Alumina-on-Alumina Hip Arthroplasty in Patients Younger Than 30 Years Old

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Abstract THA in patients younger than 30 years old presents challenges: the initial technical challenge relates to the initial disease that often causes deformities making reconstruction difficult, while the long-term challenge is wear and subsequent osteolysis and component loosening. Ceramic-on-ceramic prostheses may represent a valuable option to reduce wear. We retrospectively studied 101 patients (132 hips) with ceramic-on-ceramic prostheses implanted from 1977 to 2004. As a result of the long span of time, different implant designs and modes of fixation were used. The average age of the patients was 23.4 ± 5 years (range, 13–30 years), and the main indication for THA was femoral head necrosis. The minimum followup was 1 year (mean, 6.9 years; range, 1–26.5 years). We documented 17 revisions (13%) for aseptic loosening. Twelve were for isolated acetabular loosening, two for isolated femoral loosening, and three for loosening of both components. Survivorship was 82.1% at 10 years and 72.4% at 15 years. Inferior survivorship was observed for THA performed after secondary arthritis related to slipped capital epiphysis or trauma. Limited osteolysis was observed in one hip. The main limiting

factor in this series was the fixation of the acetabular component. However, improvements in the design and in the mode of fixation of this component should enhance long-term results.

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

Introduction

Indications for THA have dramatically increased in recent years. However, reluctance to perform this operation in younger patients remains as a result of the uncertainty of long-term survivorship of the primary arthroplasty and potential complex reconstruction after a first or second failure because it can be expected that these patients may have more than one arthroplasty during their lifetime. This uncertainty led one group of surgeons to favor hip arthrodesis or resection arthroplasty for patients with monoarticular disease [42]. However, rapid recovery, superior functional results, and the occurrence of polyarticular disease influence some patients and surgeons to pursue implantation of arthroplasties.

Schmalzried et al. [39] demonstrated in 31 patients with 37 hips that polyethylene wear was related to activity. They also demonstrated activity was related to younger patient age [40], and therefore it can be expected wear and its consequences are the limiting factors of THA in a younger population. On a larger scale, the Finnish Arthroplasty Register [23] suggested the limiting factor for survival of hip arthroplasty for patients younger than 55 years old was polyethylene wear, not fixation. Hence, because resistance to wear of hard-on-hard combinations has been demonstrated, these materials can be considered valuable options

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for young patients [12, 35]. Ceramic-on-ceramic combinations, in contrast to metal-on-metal, have the theoretical advantage of chemical inertness. Recently, our group demonstrated ceramic-on-ceramic combinations with hybrid fixation provided high survival in patients younger than 55 years [8] and no osteolysis even after 15 years [28]. However, these advantages remain to be demonstrated for a younger population.

Given the motivation for alumina-on-alumina bearing surfaces in patients younger than 30 years old, we asked if there would be a high survival rate. We then asked whether initial disease, the different modes of fixation of acetabular and femoral components, or a previous operation would influence survival.

Materials and Methods

We retrospectively reviewed 101 patients (132 hips; 64 right, 68 left) younger than age 30 who had a ceramic-on-ceramic arthroplasty between September 1979 and November 2004. No other combination was used during this period for this population. The average age of the patients was 23.4 ± 5 years (range, 13–30 years). Fifty-nine patients were male and 42 were female. Seven patients died after a minimum followup of 5 months (mean, 2.3 ± 1.7 years; range, 0.4–5 years); none of these deaths were related to the patients' surgery. This left 94 patients (108 hips) with a minimum followup of 1 year (mean, 6.9 ± 4.7 years; range, 1–26.5 years) for analysis. The average height of the patients was 169 ± 8.5 cm (range, 135–188 cm), and their average weight was 64 ± 13.9 kg (range, 45–120 kg). Fifteen percent (15 patients) were overweight or obese with a body mass index over 25 kg/m^2 (range, $25.1\text{--}40.6 \text{ kg/m}^2$). Femoral head necrosis was the most common indication, occurring in 64 of 101 hips (Table 1). Other indications included posttraumatic arthritis, inflammatory disease, osteoarthritis secondary to slipped capital femoral epiphysis, postinfection osteoarthritis, osteoarthritis secondary to hip dysplasia, and tumor; the etiology was unknown in four cases. Twenty-four hips had at least one previous operation before the THA, including one Vernon-Luck cup implantation, one bipolar prosthesis implantation, four THAs, 10 femoral neck fixations after a slipped capital femoral epiphysis or a fracture, five pelvic osteotomies, three open reductions and osteosynthesis of an acetabular fracture, and five femoral osteotomies.

We used a posterior approach in 119 hips, an antero-lateral approach in five, and a direct lateral approach with trochanteric osteotomy in eight; the choice of the approach was based on surgeon preference. An autologous acetabular bone graft was performed in 14 hips and an allograft in two hips.

We used five different types of sockets by Cera-ver-Osteal (Roissy, France) during this 25-year period. A cemented plain alumina socket was implanted in 10 hips, a press-fit plain alumina socket in 22 hips (Cerapress[®]), a titanium alloy smooth screw-in ring with an alumina insert in six hips, a fiber-mesh metal-back with an alumina insert in 14 hips (Cerafit[®]), and a hyaluronan-coated titanium metal-back with an alumina insert (Cerafit-HA[®]) in 80 hips. In all hips, a 32-mm alumina head was used. On the femoral side, a cemented titanium alloy stem was implanted in 62 hips and a fully hyaluronan-coated tapered cementless stem in the remaining 70 hips; our experience with the cementless stem began in 1997. Cement was always used with a second-generation technique. Since 1977, surgical-grade alumina was used [11].

Clinical and radiographic evaluation was performed by an independent surgeon (DP) who did not participate in patient care. Clinical evaluation included physical examination and the Merle d'Aubigné-Postel hip score [14].

Standard radiographs included an anteroposterior view of the pelvis and a lateral view of the femur. On the femoral side, we (DP) examined the radiographs in the seven zones of Gruen and Amstutz [24] for radiolucent lines and osteolysis. Evidence of component mobilization was evaluated by measurement of implant subsidence and change into varus or valgus. On the acetabular side, radiolucent lines and osteolysis were evaluated and classified according to Charnley-DeLee zones [16]. Evidence of acetabular component mobilization was evaluated by sequential measurement of inclination angle and evaluation of vertical migration related to the inferior border of the acetabulum. Considering variation in radiographic technique, an angular change of more than 4° or a migration of 5 mm or more was considered important.

Kaplan-Meier survivorship analysis [3] was performed including the entire cohort of 132 hips. A subgroup analysis with the log-rank test was performed to identify the prognostic factors (JMP statistical software; SAS Institute Inc, Cary, NC).

Results

Survivorship with revision of either component as an end point was 82.1% at 10 years (95% confidence interval; range, 72.4%–91.8%) and 72.4% at 15 years (95% confidence interval; range, 57.2%–87.6%). Survival rate at 15 years was 88.1% for the femoral implants (95% confidence interval; range, 75%–100%) and 74.5% for the acetabular implants (95% confidence interval; mean, 59.1%–89.9%). The average Merle d'Aubigné-Postel score was 17.4 ± 1 (range, 13–18). Seventy hips had a Merle d'Aubigné-Postel score of 18, 33 had a score of 16 or 17,

Fig. 1 This graph depicts the Kaplan-Meier survivorship curves for three different etiologies. The survivorship was inferior for slipped capital epiphysis and posttraumatic arthritis when compared with osteonecrosis.

Fig. 2 This graph depicts the distribution of intraoperative complications. They are evenly distributed over time; no learning curve could be demonstrated.

two a score of 15, two a score of 14, and one had a score of 13.

Survival rate was inferior ($p = 0.02$) for THA performed after slipped capital femoral epiphysis (64.9 % at 8 years) and for posttraumatic arthritis (65.5 % at 14 years) when compared with osteonecrosis (85.7% at 15 years) (Fig. 1). Hips with a previous operation had inferior survivorship ($p = 0.003$) when compared with primary arthroplasties (86.3% versus 59.7% at 10 years). We noted no differences in survival with the different designs.

Seventeen revisions for aseptic loosening were performed after a mean of 7.6 years (range, 1.9–18.6 years). The revisions were performed for 12 isolated acetabular loosening (five Cerafit-HA, one screw-in ring, one Cerafit, two cemented, and three Cerapress), two femoral loosening (all cemented), and three cases in which both components loosened (three cemented femoral components with one cemented plain alumina socket, one Cerapress, and one screw-in ring). Radiographic analysis showed two additional components at risk. One acetabular component showed possible migration with a difference of 4° in inclination angle, and one femoral component showed limited osteolysis in one zone associated with fiber-mesh detachment on the acetabular component.

Twelve intraoperative complications occurred: seven limited cracks on the proximal part of the femur, three femoral perforations, and two femoral fractures (one diaphyseal and one supracondylar). The two fractures were treated with a complementary plate. Postoperatively, eight cases of transient sciatic paralysis and two dislocations occurred. Five cases of sciatic paralysis totally recovered and three partially. The two dislocations did not recur. No learning curve was observed because the complications were distributed evenly during the period of time (Fig. 2).

Discussion

The long-term challenge for surgeons performing THA in younger patients is wear and subsequent osteolysis and component loosening: high survival rate of THA is mandatory for young people considering their long life expectancy. Ceramic-on-ceramic prostheses offer the potential to provide minimum long-term wear. We therefore asked if these implants would provide high survival rate. We then asked whether initial disease, the different modes of fixation of acetabular and femoral components, or a previous operation would influence survival.

Two major limitations of this study can be identified. First, this experience covered a large period of time with different approaches attempting optimal fixation of the acetabular component. Second, various diseases and anatomic conditions of hips reflect unique challenges

associated with each patient; the high rate of complications but absence of a learning curve tend to demonstrate this point. However, it is a relatively large series with surgeons having variable experiences and is likely representative of results in other locales.

Our data confirm this very demanding population is at high risk for revision; the 72.4% survival rate observed at 15 years was far from the standard for THA. Earlier studies of this young population highlighted the higher risk for THA revision when compared with an older population [9, 27], reaching 82% after 16.5 years for Dorr et al. [18]. These kinds of results and uncertainty of revision led some surgeons to favor hip fusion or resection arthroplasty for some of these patients, arguing hip arthrodesis can provide acceptable function [42]. However, it must be emphasized that long-term observation of patients with hip fusion brings up major concerns with the quality of functional results and the evolution of lumbar spine and ipsilateral knee issues [31, 38].

The main reason for failure observed in the current series was aseptic loosening of the acetabular component. Two main factors may explain this result. First, this observation is in accordance with our long-term experience

Table 1. Etiologies for alumina-on-alumina hip arthroplasty in patients younger than 30 years old

Etiology	Number of hips
Femoral head necrosis	64
Corticoid-induced (51)	
Sickle cell disease (8)	
Idiopathic (4)	
Gaucher disease (1)	
Posttraumatic arthritis	18
Acetabular fracture (9)	
Proximal femur fracture (7)	
Unknown (2)	
Inflammatory disease	18
Ankylosing spondylitis (5)	
Juvenile arthritis (6)	
Unknown (5)	
Hemophilia (2)	
Osteoarthritis secondary to slipped capital femoral epiphysis	12
Postinfection osteoarthritis	10
Osteoarthritis secondary to hip dysplasia	4
Unknown	4
Tumoral	2
Osteoblastoma of the acetabulum (1)	
Villonodular synovitis (1)	
Total number of hips	132

Table 2. Results of the main series of younger patients

Author (year)	Age in years (average or range)	Number of hips	Primary osteoarthritis	Survival rate
Berger et al. (1997) [5]	< 50 (37)	79	37%	98.8% at 10 years
Devitt et al. (1997) [17]	< 50 (42.3)	132	34%	75% at 20 years
Emery et al. (1997) [22]	< 50 (41)	57	40.4%	68% at 15 years
Ha et al. (2007) [25]	< 50 (37)	78	11.5%	*No revision at 5 years
Kearns et al. (2006) [32]	< 50 (41.1)	299	31.4%	46.8% at 15 years
McAuley et al. (2004) [33]	< 50 (40)	561	44%	60.4 % at 15 years
Chandler et al. (1981) [10]	< 30 (14-30)	33	0	*21% revised at 5 years
Halley and Wroblewski (1986) [27]	< 30 (26)	68	0	*14.3% socket failure
Dudkiewicz et al. [20] (2003)	< 30 (23.2)	69	1.4%	*11% revised at 6 years

* No survivorship analysis.

with the alumina-on-alumina combination. This experience covered a large period of time with differing approaches for optimal fixation of the acetabular component. In the earlier period (1979 to 1984), a cemented alumina socket was used. This mode of fixation stopped after the observation of acute loosening with debonding at the cement-socket interface related to the difference in material stiffness [36]. Smooth screw-in rings and cementless bulk alumina sockets were also eliminated after observation of high rates of aseptic loosening reaching, respectively, 13% at an average of 4 years and 6.8% at 6 years [29, 46]. More recently, several studies suggest superior outcome with hybrid hips (cementless socket, cemented stem) [7, 8] and this approach as well as cementless fixation for both components are now our preferred choices when alumina-on-alumina combinations are implanted. Second, etiologies that led to THA may represent another major risk factor for failure in this series; for example, no primary osteoarthritis was observed. On the contrary, most series reported in the literature of patients younger than 50 years old have a rate of primary osteoarthritis from 11% to 44% [5, 17, 22, 25, 32, 33]. In these later series, etiologies that led to THA were therefore different and this may also explain a part of the difference in the survival rate (Table 2). Moreover, some etiologies such as sickle cell disease [1, 2, 30, 34] or posttraumatic [4, 6, 44] or postinfection arthritis at greater risk for failure are overrepresented in the current series. However, when the analysis of the literature is limited to patients younger than 30 years old, our results compare favorably to other series [10, 20, 26, 27].

The major positive finding in our patients was a very low occurrence of osteolysis (observed in only one hip in one femoral zone). A low rate of osteolysis has previously been reported in one long-term followup of alumina-on-alumina combinations [28] and in several studies focusing on younger and/or active patients [13, 25, 41, 47], it was judged related to the tribologic performance of these

bearing surfaces that produce minimal wear debris and therefore minimal reaction to wear debris. Minimizing osteolysis and preservation of the bone stock is of particular importance in the younger population; it should be considered as a primary goal because these patients may need more than one prosthesis during their lifetime and the failure of the first one should not make the second or the third one too uncertain. Resistance to wear and limitation of osteolysis could also be obtained with a metal-on-metal combination [37]. However, theoretical concerns remain on these bearing surfaces because cobalt and chromium have been linked to carcinogenicity, mutagenicity, and hypersensitivity [15, 43, 45]. Therefore, questions such as those concerning the long-term consequences of elevated blood levels of cobalt and chrome [21] and the effect of these elevated levels on pregnancy [9, 48] or renal failure [19] remain.

THA in patients younger than 30 years old should be considered with caution. The limiting factor with an alumina-on-alumina combination was mainly fixation of the acetabular component. However, improvements in the design and in the mode of fixation of this component should enhance the long-term results because very limited osteolysis was observed.

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