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## Use of Cementless or Cemented Stems in One-Stage Exchange for Periprosthetic Joint Infection in Total Hip Arthroplasty Does Not Affect Outcomes: A Propensity-Matched Cohort Study from an Institutional Registry With a Mean Follow-Up of Six Years

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## ABSTRACT

**Background:** Periprosthetic joint infection (PJI) is the most dramatic complication of total hip arthroplasty (THA). We investigated whether a one-stage arthroplasty using a cemented or uncemented stem was associated with better survival in terms of infection and mechanical complications.

**Methods:** Patients were selected from a PJI institutional registry of THA between 2003 and 2019. After matching the two groups by propensity score at a 1:3 ratio, 241 patients were finally included: 62 in the cemented group and 179 in the cementless group. The mean age of the population was 68 years (range, 25.1 to 91.4), and 45.2% (109 of 241) of the patients were women, with a mean body mass index of 26.9 (range, 15.6 to 46.4). The mean follow-up was 6.6 years (range, 0.1 to 18.1). To compare the overall survival rate between groups, Kaplan–Meier analysis was performed.

**Results:** The overall survival rate in our series was 93.3% [88.2 to 98.7] at 10 years. At the last follow-up, nine THAs had been reinfected: four relapses and five new infections. Regarding the reinfection-free survival rate, there was no significant difference ( $P = 0.62$ ) between the cemented group (95.8% [90.2 to 100.0]) and the cementless group (94.1% [87.8 to 100.0]) at 10 years. At the last follow-up, 34 (14.1%) THAs had aseptic complications that required 30 revisions. Regarding the aseptic survival rate, there was no significant difference ( $P = 0.61$ ) between the cemented group (81.8% [71.1 to 94.0]) and the cementless group (83.3% [72.8 to 95.2]) at 10 years.

**Conclusions:** To our knowledge, this study is the first to compare outcomes between cemented and cementless stems in one-stage exchange PJI. There is no difference in reinfections or mechanical complication rates when a cemented or cementless stem is used in a one-stage revision THA exchange for PJI. Other parameters, in particular the shape of the femur and the patient's comorbidities, must be taken into account when choosing the type of stem to use.

**Level of Evidence:** Level III, case-control studies.

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Chronic periprosthetic joint infection (PJI) is a serious complication following total hip arthroplasty (THA). Revision surgery to remove the infected prosthesis and implant a new one is currently the gold standard treatment for chronic PJI [1]. A two-stage arthroplasty is the most common treatment among orthopaedic surgeons, but single-stage arthroplasty is on the rise [2–6] and is recognized as effective in experienced referral centers with good infection control [7–11]. A one-stage exchange reduces morbidity

(delay between the two stages) and costs for the health system and the patient (return to home and work) [12]. At our institution, until 2008, one-stage exchange for PJI in THA was performed only in cases without large bone defects and when the causative pathogen was identified. Subsequently, it is performed for almost all PJI THA.

A historical approach to one-stage arthroplasty has been the use of a cemented reimplantation, where the polymethylmethacrylate acts as a topical antibiotic delivery vehicle [13]. However, it is possible that biofilm may form on actively eluting antibiotic polymethylmethacrylate [14], raising concerns about the development of antibiotic-resistant microorganisms [15]. A clear advantage of cementless revision is that it allows for a bone-sparing re-revision procedure in the event of failure. In addition, cementless revisions are thought to have lower long-term revision rates compared to cemented revisions [16–18]. Regarding two-stage arthroplasty, Hipl et al. observed that chronic infection in cemented THA may be associated with increased bone loss, higher rates of reinfection, and all-cause revision after two-stage revision [19]. To our knowledge, a comparison of one-stage revision with cementless versus cemented implants for PJI has not been previously evaluated.

Therefore, the aim of this study was to compare the reinfection-free survival rate after one-stage exchange for chronic PJI between cemented and cementless femoral stems using an institutional registry database. Implant aseptic revision-free survivorship was assessed as a secondary outcome.

## Methods

The local ethics committee (institutional review board number: RNI-B-2022-7502-10) approved this single-center, prospective cohort (registered on ClinicalTrials.gov: NCT 02801253); all patients gave informed consent to participate.

### Patients

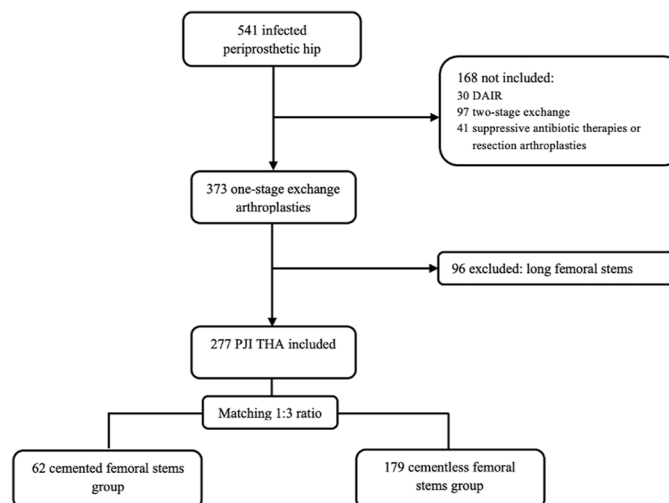
Patients were selected from a PJI institutional registry of THA between January 1, 2003, and December 31, 2019. There were 373 treated with single-stage exchange arthroplasty, 97 with two-stage surgery, 30 with debridement, antibiotics, and implant retention, and 41 with other strategies (resection, delayed reimplantation) (Figure 1). This single-center study included patients over 18 years of age undergoing single-stage exchange arthroplasty for THA PJI with  $\geq$  five years of follow-up after THA. Patients

who received a long stem after the one-stage procedure were excluded from the study. After propensity score matching of cemented and cementless femoral stems at a 1:3 ratio, 241 patients were finally included: 62 in the cemented group and 179 in the cementless group (Figure 1). The cemented stems used were composite beam designs (Oceane, Corin, Cirencester, United Kingdom), whereas the cementless stems were double-tapered designs (Meije Duo, Corin, Cirencester, United Kingdom), with an additional eight intermediate cementless stems (length < 200 mm) consisting of Corail revision stems (DePuy, Raynham, Massachusetts). Acetabular components were predominantly cementless, with cemented cups used only when reconstruction with an acetabular reinforcement ring was required.

The mean age of the population was 68 years (range, 25.1 to 91.4); 45.2% (109 of 241) of the patients were women, with a mean body mass index of 26.9 (range, 15.6 to 46.4). The mean follow-up was 6.6 years (range, 0.1 to 18.1). Demographic data for the two groups are shown in Table 1. The distribution of pathogens isolated from PJI is shown in Table 2.

### Diagnosis, Therapeutic Strategy, and Clinical Follow-up

The diagnosis of PJI was made according to the Musculoskeletal Infection Society [20] criteria. Each patient underwent joint aspiration at least two weeks before surgery, performed in the radiology department under fluoroscopic guidance and strict sterile conditions. The diagnosis and procedure were confirmed each week at the same multidisciplinary consultation, which included at least an orthopaedic surgeon, an infectious disease specialist, and a microbiologist. The surgical procedure was a single-stage removal and included excision of the scar and fistula, if present, and at least five intraoperative samples were taken from the synovial, acetabular, and femoral sites and sent to the microbiology laboratory. In the case of bone loss, a non-antibiotic-impregnated bone allograft was performed, and a new prosthesis was implanted after saline rinsing. There was no antibiotic-loaded cement used when the stem was cemented. All patients have a drain for four days postoperatively. The choice of antibiotic was initially guided by the preoperative culture results of the joint aspirate and subsequently adapted to the intraoperative culture results of the specimen [21]. All patients received postoperative antibiotics, consisting of  $\geq$  one intravenous antibiotic started during surgery after tissue sampling, administered intravenously for two to four weeks, followed by an oral regimen to complete three months of



**Figure 1.** Flow chart. PJI, periprosthetic joint infection; THA, total hip arthroplasty; rTHA, revision total hip arthroplasty; DAIR, debridement, antibiotics, and implant retention.

**Table 1**  
Demographics Data (Mean and SD for Continuous Variable).

Parameters	n	Cemented Group	n	Cementless Group	P-value
Age (SD) in years	62	68 (13.4)	179	68 (12.2)	0.55
BMI (SD)	59	26.4 (5.7)	179	27.1 (5.2)	0.48
Sex (%)					
Men	28	45.2	104	58.1	0.10
Women	34	54.8	75	41.9	
ASA score (SD)	62	1.9 (0.8)	179	2.0 (0.6)	0.59
Time of follow-up (SD)	61	8.2 (4.3)	177	6.0 (2.9)	<b>≤0.01</b>
Previous septic surgery (%)					
0	44	71	147	82.1	0.14
1	17	27.4	31	17.3	
2	1	1.6	1	0.6	
Acetabular graft (%)					
Yes	13	21.0	31	17.3	0.68
No	49	79.0	148	82.7	
Type of infection (%)					
Chronic infection	16	25.8	60	33.5	0.40
Postoperative infection (<1 mo)	13	21.0	23	12.8	
Acute hematogenous infection	18	29.0	55	30.7	
Not determined	15	24.2	41	22.9	
Type of pathogen (%)					0.56
<i>Staphylococcus aureus</i> (MS)	9	14.5	16	8.9	
<i>Staphylococcus aureus</i> (MR)	2	3.2	3	1.7	
<i>Staphylococcus epidermidis</i> (MS)	3	4.8	11	6.1	
<i>Staphylococcus epidermidis</i> (MR)	12	19.3	28	15.6	
<i>Staphylococcus capitis</i> (MS)	1	1.6	8	4.5	
<i>Staphylococcus capitis</i> (MR)	0	0	3	1.7	
<i>Staphylococcus lugdunensis</i> (MS)	1	1.6	7	3.9	
Other staphylococcus coag neg (MR)	0	0	1	0.6	
Other staphylococcus coag neg (MS)	0	0	2	1.1	
<i>Cutibacterium acnes</i>	6	9.7	18	10.1	
<i>Streptococcus agalactiae</i>	2	3.2	10	5.6	
<i>Streptococcus dysgalactiae</i>	0	0	5	2.8	
<i>Streptococcus mitis/oralis</i>	0	0	5	2.8	
Other streptococcus	3	4.8	4	2.2	
<i>Escherichia coli</i>	6	9.7	8	4.5	
<i>Enterococcus cloacae</i>	1	1.6	3	1.7	
<i>Enterococcus faecalis</i>	1	1.6	3	1.7	
<i>Pseudomonas aeruginosa</i>	2	3.2	2	1.1	
<i>Salmonella enteritidis</i>	1	1.6	0	0	
Other	4	6.5	19	10.6	
Polymicrobial infection	8	12.9	23	12.8	

Significant results were highlighted in bold.

ASA, American Society of Anesthesiologists; BMI, body mass index; MR, methicillin resistant; MS, methicillin sensitive.

**Table 2**  
Distribution of Cultured Microorganisms Isolated From Periprosthetic Joint Infection Total Hip Arthroplasty.

Pathogen	N	%
<i>Staphylococcus aureus</i> (MS)	25	10.4
<i>Staphylococcus aureus</i> (MR)	5	2.1
<i>Staphylococcus epidermidis</i> (MS)	14	5.8
<i>Staphylococcus epidermidis</i> (MR)	40	16.6
<i>Staphylococcus capitis</i> (MS)	9	3.7
<i>Staphylococcus capitis</i> (MR)	3	1.2
<i>Staphylococcus lugdunensis</i> (MS)	8	3.3
Other staphylococcus coag neg (MR)	1	0.4
Other staphylococcus coag neg (MS)	2	0.8
<i>Cutibacterium acnes</i>	24	10.0
<i>Streptococcus agalactiae</i>	12	5.0
<i>Streptococcus dysgalactiae</i>	5	2.1
<i>Streptococcus mitis/oralis</i>	5	2.1
Other streptococcus	7	2.9
<i>Escherichia coli</i>	14	5.8
<i>Enterococcus cloacae</i>	4	1.7
<i>Enterococcus faecalis</i>	4	1.7
<i>Pseudomonas aeruginosa</i>	4	1.7
<i>Salmonella enteritidis</i>	1	0.4
Other	23	9.5
Polymicrobial infection	31	12.9

MR, methicillin resistant; MS, methicillin sensitive.

postoperative therapy. Our treatment strategy is detailed in the study by Zeller et al. [7].

Telephone interviews were conducted to obtain updates from patients who were unable to attend the follow-up visits. At each visit, we looked for clinical, radiological, and biological signs of reinfection or implant failure.

### Outcomes

The primary endpoint of the study was the incidence of periprosthetic hip reinfection. Reinfection is defined as a recurrence of the prosthesis infection, which can be either a relapse with the same bacteria or a new prosthesis infection caused by a different bacterium. The secondary endpoint was the occurrence of aseptic implant failure requiring revision. This could be a loosening, dislocation, or other mechanical event in the patient's prosthesis without any clinical, biological, or radiological signs of PJI. In addition, cultures of preoperative joint aspiration fluid and intraoperative specimens must be sterile in the event of revision.

### Data Analyses

To match the two groups and limit the impact of external factors, as well as any selection bias, propensity score matching was

used. The propensity score was calculated by considering the patient's age at the time of surgery, sex of the patient, and American Society Anesthesiologists score. Each patient who underwent a cemented femoral stem for PJI THA was matched with three patients who underwent a cementless stem for PJI THA on a 1:3 basis. Matching was performed with a logit scale using a 0.1 caliper. Frequencies and percentages were used to describe discrete variables; continuous variables were described using means and standard deviations. For comparative analyses, Fisher's exact tests were used for percentages and Wilcoxon tests for continuous variables. Kaplan–Meier analyses were performed to assess survival rates at the last follow-up.  $P$ -values  $\leq 0.05$  were significant, for a power of 80% and an alpha risk of 5%. R software (version 3.5.0) was used to perform statistical analyses (<https://www.r-projectproject>).

## Results

The global survival rate after one-stage exchange for chronic PJI THA was 93.3% [88.2 to 98.7] at 10 years.

### Infected Survival Rate

At the last follow-up, nine THAs had been reinfected. The mean reimplantation–reinfection interval was 8.0 years (range, 1.8 to 14.5). There were four relapses and five new infections. All relapses occurred after five years (range, 5.9 to 13.1). The reinfection-free survival rate after one-stage exchange for chronic PJI THA was 99.5% [98.6 to 100] at five years and 95.0% [90.8 to 99.5] at 10 years.

In the cemented group, 6.6% (four of 62) of THA had been reinfected: three new infections (3 of 4) and one relapse (1 of 4). The mean reimplantation–reinfection interval was 9.4 years (range, 3.6 to 14.5). The reinfection-free survival rate, in the cemented group, was 98.1% [94.5 to 100.0] at five years and 95.8% [90.2 to 100] at 10 years.

In the cementless group, 2.8% (5 of 179) of THA had been reinfected: two new infections (two of five) and three relapses (three of five). The mean reimplantation–reinfection interval was 6.9 years (range, 1.8 to 11.4). The reinfection-free survival rate, in

the cementless group, was 99.4% [98.3 to 100] at five years and 94.1% [87.8 to 100] at 10 years.

There was no significant difference between the groups ( $P = 0.62$ , Figure 2).

Regarding new infections, no significant difference was observed between groups ( $P = 0.66$ , Figure 3) with a survival rate at 10 years of 95.8% [90.2 to 100] for the cemented group and 99.4% [98.3 to 100] for the cementless group.

For relapse, no significant difference was observed between groups ( $P = 0.19$ , Figure 4) with a 10-year survival rate of 100% [100 to 100] for the cemented group and 94.7% [88.4 to 100] for the cementless group.

### Aseptic Survival Rate

At the last follow-up, 34 (14.1%) THAs had aseptic complications. There were 12 (35.3%, 12 of 34) aseptic loosening, 12 (35.3%, 12 of 34) instabilities, six (17.6%, six of 34) periprosthetic femoral fractures, one (3%, one of 34) femoral plate breakage, and three (8.8%, three of 34) other types of complications.

Among these complications, 29 (12.0%) THAs required revision. There were 12 (41.4%, 12 of 29) aseptic loosening, 11 (38.0%, 11 of 29) instabilities, three (10.3%, three of 29) periprosthetic femoral fractures, and three (10.3%, three of 29) other types of complications. The mean reimplantation–revision interval was 3.3 (range, 0.04 to 15.9) years. The aseptic revision-free survival rate after one-stage exchange for chronic PJI THA was 90.2% [86.3 to 94.2] at five years and 83.6% [76.7 to 91.1] at 10 years.

In the cemented group, 17.7% (11 of 62) of THA required aseptic revision: six (six of 11) aseptic loosening, three (three of 11) instabilities, one (one of 11) periprosthetic femoral fracture, and one (1 of 11) other complication. The mean reimplantation–reinfection interval was 4.5 years (range, 0.04 to 15.9). The aseptic revision-free survival rate, in the cemented group, was 87.8% [79.7 to 96.8] at five years and 81.8% [71.1 to 94.0] at 10 years.

In the cementless group, 10.1% (18 of 179) of THA required aseptic revision: six (six of 18) aseptic loosening, eight (eight of 18) instabilities, two (2 of 18) periprosthetic femoral fractures, and two (2 of 18) other complications. The mean reimplantation–reinfection interval was 2.7 years (range, 0.05 to

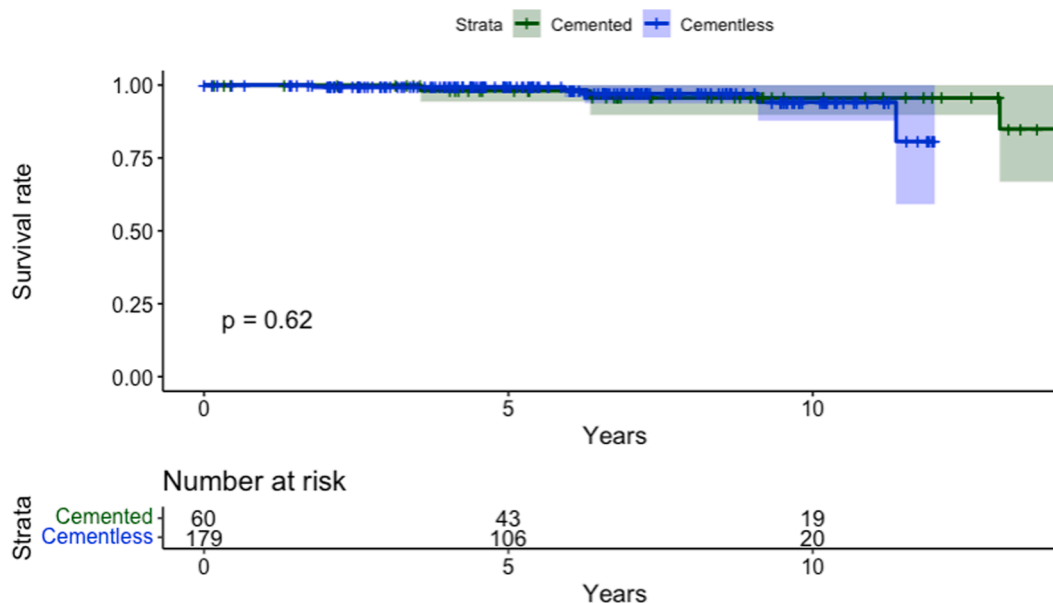


Figure 2. Kaplan–Meier curve of septic survival rate between cemented and cementless group.

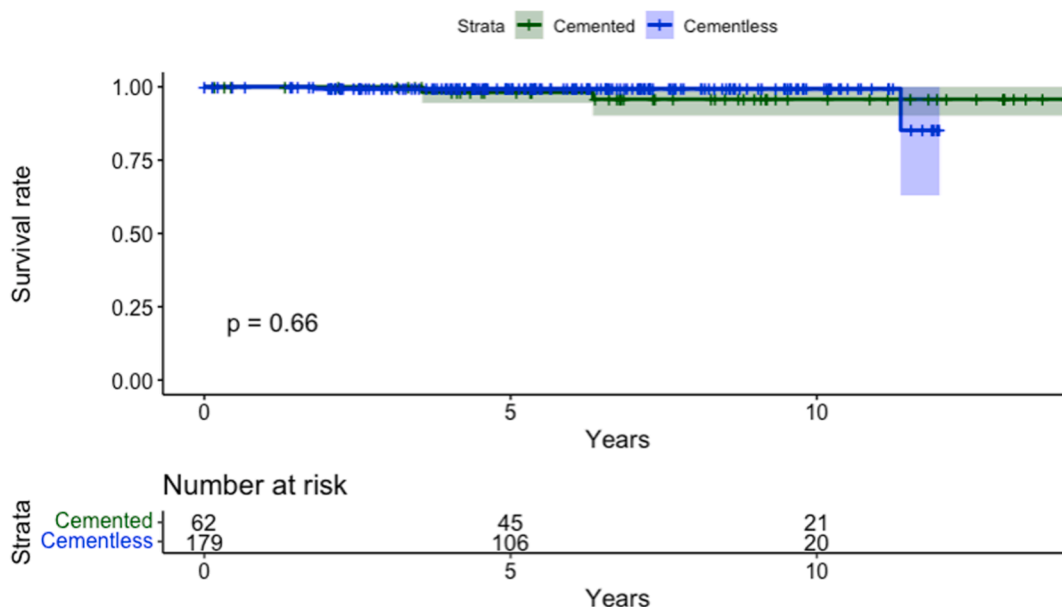


Figure 3. Kaplan–Meier curve of septic survival rate for new infections between cemented and cementless group.

10.5). The aseptic revision-free survival rate, in the cementless group, was 91.0% [86.7 to 95.5] at five years and 83.3% [72.8 to 95.2] at 10 years.

There was no significant difference between the groups ( $P = 0.61$ , Figure 5).

Finally, regarding the risk of aseptic loosening, there was no significant difference between the groups ( $P = 0.44$ ), with a 10-year survival rate of 89.7% [80.2 to 100.0] in the cemented group and 89.5% [78.8 to 100.0] in the cementless group.

## Discussion

The main finding of this study was that there is no difference in survival between cemented and cementless stems in one-stage exchange arthroplasty for PJI. We did not find any other studies

comparing the type of stem fixation after revision for PJI, and even less after a one-stage exchange. We reported a global survival rate at 10 years of 93.3% [88 to 98.7] with a reinfection-free survival rate of 95.0% [90.8 to 99.5]. These rates are similar to those reported in the literature for one-stage or two-stage exchange [2].

Zahar et al. [4] reported the results for 85 THA following one-stage septic hip arthroplasty with a median follow-up of 10.5 years. All patients had cemented stems, and the 10-year infection-free survival rate was 94%. Mangin et al. [22] reported a rate of 91.4% resolution of infection after single-stage exchange with cementless stems in a series including 35 THAs, with a median follow-up of five years. In another study, the use of a cementless stem after a single-stage exchange allowed 95.8% of PJI THAs to be treated at a median follow-up of 44.6 months [23]. Ji et al., in their studies, found that 89.2% of cementless stem patients were free of

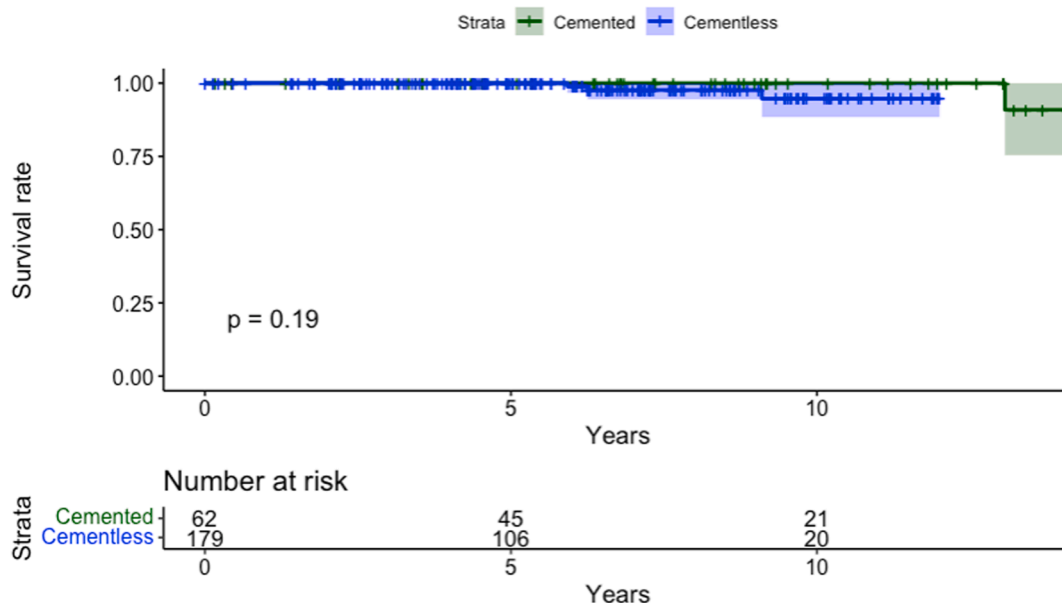


Figure 4. Kaplan–Meier curve of septic survival rate for relapse infections between cemented and cementless group.

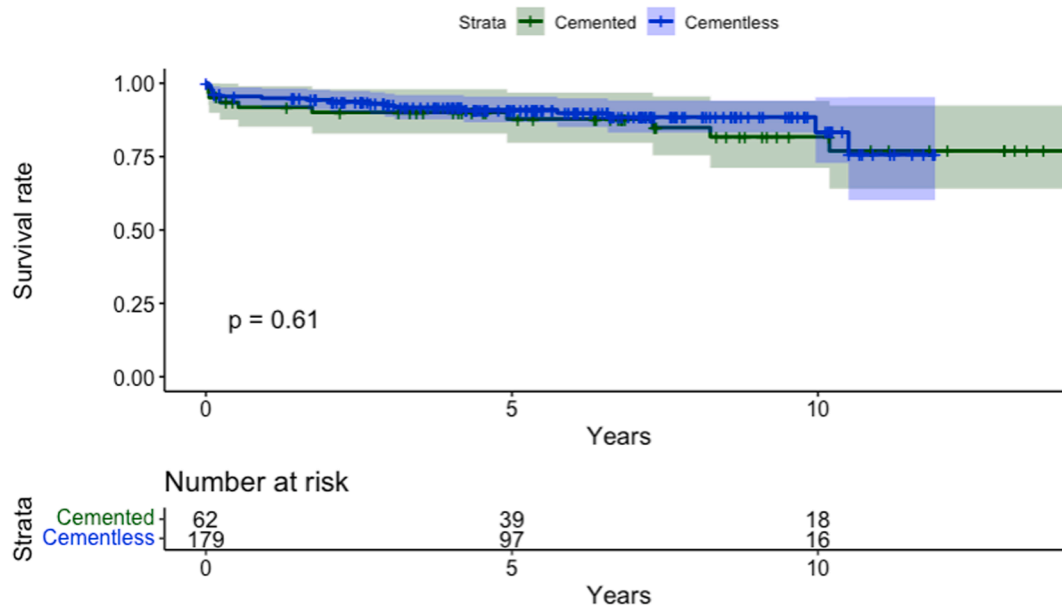


Figure 5. Kaplan–Meier curve of aseptic survival rate between cemented and cementless group.

infection after a single-stage exchange with a mean follow-up of 58 months [24]. Also, Lange reported, in the same condition, a cumulative incidence of re-revision due to infection at 8.9% [25]. In our series, we found a survival rate very similar to the literature: 94.1% [87.8 to 100.0] in the cementless group and 95.8% [90.2 to 100.0] in the cemented group at 10 years. There were no differences in complications or aseptic revision between the two groups. For primary THA, the use of cementless or cemented stems is still controversial [26–28]. Some studies observed a difference in cause-specific revision: cementless stems had a higher risk of periprosthetic fracture, and cemented stems had a lower aseptic survival rate [29,30]. In a meta-analysis, Yoon et al. [31] find that the use of a cemented stem, compared to a cementless stem, in primary THA is associated with a risk factor for PJI (odds ratio = 1.53, confidence interval 1.120 to 2.100;  $P = 0.008$ ), but the authors note that several variables, such as certain demographic variables, were not included in the analysis and may have influenced the results. In another meta-analysis comparing cemented and cementless stems in revision THA for all causes, the authors didn't find a difference, but this meta-analysis only included three trials [32]. It is therefore possible to use a standard cemented or cementless stem in a septic revision. This choice can be made taking into account other parameters such as the anatomy of the femur (using Dorr's classification) [33] or loss of bone substance [19].

Another issue regarding the choice of stem in revision THA is the use of a long or standard stem. In this study, we focused only on standard stems and didn't include long stems. Although the use of long stems in revision surgery reports satisfactory survival rates [34,35], the use of a long cemented stem may be an issue in septic patients who are at risk of reinfection. Quayle et al. reported a reinfection rate of 28.6% (6 of 21) in 21 patients after single-stage exchange for PJI using a long-cemented Exeter [36]. However, they included both primary and recurrent PJI, which may influence the results. Another solution is the use of massive prostheses in cases of major bone loss [37].

The use of antibiotic-loaded cement has historically been a strong argument in favor of allowing one-stage exchange procedures for infected joint prostheses. Its purpose was both to

optimize antimicrobial therapy through local antibiotic delivery and to prevent reinfection by targeting potential new pathogens introduced during reimplantation. However, the antibiotic contained in the cement is not always active against the causative organism. Our study also demonstrates the excellent outcomes of one-stage hip prosthesis exchange in the absence of local antibiotic therapy. Even in the cemented group, no antibiotic-loaded cement was used.

This study had several potential limitations. Our study is monocentric and ambispective. However, the prospective inclusion of these patients in our historical cohort associated with the reference center for osteoarticular infections is exhaustive and particularly uniform in terms of diagnosis and surgical approach [38]. In addition, the inclusion periods differed slightly between the two groups: cemented prostheses were predominantly included earlier in the study, resulting in a longer follow-up, whereas cementless THAs were mainly used from 2008 onward. Although it is not a randomized controlled trial, we obtained two comparable groups for age, sex, and American Society Anesthesiologists score using propensity score matching from a prospective institute arthroplasty registry. Another limitation was that we did not report postoperative clinical outcomes. However, to our knowledge, it is the first study to report 6-year outcomes comparing cementless and cemented stems in one-stage exchange arthroplasty for PJI, and in PJI, the first main outcome is infection-free survival. Also, we only had nine reinfections, and we only compared one type of cemented stem (Tapered Slim) [39] and one type of cementless stem according to the Kheir classification (type 4b) [40]. Perhaps we did not have enough power, but there was no trend between the two types of fixations in terms of results, and our results are consistent with the literature.

## Conclusions

There is no difference in reinfections or mechanical complication rates when a cemented or cementless stem is used in a one-stage revision THA exchange for PJI. Other parameters, in particular the shape of the femur and the patient's comorbidities, must be taken into account when choosing the type of stem to use.

## CRedit authorship contribution statement

**Pierre-Alban Bouché:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Aurélien Hallé:** Writing – original draft, Investigation, Formal analysis, Conceptualization. **Antoine Mouton:** Writing – review & editing, Investigation. **Thomas Aubert:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Guillaume Auberger:** Writing – review & editing, Investigation, Data curation. **Wilfrid Graff:** Writing – review & editing, Investigation. **Simon Marmor:** Writing – original draft, Supervision, Methodology, Investigation, Conceptualization.

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