was at the discretion of the surgeon. There were no specific inclusion or exclusion criteria. The following patient data were retrieved from the hospital arthroplasty computer register: age, sex, side, initial diagnosis, implant data, reason and date of revision, and complications. The data on deceased patients were obtained from the Ministry of the Interior. This study received Institutional Ethical Review Board approval.

The standard postoperative regimen included patient assessment at three, six, and twelve months after the index surgery and at one or two-year intervals thereafter. Analysis of the clinical and radiographic data from the database is beyond the scope of the present study.

Patients were divided into three groups according to the type of bearing couple that was used: MoM, MoP, or CoC. The number of patients, number of implants, and demographic patient data are presented in Table I. The numbers of prostheses in the MoP and CoC groups were similar, 200 and 218, respectively, and the number in the MoM group was smaller (sixty-nine). There were sixty patients who died during the course of the study (sixty-two prostheses: eight MoM, thirty-one MoP, and twenty-three CoC) and fourteen patients who were lost to follow-up (forty prostheses: six MoM, eight MoP, and zero CoC). Thus, a total of 395 patients (411 prostheses) (84%) remained for review.

The mean patient age at the time of the index operation was sixty years in the MoM and CoC groups and seventy-one years in the MoP group. The mean follow-up time was 8.5 years (range, 6.9 to 10.5 years). Overall, the percentage of male and female patients was 36% and 64%, respectively. The percentages of right and left hips were 53% and 47%, respectively.

The most common diagnosis for the index operation was osteoarthritis, present in 65% of MoM patients, 75% of CoC patients, and 88% of MoP patients (Fig. 1). The remaining major diagnoses were osteonecrosis of the femoral head, developmental hip dysplasia and its sequelae, osteoarthritis secondary to dysplasia, posttraumatic disorder (PT), rheumatoid arthritis, other inflammatory diseases, and other diseases.

Ratings for activity level were based on the University of California at Los Angeles (UCLA) 10-point rating system, as adapted to the customs of the local population. The questionnaire was sent to 395 patients, and 74% returned completed forms.

Twenty-two patients had undergone previous hip surgery; six in the MoP group, eight in the CoC group. In the MoP group, two patients had had a femoral osteotomy and four had had an osteosynthesis due to proximal femoral fracture. In the MoM group, one patient had undergone a pelvic osteotomy; two patients, an acetabular shelf arthroplasty (i.e.,

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### Table I: Number of Patients and Implants, Number of Implants Available for the Study, and Demographic Data for Groups of Patients with Different Bearing Couples

<table>
<thead>
<tr>
<th>Type of Bearing</th>
<th>No. of Patients</th>
<th>No. of Implants</th>
<th>No. (%) of Implants for the Study</th>
<th>Sex (No. of implants) (%)</th>
<th>Side (No. of implants) (%)</th>
<th>Mean Age (Range) (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoM</td>
<td>68</td>
<td>69</td>
<td>55 (80%)</td>
<td>13 M (19%), 56 F (81%)</td>
<td>34 R (49%), 35 L (51%)</td>
<td>60 (30 to 76)</td>
</tr>
<tr>
<td>MoP</td>
<td>199</td>
<td>200</td>
<td>161 (80%)</td>
<td>51 M (26%), 149 F (74%)</td>
<td>120 R (60%), 80 L (40%)</td>
<td>71 (45 to 82)</td>
</tr>
<tr>
<td>CoC</td>
<td>202</td>
<td>218</td>
<td>195 (89%)</td>
<td>111 M (51%), 107 F (49%)</td>
<td>104 R (48%), 114 L (52%)</td>
<td>60 (36 to 75)</td>
</tr>
<tr>
<td>Total</td>
<td>469</td>
<td>487</td>
<td>411 (84%)</td>
<td>175 M (36%), 312 F (64%)</td>
<td>258 R (53%), 229 L (47%)</td>
<td>64 (30 to 82)</td>
</tr>
</tbody>
</table>

*MoM = metal-on-metal, MoP = metal-on-polyethylene, CoC = ceramic-on-ceramic.
acetabular roof augmentation); four patients, a femoral osteotomy; and one patient, an osteosynthesis due to proximal femoral fracture. In the CoC group, one patient had undergone a pelvic osteotomy; two patients, a femoral osteotomy; and five patients, an osteosynthesis due to proximal femoral fracture.

**Hip Implants**

The BICON-PLUS acetabular cup and SL-PLUS femoral stem are depicted in Figs. 2-A and 2-B, respectively. The acetabular component consisted of a biconical, cementless threaded shell made of commercial pure titanium and an RCH-1000 Chirulen (Quadrant PHS Deutschland GmbH, Vreden, Germany) ultra-high molecular weight polyethylene (UHMWPE) liner (ISO [International Organization for Standardization] 5834-2, ASTM [American Society for Testing and Materials] F648). The UHMWPE liner was manufactured by Quadrant PHS Deutschland GmbH. Polyethylene was gamma-radiation sterilized (cobalt-60) while sealed in a threefold pouch in a nitrogen atmosphere. The dose adopted was between a minimum of 25 kilogram (kGy) and a maximum of 37 kGy. It is not substantial but it is a dose that induces some cross-linking. Combination of the liner with different inlays and femoral heads results in different articulating (bearing) surface combinations. In the MoP combination, the UHMWPE liner is combined with a metal femoral head (or ball) manufactured by Lima (Udine, Italy), and made of AISI (American Iron and Steel Institute) 316L. In MoM and CoC combinations, both the metal and ceramic inlays are stably anchored in a polyethylene bed. The metal inlay and femoral ball were made of Sikomet SM21 alloy, which is a low-carbon, forged, vacuum-melted cobalt-chromium-molybdenum (Co-28Cr-6Mo) alloy exhibiting fine grain structure with an almost carbide-free surface. In the CoC couple, the ceramic inlay and femoral ball were made of Bionox forte (CeramTec) alumina ceramics. A 28-mm diameter femoral head was used in all patients.

The SL-PLUS femoral stem is a cementless, rectangular, dual-taper straight stem made of titanium-aluminum-niobium (Ti-6Al-7Nb) alloy (Plus Orthopedics AG, now Smith & Nephew Orthopaedics) (Fig. 2-B).

**Operative Technique**

All surgical procedures were performed by senior high-volume surgeons at a single center and in a vertical laminar air flow operating room. All operative procedures were performed with use of a direct lateral or anterolateral surgical approach. Implant templating was used preoperatively to determine the sizes of the components to be implanted. Antibiotic prophylaxis with a first-generation cephalosporin was administered perioperatively and during the first twenty-four hours postoperatively. Low-molecular-weight heparin or warfarin was used routinely as thromboembolic prophylaxis for up to three months postoperatively. Patients were mobilized on the first postoperative day and were permitted to bear weight as tolerated.

**Radiographic Analysis of Revised Patients**

Anteroposterior radiographs of the pelvis were analyzed according to the method of DeLee and Charnley for the acetabular side and the method of Gruen et al. for the femoral side. Radiographic acetabular loosening was defined as the presence of a complete radiolucent line of ≥1 mm in all three zones, cup migration of ≥3 mm, or a change of more than 5° in cup inclination. The stability of the femoral component fixation was assessed with use of the classification system described by Engh et al. The femoral component was considered loose if serial radiographs demonstrated a change in the position of the femoral component with subsidence of ≥2 mm, or varus or valgus tilting.

Osteolysis was classified as linear or expansile, periarticular, or remote from the joint, according to the criteria proposed by Zicat et al. For this series, osteolysis was divided into two categories: radiolucent lines with parallel lines, and expansile lesions with ballooning shape and nonparallel demarcation lines. Osteolysis was considered minor for radiolucent lines that were at least 5 mm long and at least 2 mm wide fulfilling both criteria. If a lesion was either shorter than 5 mm or narrower than 2 mm it was not considered a minor osteolysis. Osteolysis was considered major when the diameter was larger than 5 mm in any direction.

**Statistical Analysis**

Implant survival, with a 95% confidence interval, was estimated by the Kaplan-Meier method. Data on revision operations performed on the study groups up to the date of October 1, 2009, were obtained from our hospital arthroplasty register.
was considered to be the time between the date of implantation and the date of revision. Survival was calculated for each of the bearing groups separately. The correlation of survival in various groups was tested with use of the log-rank test. This test was carried out to determine whether the difference in survival between different bearings groups was significant. A confidence interval of 95% was considered as significant.

Source of Funding
This study was supported by the Slovenian Research Agency through Grant No. J3-0052. This source of funding played no role in the course of the investigation and had no influence on the results obtained.

Results
Surgical and Other Complications

to evaluate the complication rates among the cohorts in the study, we searched the hospital computer database for patient medical records and specifically for surgical and medical complications during the hospitalization period of the patients.

We excluded leg-length differences from the analysis due to inadequate data collection, and we also excluded wound hematomas due to the subjectivity of the medical records with regard to this problem.

We grouped the medical complications according to the organ system involved, accepting the fact that groups can be very heterogeneous in terms of adverse event etiology. Altogether, there were nineteen surgical and fifty-one medical complications of various degrees of severity, including six pulmonary emboli and/or deep vein thromboses that were diagnosed with computed tomography angiography and Doppler ultrasound scan, respectively. The distribution was stratified according to the bearing couple and organ system (Table II). Among the surgical complications, there were five femoral nerve lesions, two early acute deep infections, and three hip dislocations. There were no bone fractures.

Demographic Patient Data
Although there were no specific inclusion or exclusion criteria, the surgeons closely followed the recommendation that alternative bearings are suitable for younger, more active patients, which resulted in the difference in the average age of patients in the cohorts (Fig. 3). The patients in the MoP group were, on average, eleven years older than those in the MoM and CoC groups. The number of arthroplasties performed in patients under the age of fifty years, under the age of sixty-five years, and sixty-five years of age or older differed, depending on the bearing combination that was used. The age distribution is similar within the MoM and CoC groups, and very different within the MoP group. The percentage of patients who were younger than fifty years was highest in the MoM group (17%), somewhat lower in the CoC group (13%), and lowest in the MoP group (1%).

The postoperative activity of patients in the groups also varied (Fig. 3). The highest average activity score was achieved...
in the CoC group (6 points), followed by the MoM (5 points)
and MoP (4 points) groups.

**Analysis of Survival**

Kaplan-Meier survival curves were calculated for revision
for any reason and for revision for aseptic implant loosening as
the end points (Fig. 4). At ten years, the survival with failure
defined as revision for any reason (Fig. 4-a) was highest
in the MoP group at 0.984 (95% confidence interval, 0.966
to 1.00). Survival in the CoC group, at 0.956 (95% confi-
dence interval, 0.928 to 0.983), was higher than in the MoM
group, which was at 0.879 (95% confidence interval, 0.785
to 0.973).

Survival with aseptic revision as the end point was the
same as that for revision for any reason in the MoM and MoP
group, and somewhat lower, 0.961 (95% confidence interval,
0.933 to 0.988) in the CoC group.

At ten years, survival with revision for aseptic loosening
as the end point (Fig. 4-b) was highest in the MoP group, at
0.995 (95% confidence interval, 0.985 to 1.00). Survival in the
CoC group, at 0.990 (95% confidence interval, 0.976 to 1.00),
was higher than that in the MoM group, which was at 0.894
(95% confidence interval, 0.804 to 0.984).

When revision for any reason was considered as the end
point, there was a significant difference (p = 0.005) between
the MoM and MoP groups (Fig. 4-a). The difference in survival
between the other two groups was not significant: a compari-
sion between the MoP group and the CoC group resulted in a
value of p = 0.117; and between the CoC group and the MoM
group, a value of p = 0.15. When revision for aseptic loosening
was considered, however, the survival of the MoM group was
significantly worse than that for both MoP (p = 0.001) and CoC
groups (p = 0.003) (Fig. 4-b). There was no significant dif-
fERENCE with regard to survival of the implants in the CoC and
MoP groups (p = 0.63).

**Analysis of Revisions**

There were eighteen revisions in the whole series of 411 hips
available for the study (see Appendix). The percentage of re-
vision for any reason was 4.4%. One revision (0.2%) was ne-
cessitated by infection, and seventeen revisions (4.1%) were

![Fig. 3](https://example.com/f3.png)

Comparison of mean age and mean postoperative activity for patients with three different bearing couples. Minimum and maximum data are indicated by
range bars. Please note that the left-side y-axis is for age, and the right-side y-axis for activity. The distribution of age groups (i.e., younger than fifty years,
younger than sixty-five years, and sixty-five years or older) in the particular group is presented by various patterns.

<table>
<thead>
<tr>
<th>Complications</th>
<th>MoP</th>
<th>MoM</th>
<th>CoC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary embolism and deep vein thrombosis</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Surgical complications</td>
<td>7</td>
<td>2</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Femoral nerve palsy</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Femoral neuralgia</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Ischial nerve palsy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deep infection</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Superficial wound infection</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dislocation</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Implant fracture</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Medical complications</td>
<td>19</td>
<td>11</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Respiratory</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Neurosensory</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Urinary</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Allergic</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

*MoP = metal-on-polyethylene, MoM = metal-on-metal, and CoC = ceramic-on-ceramic.*
necessitated by other problems. The percentage of revisions differed among the three groups. In the MoM group, there were six revisions (10.9% of the fifty-five MoM prostheses that were available for review), which was the highest percentage of revisions in the three groups. In the CoC group, there were nine revisions (4.6% of the 195 CoC prostheses that were available for review). The lowest number of revisions (three) was in the MoP group (1.9% of the 161 MoP prostheses that were available for review).

The main reasons for revision differed among the three groups. In the MoM group, five of six revisions were due to aseptic loosening and one was due to dislocation. In contrast, only two of nine revisions were due to aseptic loosening in the CoC group. Four of nine were due to fracture of ceramic components, resulting in an implant fracture rate of 1.8%. Ceramic fracture was thus the major reason for revision in the CoC group. The remaining three revisions were due to dislocation, infection, and fracture of the base-plate of the metal acetabular shell. In the MoP group, one of the three revisions was due to aseptic loosening and the remaining two were due to periprosthetic fracture following a fall.

Among hips that underwent revision arthroplasty, three had radiographic evidence of osteolysis. In the MoM group, osteolysis was identified in two of five cases of aseptic loosening (see Fig. E-1a and b in Appendix). In one hip, osteolysis was observed on the acetabular side as well as the femoral side. On the acetabular side, the osteolysis was expansile and was located in DeLee and Charnley zones I and III, whereas on the femoral side it was linear and located in Gruen zone 1. In another hip, osteolysis was observed only on the femoral side and was linear and located in Gruen zone 1. In the CoC group, osteolysis was identified in one of two cases of aseptic loosening. It was expansile in type and was located in DeLee and Charnley zone 1 (see Fig. E-1c and d in Appendix). All osteolytic lesions were characterized as small. No osteolysis was observed in the MoP group.

**Discussion**

Various third-generation designs of CoC and MoM bearings have been similarly implanted worldwide, especially in young and more active patients. Currently, the survival results of these alternative bearings are in the midterm phase.

Because in vitro wear of low-carbon alloy has been shown to be higher than that of high-carbon alloy, it has been postulated that the latter would achieve better in vivo survival. For low-carbon alloy, the survival with revision for any reason has ranged between 97% at nine years for patients with a mean age at time of index operation of fifty-five years, and 91% at ten years for patients with a mean age of fifty-seven years. For high-carbon alloy, the survival with revision for any reason has ranged between 94% and 98.6% at ten years for patients with a mean age at the time of index operation of sixty-two years, and fifty-six years, respectively, and 91.2% and 94.4% at twelve years for patients with a mean age at the time of index operation of sixty-three years and fifty-six years, respectively. For CoC implants with Biolox forte bearings, survival with revision for any reason was 96% for patients at nine years who had a mean age at the time of index operation of fifty years, and 99% at ten years for patients who had a mean age of forty-one years. On the basis of these data, it is difficult to reach

![Survivals for the BICON-PLUS cups with different bearing couples: metal-on-polyethylene (MOP), metal-on-metal (MOM), and ceramic-on-ceramic (COC), with revision for any reason (Fig. 4a) and revision due to aseptic loosening (Fig. 4b) as the end points. The significance between various groups is noted.](https://example.com/fig4.png)
a conclusion as to which type of bearing achieved the best midterm performance. It appears that, at ten years, the results for high-carbon MoM alloy and Biolox forte ceramics were similar and somewhat higher than those for low-carbon MoM alloy.

Comparative studies of various bearings are limited. At a mean of six years, no significant difference was observed, with regard to clinical performance, between patients who received alumina-on-alumina or MoP bearings of the ABC system (Stryker Orthopaedics, Kalamazoo, Michigan). In the MoP bearings in that study, a polyethylene liner that had been gamma-irradiated in nitrogen and vacuum packaged was used. However, the revision rate in the MoP group (i.e., 7.5%) was higher than that in the study group (i.e., 2.7%). In a matched case-control study, the hypothesis that the use of MoM bearings reduces the risk of aseptic component loosening when compared with MoP bearings was investigated. Cases were identified from a computerized joint database and multiple controls were matched to each case for sex, age, diagnosis, hospital, operation date, follow-up, stem type, and cup design. At a mean follow-up of four years, MoM bearings had a lower risk of aseptic stem and/or cup loosening than MoP bearings did, although this difference was not significant. Opposite results were obtained in a meta-analysis of literature aimed at identifying the optimal bearing for young (less than fifty-five years of age) active patients. The best bearing surface was found to be MoM, which resulted in a significantly higher rate of survival than that of MoP and CoC bearings. However, after adjusting for multiple comparisons, this difference no longer reached the conventional threshold of significance. Furthermore, the small size of the MoM and CoC groups made the statistical analysis in this study weak.

The comparison of alternative bearings in the present work shows that, for the two patient groups of similar age and activity, higher survival was achieved with CoC bearings than with the MoM group when revision for any reason was the end point; however, the difference was not significant at the ten-year follow-up. For survival with revision for aseptic loosening as the end point, the difference was significant (p = 0.003). This stems from the fact that the major reasons for revision in the two groups differed—aseptic loosening was the main reason in the MoM group, and ceramic fracture was the major reason in the CoC group. Aseptic loosening in the MoM group occurred in two cases accompanied by osteolytic lesions; in the CoC group, one case was noted. According to literature reports, osteolysis appears to be a rare event with CoC bearings. For the MoM bearings, on the other hand, osteolysis has been reported more frequently. In our previous study, sixteen of the twenty-five MoM hips that were revised for aseptic loosening and/or pain exhibited osteolysis. Recently, early osteolytic lesions localized to the greater trochanter were noted in ten of 169 MoM hips. In contrast, in two studies no osteolysis with MoM bearings was observed.

Both CoC and MoM bearings have advantages and drawbacks. The risk of fracture should be minimal in the third generation of CoC bearings, although some recent reports indicated that the risk of ceramic fracture is between 1% and 2%. This is not a negligible percentage and, whatever the reason for fracture, this risk should be clearly presented to the patients as well as to the medical community. MoM bearings cannot fracture, which is an advantage over CoC bearings. However, the increased metal serum levels associated with use of the MoM bearings and the potential for hypersensitivity reaction to metal debris are issues for concern. Both of these issues for the MoM bearings from this series were addressed in our previous reports. Despite low wear, aseptic loosening remains the main reason for revision of MoM bearings. This result implies that not only the degree of wear but also other reasons contribute strongly to the prevalence of aseptic loosening. In this context, a definite advantage of CoC over MoM bearings is that ceramic wear particles are more biocompatible than metal debris.

In the present work, conventional MoP bearings had a high survival of 0.984 at ten years with revision for the prosthesis for any reason as the end point. This result is superior to that of both alternative bearings used. The excellent survival achieved by the MoP bearing is among the highest reported for similar bearings, which range from 96% at ten years to 90% at fourteen years with revision for any reason.

To conclude, when considering the optimal bearing surface for relatively active patients with a mean age of sixty years, MoM bearings had the lowest survival. Moreover, their use raises concerns related to the long-term systemic increase of metal levels and adverse reaction to metal debris and ions. CoC bearings had better survival; however, the risk of fracture is not negligible. When choosing the optimal bearing surface for younger patients, both the benefits and the risks of a particular combination should be considered. We believe, however, that for older, less active patients, the traditional metal-on-polyethylene bearing surface is the appropriate choice, since it had excellent long-term survivorship for the vast majority of patients.

Appendix

A figure and a table showing details of individual revision cases are available with the online version of this article as a data supplement at jbjs.org.