Article published online: 2023-10-30

Comparison of Surgical Procedures in the Treatment of Hip Periprosthetic Infection

Comparação entre procedimentos cirúrgicos no tratamento da infecção de prótese do quadril

Ricardo Tomé Branco[1] Eurico Bandeira Rodrigues[2]

[1] Orthopedist and traumatologist, Orthopedics and Traumatology Service, Unidade Local de Saúde Alto Minho, Viana do Castelo, Portugal
[2] Orthopedist and traumatologist, Orthopedics and Traumatology Service, Hospital de Braga, Braga, Portugal

Address for correspondence Ricardo Tomé Branco, MD, Serviço de Ortopedia e Traumatologia, Unidade Local de Saúde Alto Minho, 4904-858 Viana do Castelo, Portugal (e-mail: ricardoptbranco@gmail.com).

Rev Bras Ortop 2023;58(5):e781–e789.

Abstract

Objective The present study aimed to compare the cure rate recovery time and Merle d'Aubigné-Postel functional (MAPF) score after single-stage surgery (C1T) or two-stage surgery (C2T) to treat prosthetic infections of the hip considering sociodemographic and clinical features of the patients.

Materials and Methods The present retrospective study occurred in a single center from 2011 to 2014 with 37 studied cases including 26 treated with C1T and 11 with C2T. We compared the cure rate recovery time and MAPF score in the two groups as well as the sociodemographic and clinical features of the patients. We also considered surgical complications and the most common infectious agents.

Results The C1T group had a faster functional recovery than the C2T group but there were no significant differences in the cure rate surgical complications or MAPF score. However C1T group patients were significantly younger which may have influenced the outcomes. *Staphylococcus spp.* was the most common infectious agent (62%).

Conclusion Although C2T appears superior regarding infection cure C1T may be preferable for faster functional recovery. However it is critical to consider individual patient characteristics when choosing treatment. Further research with a larger sample size is required to confirm these results.

Keywords
- arthroplasty, replacement, hip
- prosthesis-related infections
- hip prosthesis
- recovery of function
- reoperation

Work developed at the Orthopedic and Traumatology Service, Alto Minho Local Health Unit, Viana do Castelo, Portugal.

received
March 19, 2023
accepted
May 5, 2023

DOI https://doi.org/10.1055/s-0043-1776132.
ISSN 0102-3616.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Comparar a taxa de cura, o tempo de recuperação e a pontuação na escala funcional de Merle d'Aubigné-Postel (EFMA) entre a cirurgia em tempo único (C1T) e a cirurgia em dois tempos (C2T) no tratamento de infecções protéticas do quadril, considerando as características sociodemográficas e clínicas dos pacientes.

Materiais e Métodos Foi realizado um estudo retrospectivo num único centro, entre 2011 e 2014, com um total de 37 casos estudados, sendo 26 tratados com C1T e 11 com C2T. Foram comparadas a taxa de cura, o tempo de recuperação e a pontuação EFMA entre os dois grupos, bem como as características sociodemográficas e clínicas dos pacientes. Foram também consideradas as complicações cirúrgicas e o agente infecioso mais comum.

Resultados O grupo C1T teve uma recuperação funcional mais rápida do que o grupo C2T, mas não houve diferenças significativas na taxa de cura, nas complicações cirúrgicas ou na pontuação EFMA. No entanto, o grupo C1T era significativamente mais jovem, o que pode ter influenciado os resultados. *Staphylococcus spp.* foi o agente infecioso mais comum (62%).

Conclusão Embora a C2T pareça ser superior em termos de cura de infecção, a C1T pode ser preferível para uma recuperação funcional mais rápida. No entanto, as características individuais dos pacientes devem ser consideradas na escolha do tratamento. São necessárias mais pesquisas com um tamanho de amostra maior para confirmar estes resultados.

Palavras-chave
- artroplastia de quadril
- infecções relacionadas a próteses
- próteses do quadril
- recuperação funcional
- reoperação

Introduction

Total arthroplasty-associated infection is a serious issue today. The estimated rate of postoperative infections in total arthroplasties ranges from 1 to 7%, resulting in significant monetary costs.[1]

Over one million total hip arthroplasties occur every year worldwide.[2] Several studies point to an increase in this number due to the higher life expectancy. In addition, the risk of infection increases over time, leading to an absolute increase in the rate of periprosthetic infections.[2–6]

Hip prosthetic infection is the leading cause of hip revision surgery after mechanical etiologies, highlighting the need to find solutions to maximize its cure rate and reduce its repercussions regarding function, quality of life, and costs.[5,7]

Hip prosthetic infection treatment may employ different strategies, including single-stage (C1T) and two-stage (C2T) prosthesis replacement, suppressive therapy, and definitive surgery for infectious control, such as amputation or the Girdlestone procedure.[4,8]

However, there is no consensus on the treatment of prosthetic infection given the scarcity of controlled and randomized clinical trials directly comparing different treatment strategies, in contrast to osteomyelitis or septic arthritis, for instance.[9,10]

However, many authors consider C2T the gold standard for treating hip prosthetic infections.[10–12] The first surgical stage consists of debridement, arthroplasty explantation, and placement of a polymethylmethacrylate spacer impregnated with antibiotics.[11,13] Next, antibiotherapy is instituted for 4 to 6 weeks even though its duration is not a consensus.[4,14] The second surgical stage, a revision arthroplasty, occurs after normalization of the analytical parameters of infection.[15] However, few studies addressed the long-term follow-up of these patients.[11]

More recently, the success of C1T has been studied, demonstrating its superiority in terms of functional outcomes.[12] This treatment consists of infected tissues and implant excision and the immediate placement of a new prosthesis, followed by antibiotic treatment.[15] Patients can begin physical recovery immediately. However, the same does not seem true for the success rate of infection cure.[12]

Some studies indicate that C1T may be the best option for more sensitive infectious agents and patients with good systemic and local conditions (no fistulization or severe tissue damage).[15]

The present study aimed to compare the two surgical strategies, C1T and C2T, to treat hip prosthetic infections. We analyzed the cure rate and functional recovery of these patients, considering their characteristics (e.g., gender, age, comorbidities, and previous surgeries).

Materials and Methods

An observational, cross-sectional, retrospective, descriptive-analytical study was performed on subjects undergoing hip prosthesis revision surgery due to a diagnosis of prosthetic infection according to the Musculoskeletal Infection Society criteria[7] from January 2011 to December 2014 in a tertiary reference hospital. The inclusion criterion was a periprosthetic hip infection, and the exclusion criteria were the lack of explantation of all hip prosthesis components and placement of a hip revision prosthesis. Our institutional database identified 242 hip replacement revision surgeries. We selected 37 of the patients diagnosed with a periprosthetic hip infection. Of these, 26 underwent C1T (C1T group) and 11 underwent C2T (C2T group). Collected data included age, gender, time of evolution of the prosthetic infection, infection cure status, infection laterality, infectious agent, relevant comorbidities,[16] history of previous surgeries at the infected site, surgical complications in infection treatment, time for functional status recovery, and Merle d'Aubigné-Postel functional (MAPF) score[17] (recorded after 1 year of follow-up).

Data analysis used the IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NYM USA). Graph construction used GraphPad Prism, version 6.01 (GraphPad Software, La Jolla, CA, USA). The Shapiro-Wilk test evaluated the Gaussian distribution of continuous variables from all groups. Group comparison used the following tests: t-test for independent samples, Mann-Whitney U test, two-tailed Fisher exact test, and the respective effect magnitude measures. Results were statistically significant if $p < 0.05$ at a 95% confidence interval (CI).

Results

The study included 37 surgeries for hip prosthetic infection treatment performed from 2011 to 2014. These procedures included 26 C1Ts and 11 C2Ts.

We performed a comparative analysis of the sociodemographic and clinical characteristics of the sample (►**Tables 1** and **2**). The C2T group was significantly younger than the C1T group, with a moderate effect magnitude. Our institution avoids C2T in older patients because of the negative impact on functional recovery. Outcome analysis considered this fact.

Most infections occurred on revision implants, lasted ≥ 4 weeks, and their etiological agents were resistant organisms. Most cases presented comorbidities with a Charlson index ≥ 1.[16] Only 21.6% of subjects had surgical complications during the perioperative period. There were no statistically significant differences in clinical parameters between the two groups.

There was no mortality associated with periprosthetic infection. Five patients died of unrelated causes.

The C1T group had a lower cure rate than the C2T group (►**Fig. 1**), but we did not observe a statistically significant association between the surgical procedure and cure rate.

For a Charlson index ≥ 1, the cure rate was higher for the C2T group than for the C1T group. The opposite occurred in patients with no comorbidities (null Charlson index) (►**Fig. 2**), but there was no statistical significance.

The cure rate for primary implants was higher in the C2T group than in the C1T group, again with no statistical significance (►**Fig. 3**) In cases of revision implants, the cure rate was ~ 70%.

In cases with no previous surgical procedures at the infection site, C2T had a 25% higher cure rate than C1T (►**Fig. 4A**), but without statistical significance. In cases with previous surgical procedures, the cure rate was ~ 70% in both groups (►**Fig. 4B**).

Some authors reported an increased risk of periprosthetic infection in subjects > 75 years old.[18] We compared the cure rate in patients aged ≥ 75 and <7 5 years old (►**Fig. 5A**), but the association was not statistically significant. The cure rate was 18% lower in the ≥ 75-year-old group than in the < 75-year-old group, but the fact that the C1T group was significantly younger and had a slightly lower cure rate than the C2T group may be a confounding factor. No surgical procedure showed a statistically significant advantage according to age (►**Fig. 5B-C**).

The cure rate was higher for females but with no statistical significance (►**Fig. 6**).

Functional recovery was faster for the C1T group than for the C2T group (►**Fig. 7**). with a statistically significant difference for the two age groups (< 75 and ≥ 75 years old) (►**Fig 8**).

There were no statistically significant differences in the MAPF score between C1T and C2T (►**Fig 9**).

►**Table 3** shows the infectious agents in decreasing order of frequency. Staphylococci were the most common organism, with proportions consistent with the literature.[2,4,9,19–21] There were 3 cases (8.1%) of methicillin-resistant *Staphylococcus aureus* (MRSA) infection and 5 cases (13.5%) of methicillin-resistant *S. epidermidis* (MRSE).

We created two categories to investigate potential differences in the cure rate depending on the resistance of the

Table 1 Sociodemographic features of the patients

Variables	Total	C1T	C2T	*U*	*p*-value	*r*
	n = 37 (100%)	*n* = 26 (70.3%)	*n* = 11 (29.7%)			
	Median (IQR)	Median (IQR)	Median (IQR)			
Age[a] (in years)	74 (18.0)	77 (16.0)	64 (18.0)	83.0	**.046**	0.33
	n (%)	n (%)	n (%)		***p*-value**[b]	φ
Sex						
Male	21 (56.8)	15 (57.7)	6 (54.5)		1.000	0.029
Female	16 (43.2)	11 (42.3)	5 (45.5)			

Abbreviations: φ, phi coefficient; C1T, single-stage prosthesis replacement; C2T, two-stage prosthesis replacement; IQR, interquartile range.
[a]At the date of the surgical treatment (for C2T, it corresponds to the age at the date of the first surgical procedure).
[b]Fisher exact test. Significant *p*-values (< 0.05) are shown in bold.

Table 2 Clinical features of the patients

Variables	Total	C1T	C2T	*p-value*[a]	φ
	n = 37 (100%)	n = 26 (70.3%)	n = 11 (29.7%)		
	n (%)	n (%)	n (%)		
Infection[b]					
Primary implant	14 (37.8)	10 (38.5)	4 (36.4)	1.000	0.020
Revision implant	23 (62.2)	16 (61.5)	7 (63.6)		
	0[#]				
Number of previous surgeries[c]					
0	12 (32.4)	8 (30.8)	4 (36.4)	1.000	0.055
≥ 1	25 (67.6)	18 (69.2)	7 (63.6)		
	0[#]				
Infection time[d]					
< 4 weeks	6 (16.2)	6 (23.1)	0 (0.00)	0.151	0.286
≥ 4 weeks	31 (83.8)	20 (76.9)	11 (100)		
	0[#]				
Side[e]					
Left	16 (43.2)	14 (53.8)	2 (18.2)	0.071	0.329
Right	21 (56.8)	12 (46.2)	9 (81.8)		
	0[#]				
Infectious agent (resistance[f])					
Low	13 (38.2)	10 (41.7)	3 (30.0)	0.704	0.109
High	21 (61.8)	14 (58.3)	7 (70.0)		
	3[#]				
Comorbidities (Charlson index[g])					
0	14 (37.8)	10 (38.5)	4 (36.4)	1.000	0.020
≥ 1	23 (62.2)	16 (61.5)	7 (63.6)		
	0[#]				
Complications[h]					
Absent	29 (78.4)	21 (80.8)	8 (72.7)	0.672	0.089
Present	8 (21.6)	5 (19.2)	3 (27.3)		
	0[#]				

Abbreviations: φ, phi coefficient; C1T, single-stage prosthesis replacement; C2T, two-stage prosthesis replacement.
Notes: [a]Fisher exact test.
[b]Distinguishing whether the infection occurred in a primary implant or a revision implant.
[c]Number of any previous surgical procedure at the site of infection, except primary arthroplasty surgery.
[d]Time of evolution of the prosthetic infection; all infection cases had an evolution time of ≥ 3 weeks.
[e]Hip prosthetic infection side.
[f]Low-resistant agents include those known as easier to eliminate (non-methicillin-resistant Staphylococci), while high-resistant agents include agents those known as more difficult to eradicate (methicillin-resistant Staphylococci, Gram-negative agents, and polymicrobial cases).
[g]Charlson comorbidity index.
[h]Surgical complications include perioperative fracture, perioperative hemorrhage, dysmetria, and neuronal injury (one case with an adverse reaction to rifampicin, consisting of erythema and anemia, was not considered a surgical complication).
[#]Missing values. Significant p values (< 0.05) are shown in bold.

infectious agent (►**Fig. 10A**). There was a statistically non-significant increase of ~ 5% in the cure rate for low-resistant agents. There were no statistically significant differences in the functional recovery time between the two resistance categories (►**Fig. 10B**).

Discussion

Most cases of hip prosthesis revision due to infection occur in males (►**Table 1**), consistent with previous studies.[6] Furthermore, our study showed that, although there is no

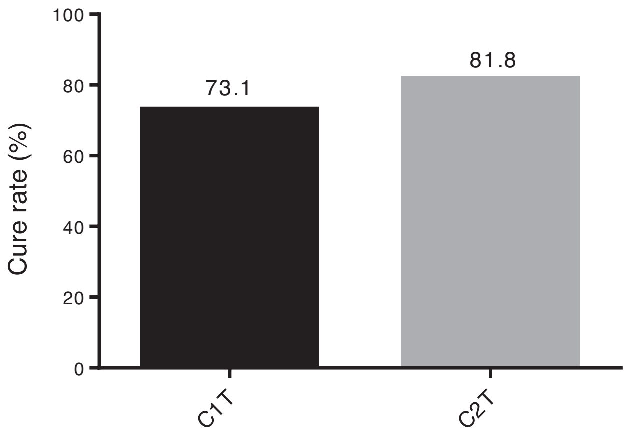

Fig. 1 Cure rate according to the surgery type for treating a prosthetic infection. $n_{C1T} = 26$; $n_{C2T} = 11$. $p = 0.695$, two-tailed Fisher exact test, $\varphi = 0.093$.

statistical significance, the cure rate is lower in males and, consequently, the infection recurrence rate is higher in these subjects (►**Fig. 6**). These two pieces of information support the hypothesis that the male gender is a risk factor for hip prosthetic infection,[3,22] even though the literature is controversial.[10,18]

During the present study, there were no deaths related to any surgery type. Previous studies in the elderly point to a hip prosthetic infection-related death rate of ~ 8%.[23] A larger sample is required to assess this parameter.

Although age can be a confounding factor, the difference in the cure rate between the two types of surgery (►**Fig. 1**) was consistent with the literature. A retrospective study of 92 patients compared C1T and C2T and showed cure rates of 56.8 and 94.5%, respectively.[8] A meta-analysis indicated an additional 3% risk of reinfection for C1T.10 However, another broader and more recent meta-analysis suggests similar cure rates for both types of surgery, ~ 92%.[24] However, the reliability of these data is questionable since no randomized clinical trial directly compared the effectiveness of these procedures.[24]

One study described an increased risk of periprosthetic infection for Charlson indices ≥ 1.[18] However, no study compared the two procedures considering comorbidities. Our study favors C2T in patients with one or multiple comorbidities and C1T in subjects without comorbidities (►**Fig. 2**).

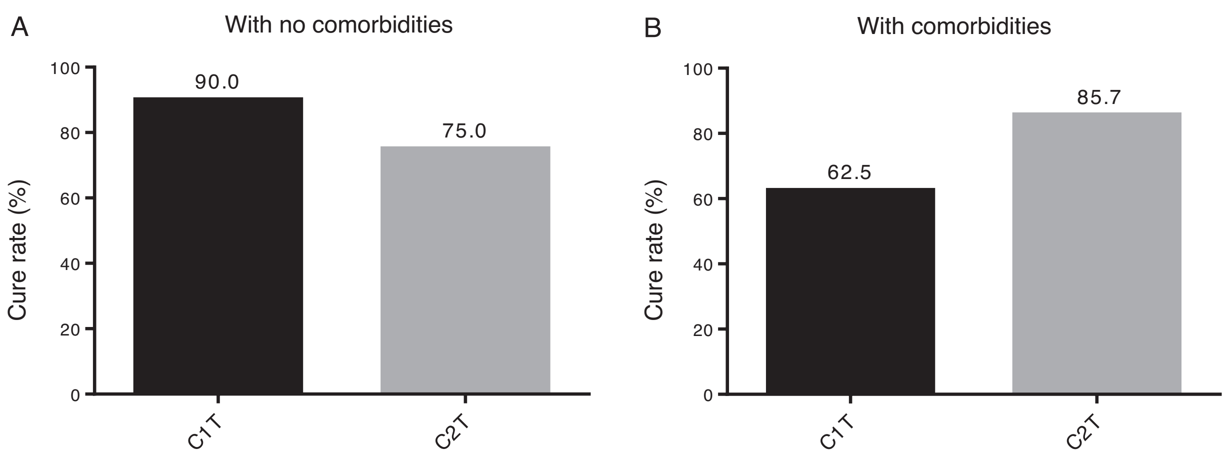

Fig. 2 (**A**) Cure rate in the group with no comorbidities (Charlson index = 0) for each type of surgery to treat prosthetic infection. $n_{C1T} = 10$; $n_{C2T} = 4$. $p = 0.505$, two-tailed Fisher exact test, $\varphi = 0.194$. (**B**) Cure rate in the group with comorbidities (Charlson index ≥ 1) for each type of surgery to treat prosthetic infection. $n_{C1T} = 16$; $n_{C2T} = 7$. $p = 0.366$, two-tailed Fisher exact test, $\varphi = 0.232$.

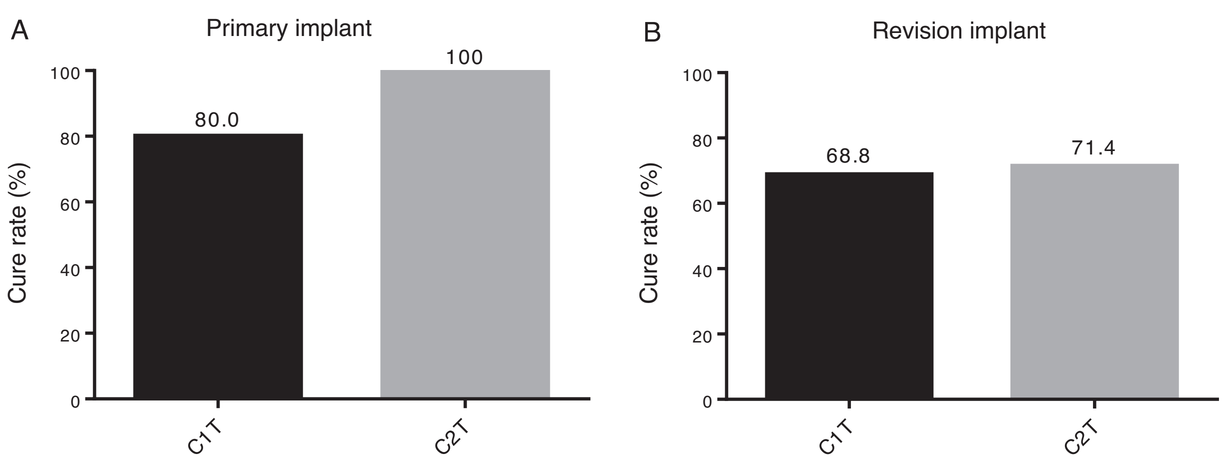

Fig. 3 (**A**) Cure rate in the primary implant group for each type of surgery to treat prosthetic infection. $n_{C1T} = 10$; $n_{C2T} = 4$. $p = 1.000$, two-tailed Fisher exact test, $\varphi = 0.258$. (**B**) Cure rate in the revision implant group for each type of surgery to treat prosthetic infections. $n_{C1T} = 16$; $n_{C2T} = 7$. $p = 1.000$, two-tailed Fisher exact test, $\varphi = 0.027$.

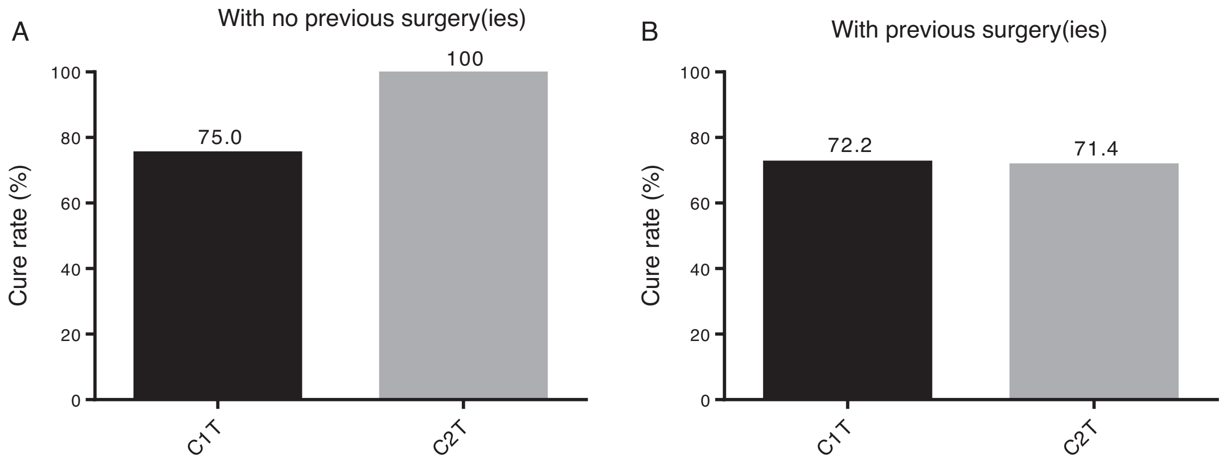

Fig. 4 (**A**) Cure rate in the group without previous surgeries at the infection site except primary arthroplasty (e.g., osteotomy, surgical debridement for any reason, partial or total prosthesis replacement due to infection or another reason) for each type of surgery to treat prosthetic infection. $n_{C1T} = 8$; $n_{C2T} = 4$. $p = 0.515$, two-tailed Fisher exact test, $\varphi = 0.316$. (**B**) Cure rate in the group with previous surgery(ies) at the infection site for each type of surgery to treat the prosthetic infection. $n_{C1T} = 18$; $n_{C2T} = 7$. $p = 1.000$, two-tailed Fisher exact test, $\varphi = 0.008$.

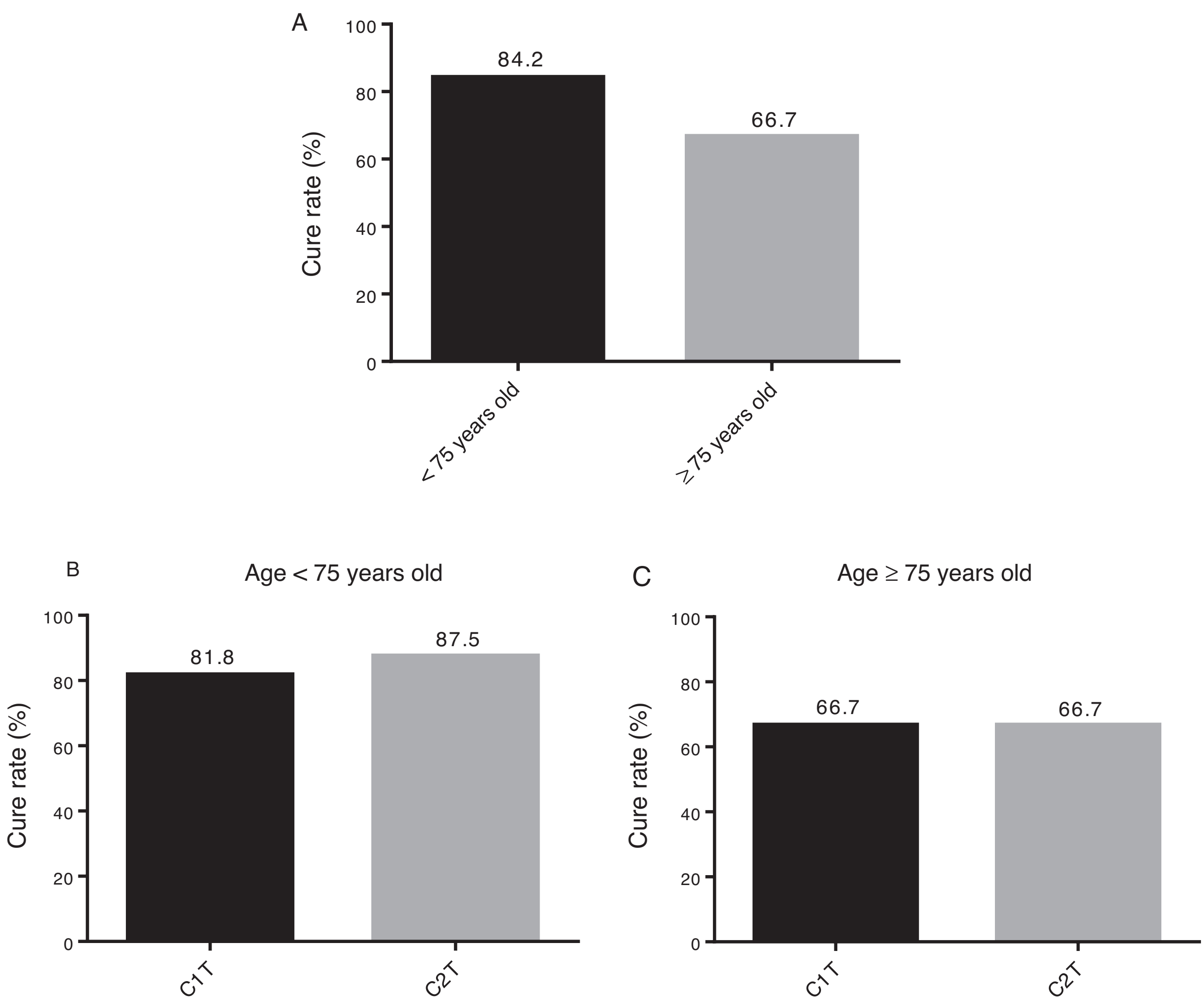

Fig. 5 (**A**) Cure rate in patients aged < 75 years old versus ≥ 75 years old. $n_{<75\ years} = 19$, $n_{\geq 75\ years} = 18$. $p = 0.269$; two-tailed Fisher exact test, $\varphi = 0.204$. (**B**) Cure rate in patients aged < 75 years old for each type of surgery to treat prosthetic infection. $n_{C1T} = 11$; $n_{C2T} = 8$. $p = 1.000$, two-tailed Fisher exact test, $\varphi = 0.077$. (**C**) Cure rate in patients aged ≥ 75 years old for each type of surgery to treat prosthetic infection. $n_{C1T} = 15$; $n_{C2T} = 3$. $p = 1.000$, two-tailed Fisher exact test, $\varphi < 0.001$.

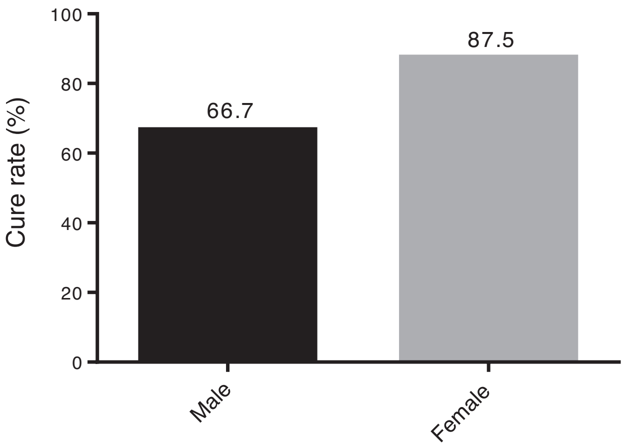

Fig. 6 Cure rate in male versus female patients. $n_{male} = 21$, $n_{female} = 16$. $p = 0.248$, two-tailed Fisher exact test, $\varphi = 0.241$.

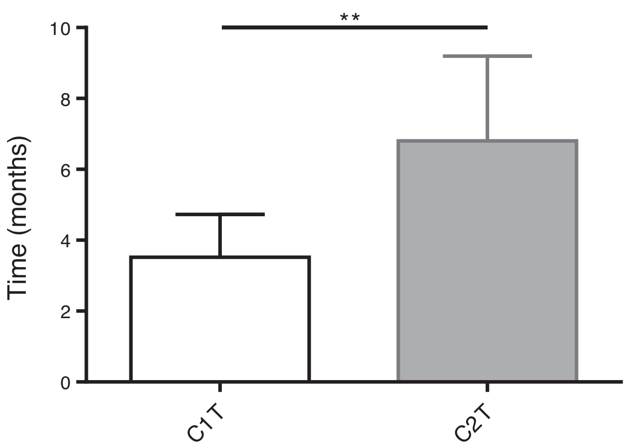

Fig. 7 Comparison of functional recovery time in months in the C1T group ($n_{C1T} = 21$; $M = 3.52$, $\sigma = 1.21$) and in the C2T group ($n_{C2T} = 10$; $M = 6.80$, $\sigma = 2.39$), $t\ (11) = 4.08$, $p = 0.002$, $d = 1.73$. Error bars indicate σ. $^{**}p < 0.01$.

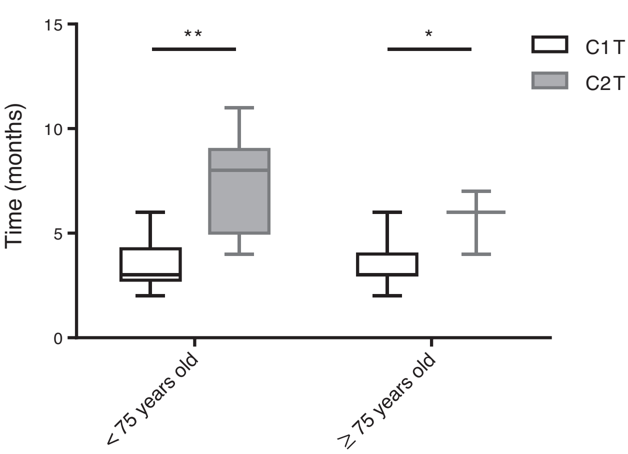

Fig. 8 Comparison of functional recovery time in months in patients aged < 75 years old (C1T group: $n_{C1T} = 10$; median = 3.00; interquartile range (IQR) = 1.50; C2T group: $n_{C2T} = 7$; median = 8.00; IQR = 4.00; $U = 6.00$; $p = 0.004$; $r = 0.69$ and ≥ 75 years old (C1T group: $n_{C1T} = 11$; median = 3.00; IQR = 1.00; C2T group: $n_{C2T} = 3$; median = 6.00; IQR not calculable; $U = 4.00$; $p = 0.046$; $r = 0.53$). Bars represent the maximum and minimum values. $^{*}p < 0.05$; $^{**}p < 0.01$.

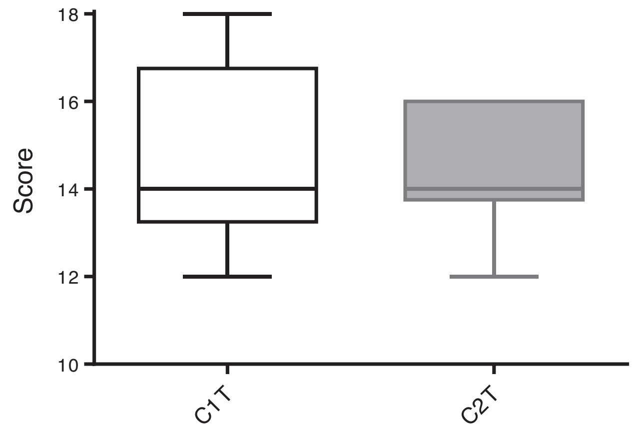

Fig. 9 Merle d'Aubigné-Postel functional (MAPF) score in the C1T group ($n = 20$; median = 14.0, IQR = 4.00) and in the C2T group ($n = 10$; median = 14.0; IQR = 2.00); $U = 92.5$; $p = 0.729$; $r = 0.063$. Cases with no score record were excluded ($n = 7$). Bars represent the maximum and minimum values.

Table 3 Infection-related organisms

Organism	n (%)
Staphylococcus aureus	12 (32.4)
Coagulase-negative *Staphylococci*	11 (29.7)
Polymicrobial infections[a]	7 (18.9)
Gram-negative agents	4 (10.8)
Unidentified organism	3 (8.1)
Total	37 (100)

Note: [a]Including all cases with two or more infectious agents identified, except two cases (*Staphylococcus stimulans* + *S. capitis* and *S. lugdunensis* + *S. capitis*) included in the coagulase-negative *Staphylococci* category.

►**Table 2** shows that most patients were operated on at the site of infection in addition to primary arthroplasty. These patients seemed to present a higher infection risk (►**Figs. 3** and **4**), as, in addition to the risk associated with each surgery, these procedures damage the microvasculature and lead to fibrosis, weakening the local immune response, which may exacerbate an indolent, previously insignificant infection.[12] C2T appeared beneficial in patients who, in addition to primary arthroplasty, have never undergone surgery in the same location. However, there was no superiority associated with any surgery in patients with a previous surgical history at the infected site.

Our data could not find a clear benefit in either type of surgery depending on age (►**Figs. 5** and **6**). Moreover, there was a significant difference between the two groups (►**Table 1**). Some authors argue that age is a risk factor for prosthetic infection, but data is contradictory.[23,25]

►**Fig. 7** shows that C2T resulted in a statistically significant higher functional recovery time than C1T. However, ►**Fig. 8** reveals that the difference in recovery time between the 2 groups is lower for subjects ≥7 5 years old. In addition to the greater confidence in the statistical difference, the effect magnitude is higher for ages < 75 years

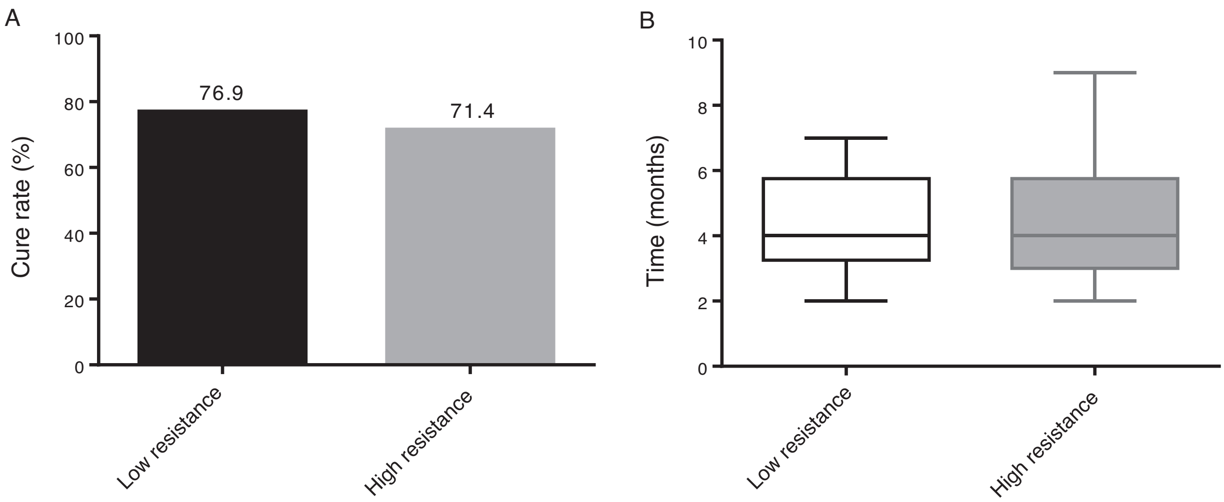

Fig. 10 (**A**) Cure rate in cases of infection caused by low-resistant agents (non-methicillin-resistant Staphylococci, $n = 13$) versus high-resistant agents (methicillin-resistant Staphylococci, Gram-negative, and polymicrobial agents, $n = 21$); $p = 1.000$; two-tailed Fisher exact test; $\varphi = 0.061$. Cases with no organism detection ($n = 3$) were excluded from the analysis. (**B**) Functional recovery time in months in cases of infection caused by low-resistant ($n = 12$; median $= 4.00$; IQR $= 2.50$) versus high-resistant agents ($n = 16$; median $= 4.00$, IQR $= 2.75$); $U = 91.5$; $p = 0.832$; $r = 0.004$. Cases with no recovery time record ($n = 6$) or no organism detection ($n = 3$) were excluded. Bars represent the maximum and minimum values.

old. These data seem to suggest a weakening of the effect of C2T on the recovery time in older subjects (that is, $\geq$ 75 years old). Therefore, there is an apparent advantage in considering the functional recovery time as a treatment choice criterion (C1T versus C2T), especially for ages < 75 years old.

The present study detected no differences in the final functional activity level according to the MAPF score. Other studies reported average scores of 13.1 to 15.4 points after C2T and 13.8 points after C1T.[13,21,26,27] However, none of the studies directly compared the scores between the two types of surgery.

Surgical complications increase the risk of periprosthetic infection. One study related intraoperative fracture in knee arthroplasty with an increased risk of infection.[28] Other studies indicated that intraoperative hemorrhage or hematoma is associated with a greater risk of periprosthetic infection.[3,4] Our data (►**Table 2**) showed an 8% increase in the C2T group compared with the C1T group in the rate of surgical complications, without statistical significance. Therefore, we cannot make an association between the type of surgery and the rate of surgical complications, as previously suggested.[29] However, another study proposed that the risk of complications in C2T will be approximately two times higher than in C1T, with the risk of surgical complications at each C2T stage similar to C1T.[12]

Some authors proposed that Gram-negative agents, multidrug-resistant organisms, and polymicrobial infections lead to worse outcomes.[10,30] However, other studies showed that antimicrobial susceptibility testing results cannot predict the outcome of periprosthetic infection.[9] Therefore, our data do not allow conclusions on the outcome of severe infections.

There was a selection bias since the decision on the type of surgery was not random. The exclusion of patients who did not complete the second stage of surgery probably resulted in a bias favoring C2T.

The nature of the present study does not allow us to determine whether the cases with no infectious agent detection were due to early antibiotic therapy.

The infection diagnostic criteria used (proposed by the American Musculoskeletal Infection Society[7]) do not ensure the avoidance of false-negative and false-positive results. As such, some infection cases included may have corresponded to the simple aseptic detachment of the prosthesis and contamination in the microbiological tests (most frequently by coagulase-negative *Staphylococci*), whereas some cases of true infection may have been excluded.[9,15]

Data regarding functional recovery time are independent of the infection cure, which could be a confounding factor. Furthermore, the pain threshold may vary between younger and older subjects for sociocultural reasons. It is also possible that the functional recovery of younger patients will take longer as they will achieve a higher range of mobility than older subjects. Moreover, there were no preoperative MAPF scores.

Conclusion

Our study shows an advantage in the recovery time in subjects undergoing C1T. However, we cannot draw reliable conclusions comparing the cure rate after C1T and C2T. More studies with a larger sample size (ideally, 3,500 patients[10]) are required, considering risk factors and potential confounder factors.

Financial Support
The present research received no specific funding from public, commercial, or not-for-profit sector agencies.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Illingworth KD, Mihalko WM, Parvizi J, Sculco T, McArthur B, el Bitar Y, Saleh KJ. How to minimize infection and thereby maximize patient outcomes in total joint arthroplasty: a multicenter approach: AAOS exhibit selection. J Bone Joint Surg Am 2013;95(08):e50

2 Pivec R, Johnson AJ, Mears SC, Mont MA. Hip arthroplasty. Lancet 2012;380(9855):1768–1777

3 Baek SH. Identification and preoperative optimization of risk factors to prevent periprosthetic joint infection. World J Orthop 2014;5(03):362–367

4 Del Pozo JL, Patel R. Clinical practice. Infection associated with prosthetic joints. N Engl J Med 2009;361(08):787–794

5 Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ. The epidemiology of revision total hip arthroplasty in the United States. J Bone Joint Surg Am 2009;91(01):128–133

6 Dale H, Fenstad AM, Hallan G, Havelin LI, Furnes O, Overgaard S, et al. Increasing risk of prosthetic joint infection after total hip arthroplasty. Acta Orthop 2012;83(05):449–458

7 Oussedik S, Gould K, Stockley I, Haddad FS. Defining peri-prosthetic infection: do we have a workable gold standard? J Bone Joint Surg Br 2012;94(11):1455–1456

8 Wolf M, Clar H, Friesenbichler J, Schwantzer G, Bernhardt G, Gruber G, et al. Prosthetic joint infection following total hip replacement: results of one-stage versus two-stage exchange. Int Orthop 2014;38(07):1363–1368

9 Zimmerli W, Trampuz A, Ochsner PE. Prosthetic-joint infections. N Engl J Med 2004;351(16):1645–1654

10 Lange J, Troelsen A, Thomsen RW, Søballe K. Chronic infections in hip arthroplasties: comparing risk of reinfection following one-stage and two-stage revision: a systematic review and meta-analysis. Clin Epidemiol 2012;4:57–73

11 Chen SY, Hu CC, Chen CC, Chang YH, Hsieh PH. Two-stage revision arthroplasty for periprosthetic hip infection: Mean follow-up of ten years. BioMed Res Int 2015;2015:345475

12 Hernigou P, Flouzat-Lachianette CH, Jalil R, Uirassu Batista S, Guissou I, Poignard A. Treatment of infected hip arthroplasty. Open Orthop J 2010;4:126–131

13 Bori G, Muñoz-Mahamud E, Cuñé J, Gallart X, Fuster D, Soriano A. One-stage revision arthroplasty using cementless stem for infected hip arthroplasties. J Arthroplasty 2014;29(05):1076–1081

14 Hsieh PH, Huang KC, Lee PC, Lee MS. Two-stage revision of infected hip arthroplasty using an antibiotic-loaded spacer: retrospective comparison between short-term and prolonged antibiotic therapy. J Antimicrob Chemother 2009;64(02):392–397

15 Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al; Infectious Diseases Society of America. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. Clin Infect Dis 2013;56(01):e1–e25

16 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40(05):373–383

17 D'Aubigne RM, Postel M. Functional results of hip arthroplasty with acrylic prosthesis. J Bone Joint Surg Am 1954;36-A(03): 451–475

18 Mahomed NN, Barrett JA, Katz JN, Phillips CB, Losina E, Lew RA, et al. Rates and outcomes of primary and revision total hip replacement in the United States medicare population. J Bone Joint Surg Am 2003;85(01):27–32

19 Bosco JA, Catanzano AJ, Stachel AG, Phillips MSPrince Rainier R Tejada. Expanded gram-negative antimicrobial prophylaxis reduces surgical site infections in hip arthroplasty. J Arthroplasty 2016;31(03):616–621

20 Stockley I, Mockford BJ, Hoad-Reddick A, Norman P. The use of two-stage exchange arthroplasty with depot antibiotics in the absence of long-term antibiotic therapy in infected total hip replacement. J Bone Joint Surg Br 2008;90(02):145–148

21 Hoberg M, Konrads C, Engelien J, Oschmann D, Holder M, Walcher M, et al. Similar outcomes between two-stage revisions for infection and aseptic hip revisions. Int Orthop 2016;40(03):459–464

22 Reina N, Delaunay C, Chiron P, Ramdane N, Hamadouche MSociété française de chirurgie orthopédique et traumatologique. Infection as a cause of primary total hip arthroplasty revision and its predictive factors. Orthop Traumatol Surg Res 2013;99(05):555–561

23 Choong PF, Dowsey MM, Carr D, Daffy J, Stanley P. Risk factors associated with acute hip prosthetic joint infections and outcome of treatment with a rifampinbased regimen. Acta Orthop 2007;78 (06):755–765

24 Kunutsor SK, Whitehouse MR, Blom AW, Beswick ADINFORM Team. Re-infection outcomes following one- and two-stage surgical revision of infected hip prosthesis: A systematic review and meta-analysis. PLoS One 2015;10(09):e0139166

25 Urquhart DM, Hanna FS, Brennan SL, Wluka AE, Leder K, Cameron PA, et al. Incidence and risk factors for deep surgical site infection after primary total hip arthroplasty: a systematic review. J Arthroplasty 2010;25(08):1216–22.e1, 3

26 Liu K, Zheng J, Jin Y, Zhao YQ. Application of temporarily functional antibiotic-containing bone cement prosthesis in revision hip arthroplasty. Eur J Orthop Surg Traumatol 2014;24(01): 51–55

27 Kelm J, Bohrer P, Schmitt E, Anagnostakos K. Treatment of proximal femur infections with antibiotic-loaded cement spacers. Int J Med Sci 2009;6(05):258–264

28 de Dios M, Cordero-Ampuero J. [Risk factors for infection in total knee artrhoplasty, including previously unreported intra-operative fracture and deep venous thrombosis]. Rev Esp Cir Ortop Traumatol 2015;59(01):36–43

29 Gehrke T, Kendoff D. Peri-prosthetic hip infections: in favour of one-stage. Hip Int 2012;22(Suppl 8):S40–S45

30 Joulie D, Girard J, Mares O, Beltrand E, Legout L, Dezèque H, et al. Factors governing the healing of Staphylococcus aureus infections following hip and knee prosthesis implantation: a retrospective study of 95 patients. Orthop Traumatol Surg Res 2011;97(07): 685–692

