Original article

Is cemented metal-polyethylene 22.2 mm hip arthroplasty a gold standard? Results of a series of 105 primary arthroplasties at a minimum of ten years follow-up

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1. Introduction

Cemented metal–on–polyethylene bearing total hip arthroplasty (THA) with a 22.2 mm Charnley-Kerboull type system, or low friction arthroplasty (LFA), is a reference in primary hip arthroplasties [1]. Nevertheless, there have been very few randomized studies comparing this hip replacement system with others [2–4], and it has not always been shown to be better [3–6], even though this type of evaluation is considered to be indispensable to confirm the quality of a new system [1].

Its reputation is also based on long-term follow-up after many years on the market [7–9]. Although this type of hip replacement was proposed in younger active populations with a high risk of wear [9], results of different trials in these populations have not always been as good [3,10,11] especially in the youngest subjects and in certain etiologies such as necrosis [11–13]. The rate of survival therefore varies, in particular in data from health registries (between 85% ad 92% after 10 years of follow-up) [6,10]. Thus, we evaluated survival of this prosthesis in a group that fulfilled recommendations set out by the French National Health Authority (Haute
Autorité de santé [HAS]) [1]. Our hypothesis was that 10-year survival would be more than 90% according to National Institute for Health and Clinical Excellence (NICE) criteria [14].

2. Materials and methods

2.1. Patients

Between January 1998 and March 2001, 93 patients (105 prostheses) underwent primary THA with a 22.2 mm metal-on-polyethylene bearing. During this period, this prosthesis was indicated in patients over the age of 60 and in those in whom a cementless stem could not be used because the femoral shaft was too wide or too narrow. The series included 93 patients, 30 men and 63 women (gender ratio 0.47) mean age at surgery 72.6 years old (60–86).

The mean body mass index was 26.4 (38.6–17.4). Twenty-six patients had a BMI > 30 (27.9%). The patients were not highly active according to the Devane et al. score [15] because 57 were grade III, 34 grade II and 2 grade I. Thirty-two patients (35 prostheses) in the primary THA group had died at the final follow-up and 21 patients (23 prostheses) were lost to follow-up leaving 40 patients (47 prostheses) who were examined at the follow-up consultation for this study (Table 1). The number of years of follow-up and the number of revisions in each group are described in Table 1.

2.2. Surgical technique

The Charnley-Kerboull system with an MKIII™ (Stryker-Howmedica, Hérouville, France) femoral component was cemented according to a second-generation technique (retrograde on the distal obdurator with aspiration) using Simplex™ cement (Stryker-Howmedica, Hérouville, France). There were 60 monoblock systems and 45 with modular heads; the choice was left up to the surgeon. All of the 22.2 mm heads were Orthinox™ (Stryker-Howmedica, Hérouville, France). Two types of cemented polyethylene cups were used, all cups were 22.2 mm and the choice was left up to the surgeon: 65 cross-linked ultra high molecular weight polyethylene MKIII cups (Stryker-Howmedica, Hérouville, France) sterilized with 3Mads of nitrogen (Duration™ procedure) and 40 ultra high molecular weight polyethylene Reflection™ cups (Smith et Nephew, Le Mans, France) sterilized with ethylene oxide. The cup cementing technique was the same in all cases using high viscosity Gentamicine cement (Heraus, Wehrheim, Germany) after creating 3 to 5 plugs depending on the size of the cup and after drying the cavity by aspiration.

All THA were performed under laminar flow by posterolateral approach with the patient in the lateral decubitus position by 3 senior surgeons or under their control (AD, CF, HM) with reinsertion of the hip capsule and the pelvic trochanteric muscles. Weight-bearing was allowed after ablation of the drains 24 or 48 hours after surgery. The patient was given advice to prevent dislocation.

2.3. Method of evaluation

The results were retrospectively evaluated in 40 patients after a mean follow-up of 10.6 years (10–13 years) by an observer who did not participate in surgery (47 hips with 29 MKIII cups and 18 Reflection™ cups, 26 monoblock and 21 modular stems). Function was evaluated by the Merle d’Aubigné score [16] and the Oxford self-assessment score [17] and activity by the Devane et al. score [15]. AP X-rays of the pelvis and lateral X-rays of the hip were performed at the final postoperative follow-up and compared to intermediate postoperative X-rays. Radiolucencies were evaluated according to DeLee and Charnley [18] for the acetabulum and according to Gruen et al. [19] for the femur. Mean cup inclination in relation to the teardrop line was 48° (40–57).

A cup was defined as loose on X-rays if there was more than 5° tilt or more than 5 mm migration [20]. In the same way, loosening of the femur was defined as more than 5 mm subsidence measured between the shoulder of the prosthesis and the tip of the greater trochanter [21]. Penetration into the polyethylene (linear wear) was determined by measuring the distance between the center of the femoral head component and the periphery of the cup visualized by a radio-opaque metal marker band on the AP X-ray of the pelvis at the final follow-up according to the method described by Livermore et al. [22].

Correction of X-ray enlargement was obtained by using the known diameter of the head component as a reference (22.2 mm). Analysis of radiolucencies and loosening was performed by two observers separately (PM, LV). In case of disagreement, a new analysis was performed and compared. Wear and inclination were assessed through a single X-ray measurement.

2.4. Statistical method

Qualitative variables were compared using the Chi² and Fisher exact test. Discrete variables were compared using the Student t-test and the Kruskal Wallis test for small groups. P < 0.05 was considered to be significant. Survival analysis was performed using the Kaplan–Meier method with the following end-point:

- revision surgery for whatever reason;
- radiological loosening, operated or not. Confidence intervals were calculated with a 95% risk.

3. Results

3.1. Analysis of survival and revision surgery

Survival was only influenced by acetabular cup complications: it was 89.4% (CI95%: 78–95) after 10 years of follow-up (Fig. 1). If non-revised radiographic loosening was included, survival at 10 years decreased to 78% (CI95%: 61–91). Thus, our hypothesis was not confirmed since survival was below the 90% NICE guidelines.

Revision surgery was necessary in eight prostheses including five hips (5 patients) out of the 43 patients who were seen at the final follow-up and three hips (3 patients) out of the 32 patients (35 prostheses) who died during the study period. Revision in the five patients seen at the final follow-up only involved the cup. One MKIII cup, revised after 18 months of follow-up for recurrent posterior dislocation, was replaced by a dual-mobility cup. Another MKIII cup was revised at 8 years postoperative for wear and loosening.

Fig. 1. At 10 years of follow-up survival was 89.4% (CI95%: 78–95) and patients were censored at surgical revision for any cause.

Table 1
Comparison of reviewed, deceased and lost to follow-up patients.

<table>
<thead>
<tr>
<th></th>
<th>Reviewed patients (n = 40)</th>
<th>Deceased patients (n = 32)</th>
<th>Lost to follow-up patients (n = 21)</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at THA</td>
<td>69.6 (60–82)</td>
<td>75.9 (66–86)</td>
<td>74.2 (68–78)</td>
<td>ns</td>
</tr>
<tr>
<td>Gender ratio (M/W)</td>
<td>0.24</td>
<td>0.42</td>
<td>0.39</td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td>Indication</td>
<td>Arthritis 42</td>
<td>Arthritis 33</td>
<td>Arthritis 23</td>
<td>ns</td>
</tr>
<tr>
<td>Level of preoperative activity Devane et al. [15]</td>
<td>I: 1</td>
<td>I: 1</td>
<td>I: 1</td>
<td>ns</td>
</tr>
<tr>
<td>Follow-up (years)</td>
<td>10.6 (10–13)</td>
<td>5.2 (2–10)</td>
<td>4.8 (2–7)</td>
<td>ns</td>
</tr>
<tr>
<td>Revisions</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>ns</td>
</tr>
<tr>
<td>Rate of loosening revised or not</td>
<td>12.2%</td>
<td>8.5%</td>
<td>0%</td>
<td>ns</td>
</tr>
</tbody>
</table>

(P = 0.04) (Figs. 2 and 3). The six late dislocations (at between 6 and 12 years of follow-up) occurred in cups with significant wear (mean radiographic penetration 2.3 mm).

There was no significant loosening in any of the femoral components, although 17 (34%) presented with non-progressive radiolucencies in zones 1 and 7. There were no significant bone spurs except for the usual rounding at the cut of the femoral neck. There were no postoperative infections.

3.3. Functional results

The mean follow-up of the 40 patients (47 THA) in the study was 10.6 years (10–13). Mean age at the final follow-up was 82 (69–92). The mean Oxford score was 22 points out of 60 (13–45) with 20 hips rated 25 or more and 8 hips rated 30 or more. The Merle d’Aubigné [16] score at the final follow-up (excluding the 5 revisions) was 14.2 (11–17) vs. 10.6 (6–11) preoperatively (P < 0.05), with mean pain, walking and mobility scores of 4.7 (3–6), 3 (1–5) and 5 (4–6) respectively. At the final follow-up, 40 patients had a low level of activity with 12 (30%) grade I patients and 28 (70%) grade II patients according to Devane et al. [15]. The activity level decreased non-significantly considering the preoperative level with 24 (60%) grade III patients and 16 (40%) grade II patients.

4. Discussion

With a survival rate of less than 90% at 10 years, our working hypothesis was not confirmed, even though the HAS guidelines were followed by selecting patients who were over sixty and not highly active [1]. The advanced age of the patients helps explain the high mortality rate (34%), mostly men, but the other characteristics of the deceased patients were comparable to the patients in the study (Table 1). Theoretically, our population had a moderate risk of wear and loosening, but this was not confirmed in our study because in our population of 47 THA assessed at follow-up, 12 (25.5%) had 2–4 mm of wear and 10 (21%) had cup loosening with or without revision surgery. Our rate of revision was higher than that in non-Scandinavian series in the literature (Table 3) where survival at 10 years was above 90% [7–9,22–28]. On the other hand, the results in other, mainly Scandinavian studies were closer to ours [3,29] with less than 90% survival at 10 years (Table 3).

The current study had limitations. First, although the mortality rate (34%) was high, this was due to the evaluation of this prosthesis in subjects over 60, who were a mean 82 years old at the final follow-up. Thus, most of the patients in the study were moderately active, which should have minimized the revision rate. Second, the percentage of lost to follow-up was high (22%), although their characteristics were similar to those of the rest of the population, and they were followed-up for a mean 4.8 years. Third, THA was performed by several surgeons, which could create a performance bias.
Although a Radiographic error was confirmed in those instances, we do not cite recent studies, which are representative of regular surgical practice. Fourth, two cup models were used, however the revision and loosening rate was the same in both cups even if the there was greater wear in Reflection™ cups. Finally, our method of evaluation of penetration had a potential error of approximately 3 mm [30], and probably underestimated wear.

Different factors are usually negatively associated with survival and wear such as age younger than 50, weight over 78 kg and/or being highly active [24]. Our series included elderly patients who were not overweight with a modest level of activity (Table 1). Although our cementing technique might explain our cup failures, it was similar to those in earlier series [27,28], and there was no failure of femoral fixation. Unlike other series with highly experienced surgeons [7,9,27], this was a multi-surgeon study, although senior surgeons always supervised the juniors. This probably explains the better results in the former studies. Moreover, Scandinavian studies, which were also multi-surgeon, had results similar to ours, confirming a probable performance bias in the other studies [3,29]. Despite the participation of young surgeons and the use of the posterior approach, only one revision was due to early dislocation. The other later dislocations (which occurred after the 6th year) were probably due to wear because they had a higher rate of linear wear than the average in our series.

The functional scores at the final follow-up were low but negatively influenced by the patient’s age as well as cup loosening, which affect function. Only 3 cases of cup loosening were well tolerated and were not revised, perhaps because of the low level of activity of these patients. There were no infections and especially no cases of femoral loosening which confirms the quality of the cement fixation of the MkIII component, as previously confirmed in the LFA series [31].

5. Conclusion

Survival at 10 years in this series of cemented 22.2 mm metal-on-polyethylene bearing THA was in the low range of that in the literature and was below the NICE criteria, even though our population did not have a high risk of wear and loosening. On the other hand, this series confirmed the efficacy of cement fixation of the Charnley-Kerboull-type femoral component. Polyethylene wear was the main cause of failure of this type of THA and the

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### Table 2
Radiographic results in 47 total hip arthroplasty (THA) assessed at follow-up.

<table>
<thead>
<tr>
<th>Looseened cup</th>
<th>No Radioluencies</th>
<th>Radiolucency ≥ 1 zone</th>
<th>Radiolucency &gt; 2 zones</th>
<th>Absence of wear</th>
<th>Wear ≥ 2 mm (2–4 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 revised 3 non-revised</td>
<td>23</td>
<td>26</td>
<td>12</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

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### Table 3
Comparison of the results of Charnley low friction total hip arthroplasty (THA).

<table>
<thead>
<tr>
<th>Follow-up</th>
<th>Number of primary THA</th>
<th>Number of THA assessed</th>
<th>Age at THA</th>
<th>Survival</th>
<th>Cup loosening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bjørgul et al. [2]</td>
<td>14</td>
<td>120</td>
<td>71</td>
<td>&gt;75</td>
<td>85%</td>
</tr>
<tr>
<td>Bjørgul et al. [5]</td>
<td>10</td>
<td>120</td>
<td>118</td>
<td>65</td>
<td>90%</td>
</tr>
<tr>
<td>Caton et Prudhon [7]</td>
<td>25</td>
<td>86</td>
<td>45</td>
<td>66</td>
<td>7%</td>
</tr>
<tr>
<td>Nich et al. [12]</td>
<td>15</td>
<td>122</td>
<td>96</td>
<td>51</td>
<td>88.5%</td>
</tr>
<tr>
<td>Hozack et al. [24]</td>
<td>10</td>
<td>1041</td>
<td>26</td>
<td>18</td>
<td>92%</td>
</tr>
<tr>
<td>Wroblewski et al. [25]</td>
<td>20</td>
<td>28</td>
<td>26</td>
<td>18</td>
<td>32%</td>
</tr>
<tr>
<td>Joshi et al. [26]</td>
<td>25</td>
<td>330</td>
<td>62</td>
<td>56</td>
<td>90%</td>
</tr>
<tr>
<td>Hulleberg et al. [29]</td>
<td>113</td>
<td>138</td>
<td>93</td>
<td>73</td>
<td>85%</td>
</tr>
<tr>
<td>Current series</td>
<td>11</td>
<td>105</td>
<td>47</td>
<td>73</td>
<td>89.4%</td>
</tr>
</tbody>
</table>

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Fig. 3. Progression of a prosthesis associating a Reflection™ cup and modular MkIII™ stem postoperatively (left) and after 11 years of follow-up (right) with 2.7 mm penetration on the cup and cup migration revised by an acetabular cage and morselized bone grafting with a cemented dual mobility cup (patient aged 87).
introduction of cross-linked polyethylene, which is less sensitive to wear, should result in long-term improvement of survival.

Disclosure of interest

HM is an educational and research consultant for Zimmer and Tornier and receives royalties from Tornier. AD, CF, GW, LV, PM declare that they have no conflicts of interest concerning this article.

References


