A long-term follow-up study of the cementless THA with anatomic stem/HGPII cup with 22-mm head

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Received: 17 October 2007 / Accepted: 24 November 2007 / Published online: 9 January 2008
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Abstract The anatomic femoral component and Harris-Galante porous II (HGPII) cup were developed to provide more reliable bone ingrowth. We performed 20 cementless total hip arthroplasties (THAs) with anatomic stem/HGPII cup with 22-mm head in 14 consecutive patients, and evaluated the clinical and radiological results for a mean follow-up of 12.8 years. The all-anatomically designed stem provided excellent clinical and radiographic results. Four acetabular components underwent revision: three for fracture of the locking mechanism and wear of the polyethylene liner and one for the locking mechanism failure with dislocation of the HGPII cup. The abduction angles of the four revised acetabular components were apparently higher. The survivorship 13 years after surgery was 78%. Our findings show good long-term results using the anatomic femoral component, while the HGPII cup combined with 22-mm head seems to have poor durability due to locking mechanism failure.

Résumé Le composant fémoral anatomique et la cupule Harris-Galante porous II (HGPII) ont été développés de façon à améliorer la repousse osseuse. Nous avons réalisé 20 prothèses totales de hanche sans ciment avec une queue anatomique et une cupule HGPII et un couple de friction avec une tête de 22 mm chez 14 patients consécutifs. Nous avons réalisé une évaluation clinique et radiologique des

résultats après un suivi moyen de 12,8 ans. Toutes les pièces fémorales ont donné d'excellents résultats sur le plan clinique et radiographique. Cependant, 4 composants acétabulaires ont nécessité une révision, 3 pour fracture de mécanisme de verrouillage de l'insert et usure de l'insert, 1 pour défaut du verrouillage du mécanisme de la fixation de l'insert et luxation de la cupule. L'angle de verticalisation des 4 cupules révisées a été plus important. Le taux de survie à 13 ans a été de 78%. Nous pensons que cet implant donne de bons résultats à long terme sur le plan fémoral, il n'en est pas de même en ce qui concerne la cupule HGPII associée à une tête de 22 mm, celle-ci semble avoir une durée de vie diminuée du fait du défaut de mécanisme de blocage de l'insert.

Introduction

Since the introduction of total hip arthroplasty (THA), implant fixation and polyethylene wear have been the most important problems requiring solutions. There are many system designs available today for cementless THA. The anatomic THA was one of the early cementless designs [15]. A published study of the anatomic hip indicated that the anatomically designed femoral component can provide early, satisfactory pain relief in younger, active patients. Additional experience and follow-up were required to determine if the long-term objectives were realised. Loosening of the acetabular component is recognised as the major long-term problem associated with THA with cement [3, 9]. A number of techniques to improve fixation of the acetabular component have been reported [2, 12, 22]. In the 1980s, cementless porous-coated acetabular components were developed to improve the durability of acetabular fixation. We began to use the cementless hemispheric

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porous-coated acetabular component, Harris-Galante porous II (HGPII), and anatomic femoral component with 22-mm head (Zimmer, Warsaw, IN) in November 1991.

The purpose of this study is to provide the clinical and radiographic outcomes, after long-term follow-up, in a consecutive series of patients treated with cementless THA with the anatomic stem/HGPII cup with 22-mm head.

Patients and methods

Between November 1991 and March 1997, 20 primary cementless THA with the HGPII cup/anatomic stem were performed in 14 consecutive patients (6 men and 8 women). The average age of the patients at the time of surgery was 54.4 years (range, 20.0–78.0 years). The average weight was 56.9 kg (range, 45.0–74.0 kg) and the average height was 155.0 cm (range, 145–178.0 cm). The preoperative diagnosis was osteoarthritis in all 20 hips, including developmental dysplasia in 19 hips and post-traumatic arthritis in one hip. All of the operations were performed by the same surgeon via a posterior approach. No patient was lost to follow-up. All 20 hips were evaluated after a mean follow-up of 12.8 years (range, 10.0–15.3 years).

The HGPII acetabular component and anatomic femoral component were used in all patients. The uncemented acetabular component is made from a titanium alloy metal shell and has a sintered titanium fiber-metal porous coating. The metal shell was inserted; the diameter of the implant matched the two-plus diameter of the last reamer used to prepare the acetabular. The outer diameter of the metal shell varied. Multiple screwholes allowed for dome screw fixation. The acetabular component was fixed with titanium 6.5-mm-diameter screws to ensure primary stability. The polyethylene used at this time was machined and sterilised with gamma irradiation in air. The femoral component was the anatomic stem consisting of Ti-6Al-4V alloy, with the surfaces of the proximal aspect coated with titanium fiber-metal mesh. The stem had no collar. The fluted stem composed the distal half of the device. The design of the femoral component has a posterior intertrochanteric bow and an anterior distal bow. This prosthetic design relies on maximum metaphyseal fill to provide initial implant stability. Flexible reamers were used to ream the medullary canal to the diameter of the desired stem, followed by rasping of the metaphysis and canal. If any motion of the broach was detected within the proximal part of the femur, the next larger broach was used until this motion was eliminated and the final component was then implanted. The femoral component varied. The modular femoral head was a chromium-cobalt alloy component mated to the femur by interference fit with a conical taper. A 22-mm head was used in all patients. In nine hips an acetabular

autograft was used to fill a bone defect. All patients walked with partial weight-bearing allowed on the seventh postoperative day and then full weight-bearing at 1 month postoperatively.

The clinical results were analysed using the Merle d'Aubigne and Postel scoring system [18]. Serial radiographs were obtained and analysed by an independent observer. The inclination of the acetabular component was measured and the presence of radiolucent lines was evaluated using the zones described by DeLee and Charnley [4] for the acetabular component and those described by Gruen et al. [10] for the femoral component. Radiological loosening of the acetabular component was evaluated using the methods of Hodgkinson et al. [13]; loosening was defined as migration or radiolucency greater than 1 mm in all of the DeLee and Charnley zones [4]. Radiological loosening of the femoral component was evaluated using the method described by Engh et al. [17]. Linear wear of the acetabular component was determined by measuring the change in the shortest distance between the centre of the femoral head and the periphery of the acetabular component and by comparing the immediate postoperative radiograph with that taken at the last follow-up visit, as described by Livermore et al. [22]. The measurements were taken using calipers with an accuracy of 0.5 mm. Peri-prosthetic cystic or scalloped lesions with a diameter greater than 2 mm that were not present on the immediate postoperative radiograph were defined as osteolysis.

Statistical analysis was performed using the Wilcoxon signed rank test or Mann-Whitney U test. A *p* value of 0.05 was considered to be significant. Kaplan-Meier survivorship analysis was performed using revision for any reason as the end point.

Results

At the final follow-up, four hips (in three patients) had undergone revision with a mean duration between the initial operation and revision of 7.9 years (range, 4.9–11.4 years). Of these, three hips were revised at 8.9 years (range, 5.5–11.4 years) after the initial operation and their radiographs showed probable acetabular liner locking mechanism failure and wear of the polyethylene liner (Fig. 1a). The metallic locking mechanism was broken and the polyethylene liner was worn and loose in the acetabular component (Fig. 1b). Both the metal shell components and the femoral components were well fixed. The well-fixed acetabular component and worn polyethylene liner were changed to a new metal shell and polyethylene liner using the same approach. One patient fell, 4.9 years after the arthroplasty, and sustained a fracture of the metal tines of the locking mechanism with dislocation of the acetabular component.

Fig. 1 **a** Anteroposterior radiograph showing acetabular component dissociation. The 22-mm inner head is positioned eccentrically within the acetabular metal shell. The liner is dissociated inferiorly from the shell. **b** Retrieved metal shell showing the broken metallic tine locking mechanism

The mean abduction angles of four revised hips (average, $43.5^\circ \pm 6.0^\circ$) were significantly higher than the angles of the 16 hips that were not revised (average, $35.3^\circ \pm 5.4^\circ$; $p < 0.05$). The average polyethylene thickness and oscillation angle in the unrevised group were not significantly different from the four revised hips (Table 1). The femoral component was not loosened and the acetabular component required replacement.

The Kaplan-Meier survivorship analysis revealed a 13-year survival rate of 78% (95% CI: 59–97%) with revision for any cause as the end point (Fig. 2). The clinical results of the 11 patients (16 hips) who did not undergo revision revealed that the mean Merle d'Aubigne and Postel score for this group had improved significantly from 11.1 points (range, 5–15 points) preoperatively to 16.5 (range, 12–18 points) postoperatively ($p < 0.01$). The mean score for pain improved from 3.7 preoperatively to 5.7 at the last follow-up, while that of mobility improved from 5.3 to 4.9 and that of walking ability improved from 2.1 to 5.8. None of the patients reported any pain in the thigh.

Table 1 Comparison of results for unrevised and revised hips as mean $\pm$ SD

	Unrevised hips	Revised hips
Thickness of polyethylene	10.2 ± 1.1	10.5 ± 1.3
Abduction angle	35.3 ± 5.4	$43.5 \pm 6.0^*$
Oscillation angle	106.3 ± 0.9	105.5 ± 0.9

*Significantly higher than those of unrevised hips, $P < 0.05$

Fig. 2 Survivorship curve for the cementless THA with anatomic stem/HGPII cup combined with 22-mm femoral head with revision for any reason as the end point

Radiological findings revealed that three hips had a radiolucent line in zone 1 on the acetabular side according to the classification of DeLee and Charnley [4]: one in zone 2 and three in zone 3. The mean rate of wear of the acetabular component was 0.16 mm/y (range, 0.00–0.54 mm/y). On the femoral side, 12 hips had a radiolucent line in Gruen zone 1, two in zone 2, 13 in zone 4, two in zone 5, and three in zone 6, but none had a radiolucent line in zones 3 and 7 [10]. Some hips had lesions in more than one zone. None of the radiolucent lines was wider than 2 mm. Loosening of the acetabular component was observed in one of the unrevised hips. All of the femoral components exhibited radiological evidence of bone ingrowth at the last follow-up (Fig. 3) [6]. None of the 20 hips exhibited osteolysis.

Fig. 3 Anteroposterior radiograph showing the components are well fixed 11 years postoperatively

Discussion

The main purpose of this study was to evaluate the long-term (more than 10 years) results of cementless THA incorporating an anatomic stem/HGPPII cup with 22-mm head. After an average of 12.8 years, 78% of the hips demonstrated good or excellent clinical results. Furthermore, there was no aseptic femoral loosening, no femoral osteolysis, and no thigh pain up to 10 years after the arthroplasty. However, it was found that there was failure of the locking mechanism in four acetabular components.

We found that the tines of the locking mechanism in the HGPPII acetabular component were broken in four hips. Lachiewicz et al. reported that only three HGPPII acetabular components required a revision in 78 hips with a mean follow-up period of 8 years [16]. Archibeck et al. also reported that five patients in 74 underwent exchange of the HGPPII cup at middle-term follow up [1]. The diameter of these femoral heads was larger than the 22-mm inner diameter used in our series. There was no significant difference as to mean polyethylene thickness and oscillation angle; however, it was suggested that the failure of the HGPPII cup was associated with size of inner head diameter. Dislocation associated with a radiographically visible inner head positioned eccentrically within the acetabular metal shell was the primary indication for revision for locking mechanism failure. Mechanical failure, defined as broken metal tines detected during revision, was responsible for the locking mechanism fractures. An association was generated between radiographically visible dislocation and polyethylene failure with a portion of the locking mechanism showing distorted metal flanges. In our study, the abduction angles of the revised acetabular components were apparently higher. Peters et al. reported that the angle of inclination was changed or the orientation of the polyethylene liner was changed relative to the elevated rim and dislocation occurred because failure of the locking mechanism occurred from wear and shifting of the polyethylene liner [1, 5, 16, 19]. We suggested that failure of the locking mechanism arose from the mobility of the polyethylene liner because of a higher inclination angle of the acetabular component from wear. Gaffey et al. reported that the rate of wear was greater in association with cementless components than in association with cemented components [8]. Rotational force onto the articular surface, which disrupts the normally low-friction articulation and transfers oblique forces to the polyethylene liner through interaction with the femoral head, was augmented and then the polyethylene liner became worn and mobile.

As a result of the disappointing studies associated with proximally coated cementless femoral components such as the Harris-Galante-I stem (HGPI), the next generation of anatomic stems was developed [23]. The HGPI femoral

component had a relatively small porous surface area that was noncircumferential, resulting in a susceptibility to distal osteolysis. As a consequence a proximally coated femoral component with a circumferential porous surface was used and compared favourably with previously published reports on other successful cementless designs. Incomplete sclerotic and radiolucent lines adjacent to the prosthesis do not correlate well with implant stability. Most stems in our series had a radiolucent line next to the noncoated surface of the implant that was not indicative of stem loosening. In none of these hips was there other evidence of aseptic loosening, such as subsidence or complete radiolucency. Ragab et al., in their review, noted that the porous coated anatomic stem used in our series had a partial pedestal at a 28% rate and all of these stems had a radiographically stable implant [20]. In the case of proximally coated anatomic femoral components, no completely radiolucent line as an indicator of loosening was found and all stems were stable, so partial radiolucencies are not considered an important finding at long-term follow-up.

In our series, none of the hips were associated with thigh pain. In other series of proximally coated femoral components, the prevalence of thigh pain has been variable [21, 24]. Xenos et al., in a study of the porous-coated anatomic stem, found a peak prevalence of thigh pain, which decreased to 12% after 10 years [25]. Engh et al. identified 8% thigh pain in a study of extensively coated femoral stems followed for a minimum of 10 years [7]. We generated data over an average of 13 years on the cementless proximally porous-coated anatomic femoral components and our findings of clinically excellent results compare favourably with those available in the literature.

Particulate debris from polyethylene wear and the resultant osteolysis remain the primary factors limiting the longevity of hip prostheses [11, 14]. Femoral osteolysis was not seen in our series.

In conclusion, the outcome of cementless THA depends on many factors, including component design and head size, inclination angle of the acetabular component, and surgical technique. In our long-term (mean 12.8 years) results, the use of the anatomic circumferentially porous-coated femoral stem provides reproducible ingrowth and excellent clinical results, while a tendency for locking mechanism failure and loosening of the polyethylene liner of the HGPPII cup combined with 22-mm femoral head introduces a note of caution.

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