J. Blacha · J. Gągała

Clinical and radiological results of hydroxyapatite-coated acetabular cups

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Abstract We prospectively studied a consecutive series of 60 primary total hip arthroplasties in 52 patients. All patients had a hydroxyapatite-coated hemispherical acetabular cup (OCTOFIT). Mean patient age was 52.5 (34–73) years. In 38 hips, a 28-mm and in 22 hips a 32-mm diameter cobalt-chrome femoral head was used. We could follow 53 hips for a mean of 81 (28–125) months. Four cups were revised because of osteolysis, and in another six cups, slight osteolysis without migration was seen. The average annual linear wear rate was 0.05 mm (± 0.05) for 28-mm heads and 0.16 mm (± 0.09) for 32-mm heads ($p < 0.0001$). Survivorship analysis predicted a survival rate of $86 \pm 6.7\%$ at 10 years.

Résumé Nous avons étudié de façon prospective une série consécutive de 60 arthroplasties totales primaires de hanche chez 52 malades. Tous les malades avaient une cupule acétabulaire hémisphérique enduite d'hydroxyapatite (OCTOFIT). L'âge moyen des malades était de 52,5 ans (34–73). La tête était en chrome-cobalt, de 28 mm pour 38 hanches et de 32 mm pour 22 hanches. Nous avons suivi 53 hanches pendant une moyenne de 82 mois (28–125). Quatre cupules ont été révisées à cause d'une ostéolyse et pour six autres cupules existait une discrète ostéolyse sans migration. L'usure linéaire moyenne annuelle était de 0,05 mm ($\pm 0,05$) pour les têtes de 28 mm et 0,16 mm ($\pm 0,09$) pour les têtes de 32 mm ($p < 0,0001$). L'analyse de Kaplan–Meier a prédit un taux de la survie de $86 \pm 6,7\%$ à 10 années.

Introduction

Aseptic loosening of prosthetic components often starts around the cup with signs of osteolysis, radiolucencies, and migration. Hydroxyapatite (HA) coatings have been shown to provide a secure bond between the prosthesis and bone soon after implantation [4, 22]. However, clinical studies of the HA-coated acetabular cups have yielded mixed results [2, 5, 11, 20, 21, 25]. The purpose of this study was to evaluate the clinical and radiological medium-term results of a hemispherical HA-coated acetabular cup.

Patients and methods

The study group consisted of 60 consecutive primary hip arthroplasties with use of OCTOFIT acetabular cup (Tornier, France) that were performed on 52 patients (eight bilateral procedures) from 1992 through 1998. The OCTOFIT cup had a hemispherical, totally HA-coated press-fit metal back with eight screw holes. The metal cup has a macro-relief scaled surface and three pins at the top of the hemisphere. We have used metal backs with diameters from 48 to 58 mm. We also used polyethylene inserts and cobalt-chrome metal femoral heads. The diameter of the femoral heads was 28 mm in 38 hips and 32 mm in 22 hips, respectively. In 58 arthroplasties, we used uncemented proximally coated stems. The diagnoses that led to total hip replacement (THR) are listed in Table 1. No hip had more than one diagnosis. Mean patient age at the time of surgery was 52.5 (37–73) years. There were 35 left hips.

All patients were followed prospectively. Pain, function, and range of movement were graded using Harris hip score (HHS) [13]. Radiograms were evaluated for presence of gaps, signs of osteointegration, osteolysis, and cup migration. The prosthesis was considered as osteointegrated when there was direct contact between bone and prosthesis without any gaps or radiolucent lines. Migration of the acetabular component was recorded as

J. Blacha (✉) · J. Gągała
Orthopaedic and Traumatology Department, Medical Academy
of Lublin, University Hospital nr 4,
ul. Jaczewskiego 8,
20-951 Lublin, Poland
e-mail: ortbla@asklepios.am.lublin.pl
Tel.: +48-81-7425537
Fax: +48-81-7425645

Table 1 Details of 60 hips (52 patients) operated between 1992 and 1998

Mean age in years (range)	52.5 (34–73)
Male/female	13:39
Mean body weight in kg (range)	75.3 (55–111)
Diagnoses	
Primary osteoarthritis (OA)	32
Arthritis secondary to	
Developmental dislocation of the hip	14
Osteonecrosis of the femoral head (ON)	7
Rheumatoid arthritis (RA)	1
Traumatic hip dislocation (TR)	2
Septic arthritis in childhood (S)	1
Femoral neck fracture (FNF)	1
Nonunion of fractured femoral neck	2
Previous operation	
None	47
Acetabuloplasty in childhood	3
Femoral osteotomies in childhood	4
Core decompression in ON	3
Osteosynthesis of the fractured femoral neck	2
Resection arthroplasty (Girdelstone) after septic total hip replacement (THR)	1
Charnley class	
A	23
B	28
C	1

present when displacement was greater than 5 mm or 5°. Osteolysis was recorded as present when intense and progressive loss of bone density in localized area, scalloped erosion or linear lesion of bone was noted. Linear wear of the liners was measured as described by Thanner et al. [23] (method b).

End points 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 original cup from the time of initial operation until end point. Chi-square tests, two-tailed Student's *t* test or logical regression were performed depending on variables studied. The Statistica (StatSoft, Inc. 2001, version 6) program was used for statistical analyses.

Results

Patients were treated by five experienced surgeons using a posterolateral (32 hips), anterolateral (19 hips), or lateral (nine hips) approach. Forty-nine cups were inserted with exact-fit technique and 11 cups with the press-fit technique. In nine cups, additional fixation (screws or pins) was used at the discretion of the surgeon. In one hip, a 28-mm head was combined with a 32-mm polyethylene liner by mistake. In eight hips, a dysplastic acetabulum was augmented using the femoral head (morselized grafts in five hips and solid grafts in three hips). There were no infections.

All patients had a significant clinical improvement 1 year after the operation. The average preoperative HHS was 45.1 points, range 19–60 (SD 8.3), and increased to 94.7, range 77–100 (SD 7.8) points at 1 year post-operatively. At the latest follow up, the average HHS was 93.9, range 60–100 (SD 7.3) points. Two patients with cup migration had deterioration of HHS from 85 and 83 to 68 and 60, respectively. We found two symptomatic cases of deep venous thrombosis. One patient had ten posterior hip dislocations. Four patients had ectopic ossifications [3].

For all cups, the radiographic inclination was in the range of 35–55°. In six hips, there were small deficits in the bony coverage of the cup; all had osteoarthritis secondary to developmental dislocation of the hip (DDH). In two other cases, the cup was placed medially.

On the immediate postoperative radiograms, gaps (1–2 mm width) were present between the metal back and bone in zone I (nine hips) and zone II (four hips) [8]. After the first postoperative year, all gaps had disappeared, the bone grafts showed signs of incorporation, and the acetabular components were regarded as totally osteointegrated.

The mean follow-up was 81 (28–125) months. Three patients were lost to follow-up. Three patients (four hips) died 28, 56, 71 and 80 months after the operation of unrelated causes (myocardial infarct, liver cancer). One of these patients had mild osteolysis around the acetabular cup at the latest follow-up. Four cups were revised at an average of 79 (53–94) months after the primary operation due to progressive osteolysis. Two cups had also migrated. Details of revised cups are listed in Table 2. In all revised cups, we found wear of the polyethylene insert without signs of scratching or spots of impingement. The two

Table 2 Details of the revised acetabular OCTOFIT components. *THR* total hip replacement, *ON* osteonecrosis of the femoral head, *OA* primary osteoarthritis

Case	Diagnosis	Gender	Age at primary THR (years)	Weight (kg)	Head length/diameter	Cup size/number of additional pins or screws	Time to revision (months)	Osteolysis around	Total wear (mm)/annual wear	Migration
1	ON	M	43	81	M/28	58/32/2 ^a	86	Cup	0.11/0.016	No
2	ON	F	43	66	M/32	56/0	53	Cup	1.68/0.38	No
3	OA	M	60	80	S/32	56/1	94	Cup/stem	2.17/0.28	Yes
4	OA	F	59	79	M/28	56/0	83	Cup	0.2/0.03	Yes

^aArticulation 28-mm diameter head with 32-mm internal diameter polyethylene insert.

loose retrieved metal backs showed absence of HA coating, and the two stable retrieved cups showed large areas of HA absorption. Using revision due to any reason as the end point, the cumulative survival rate was $86 \pm 6.7\%$ (95% confidence limit) at 10 years. Fig. 1 presents the cumulative survivorship curve.

At the most recent follow-up, 49 of the original acetabular components (39 patients) were still in situ. Osteolysis was seen around ten cups (16.6%) of which four were revised; one patient had died. Five cases are still under observation. The osteolysis is clinically asymptomatic and the cups remain stable. In three hips, slight osteolysis was seen around the proximal part of the femoral stem in Gruen zones I and VII [12]. All stems functioned well.

The average amount of total linear wear was 0.61 mm (0.67 SD), and the average annual linear wear rate was 0.09 mm (0.08 SD). The 32-mm femoral heads were associated with a higher total linear wear and a higher annual wear rate than the smaller 28-mm heads. The average total linear wear was 1.3 mm (0.6 SD) and 0.34 mm (0.47 SD), respectively, and the annual wear rate was 0.16 mm (0.09 SD) and 0.05 mm (0.05 SD), respectively ($p < 0.001$).

Mean annual wear in the patients with osteolysis was 0.096 mm (five hips with 28-mm heads) and 0.253 mm (five hips with 32-mm heads) and was significantly higher than in the group without osteolysis ($p < 0.02$). We found no significant relationship between the use of 32-mm femoral head and cup failure, and we found no significant relationship between wear and diagnosis, age, gender, weight, hip score, size of metal back and number of additional pins or screws.

Discussion

Even with no ideal preparation of the bone bed, the current study has confirmed an excellent and early pain relief and apparently good initial fixation of the hemispherical acetabular cups. Gaps between metal back and bone can be filled up to 2 mm [22]. Patients were pain free and loaded the artificial joint almost as a normal hip. The previously reported studies of THR using HA-coated hip prostheses were generally encouraging with low rates of early complications, loosening, and revision. Tonino et al. [25] presented 99% survivorship at 5 years and no revisions for osteolysis. Oosterbos et al. [20], who studied 250 cups, found no revision for aseptic loosening and only eight cases of acetabular osteolysis.

Some studies, however, have given cause for concern [5, 17]. Morscher et al. [19] reported concern about the migration of HA granules into the joint space producing third-body wear. Chung [5] reported 10% cup revision at an average of 76.6 months after operation. Blacha [2] reported 23% revisions of ABG prosthesis at an average of 5.9 years after operation. Patients in the current study showed less osteolysis, but their mean age was higher. The clinical results in this study were not influenced by the femoral stem.

In younger patients, there have been reports on wear and osteolysis around modular hemispherical hip prostheses. Dunkley et al. [10] reported a 10.9% of revision for excessive wear of porous-coated metal backed acetabular cups but no cases of acetabular osteolysis. Barrack et al. [1] reported an 11% incidence of expansile lytic lesions of the pelvis in the series of 132 patients at 5–8 years using a hemispherical porous-coated cup. Dorr et al. [9] reported 8% revision and only 2% of osteolysis around titanium porous-coated acetabular components. Rokkum et al. [21] presented a survival rate of 77.5% at 8 years for polyethylene inlay of HA-coated threaded cups. Manley

Fig. 1 Kaplan–Meier survivorship curve estimated for the acetabular OCTOFIT cup with the revision for any reason as an end-point

[17] reported higher probability for revision of HA-coated press-fit cups than for HA-coated threaded cups or porous-coated press-fit cups. Latimer and Lachiewicz [15] reported no porous-coated acetabular revisions, with a mean rate of linear wear of 0.1 mm/year.

It has been proven that a higher diameter of the femoral head produced higher wear of the polyethylene [16]. The prevalence of osteolysis increased significantly with wear [18]. Barrack et al. [1] found the wear rate was 0.22 mm/year in cases with radiographic lysis and 0.08 mm/year in cases without lysis. Periprosthetic osteolysis was likely if polyethylene wear was greater than 0.1 mm/year [18]. Giannikas et al. [11] noted wear in 60% of the inserts of ABG cups with an average of 0.25 mm/year, although without radiolucencies. Even with the annual wear below the threshold value, as we observed in the group with 28-mm head, osteolysis can occur; however, the mean annual wear rate was always higher in patients with acetabular osteolysis in comparison with patients without osteolysis. Kim et al. [14] found 9% acetabular osteolysis with an average annual wear rate of 0.12 mm (22 mm metal heads).

There are many factors affecting the clinical outcome and longevity of THA using HA-coated prostheses. Chung et al. [5] indicated that the extent of bone ingrowth on the smooth-surfaced HA-coated acetabular cup is minimal and too weak to maintain long-term cup stability. The OCTOFIT cup design with pins and machine-knurl surface may suggest that the intended interlocking acetabular fixation has been achieved. But even an excellent initial fixation did not prevent osteolysis. The influence of holes in the metal back on formation of osteolysis is unclear. Claus et al. [6] found no difference between metal shells with multiple holes and no holes at all. Thanner et al. [24] indicated that early fixation of the press-fit cup can be achieved without additional screws. We have not observed any specific location of osteolysis in the revised cups, but the loose cups had completely lost their coating. Loss of supporting bone could be responsible for separation of the metal back from the bone and socket migration. Stable cups had bone ingrowth in the metal-bone contact area.

Clinical and radiographic results associated with hydroxyapatite-coated hemispherical cups were generally unfavorable compared with the results published in the literature [7, 9, 11, 14, 17, 20, 25].

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