A 20-year follow-up evaluation of total hip arthroplasty in patients younger than 50 using a custom cementless stem

Edouard Dessyn, Xavier Flecher, Sebastien Parratte, Matthieu Ollivier and Jean-Noël Argenson

Abstract
Aim: The purpose of this study is to report the 20-year follow-up of a continuous series of 232 total hip arthroplasties (THAs) performed in patients aged less than 50 at the index surgery.

Patients and methods: This is a retrospective monocentric study which reports the clinical, radiographical and survival results of 232 THAs performed with a custom cementless femoral stem in 212 patients evaluated at follow-up ranging from 14 to 27 years.

Results: At the time of follow-up, the mean Harris Hip Score was 94.1 (range 48–100). The Hip disability and Osteoarthritis Outcome Score was >80 points in all 5 categories for 146 patients (68.9%). 18 hips (8.5%) showed radiographical femoral abnormalities. 23 hips (10.8%) underwent revision of the implants. 13 were isolated cup revisions. 3 more hips had bipolar revisions for aseptic loosening at 15, 20 and 21 years. Taking stem revision for aseptic loosening as an endpoint, survivorship was 96.8% at 20 years (95% confidence interval, 95.1–98.5; patients at risk 76) and 94.5% at 25 years (91.7–97.3; patients at risk 12).

Conclusions: The results of this study confirm that THA using this custom-designed stem can provide excellent clinical and radiographical outcomes at a mean follow-up of 20 years in patients younger than 50. The individual 3D femoral stem and prosthetic neck has been able to restore extra- and intramedullary functional anatomy in this young and active cohort of patients.

Keywords
Custom, patients under 50, total hip arthroplasty

Introduction
With the long-term proven clinical efficiency of total hip arthroplasty (THA) in patients older than 65 years, the indications for THA tend to have grown since the beginning of the 1990s. Nevertheless, as recently described by Bayliss and colleagues in The Lancet, young age increases the failure rate risk of both hip and knee implants in arthroplasty. Indeed, they showed that the lifetime risk of THA revision increased from 5% for patients aged around 70 to almost 30% for patients aged around 50 years, with a lifetime risk of revision 15% lower for women. With patient demand growing, around 52% of primary THAs could be implanted in patients aged less than 65 by 2030, with the highest increase for patients aged between 45 and 55 years. Furthermore, it is now widely accepted that THA in young patients seems to lead to more technical difficulties and higher rates of osteolysis or aseptic loosening. Some of the reasons could be related to the frequent modified anatomy of the proximal femur in young and active patients suffering from arthritis secondary to developmental dysplasia of the hip (DDH), avascular necrosis (AVN).
or trauma, as previously shown by the authors. The higher functional demand and activity level of these young and active patients may also lead to more wear and loosening issues. Considering the increased need for surgery for these young and active patients and the need to maintain their activities and quality of life, we explored a way to restore the anatomy and maintain the function of their hips.

Due to these anatomical variations of the proximal femur, initial primary stability, the key to long-term fixation, may be difficult to obtain with most of the commercially available prostheses, including standard, modular or anatomical implants. Indeed, distortion of the proximal femoral anatomy equally affects the intramedullary canal and the extramedullary parameters of the upper part of the femur. Previous studies have reported good mid-term survivorship and functional outcomes using a cementless femoral custom-made stem. The use of a cementless femoral stem aims to obtain primary stability for short-term bone ingrowth and to ensure long-term fixation with minimal osteolysis while restoring the strain transmission. Using preoperative 3-dimensional (3D) computed tomography (CT) scan-based planning also offers the surgeon a way to correct offset and leg length issues allowing individual correction in all 3 planes.

The aim of this study is to evaluate if, in a young and active population with frequent anatomical abnormalities, the use of a custom femoral cementless stem can maintain, at an average of 20 years of follow-up, good functional, radiographical and survival results.

**Patients and methods**

A continuous consecutive series of 232 primary uncemented THA was retrospectively evaluated in 212 patients aged less than 50 at the time of the surgery and operated on between January 1990 and September 2002. Primary hip osteoarthritis (OA), AVN, DDH classified grade 1 or 2 of the classification of Crowe et al. and an age between 17 and 50 years at the time of the index procedure were the inclusion criteria. All patients had an activity score of Devane et al. superior to Grade 3. The approval of the local ethical committee was obtained. The demographic description of the population is summarised in Table 1.

![Table 1. Demographic data of the 212 patients (233 hips).](image-url)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td>42.6 ± 4 (20–50)</td>
</tr>
<tr>
<td>Weight in kg</td>
<td>71 ± 15 (42–120)</td>
</tr>
<tr>
<td>Height in cm</td>
<td>170 ± 10 (142–192)</td>
</tr>
<tr>
<td>BMI in kg/m²</td>
<td>25 ± 5 (16–48)</td>
</tr>
<tr>
<td>Male</td>
<td>106</td>
</tr>
<tr>
<td>Female</td>
<td>106</td>
</tr>
<tr>
<td>Secondary osteoarthritis</td>
<td>115 (49.4%)</td>
</tr>
<tr>
<td>Developmental dysplasia of the hip</td>
<td>88</td>
</tr>
<tr>
<td>Post-traumatic</td>
<td>27</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>77 (33%)</td>
</tr>
<tr>
<td>Primary osteoarthritis</td>
<td>41 (11.6%)</td>
</tr>
<tr>
<td>Charnley A</td>
<td>194</td>
</tr>
<tr>
<td>Charnley B</td>
<td>34</td>
</tr>
<tr>
<td>Charnley C</td>
<td>5</td>
</tr>
<tr>
<td>Preoperative Harris Hip Score</td>
<td>54.2 (26–87)</td>
</tr>
<tr>
<td>Preoperative Merle D’Aubigne-Postel score</td>
<td>7.6 (0–13)</td>
</tr>
<tr>
<td>Watson-Jones approach</td>
<td>233</td>
</tr>
<tr>
<td>UHMWPE liner</td>
<td>233</td>
</tr>
<tr>
<td>28-mm diameter alumina-made femoral head</td>
<td>233</td>
</tr>
<tr>
<td>Mean follow-up in years</td>
<td>20 (14–27)</td>
</tr>
</tbody>
</table>

BMI, body mass index; UHMWPE, ultra-high-molecular-weight polyethylene.
To obtain the 3D design of the femoral stem and to promote its intramedullary fit, a CT scan was performed preoperatively, which enabled the promotion of cancellous bone contact without any cortical bone contact of the stem using a custom stainless-steel rasp designed with the same shape as the definitive femoral stem. The appropriate prosthetic neck offset and anteversion were also calculated based on this preoperative CT scan analysis (Figure 1).7 The contralateral side if normal or the lever arm ratio and the abductor angle if abnormal were used to estimate the lateral correction needed for each patient.13,14 The same uncemented Ti-alloy hydroxyapatite (HA)-coated cup (Hilock; Symbios) with a conventional ultra-high-molecular-weight polyethylene (UHMWPE) liner was used for all patients combined with a 28-mm diameter alumina femoral head.

The clinical evaluations were performed by the surgeon preoperatively, at 3 months postoperatively, then at yearly intervals until the last follow-up, during which a radiographical and clinical evaluation was carried out by 1 orthopaedic resident (ED) not involved in the treatment. The Merle D’Aubigne-Postel and Harris Hip Score (HHS) were used to evaluate the patient’s preoperative and postoperative functional level.15,16 The existence of thigh pain was also recorded. The Hip disability and Osteoarthritis Outcome Score (HOOS),17 a subjective functional evaluation, was performed postoperatively. It was not determined preoperatively since it was not described at the beginning of this study.18 The University of California at Los Angeles (UCLA) score was also used to evaluate the patient’s level of activity.19

AP views of the pelvis, of the hip and true lateral views of the hip were performed to evaluate the postoperative radiographical results. A comparison with the first postoperative radiograph was then used to search for any radiolucency, osteolysis or subsidence. To study postoperative leg lengths, we measured the distance from the lesser trochanter to the acetabular teardrop. This was only carried out by one of us (ED) in order to avoid inter-observer variability. We used the 7 zones described by Gruen et al.20 to analyse the femur and the progressive appearance of radiolucency, or radiolucency greater than 2 mm in width and the presence of osteolysis. The criteria of Engh and Bobyn21 were used to evaluate femoral component stability. Polyethylene wear was not measured in this series using conventional polyethylene since we now know the benefit gained from the use of crosslinked polyethylene,22 but revisions for wear were recorded.

For continuous variables, we described the demographic patient data with means, standard deviations, medians and ranges. For categorical variables, counts and percentages were routinely used. The HOOS and UCLA score were statistically described using descriptive statistics; means and range were used to analyse radiographical outcomes such as stem stability and osteolysis. For all patients, a 20-year and 25-year survival analysis was performed with the Kaplan-Meier technique (with 95% confidence intervals [CI]) considering revision for any reason or stem revision only as endpoints.23 SPSS software was used to perform the analysis (Version 16.0; SPSS Inc, Chicago, IL). All calculations assumed 2-tailed tests. We chose to use a p value <0.05 as statistically significant.

All investigations were conducted in conformity with ethical principles of research, and informed consent for participation in the study was obtained.

**Results**

At the time of the index surgery, the mean age of patients was 39.6 years (range 17–50 years). At the latest follow-up, the mean age was 52.9 years (range 22–77 years) and 148 patients were still working. 12 patients died including 2 who underwent a femoral revision at 14.7 and 21.1 years respectively. Clinical evaluations were completed for all living patients with a surviving custom femoral stem. Radiographs were taken at an average of 20 years (range 15–27 years) and were available for 112 patients (125 hips, 53.6%).
At the time of follow-up, the HHS and the Merle D’Aubigne-Postel score significantly improved from preoperatively to a respective mean of 94.1 (range 48–100) and 15.9 (range 9–18) (Table 2). 154 hips (66.1%) were pain free. 179 hips (76.8%) had full range of motion and 160 patients (75.5%) had full recovery of activity. The HOOS was >80 points (max. 100) in all 5 categories for 68.9% of patients with an average of 89.9 for pain, 85.5 for symptoms, 84.2 for activity daily living, 77 for sport and 85.9 for quality of life. At the most recent follow-up, the mean UCLA score improved from 5.2 ± 1.6 points to 7.0 ± 2 points (p = 0.007) and 161 had a score >6, indicating regular involvement in moderate physical activities.

The mean postoperative leg length discrepancy was 2.3 mm (range 0–13 mm) and was less than 5 mm for 94% of patients. For the 125 hip radiographs available at a mean follow-up of 20 years, no patient had subsidence of the femoral stem (Figure 2). Furthermore, femoral abnormalities were recorded in 18 patients (8.5%): 6 cases of cortical hypertrophy (3 in Gruen Zone 4, 2 in Gruen Zone 2, 1 in Gruen Zone 3), 7 osteolysis (4 in Gruen Zone 1, 3 in Gruen Zone 1 and 8), 4 stem-cortical contacts (1 in Gruen Zone 12 and 3 in Gruen Zone 6) without thigh pain, and 1 patient with cortical pedestal with pain. A study of bone remodelling showed no or minimal stress shielding. Radiographic abnormalities were observed in the acetabulum for 10 patients (4.7%): 3 with migration and 7 with complete radiolucent lines.

Reoperations without revision of at least 1 of the implants occurred for 12 hips (5.1%): 4 infections required surgical washout; 3 symptomatic heterotopic ossifications needed to be removed; 1 postoperative diaphyseal femoral fracture had to be fixed with a plate in a 41-year-old; 1 polyethylene liner-cup dislocation needed its liner to be replaced in the retained cup; 1 painful trochanteric wire had to be removed; 1 greater trochanteric fracture nonunion was re-fixed after a fracture and fixation with cerclage wires during the index surgery; 1 dislocation needed to be surgically reduced. 8 dislocations occurred (3.4% patients) and were treated by closed reduction. Since the beginning of the study, 23 hips (9.9%) underwent revision of the implants. 13 were isolated cup revisions, including 7 for loosening and 6 for isolated polyethylene wear. 3 more hips had revisions of both components for aseptic loosening at 21.4, 15.5 and 20.1 years. The 7 remaining hips were revised for deep infection with a 2-stage procedure for 6 hips, and for chronic instability for 1 hip.

Taking revision for any reason as an endpoint, survivorship was 77.7% at 20 years (95% CI, 72.4–83; patients at risk 76). Taking stem revision for aseptic loosening as an endpoint, survivorship was 96.8% at 20 years (95% CI, 95.1–98.5; patients at risk 76) and 94.5% at 25 years (91.7–97.3, patients at risk 12) (Figure 3).

### Discussion

The 20-year survival rate of custom cementless femoral stem reported in the present study is encouraging, as well as the good functional outcome in a young and active population presenting with frequent anatomical abnormalities with only 11% of primary osteoarthritis. To our knowledge, this is the largest population with custom cementless femoral stem revisions.
stem being followed clinically and radiographically at 20 years of follow up, with the use of a quality of life hip score such as the HOOS in young and active patients.

As seen in Table 3, few studies have reported long-term survivorship of cementless stems in patients younger than 50–24–27 years, as confirmed by De Kam et al.28 in their descriptive literature review. Muirhead-Allwood et al.29 presented the 10- to 17-year results of a series of 112 computer-assisted design cementless components with a 97.3% (CI at 95–99%) survivorship and no revision for failure of the femoral component. At a mean of 14 years for a cohort of patients aged less than 40 years, Akbar et al.30 reported no femoral failures for a custom cementless femoral stem. In patients with osteoarthritis caused by congenital dislocation of the hip, the 10-year survival of custom-made cementless femoral stem has already been reported showing encouraging results.31,32 In 2015, Swarup et al.33 reported a 10-year survival rate of 85% for standards implants in THA performed in young patients with juvenile idiopathic arthritis, and there was no significant difference between cemented and uncemented implants or between standard and custom stems. In their series, Delaunay et al.26 reported a survival rate of 100% at 10 years of follow-up with cementless standard femoral implants and metal-on-metal articulation in active patients younger than 50 years, including twice as many patients with primary OA compared to the present series. Del Piccolo et al.34 reported that both short cementless stems and conventional cementless stems were able to provide stable fixation and good results in patients under 50 years at less than 6 years of follow-up.

Götze et al.46 showed, in an *in vitro* study, that an individualised custom stem fit into the endosteal cortical bone decreased micro motion. Avoiding the use of distal canal filing stems in any type of femoral anatomy, frequently related to osteoarthritis affecting young patients, while preserving the cancellous bone during intramedullary preparation may represent an important advantage in case of revision twenty years later for a population still very active, as demonstrated in the present study with an average age of 53 at 20 years of follow-up.

![Figure 3](image.png)

**Figure 3.** Kaplan-Meier survivorship analysis with revision of the femoral stem for any reason as an endpoint. The 20-year survival rate of the femoral stem was 96.8% (95% confidence interval, 95.1–98.5, patients at risk 76).

**Table 3.** Comparison of mid- to long-term follow-up of cementless THAs in young patients.

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of hips</th>
<th>Mean age (years)</th>
<th>Mean follow-up (years)</th>
<th>Mean HHS (points)</th>
<th>Thigh pain (%)</th>
<th>AF loosening</th>
<th>Survivorship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al.35</td>
<td>118</td>
<td>47 (21–49)</td>
<td>9.8 (8–11)</td>
<td>92</td>
<td>10</td>
<td>0%</td>
<td>99 at 10 years</td>
</tr>
<tr>
<td>Reigstad et al.36</td>
<td>75</td>
<td>52 (24–68)</td>
<td>16 (15–18)</td>
<td>89 (54–100)</td>
<td>1.3%</td>
<td>88 at 18 years</td>
<td></td>
</tr>
<tr>
<td>Schramm et al.37</td>
<td>89</td>
<td>51 (20–77)</td>
<td>10</td>
<td>98</td>
<td>17</td>
<td>0%</td>
<td>88 at 18 years</td>
</tr>
<tr>
<td>Zenz et al.38</td>
<td>56</td>
<td>56</td>
<td>10</td>
<td>91</td>
<td>47</td>
<td>0.7%</td>
<td>98 at 10 years</td>
</tr>
<tr>
<td>Duffy et al.39</td>
<td>84</td>
<td>38 (16–50)</td>
<td>10</td>
<td>88 (48–100)</td>
<td>6%</td>
<td>88 at 10 years</td>
<td></td>
</tr>
<tr>
<td>Capello et al.40</td>
<td>123</td>
<td>39 (18–49)</td>
<td>&gt;10</td>
<td>91.5</td>
<td>0.8</td>
<td>0.9%</td>
<td>94.6 at 10 years</td>
</tr>
<tr>
<td>McAuley et al.41</td>
<td>561</td>
<td>40 (16–50)</td>
<td>6.92 (0–19)</td>
<td>92 (62–100)</td>
<td>2%</td>
<td>7%</td>
<td>98 at 12.5 years</td>
</tr>
<tr>
<td>Muirhead-Allwood et al.29</td>
<td>112</td>
<td>46.2 (25–62)</td>
<td>13 (10–17)</td>
<td>90.3 (38–100)</td>
<td>0%</td>
<td>0%</td>
<td>98.2 at 13 years</td>
</tr>
<tr>
<td>Patel et al.42</td>
<td>69</td>
<td>61 (22–75)</td>
<td>5</td>
<td>96 (55–100)</td>
<td>0%</td>
<td>0%</td>
<td>100% at 5 years</td>
</tr>
<tr>
<td>Al-Khateeb et al.43</td>
<td>15</td>
<td>32.8 (23–55)</td>
<td>10.1 (5–15)</td>
<td>80 (51–94)</td>
<td>0%</td>
<td>0%</td>
<td>100% at 10 years</td>
</tr>
<tr>
<td>Santori et al.8</td>
<td>129</td>
<td>51 (21–71)</td>
<td>8 (4.9–14.1)</td>
<td>95 (76–100)</td>
<td>0%</td>
<td>0%</td>
<td>98 at 12.5 years</td>
</tr>
<tr>
<td>Swarup et al.33</td>
<td>97</td>
<td>22 (SD 7)</td>
<td>12 (2–23)</td>
<td>86% at 10 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osagie et al.44</td>
<td>14</td>
<td>36.5 (15–50)</td>
<td>3</td>
<td>71 (47–89)</td>
<td>0%</td>
<td>0%</td>
<td>100% at 14 years</td>
</tr>
<tr>
<td>Akbar et al.30</td>
<td>72</td>
<td>35 (22–40)</td>
<td>14 (10–16)</td>
<td>87 (42–100)</td>
<td>0%</td>
<td>0%</td>
<td>92% at 18.3 years</td>
</tr>
<tr>
<td>Sewel et al.45</td>
<td>40</td>
<td>37.5 (18–61)</td>
<td>10.1 (4–18)</td>
<td>80 (51–94)</td>
<td>2.5%</td>
<td>0%</td>
<td>96.8% at 20 years</td>
</tr>
<tr>
<td>Our study</td>
<td>233</td>
<td>43 (20–50)</td>
<td>20 (15–26.7)</td>
<td>94 (48–100)</td>
<td>2.8</td>
<td>1.3%</td>
<td>94.5% at 25 years</td>
</tr>
</tbody>
</table>

HHS, Harris Hip Score; AF, aseptic femoral.
Extramedullary anatomy can be also corrected regarding 3D femoral offset, which includes antversion and leg length discrepancies. This facilitates surgery avoiding any additional femoral osteotomy or the use of metaphyseal modularity, reducing the potential for metallic wear debris. The restoration of optimal 3D offset has been shown to play a significant role in periarticular muscle function and range of motion, 2 factors of great importance for an active population. In our study, clinical and functional scores remained excellent at nearly 20 years of follow-up which compares favourably with studies looking at clinical outcomes after THA in young patients. Very few studies have evaluated the quality of life in these young patients after the surgery, including the level of physical and sporting activities. Muirhead-Allwood et al. reported excellent results for visual analogue scales evaluating patient satisfaction at a mean of 13 years follow-up. In our study, more than 75% of patients had a full recovery of their activities and had a UCLA score superior to 6 indicating regular involvement in moderate physical activities. The HOOS has also shown that almost 80% of patients felt no limitation during their usual moderate and regular physical activities and that 86% had a high quality of life after the THA.

This study has some limitations. 1st, it is a retrospective monocentric study without a control group, but custom THA was a relatively uncommon procedure in the early 1990s. 2nd, the x-ray analysis is limited to 125 hips out of 232, mainly because some patients refused to come to the surgical department because of living too far away. For these patients, we could then only study their functional patterns and the survival rate of their femoral components. Nevertheless, the radiographical study of this series remains relevant since the initial cohort was important. Next, we did not perform any measurement of polyethylene wear. Finally, the relatively high percentage of patients not free of pain (33.9%) could be explained by the fact that most of the patients reporting pain were complaining of « slight, occasional and no compromising activities » pain for the HHS or of monthly and occasional pains for the HOOS.

Our results confirm that the custom-designed stem evaluated in this study can provide excellent clinical and radiographical outcomes at a mean of 20 years of follow-up for THA in patients younger than 50. We believe that the cancellous bone conservation and the perfect intramedullary adaptation to the proximal femoral anatomy allowed by the 3D custom-made femoral stem provided long-term survival rate and stable fixation without adverse bone reaction. We also think that the long-term functional efficiency of the cementless custom-made femoral stem in a young and active population was due to the three-dimensional CT scan analysis of the extramedullary parameters and the custom-made design offered by the prosthetic neck. However, continuous follow-up is required in this young and active population, including further analysis of wear rate on the acetabulum side.

Authors’ note
This work was performed at the Institute for Locomotion, Aix-Marseille University, Marseille, France.

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