ORIGINAL ARTICLE

Factors governing the healing of *Staphylococcus aureus* infections following hip and knee prosthesis implantation: A retrospective study of 95 patients

D. Joulie\(^a,1,*\), J. Girard\(^a,b,1\), O. Mares\(^a,1\), E. Beltrand\(^c,1\), L. Legout\(^d,1\), H. Dezèque\(^a,1\), H. Migaud\(^a,b,1\), E. Senneville\(^d,1\)

\(^a\) C Department of orthopaedics, Roger Salengro Hospital, Lille Regional Teaching Hospital Center, boulevard Prof-Emile-Laine, 59037 Lille, France
\(^b\) North of France, Lille University, 59000 Lille, France
\(^c\) Department of orthopaedic surgery and traumatology, Tourcoing Hospital Center, 155, rue du Président-Coty, BP 619, 59208 Tourcoing, France
\(^d\) Department of tropical and infectious diseases, Tourcoing Hospital Center, 155, rue du Président-Coty, BP 619, 59208 Tourcoing, France

Accepted: 27 May 2011

KEYWORDS
Sepsis;
Hip prosthesis;
Knee prosthesis;
Antibiotics;
One-stage revision;
Two-stage revision;
Debridement;
Total joint infection

Summary

Introduction: The prognostic factors for total hip arthroplasty (THA) and total knee arthroplasty (TKA) *Staphylococcus aureus* prosthetic joint infections are poorly known, notably because of the heterogeneous management in terms of both antibiotic administration and adopted surgical strategy. Uniform treatment regimens would make it easier to define the outcome of these *S. aureus* infections.

Patients and methods: Between 2001 and 2006, 95 patients with a *S. aureus* joint infection after THA or TKA were treated, strictly following a standardized protocol according to the recommendations of Zimmerli et al. The patients’ mean age was 65.7 years, 71 with THA and 28 with TKA (four patients had two infected joints). These 95 patients presented 120 infectious episodes, all of whom had surgical treatment: 53 lavages (44.1%), 17 one-stage prosthesis revisions (14.2%), 29 two-stage prosthesis revisions (24.2%), and 21 prostheses removed (17.5%). On the intraoperative samples taken, methicillin-sensitive *S. aureus* (MSSA) was isolated in 88 patients (73.3%) and methicillin-resistant *S. aureus* (MRSA) in 18 patients (15%); finally 14 patients were included because of the positive results of preoperative samples taken. Twenty-seven infections (22.5%) were multibacterial, including at least *S. aureus* and 93 were single *S. aureus* bacteria. Success

\(^*\) Corresponding author. Tel.: +33 6 15 73 70 24.
E-mail address: jouliedona@yahoo.fr (D. Joulie).

1877-0568/5 - see front matter © 2011 Published by Elsevier Masson SAS.
doi:10.1016/j.otsr.2011.05.013
Introduction

The mean rate of infection for arthroplasties is 1.25% for total hip and knee arthroplasties, varying from 0.55% to 2.4% for total hip arthroplasties (THAs) and from 0.6% to 1.77% for total knee arthroplasties (TKAs) [1,2]. Gram-positive bacteria are the most frequent, notably *Staphylococcus aureus*, which accounts for 22 to 35% of the cases reported in the literature [1,2,3], with methicillin resistance encountered in 0.54 to 9% of THA and TKA joint infections [4,5]. The efficacy of the therapeutic protocols is judged by the absence of recurrence during the longest monitoring period possible, with a minimum of 1 to 2 years recommended [2,4,6]. A large number of factors influence the results, including the patient himself and his co-morbidities, the type of implant, the type of infection, and the treatment, as well as the time to treatment [6].

The objective of this study was to determine the success rate of THA and TKA *S. aureus* joint infection treatment and to specify any prognostic factors. This study was conducted in a reference center for the treatment of complex osteoarticular infections (CROIOAC) where, since 1996, the recommendations made by Zimmerli et al. [7] have been applied.

Patients and methods

Inclusion criteria

The patients were included in two branches of the northwest Lille-Tourcoing CROIOAC between 1 June 2001 and 30 June 2006. A single team of infectious disease specialists prospectively applied a therapeutic protocol following the recommendations provided by Zimmerli et al. [7], adapting them to the framework of a weekly multidisciplinary consultation meeting.

We included all patients who had a hip prosthesis (total or hemiarthroplasty) or knee prosthesis (total or hinge) with the joint infected with *S. aureus*. The diagnosis of *S. aureus* infection was made based on at least one reliable sample (preoperative puncture, bone biopsy, or intraoperative sample) that resulted in a positive *S. aureus* culture.

*S. aureus* infections predating the arthroplasty procedure, undocumented infections, and patients presenting a contraindication to medical-surgical treatment were excluded, following the protocol.

Based on these criteria, 106 patients were treated, four of whom presented a *S. aureus* infection in two joints. Eleven patients were excluded for the following reasons: one patient was in litigation with the hospital, six patients had medical files that could not be used, and four patients were lost to follow-up.

Each surgical intervention (drainage or lavage, one- or two-stage prosthesis revisions, prosthesis removal) was counted as a single clinical episode. This study analyzed 99 hip (n = 71) and knee (n = 28) arthroplasties with *S. aureus* infection in 95 patients who presented 120 different clinical episodes (21 patients underwent several infectious clinical episodes following the arthroplasties included in the study).

Patients

The mean age at the time of the first infection was 65.7 ± 6 years (range, 16—96 years); (42 males, 53 females). Eighty-nine patients (93%) had at least one co-morbidity and 60 (63%) at least two (Table 1). For 83 patients, this was an arthroplasty of an untreated joint, whereas 16 patients had already undergone one or several interventions before implantation of the prosthesis studied. The indications for arthroplasty were the following: 59 cases of primary osteoarthritis, six cases of post-traumatic arthrosis, eight cases of osteoarthritis with dysplasia, 12 fractures, four tumors, three cases of osteonecrosis of the femoral head, and seven cases of rheumatoid arthritis. There were 62 THAs (62.6%), 22 TKAs (22.2%), six hinge prostheses (6.1%), and nine hemi-arthroplasty of hip (9.1%). Implant fixation is detailed in Table 2.

The infections were classified as reported in Tsukayama et al. [8]. Of the 120 infections, there were 21 early infections (17.5%) (up to 1 month after surgery), 31 late infections (25.8%) (from the 30th postoperative day to the end of the 1st year), 45 chronic infections (37.5%) (beyond the 1st year), and 23 acute hematogenous infections (19.2%). Forty-six of the 120 infectious episodes (61.6%) were accompanied by a fistula. Preoperative knowledge of the infecting
Factors

The mean time between the onset of infectious signs and the medical-surgical management was 141.5 days ± 236.4 days (range, 1–1460 days). Four types of intervention were performed for the 120 infectious episodes: 53 lavages without changing the implant, 17 one-stage implant revisions, 29 two-stage implant revisions, and 21 prosthesis removals (followed by arthrodesis or head/neck resection). A synovectomy that was as complete as possible was associated in all cases. The choice between the different procedures followed the recommendations of Zimmerli et al. [7] by adapting the use of antibiotics to their sensitivity and to any contraindications to antibiotic use; prosthesis removal was reserved for patients who had undergone multiple procedures with repeated failure.

Pre- and intraoperative samples systematically associated a standard bacteriological sample and direct seeding on liquid enriched with Rosenow medium [9], with a mean 6.6 ± 3.6 samples (range, 1–16) taken per intervention. A strain of S. aureus was isolated for each patient, from either preoperative samples (n = 14) or intraoperative samples (n = 106). The proportion of S. aureus strains resistant to methicillin (MRSA) was 23% for preoperative samples (3/14) and 15% for intraoperative samples (16/106). Twenty-seven infectious episodes (22.5%) were multibacterial, associating another bacterium (Enterococcus spp., coagulase-negative Staphylococcus, Serratia spp., Escherichia coli) with S. aureus.

The postoperative probabilistic antibiotic therapy (third- or fourth-generation vancomycin + cephalosporin) was adapted if it responded to the intraoperative microbiological results and if it was started as soon as intraoperative samples were finished and continued until replaced by per os adapted antibiotic therapy (this was the case for 111 of 120 infectious episodes [92.5%]). The mean duration of intravenous probabilistic antibiotic therapy was 7 ± 6 days (range, 1–35 days). All antibiotic treatments administered beyond this probabilistic treatment were adapted to the sensitivity of the bacteria found during intraoperative and/or preoperative sampling. Dual antibiotic therapy including rifampicin was prescribed for 62 patients (63.9%), with this antibiotic always used in association, and was systematically chosen when there was no contraindication. The mean duration of definitive antibiotic therapy was 122.3 ± 64.6 days (range, 3–372 days) (the patient with only 3 days of antibiotic treatment demonstrated multiple intolerances to the antibiotics, experienced infectious failure, and died at 1 month).

**Evaluation of the results**

For the surviving patients, the results were assessed at a mean follow-up of 38 ± 24.9 months (range, 12–90 months). The medical files were evaluated and all the patients were contacted by telephone to determine the status of their scar, the results of their last biological workup (ESR, CRP) (a prescription was sent to them if their last workup had been done more than 3 months before), any antibiotic taken, and any surgical revision performed. At the last follow-up, at a

---

**Table 1** Analysis of the influence of co-morbidity factors on infection healing.

<table>
<thead>
<tr>
<th></th>
<th>Healed patients</th>
<th>Unhealed patients</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at time of infection</td>
<td>66 years (18–96)</td>
<td>65 years (18–94)</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes (n = 30)</td>
<td>63%</td>
<td>37%</td>
<td>NS</td>
</tr>
<tr>
<td>Vascular disorder in lower limbs (n = 36)</td>
<td>63%</td>
<td>37%</td>
<td>NS</td>
</tr>
<tr>
<td>Rheumatoid arthritis (n = 7)</td>
<td>70%</td>
<td>30%</td>
<td>NS</td>
</tr>
<tr>
<td>Immunosuppression (n = 16)</td>
<td>87.5%</td>
<td>12.5%</td>
<td>NS</td>
</tr>
<tr>
<td>Evolutive neoplasia (n = 7)</td>
<td>86%</td>
<td>14%</td>
<td>NS</td>
</tr>
<tr>
<td>Alcohol intoxication (n = 37)</td>
<td>76%</td>
<td>24%</td>
<td>NS</td>
</tr>
<tr>
<td>Tobacco intoxication (n = 34)</td>
<td>79%</td>
<td>21%</td>
<td>NS</td>
</tr>
</tbody>
</table>

---

**Table 2** Healing rate for infection depending on type of original arthroplasty fixation (n = 118 with missing initial fixation data for two patients).

<table>
<thead>
<tr>
<th>Type of prosthesis fixation</th>
<th>Number of patients</th>
<th>All joints combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healed</td>
<td>Unhealed</td>
</tr>
<tr>
<td>Cement</td>
<td>53 (45%)</td>
<td>30 (57%)</td>
</tr>
<tr>
<td>Cementless</td>
<td>24 (20%)</td>
<td>21 (88%)</td>
</tr>
<tr>
<td>Hybrid</td>
<td>41 (35%)</td>
<td>29 (71%)</td>
</tr>
<tr>
<td>P</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>
minimum of 12 months, a patient was considered healed if he or she presented all the following signs:

(1) ESR and/or CRP normal;
(2) and a noninflammatory scar with no fistula;
(3) and had never taken antibiotics for the arthroplasty since discharge;
(4) and had never been reoperated for the arthroplasty.

Pain was not judged to be a valid criteria because of the number of operations undergone by the patients. This was also true for the radiological criteria, which are not predictive of infection healing.

Twenty-two patients (23%) had died at a mean follow-up of 12 months (range, 1–30 months). The patients who had died before 1 year were considered unhealed and for the patients who died after 1 year, the four healing criteria had been observed such that among these 22 deaths, six were considered healed and 16 unhealed.

Statistical analysis

The statistical analysis was done with Stat View™ and SAS™ software. Univariate analyses were performed using the Chi² test for categorical variables, with Yates correction for the small numbers of patients. Analyses of variance were used for comparisons of means and regression tests for quantitative variables. The univariate analyses identified the factors having an influence on the healing of infection. The independence of these factors was evaluated using logistical regression and their level of influence was determined by calculating the odds ratios (with 95% confidence interval). The significance level was established at 5%.

Results

After 38 ± 24.9 months (range, 12–90 months) of follow-up, 81 of the 120 infectious episodes had healed (67.5%) and 77 of the 95 patients were considered healed (81%). Neither age at arthroplasty nor any of the co-morbidity factors had a significant influence on the healing rate, whether they were isolated or associated (Table 1). Similarly, neither the number of interventions before prosthesis implantation (0.22 ± 0.57 in healed patients versus 0.23 ± 0.62 in unhealed patients [NS]) nor the indication for arthroplasty significantly influenced the healing rate (NS).

On the other hand, the healing rate was higher for the THA patients (47/62 [75%]) compared to the TKA patients (14/22 [63.6%]), the hemi-arthroplasty of hip (4/9 [44%]), and hinge knee implants (2/6 [33%]; P < 0.05). Overall, the healing rate was 72% (51/71) for the hip arthroplasties (THA and hemi-arthroplasty of hip) and 57% (16/28) for the knee arthroplasties (TKA and hinge prostheses) (NS). The healing rate differed depending on the implant fixation method, with a better prognosis for the cementless arthroplasties (P < 0.05) (Table 2).

The time from infectious signs to surgical management, including cases undergoing simple lavage, had no influence on the healing rate (Table 3). For the simple lavages, the 37 cases managed with this treatment before 1 month after the onset of infectious signs had a 57% success rate against the infection (21/37) versus 62% (10/16) of the lavages carried out beyond 1 month (NS).

The type of infection or the presence of a fistula did not significantly modify the healing rate in the 120 cases of infection (NS) (Table 4). On the other hand, preoperative identification of the pathogens was correlated with a higher healing rate (P < 0.05) (Table 4). Similarly, prosthesis revisions (in one- or two-stages) showed a higher rate of infection healing than lavages or prosthesis removal (P = 0.0005) (Table 4). If analysis is limited to the hip revisions, the healing rate of one-stage revisions was 94% (15/16) versus 86% (19/22) for the two-stage revisions (NS).

The healing rate was not influenced by methicillin resistance (NS) (Table 5). However, monomicrobial infections showed a higher healing rate than polymicrobial infections (P < 0.05) (Table 4). Adaptation of the probabilistic antibiotic therapy influenced the infection-healing rate (P < 0.05) (Table 4). On the other hand, neither the duration of the intravenous probabilistic therapy (7 ± 5.2 days in cases of healing versus 7.8 ± 7.4 days when the infection was not healed) nor the total duration of the antibiotic therapy (124 ± 62 days in healed cases versus 117.9 ± 69 days with the infection not healed) had a significant influence on the infection healing rate (NS).

Of the six parameters that had a significant favorable influence on the S. aureus infection healing rate (infection of a cementless arthroplasty, THA infection, bacteriologification known before surgery, prescription of adapted probabilistic postoperative antibiotic therapy, one- or two-stage prosthesis revision, and monomicrobial infection), only the last two were independent factors, with an odds ratio of 5 (1.6–14.9) for prostheses revisions versus lavages and prosthesis removal and 2.9 (1.1–7.7) for monomicrobial infections versus polymicrobial infections.

Discussion

The objective of this study was to determine the healing rate for S. aureus joint infection following THA or TKA in a reference medical center with application of a specific protocol by a multidisciplinary team. In terms of healing
with a surgical intervention, the rate was only 67.5%, which may seem low, but the healing rate per patient was 81%, which is near the results published in the literature [10]. We concentrated on *S. aureus* joint infections because of their frequency and most particularly to make the study more homogeneous. This procedure is rare, with only two studies evaluating only *S. aureus* infections on implants identified in the literature, which found comparable results [4,10].

The secondary objective was to determine the factors influencing the healing of a hip or knee *S. aureus* joint infection. Six factors influenced the healing rate:

1. for three factors, the medical-surgical team cannot influence the course of the disease: the type of arthroplasty (better rate for THAs), cementless fixation (better rate for cementless fixation), and polymicrobial infections with a higher failure rate;
2. for three additional factors, the managing team can influence the healing rate by attempting to determine the type of bacterium preoperatively, limiting the use of simple lavage in favor of one- or two-stage prosthesis revision, and adapting the probabilistic antibiotic therapy. The influence of success factors is variably appreciated in the literature:
   (a) Brandt et al. [11] observed no difference between THA and TKA *S. aureus* infections treated by one- or two-stage prosthesis revision,
   (b) Vielpeau and Lortat-Jacob [6] observed an identical success rate between one- and two-stage prosthesis revisions in infected joints.

### Table 4
Healing rate depending on type of infection, surgical procedure, presence of a fistula, preoperative identification of bacterium, and infection being monobacterial.

<table>
<thead>
<tr>
<th>Type of infection</th>
<th>Healed (%)</th>
<th>Unhealed</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>14 (67%)</td>
<td>7</td>
<td>NS</td>
</tr>
<tr>
<td>Late</td>
<td>18 (58%)</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>32 (71%)</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Acute hematogenic</td>
<td>17 (74%)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Presence of fistula</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without fistula</td>
<td>50 (67%)</td>
<td>24</td>
<td>NS</td>
</tr>
<tr>
<td>With fistula</td>
<td>31 (67%)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Preoperative identification of bacterium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacterium identified preoperatively</td>
<td>48 (75%)</td>
<td>16</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Bacterium not identified preoperatively</td>
<td>33 (59%)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Type of intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-stage prosthesis revision</td>
<td>15 (94%)</td>
<td>2</td>
<td>0.0005</td>
</tr>
<tr>
<td>Two-stage prosthesis revision</td>
<td>25 (86.2%)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Lavages</td>
<td>30 (57%)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Prosthesis removal</td>
<td>10 (34%)</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Mono- or polymicrobial infection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monomicrobial</td>
<td>68 (73%)</td>
<td>25</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Polymicrobial</td>
<td>13 (48%)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Probablistic antibiotic therapy adaptation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapted</td>
<td>78 (70%)</td>
<td>33</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Not adapted</td>
<td>3 (33%)</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5
Healing rate depending on the surgical technique *Staphylococcus aureus* sensitivity to methicillin.

<table>
<thead>
<tr>
<th></th>
<th>MSSA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>MRSA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All procedures combined</td>
<td>67.6% (67/99)</td>
<td>67% (14/21)</td>
<td>NS</td>
</tr>
<tr>
<td>Lavage</td>
<td>57.5% (24/42)</td>
<td>55.6% (6/11)</td>
<td>NS</td>
</tr>
<tr>
<td>One-stage prosthesis revision</td>
<td>93% (14/15)</td>
<td>100% (2/2)</td>
<td>NS</td>
</tr>
<tr>
<td>Two-stage prosthesis revision</td>
<td>88.4% (22/26)</td>
<td>100% (3/3)</td>
<td>NS</td>
</tr>
<tr>
<td>Prosthesis removal</td>
<td>43.7% (7/16)</td>
<td>60% (3/5)</td>
<td>NS</td>
</tr>
</tbody>
</table>

MSSA: methicillin-sensitive *S. aureus*; MRSA: methicillin-resistant *S. aureus*.

<sup>a</sup> A total of 88 intraoperative *S. aureus* cultures were sensitive to methicillin (MSSA) and 18 were resistant to methicillin (MRSA), to which 11 MSSA and three MRSA identified on the preoperative cultures must be added.
The present study is the first to report a better healing rate for cementless prostheses compared to cemented implants. This result was suggested by Vieillepeau and Lortat-Jacob [6], who reported a higher success rate for revisions of a single infected THA implant when the component left in place was cementless. This result can be explained by a smaller number of interfaces for the cementless prosthesis.

Presence of a fistula is often considered detrimental to the healing of a joint infection [12,13]. Raut et al. [12] obtained 86% healing in 57 single-stage total hip prostheses revisions infected with fistula, but with a heterogeneous bacterial population (including only 11 cases of S. aureus). For the infected knee joints, Silva et al. [13] observed a lower healing rate in patients presenting an active fistula before surgery. The present series differs in that it demonstrates that the presence of a fistula does not modify the healing rate; however, we treated a single type of bacteria with a uniform protocol.

Knowledge of the responsible bacterium before surgical revision was a success factor in this study. Hip and knee puncture has been reported to be valuable in the literature, with sensitivity varying from 84% to 100% and specificity from 57% to 100% [14–16], but we believe that it should not be neglected given that it is a simple exam diagnosing infection and identifying the causal bacterium [14–16]. No studies were found that evaluated the impact of preoperative knowledge of the causal bacterium on the healing rate. Its favorable influence can be explained by the fact that in these situations, probabilistic postoperative antibiotic therapy has a greater chance of being optimal [17].

In the present study, a period of less than 4 to 6 weeks between implantation or the beginning of infection and surgical management was not associated with a better healing rate [6]. The role to be played by simple lavage needs to be better defined, even if this treatment can be easily administered to fragile patients (4.6.10). We observed no differences in the infection healing rate between one- and two-stage implant revision, but the study’s protocol reserved single-intervention procedures for cases demonstrating all the favorable factors [18–20], whereas prosthesis removal was reserved for patients who had undergone several surgeries with repeated failure in terms of infection healing [6].

No studies were found in the literature with one- or two-stage prosthesis revisions in cases of S. aureus infection. Brandt et al. [11] reported on S. aureus-infected joints after total hip and knee replacement, but treatment included nearly exclusively two-stage implant revisions, resulting in a 97.2% healing rate at 5 years for these two-stage revisions. The present study suggests that in a population of S. aureus-infected THA joints, single-stage prosthesis revision gives the same results as a two-stage revision, whatever the preoperative clinical condition (whether or not there is a fistula), the presentation of the infection (acute or chronic), and the methicillin sensitivity (MSSA or MRSA) may be.

The bacteria most often encountered in hip and knee arthroplasties are S. aureus and coagulase-negative staphylococci [2,8,21]. The proportion of S. aureus infections varies from 18.6% to 35% [21–23] and the proportion of MRSA compared to MSSA varies from 0% for Tsukayama et al. [8] to 50% for Harwood et al. [24]. In the present series, the proportion of MRSA in intraoperative cultures is 15% (18 cases), with no influence on the chances of healing (Table 5), which could at least partially explain, given the systematic use of rifampicin (except when contraindicated), that this antibiotic has a practically equivalent anti-staphylococcal activity, whether or not the strain is sensitive or resistant to methicillin [25]. When carrying out only surgical lavages, Barberán et al. [10] observed a lower healing rate for MRSA, and in multivariate analysis Salgado et al. [4] demonstrated that MRSA infection associated with the hip and lavage treatment or one-stage prosthesis revision combined with antibiotic therapy not including rifampicin was a failure factor for S. aureus infections (odds ratio, 9.2 [2.4–35.4]).

The majority of prosthesis infections are monobacterial, with a rate varying from 75% to 91% [8,21,22]. Out of 1299 infected hip prostheses, Jackson et al. [26] showed that polymicrobial infections are a factor of failure. For 102 infected hip joints treated with prosthesis revision, Sanzen et al. [27] observed 81.3% (74/91) healing in monobacterial infections versus 27% (3/11) in polymicrobial infections. The present series confirms the gravity of this factor, which appeared to be independent in multivariate analysis. This feature has a negative effect in making probabilistic postoperative antibiotic therapy and its later adaptation more difficult, notably reducing treatment compliance because of the multiplication of antibiotics.

No consensus currently exists on the duration (parenteral and oral) of the antibiotic therapy for hip and knee joint S. aureus infections [28–30]. Various teams agree on a few points: dual antibiotic therapy, intraoperative IV antibiotics relayed by oral antibiotics, and antibiotic therapy adapted to the antibiogram [28–31]. For the choice of antibiotics, if there is no contraindication, it seems that the association of rifampicin and quinolones ensures the highest success rate [6,25,28–31]. The literature reports indicate that MRSA are treated with glycopeptides (vancomycin or teicoplanin), but no studies have corroborated this choice [6]. Use of linezolid is limited by substantial accumulated toxicity, notably hematologic, and daptomycin has not yet been used on a large scale in this indication despite demonstrated efficacy on staphylococci in the exponential growth phase and stationary in conditions of biofilm associated with powerful concentration-dependent-type bactericidal action [24,31,32].

This study underscores the need for early well-adapted antibiotic therapy while waiting for the results of the antibiogram on intraoperative cultures. No studies that had evaluated the role played by probabilistic antibiotic treatment were found in the literature. This study presents limitations related to the retrospective design and the absence of a control group. However, it assessed a single medical-surgical protocol set up prospectively by a single medical team and underlines the decisive role of the infectious disease specialist within this team, notably for the individualized adjustment and follow-up of treatments.

Conclusion

The results of this study establish that by following a management protocol inspired by the work published by
Zimmerli et al. [7], the success rate for medical-surgical treatment in a specialized center of a knee or hip joint  
S. aureus infection following implantation is 81%. Improvement of these patients’ prognosis is based on better 
management including the identification of the causal bacteria, limitation of lavages with preference for prosthesis 
revision, and prescription of probabilistic postoperative antibiotic therapy adapted to the results of intraoperative 
prosthetic joint samples.

Disclosure of interest

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

Acknowledgements

The authors wish to thank Prof. Alain Duhamel for his invaluable assistance in the statistical analysis.

References
