


# 7-year results of primary total hip arthroplasty with the uncemented Avenir stem

HIP International  
2019, Vol. 29(4) 418–423  
© The Author(s) 2018  
Article reuse guidelines:  
sagepub.com/journals-permissions  
DOI: 10.1177/1120700018810211  
journals.sagepub.com/home/hpi  


Roger Erivan<sup>1</sup>, Guillaume Villatte<sup>1</sup>, Jean-Michel Brientini<sup>2</sup>,  
David Kreider<sup>3</sup>, Stéphane Descamps<sup>1</sup> and Stéphane Boisgard<sup>1</sup>

## Abstract

**Aims:** The aim of the present study was to evaluate the 7-year functional outcome and radiographic results of primary total hip arthroplasties (THAs) performed with the uncemented Avenir stem.

**Patients and methods:** Between January 2006 and October 2008, 100 consecutive primary hips in 92 patients were enrolled at 2 centres. The mean age at operation was 58.5 years (27–87 years). Mini-incision (50%) and standard approaches (50%) were used to implant 22 standard and 78 lateralised stems.

**Results:** The 7-year Kaplan-Meier survival rate was 98.9% (95% CI, 92.9–99.8) with stem revision for any reason as endpoint. No stem related complications occurred. 1 stem revision was due to deep infection at 51 months post-op. We had 4 acetabular revisions. The mean Harris Hip Score (HHS) at 7 years follow-up was 93.1 points (60–100). Radiographic analysis showed 2 patients had non-progressive radiolucent lines and no patient had any signs of stem subsidence or loosening.

**Conclusion:** The 7-year implant survival and the functional outcomes for THA performed with the study device are excellent and were in line with those documented for comparable contemporary uncemented fully HA-coated stems. Longer term follow-up of this consecutive series needs to be performed.

## Keywords

Aseptic loosening, cohort follow-up, hip arthroplasty, primary hip replacement, uncemented stem

Date received: 21 July 2017; accepted 16 May 2018

## Introduction

Based on design concepts of the proven cemented Müller Straight Stem (Zimmer Biomet, Winterthur, Switzerland) and uncemented fully hydroxyapatite (HA)-coated stems such as the Furlong HAC Stem (JRI Orthopaedics Ltd, Sheffield, UK) or the Corail Stem (DePuy Orthopaedics Inc., Warsaw, IN, USA), the uncemented Avenir Stem (the study device, Zimmer Biomet, Winterthur, Switzerland) was released in 2005. The stem is made from titanium alloy (Ti6Al4V) with a proximal macro surface structure, a titanium plasma pre-coating and is entirely coated with hydroxyapatite. It features a rectangular cross-section, a constant CCD angle of 135° and a 12/14 taper. It is implanted through a bone compaction technique that promotes accurate line-to-line rasp/implant sizing designed to help align bone, rasp and implant resection lines. The stem is available in 9 Standard and 9 Lateral sizes, with smaller

increments between small stem sizes to allow finer adjustments in tight femoral canals.

A study was initiated in 2010 to enrol patients that had undergone total hip arthroplasty (THA) with the subject stem at a minimum 3 years post-op, after which they would be followed prospectively up to 10 years. In January 2016 an interim study analysis was performed to evaluate the functional outcomes and radiographic results of the study

<sup>1</sup>Université Clermont Auvergne, CHU Clermont-Ferrand, CNRS, SIGMA Clermont, ICCF, Clermont-Ferrand, France

<sup>2</sup>Polyclinic of Franche-Comté, Besançon, France

<sup>3</sup>Zimmer Biomet, Warsaw, Indiana, USA

## Corresponding author:

Roger Erivan, Services d'Orthopédie A et B, Hôpital Gabriel Montpied, 58 Rue Montalembert, BP 69, 63003 Clermont Ferrand Cedex 1, France.

Email: rerivan@chu-clermontferrand.fr

**Table 1.** Primary diagnosis.

Diagnosis	n
Osteoarthritis	73
Osteonecrosis	17
Rheumatoid arthritis	3
Acute fracture	2
Post-traumatic arthritis	2
Subluxation of the hip	1
Other	2
<b>Total</b>	<b>100</b>

device at 7-year follow-up. The purpose of this study analysis was to evaluate the clinical and radiographic results of the study device at 7-year follow-up. We hypothesised that the subject stem will achieve similarly favourable outcomes as compared to contemporary uncemented fully HA-coated stems.

## Patients and methods

Between January 2006 and August 2008, 100 consecutive THAs in 92 patients were performed by 2 surgeons (the authors JMB, SB) in 2 hospitals using the study device.

The study cohort included 52 (57%) men and 40 (43%) women, at a mean age of 58.5 (27–87) years at the time of surgery. Mean body mass index (BMI) was 27.7 (21–44) kg/m<sup>2</sup>. No patients were excluded from analysis. Indications for surgery are listed in Table 1.

## Operative information

Mini-incision (50%) and standard approaches (50%) were used to implant 22 Standard and 78 Lateral stems. The acetabular components used included the Cedior press-fit cup in 55 hips, the Logos uncemented cup in 27 hips, the Allofit uncemented cup in 17 hips, and the Müller Low Profile cemented cup in 1 hip. All components are manufactured by Zimmer Biomet. A Metasul metal-on-metal bearing articulation (Zimmer Biomet, Winterthur, Switzerland) was used in 66 hips, metal-on-polyethylene articulation in 33 hips, and a ceramic-on-polyethylene articulation in 1 hip.

## Functional outcome and radiographic assessment

Pre- and postoperative clinical assessment was performed using the Harris Hip Score (HHS) by an independent observer. The results were classified as: excellent (90–100), good (80–89), fair (70–79), and poor (<70).

The radiological evaluation was based on anteroposterior (pelvis and femur) and lateral (femur) radiographs. Osteolysis and radiolucencies were recorded according to Gruen and Callaghan radiographic zone analysis.<sup>1,2</sup>

Furthermore, femoral heterotopic ossification and changes in the stem position, including subsidence and loosening, were evaluated. Functional outcomes and radiological evaluation were performed preoperatively, at 3–4 years postoperatively and at 5 and 7 years, along with evaluation of the range of motion.

Patient satisfaction data were collected and summarised at the procedure level by an independent observer. At 7 years, 82 patients (89 procedures) answered the satisfaction question. 7 of the 82 patients underwent bilateral surgery.

## Statistical analysis

Categorical data were summarised using counts and percentages. Continuous data were expressed as a mean and range. A *p* value of < 0.05 was considered statistically significant. Kaplan-Meier (K-M) survivorship analyses with corresponding 95% confidence interval (CI) were performed with the endpoints of stem revision for any reason and any component revision for any reason. Statistical analysis was performed with PASW 18 & IBM SPSS 20 (SPSS Inc., Chicago IL).

## Ethical approval

This study was approved by the French regulatory authorities (CCTIRS n°10.595). Informed consent was obtained from all individual participants included in the study.

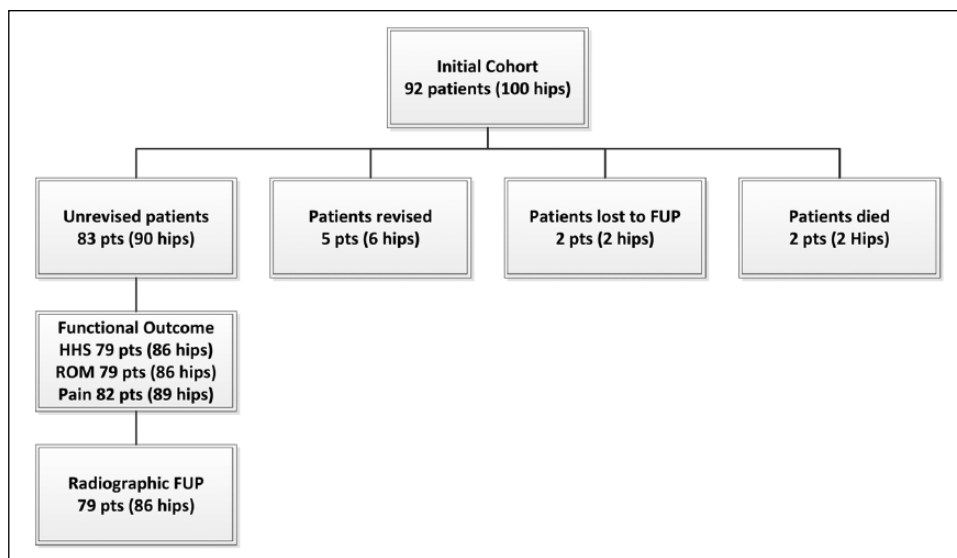
## Results

At the time of this review in January 2016, of the 100 THAs (92 patients) enrolled in the study, 2 patients (2 hips) died and 2 patients (2 hips) were lost to follow-up. 5 patients (6 hips) were revised. A total of 83 patients (90 hips) were available for functional outcome and radiographic assessment at a mean of 7 years (Figure 1).

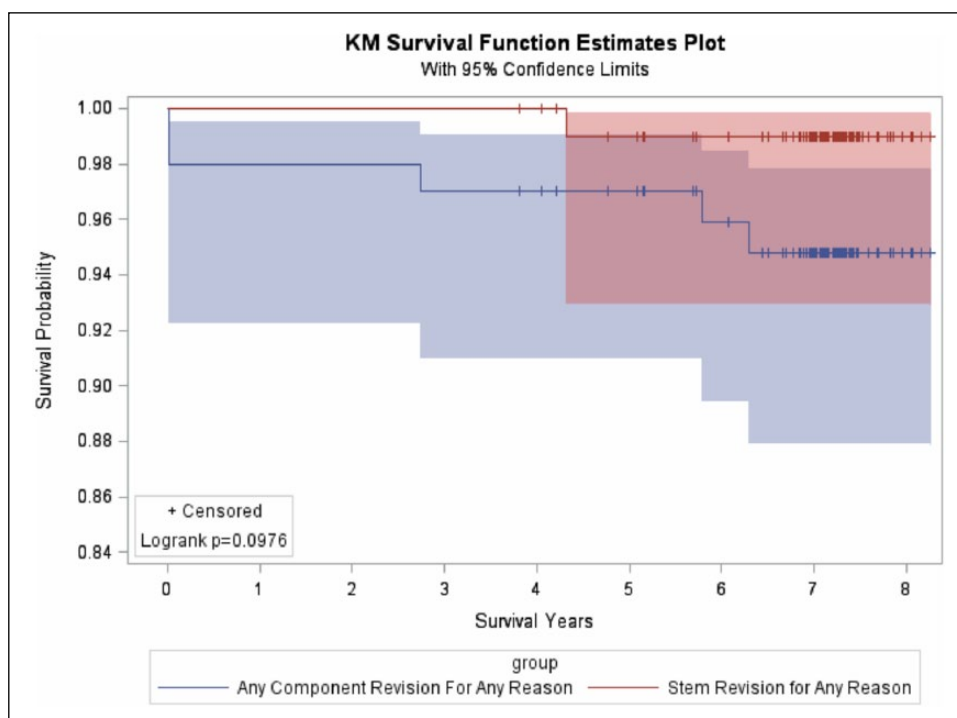
## Complications

Postoperative complications included 2 deep infections. 1 hip was successfully treated with Rifadin and Batrim, and the other hip was revised at 51 months (the entire prosthesis was revised). Metallosis due to dislocation of the Metasul cup in 1 hip caused an exchange of a cup and head 6 years postoperatively. 2 cases of “bascule” [migration] of inlay (inserts not properly inserted in the shells) led both to acetabular revision 6 days after the surgery. Cup pain in 1 patient after trauma led to a revision of the cup 3 years post-op.

Furthermore, 1 patient experienced hip instability at 1 year, followed by subluxation at 2 years that was successfully treated with traction. 1 intraoperative calcar crack was treated successfully with cerclage. Other complications included 1 dislocation treated with closed reduction, 1 scar inflammation without reoperation, and 1 pulmonary embolism.



**Figure 1.** Distribution of total hip arthroplasties at 7-year follow-up. (FUP).



**Figure 2.** Kaplan-Meier survival curve with 95% confidence intervals (CI), considering stem revision for any reason and any component revision for any reason as endpoints. 7-year survival was estimated at 98.9% (95% CI, 92.9–99.8%; 90 hips at risk) and 94.7% (95% CI, 87.9–97.8%; 87 hips at risk) respectively.

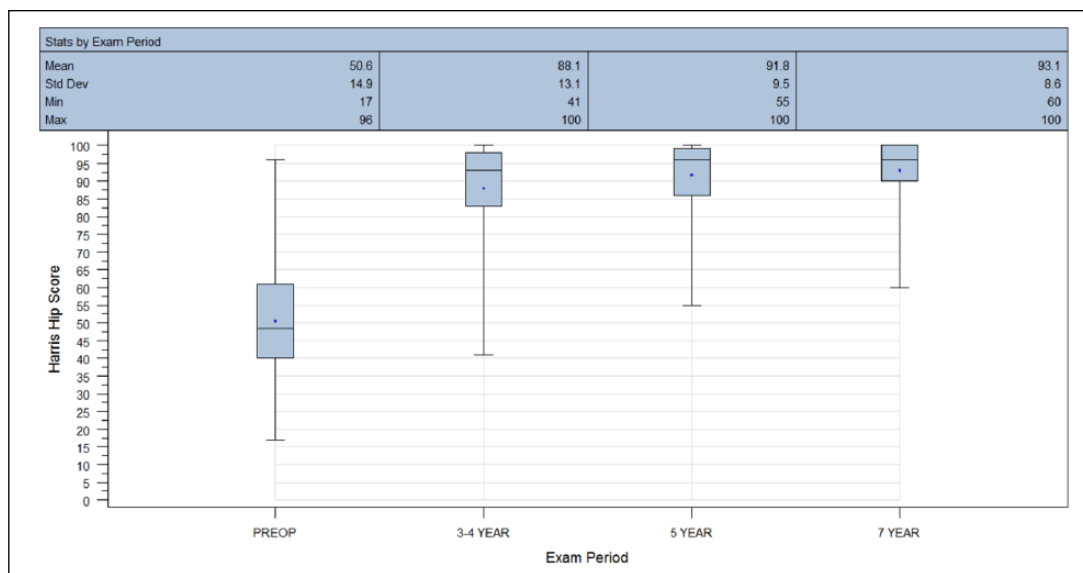
### Survival

The Kaplan-Meier survivorship at 7 years (Figure 2) was 98.9% (95% CI, 92.9–99.8%; 90 hips at risk) with stem revision for any reason as endpoint and 94.7% (95% CI, 87.9–97.8%; 87 hips at risk) with any component revision for any reason as endpoint.

### Functional outcomes assessment

The mean HHS improved significantly from 50.6 points (17–96; 98 hips) preoperatively to 93.1 points (60–100; 86 hips) at 7-year follow-up ( $p < 0.0001$ ; unpaired  $t$ -test) (Figure 3).

At the 7-year follow-up visit, in 56 cases (62.9%) patients reported no hip pain, in 26 cases (29.2%) slight



**Figure 3.** Harris Hip Score distribution by exam period.

pain, in 4 (4.5%) mild pain, and in 3 moderate pain (3.4%). Mean range of motion significantly increased from 82.3° (30–120°) of flexion preoperatively to 104.4° (90–120°) at 7 years ( $p < 0.0001$ ; unpaired  $t$ -test). Patient satisfaction results showed all 82 patients (89 procedures) were satisfied with their hip surgery at 7 years.

### Radiographic assessment

The 7-year radiographic results of 86 hips showed 6 cases of a non-progressive 1-mm radiolucency around the femoral component in zones 1, 2, 7, 8, 11, and 14. Non-progressive femoral osteolysis was observed in 1 patient on a lateral view at 7 years (3 mm in zone 8 and 2 mm in zones 12 and 13). Femoral heterotopic ossification was detected in 27 hips (31.4%) at 7 years: 23 were Brooker Classification grade I, none were grade II, 4 grade III, and none were grade IV. Stem position was 78% neutral, 18% in varus (2–4°) and 4% in valgus (2–8°) in the anteroposterior view, and 70% neutral, 15% anterior and 15% posterior in the lateral view. No stem shift or subsidence was detected. There were no instances of stem loosening.

### Discussion

The survival rate is 1 of the most important parameters to consider when evaluating THA outcomes.<sup>3,4</sup> No studies have documented yet the results of the uncemented Avenir stem. However, the survival of this stem has been documented in 2 national registry reports. The 2016 report of the Australian Orthopaedic Association National Joint Replacement Registry documented a 3-year K-M revision rate, with revision of any component for any reason as endpoint, of 1.7% (95% CI, 1.0–2.9) for the Avenir Stem/

Continuum cup combination (882 THAs), and a 5-year K-M revision rate, with revision of any component as endpoint, of 1.0% (95% CI, 0.4–2.4) for the Avenir Stem/Trilogy cup combination (555 THAs).<sup>5</sup> The 16-year report of the New Zealand Joint Registry documented the results of THA performed with the study device in combination with 4 cups, for a total of 461 primary THA.<sup>6</sup> The pooled number of revisions per 100 observed component years was 0.7 (Exact 95% CI, 0.4–1.2) at a mean implantation time of 3.6 years.

Our mid-term results of primary THA performed with the study device showed a 7-year K-M survival rate of 98.9% (95% CI, 92.9–99.8), with stem revision for any reason as the endpoint. None of the subject stems were revised for aseptic loosening at 7-year follow-up review. The K-M survival rate of the study device is comparable with the 7-year survival rates of comparable contemporary uncemented fully HA-coated stems.

The mean HHS in the patients who reached the 7-year follow-up visit in our study was 93.1 ± 8.6 points, therefore corresponding to the excellent result category (90–100 points).

The literature has reported good results for the similar Furlong HAC-Coated stem and Corail fully HA-coated stem (Table 2), and the cemented Müller Straight Stem.<sup>7–10</sup>

The Avenir system was designed to simplify femoral preparation using a broach only technique. The specific Avenir rasps were designed to subtly balance bone compaction and cortical contact where needed. Additionally, the rasps provide a precise size match between rasp and final implant, which allows the stem to seat in the same position as the last rasp used, thus helping to reduce initial gaps between implant and bone. We believe that this

**Table 2.** Primary results documented in the present study and in published studies on the Furlong HAC-Coated stem and Corail stem reporting 7 or more years Kaplan-Meier survival. Only the 7-year survival rate is reported in the table in order to compare with results of our cohort.

Study	Primary hips (n)	Follow-up years (range)	Mean HHS at follow-up (range)	7-year K-M survival rate by endpoint	
				Stem revision for any reason	Stem revision for stem aseptic loosening
Present study	90	7 (3.8–8.3)	93.1 (60–100)	98.9%	100%
<i>Furlong HAC Stem studies</i>					
Chandran et al. <sup>7</sup>	125	7 (NR)	NR	~99%	NR
Sandiford et al. <sup>8</sup>	72	7 (NR)	NR	100%	NR
Syed et al. <sup>9</sup>	38	7 (NR)	NR	100%	NR
<i>Corail Stem studies</i>					
Cho et al. <sup>10</sup>	86	7 (NR)	NR	NR	100%
Hallan et al. <sup>11</sup>	5456	7 (NR)	NR	98.9%	~99%
Merini et al. <sup>12</sup>	295	7 (NR)	NR	~93%	NR
Vidalain <sup>13</sup>	347	7 (NR)	85.1 (NR)	100%	NR

HHS, Harris Hip Score; K-M, Kaplan-Meier; NR, not reported.

~ denotes that the approximate value was retrieved from the graph in the original publication.

bone-conserving compaction broaching technique and the line-to-line rasp/implant sizing contributed to the stable fixation of the fully HA-coated stems in our study. Indeed, pure compaction broaching for femoral canal preparation has been reported in the literature for over a decade with early animal studies reporting improved initial stability and increased peri-implant bone density, including HA coated implants.<sup>11–13</sup> The literature cites favourable mid- to long-term outcomes in primary THA using the pure compaction broaching technique.<sup>14–17</sup> Studies comparing outcomes of THA after use of the pure compaction technique in comparison to the conventional broaching technique are few. A recently reported 5-year randomised radiostereometric analysis and dual energy x-ray absorption study found increased migration of bone compaction stems compared to stems whose femoral canals were conventionally broached (mean 0.34 mm vs. 0.13 mm ( $p = 0.01$ )).<sup>18</sup> Nonetheless, the authors cited similar complications and mean HHS scores at 7 years post-surgery, thus concluding that differences in the evaluated parameters of pure bone compaction versus broaching were not clinically relevant. No stems were revised in either group.

Our study has a few limitations, including its relatively small study population and non-comparative study design. However, this is the first study documenting the results of this study device.

## Conclusion

In conclusion, the 7-year results of THA performed with the uncemented Avenir stem are in line with those documented for similar stems. Longer term follow-up of this consecutive series needs to be performed.

## Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: SB: consultant for Zimmer Biomet. DK: employee of Zimmer Biomet.

## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## References

1. Gruen TA, McNeice GM and Amstutz HC. “Modes of failure” of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res* 1979; 141: 17–27.
2. Callaghan JJ, Dysart SH and Savory CG. The uncemented porous-coated anatomic total hip prosthesis. Two-year results of a prospective consecutive series. *J Bone Joint Surg Am* 1988; 70: 337–346.
3. Prokopetz JJ, Losina E, Bliss RL, et al. Risk factors for revision of primary total hip arthroplasty: a systematic review. *BMC Musculoskelet Disord* 2012; 13: 251.
4. Sandiford N, Doctor C, Rajaratnam SS, et al. Primary total hip replacement with a Furlong fully hydroxyapatite-coated titanium alloy femoral component: results at a minimum follow-up of 20 years. *Bone Joint J* 2013; 95: 467–471.
5. Australian Orthopaedic Association National Joint Replacement Registry. 2016 annual reports: Australian Orthopaedic Association National Joint Replacement Registry, <https://aoanjrr.sahmri.com/fr/annual-reports-2016> (2016, accessed 20 July 2017).
6. NZ Joint Registry | New Zealand Orthopaedic Association, <https://nzoa.org.nz/nz-joint-registry> (accessed 21 July 2017).
7. Clauss M, Luem M, Ochsner PE, et al. Fixation and loosening of the cemented Muller straight stem: a long-term

- clinical and radiological review. *J Bone Joint Surg Br* 2009; 91: 1158–1163.
8. Chandran P, Azzabi M, Miles J, et al. Furlong hydroxyapatite-coated hip prosthesis vs the Charnley cemented hip prosthesis. *J Arthroplasty* 2010; 25: 52–57.
  9. Syed MA, Hutt NJ, Shah N, et al. Hydroxyapatite ceramic-coated femoral components in young patients followed up for 17 to 25 years: an update of a previous report. *Bone Joint J* 2015; 97: 749–754.
  10. Merini A, Viste A, Desmarchelier R, et al. Cementless Corail™ femoral stems with laser neck etching: long-term survival, rupture rate and risk factors in 295 stems. *Orthop Traumatol Surg Res* 2016; 102: 71–76.
  11. Kold S, Rahbek O, Toft M, et al. Bone compaction enhances implant fixation in a canine gap model. *J Orthop Res* 2005; 23: 824–830.
  12. Kold S, Rahbek O, Vestermark M, et al. Bone compaction enhances fixation of weightbearing titanium implants. *Clin Orthop Relat Res* 2005; 431: 138–144.
  13. Kold S, Rahbek O, Zippor B, et al. Bone compaction enhances fixation of hydroxyapatite-coated implants in a canine gap model. *J Biomed Mater Res Part B Appl Biomater* 2005; 75: 49–55.
  14. Cho JH, Garino JP, Choo SK, et al. Seven-year results of a tapered, titanium, hydroxyapatite-coated cementless femoral stem in primary total hip arthroplasty. *Clin Orthop Surg* 2010; 2: 214–220.
  15. Vidalain JP. Twenty-year results of the cementless Corail stem. *Int Orthop* 2011; 35: 189–194.
  16. Min BW, Song KS, Bae KC, et al. The effect of stem alignment on results of total hip arthroplasty with a cementless tapered-wedge femoral component. *J Arthroplasty* 2008; 23: 418–423.
  17. Swanson TV. The tapered press fit total hip arthroplasty: a European alternative. *J Arthroplasty* 2005; 20(Suppl. 2): 63–67.
  18. Hjorth MH, Stilling M, Søballe K, et al. Preparation of the femoral bone cavity in cementless stems: broaching versus compaction. *Acta Orthop* 2016; 87: 575–582.