# Implant retention and high rate of treatment failure in hematogenous acute knee and hip prosthetic joint infections

N. Pansu, M. Hamoui, F. Manna, A. Makinson, S. Dufour, D. Morquin, F. Canovas, J. Reynes, V. Le Moing

# Traitement conservateur des infections aiguës hématogènes de prothèses de hanche et de genou : un risque élevé d'échec

# Implant retention and high rate of treatment failure in hematogenous acute knee and hip prosthetic joint infections

N Pansu[1], M Hamoui[3], F Manna[4], A Makinson[1,2], S Dufour[1], D Morquin[1], F Canovas[3], J Reynes[1,2], V Le Moing[1,2]

[1] Infectious and Tropical Diseases Dept, Montpellier University Hospital, Montpellier, France.
[2] Inserm U1175, University of Montpellier, Montpellier France.
[3] Orthopedic Surgery Dept, Montpellier University Hospital, Montpellier, France.
[4] Epidemiology and Clinical Research Unit, University Hospital, Montpellier, France

## Corresponding author

N. Pansu, Infectious and Tropical Diseases Department hôpital Gui de Chauliac, 80 avenue Augustin Fliche 34000, Montpellier, France
E-mail : n-pansu@chu-montpellier.fr
Phone : +33467337714. Fax +33467336985

This work was presented as an abstract and poster at the French national congress for infectious diseases on June 21-23, 2017 in St Malo.

**Keywords**: hematogenous infection; conservative surgery; hip prosthetic joint; knee prosthetic joint ; *Staphylococcus aureus*

**Mots clés** : infection hématogène ; chirurgie conservatrice ; prothèse de hanche ; prothèse de genou ; *Staphylococcus aureus*

**Abstract**

***Objectives*.** Only few studies evaluated hematogenous prosthetic joint infections. We aimed to describe the characteristics of these infections and factors associated with management failure.

***Methods*.** We selected hematogenously-acquired infections, defined by the occurrence of infectious symptoms more than a year after implantation among records of patients treated for hip and knee prosthetic joint infections at Montpellier University Hospital between January 2004 and May 2015. Failure was defined by death due to prosthesis-related infection, need for prosthesis removal in case of conservative treatment, or recurrence of infectious signs on a new prosthesis.

***Results*.** Forty-seven patients with hematogenous prosthetic joint infection were included (33 knee infections and 14 hip infections). Infectious agents were streptococci (43%), *Staphylococcus aureus* (43%), Gram-negative bacilli (13%), and *Listeria monocytogenes* (2%). Thirty-one patients were initially treated with debridement and implant retention and 15 with prosthesis removal (three with one-stage surgery, 10 with two-stage surgery). The median duration of antibiotic therapy was 66.5 days. The overall failure rate was 52% (24/48), 71% (22/31) with implant retention strategy, 13% (2/15) with prosthesis removal, and 63% (12/19) in case of *Staphylococcus aureus* infection. Conservative treatment was appropriate (arthrotomy on a well-implanted prosthesis without sinus tract and symptom onset <21 days) in 13/31 patients (42%) with a failure rate still high at 69% (9/13). The only factor associated with failure was conservative surgical treatment.

***Conclusion*.** The high risk of failure of conservative treatment for hematogenous prosthetic joint infections should lead to considering prosthesis replacement as the optimal strategy, particularly with *Staphylococcus aureus*.

**Résumé**

***Objectifs*.** Nous avons étudié les caractéristiques des infections hématogènes de prothèse articulaire et les facteurs associés à l'échec de prise en charge.

***Méthodes*.** Ces infections, définies par l'apparition de symptômes plus d'un an après l'implantation, ont été rétrospectivement sélectionnées parmi les dossiers de patients pris en charge pour infection de prothèses de hanche et de genou entre juin 2004 et mai 2015. L'échec de prise en charge était défini par le décès lié à l'infection, l'ablation de prothèse en cas de traitement conservateur ou la récidive de signes infectieux sur une nouvelle prothèse.

***Résultats*.** Quarante-sept patients présentant une telle infection ont été inclus (33 genoux, 14 hanches). Les bactéries étaient des streptocoques (43 %), *Staphylococcus aureus* (43 %), des bacilles gram-négatifs (13 %), *Listeria monocytogenes* (2 %). Trente-et-un patients ont été initialement traités par lavage et maintien des implants et 15 par ablation de prothèse. La durée médiane d'antibiothérapie était de 66,5 jours. Le taux global d'échec était de 52 %, 71 % en cas de maintien, 13 % en cas d'ablation et 63 % en cas d'infections à *Staphylococcus aureus*. Le traitement conservateur était approprié (arthrotomie sur une prothèse scellée, sans fistule et symptomatique depuis < 21 jours) chez 42 % des patients avec un taux d'échec élevé (69 %). Le seul facteur associé à l'échec était le traitement conservateur.

***Conclusion*.** Le risque élevé d'échec du traitement conservateur doit faire considérer le changement de prothèse comme le traitement optimal, particulièrement en cas d'infection à *Staphylococcus aureus*.

## Introduction

Late-onset acute prosthetic joint infections (PJI) are usually considered hematogenous. These infections are a rare complication of prosthetic joint implants, with an incidence of 0.1-0.6% in a lifetime [1-3]. Pathophysiology and causative microorganisms differ from early post-operative infections. Nevertheless, treatment guidelines do not consider post-operative and hematogenous prosthetic joint infections differently and in case of acute symptoms for less than three weeks, debridement and implant retention (DAIR) are recommended in hematogenous infections as in early post-operative infections [4]. High rates of failure have been reported with DAIR [5-7] but only few studies focused on hematogenous PJI.

We reviewed all hematogenous PJI managed in our center, to analyze the efficacy of various surgical treatment strategies and to search for risk factors associated with treatment failure.

## Patients and methods

### Population

Medical records of patients admitted for hematogenous PJI at Montpellier university hospital between January 2004 and May 2015 were selected among PJI records extracted from the hospital software and reviewed using a standardized form.

### Definitions

Hematogenous PJI was defined as per Tsukayama *et al.*'s classification: presence of acute symptoms (pain, fever, fluid and/or sinus tract) for less than 21 days before any antibiotic therapy initiation on a prosthetic knee or hip, after an asymptomatic period of more than one year after implantation [8].

We only included infections microbiologically documented by culture of joint aspirate, intraoperative samples or blood samples positive to any microorganism, excluding *Cutibacterium acnes* and coagulase-negative staphylococci-positive cultures. Patients with positive blood cultures only were included in case of purulence identified during prosthesis surgery or joint aspiration. Patients who had a previous surgical revision for sepsis were not included.

Surgical treatment was considered adequate when corresponding to the 2013 Infectious Diseases Society of America (IDSA) recommendations [4]: conservative surgery with implant retention by arthrotomy in case of infection onset <3 weeks, in a well-implanted prosthesis with no sinus tract, or implant change otherwise.

Antibiotic therapy was considered adequate if corresponding to the French infectious diseases society (SPILF) guidelines [9] or IDSA recommendations [4]: at least six weeks of treatment using intravenous cefazolin (100 mg/kg/day) or cloxacillin (200 mg/kg/day) or vancomycin (30-40 mg/kg/day) in case of allergy or resistance followed by a combination of oral rifampicin (900-1,800 mg/day), clindamycin (1,800-2,400 mg/day), fusidic acid (1,500 mg/day), co-trimoxazole (2,400/480-3,200/640 mg/day), or quinolone (ofloxacin 400-600 mg/day, ciprofloxacin 1,000-1,500 mg/day, levofloxacin 500-750 mg/day) for *Staphylococcus aureus.* A short treatment duration with empirical vancomycin was considered adequate for methicillin-susceptible *S. aureus* if followed by adequate oral therapy, and daptomycin 6-10 mg/kg/day was considered adequate for methicillin-resistant *S. aureus* in case of renal failure [4]. For streptococcal infections, an intravenous treatment with amoxicillin (100-200 mg/kg/day) or a third-generation cephalosporin (6 g/day of cefotaxime or 2 g/day of ceftriaxone) followed by oral amoxicillin or clindamycin (in case of

intolerance, combined with rifampicin and quinolone or co-trimoxazole) was also tolerated. For Gram-negative bacilli, intravenous treatment with a third-generation cephalosporin or carbapenem (meropenem 6 g/day or imipenem 3 g/day) followed by oral quinolone or ceftazidime 6 g/day and ciprofloxacin for *Pseudomonas aeruginosa* was considered adequate.

Successful treatment was defined by resolution of symptoms with a follow-up of more than 12 months after surgery.

Failure was defined by the:

(i) need for prosthesis removal because of an infectious cause in case of DAIR;

(ii) recurrence of infectious signs on the new implant in case of non-conservative treatment;

(iii) death due to prosthesis-related infection.

**Statistical analysis**

Statistical analyses were performed on XLSTAT and SAS version 9.4 software (SAS Institute, Cary, North Carolina). Results were expressed as means or medians for quantitative variables and as percentages for qualitative variables. Normality of distributions was c-checked by Shapiro-Wilk test. Categorical variables were compared using the $Chi^2$ test or Fischer's exact test. Continuous variables were compared by Student's *t* test or Wilcoxon Mann-Whitney test. Survival analysis comparing the two types of treatment was performed using Kaplan-Meier model. Predictive factors of failure were studied using a logistic regression with univariate and multivariate stepwise analysis, using Benjamini-Hochberg's correction to avoid errors due to multiple tests.

## Results

### Population

Forty-seven of the 330 PJIs in our hospital were identified as hematogenous PJI, including 33 knee prosthesis infections (three bilateral infections) and 14 hip prosthesis infections (one bilateral infection). Mean age of patients was 72.9 years (range 59-88). Mean time after surgery was 8.9 years (range 1-28.6). The main symptoms were pain (93%) and fever (65%). Fluid collection of the prosthetic joint and elevated C-reactive protein were more frequent in prosthetic knee infections. Four patients had sinus tract. Nine had osteitis signs on X-rays. Data is summarized in Table 1.

### Microbiological data and suspected portal of entry

In 28 patients with a suspected primary infection, cutaneous infection was the most frequent suspected portal of entry. Among all patients included (n=47), five patients had infective endocarditis and six had other confirmed infectious localizations. *Staphylococcus aureus* (43%) and streptococcal species (43%) were the most frequent pathogens. Microbiological data is detailed in Table 2.

### Medical therapy

Median duration of antibiotic therapy was 66.5 days [range 11-1,020], including a median of 20 days of intravenous therapy [range 0-124]. All patients received at least six weeks of antibiotic therapy, except two patients who died prematurely from septic shock. Seventeen patients received more than 12 weeks of antibiotic therapy. Two patients only received oral

therapy. Median duration of antibiotic therapy was 65 days [range 46-1,020] for *S. aureus* infections, 88 days [range 46-198] for streptococcal infections, 92 days [range 44-233] for Gram-negative bacilli infections, and 44 days for *Listeria monocytogenes* infections.

Considering oral therapy, 13 (65%) *S. aureus* infections were treated with a combination including rifampicin (four with co-trimoxazole, six with quinolones, two with glycopeptides, one with fusidic acid), two only received intravenous therapy with cefazolin and oxacillin and four combined with clindamycin, co-trimoxazole, or quinolone. Nine streptococcal infections were treated with clindamycin, six with amoxicillin, and three with rifampicin and quinolone or co-trimoxazole. Five Gram-negative bacilli infections were treated with quinolones, combined with ceftazidime for *Pseudomonas aeruginosa*. Amoxicillin was used alone for *Campylobacter fetus* and combined with rifampicin for *Listeria* infections. Antibiotic therapy was considered adequate in 42 patients (91%) of the 46 who underwent surgery. Of the four patients with inadequate treatment, two were presenting with streptococcal infections and were treated with pristinamycin and rifampicin for one and the other patient was only treated with three weeks of adequate treatment followed by imipenem because of another infection. One patient received pristinamycin and ciprofloxacin and one did not receive intravenous therapy for *S. aureus* infections. The 47$^{th}$ patient, who was treated with medical therapy only, received co-trimoxazole and rifampicin.

**Surgical treatment**

Thirty-one patients were treated by conservative surgery (10 by arthroscopy, 21 by arthrotomy) and 15 were treated by prosthesis removal (three with one-stage replacement, 10 with two-stage replacement, two with resection-arthroplasty). One patient was treated with medical therapy only. Median time between symptom onset and surgery was 7 days for

knee PJI and 26 days for hip PJI ($p$=0.016). Conservative treatment was significantly more frequently used for knee PJI ($p$<0.0001).

Among the nine patients with osteitis signs on X-rays, five were treated with DAIR and four with ablation. Among the four patients who had ablation, only one prosthesis was found unsealed during surgery.

Among the 46 patients who underwent surgery, six showed intraoperative aspect of prosthesis loosening, one in the DAIR group (for which treatment was considered inappropriate) and five in the non-conservative treatment group. Only one of this six patients had osteitis signs on X-rays before surgery.

**Outcome**

Overall success after the first-line therapy was 48% (22/46) in patients who underwent surgery, 29% (9/31) with conservative surgery, and 87% (13/15) with non-conservative surgery ($p$=0.0002). The patient treated with medical therapy only was lost to follow up after eight months. Results are presented in Figure 1.

Management was considered inappropriate in 18 of the 31 patients who underwent conservative surgery (58%):

- inadequate surgery indication in 7/31 (23%): three patients had a sinus tract (all in the failure group), four presented with symptoms for more than three weeks (three in the failure group, one in the success group);
- inadequate surgical procedure in 11/31 patients (35%) treated by arthroscopy (five in the success group, six in the failure group).

Among the 24 patients eligible for DAIR, eight (33%) were cured and among the 13 patients (42%) for whom conservative treatment was considered adequate, only four were cured (31%). Success rates were 37% (7/19) in patients presenting with *S. aureus* infection (only 21% in the conservative surgery group), 60% (12/20) in patients presenting with streptococcal infection (33% in the conservative surgery group), and 33% (2/6) in patients with Gram-negative bacilli infections.

On Kaplan Meier analysis, probability of treatment failure was significantly higher in case of prosthesis retention ($p$=0.0004), as shown in Figure 2.

We performed a univariate analysis on possible predictive factors for treatment failure in the 46 patients undergoing surgery. Results are presented in Table 3. When taking into account multiple comparisons, the only factor significantly associated with failure was conservative surgery.

At the end of the follow-up period 31 patients were cured (22 after the first-line therapy, nine after two or more lines of therapy), three died from infection-related causes: two from septic shock when receiving a first-line therapy, one from ventilator-associated pneumonia after surgery for prosthesis removal following two unsuccessful DAIR. Ten patients died from non-infectious causes, one was still receiving treatment for PJI, and two were lost to follow-up. Only nine patients retained their implant. Outcomes are detailed in Figure 3.

## Discussion

Our study is one of the largest focusing exclusively on hematogenous PJI, and revealed poor results in hematogenous PJI treated with DAIR, with more than 70% of failure.

Primary infection was identified in more than half of patients, and similarly to other studies cutaneous infection or traumatism was the main portal of entry [10], and *Staphylococcus aureus* was the most frequent pathogen [10-11]. The risk of hematogenous PJI infection following *S. aureus* bacteremia may be as high as 30% [12-13], and this shows the importance of skin care in patients with prosthetic joints.

As previously reported [7, 12, 14-16], we observed a high proportion of knee prosthesis infections, with higher rates of failure. Plausible explanations are a larger prosthetic surface and a more complex joint interface [12]. Clinical signs of knee prosthesis infections are more severe, leading to a rapid diagnosis justifying more frequently conservative surgery with DAIR. However, hip prosthesis infection diagnoses are often delayed, and prosthesis exchange is more commonly used, as formerly reported by Vu *et al.* [14].

We observed high rates of failure when DAIR was performed. In some cases of failure, representing more than half of patients who had conservative surgery, DAIR should not have been performed, as per recommendations, as symptom onset dated from more than three weeks before surgery or as patients presented with sinus tract or prosthesis loosening [4]. However, even when indications and modalities of DAIR strictly complied with guidelines, success rates remained low.

The effectiveness of DAIR widely varies in the literature, from 11% to 100% [5, 16-21] (all types of acute infections). Most studies report a lower effectiveness of DAIR in hematogenous than acute post-operative infections [5-7, 16]. In a study focusing on hematogenous PJI, Konigsberg *et al*. [20] reported that DAIR was successful in almost 76% of cases. However, Rodriguez *et al.* [15] reported a lower rate (59%), more similar to our results. Various causative agents, surgery modalities (quality of debridement, exchange of

mobile components), and time between symptom onset and surgery in these studies may explain these discrepancies.

Infection with *S. aureus* seemed to be associated with conservative treatment failure [5, 18, 20, 22-24], possibly due to an earlier diagnosis. Rates of failure for *S. aureus* infections were 62% according to Lora-Tamayo *et al.* [5] and 57.8% according to Rodriguez *et al*. [15]. The causative agent play an important part in treatment outcome in our study. Rate of failure was higher (63%) in staphylococcal than streptococcal infections (40%), even though the difference was not statistically significant probably due to a lack of power. Although streptococcal infections are usually associated with better prognosis [25, 26], recent works reported rates of failure close to 50% with conservative treatment [17, 27], which corroborates our results.

Prosthesis replacement seemed to be associated with better outcome in our study as well as in other studies [28, 29]. Nevertheless, this intervention can be difficult and risky, particularly in elderly people or in case of multiple surgeries, and functional results can be less satisfying than with DAIR, especially with knee prostheses. One-stage prosthetic replacement is an increasingly evaluated alternative [30, 31].

Konigsberg *et al.* reported that almost 90% of patients were treated within seven days following symptom onset, and they reported high success rates. Other authors reported an association between failure and longer time to surgery [21]. This association was not obvious in our study, as time to surgery tended to be shorter in patients experiencing failure. An explanation is that time to surgery was shorter with knee prosthesis (7 versus 26 days), probably because diagnosis of the infection was easier in these joints, and DAIR was more frequently used and associated with higher failure rates. Of note, time to surgery was

identical in patients with knee prosthesis experiencing failure and success (7.5 days in both groups).

Many other prognostic factors have been described (immunosuppressive therapy [6], arthroscopic debridement [5], short duration of antibiotic therapy [18], associated bacteremia [6], sinus tract [19]) but we did not identify such factors in our work.

Our study has several limitations. Because of its observational design, indication biases may be present, and treatments were not standardized. However to our knowledge, it is one of the largest series of hematogenous PJI. Heterogeneous characteristics of the population and infections are complex. We cannot formally rule out the inclusion of very late post-operative infections instead of hematogenous PJI. Some patients had signs of osteitis on X-rays suggesting chronic infections. Nevertheless, the very long time since implantation of prostheses without clinical symptoms makes this misclassification very unlikely.

**Conclusion**

If conservative surgical treatment remains the reference for hematogenous PJI for specific patients according to recommendations, the high risk of failure particularly for *S. aureus* infections, should lead surgeons to reconsidering prosthesis replacement as the preferred option. Prospective studies are nevertheless necessary to confirm these findings.

**Disclosure of interest**

The authors declare no conflict of interest

**Contribution of authors**

N. Pansu, M. Hamoui, and V. Le Moing were responsible for designing the study, data collection and analysis, drafting and revising the article, and for the final approval.

F. Manna was responsible for major statistical analysis and interpretation of data, reviewing of the article, and final approval.

J. Reynes, D. Morquin, A. Makinson, S. Dufour, and F. Canovas made contribution to data interpretation, critically reviewed the article, and approved the final version of the article for publication.

**References**


1. Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, Parvizi J. Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. J Arthroplasty. 2009 Sep;24(6 Suppl):105–9.

2. Cook JL, Scott RD, Long WJ. Late haematogenous infections after total knee arthroplasty: experience with 3013 consecutive total knees. J Knee Surg. 2007 Jan;20(1):27–33

3. Maderazo EG, Judson S, Pasternak H. Late infections of total joint prostheses. A review and recommendations for prevention. Clin Orthop Relat Res. 1988 Apr;(229):131–42.

4. Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al. Executive Summary: Diagnosis and Management of Prosthetic Joint Infection: Clinical Practice Guidelines by the Infectious Diseases Society of America. Clin Infect Dis. 2013 Jan 1;56(1):1–10.

5. Byren I, Bejon P, Atkins BL, Angus B, Masters S, McLardy-Smith P, et al. One hundred and twelve infected arthroplasties treated with "DAIR" (debridement, antibiotics and implant retention): antibiotic duration and outcome. J Antimicrob Chemother. 2009 Jun;63(6):1264–71.

6. Lora-Tamayo J, Murillo O, Iribarren JA, Soriano A, Sánchez-Somolinos M, Baraia-Etxaburu JM, et al. A large multicenter study of methicillin-susceptible and methicillin-resistant Staphylococcus aureus prosthetic joint infections managed with implant retention. Clin Infect Dis. 2013 Jan;56(2):182–94.

7. Vilchez F, Martínez-Pastor JC, García-Ramiro S, Bori G, Tornero E, García E, et al. Efficacy of debridement in haematogenous and early post-surgical prosthetic joint infections. Int J Artif Organs. 2011 Sep;34(9):863–9. `

8. Tsukayama DT, Estrada R, Gustilo RB. Infection after Total Hip Arthroplasty. A Study of the Treatment of One Hundred and Six Infections*. The Journal of Bone & Joint Surgery. 1996 Apr 1;78(4):512–23.

9. SPILF. « Recommandations de bonne pratique clinique : Infections ostéo-articulaires sur matériel (prothèse, implant, ostéosynthèse) » mai 13, 2009. Available on http://www.infectiologie.com/UserFiles/File/medias/_documents/consensus/inf-osseuse-court.pdf. Accessed November 11, 2018

10. Zeller V, Kerroumi Y, Meyssonnier V, Heym B, Metten M-A, Desplaces N, et al. Analysis of postoperative and haematogenous prosthetic joint-infection microbiological patterns in a large cohort. J Infect. 2018 Apr;76(4):328–34.

11. Rakow A, Perka C, Trampuz A, Renz N. Origin and characteristics of haematogenous periprosthetic joint infection. Clin Microbiol Infect. 26 oct 2018;

12. Tande AJ, Palraj BR, Osmon DR, Berbari EF, Baddour LM, Lohse CM, et al. Clinical Presentation, Risk Factors, and Outcomes of Haematogenous Prosthetic Joint Infection in Patients with Staphylococcus aureus Bacteremia. Am J Med. 2015 Oct 8;

13. Sendi P, Banderet F, Graber P, Zimmerli W. Periprosthetic joint infection following Staphylococcus aureus bacteremia. J Infect. 2011 Jul;63(1):17–22.

14. Vu D-L, Uçkay I, Gonzalez A, Rohner P, Hoffmeyer P, Lübbeke A. Factors related to outcome of early and delayed prosthetic joint infections. Journal of Infection. 2016 Feb;72(2):255–7.

15. Rodríguez D, Pigrau C, Euba G, Cobo J, García-Lechuz J, Palomino J, et al. Acute haematogenous prosthetic joint infection: prospective evaluation of medical and surgical management. Clin Microbiol Infect. 2010 Dec;16(12):1789–95.

16. Setor K. Kunutsor , Andrew D. Beswick , Michael R. Whitehouse,Vikki Wylde , Ashley W. Blom , Debridement, antibiotics and implant retention for periprosthetic joint infections: A systematic review and meta-analysis of treatment outcomes, Journal of Infection (2018), doi: https://doi.org/10.1016/j.jinf.2018.08.017. Accessed December 22, 2018

17. Fiaux E, Titecat M, Robineau O, Lora-Tamayo J, El Samad Y, Etienne M, et al. Outcome of patients with streptococcal prosthetic joint infections with special reference to rifampicin combinations. BMC Infect Dis. 2016 Oct 13;16(1):568.

18. Letouvet B, Arvieux C, Leroy H, Polard J-L, Chapplain J-M, Common H, et al. Predictors of failure for prosthetic joint infections treated with debridement. Med Mal Infect. 2016 Feb;46(1):39–43.

19. Marculescu CE, Berbari EF, Hanssen AD, Steckelberg JM, Harmsen SW, Mandrekar JN, et al. Outcome of prosthetic joint infections treated with debridement and retention of components. Clin Infect Dis. 2006 Feb 15;42(4):471–8.

20. Konigsberg BS, Della Valle CJ, Ting NT, Qiu F, Sporer SM. Acute haematogenous infection following total hip and knee arthroplasty. J Arthroplasty. 2014 Mar;29(3):469–72.

21. Koh IJ, Han S-B, In Y, Oh K-J, Lee D-H, Kim TK, et al. Open debridement and prosthesis retention is a viable treatment option for acute periprosthetic joint infection after total knee arthroplasty. Arch Orthop Trauma Surg. 2015 Jun;135(6):847–55.

22. Swenson RD, Butterfield JA, Irwin TJ, Zurlo JJ, Davis CM. Preoperative Anemia Is Associated With Failure of Open Debridement Polyethylene Exchange in Acute and Acute Haematogenous Prosthetic Joint Infection. J Arthroplasty. 2018 Jun;33(6):1855–60.

23. Deirmengian C, Greenbaum J, Lotke PA, Booth RE, Lonner JH. Limited success with open debridement and retention of components in the treatment of acute Staphylococcus

aureus infections after total knee arthroplasty. J Arthroplasty. 2003 Oct;18(7 Suppl 1):22–6.

24. Koyonos L, Zmistowski B, Della Valle CJ, Parvizi J. Infection control rate of irrigation and débridement for periprosthetic joint infection. Clin Orthop Relat Res. 2011 Nov;469(11):3043–8

25. Meehan AM, Osmon DR, Duffy MCT, Hanssen AD, Keating MR. Outcome of penicillin-susceptible streptococcal prosthetic joint infection treated with debridement and retention of the prosthesis. Clin Infect Dis. 2003 Apr 1;36(7):845–9.

26. Zürcher-Pfund L, Uçkay I, Legout L, Gamulin A, Vaudaux P, Peter R. Pathogen-driven decision for implant retention in the management of infected total knee prostheses. International Orthopaedics (SICOT). 2013 Aug 1;37(8):1471–5.

27. Zeller V, Lavigne M, Leclerc P, Lhotellier L, Graff W, Ziza JM, et al. Group B streptococcal prosthetic joint infections: a retrospective study of 30 cases. Presse Med. 2009 Nov;38(11):1577–84.

28. Bengtson S, Blomgren G, Knutson K, Wigren A, Lidgren L. Haematogenous infection after knee arthroplasty. Acta Orthop Scand. 1987 Oct;58(5):529–34.

29. Bradbury T, Fehring TK, Taunton M, Hanssen A, Azzam K, Parvizi J, et al. The Fate of Acute Methicillin- Resistant Staphylococcus aureus Periprosthetic Knee Infections Treated by Open Debridement and Retention of Components. The Journal of Arthroplasty. 2009 Sep;24(6, Supplement):101–4.

30. Jiranek WA, Waligora AC, Hess SR, Golladay GL. Surgical Treatment of Prosthetic Joint Infections of the Hip and Knee: Changing Paradigms? J Arthroplasty. 2015 Jun;30(6):912–8.

31. Ure KJ, Amstutz H, Nasser S, Schmalzried T. Direct-exchange arthroplasty for the treatment of infection after total hip replacement. An average ten-year follow-up. J Bone Joint Surg Am. 1998 Jul;80(7):961

32. Tande AJ, Patel R. Prosthetic joint infection. Clin Microbiol Rev. avr 2014;27(2):302-45.

**Figure 1.** Évolution des 47 infections de prothèse après la première ligne thérapeutique, selon le type de chirurgie

**Figure 1.** Outcome of the 47 PJIs at the end of the first-line therapy, by surgical procedure.

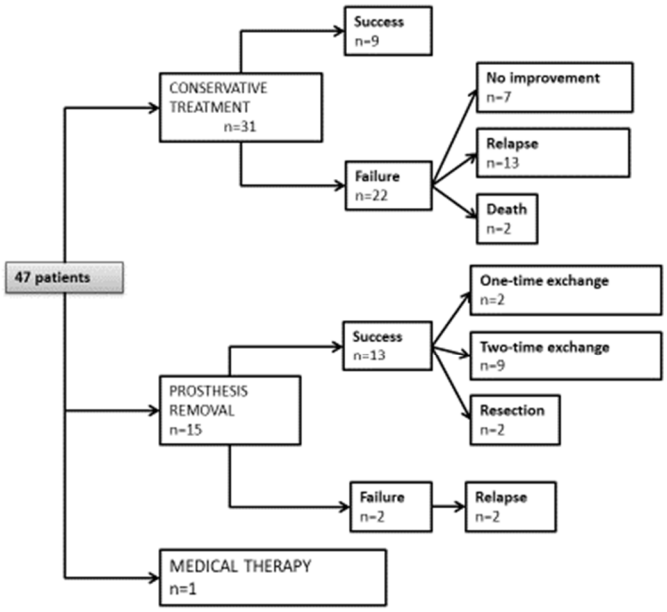
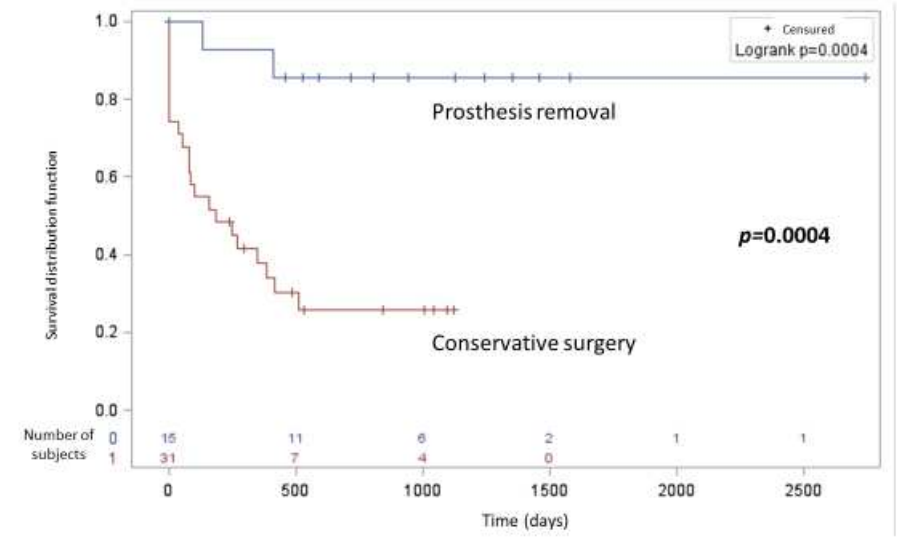


Figure 2. Probabilité de succès selon le type de chirurgie (analyse de type Kaplan Meier)
Figure 2. Probability of success by type of surgery (Kaplan Meier analysis)




x

Figure 3. Outcome of patients after failure of first-line therapy
Figure 3. Devenir des patients en échec de traitement de 1ère ligne

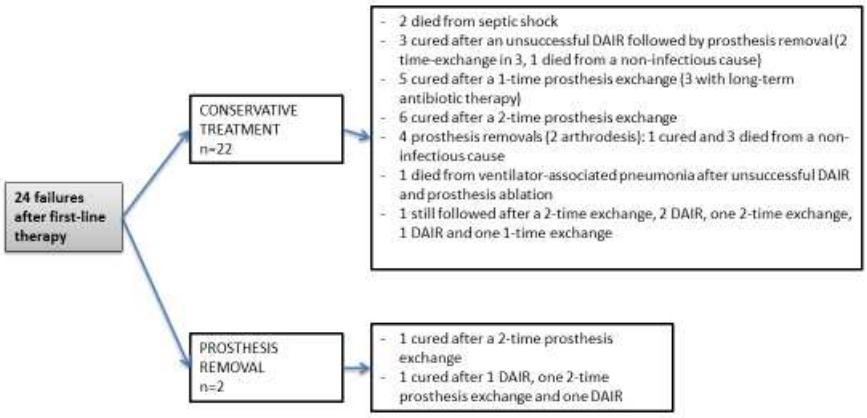


**Tableau I.** Caractéristiques cliniques, biologiques et radiologiques des 47 infections de prothèses hématogènes

**Table I.** Clinical, biological, and radiological characteristics of 47 hematogenous PJIs.

| Variable | N (%) or median [min-max] |
|---|---|
| Sex (male/female) | 30/17 |
| Age (years) | 72 [59-88] |
| Knee prosthesis | 33 (70) |
| Hip prosthesis | 14 (30) |
| History of surgical revision | 16 (34) |
| Comorbidities | |
| Diabetes mellitus | 14 (30) |
| Chronic renal failure | 5 (11) |
| Cardiac failure | 12 (26) |
| Respiratory failure | 3 (6) |
| Rheumatoid arthritis | 3 (6) |
| Immunosuppressive therapy | 5 (11) |
| Corticosteroids | 4 (8.5) |
| Malignancy | 3 (6) |
| Cirrhosis | 2 (4) |
| BMI >30 kg/m$^2$ | 16 (38) |
| Active tobacco consumption | 2 (5) |
| Active alcohol consumption | 2 (5) |

| | |
|---|---|
| Clinical features | |
| Fever | 30 (65) |
| Sinus tract | 4 (9) |
| Pain | 42 (93) |
| Fluid collection | 28 (64) |
| C-reactive protein (mg/l) | 219 [21-615] |
| Positive blood cultures | 22 (61) |
| Radiologic osteitis (X-ray) | 9 (27) |

BMI: Body Mass Index

Tableau II. Micro-organismes impliqués et portes d'entrées infectieuses suspectées (sites infectieux à distance) des 47 infections de prothèses hématogènes.

Table II. Causative agents and suspected portals of entry (primary infections) in 47 hematogenous PJIs

| Micro-organisms and portals of entry | N (%) | No. of portals of entry |
|---|---|---|
| *Staphylococcus aureus* | 20 (43) | |
| Methicillin-susceptible | 18 (38) | |
| Prostatitis | | 2 |
| Skin wound | | 2 |
| Psoriasis | | 2 |
| Peripheral catheter-related infection | | 1 |
| Erysipelas | | 2 |
| Skin surgery | | 1 |
| Methicillin-resistant | 2 (4) | |
| Nosocomial urinary tract infection | | 1 |
| Skin wound | | 1 |
| *Streptococcus* spp. | 20 (43) | |
| *Streptococcus pneumoniae* | 4 (9) | |
| Pneumonia | | 1 |
| Otitis media | | 1 |
| A, B, C, G-group streptococci | 15 (32) | |
| Dental infection | | 1 |
| Pressure sore | | 1 |
| Erysipelas | | 6 |
| Skin wound | | 1 |
| D-group streptococci | 1 (2) | |
| Colonic polyp | | 1 |
| Gram-negative bacilli | 6 (13) | |
| *Pseudomonas aeruginosa* | 1 (2) | |
| Cutaneous ulcer | | 1 |
| *Escherichia coli* | 3 (6) | |
| Cholecystectomy | | 1 |
| Urinary tract infection | | 2 |
| Other Gram-negative bacilli | 2 (4) | |

| | | |
|---|---|---|
| *Listeria monocytogenes* | 1 (2) | |
| Suspected primary infection | | 28 |
| No primary infection found | | 19 |
| Total | 47 | 47 |

**Tableau III.** Facteurs de risque d'échec du traitement en analyse univariée chez les 46 patients ayant bénéficié d'une prise en charge chirurgicale

**Table III**. Risk factors for treatment failure on univariate analysis in 46 patients who underwent surgery

| Variable | Failure (N, %) | Success (N, %) | *p* value | Corrected *p* value* |
|---|---|---|---|---|
| Male gender | 17 (59) | 12 (41) | 0.2529 | 0.7195 |
| Age in years (mean) | 72.3 | 73 | 0.7840 | 0.9582 |
| Body mass index (kg/m$^2$) | 27.7 | 29.9 | 0.313 | 0.7195 |
| Charlson score | 2.1 | 1.5 | 0.2030 | 0.7195 |
| Diabetes mellitus | 8 (62) | 5 (38) | 0.4248 | 0.7379 |
| Rheumatoid polyarthritis | 2 (64) | 1 (36) | 1 | 1 |
| Immunosuppressive therapy or corticosteroids | 5 (71) | 2 (29) | 0.4176 | 0.7379 |
| Tobacco (Active/Past/Never) | 1(50)/6(46)/16(53) | 1(50)/7(54)/1447) | 0.8706 | 1 |
| Alcohol (Active/Past/Never) | 1(50)/1(50)/21(43) | 1(50)/1(50)/19(57) | 1 | 1 |
| Prosthesis type (hip/knee) | 4 (31)/20 (61) | 9 (69)/13 (39) | 0.0681 | 0.4125 |
| Number of prosthesis involved >1 | 1 (25) | 3 (75) | 0.3364 | 0.7195 |
| Presence of cement | 18 (49) | 19 (51) | 1 | 1 |
| History of revision surgery | 9 (56) | 7 (44) | 0.6861 | 0.8843 |

| | | | | |
|---|---|---|---|---|
| Prosthesis age (years) | 7.1 | 10.7 | 0.2860 | 0.7195 |
| Fever | 18 (60) | 12 (40) | 0.2049 | 0.7195 |
| Sinus tract | 3 (75) | 1 (25) | 0.6077 | 0.8720 |
| Pain | 21 (51) | 20 (49) | 1 | 1 |
| Fluid collection | 18 (64) | 10 (36) | 0.0525 | 0.4125 |
| Osteitis (on X-rays) | 5 (56) | 4 (44) | 0.6968 | 0.8843 |
| Prosthesis leaking | 0 (0) | 8 (100) | 0.0052 | 0.0863 |
| C-reactive protein (mean, mg/l) | 236 | 261 | 0.4910 | 0.7716 |
| Leucocytes count (mean, /mm3) | 12,304 | 11,514 | 0.5740 | 0.8610 |
| Type of microorganism | | | 0.3113 | 0.7195 |
| *S. aureus* | 12 (63) | 7 (37) | | |
| Streptococcal sp. | 8 (40) | 12 (60) | | |
| Gram-negative bacilli | 4 (67) | 2 (33) | | |
| Other | 0 (0) | 1 (100) | | |
| *S. aureus* infection | 12 (63) | 7 (37) | 0.2109 | 0.7195 |
| Other microorganisms | 12 (44) | 15 (56) | | |
| Associated bacteremia | 14 (64) | 8 (36) | 0.0704 | 0.4125 |
| Endocarditis | 4 (80) | 1 (20) | 0.3488 | 0.7195 |
| Associated arthritis | 6 (67) | 3 (33) | 0.4638 | 0.7653 |
| Use of arthroscopy | 6 (60) | 4 (40) | 0.6775 | 0.8843 |
| Ablation of mobile components | 4 (57) | 2 (43) | 0.3899 | 0.7379 |
| Time from symptom onset to surgery (median, days) | 7.5 | 11 | 0.0750 | 0.4125 |
| Inadequate antibiotic therapy | 2 (50) | 2 (50) | 1 | 1 |

| | | | | |
|---|---|---|---|---|
| Intravenous antibiotic therapy period (median, days) | 20.5 | 16 | 0.285 | 0.7195 |
| Type of surgery: | | | | |
| Conservative/ablation | 22/2 | 9/13 | 0.0002 | 0.0081 |
| Conservative surgery | 22 (71) | 9 (29) | | |
| Hip prosthesis | 3 (100) | 0 (0) | | |
| Knee prosthesis | 19 (68) | 9 (32) | | |
| *S. aureus* infection | 11 (79) | 3 (21) | | |
| Ablation | 2 (13) | 13 (87) | | |
| Hip prosthesis | 1 (10) | 9 (90) | | |
| Knee prosthesis | 1 (20) | 4 (80) | | |
| *S. aureus* infection | 1 (20) | 4 (80) | | |

* *Corrected p value with Benjamini-Hochberg correction procedure*
*Results are shown for 46 patients who underwent surgery. The 47$^{th}$ patient was treated with medical therapy only and has not been included in the statistical analysis.*