Is There a Risk in Placing a Ceramic Head on a Previously Implanted Trunion?

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Abstract

Background Strategies for revising a ceramic-on-ceramic total hip prosthesis are controversial. Some consider reimplantation of a ceramic head on a well-fixed femoral stem inadvisable as it may lead to a fracture of the newly implanted head.

Questions/purposes We assessed (1) the risk of fracture when a new ceramic head was placed on a previously implanted trunion; (2) the survival rate of the revised hips; and (3) hip function and acetabular and femoral component loosening at midterm followup.

Patients and Methods We retrospectively reviewed all 126 patients (139 hips) who had revision of alumina-alumina hip arthroplasties between January 1977 and December 2005. Of these, 99 patients (110 hips) had revision of the socket only with retention of the femoral component. The femoral head was left in place in 33 hips, the same alumina head was re-implanted in seven hips, a

new alumina head was implanted in 45 hips, a metallic head in 16, and a zirconia head in nine. Twenty-six patients (29 hips) died and nine (10 hips) were lost to followup before 5 years; this left 71 hips for review. Minimum followup was 60 months (mean, 112 months; range, 60–319 months).

Results Eighteen hips required rerevision surgery, 11 for aseptic loosening, two for septic loosening, two for fracture of a ceramic liner, one for recurrent dislocation, one for ipsilateral femoral fracture, and one for unexplained pain. Among the 61 ceramic heads implanted on a well-fixed stem, no fracture of the head occurred at a mean 88 months' followup. The survival rate at 10 years with mechanical failure as the end point was 81.6%.

Conclusions We observed no fractures of the ceramic heads implanted on a previous titanium trunion. This approach is possible if inspection shows no major imperfection of the Morse taper.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at Hôpital Lariboisière.

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Introduction

Alumina-on-alumina bearing surface has become an alternative to standard surface bearings because of decreased wear production [5, 6, 28, 31] and lower rates of osteolytic lesions [4, 18, 37]. Although comparative studies report superior sliding capacities on hip simulators and from retrieved implants of alumina-on-alumina versus metal-on-PE bearings [7, 8, 13], early studies showed a high rate of aseptic loosening of the bulk cemented socket and risk of component fracture [27, 30]. Advances in the quality of the material have decreased the risk of fracture to

approximately 0.02% to 0.1% [19, 35]. Currently, the main challenge facing alumina-on-alumina arthroplasty is the long-term fixation of the acetabular component, with survival rates of 88.6% to 98.3% at 10 years [2, 3, 30].

Recently, a number of authors have raised concerns regarding the use of titanium acetabular shells coupled with ceramic press-fit liners, including malseating of the ceramic liner [27, 30], fracture of the liner [20], and noise [23, 26, 34], all being potential reasons of failure and revision surgery of ceramic prostheses.

Strategies for revising a ceramic-on-ceramic THA are still controversial [19, 29, 32, 35]. According to ceramic manufacturers [35], the reimplantation of a ceramic head on a well-fixed femoral stem is inadvisable because the taper is likely to be damaged by the removal of the femoral head or a fracture of the ceramic. Potential damaged areas of the taper may create an area of stress riser that can be responsible for the initiation and propagation of a crack that ultimately would lead to a fracture of the newly implanted head. However, the risk of fracture of a new ceramic head implanted on a well-fixed stem seems to be low, as few cases have been reported in the literature [32].

Therefore, we performed a retrospective study to assess (1) the risk of fracture of ceramic heads implanted on used trunions; (2) the 10-year survival rate of the revised hips; (3) hip function (using the Merle d'Aubigné Postel score [PMA]) and acetabular and femoral component loosening at midterm followup.

Patients and Methods

Through a search of operative records, we identified 126 patients (139 hips) who had revision of an alumina-alumina hip prosthesis between January 1977 and December 2005 for mechanical failure. Of these 139 hips, 110 (99 patients) had revision only of the acetabulum with a retained femoral component. The indication for revision was isolated aseptic loosening of the acetabular component in 91 hips, unexplained pain in seven, fracture of a ceramic implant in eight (one head, seven sockets), and recurrent dislocation in four (Table 1).

Table 1. Indications for revision surgery

Indication for revision	Number of hips
Socket loosening	91
Unexplained pain	7
Alumina liner fracture	7
Alumina head fracture	1
Recurrent dislocation	4
Total	110

We excluded six patients who had revision for sepsis. The time elapsed between the most recent arthroplasty and revision averaged 76 months (range, 2–222 months). There were 68 women (69%) and 31 men (31%), with an average age at the time of revision of 64 years (range, 27–92 years). Mean ($\pm$ SD) patient weight was 67 ± 11 kg (range, 40–104 kg), and height was 163 ± 13 cm (range, 148–180 cm). The predominant underlying condition leading to THA was osteoarthritis in 54% of the cases (Table 2). The revision surgery was the first revision for 100 hips and the second for 10 hips. Of the original 99 patients, 26 patients (29 hips) died, two patients (two hips) were living abroad and could not be contacted, and seven (eight hips) were lost to followup before 5 years, leaving 64 patients (71 hips—64%) for review. In the group of 26 patients who died, 18 patients were older than 70 years at the time of revision surgery (age, 72 ± 10 years), and 19 were born before 1920 and would have been older than 90 years at the time of this review. Minimum followup was 60 months (mean, 112 months; range, 60–319 months). No patient was recalled specifically for this study; all data were obtained from records. Our review had prior approval of our institutional review board.

Bone stock deficiencies were classified according to the American Academy of Orthopaedic Surgeons (AAOS) system [10]. The classification was based on the analysis of preoperative plain radiographs and on the description of bone defects in operative notes. Acetabular bone stock losses were classified as follows: 16 hips had no acetabular deficiency, two had a segmental Type I defect, 62 had a cavitary Type II defect, 30 had a combined Type III defect, and none had a Type IV pelvic discontinuity. On the femoral side, bone defects were limited to the calcar in 90% of the hips. According to the AAOS classification system [9], the defects were classified as cavitary Type II defects in 108 hips and combined Type III defects in two hips. Bone grafting was only necessary on the acetabular side. Contained acetabular bone defects were packed with

Table 2. Underlying diagnoses

Initial diagnosis	Number of hips (%)
Osteoarthritis	60 (54.6)
Posttraumatic arthritis	4 (3.6)
Osteonecrosis	14 (12.8)
Developmental dysplasia of the hip	24 (21.9)
Legg-Calvé-Perthes disease	2 (1.8)
Inflammatory arthritis	3 (2.7)
Other*	3 (2.7)
Total	110 (100)

* Congenital coxa vara (one), sickle cell disease (one), slipped capital femoral epiphysis (one).

morselized allograft, whereas relevant segmental bone defects were reconstructed with bulk allografts supported with either the Kerboul acetabular reinforcement device (Stryker Howmedica, Herouville Saint Clair, France) (39 hips, 35.4%) or a Müller reinforcement ring (Zimmer, Inc, Warsaw, IN) (three hips, 2.7%).

Different designs and modes of fixation had been explored on the socket side during this 25-year period. The acetabular component was inserted with cement in 54 hips (49%) and without cement in 56 hips (51%). Fifty-four were cemented plain alumina sockets, 34 were titanium alloy smooth screw-in rings with an alumina insert, 16 were fiber-mesh metal backs with an alumina insert, and six were press-fit bulk alumina sockets. All revised prostheses were manufactured by Ceraver® (Roissy, France). On the femoral side, a collared smooth stem made of anodized titanium alloy was cemented in 103 cases with the so-called second-generation technique, and a fully hydroxyapatite-coated tapered cementless stem was inserted in the remaining seven hips. Our experience with the cementless stem began in 1997.

The revision arthroplasty was performed through a posterior approach in 73 hips (66.3%), a transtrochanteric approach in 26 hips (23.7%), and a Hardinge transgluteal approach in 11 hips (10%). Only the acetabular component was changed in all 110 hips. The alumina head was left in place in 33 hips, the same alumina head was removed for better exposure and reimplanted in seven, a new alumina head was implanted on the same stem in 45, a metallic head in 16, and a zirconia head in nine. Overall, an alumina-alumina combination was implanted in 31 hips (20 press-fit metal backed, five threaded titanium, five cemented sockets, one press-fit bulk alumina socket), an alumina-polyethylene in 55, a metal-polyethylene in 15, and a zirconia-polyethylene in nine. Polyethylene cups were cemented in 91% of the cases (Table 3).

The postoperative regimen included early mobilization and strengthening exercises begun on the first postoperative day. All patients received inpatient physical therapy for a mean of 6 weeks under the supervision of qualified therapists and physicians in a rehabilitation center. Patients were restricted to 50% body weightbearing with two crutches until the sixth postoperative week, at which time they were

encouraged to weightbear fully as tolerated. When acetabular bone grafting was performed, the protocol was slightly modified, allowing walking without weightbearing during the first 6 weeks and 50% body weightbearing from 6 to 12 weeks.

All patients underwent postoperative followup evaluation with a complete physical examination in the outpatient clinic at 6 weeks, 3 months, 6 months, 1 year, and annually thereafter. The Merle d'Aubigné-Postel rating system was used to quantify hip pain, mobility, and stability [11].

Two of us (JD, DH) independently reviewed standardized AP pelvic radiographs taken preoperatively and at the latest followup. On the socket side, the parameters assessed were the inclination angle of the cup, vertical and horizontal migration of the hip center, the presence of radiolucent lines in six zones of the socket, and when a polyethylene cup was implanted, measurement of wear with the method of Livermore et al. [25]. The interobserver variability for the measurement of cup inclination angle is estimated to be within 2°, and the accuracy of the Livermore method has a median error of less than 0.6 mm [12]. When a Kerboul acetabular device was implanted, parameters analyzed included the positioning of the hook under the inferior margin of the acetabulum and the inclination angle of the acetabular device. Acetabular loosening was defined as a change in the opening angle of the socket of more than 4°, a cup migration of more than 4 mm, or a failure of the acetabular reinforcement device. On the femoral side, several parameters were investigated: the distance between the collar of the prosthesis and the lesser trochanter, the presence of radiolucent lines in seven zones of the femur according to Gruen et al. [16], and the presence of cement fracture lines.

Qualitative data were expressed as counts and percentages within groups, and quantitative data by mean $\pm$ SD. Qualitative data (gender, preoperative diagnosis) were compared using the chi square test or Fisher's exact test. For quantitative data (PMA score, inclination angle of the acetabulum), we determined differences between pre- and postoperative values using Student's *t* test and the Mann-Whitney test depending on the distribution of the data. We attempted to determine whether there was a relationship between iterative aseptic loosening, if present, and gender, age of more than 50 years, body mass index of 30 or greater, high level of activity, type of prosthesis implanted at revision surgery, and amount of preoperative osteolysis. To test differences among at least three groups, we performed ANOVA or the Kruskal-Wallis test when the data did not meet the assumptions of normality. We performed actuarial survivorship analysis [15] using mechanical failure and revision for any mechanical failure of either component at the time of followup as the end points. The survival curve was derived from the cumulative survival

Table 3. Fixation status of the socket after the revision surgery

Socket	Alumina	Polyethylene
Cemented socket	5	72
Titanium screw-in ring with a insert	5	6
Fiber mesh metal back with an insert	20	1
Press-fit bulk socket	1	0
Total	31	79

rate over time as calculated from the actuarial life table. The standard error, given as a percentage, and the 95% confidence intervals (CIs) were calculated from the data in the life table. Comparative survivorship analysis was performed using the log-rank test. We used StatView[®] 5.0 software (SAS Institute, Inc, Cary, NC) for all analyses.

Results

Among the 61 ceramic heads implanted during revision surgery on a well-fixed stem, no fracture of the head occurred at 88 ± 65 months' followup. Among the 15 metallic heads implanted on a well-fixed stem, no revision surgery was performed for femoral head wear or metallosis.

Survivorship at 10 years with revision for mechanical failure as the end point was 83.1% (95% CI, 73.6%–92.6%). With mechanical failure as the end point, the hip being revised or not, the survival rate at 10 years was 81.6% (95% CI, 71.8%–91.4%) (Fig. 1). The implantation at revision surgery of a cementless threaded titanium component and an alumina cup both yielded lower survival rates (respectively, $p < 0.001$ and $p < 0.001$). There was a relationship ($p < 0.001$) between the mode of fixation on the socket and the bearing surface, as 83.8% of the implanted alumina cups were not cemented versus 8.8% of the polyethylene cups (Table 3). Among the 31 alumina

sockets implanted at the first revision surgery, seven were rerevised for loosening and one had evidence of aseptic loosening. No differences in the survival rate between men and women, or between different age groups, or between groups with different levels of daily activities could be found.

The PMA score of the 71 available hips at least 5 years after surgery increased from 11.2 ± 2.6 to 15.4 ± 2.9 at the latest followup. The scores for pain (4.9 ± 1.5), hip motion (5.75 ± 0.5), and walking ability (4.8 ± 1.5) were all improved compared to the preoperative scores. Eighteen hips required further revision surgery, 11 of which were for aseptic loosening (Table 4). Rerevision was performed 103.5 ± 68.3 months after revision surgery (range, 5–241 months). Nine hips required revision for aseptic loosening of the socket. Three more hips had isolated tilting or migration of the socket, and two had progressive demarcations around the socket at last followup examination. One hip underwent femoral stem replacement for aseptic loosening of both the femoral and acetabular components and one for isolated aseptic loosening of the femur. Four patients (3.6%) had a recurrent dislocation, one of which required revision surgery at 2 months for permanent dislocation and trochanteric nonunion fixed with a specially designed trochanteric plate. One patient had a deep infection requiring débridement and drainage. Another patient had postoperatively a retroperitoneal hematoma that was drained. The hip was revised 14 years later for septic loosening of both the femoral and acetabular components. Among the seven fractures of the alumina liner reviewed in this series, three were managed by a single replacement of the alumina liner. Two of them experienced a refracture of the liner at 5 months and 88 months after the first revision surgery. Both concerned 50-mm-diameter sockets, which design had been modified by the manufacturer in the year 2000 to diminish the initial overlap of the liner to avoid impingement with the femoral neck.

Fig. 1A–B Actuarial survivorship curves show the survival rate at 10 years was (A) 81.6% (95% CI, 71.8%–91.4%) with mechanical failure as the end point and (B) 83.1% (95% CI, 73.6%–92.6%) with revision for mechanical failure as the end point.

Table 4. Causes of rerevision surgery

Rerevision surgery	Number of hips
Aseptic loosening of the acetabulum	9
Aseptic loosening of the femoral stem	1
Aseptic loosening of the acetabulum and the femoral stem	1
Septic loosening	2
Fracture of the ceramic liner	2
Recurrent dislocation	1
Ipsilateral femoral fracture	1
Unexplained pain	1
Total	18

Discussion

Despite general opinion that a ceramic head should be implanted on a new Morse taper, there is very little literature evaluating the risk of ceramic head breakage after implantation on a used trunion. We performed a retrospective study to evaluate the risk of fracture of ceramic heads fixed on used trunions in patients who had revision of the socket only with retention of the femoral component.

There are several limitations to our study. First, ours was a retrospective study that involved a large number of different materials, qualities, and designs, especially on the socket side, some of which have been abandoned today. As no clear guidelines were available, various strategies were adopted in this series with regard to revision surgery and the implantation of a ceramic head on a well-fixed femoral stem. This is, however, a large series, which contributed to our knowledge of this material and this bearing over the years. Second, owing to the retrospective nature of this study, which spans a period of 25 years, we lost nine patients to followup and 26 patients died, leaving 71 hips for review. This is, however, comparable to other long-term studies. Third, the implantation of a ceramic head on a retained femoral stem was decided on the basis of visual examination of the Morse taper during surgery and the absence of mobility of the newly implanted head on the taper. A more reliable method would be certainly valuable to better describe the anomalies of the mating surface and to evaluate the quality of the taper before fixing the head.

Our data show reimplantation of a ceramic head on a used Morse taper can be performed without a substantial risk of fracture during revision of ceramic-on-ceramic prostheses. Removal of the femoral head was sometimes performed to enhance exposure during surgery, but care was taken to protect the Morse taper when a new ceramic head was inserted on the trunion. Since Pulliam and Trousdale [32] have reported a case of a ceramic head breakage implanted on a used taper, several authors have strongly recommended routine change of the femoral stem if another ceramic ball is to be implanted. Manufacturers also support this attitude and insist on the need to exchange a used trunion. They claim a damaged taper may have a limited zone of contact with the new ceramic head and then act as a stress riser with a risk of further fracture [36]. Moreover, secure fixation of the head on a damaged taper may be impaired, with a theoretical risk of massive wear from abnormal movement between the head and taper.

Given the lack of clear data available on the revision of ceramic-ceramic implants at the time these were performed, reuse of the same ceramic ball after dissociation was performed in seven hips, and implantation of a new ceramic ball on a used cone was performed in 54 hips. In all cases, inspection of the Morse taper showed only small

scratches, and a protection cap was used during surgery. Among these hips, we observed no ceramic fracture at a mean of 88 ($\pm$ 65) months' followup. The removal of a well-fixed stem poses major drawbacks in terms of blood loss, surgical time, future discomfort, and increased risk of surgical complications for the patient, impairing long-term hip function. We recommend surgeons perform a visual evaluation of the cone, test the fit and mobility of the ceramic head on the Morse taper, and retain the stem only if these checks are positive. If there is any uncertainty about the cone, the stem should definitely be replaced. Our observations support this strategy. This also can be easily explained to the patient. If the Morse taper is damaged, one solution would be to replace the ceramic head by a metallic ball. However, alumina particles remaining in the surrounding tissues may be responsible for third-body wear of the metallic ball, as reported by several authors [1, 24].

We found the commonest surgical indicator for revision of alumina-on-alumina prostheses was the isolated fixation failure of the socket. This was related to the use of poor designs, such as the cemented bulk alumina socket or a smooth-threaded titanium ring. Both have been abandoned today due to unacceptable rates of failure and are no longer recommended for use [18, 22, 33]. The low rate of effective osteolysis encountered with an alumina-on-alumina combination could explain why isolated revision of the socket was frequently performed and why limited bony reconstruction was necessary in most hips [14, 17, 18, 21].

When the femoral stem is well fixed, we believe revision of the acetabular component alone is wise to decrease patient morbidity, surgical time, and long-term patient hip function. With a consistent followup, we observed no fractures of the ceramic heads implanted on a previous titanium trunion, which supports the possibility to simply exchange the ceramic head when the femoral stem is preserved. This approach is possible if careful inspection shows no major imperfection of the Morse taper.

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