

# Similar success rates for single and multiple debridement surgery for acute hip arthroplasty infection

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**Background** — Treatment of an acute total hip arthroplasty (THA) infection aims at control of the infection with retention of the implant by surgical debridement and antibiotic treatment. There is no clear evidence whether a single surgical debridement is sufficient or whether multiple procedures are necessary for optimal treatment.

**Methods** — From a prospective database of patients with acute THA infection, we retrospectively reviewed 68 patients treated in 2 large teaching hospitals. Hospital S used a protocol in which each patient received a single surgical debridement and only additional surgery if infectious symptoms persisted (group S; n = 33). In hospital M, patients always received multiple surgical debridements (group M; n = 35). Both groups received systemic antibiotic treatment. Removal of the implant or persistent infection at follow-up was considered failure of treatment. Mean follow-up of the patients was 5 (2–11) years.

**Results** — Mean time between implantation and debridement was 19 days. 4 patients in group S were considered failure, as opposed to 10 patients in group M ( $p = 0.09$ ). 9 patients in group S had additional surgery, which resulted in 3 of the 4 failures. At final follow-up, 30 patients in group S and 33 patients in group M had a good clinical result ( $p = 0.6$ ).

**Interpretation** — In patients with acute THA infection, a single debridement with only additional surgery on indication appears to be at least as successful for retention of the primary implant and control of infection as a strategy with multiple surgical debridements.

acute hematogenic infections, the aim of treatment is control of infection and retention of the implant. In contrast, in delayed or late postoperative infections the matured bacterial biofilm cannot be fully removed from the implant and surgical treatment consists of a 1- or 2-stage revision of the implant. Both surgical strategies should be accompanied by a course of systemic antibiotics (Zimmerli et al. 2004, Bernard et al. 2010). To facilitate treatment decisions, algorithms have been developed. Especially the algorithm proposed by Zimmerli et al. (2004) has gained popularity in recent years. Several reports have shown that these guidelines improve success rates (Giulieri et al. 2004, Betsch et al. 2008, De Man et al. 2011).

The surgical strategy for retention of the implant consists of extensive irrigation and debridement of the infected joint, often accompanied by the exchange of modular implant components and application of local antibiotic carriers, such as beads or collagen fleeces. However, there is no scientific evidence or consensus as to whether a single surgical debridement is sufficient or whether multiple repeat procedures are necessary for optimal treatment. Studies involving both strategies have been published, with success rates ranging from poor to excellent (Azzam et al. 2010, Estes et al. 2010, Van Kleunen et al. 2010, Aboltins et al. 2013, Geurts et al. 2013, Kuiper et al. 2013, Romano et al. 2013). As a consequence of this, different surgeons use different treatment regimes.

We investigated results of 2 different surgical protocols for control of the infection in combination with retention of the primary implant in patients with early postoperative infection after primary THA. We hypothesized that a single-shot debridement regime would be as effective in controlling the infection and retaining the implant as a regime that routinely used multiple surgical debridements.

The strategy for treating prosthetic joint infection depends on the type infection encountered. In early postoperative and

## Patients and methods

### Study design

We performed a retrospective analysis of a prospective database of all patients treated for early postoperative deep infection of their primary total hip arthroplasty (THA) in 2 large teaching hospitals between 2001 and 2008. The definition of early postoperative infection was infection within 3 months after implantation (Zimmerli et al. 2004). Additionally, the implant had to be stable and soft tissue coverage of the hip not compromised. Hospital S performs approximately 700 primary THAs a year. Hospital M performs approximately 350 primary THAs a year. All patients were identified using the prospective institutional infection registration databases of the hospitals. The study was approved by the institutional ethics committee (WO12.111).

All the patients underwent debridement surgery in combination with antibiotic treatment with the aim of retaining the implanted prosthesis. Indication for surgery was the clinical diagnosis of infection, based on a combination of clinical signs (wound discharge, redness, swelling, and fever), superficial wound culture, and laboratory results (CRP, ESR, and leukocyte count). The treating orthopedic surgeon set this diagnosis. Standard of care in hospital S was surgical treatment with a single debridement and only repeat surgery on indication (protocol S). In contrast, patients in hospital M were routinely treated with multiple surgical debridements (protocol M). The patients were analyzed according to the intention-to-treat principle. A power calculation showed that we would need 88 patients in each group to find a significant difference in our primary outcome (power 0.8,  $\alpha$  0.05, difference 0.17). This calculation was, however, disregarded, as it would have meant at least 10 more years of inclusion.

### Treatment protocols

*Protocol S.* 7 orthopedic surgeons performed the surgeries in hospital S. All of them routinely performed primary THA, and 3 also performed revision THA. Patients underwent an open irrigation and debridement of the infected hip joint. The joint was opened using a posterolateral approach and multiple tissue cultures were taken from the joint fluid, (pseudo-) capsule, and membranous tissue at the interface of bone and implant/cement. Subsequently, all infected and non-vital-appearing soft tissue surrounding the hip wound was resected. Then the wound was irrigated with 3–6 L saline and remaining non-vital tissue was removed. In most patients, the femoral head was replaced by a new CoCr head; liners of uncemented shells were not replaced. Before closure of the wound, multiple commercially available gentamicin-collagen fleeces (median 2 fleeces (range 1–3): Garacol; Schering-Plough, Maarsse, the Netherlands) were placed both intra-articularly and under the fascia. The use of these fleeces was local routine based on good gentamicin susceptibility of many pathogens in primary cases, a high burst release for 24–48 h, and the fact that there

is no necessity for surgical removal. The wounds were closed in a standard manner and no drains were used.

Postoperatively, patients were clinically monitored and infection parameters in the blood (CRP, ESR, and leukocyte counts) were measured on a regular basis. The patient was scheduled for repeat debridement at 14 days after the initial debridement only if there were clinical signs of ongoing infection (e.g. persistent wound drainage at day 12, fever, or persistently high infection parameters in blood). In these cases, the procedure was performed in the same way as the first operation.

The decision to remove an infected hip implant was made by the treating orthopedic surgeon, based either on no improvement of the clinical status or on the fact that the antibiotic-resistance pattern of the bacteria cultured made further in situ treatment impossible.

*Protocol M.* 7 orthopedic surgeons performed the surgeries in hospital M. All of them routinely performed primary THA, and 5 also performed revision THA. The patients underwent an open irrigation and debridement of the infected hip joint. The hip joint was opened using either a direct lateral or a posterolateral approach (25 vs. 8, depending on the approach at index surgery) and multiple tissue cultures were taken from the joint fluid, (pseudo-) capsule, and membranous tissue at the interface of bone and implant/cement. Then all infected and non-vital-appearing soft tissue surrounding the hip wound was resected. The wound was then irrigated with 3–6 L saline and remaining non-vital tissue was removed. As this was not routine practice, the femoral head was replaced with a new CoCr head during the last surgery only in a few patients; liners of uncemented shells were not replaced. Before closure of the wound, several chains of commercially available gentamicin beads (median 90 (range 30–180) beads; Septopal; Biomet, Dordrecht, the Netherlands) were placed both intra-articularly and under the fascia. The use of these bead chains was local routine based on good gentamicin susceptibility of many pathogens in primary cases, sustained antibiotic release up to 2 weeks, and the fact that repeat surgery was scheduled in any case. Wounds were closed in a standard manner and no drains were used. Postoperatively, patients were clinically monitored and infection parameters in the blood (CRP, ESR, and leukocyte counts) were measured on a regular basis.

After the first operation, the patients were routinely scheduled for a second and third debridement, 2 and 4 weeks after the initial debridement. During the second operation, new culture samples were taken, the joint was debrided in the same way as in the initial debridement, and new gentamicin beads were placed. During the third debridement, samples were taken for culture and the wound was debrided again, but this time the gentamicin beads were removed and no new local antibiotic carrier was used.

The decision to remove an infected hip implant was made by the treating orthopedic surgeon, based either on no improvement in the clinical status of the patient or on the fact that

the antibiotic-resistance pattern of the bacteria cultured made further in situ treatment impossible.

### Antibiotic treatment

In both hospitals, patients were started on broad-spectrum intravenous antibiotics immediately after the intraoperative culture samples had been obtained. The treatment was adjusted to the bacteria cultured and their resistance patterns. Before 2004 patients received systemic antibiotic treatment that was comparable to and later guided by the recommendations of Zimmerli et al. (2004). As staphylococci were the predominant microorganisms, for most patients this meant a combined antibiotic treatment including rifampin. 3 patients in each hospital, for whom a combination with rifampin would have been possible, only received antibiotic monotherapy. None of these treatments led to a failure.

If there was a dry wound in combination with decreasing CRP and ESR, and oral options were available, patients switched to oral antibiotics after approximately 2 weeks. The total duration of antibiotic treatment usually recommended was at least 3 months.

### Follow-up, endpoint, and confounders

All patients had follow-up of at least 2 years, or until permanent resection arthroplasty (3 patients).

The primary endpoint was treatment failure, defined as either removal or revision of the implant or persistent infection at final follow-up. Secondary endpoints were the number of patients with a permanent resection arthroplasty and clinical end result at final follow-up defined as THA in situ and no signs of infection on blood analysis (ESR < 35 and CRP < 10) or of radiographic loosening. In addition to the primary and secondary endpoints, we evaluated patient demographics and tried to identify potential confounders. This included factors such as the McPherson systemic host grade for comorbidity (A = little, B = moderate, C = much) (McPherson et al. 2002), ASA classification, and individual parameters such as smoking, diabetes, and body mass index.

### Statistics

Categorical outcomes were analyzed using the Pearson chi-square test. Continuous outcomes were analyzed using the Student t-test. Confounders were identified using the Pearson chi-square test or Student t-test and if a significant relationship was detected, correction was performed using logistic or linear regression analysis. Any p-value less than 0.05 was considered significant. Statistical analysis was done using PASW Statistics 18.0.

## Results

### General

During the study period, 68 patients were treated for early

Table 1. Demographic and surgery-related data

	Hospital S	Hospital M	p-value
Sex (F/M)	21 / 12	20/15	0.6
Mean age, years (SD)	74 (9.2)	67 (11.3)	0.004
ASA classification			
I	6	10	0.1
II	10	16	
III	16	8	
IV	1	0	
Unknown	1		
McPherson systemic host grade			
A	10	12	0.02
B	14	22	
C	9	1	
Fixation of implant			
Cemented/hybrid	30	28	
Uncemented	3	7	0.2
Mean time between THA and infection, days (SD)	19 (7.8)	19 (8.8)	0.9
No. of debridements			
1	24	0	< 0.001
2	5	1	
3	1	23	
4	2	11	
5	1	0	
Mean body mass index (SD)	29 (5.9)	29 (5.7)	0.9
Smoking (yes/no)	7 / 26	6 / 25	0.9
Unknown		4	
Diabetes (yes/no)	7 / 26	5 / 30	0.5
Mean follow-up, years (SD)	5.4 (1.7)	4.7 (1.4)	0.06

postoperative infection of their THA with irrigation and debridement. 33 patients were treated in hospital S according to protocol S (single debridement: group S). 35 patients were treated in hospital M according to protocol M (multiple debridements: group M). Although many demographic parameters were similar, there were some differences (Table 1). The mean age at time of surgery in group S was 74 (47–89) years, as compared to 67 (41–83) in group M. The McPherson systemic host grade was higher in patients in group S. The mean time between implantation of the THA and first debridement surgery was 19 days in both groups. Only 1 patient in each hospital had the debridement more than 6 weeks after implantation. The median number of surgeries in patients of group S was 1 (1–4), as compared to 3 (2–4) in group M. 9 of the 33 patients in group S who were initially scheduled for a single debridement received 1 or more additional surgeries. For all 9 patients, the repeat surgery was a second debridement with retention of the implant, scheduled at 14 days after the initial debridement.

The bacteria cultured during the first debridement were comparable between the 2 hospitals (Table 2). Mean and median durations of antibiotic treatment in group S were 13 and 12 weeks, respectively, ranging between 5 and 25 weeks. Exceptions were 2 patients with a complicated treatment and prolonged antibiotic treatment for 50 and 85 weeks; both were treatment failures. Mean and median durations of antibiotic

Table 2. Bacteria cultured after the first debridement

	Hospital S	Hospital M
<i>S. aureus</i>	23	16
Coagulase-neg. Staphylococci	4	7
Streptococci	0	2
Enterococci	1	2
Gram-negative bacillus	3	0
<i>P. acnes</i>	0	2
Enterobacter	0	1
Polymicrobial	0	2
Negative cultures	2	3

treatment in group M were 23 and 26 weeks, respectively, ranging between 11 and 34 weeks (including all patients). In this group, duration of antibiotic treatment was comparable for patients who were regarded as successes or failures.

With all patients included, the mean total hospitalization time for patients in group S was 29 (8–88) days and it was 59 (15–166) days in group M ( $p < 0.001$ ). In group S, there was

a mean follow-up of 5.4 (2.8–9.2) years as compared to 4.7 (2.3–7.5) years in group M.

### Results of treatment

In group S, treatment failed in 4 of the 33 patients (Table 3). In 2 of these patients the prosthesis had to be extracted; 1 had a successful 2-stage revision and the other had a permanent resection arthroplasty. The 2 other patients had persistent infection or died due to the THA infection. 1 was an ASA IV patient with severe rheumatoid arthritis, use of multiple immunosuppressant drugs, and hematogenous spread of the infection to her total knee arthroplasty. Instead of performing additional surgery, lifelong suppressive antibiotics were chosen. The other was an ASA II patient with no substantial risk factors, except old age (85 years), who died of sepsis shortly after a second debridement. 3 of the 4 failures were in the subgroup of 9 patients in whom it was necessary to perform additional surgery. In 1 of these 9 patients, a second susceptible microorganism was cultured during repeat surgery in addition to the *S. aureus* initially found, and resulted in suc-

Table 3. Treatment failures

Case	Culture 1st debridement	Culture 2nd debridement	Culture last debridement	Days to removal	Reason for failure	Culture at removal	Reason for resection arthroplasty
Hospital S							
9	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)	250	persistent culture of mo	negative	na
20	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)	375	persistent culture of mo	<i>S. aureus</i> (S)	poor soft tissue and bone status after 14 infection surgeries
29	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)		na	sepsis/death	na	na
30	<i>S. aureus</i> (S)			na	spread to TKA	na	na
Hospital M							
34	negative	negative	CNS (floxa & vanco R)	47	persistent culture of resistant mo	negative	na
37	<i>S. aureus</i> (S)	CNS (floxa R, vanco S) & <i>S. aureus</i> (S)	negative	300	progressive osteolysis cup & stem	CNS (floxa R, vanco S)	na
40	<i>S. aureus</i> (S)	<i>S. aureus</i> (S)	<i>Corynebacterium</i> sp. (R) & CNS (floxa R, vanco S)	74	wound dehiscence & resistant mo	CNS (floxa R, vanco S)	poor soft tissue and bone status after 16 infection surgeries
43	CNS (S)	CNS (S)	CNS (S)	43	persistent culture of mo	negative	na
50	<i>Streptococcus</i> sp. (S)	CNS (S)	CNS (floxa R, vanco S)	77	persistent fistula &	negative	na
53	<i>S. aureus</i> (S)	Anaerobic Gram-neg. rod (S) & <i>Streptococcus</i> sp. (S)	MRSE (R)	47	persistent culture of resistant mo	resistant mo MRSE (R)	na
57	<i>Propionibacterium</i> sp. (S)	<i>Propionibacterium</i> sp. (S)	<i>Corynebacterium</i> sp. (R) & CNS (R, vanco S)	65	clinical deterioration & resistant mo	CNS (floxa R, vanco S) & <i>P. aeruginosa</i> (S)	na
63	<i>P. aeruginosa</i> (S), CNS (S), <i>S. aureus</i> (S)	negative	<i>Corynebacterium</i> sp. (S), <i>Candida albicans</i> (S), <i>Enterococcus faecalis</i> (S)	60	persistent culture of mo	anaerobic Gram-neg. rod (S)	patient had no wish for further surgery
64	<i>S. aureus</i> (S)	CNS (floxa R, vanco S)	CNS (floxa R, vanco S)	38	persistent culture of resistant mo	CNS (floxa R, vanco S)	na
65	<i>S. aureus</i> (S)	CNS (floxa R, vanco S)	CNS (floxa R, vanco S)	64	persistent culture of resistant mo	CNS (floxa R, vanco S)	na

S: sensitive; R: resistant; floxa: floxacillin; vanco: vancomycin; mo: microorganism; na: not applicable.

cess. The 8 others either showed no growth or growth of the same susceptible microorganism.

In group M, treatment failed in 10 of the 35 patients. In all 10 failures, the THA had to be extracted. There were no patients with persistent infection. 8 patients underwent a successful 2-stage revision, whereas 2 had a permanent resection arthroplasty. An interesting observation was that in this group, the reason for extraction of the THA was often the identification of (different) antibiotic-resistant bacteria, which were not treatable with retention of the prosthesis, in intraoperative cultures of the second or third debridement. This happened even though the microorganism cultured after the first debridement had good antibiotic susceptibility. The cultures of the successful patients in this group showed either no growth or the same susceptible microorganism during repeat surgery.

Although the difference in failure rates was large (4/33 as opposed to 10/35), it was not statistically significant ( $p = 0.09$ ). We found no statistically significant differences in secondary outcomes. In 1 patient in group S and in 2 patients in group M, infection treatment resulted in a permanent resection arthroplasty. In addition, 30 of the initial 33 patients in hospital S had no clinical or radiographic signs of infection and had a THA in situ at their final follow-up, as compared to 33 of the 35 patients in hospital M. There was a significant difference in the number of THA removed (2 vs. 10;  $p = 0.02$ ).

### Confounders

None of the potential confounders (ASA classification, McPherson systemic host grade, BMI, smoking, diabetes mellitus) had a statistically significant effect on the success or failure of treatment. As the ASA classification was almost statistically significant ( $p = 0.06$ ), logistic regression analysis was performed to correct for this parameter. This showed no significant effect on the outcome success or failure between hospitals. There was no significant effect on successful outcome of the number of days between implantation and infection ( $p = 0.3$ ).

### Discussion

We found that the strategy of a single surgical debridement with only additional surgery on indication, in combination with systemic antibiotics, was an effective treatment for early postoperative infection after THA, with an overall success rate of 88%. A single operation was sufficient in more than two-thirds of the patients. In another two-thirds of patients who needed additional surgery, the hip prosthesis could be retained and infection was also cured. This result compared favorably with that of a treatment strategy involving routine multiple debridements, which was successful in 71% of patients.

A notable finding was the emergence of resistant bacteria in many patients in the multiple debridement group (group M). Even though the initial cultures showed growth of sensitive

bacteria, which were effectively treatable with either intravenous or oral antibiotics, repeat cultures during the second or third debridement identified resistant bacteria such as methicillin-resistant *Staphylococcus epidermidis* or *Corynebacterium* species, where in situ treatment would not be possible. This forced the treating surgeon to remove the implant. There are different possible explanations for this emergence of antibiotic resistance. The systemic or local antibiotic treatment may have induced the resistance. Alternatively, a small number of resistant bacteria—previously undetected in an abundance of sensitive bacteria—was identified at a later stage, when most of the sensitive bacteria had been effectively eradicated. A third, in our opinion more probable, explanation would be contamination or colonization of the surgical wound with resistant bacteria from the skin during repeat surgery—especially since each additional debridement is another disturbance of the already compromised soft tissues.

The success rates of both treatment strategies can be considered to be good. Previous publications on debridement surgery with retention of the implant have shown a large variation in success rates, ranging from 21% to 90% (Crockarell et al. 1998, McPherson et al. 2002, Giulieri et al. 2004, Martinez-Pastor et al. 2009, Azzam et al. 2010, Estes et al. 2010, Van Kleunen et al. 2010, Engesaeter et al. 2011, Koyonos et al. 2011, Choi et al. 2012, Sukeik et al. 2012, Westberg et al. 2012, Fehring et al. 2013, Geurts et al. 2013, Kuiper et al. 2013). However, in many publications it is not clear what the exact treatment protocol was. In addition, there have been no publications directly comparing different treatment regimes. The high success rates in our study may have been positively influenced by the fact that the bacteria initially causing the infection all had good antibiotic sensitivity. Culture of the first debridements did not show any growth of MRSA, MRSE, or resistant Enterococci.

Our findings can have direct implications for clinical practice. We should aim at treatment strategies that are both efficient and cost-effective. The strategy of a single surgical debridement with only repeat surgery on indication proved to be at least as effective in controlling the infection and retaining the hip implant as routinely performing multiple debridements, without compromising the clinical end result. This strategy will reduce the costs of multiple surgeries, longer hospitalizations, and revision implants. Perhaps even more importantly, it will reduce the morbidity and psychological discomfort of the patient.

One limitation of our study was that it was a retrospective comparative study and the number of patients included was small. Of course, large randomized trials are warranted, but with the low incidence of early postoperative infection after THA, this will be difficult to achieve. Despite the 8-year inclusion period, we found only 68 eligible patients in these 2 large teaching hospitals that perform a total of about 1,000 primary THAs a year. Another limitation was the fact that the patient characteristics of the 2 study groups were not exactly the

same. The patients in the single debridement group (group S) were older and had more comorbidity, as reflected in the ASA classification and McPherson systemic host grade. Despite the worse health status of the patients in this group, this strategy did perform better. In addition, these comorbidity factors could not be identified as confounders. A final limitation was the fact that different local antibiotic carriers were used in the 2 groups. This was dictated by the local protocols. Although both the beads and fleeces give a high burst release of gentamicin, the duration of their activity is different (Moojen et al. 2008, Swieringa et al. 2008). Even though the beads release antibiotics for more than 2 weeks, they could become a foreign body themselves, with the risk of maintaining the infection. We cannot say whether this difference influenced the results.

The main strength of the present study was that it directly compared 2 treatment regimes. As both teaching hospitals used their own standard protocols for all the patients included, this reduced the risk of selection bias. Performing the analysis according to the intention-to-treat principle also ensured a fair comparison of treatment strategies. As patients initially scheduled for a single debridement who needed additional surgery based on lack of improvement of their clinical situation were more likely to result in failure, other means of analysis would have been unfair to the multiple debridement strategy. Another strength was the fact that it was not surgeons who specialized in infection surgery who operated on all patients, but orthopedic staff surgeons or supervised residents, which more accurately reflect everyday clinical practice in most hospitals.

Future research should focus on not only the surgical management itself, but also on issues such as duration of systemic antibiotic therapy and efficacy of different local antibiotic carriers. Another interesting to investigate would be whether the results obtained can be extrapolated to infected total knee arthroplasties.

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