THA with the ABG I Prosthesis at 15 Years

Excellent Survival with Minimal Osteolysis

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Abstract Following recent reports of poor results with the hydroxyapatite-coated ABG I prosthesis, we report the survival of a series of 63 patients (69 hips) at a mean of 15 years (range, 13–17 years). In total, eight patients had revision procedures. The reason for revision was acetabular loosening in all cases. In only one case was there associated clinical and radiographic loosening of the femoral stem. The 15-year survival of the acetabular component was 86.9% (95% confidence interval, 71.7%–96.0%) and the 15-year survival of the femoral component was 98.6% (95% confidence interval, 88.8%–100.0%). Periacetabular osteolysis was seen in 10 of 59 (17%) surviving hips. In these hips the components remained well fixed owing to the remaining bone-component contact. There was no difference in the Oxford hip score between patients with well-fixed hips and evidence of osteolysis and patients with hips without evidence of osteolysis. Multivariate analysis failed to reveal any factors associated with the presence of osteolysis (gender, age at primary surgery, Oxford hip score, cup abduction, and acetabular polyethylene wear rates). The ABG I prosthesis continues to show excellent

long-term results. Ongoing radiographic review is recommended to detect progressive osteolysis that otherwise remains clinically silent until failure.

Level of Evidence: Level IV, Case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

The ABG I prosthesis (Anatomique Benoist Gerard; Stryker Howmedica Osteonics, Newbury, UK) is an anatomically designed cementless total hip prosthesis. It consists of an hydroxyapatite (HA) proximally coated femoral stem aiming for metaphyseal fixation. The acetabular component is an HA-coated titanium shell with an UHMWPE liner. Early results suggested excellent short- to midterm results [12, 16, 27, 33, 34]. Favorable 10-year survival rates of 92.6% [3] and 97% [23] have been described. Other reports, however, have suggested unacceptably high failure rates associated with marked wear of the polyethylene liner [3, 8, 12, 27] and substantial periacetabular osteolysis [2, 8]. Of additional concern was the fact that the osteolysis was often clinically silent.

Our unit experience was that very few implanted ABG I prostheses had required revision by 10 years. However, we remained concerned by the threat of impending catastrophic failure with widespread loss of acetabular bone stock secondary to osteolysis in this patient group. We therefore undertook a clinical and radiographic review of all ABG I prostheses implanted between 1990 and 1994. Our aim was to establish implant survival, polyethylene wear, presence of periacetabular osteolysis, any current clinically relevant symptomatology, and the relationship between these factors.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution either has waived or does not require approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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Patients and Methods

Using data held in our trust joint registry, we identified a series of 63 patients (69 hips) who underwent primary THAs using the ABG I prosthesis between January 1990 and December 1994. These data then were verified against theater logs and patient records to ensure complete data capture for this prosthesis during this period. None of the identified patients was excluded from the analysis and these patients were not selected from a larger cohort. Therefore, as far as we could ascertain, they represent a consecutive series for this period. All procedures were done by or under the direct supervision of the senior author (JA) using a Hardinge approach with the patient in the lateral position. There were 34 men (37 hips) and 29 women (32 hips) with a mean age at the time of primary surgery of 53 years (range, 28–65 years). The relatively young mean age of the cohort relates to the senior author's preference to use cementless hips in young patients in an attempt to preserve bone stock for subsequent revision surgery and is comparable to the mean ages from similar studies using the ABG I prosthesis [2, 8, 12]. A metal-on-polyethylene bearing (sterilized through gamma irradiation [25–35 kGy] in air) with a stainless steel 28-mm-diameter head was used in all hips.

During a 4-month period between November 2007 and February 2008, all surviving patients were contacted. At the time of review, there were 59 surviving hips; eight had undergone revision surgery (Table 1) and two patients (two hips) had died. In the case of deceased patients, hospital and general practitioners' records were reviewed to ascertain the survival of the implant. There was no loss to followup. The followup interval for surviving implants was recorded as the interval between the date of the operation and the date of either death of the patient or confirmation of the survival of the implant. Minimum followup was 13 years (mean, 15 years; range, 13–17 years).

As part of their routine joint replacement surveillance, all patients had AP pelvic radiographs in the preceding 2 years (mean, 8 months; range, 0–21 months). The most recent images were rendered anonymous and then examined by two consultants (IAM, AP) for the presence of osteolysis and evidence of loosening. The operating surgeon was not involved in reviewing these images. Hips were divided into one of two groups depending on the presence or not of periacetabular osteolysis. The site of osteolysis was determined using the methods described by DeLee and Charnley [7] for the acetabulum and by Gruen et al. [13] for the femur. All surviving patients who had not had revision surgery were evaluated clinically using the Oxford hip score (OHS) (best score = 12, worst score = 60) [5, 6, 11]. A corresponding preoperative OHS was not available for this cohort, as the primary surgery was performed before its inception.

Eccentric acetabular polyethylene wear was calculated according to the method described by Røkkum and Reigstad [28], and cup abduction was calculated using the interteardrop line as a horizontal reference point [32].

Life table analysis, as detailed by Armitage and Berry [1], was used to determine implant survivorship. Asymmetric binomial confidence limits, as described by Rothman [29], were calculated using the “effective number at risk” method described by Murray et al. [22]. The end point (revision) was defined as additional surgery, regardless of indication, that involved replacement of any of the original components. Statistical analysis was performed using SPSS® Version 11.0 (SPSS Inc, Chicago, IL).

Results

No implant was revised before Year 10. The 10-year survival was, therefore, 100% (95% confidence interval [CI], 94.7%–100.0%) for the femoral and acetabular

Table 1. Breakdown of the eight patients requiring revision surgery

Age at time of surgery (years)	Gender	Year of failure	Mode of failure	Comments
27	Male	11th	Aseptic acetabular loosening	Acetabular revision
55	Female	11th	Aseptic acetabular loosening	Acetabular revision
53	Male	11th	Aseptic acetabular loosening	Acetabular revision
37	Male	11th	Aseptic acetabular loosening	Both components revised owing to intraoperative difficulties with soft tissue balancing after acetabular revision
35	Male	14th	Acetabular wear with aseptic loosening	Acetabular revision
40	Female	15th	Aseptic acetabular loosening	Acetabular revision
49	Male	15th	Aseptic acetabular loosening	Acetabular revision
55	Male	16th	Aseptic acetabular and femoral loosening	Acetabular and femoral revision

Table 2. Life table analysis for the uncemented ABG I prosthesis with revision of the acetabular component as the end point

Years since operation	Number at start	Number revised	Withdrawn	Death	Loss to followup	Number at risk	Annual failure rate (%)	Annual success rate (%)	Survival rate (%)	95% confidence interval
0–1	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
1–2	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
2–3	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
3–4	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
4–5	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
5–6	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
6–7	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
7–8	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
8–9	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
9–10	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
10–11	69	4	0	0	0	69	5.8	94.2	94.2	85.8–98.1
11–12	65	0	0	0	0	65	0	100.0	94.2	85.5–98.3
12–13	65	0	0	0	0	65	0	100.0	94.2	85.5–98.3
13–14	65	1	21	0	0	54.5	1.8	98.2	92.4	82.0–97.7
14–15	43	2	12	1	0	36.5	5.5	94.5	86.9	71.7–96.0
15–16	28	1	11	0	0	22.5	4.4	95.6	82.5	61.1–96.8
16–17	16	0	7	1	0	12	0	100.0	82.5	51.7–100.0

components. The 15-year survival of the acetabular component was 86.9% (95% CI, 71.7%–96.0%) (Table 2; Fig. 1). The overall 15-year survival of the femoral component was 98.6% (95% CI, 88.8%–100.0%) (Table 3; Fig. 2); however, this includes a well-fixed component revised owing to difficulties with soft tissue balancing at the time of acetabular revision. If this is discounted and only aseptic loosening is considered, the 15-year survival of the femur was 100% (95% CI, 91.3%–100.0%). The mean age at the time of primary surgery was younger ($p < 0.05$) in patients who underwent revision surgery than

in patients who did not have revision surgery (44 years versus 54 years).

The mean OHS in the surviving hips was 24.4 (SD, 10.9). Of the 59 surviving hips, 10 showed radiographic evidence of osteolysis (Fig. 3), and 49 were found to be well fixed with no evidence of osteolysis. There was no relationship ($p = 0.69$) between the OHS and the presence of osteolysis (osteolysis present: mean OHS, 25.7 [SD, 13.0]; osteolysis absent: mean OHS, 24.2 [SD, 10.6]) (Table 4).

On radiographic review of the 10 patients with evidence of osteolysis, all components were considered well fixed, with no patients believed to warrant urgent review with a view to revision surgery. One had isolated involvement of DeLee and Charnley Zone 1, one had involvement in Zone 2 alone, and none had involvement in Zone 3 alone. Six had involvement of two adjacent zones (Zones 1 and 2 [five patients], Zones 2 and 3 [one patient]) and two had osteolysis in all three zones. Despite the presence of osteolysis in all three zones, there were significant islands of bony contact between these areas of osteolysis (Fig. 3). These components, therefore, were deemed to be well fixed. Femoral osteolysis was seen in five cases. This always involved Gruen Zone 1, with the addition of other zones in two hips (Zones 1 and 2 [one hip]; Zones 1, 2, 6, and 7 [one hip]).

Eccentric acetabular wear was seen in 56 (95%) surviving cups and was greater than 2 mm in 31 (53%) cups. The mean absolute wear was 2.03 mm (SD, 1.18 mm;

Fig. 1 A survival curve with binomial 95% CIs for the acetabular component of the ABG I prosthesis is shown.

Table 3. Life table analysis for the uncemented ABG I prosthesis with revision of the femoral component as the end point

Years since operation	Number at start	Number revised	Withdrawn	Death	Loss to followup	Number at risk	Annual failure rate (%)	Annual success rate (%)	Survival rate (%)	95% confidence interval
0–1	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
1–2	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
2–3	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
3–4	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
4–5	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
5–6	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
6–7	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
7–8	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
8–9	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
9–10	69	0	0	0	0	69	0	100.0	100.0	94.7–100.0
10–11	69	1	0	0	0	69	1.4	98.6	98.6	92.3–100.0
11–12	68	0	0	0	0	68	0	100.0	98.6	92.2–100.0
12–13	68	0	0	0	0	68	0	100.0	98.6	92.2–100.0
13–14	68	0	21	0	0	57.5	0	100.0	98.6	91.3–100.0
14–15	47	0	12	1	0	40.5	0	100.0	98.6	88.8–100.0
15–16	34	1	11	0	0	28.5	3.5	96.5	95.1	80.1–100.0
16–17	22	0	7	1	0	18	0	100.0	95.1	74.4–100.0

Fig. 2 A survival curve with binomial 95% CIs for the femoral component of the ABG I prosthesis is shown.

range, 0–4.8 mm). Annual wear rates ranged from 0 to 0.30 mm/year, with a mean value of 0.14 mm/year (SD, 0.08 mm/year). There was no relationship ($p = 0.42$) between the rate of polyethylene wear and the presence of osteolysis (osteolysis present: mean wear rate, 0.16 mm/year [SD, 0.09 mm/year]; osteolysis absent: mean wear rate, 0.14 mm/year [SD, 0.08 mm/year]) (Table 4).

Mean cup abduction was 47.3° (SD, 8.7° ; range, 26° – 71°) in the surviving cups. Cup abduction was less than 35° in seven (12%) cups, 35° to 55° in 44 (75%) cups, and greater than 55° in eight (14%) cups. There was no

Fig. 3 An AP radiograph of a surviving ABG I prosthesis shows evidence of osteolysis in all three DeLee and Charnley acetabular zones. The osteolysis in Zones 2 and 3 is of low volume and this implant was considered well fixed. This patient had an OHS of 14 of 60 at 13 years postoperation.

Table 4. Multivariate analysis of influence of clinical factors

Factor	p Value
Male gender	0.08
Age at primary surgery	0.52
Oxford hip score	0.64
Cup abduction	0.89
Yearly acetabular wear rate	0.73

relationship ($p = 0.89$) between the cup abduction and the presence of osteolysis (osteolysis present: mean cup abduction, 47.0° ; osteolysis absent: mean cup abduction, 47.4°) (Table 4).

Logistic regression modeling was performed to establish the influence of gender, age at primary surgery, cup abduction, OHS, and yearly acetabular polyethylene wear on the presence of osteolysis in the surviving acetabular components (Table 4).

In seven of the eight revisions, the indication for revision was aseptic acetabular loosening. In all seven cases, there was no evidence of femoral loosening either before revision or intraoperatively. In six cases, the stem, therefore, was left in situ, with revision of the acetabular component and femoral head only. In one case, the stem, despite being well fixed, required revision owing to difficulty with soft tissue balancing after revision of the cup. In the case of the final revision, the femoral and acetabular components were clinically and radiographically loose.

A review of the operative notes of all eight revisions revealed there were no specific difficulties encountered at the time of revision. The surgeons noted numerous small contained acetabular defects after removal of the cup in all cases. These were dealt with exclusively by impaction grafting using less than one femoral head and standard cemented/uncemented cups without the need for additional support.

Neither of the two deceased patients had undergone revision surgery and the implants had been in situ for 14 and 16 years at the time of death. These two hips were noted to be well fixed with no evidence of osteolysis at the time the patients died.

Discussion

There have been numerous reports of excellent middle to long-term results with the ABG I prosthesis [3, 12, 16, 24, 27, 33, 34]. Some series, however, have raised concerns regarding unacceptably high failure rates, polyethylene wear, and periacetabular osteolysis [2, 8]. Particularly alarming was the discovery that massive osteolysis often remained clinically silent. The purpose of this study was to

determine the longer-term survival of the ABG I prosthesis. We also evaluated the rate of polyethylene wear, the presence of periacetabular osteolysis, current clinical symptomatology, and the relationship between these factors.

This study benefited from a minimum of 13 years' followup with no patients lost to followup [21]. However, we were limited by an inability to trace operative records, which would have provided additional information regarding polyethylene thickness and primary diagnosis at the time of surgery. Another limitation may have been the use of the OHS for clinical assessment. As with any hip-specific score, patient response could be influenced by the coexistence of concurrent knee, hip, or spinal disease in other joints [15, 35]. However, this is unlikely to have a major bearing, as the young original cohort would be unlikely to have such problems in considerable numbers.

Our series of patients with 69 ABG I prostheses with a minimum of 13 years followup had a 15-year survival rate of 86.9% (95% CI, 71.7%–96.0%) for this implant. In all eight revision cases, the primary reason for revision was aseptic acetabular loosening. Concurrent loosening of the femoral stem occurred in one case.

There are a small number of long-term outcome studies reporting on the survivorship of uncemented THAs. Our findings are consistent with data from comparable series [24] and national data from the Finnish and Norwegian arthroplasty registries [10, 14, 19]. Oosterbos et al. [24] reported 10-year survival rates in excess of 95%, with aseptic acetabular loosening being the primary mode of failure with the ABG I prosthesis. Eskelinen et al. [10] found similarly high rates of long-term survival with the ABG I prosthesis from the Finnish registry. In another survivorship analysis from the Finnish registry, Makela et al. [19] examined the survival of uncemented implants dependent on design rationale. In the group with cementless, anatomic, proximally HA-coated stems and HA-coated press-fit cups, they reported survivorship, using aseptic loosening as the end point, of 91% at 15 years for the stem, 95% at 10 years for the cup, and 80% at 15 years when these implants were used in combination. The 15-year survival rates in our patient group also compare favorably with those seen with cemented hip prostheses in younger patients [18] and to a longer survival analysis of other HA-coated press-fit cups, which were reported to have 75% survival at 15 years [26].

In our series, the survival of the HA-coated femoral stem at a maximum of 17 years was 95.1% (95% CI, 74.4%–100.0%), with revision for any reason as the end point. With aseptic loosening as the end point, the survival was 96.5% (95% CI, 82.2%–100.0%) at 17 years. These figures are comparable to longer-term analyses performed on other HA-coated femoral stems [9, 25, 30]. In a recent

publication of a study from the Norwegian registry, Hallan et al. [14] reported 100% survival at 10 years for the ABG stem using revision for aseptic loosening as the end point. When revision of the stem for any cause was used as an end point, the 10-year survival rate was 96.6% in all patients and 95.2% in those 50 years or younger.

The mean annual wear rate (0.14 mm/year) and rates of osteolysis were lower than expected. Other authors have reported acetabular polyethylene wear rates between 0.24 and 0.32 mm/year [3, 8, 12, 27] and some have raised concerns regarding the associated high rates of periacetabular osteolysis with this implant [2, 8]. On radiographic review of our surviving THAs, periacetabular osteolysis was seen in 17% of patients. Duffy et al. [8] found 23 of 97 hips (24%) failed attributable to osteolysis at a mean followup of 69 months. Of patients who were clinically and radiographically reviewed, 1/3 had “marked wear and osteolysis.” In Blacha’s [2] series of 65 primary hips, he observed osteolysis around the cup in 18 cases. In all, 15 were revised either because of loosening or wear with progressive osteolysis and the 9-year survival in that series was only 59%. In contrast, Rogers et al. [27] found only 5% of cups in their series of 100 hips with ABG I prostheses had periacetabular osteolysis at a mean of 6 years, and Giannikas et al. [12] reported none of their 71 cups had periacetabular osteolysis at a mean of 4.8 years.

It is not clear why rates of periacetabular osteolysis vary so widely among these series. The differences may be related to the different material of the femoral head (cobalt-chrome rather than ceramic) and to differences in surgical practice. Unfortunately, important information on surgical technique, numbers of surgeons performing procedures in each series, femoral head material, and cup inclination is not reported in numerous articles, making comparison with our findings difficult. It may be our rates of periacetabular osteolysis are low because the associated rates of polyethylene wear also were low. As far as we can ascertain, we used the same polyethylene and sterilization and storage techniques used in other series. However, it is noteworthy, in the series of Duffy et al. [8], the bearing was zirconia ceramic on polyethylene in a considerable number of cases (> 62%).

The poor performance of the ABG I polyethylene has been attributed largely to the fact that it was sterilized by gamma irradiation in air (25–35 KGy) [3, 8, 16]. This method of sterilization has been shown to have a detrimental effect on wear properties owing to increased oxidative degeneration in the polyethylene [20, 31]. It is our understanding that the ABG I polyethylene cups always were sterilized through gamma irradiation in air until their phase out began in 1996. The first polyethylene liners for the ABG II, introduced in 1995, were sterilized in a similar manner. In 1997, the first ABG II Duration® liner was

implanted. Although this also was gamma sterilized, it subsequently was annealed for 144 hours at 50°C in an attempt to improve wear properties. Subsequent polyethylenes from Stryker (Crossfire® 1998) again used gamma irradiation for sterilization until the introduction of X3® in 2005, by which time sterilization using gas plasma was used.

It has been suggested the design of the ABG I acetabular shell, with its multiple holes, substantially contributes to this process by exposing underlying cancellous bone to wear debris, with the resultant inflammatory reaction leading to osteolysis [17]. In a review of the cementless Omnifit® (Stryker) acetabular component, Nieuwenhuis et al. [23] analyzed the volume of osteolysis and survival rate dependent on acetabular shell type. They found there was a relationship between an increasing volume of osteolysis and decreasing survival rate in cups with a larger number of holes. This phenomenon, however, is not particular to acetabular shells with holes, and other authors have reported equally high rates (89%) of osteolysis with other HA-coated cup designs [4].

We found the hips in which osteolysis is present continue to function well, with no clinically detectable difference in their symptoms and OHSs when compared with hips with implants deemed free of osteolysis. Multivariate analysis also failed to show any clinical variable was linked to the presence of osteolysis. This underlines the concerns raised by Duffy et al. [8] that osteolysis often remains clinically silent until the time of failure. In contrast to that study, however, we did not encounter high volumes of osteolysis with associated catastrophic implant failure. Periacetabular osteolysis was seen in 17% of patients. When encountered it involved more than one DeLee and Charnley zone in 80% of cases. We found, however, that in all cases, these zones were separated by substantial islands of bony contact and the components remained well fixed. At the time of revision, all osteolytic defects were contained and managed with bone grafting and use of standard implants.

Our series shows survivorship of the ABG I prosthesis remains excellent at a mean of 15 years’ followup. We did not experience the high rates of failure and periacetabular osteolysis or acetabular polyethylene wear seen in other series. It is concerning, however, that the patients we identified with radiographic evidence of osteolysis remain clinically asymptomatic. This emphasizes that simple clinical scoring systems cannot be relied on in isolation to identify progress to failure and highlights the need for ongoing radiographic review of this patient cohort. This is particularly concerning given the funding for joint arthroplasty surveillance services is being withdrawn by numerous primary care trusts in the United Kingdom, limiting the ability to effectively monitor these patients.

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