Outcomes at least 10 years after cemented PF® (Zimmer) total hip arthroplasty: 83 cases

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KEYWORDS
Cemented total hip prosthesis; Ceramic-on-polyethylene; Periprosthetic bone alterations

Summary
Introduction: Cementless total hip arthroplasty (TKA) is gaining ground over cemented TKA. The objective of this study was to assess survival rates of a cemented THA implant (PF®, Zimmer), after at least 10 years and to assess changes in acetabular bone structure.

Material and methods: Eighty-three ceramic-on-polyethylene THA prostheses were implanted between 1998 and 2001. Clinical outcomes were assessed using the Harris hip score and Postel Merle d’Aubigné score. For each hip, radiographs were examined for acetabular radiolucent lines, geodes, and granulomas; in addition, changes in bone structure and trabeculae were assessed comparatively to the other hip and classified from no change to severe osteolysis. Changes in trabeculae served to assess the loads applied to the bone. Polyethylene wear was assessed using the Livermore method.

Results: A single patient was lost to follow-up. At last follow-up, 16 patients had died and six were contacted and had not required revision surgery; the remaining 52 patients (59 THAs) were re-evaluated and none had evidence of loosening. The Harris hip score at last evaluation was 91.6 compared to 60.5 preoperatively. No hips had evidence of acetabular osteolysis. For two hips, the radiographs showed complete acetabular radiolucent lines less than 2 mm in width, with no mobilisation. Trabecular distribution was homogeneous with no stress shielding. Mean annual rate of wear was 0.08 mm. No instances of femoral component loosening were recorded; granulomas involving no more than five Gruen zones were seen in three cases.

Discussion: This study confirms the reliability of cemented THA, with a 12-year survival rate of 98.3%, in keeping with earlier data. Thus, our results establish that cemented ceramic-on-polyethylene prostheses remain valid options for THA.

Level of evidence: IV.

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Introduction

Cemented polyethylene acetabular components are gradually losing popularity, despite evidence of good long-term results: Caton and Prudhon reported an 85% survival rate after 25 years [1], Berry et al. an 86.5% survival rate after 10 years [2]. However, despite the drawbacks to cemented implants, they remain the most commonly used prosthesis. The acetabular component has been the most extensively studied of components, with a number of studies reporting survival rates of over 90% at 10 years [3-5]. This is due to the high friction between bone cement and bone, which acts as a barrier to wear. The hypothetically lower rate of osteolysis in the cemented acetabular component is the main advantage over the cementless one, despite the danger of complications such as cement fractures, infection, and the need for cement removal. This study aims to assess the survival of cemented ceramic-on-polyethylene THA after a minimum of 10 years of follow-up in a single centre, to assess changes in bone structure, and to classify acetabular radiolucent lines.
25 years [2], and Callaghan et al. a 78% survival rate after 35 years [3].

We studied a case-series of 83 cemented total hip arthroplasties (THAs) to assess prosthesis survival at last follow-up. We also evaluated potential acetabular bone changes to determine whether the acetabular bone structure remained satisfactory in the medium-term after the implantation of a cemented acetabular cup.

Material and methods

We included patients who underwent THA with a PF® cemented polyethylene cup and a PF® cemented stem (Synthes initially then Zimmer) and who were re-evaluated at least 10 years later. We identified 83 THAs performed between February 1998 and March 2001 in 76 patients, 31 women and 45 men with a mean age of 66 years (range, 40–82 years). The underlying diagnosis was primary hip osteoarthritis in 73 (88%) cases and secondary hip osteoarthritis in 10 cases. Mean body mass index (BMI) at surgery was 26.3 kg/m²; 47 patients were overweight (BMI between 25 and 30 kg/m²) and seven were obese (BMI between 30 and 35 kg/m²).

The acetabulum was reamed to bleeding sub-chondral bone; three to five postholes were prepared using a square-tipped awl, and pulsed saline lavage was then performed to prepare the cancellous bone for cementing.

The compression-molded PF® acetabular component was made of ultra-high-molecular-weight polyethylene (UHMWPE) without calcium stearate and was sterilised by gamma irradiation in an inert atmosphere. The hemispheric shape of the cup with grooves running parallel to the equator maximised cement pressurisation during implantation. Cup diameter ranged from 48 to 60 mm (Fig. 1).

The femur was rasped repeatedly until cortical contact was achieved laterally and medially. The femoral component was cemented under suction, after implantation of a plug made of synthetic material or bone. Gentamycin-impregnated cement was used (Cerafix Genta low viscosity, Ceraver). The PF® stem was straight, made of chromium-cobalt, cone-shaped, tapered, with an oval cross-section, vertical proximal grooves, and a matte finish. The cervico-diaphyseal angle was 130°. Two versions were available, standard and lateralised (+6-mm offset). The alumina head (Sulox™, Protec) was 28 mm in diameter, and three neck lengths were available.

All patients were re-evaluated at least 10 years after THA (mean, 143 months). Among the patients who died, mean time from THA to death was 7.6 years. Functional outcomes were assessed using the Postel Merle d’Aubigné (PMA) score [4] and the Harris Hip Score (HHS) [5]. HHS results were classified as follows: excellent, 90–100, good, 80–89, fair, 70–79, and poor, less than 70. The radiographic work-up consisted of an anteroposterior view of the pelvis, an anteroposterior view of the hip, and a surgical profile of the hip. The enlargement coefficient was computed from the apparent diameter of the prosthetic femoral head.

Acetabular polyethylene wear was assessed using the Livermore method [6] and radiolucent line location using the Delee and Charnley zones. The radiographic bone structure surrounding the acetabulum was assessed at last follow-up comparatively with the other hip, using a score that could range from 1 (osteolysis with a bony defect) to three (no change). On the same radiographs, trabecular density and orientation between the prosthetic acetabular rim and the iliac bone was used as an indicator of bone loading and was assessed as follows: three, no trabecular alterations; two, slight trabecular alterations; and one, trabecular orientation along the loading axis.

At the femur, radiolucent lines and granulomas were assessed using the Gruen and Callaghan classification system [7].

Results

Of the 76 study patients (with 83 THAs), only one (1 THA) was lost to follow-up, during the postoperative period. At re-evaluation, 16 patients (16 THAs) had died; none had required revision surgery. In addition, six patients were unable to travel but were interviewed and reported no pain or revision surgery. Finally, one patient experienced an infection that required exchange THA.

Mean follow-up in the overall sample including the patients who died was 11 years. In the 52 patients (59 THAs) who were re-evaluated after at least 10 years, mean follow-up was 11.9 years. At re-evaluation, 44 (74.5%) hips were completely pain-free and 15 were painful but showed no radiographic evidence of loosening (nine had infrequent mild pain, three moderate pain, and three severe pain originating from the spine).

The mean PMA score improved from 13.7 preoperatively to 16.74 at last re-evaluation. The mean HHS was 60.5 preoperatively and 91.6 at last re-evaluation; thus, the mean improvement was 31.1 points.

Revision surgery was required in three patients: one had early infection with a favourable outcome, another required one-stage exchange THA for delayed infection, and the third required removal of the trochanterotomy sutures. Dislocation occurred in three cases, none of which required surgery. No cases of mechanical loosening were recorded.

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cases, four zones in one case, five zones in one case, and six zones in one case. No major bone structure attenuation was noted in zone 2.

No femoral stem displacement was noted in any of the hips. Granulomas and radiolucent lines were visible in three (5%) cases; they involved five zones, four zones, and one zone, respectively. These abnormalities had no clinical impact.

**Discussion**

In our case-series with only one of 83 hips lost to follow-up and a follow-up duration of at least 10 years, no cases of mechanical loosening were recorded and 10-year prosthesis survival was 98.3%. These data confirm the good medium-term outcomes of cemented THA. They also support data establishing the long-term reliability of cemented polyethylene acetabular cups, with a 96% survival rate after 16 years [8] and no cup exchange after 16 years of mean follow-up according to Gardes et al. [9]. Further evidence of long-term reliability comes from the 86.5% survival rates after 25 years reported by Caton and Prudhon [1] and Berry et al. [2].

The polyethylene wear rate of 0.08 mm/year was consistent with previous reports (0.06–0.13 mm/year) [6,10,11].

The polyethylene is the weakest point of these prostheses [12]. Wear debris is released, resulting in granuloma formation. Experimentally, ceramic heads are associated with less wear than steel heads [13]. The alumina heads used in our series seem to produce better outcomes than do zirconium oxide heads [14,15]. In a 2004 study, McCombe and Williams [16] evaluated the influence of polyethylene thickness on wear. In our study, initial polyethylene thickness had no impact on the wear rate.

With metal-backed components, the considerable stiffness of the polyethylene-metal interface results in greater stresses between the head and the polyethylene, which increase the rate of wear [16–18]. Many studies have evaluated the presence of radiolucent lines, granulomas, and polyethylene wear [19–21] with cementless metal-backed cups. A systematic review by Pakvis et al. [22] found no significant evidence that cemented cups were superior over cementless cups. Furthermore, three groups [17,23,24] found no significant differences in terms of long-term survival, although Krückhans and Dustmann [25] reported better outcomes with cemented cups. A study of the Swedish Hip Arthroplasty Register conducted by Hailer et al. [26] (170 413 THAs) found higher survival rates with cemented versus cementless prostheses (94% vs. 85%, respectively). In the same study, however, aseptic femoral stem loosening was less common with cementless than with cemented stems.

A major issue with press-fit metal-backed cups is their considerably greater stiffness compared to the acetabular bone. The forces that hold press-fit cups to the bone are chiefly applied at the rim of the cup, resulting in stress shielding with bone loss in Gruen zones 2 and 5. Dual-energy X-ray absorptiometry (DEXA) studies of acetabular bone mineral density (BMD) showed severe acetabular bone loss within the first year after implantation of a metal-backed cup [27]. Also using CT, Mueller et al. [28] found a 30% BMD decrease after 1 year with metal-backed cups, whereas BMD

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**Figure 2** Distribution of 10-year polyethylene wear values.

**Figure 3** Relationship between cup diameter and polyethylene (PE) wear.

Mean polyethylene wear (Fig. 2) was 0.82 mm, i.e., 0.08 mm/year (range, 0–1.8 mm). Wear was greater than 1 mm for 18 cups and less than 0.5 mm for 19 cups. No correlations were found between polyethylene wear and initial polyethylene thickness (Fig. 3) or BMI.

No acetabular granulomas were identified. In two hips, a complete radiolucent line predominating in zones 1 and 3 was seen; the cup was stable and the clinical outcome excellent in both cases. Incomplete radiolucent lines less than 2 mm in width were visible in 21 cases. In 5 cases, these lines were present postoperatively and unchanged on the radiographs obtained at last follow-up (Table 1).

The bone trabeculae were slightly altered in two (3.4%) cases. Trabecular loss was noted in zones 3, 5, and 6, as well as an increase in the number of trabeculae in zone 1.

Slight bone structure attenuation was noted in 18 (30%) cases. All zones were affected. A single zone was altered in eight cases, two zones in three cases, three zones in four cases, four zones in one case, five zones in one case, and six zones in one case. No major bone structure attenuation was noted in zone 2.

No femoral stem displacement was noted in any of the hips. Granulomas and radiolucent lines were visible in three (5%) cases; they involved five zones, four zones, and one zone, respectively. These abnormalities had no clinical impact.

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**Table 1** Topographic distribution of the radiolucent lines visible on the antero-posterior radiograph.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Number of hips with lines</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>8.5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>13.6</td>
</tr>
<tr>
<td>1, 2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2, 3</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>1, 3</td>
<td>6</td>
<td>10.2</td>
</tr>
<tr>
<td>1, 2, 3</td>
<td>2</td>
<td>3.4</td>
</tr>
</tbody>
</table>
decreased by only 7% to 10% [29] or remained unchanged [27] with cemented polyethylene cups. One explanation is the greater elasticity of cemented polyethylene cups, whose elasticity module is similar to that of bone. The uniform load distribution avoids alterations in bone quality behind the acetabulum, in contrast to observations made with several metal-backed cup designs. Our study confirms this point, as bone structure remained unchanged in 70% of cases and trabecular distribution remained uniform in 96% of cases.

Mechanical loosening of the femoral component did not occur in any of our patients. The PF® stem design matches the femur perfectly, allowing optimal filling of the diaphyseal canal and the creation of a uniform but thin cement mantle (fixation according to the French paradox). The concept of this implant, which differs from the Charnley-type implant, evolved based on the experience acquired with the Müller self-locking stem. This stem has provided good results [30], with a 10-year femoral stem survival rate of 98.3% in a study by Brémaud. Nevertheless, large granulomas were found, although they may have been related to failure of the friction couple (32-mm metallic head). The PF® stem, which evolved from the validated concept underlying the Müller Straight Stem [31], exhibits a number of features that remain open to debate. Thus, whether a smooth or rough finish of the stem is preferable remains unclear, as excessive roughness may result in cement abraision [32]. Obtaining a stable stem is crucial. The presence of metaphyseal grooves improves stability by counteracting rotational forces at the prosthesis/cement interface. Nevertheless, their role is controversial, as they may result in increased stress at the cement/bone interface [33].

Implant geometry is of paramount importance. However, clinical experience has established that cement quality and cementing technique also exert a major influence on outcomes [31]. All the implants in our case-series were cemented using contemporary techniques (pulsed saline lavage, plug, and diaphyseal suction).

Our results confirm the medium-term reliability of the PF® (Zimmer) total hip prosthesis. Thus, survival was 98.3% after nearly 12 years. Despite the development of hard-on-hard friction couples and cementless prostheses, cemented ceramic-on-polyethylene prostheses seem to remain a valid option that may generate new interest in the current era of healthcare cost containment. The main drawback of cementless prostheses is that the metal-backed cup results in stress shielding with osteolysis in zones 2 and 5. Recently developed polyethylene cups coated with titanium may obviate the need for metal backing, thereby providing an alternative to cementless metal-backed cups.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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