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ORIGINAL ARTICLE

Infected total hip arthroplasty revision: One- or two-stage procedure?

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KEYWORDS

Total hip
arthroplasty;
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Summary

Introduction: Better outcomes have been reported for two-stage total hip arthroplasty (THA) revision for infection. However, one-stage revision arthroplasty remains an attractive alternative option since it requires only one operation. A decision tree has been developed by the authors in order to determine which type of surgical procedure can be performed safely. The goal of this study was to assess this decision tree for THA replacement in the case of a peri-prosthetic infection.

Hypothesis: A one-stage procedure may be as successful as a two-stage procedure provided some criteria are fulfilled.

Methods: A prospective study included 84 patients, all diagnosed with infected THA who had prosthesis replacement. A one-stage exchange was performed in 38 cases and a two-stage procedure in 46 cases. A two-stage procedure was decided in the case of important bone loss or unidentified germ. Postoperatively, patients received intravenous antibiotics (six weeks), then oral antibiotics (six weeks). The main evaluation criterion was the rate of infection eradication at 2 years minimal follow-up since surgery. If new infection was suspected, a hip aspiration was performed to determine whether it was non-eradication (same germ) or a new re-infection (other germ), which was not considered as a failure.

Results: The initial infection was cured in 83 out of 84 patients (98.8%), 38 (100%) for the one-stage group and 45 (97.8%) for the two-stage group. Three patients were re-infected with different germs in the two-stage group. Eighty out of 84 (95.2%) patients were infection free, all patients (100%) of the one-stage group and 42 patients (91.3%) of two-stage group.

Discussion: If some selection criteria were respected, a high success rate in THA replacement for infection may be achieved with a one-stage procedure. It permits to reduce the costs with no loss of chance for the patients. The decision tree was validated.

Level of evidence: Level III; prospective case control study.

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Introduction

Infection after total hip arthroplasty (THA) remains a severe and costly complication [1,2]. Although the infection rate after THA has been significantly reduced ranging between 0.3% and 2.2% [3–5], it is still a cause for concerns. In fact, between 7% and 16% [6,7] of THA revisions are carried out for infection according to the Scandinavian register. Bozic et al. [8] showed that 14% of THA revision procedures were performed for chronic infection and for Jafari et al. [9], infection was the most common cause of THA failure (30.2%). Mostly, the control of the infection requires removing the implants. Afterwards, the treatment strategy varies according to authors with three different procedures: no re-implantation, immediate placement of new implants or a two-stage surgery re-implantation [10,11]. The reported success rates vary from 85% to 95% with better outcomes for a two-stage surgery comparatively to a one-stage surgery (Elson [12] 96.5% vs 87.6%, Garvin et al. [13] 94.4% vs 89.9%).

However, the two-stage procedure has many disadvantages: patients undergo two operations with a higher morbidity risk, longer hospital stay duration and a loss in quality of life [14]. Furthermore, the two-stage replacement generates an increase in the cost of about 1.7 fold comparatively to the one-stage [2]. Some authors proposed specific criteria in order to select the patients who may benefit of a one-stage procedure with no loss of chance in treating the infection [15–18].

Our hypothesis was that a one-stage procedure might be as successful as a two-stage procedure if some criteria are fulfilled. Based on our experience, a decision tree was developed in our department in order to determine the type of surgical management according to some criteria. The goal of this study was to evaluate prospectively the rate of controlled infections when using this protocol for the treatment of infected THA and to determine whether the criteria used were relevant. The results would be helpful to determine what would be the best strategy according to the patient.

Materials and methods

Inclusion and exclusion criteria

A prospective non-randomised study was carried out in our department from September 2002 to June 2006 and included all patients diagnosed with infected hip arthroplasty. The replacement was performed in patients:

- who had a good general health according to American Society of Anaesthesiologists (ASA) physical status classification [19] allowing surgery and prosthesis re-implantation (ASA 1 to 3);
- if the infection duration was more than two weeks from implantation;
- or in the case of loosening.

The one-stage procedure was performed if the germ was known before exchange and if the bone loss was considered as minor by the surgeon both preoperatively on radiographs and peroperatively after components removal, according to Paprosky classification [20,21]. The bone damage was

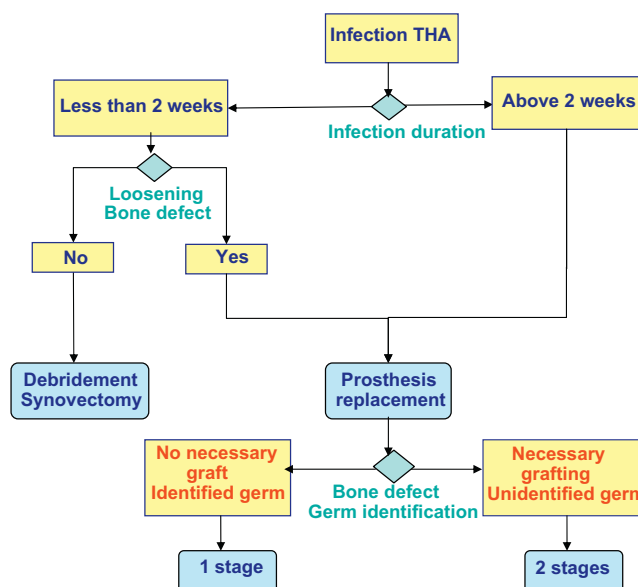


Figure 1 Decision tree.

considered major if massive cortico-cancellous bone grafting was necessary (Fig. 1).

The inclusion criteria were: a previous THA, a diagnosis of infection based on bacterial identification in cultures samples collected by hip aspiration preoperatively or peroperatively and a written informed consent for the performance of the study. The exclusion criteria were: patients non-operated for re-implantation and the patient refusal. An ethical comity (CPP Ile-de-France VI) approved this study.

All components were removed in all the cases. In the case of a two-stage replacement, the second procedure was carried out after an average duration of six weeks after the antibiotherapy completion. Between the two stages an articulated hand made cement spacer without antibiotics was used in order to avoid limb shortening and to allow a physiotherapy including hip mobilisation and muscle training.

At least three staggered deep peroperative samples were taken for microbiological diagnosis during the first stage and before re-implantation for the two-stage procedure. Systemic antibiotics were given through a central venous access and afterwards oral antibiotics were indicated. At least two efficient antibiotics were prescribed according to the antibiograms performed on the cultures samples. For two-stage procedure, if germs were found during the second stage, a complementary antibiotherapy adapted to the antibiogram was performed after re-implantation. The efficiency and the tolerance of antibiotics were controlled by calculating their systemic antibiotic concentrations. No local antibiotherapy was used.

During this period, 122 consecutive patients diagnosed with infected hip arthroplasty were treated in our department. Four patients died before 2 years of follow-up for a different reason. Among these 118 patients, two-stage replacement was performed in 46 patients, one-stage replacement in 38 patients, a resection or a coaptation in ten patients, a curative debridement in nine patients and a

Table 1 Description of one- and two-stage group.

	One-Stage Group	Two-Stage Group	Statistic analysis (<i>p</i>)
Age	63.60 ± 14.8	66.87 ± 12.1	0.27 (NS)
Sex ratio	18F/20M	20F/26M	0.72 (NS)
BMI	28.3 ± 5.3	25.4 ± 4.4	0.009
Initial hip disease			0.64 (NS)
Primary osteoarthritis	26	29	
Osteonecrosis	4	3	
Post traumatic	5	6	
CDD	2	3	
Others	1	5	
Number of previous surgeries	2.2 ± 1.9	3.2 ± 2.4	0.04
Preoperative score (Postel Merle d'Aubigné [22])	11.1 ± 3.1	9.6 ± 4.2	0.07 (NS)
Acetabular bone loss according to Paprosky [20]			0.0001
Type I	24 (63.2%)	3 (6.5%)	
Type IIA	7 (18.4%)	11 (24%)	
Type IIB	5 (13.2%)	7 (15.2%)	
Type IIC	1 (2.6%)	3 (6.5%)	
Type IIIA	0 (0%)	19 (41.3%)	
Type IIIB	1 (2.6%)	3 (6.5%)	
Femoral bone loss according to Paprosky [21]			0.08 (NS)
Type I	15 (39.5%)	7 (15.2%)	
Type II	14 (36.8%)	24 (52.2%)	
Type IIIA	7 (18.4%)	13 (28.3%)	
Type IIIB	2 (5.3%)	2 (4.3%)	
Type IV	0 (0%)	0 (0%)	
Surgical complication	7 (18.4%)	14 (30.4%)	0.20 (NS)
Initial infection eradication	38/38 (100%)	45/46 (97.8%)	0.36 (NS)
Patients infection free	38/38 (100%)	42/46 (91.3%)	0.11 (NS)
Merle d'Aubigné score at follow-up	15.5 ± 2.6	15 ± 3	0.46 (NS)

CDD: congenital developmental dysplasia.

lifetime suppressive antibiotics with or without a debridement in 15 patients.

Two deaths were due to infection: one patient after resection and one after debridement with a lifetime suppressive antibiotics.

Description of the one-stage group

Thirty-eight patients had a direct exchange of the implants. They were composed of 18 women and 20 men with a mean age of 63.6 ± 14.8 years (range, 25–90). Two patients were diabetic and one patient had an immunosuppressive treatment for psoriatic arthritis. Three patients were classified as ASA 1, 31 as ASA 2 and four as ASA 3. The average body mass index (BMI) was 28 ± 5 (range, 18–43), 14 patients were obese (BMI ≥ 30). These patients had previously in average 2.2 ± 1.8 (range, 1–10) surgical procedures of the infected hip. The initial THA was performed for primary osteoarthritis in 26 cases; the other aetiologies are reported in Table 1. Three patients had a fistula. The mean duration of infection before surgery was 12 months (from ten days to 6.5 years). For two patients, the infection duration was less than two weeks but with loosening of the implants. Before the revision, the mean Postel-Merle-Aubigné (PMA) score [22] was 11.1 ± 3.1 (range, 5–16), the mean Erythrocyte Sedimentation Rate (ESR) was 43.4 ± 32 mm (range, 2–100),

less than 30 for 16 patients and the C-reactive protein (CRP) was about 40 ± 50 mg/L (range, 1–223), less than 10 in nine patients. The bone loss according to the Paprosky score [20,21] is shown in Table 1. The most frequent germ was the *Staphylococcus* spp. (22/38); the other germs are shown in Fig. 2. In four patients (10.5%), bacteria were multi-resistant (i.e. sensitive to less than three antibiotics families). The mean follow-up for this group ranged from 24–61 with an average of 35 ± 11.5 months and no patient was lost to follow-up.

The approach was posterior lateral in 26 cases and anterolateral in 12 patients. A trochanterotomy was performed in eight cases. A femorotomy was performed in two cases and nine times a femoral window was used in order to get out the cement plug or the diaphyseal restrictor. A cortico-cancellous grafting was performed on the acetabular side in six cases and an acetabular plate (Kerboull plate) was used in nine cases in order to get a good mechanical support. Cemented cups were implanted in 28/38 patients. Cemented femoral stems were used in 25/38 cases. A standard stem was used in 30/38 cases and long ones in eight cases. The cement used was not antibiotic-loaded.

Systemic antibiotics were given through a central venous access for an average duration of 42 ± 12.4 days (range, 7–86) and afterwards oral antibiotics were given for 51.1 ± 27.1 days (range, 0–138).

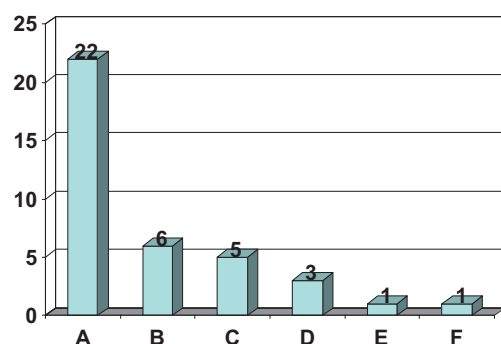


Figure 2 Bacteria found in the one-stage replacement group. A. *Staphylococcus* 22 (MR *S. epidermidis* 7, MS *S. epidermidis* 3, GISE 2, MS *S. aureus* 4, MR *S. aureus* 2, *S. capitis* 2, *S. caprae* 1, *S. lugdunensis* 1). B. anaerobic bacteria 6 (*Propionibacterium acnes* 4, *Propionibacterium avidum* 1, *Peptostreptococcus micros* 1). C. *Streptococcus* 5 (group B 2, others 3). D. polymicrobial 3 (1 *P. acnes* + *S. capitis* // 1 *P. acnes* + *Corynebacterium striatum* // 1 MR *S. epidermidis* + MS *S. aureus* + *Proteus mirabilis* + *Enterococcus faecalis* + *C. striatum*). E. *Escherichia coli* 1. F. *E. faecalis* 1.

Seven patients had a surgical complication: two haematoma which did not require a revision, one false reaming route detected and corrected during the surgical procedure, three early postoperative dislocations and one recurrent dislocation that required a revision with the cup removal and implantation of a retentive device.

Four patients presented a complication due to the central venous access: two catheter infection, one thrombosis and one pneumothorax. Furthermore, 13 patients (34.2%) had a minor complication that required an exchange of the antibiotics in six cases: two drug interactions, two hypersensitivity reactions (mynocine), one cutaneous rash (rifampicin) and one increase of serum creatinin level (fosfomycin).

Description of the two-stage group

Forty-six patients had a two-stage replacement of the implants. The two-stage replacement were indicated when there was lack in microbial preoperative diagnosis in four patients and a major bone loss, especially on acetabular side, for all others patients. One patient was scheduled for a one-stage procedure but peroperatively bone stock didn't allow direct exchange. The two-stage group was composed of 20 women and 26 men with a mean age of 66.9 ± 4.2 years (range, 45–89). Three patients were diabetic. Three patients were classified as ASA 1, 35 as ASA 2 and eight as ASA 3. The average BMI was 25.4 ± 4.9 (range, 18–38), nine patients were obese (BMI ≥ 30). These patients had previously 3.19 ± 1.4 (range, 1–12) surgical procedures on the infected hip. The initial THA was performed for primary osteoarthritis in 29 cases; the other aetiologies are reported in Table 1. Five patients had a fistula. The mean duration of infection before surgery was 24 months (from 11 days to 12 years). For three patients the infection duration was less than two weeks but with loosening of the implants. Before revision, the mean Postel-Merle-Aubigné score [22] was 9.6 ± 2.1 (range, 3–17), the mean ESR was

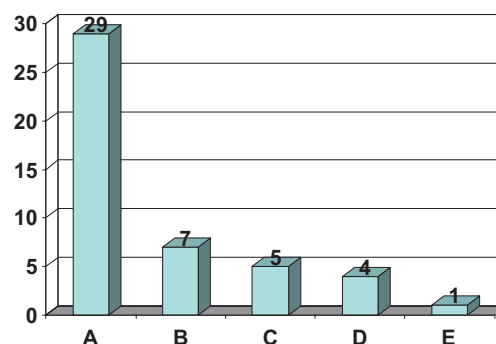


Figure 3 Bacteria found in the two-stage replacement group. A. *Staphylococcus* 29 (MR *S. epidermidis* 11, MS *S. epidermidis* 4, GISE 3, MS *S. aureus* 5, MR *S. aureus* 1, *S. capitis* 3, *S. lugdunensis* 1, *S. warnerii* 1). B. anaerobic bacteria 7 (*Propionibacterium acnes* 4, *Micrococcus* sp. 1, *Corynebacterium* 2). C. *Streptococcus* 5 (group B 3, others 2). D. polymicrobial 4 (1 *Peptostreptococcus micros* + MS *Staphylococcus* spp. // 1 MR *S. aureus* + *Streptococcus* group B + *Pseudomonas aeruginosa* + *Propionibacterium avidum* // 1 *Clostridium perfringens* + *Candida glabrata* // 1 *Staphylococcus capitis* + *Corynebacterium macginleyi*). E. *Enterococcus faecalis* 1.

52.3 ± 7.1 mm (range, 2–100), less than 30 for 11 patients, and the CRP was about 65.9 ± 5.7 mg/L (range, 2–475), less than 10 in eight patients. The bone loss according to the Paprosky score [20,21] is shown in Table 1. The most frequent germ was *Staphylococcus* spp. (29/46); the other germs are shown in Fig. 3. In seven patients (15.2%), bacteria were multi-resistant. A hip aspiration was performed before the second stage in 41/46 patients, at least 15 days after ending administration of antibiotics, but all these cultures were negative. All patients (46/46) had culture of the samples taken at the time of the second stage. In 17 among 46 patients, the culture found germs, identical to the initial causal one in eight cases. For these 17 patients, the mean duration of the complementary antibiotics administration was 52.9 ± 23.2 days (range, 30–90). The mean duration between the two procedures was 4.45 ± 0.7 months. The mean follow-up ranged from 24 to 68 with an average of 35 ± 19 months and no patient was lost to follow-up.

A posterior lateral approach was used in 36 patients and an anteriorlateral approach in 10 patients. A trochanterotomy was performed in 12 cases. A femorotomy was used in 12 cases in order to get out all the cement and a complementary femoral corticotomy was required in 11 patients in order to remove the plug or the diaphyseal restrictor. A spacer made with a Kuntcher nail and a sphere of cement was placed during the first stage. In two patients who had a severe bone loss, no spacer was used because of a high risk of spacer dislocation. During the second stage, a corticocancellous grafting was performed on the acetabular side in 32 cases and an acetabular plate was used in 30 cases in order to get a good mechanical support. A cemented cup was implanted in 41/46 patients. Cemented femoral stems were used in 29/46 cases. A standard stem was used in 32/42 cases and long ones with length ranging from 200 mm to 300 mm in 16/46 cases.

Intravenous antibiotics were given through a central venous access for an average duration of 47 ± 20.5 days (range, 10–90) and afterwards oral antibiotics were given for 47 ± 19 days (range, 15–78).

Complications occurred in 14 patients (nine after the first stage and five after the second stage). After the first stage, haematoma occurred in four cases, two patients had a femoral fracture that required an osteosynthesis and four (8.7%) patients presented a spacer dislocation. After the second stage, one haematoma and four dislocations occurred, one patient had repeated revision to manage instability by means of a retentive cup.

After the first stage, three patients presented a complication due to the central venous access: two cases of catheter infection and one pneumothorax. Furthermore, 18 patients (39%) had a minor complication which required an exchange of the antibiotics in 13 cases: three acute renal insufficiencies (gentamicin), two leucopenia (vancomycin, rifampicin), two cutaneous rash (mynocin, rifampicin), two hypersensitivity reactions (mynocin), one hepatic cholestasis (fusidic acid), one severe nausea (rifampicin), one hepatic cytolysis (rifampicin) and one drug interaction. Among the 17 patients who had a complementary antibiotherapy after the second stage, five patients (29.4%) presented complications related to the antibiotics requirement a modification of the treatment for four patients

Method of assessment

The infection was considered as controlled if at a minimum of 2 years follow-up, patients had no clinical, no biological and no radiological signs of infection related [23]. In the case of suspicion of infection, hip aspiration was performed and bacterial identification was made with cultures samples in order to determine whether it was a non-control of the initial infection or a re-infection with different germs. The success rate was defined as the percentage of controlled initial infections at 2 years minimal follow-up.

Patients were analysed preoperatively and at the last follow-up, clinically with the PMA score, and biologically with blood tests including the ESR and the CRP. Hip X-rays including anterior-posterior and lateral views were performed pre-operatively and at the last follow up. No patient was lost at follow-up.

Statistical methods

Distribution of variables was tested for normality using the Ryan-Joiner test. For normally distributed variables, when two groups had the same variances, differences between them were analysed by using Student's *t*-test. For abnormally distributed variables or normally distributed variables with different variances, we used the Mann and Whitney test. Chi² test or Fischer exact was used to compare qualitative parameters. A *p* value of less than 0.05 was considered to be significant.

Results

The initial infection was not controlled in one patient who had a two-stage replacement. Therefore, the success rate was of 100% (38 out of 38) in the one stage group and of 97.8% (45 out of 46) in the two-stage group. This infection was finally controlled after a repeated two-stage replacement with a follow-up of 24 months.

However, three patients in the two-stage group had a re-infection with a different germ (Table 2). At follow-up, 80 out of 84 (95.2%) patients were infection free, all patients (100%) of the one-stage group and 42 patients (91.3%) of two-stage group. The patients with a re-infection were treated as follow: a surgical debridement with prosthesis retention was performed in one case; one patient underwent a one-stage replacement, and the last patient had a chronic oral antimicrobial suppression therapy because of a poor general health status that did not allow a re-implantation. At the last follow-up of 18.8 ± 9 months, these patients remained asymptomatic and had a functional prosthesis.

The bone loss was significantly more important in the two-stage group as it was a selection criterion (Table 1). Otherwise, there was no significant difference between the two groups regarding age, sex ratio, initial hip disease, pre-operative and postoperative clinical score (Table 1). In the other hand, there was a significant difference for BMI that was higher in the one-stage group and the number of previous hip surgical procedures ($p < 0.05$) that was higher in the two-stage group (Table 1). The complication rate was higher in the two-stage procedures but no significant. There was no significant difference for the success rate between the two groups. However, there was a higher risk for re-infections in the two-stage group (0% vs 6.5%).

Table 2 Patients who had a re-infection with a different germ.

Initial germ	<i>MR Staphylococcus aureus</i>	<i>Propionibacterium acnes</i>	<i>MR Staphylococcus epidermidis</i>
Age	77	85	62
Number of previous procedures	4	1	4
Germ at 2nd stage	<i>GI Staphylococcus epidermidis</i>	No germ	No germ
Germ responsible of re-infection	<i>Streptococcus lugdunensis</i>	<i>Citrobacter koserii</i>	<i>MS Staphylococcus epidermidis</i>
Delay for re-infection (months)	8	6	26
Treatment of re-infection	Chronic oral antimicrobial suppression therapy	Debridement	One-stage removal replacement
Last follow up with controlled infection (months)	26	33	12

Discussion

The main finding of this study was that if some selection criteria were respected, a high success rate in THA revision done for infection might be achieved with a one-stage procedure, similar to the two-stage procedures. The criteria used to select the patients who may benefit of a one-stage procedure were found to be relevant.

In our study, the infection was controlled in all the patients treated with a one-stage procedure giving a 100% success rate. This finding compares well to the results previously reported by Ure et al. [15] who achieved also a 100% success rate when using a one-stage procedure in selected patients. Similar results were also reported by Callaghan et al. [16] with a 91.7% success rate. Callaghan's criteria [16] were quite similar to ours: no significant immunocompromised patient, no sinus tracts, an adequate bone available for revision and an obtainable complete soft tissue and bone debridement. However, they had only a small number of patients (20 and 24) and their study was not comparative, without a control two-stage group. In our study, fistula was not an exclusion criterion for one-stage revision. Previously, Raut et al. [18] had shown that an actively discharging sinus is not in itself a contraindication to one-stage revision.

The two-stage procedure replacement of THA for sepsis is widely used and admitted in the literature [24]. However, increasing the number of surgical procedures increases also the risk of infection [25]. Indeed, we found that in 6.5% of cases (3/46), although the initial infection was controlled a new infection occurred with a different germ.

There was no significant difference in success rate between the two groups, but there was no re-infection in the one-stage group. However, the surgical procedure was more complicated in the two-stage group, with more severe bone loss. Furthermore, these patients had a higher rate of previous hip surgery, which is known to be correlated to a higher risk failure to cure infection [25].

For the two-stage procedures, even though no antibiotic impregnated cement spacer was used, the initial infection was controlled in more than 97% of cases, and 91.3% of patients had no infection at follow up. These results are similar to those reported in the literature, especially when compared with the success rate reported by authors using antibiotic impregnated cement spacer [26]. To our knowledge, there is no reported study comparing among a large cohort, two groups of patients who underwent a two-stage procedure using even a normal cement spacer or an antibiotic-loaded cement spacer. In fact, Cabrita et al. [26] compared patients with a spacer and patients with no spacer, so there was not only the antibiotic factor but also the stabilisation of the hip.

At the time of the re-implantation in the two-stage group, germs were found in 37% of cases despite the fact that a pre-operative hip aspiration was found negative. This lack of value of the hip aspiration before the second stage has to be kept in mind. Some authors proposed to perform intra-operative frozen section in order to decide of the re-implantation [27].

The main limitation of the present study was that the patients were not randomized for the surgical technique.

However, the aim was to validate the hypothesis that the one-stage procedure was a successful technique with no loss of chance for the patients if some selection criteria were respected.

Conclusion

The one-stage procedure was found to be a successful surgical procedure to treat THA infection provided that selection criteria were fulfilled (germ known preoperatively and minor bone loss). This decision tree may help optimize the treatment and minimize the global cost with no loss of chance for the patient.

Disclosure of interest

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

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