High osteolysis and revision rate with the hydroxyapatite-coated ABG hip prostheses

65 hips in 56 young patients followed for 5–9 years

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Background **There are few reports on the outcome of uncemented HA-coated cups in young patients.**

Patients **I evaluated the 7-year (5–9) results of HA-coated hip prosthesis (ABG, Stryker) in a consecutive series of 65 primary arthroplasties on 56 patients (mean age 44 years). 2 patients were lost to follow-up and 3 died.**

Results **The cumulative survival rate with revision for any reason as endpoint at 9 years was 98% (95% CI, 96–100) for the stem, 69% (61–77) for the acetabular metal backing, and 59% (50–67) for the polyethylene liner. 15 of 65 cups were revised on average 6 years after the primary operation and 3 more are planned. Revisions were done in 3 hips because of loosening and migration of the cup, and in 12 hips because of wear and progressive osteolysis around stable components. Only hips with migration had clinical symptoms. Visual inspection of polyethylene liners revealed wear of the articulation in all cases, loosening of the locking mechanism in 10 cases and nonarticular surface deformity in 7 hips. All original stems are in situ although femoral osteolysis was seen in 12 cases and 1 hip was reoperated because of periprosthetic traumatic fracture. Despite the high revision rate, the clinical improvement was good: the average pre- and postoperative Harris Hip Scores at the most recent follow-up were 41 and 90, respectively.**

Interpretation **While the results on the femoral side were good, the survival rates of the acetabular cups were poor and we stopped using ABG I hip prostheses.**

Most modern artificial hip joints will perform well for up to 10 years, with survivorship exceeding 90%. During the past 15 years, uncemented hemispherical HA-coated cups and proximally HA-coated stems have gained popularity as primary implants. Most series describe results in older or middle-aged patients (Capello et al. 1997, 1998, Tonino et al. 1995, 2000, Araujo et al. 1998, Oosterbos et al. 2001, Giannikas et al. 2002). Here I report the medium-term results from one design of total hip replacement in a group of young and active patients.

Patients and methods

Between 1992 and 1997, 65 consecutive ABG primary arthroplasties were done in 56 patients (33 female) at the Orthopedic Department, Medical Academy of Lublin. The mean age of the patients at the time of hip surgery was 44 (16–67) years (Table 1).

The Anatomique Benoist Girard uncemented hip prosthesis (ABG I, Stryker, UK) has a hemispherical, totally HA-coated press-fit metal cup with 10–12 screw holes and 1 hole for impactor. The stem is made of titanium alloy (Ti6A14V) and the proximal third is HA-coated with macro-structured surface. Polyethylene hooded inserts and cobalt chromium alloy heads (28 mm in 61 cases, 22 mm in 4 cases) were used in our series. We used shell diameters between 42 and 62 mm. Cups with external diameter of 46 mm or less were used in 8

Table 1. Details of 65 hips (from 56 patients) operated on between 1992 and 1997

Mean age in years (range)	44	(16–67)
Number of hips in patients		
< 31 years	2	
31–40 years	24	
41–50 years	25	
51–60 years	11	
≥ 61 years	3	
Male:female	23:33	
Mean body weight in kg (range)	74	(48–105)
Mean height in cm (range)	168	(150–186)
Diagnoses		
Primary osteoarthrosis (OA)	10	
Arthritis secondary to		
DDH	25	
Osteonecrosis of the femoral head (ON)	12	
Rheumatoid arthritis (RA)	4	
Ankylosing spondylitis	1	
Traumatic hip dislocation (TR)	3	
Septic arthritis in childhood (S)	2	
Femoral neck fracture (FNF)	5	
Non–union of fractured femoral neck	3	
Previous operation		
None	39	
Acetabuloplasty in childhood	10	
Femoral osteotomies in childhood	9	
Core decompression in ON	4	
Open reduction and osteosynthesis of acetabular fracture following traumatic hip dislocation	2	
Osteosynthesis of the fractured femoral neck	1	
Charnley class		
A	26	
B	28	
C	2	

hips, cups with diameter from 48 to 54 mm were used in 32 hips and cups exceeding 54 mm were used in 25 hips. The stem sizes varied from 1 to 8. 9 patients were operated bilaterally. Operations were done by 5 senior orthopedic surgeons.

The surgical approach to the hip was posterolateral (23 hips), anterolateral (33 hips) or lateral (9 hips). Most of the cups (38 cups) were inserted with press-fit technique while 27 cups were inserted with the exact-fit technique. Fixation with additional spikes or screws was used for 35 of the cups. Autograft from the resected femoral head was used to build up a dysplastic acetabular roof (morselized in 3 hips, solid graft stabilized by screws in 3 hips) or to fill cysts in 1 hip.

All patients were followed prospectively and were evaluated pre- and postoperatively at 3–6 months, 12 months and yearly thereafter. Pain, function and range of movement were graded using Harris Hip Score (Harris 1969) (by the surgeon or the author). The mean follow-up time was 80 (32–118) months.

At each follow-up visit, an anterio-posterior radiograph was taken of both hips and in 80% of cases a lateral view of the operated hip was taken. I evaluated presence of gaps, signs of osteointegration, cup migration, stem subsidence and osteolysis of the acetabulum or femur. The prosthesis was defined as osteointegrated if there was bone contact without any gaps or radiolucent lines. Migration of the acetabular component in the medial and/or superior direction and change of inclination was recorded. Stem subsidence was defined by measuring the distance from the tip of the stem to the tip of greater trochanter. Migration and subsidence were recorded when displacement was greater than 5 mm or 5 degrees. Osteolysis was recorded as being present when intense and progressive loss of bone density in localized areas, scalloped erosion or linear lesion of bone was noted. Endpoints considered in this study included revision of any prosthesis component for any reason.

The Kaplan-Meier method was used to calculate the probability of retention of the stem, metallic shell and the PE inlay. The Statistica program (StatSoft, Inc. 2001, version 6) was used.

Results

There were 4 nondisplaced longitudinal femoral fractures, which did not require osteosynthesis. 1 fracture of the greater trochanter required internal fixation. There were no wound complications. All femoral fractures united without influencing hip function. There were 5 cases of deep venous thrombosis and 1 case of temporary peroneus nerve palsy that recovered after 3 months and 2 dislocations. None developed into recurrent dislocation. 4 patients had ectopic ossification, grade I – 1 hip, grade II – 1 hip and grade III – 2 hips (Brooker et al. 1973). There were no infections.

At the most recent follow-up, 45 of the original acetabular components remained in situ in 39 patients. 2 patients were lost to follow-up within the first postoperative year. 3 patients (3 hips) died

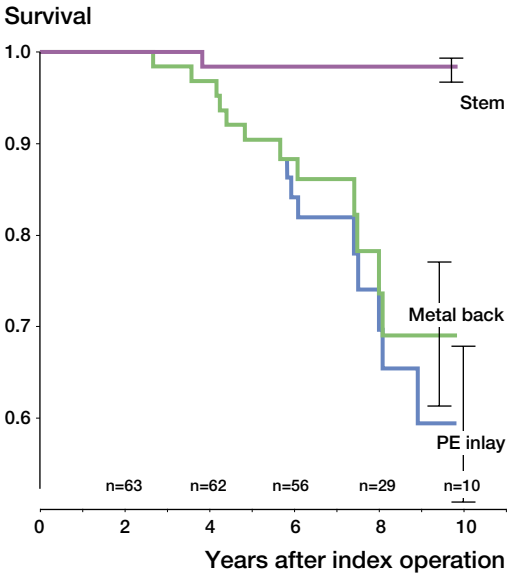
of unrelated causes (myocardial infarct, pulmonary cancer, cerebral insult) 52, 71 and 80 months after hip operation. At their most recent follow-up, all 3 patients were pain-free and had no signs of loosening or osteolysis around prosthesis.

By 1 year after operation, all patients showed excellent clinical improvement. The average preoperative HHS was 41 points. After 3 months, it increased to 86 points and at one year, to 92 points. At 2, 3, 4 and 5 years, the mean HHS was 93, 91, 92 and 89, respectively. At the latest follow-up, the average HHS was 90 points. At the time of revision there was a substantial reduction in 3 cases only, from 88, 93, 92 points to 77, 59 and 78, respectively. All other revised patients were almost asymptomatic. Only mild and occasional pain located in the groin was observed in 9 patients, which resulted in a decrease in HHS from 2 to 4 points as compared to the previous score.

Radiographic orientations of the 64 cups were within 30–50°. Only 1 cup was inserted at too vertical an angle (58°). The bone coverage was slightly incomplete in 3 cases (less than 10% uncoverage). 3 other cups were located more than 5 mm from the anatomical center of rotation (2 cups superior, 1 cup medial). All of these cases had OA secondary to DDH. 2 stems were inserted in valgus position (5° and 9°), and 2 in varus position (5° and 7°). These cases had OA secondary to DDH also. In postoperative radiographs, gaps (less than 2 mm in width and less than one-third of the coverage in length) were seen at the bone-metallic shell interface in 12 cases. These gaps had disappeared after 1 year. After the first postoperative year, all prostheses were regarded as being fixed to bone.

Using revision for any reason as the end point, the cumulative survival rate for cups was 89% at 5 years and 59% at 9 years. The Figure shows a cumulative survivorship curve for the original stem, metal back and polyethylene inlay.

3 cups changed inclination and 2 showed linear migration. 3 of these hips presented clinical symptoms and were revised, and 2 are pending for revision. In 4 cups, migration occurred secondary to acetabular osteolysis. Migration occurred without osteolysis in 1 hip only. In that particular case, the indication for the primary intervention was osteoarthritis secondary to posttraumatic hip dislocation with malunion of fractured posterior



Kaplan-Meier survivorship curves estimated for the stem, the acetabular metal back and the polyethylene inlay. 95% CI are indicated at 10 years. On the x-axis, n represents the number of hips at each time interval.

column of the acetabulum. Primary stability of the implanted cup was regarded as being good, and early clinical and radiographic results were good, but after 2 years migration and loosening of the cup was observed. Revision of the cup was done 32 months after primary intervention. Osteolysis was observed in 22 hips. In 9 cases, osteolysis was seen only on the acetabular side and in 4 cases only on the femoral side. 9 hips showed osteolysis around both components. There were 2 patterns of acetabular osteolysis: relatively rapidly growing with indistinct margins (12 cases) and localized lesions with sclerotic margins (6 cases). Acetabular osteolysis was seen in 12 cups with pins or screws and in 6 cups without additional fixation.

There were two areas of localized osteolysis in the femur: the greater trochanter area and the calcar region. Linear osteolysis was observed around the proximal part of the stem in only one case. This stem is still stable and the clinical result is excellent. There was no diaphyseal osteolysis.

We revised 15 (9 women and 4 men) cups at an average of 70 months after THA (Table 2). Revisions of 3 cups were done because of radiographic and clinical signs of loosening and migration. 12 other cups were revised because of wear

Table 2. Details of revised acetabular components

Case	Dgn [a]	Sex	Age at primary THR (years)	Weight kg	Head length/ diameter	Cup size/ number of additional pins or screws	Months to revision	Osteolysis around	Migration	Exchange metal back/ PE inlay
1	ON	M	34	95	M/28	56 / 3	89	Cup	No	Both
2	OA	F	34	59	S/28	56 / 1	97	Cup/stem	No	Both
3	TR	M	39	95	M/28	60 / 1	32	No	Yes	Both
4	ON	M	53	85	M/28	58 / 0	50	Cup	Yes	Both
5	ON	M	52	85	M/28	58 / 0	71	Cup	No	Inlay only
6	OA	F	54	64	M/28	52 / 0	107	Stem	No	Inlay only
7	DDH	F	32	58	M/22	44 / 1	96	Cup/stem	No	Both
8	DDH	F	30	65	S/28	58 / 1	58	Cup/stem	No	Both
9	ON	M	31	82	M/28	48 / 3	68	Cup/stem	Yes	Both
10	S	F	31	68	L/28	50 / 0	43	Cup	No	Both
11	DDH	F	31	64	M/28	54 / 2	53	Cup/stem	No	Both
12	DDH	F	45	67	S/28	50 / 3	51	Cup/stem	No	Both
13	RA	F	36	65	M/28	54 / 1	73	Cup/stem	No	Both
14	S	M	32	89	M/28	52 / 0	70	Cup	No	Inlay only
15	DDH	F	46	72	L/28	50 / 1	90	Cup	No	Both

[a] Diagnosis, see abbreviations in Table 1

and progressive osteolysis without clinical and radiographic signs of loosening. 10 of the revised cups had been additionally stabilized with spikes or screws, while 5 had no additional stabilization. Osteolytic lesions were located in the bone opposite to holes in the metal shell in 9 cases, and in 6 cases, around the spikes and screws used. 4 cups were totally loose during revision. 3 of them had radiographic signs of migration, and one was regarded preoperatively as stable. 8 stable cups were easily removed without additional destruction of the acetabular bone stock by the use of standard ABG instruments. Osteolytic defects were filled with impacted allografts and new cups (no ABG) were implanted. In 3 revised cups, intraoperatively assessed stability was so good that the metal shell was left in place, bone lesions were filled with allografts through screw holes, and a new polyethylene cup (no ABG inlay) was cemented into the stable metal shell.

In 4 of 15 revised cups, dark gray discoloration of the soft tissues without visible scratches on the metal shell or signs of impingement was observed. Visual inspection of all polyethylene liners revealed internal wear and a smooth load-bearing surface. Total destruction of the locking mechanism was observed in 10 cups. In 7 cases, nonarticular surface deformities were seen as an imprint of screw heads (5 cases) and hole extrusions (2 cases). No signs of impingement were observed. The loose metal-backs were devoid of HA coating. The stable cups retrieved showed large areas of HA resorption (more than 90%) and small areas of bone ingrowth. The detailed areas of bone ingrowth and HA loss were not determined. I found no wear of the taper cone.

At latest follow-up, 3 more patients were offered revision to prevent further excessive bone loss and migration.

All 61 femoral components followed remained in situ without loosening or subsidence. Mild hypertrophy of the femoral cortex at the level of the tip of the stem occurred in 7 cases, and was not associated with loosening or thigh pain. There were two traumatic periprosthetic fractures. One femoral shaft fractured at the level of the tip of the femoral component 46 months postoperatively, and was treated operatively. Stem was left in situ and open reduction and stabilization with plate and cables was performed. 2 years later the fracture is united, the stem is stable, and the patient is pain-free. Fracture of the greater trochanter occurred in 1 patient 41 months after the operation. The fracture healed after conservative treatment.

In all revised cases, focal osteolysis around the stem was seen to a greater extent than estimated on

radiographs. Lysis especially, located on the anterior part of the resected femoral neck, was underestimated on a-p and lateral radiographs.

Discussion

Within a short period, HA-coated prostheses may become bonded to the bone (Furlong and Osborn 1991, Coathup et al. 2001) even if there is a small gap up to 2 mm (Søballe et al. 1991). Our previous observations support these findings (Blacha et al. 1998). Gaps observed in our patients did, however, disappear more slowly than reported in the literature (Rossi et al. 1995, Tonino et al. 1995). Most gaps were observed in dysplastic hips, which indicate suboptimal preparation of the acetabular bone, but defects seemed to heal even in these cases.

Previously reported studies of THR with use of HA-coated hip prostheses have generally been encouraging, with low rates of early complications, loosening and revision (Koch et al. 1993, Araujo et al. 1998, Capello et al. 1998, Loupasis et al. 1998). Tonino et al. (2000) presented 99.2% survivorship at 5 years and no revisions for osteolysis in a group of 398 patients with a mean age of 64 years. Geesink and Hoefnagels (1995) presented a survival rate of 100% for the stem and 99% for threaded cups after 6 years in a group of 118 patients aged 53 years. Oosterbos et al. (2001) studied 250 cups and found no revision for aseptic loosening and only 8 cases of acetabular osteolysis. Some studies, however, have given cause for concern. Chung et al. (2002) reported 10% cup revision at an average of 76.6 months after operation in a group of 289 patients (average age 59 years). Similar results were presented by Manley et al. (1998). Morscher et al. (1998) described osteolysis after third-body wear by HA particles. Giannikas et al. (2002) reported good clinical outcome in a series of 71 hips (average age 55 years), without radiolucencies around the cup but with high wear (mean 0.25 mm per year) in 60% of inserts. In our group of patients, 15 of 65 cups (21%) were revised after an average follow-up time of almost 6 years, which exceeds the incidence reported in earlier series of HA-coated prostheses. Our patients were younger and the indication for revision was mainly based on radiographic findings. Pain was a symptom of late migration, not osteolysis. Dunkley et al. (2000) reported 11% revisions for excessive wear of porous-coated metal-backed acetabular cups, but no cases of acetabular osteolysis in 55 hips with an average age of 41 years. In my series, the wear of the cup indicates risk of osteolysis. Barrack et al. (1997) reported 11% incidence of expansile lytic lesions of the pelvis in a series of 132 patients at 5–8 years using a hemispheric porous-coated cup. Conventional radiographic analysis usually underestimates the real extent of lytic defects. Loss of supporting bone results in migration of the prosthesis, which may cause symptoms. These observations emphasize the importance of regular radiographic follow-up, especially where previous long-term results are missing and the group of patients is young.

Rokkum et al. (1999) presented a 78% survival rate for the polyethylene inlay in an HA-coated threaded cup after 8 years. There were no stem revisions. Capello et al. (1997) presented excellent results in a young group of patients (mean 39 years), but only regarding the stem. Similar observations were done by D'Antonio et al. (1996, 1997) and Vedantam and Ruddlesdin (1996). The success ratio of the stem is very high also in my material. Good primary stability due to design and HA-coating may have contributed to this outcome, but the progression of focal osteolysis may alter it. Capello et al. (2002) also reported a high ratio of proximal femoral osteolysis around well-fixed and well-performing proximally HA-coated stems in groups of younger and older patients. Radl et al. (2000) indicated a high ratio of periprosthetic fractures around proximally HA-coated femoral components. Yee at al. (1999) found no significant difference between HA-coated and porous-coated stems. It may be that these results are not applicable to the ABG stem because of different shape and surface.

There are many factors which affect the clinical outcome and longevity of THA with the use of HA-coated prostheses. Chung et al. (2002) indicated that the extent of bone ingrowth on smooth-surfaced HA-coated acetabular cups is minimal and too weak to maintain long-term cup stability. Buma and Gardeniers (1995) have shown complete resorption of an HA coating after four years. I observed that loose cups had completely

lost their coating. Loss of coating and loss of supporting bone could be responsible for separation of metal-back from the bone and socket migration. It is less likely that the coating would have been resorbed after loosening. Extensive loss of coating has also been seen in cases without migration.

The ABG metal cup has many holes which reduce the potential area for osteointegration, and they may be an entry site for fluid and polyethylene debris into the acetabular bone. The nonarticular surface deformity seen in cases with and without screws indicates motion, deformation of plastic or impingement between the metal shell and the convex side of the polyethylene insert (Huk et al. 1994, Barrack et al. 1997). Although it is not possible in my study to determine the extent to which backside wear influenced the degree of osteolysis, I believe that the screw holes and liner motion contributed to the high rate of failure for our ABG cups. Manley et al. (2002) suggested that polyethylene liner inserted into a metal-back with holes might act as the membrane of a pump. It is a matter of debate whether the fluid pressure itself, particles, or both can result in osteolysis adjacent to holes in the metallic shell (Schmalzried et al. 1992, Manley et al. 2002).

The influence of modular pegs or screws on osteolysis and loosening is unclear. Dorr et al. (1998) reported only 1 case of focal osteolysis in 108 patients who were followed for 5–7 years with the use of porous-coated hemispheric acetabular component without screw fixation, whereas reoperation ratio due to worn or loose polyethylene inserts reached 8%. Porous-coated acetabular components with screw fixation had no complications related to the use of the screws (Latimer and Lachiewicz 1996), and osteolysis around the screw was very rare (Schmalzried and Harris 1992). We observed osteolysis around 34% of cups with additional fixation and around 20% of cups without pins or screws. All polyethylene inserts used in our series had elevated rims. Potentially adverse effects of the elevated rim on generation of wear debris remain unknown. Murray (1992) reported severe erosion of the long posterior wall Charnley acetabular implant. Cobb et al. (1997) have shown no differences in probability of revision between standard and elevated-rim liners.

Polyethylene wear and osteolysis were the primary problems associated with HA-coated ABG hip prosthesis in our young patients. Better bearing materials and elimination of possible paths for penetration of wear debris to the bone may extend the long-term performance of this type of prosthesis.

No competing interests declared.

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