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ORIGINAL ARTICLE

# Acute spinal implant infection treated with debridement: does extended antibiotic treatment improve the prognosis?

Pau Bosch-Nicolau[1] · Dolors Rodríguez-Pardo[1,2] · Carles Pigrau[1,2] · Ferran Pellisé[3] · Sleiman Haddad[3] · Mayli Lung[2,4] · Benito Almirante[1,2]

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**Abstract**
The study aims to determine whether 8 weeks of antibiotics is non-inferior to 12 weeks in patients with acute deep spinal implant infection (SII). In the retrospective study of all SII cases (2009–2016), patients aged ≥ 15 years with microbiologically confirmed SII treated with debridement and implant retention were included. Whenever possible, tailored antibiotic treatment was used: rifampin/linezolid in gram-positive and quinolones in gram-negative infection. Patients were divided into short treatment course (8 weeks, ST group) and extended treatment (12 weeks, ET group). Primary outcome measure was percentage of cures at 1-year follow-up. One-hundred-twenty-four patients considered, 48 excluded based on the above criteria, leaving 76 patients, 28 ST and 48 ET. There were no differences in patient age, comorbidities, underlying pathologies, infection location, or surgery characteristics between groups. Surgery-to-debridement time was similar (18.5-day ST vs. 19-day ET; $P = 0.96$). Sixteen SII cases (21.1%) occurred with bloodstream infection. Pathogens found were *Enterobacteriaceae* (35, 46.1%), *Staphylococcus aureus* (29, 38.2%), coagulase-negative staphylococci (12, 15.8%), *Pseudomonas aeruginosa* (12, 15.8%), and *Enterococcus faecalis* (7, 9.2%). Twenty seven (35.5%) had polymicrobial infection. *E. faecalis* was more frequent in the ST group (7, 25% vs. 0; $P < 0.001$), and *P. aeruginosa* in ET (1, 3.6% vs. 11, 22.9%; $P = 0.05$). Five patients died of causes unrelated to SII. At 1-year follow-up, cure rates (21/26 ST, 80.8% vs. 39/45 ET, 86.7%; $P = 0.52$) and recurrences (2/26, 7.7% vs. 2/45, 4.4%; $P = 0.62$) were similar. Eight-week antimicrobial courses were not inferior to 12 weeks in patients with acute deep SII treated with prompt debridement, proper wound healing, and optimized antibiotics.

**Keywords** Spinal infection · Bone infection · Prosthetic joint infections · Antibiotic treatment duration

## Introduction

Spinal implant infection (SII) occurs in 0.7 to 12% of instrumented spinal surgery patients, depending on the complexity of surgery and personal risk factors [1, 2]. The burden of these infections is important in terms of patient morbidity and healthcare resource use and costs [3, 4].

Acute SII infections (i.e., occurring in the first postoperative month) are a particular challenge [5]. Because vertebral fusion has not been attained, it may not be possible to remove the prosthetic material (a basic principle in infections including foreign bodies), and this can be an obstacle to optimal treatment [6]. In this scenario, most authors recommend prompt debridement, saline lavage, antibiotic treatment, and implant retention (DAIR) [7, 8].

There are no clinical trials assessing the duration of antibiotics in acute SII treated with DAIR, and the few related studies report discordant results. In SII treated with a short course (30–40 days) of parenteral or oral antibiotics, Kowalsky et al. reported better results in those receiving subsequent suppressive treatment [9]. Other authors have described 2-year survival rates of 88% and 82.2% in patients treated with prompt

✉ Dolors Rodríguez-Pardo
dolorodriguez@vhebron.net

1 Infectious Diseases Department, University Hospital Vall d'Hebron, Universitat Autónoma de Barcelona, Passeig Vall d'Hebron 119-129, 08035 Barcelona, Spain

2 Red Española de Investigación en Patología Infecciosa (REIPI), Madrid, Spain

3 Orthopaedic Surgery Department (Spinal Unit), University Hospital Vall d'Hebrón, Universitat Autónoma de Barcelona, Barcelona, Spain

4 Microbiology Department, University Hospital Vall d'Hebron, Universitat Autónoma de Barcelona, Barcelona, Spain

surgery and combination antibiotic therapy lasting 12 weeks and 11 weeks, respectively, [10, 11]. However, a 6-week antibiotic regimen yielded outcomes similar to those expected with 12-week antibiotic regimens in a recent non-comparative study [12]. Evidence has also emerged supporting the effectiveness of short antibiotic courses in prosthetic joint infections [13–15].

The aim of this observational study was to determine whether 8 weeks of antibiotic treatment is non-inferior to 12 weeks in patients with acute SII, treated with DAIR.

## Materials and methods

### Study design and inclusion criteria

It is a retrospective cohort study, in which data were collected from all patients ≥ 15 years of age with SII (January 2009–December 2016) in Vall d'Hebron Teaching Hospital (Barcelona, Spain). The same surgical team treated all patients.

Patients fulfilling the following criteria were included: microbiologically confirmed deep SII, with onset within 30 days after the procedure. Devices implanted included titanium rods, plates or screws, and an intervertebral cage in some patients. SII surgical treatment consisted of debridement, saline lavage, and implant retention. Patients were excluded if they had superficial infection, if infection preceded instrumentation, if debridement was not performed, or if the implant was removed.

### Definitions and patient classification

Deep SII was established based on clinical signs and symptoms, and growth of the same bacterium in at least two specimens of bone or tissue surrounding the implant. Coagulase-negative staphylococci (CoNS) and other potential culture contaminants (e.g., *Corynebacterium* spp., *Bacillus* spp., or *Cutibacterium* spp.) were considered true pathogens only when isolated from at least two sterile bone biopsy samples or two or more blood cultures drawn on separate occasions, and, in the case of CoNS, having the same antimicrobial susceptibility. Polymicrobial infections were established when ≥ 2 microorganisms were isolated in the same conditions described above. Blood cultures were considered positive when the same pathogen was isolated in both blood and surgical samples.

We assessed the patients' complete medical and nursing records. Demographic data, comorbidities, clinical presentation, surgical approach, outcome, microbiological data, and antimicrobial therapy were recorded. Comorbidities were collected: renal impairment (baseline creatinine > 1.2 mg/dL), diabetes mellitus treated with insulin or oral hypoglycemic agents, Child B or C cirrhosis, obesity (BMI > 30), and immunosuppressed status (receiving any immunosuppressive agent, chemotherapy, or corticosteroids at doses of > 7.5 mg/day of prednisone or equivalent). We also recorded the underlying condition requiring surgery, the surgical site and approach, transfusion requirements, and whether vertebral cages or bone grafts were used in addition to the main implants. Standard antibiotic prophylaxis was administered with cefazolin or clindamycin plus one dose of gentamycin in patients with known beta-lactam allergy. Patients with known skin or urinary colonization with resistant microorganisms received individualized prophylaxis.

During surgical debridement, the extent of infection was determined and necrotic and infected tissues were excised. The surgical site was washed with pulsed saline and closed on aspirative drains. Antibiotic treatment adapted to the susceptibility of the infective strain was started intravenously during debridement, always by an infectious disease specialist.

During the study period the planned duration of antibiotic therapy was 12 weeks following latest published evidence. Whenever possible, after a minimum of 2 weeks of targeted intravenous therapy, treatment was switched to oral therapy including anti-biofilm agents (rifampin or linezolid in gram-positive and ciprofloxacin in gram-negative isolates). All treatments were prescribed by the same infectious diseases consultant (DP or CP). Close follow-up was ensured in all patients. After 8 weeks, antibiotic treatment was discontinued when appropriate wound healing was observed and the patient presented 1 of the following conditions: poor vascular accesses, outpatient treatment, and lack of alternative oral antibiotic options or poor treatment tolerance (secondary effects or interactions). Based on the total length of antimicrobial therapy, patients were divided into two groups: short treatment course (8 weeks, ST group) and extended treatment (12 weeks, ET group).

### Outcomes

Cure was defined as an absence of clinical signs of infection after a minimum follow-up of 1 year after antibiotic discontinuation. Unrelated death was established when a death with no relation to the infection or its treatment occurred during follow-up. Relapses were defined as reappearance of clinical signs after treatment discontinuation during the first year of follow-up or need for a new surgical debridement more than 2 weeks after the first, with growth of the same microorganism. Reinfections were defined as reappearance of clinical signs after treatment discontinuation during the first year of follow-up or a new debridement requirement more than 2 weeks after the first, with growth of a different microorganism.

### Statistical analysis

Categorical variables are expressed as percentages, and numerical data as the mean ± SD for variables with a normal distribution or the median (IQR) for those with a skewed distribution. Categorical variables were compared with the chi-square test or Fisher exact test, and continuous variables with the Student *t* or the Mann-Whitney *U* test, depending on distribution. All statistical tests were two-tailed, and significance was set at $P < 0.05$. Statistical analyses were performed using SPSS version 20.0 (SPSS, Inc., Chicago, IL, USA).

### Ethics statement

The study was approved by the Ethics Committee of Vall d'Hebron Research Institute and informed consent was waived.

## Results

### Clinical characteristics

From January 2009 to December 2016, 124 cases of SII were diagnosed in patients > 15 years of age. Forty eight were excluded: 28 had late-onset symptoms, 16 superficial wound infections, 2 implant removal, and 2 were not surgically debrided. The ST group contained 28 (36.8%) patients and the ET group 48 (63.2%). Baseline patient characteristics are shown in Table 1. There were no differences between groups in terms of age, sex, or comorbidities, and surgeries were similar, with the exception of more common thoracolumbar spine involvement in the ST group (35.7 vs. 14.6; $P = 0.04$). There were no differences in transfusion or bone graft requirements, whereas vertebral cages were implanted more often in ET (7.1% vs. 27.1%; $P = 0.04$).

### Diagnosis and etiological agents

Infection diagnosis characteristics are detailed in Table 2. Although dehiscence was more frequent as an infection symptom among ST group comparing to ET group (60.7% vs. 33.3%; $P = 0.03$), other clinical manifestations were comparable between both groups. When we analyzed mean interval between implant placement and the infection diagnosis (14.5 ST vs. 13 days ET; $P = 0.8$) time between the index surgery and debridement (19-day ST vs. 19-day ET; $P = 0.96$) or between the infection diagnosis and debridement (4.5-day ST vs. 4-day ET; $P = 0.83$), no differences were observed.

The most commonly isolated microorganisms were *Enterobacteriaceae* (46.1%), associated with other pathogens in 57% of cases (Table 3). *Staphylococcus aureus* was isolated in 29 (38.2%) patients, and mainly alone (72%). CoNS and *Pseudomonas aeruginosa* were found in 12 patients each, mainly in polymicrobial infections (58% and 66%, respectively). All *Enterococcus faecalis* were found in polymicrobial infections, whereas *Cutibacterium acnes* was isolated as a single pathogen in four cases. Comparison of the causal microorganisms between groups showed statistical differences in only two pathogens: all patients with *E. faecalis* were treated with an ST course, and all but one with *P. aeruginosa* were treated with an ET course. Overall, blood cultures were positive in 21.1%, with no differences between groups.

### Treatment and outcomes

ST patients received a median total antibiotic treatment of 8 weeks (7.25-8w) and the ET group, 12 weeks (12-12w). Intravenous cloxacillin followed by levofloxacin and rifampin was preferred for methicillin-susceptible *S. aureus*. In *Enterococcus* spp. infection, intravenous beta-lactams or teicoplanin were sequenced to oral linezolid. In gram-negative infection, intravenous cephalosporins or carbapenems were sequenced to ciprofloxacin or cotrimoxazole. There were no differences between ST and ET in the use of anti-biofilm agents (rifampin, quinolones, or linezolid) as backbone treatment, (69.2% vs. 86.7%; $P = 0.12$).

Overall, mean patient follow-up was 24 months (range 15–24). During this period, five patients (6.6%) died of causes unrelated to the infection. Three had metastatic malignancies, and the intervention was for pain relief or neurologic complications. Another was a 16-year-old boy with cerebral palsy who developed other complications during follow-up. Finally, an 88-year-old woman with several comorbidities died due to heart failure 2 weeks after surgery.

In the patients completing 1-year follow-up, 60/71 (84%) cured: 21/26 (80.8%) in the ST group and 39/45 (86.7%) in ET ($P = 0.51$). There were no statistical differences between ST and ET patients, respectively, regarding relapses (7.7% vs. 4.4%; $P = 0.62$) or reinfections (11.5% vs. 8.9%; $P = 0.7$). Table 4 shows the characteristics of patients failing treatment.

## Discussion

This study addresses the suitability of 8-week antibiotic courses to treat acute deep SII. There is no consensus on optimal treatment duration in early-onset infection in this population, and no related therapeutic guidelines [7]. Current clinical practice is based on a few observational studies [10, 11]. Our results show high cure rates in patients treated with DAIR and tailored antibiotics, with no differences between those receiving shorter or more extended antibiotic courses.

Our series includes a variety of instrumented spinal surgery patients. The most common indication for surgery was degenerative disease, as in most reports [1, 5], followed by

**Table 1** Baseline characteristics of patients with acute spinal implant infection

| | ST (8 weeks), $n = 28$ | ET (12 weeks), $n = 48$ | $P$ value |
|---|---|---|---|
| Sex | | | |
| Female | 16 (57.1%) | 26 (54.2%) | ns |
| Median age, years (IQR) | 60.5 (36–75) | 62.5 (55–71) | ns |
| Comorbidities | | | |
| Obesity, BMI > 30 | 8 (30.8%) | 15 (34.1%) | ns |
| Immunosuppression | 5 (17.9%) | 11 (22.9%) | ns |
| Diabetes mellitus | 3 (10.7%) | 5 (10.4%) | ns |
| Renal insufficiency | 0 | 1 (2.1%) | ns |
| Liver cirrhosis | 0 | 2 (4.2%) | ns |
| Charlson index (IQR) | 2 (0.25–4) | 3 (2–4.75%) | ns |
| Underlying pathology | | | |
| Degenerative | 10 (35.6%) | 21 (43.8%) | ns |
| Deformity[a] | 8 (28.6%) | 13 (27.1%) | ns |
| Fracture | 6 (21.5%) | 7 (14.5%) | ns |
| Malignancy[b] | 4 (14.3%) | 7 (14.6%) | ns |
| Surgical site | | | |
| Cervical | 2 (7.1%) | 4 (8.3%) | ns |
| Dorsal | 4 (14.3%) | 8 (16.7%) | ns |
| Lumbar | 10 (35.7%) | 27 (56.2%) | ns |
| Cervicothoracic | 0 | 2 (4.2%) | ns |
| Thoracolumbar | 10 (35.7%) | 7 (14.6%) | $P = 0.043$ |
| Cervicothoracolumbar | 2 (7.1%) | 0 | ns |
| Surgical approach | | | |
| Anterior | 0 | 2 (4.2%) | ns |
| Posterior | 24 (85.7%) | 44 (91.7%) | ns |
| Double approach | 4 (14.3%) | 2 (4.2%) | ns |
| Other characteristics | | | |
| Blood transfusion[c] | 12 (42.9%) | 16 (33.3%) | ns |
| Bone graft | 16 (57.1%) | 30 (62.5%) | ns |
| Intervertebral cage | 2 (7.1%) | 13 (27.1%) | $P = 0.041$ |

Data are expressed as the number (%), unless otherwise indicated

BMI body mass index, ET extended treatment, IQR interquartile range, ST short treatment

[a] Patients with scoliosis or severe deformities associated with cranial palsy

[b] Including primary tumors or metastatic malignancies

[c] Need for ≥ 1 unit of packed red blood cells

deformity corrections, which usually involve more complex surgeries and longer fusions [8, 16]. These procedures were equally distributed in the two groups. Other risk factors, such as diabetes mellitus, obesity, immunosuppression, blood transfusion requirement, and posterior approach, were also balanced between the groups, indicating a similar baseline risk of infection and decreasing the possibility of selection bias [2, 4, 17–19]. A higher percentage of thoracolumbar surgeries were performed in ST, but lumbar involvement, described as a risk factor for infection [18], was similar in the two groups. Another difference was more frequent use of interbody cages in ET patients, although this material, together with bone allograft, has not been related to a risk infection or relapse [20].

Time from the index surgery to infection diagnosis was 14.5 days in the ST group and 13 days in ET, similar to reported values [6]. As has been extensively described [9], the signs and symptoms included wound exudation in > 70% of patients, followed by fever, back pain, and wound dehiscence. The time from diagnosis to debridement may be crucial for avoiding relapses [21]. Both our groups underwent prompt DAIR in 4 to 4.5 days, an interval similar to that cited by Dubeé et al [10].

Bloodstream infection occurred in 35%, a value in accordance with reported rates [9, 10]. In contrast to most other series, in which *S. aureus* was the main pathogen, *Enterobacteriaceae* predominated in the present study [5,

**Table 2** Infection diagnosis characteristics of patients with acute spinal implant infection

| | ST (8 weeks), $n = 28$ | ET (12 weeks), $n = 48$ | $P$ value |
|---|---|---|---|
| Time from index surgery to debridement, days (IQR) | 19 (14.25–23.75) | 19 (13.25–25.75) | ns |
| Implant to infection diagnosis, days (IQR) | 14.5 (10.25–18.75) | 13 (8.5–20) | ns |
| Infection diagnosis to debridement, days (IQR) | 4.5 (2–6.75) | 4 (2–8) | ns |
| Symptoms | | | |
| Back pain | 10 (35.7%) | 18 (37.5%) | ns |
| Fever | 13 (46.4%) | 20 (41.7%) | ns |
| Discharge | 23 (82.1%) | 35 (72.9%) | $P = 0.03$ |
| Dehiscence | 17 (60.7%) | 16 (33.3%) | ns |
| Fistula | 0 | 1 (2.1%) | ns |

Data are expressed as the number (%), unless otherwise indicated

IQR interquartile range

12, 22]. This may be explained by the older age and mainly lumbar spine involvement of most patients. Other authors have suggested that gram-negative bacteria likely colonize the lumbar skin of older patients who may have urinary catheters, neurogenic bladder, or other factors predisposing to urinary tract colonization [18, 19, 23].

**Table 3** Microbiological agents involved in acute spinal implant infection

| Isolated agent | Total, $n = 76$ | ST (8 weeks), $n = 28$ | ET (12 weeks), $n = 48$ | $P$ value |
|---|---|---|---|---|
| *Staphylococcus aureus* | 29 (38.2%) | 11 (39.3%) | 18 (37.5%) | ns |
| Methicillin-susceptible | 22 (28.9%) | 9 (32.1%) | 13(27.1%) | |
| Methicillin-resistant | 7 (9.2%) | 2 (7.1%) | 5 (10.4%) | |
| *Coagulase-negative* | 12 (15.8%) | 6 (21.4%) | 6 (12.5%) | ns |
| Methicillin-susceptible | 2 (2.6%) | 2 (7.1%) | 0 | |
| Methicillin-resistant | 10 (13.2%) | 4 (14.3%) | 6 (12.5%) | |
| *Streptococcus* spp. | 1 (1.3%) | 0 | 1 (2.1%) | ns |
| *Enterococcus faecalis* | 7 (9.2%) | 7 (25%) | 0 | $P < 0.001$ |
| *Enterobacteriaceae* | 35 (46.1%) | 14 (50%) | 21 (43.8%) | ns |
| *Citrobacter* spp. | 3 (3.9%) | 1 (3.6%) | 2 (4.2%) | |
| *Enterobacter* spp. | 7 (9.2%) | 1 (3.6%) | 6 (12.5%) | |
| *Escherichia coli* | 16 (21.1%) | 10 (35.7%) | 6 (12.5%) | |
| *Proteus mirabilis* | 5 (6.6%) | 1 (3.6%) | 4 (8.3%) | |
| *Klebsiella* spp. | 7 (9.2%) | 2 (7.1%) | 5 (10.4%) | |
| *Morganella morganii* | 2 (2.6%) | 0 | 2 (4.2%) | |
| ESBL-Enterobacteriaceae | 3 (3.9%) | 2 (7.1%) | 1 (2.1%) | |
| *Pseudomonas aeruginosa* FQ-S | 12 (15.8%) | 1 (3.6%) | 11 (22.9%) | $P = 0.046$ |
| *Cutibacterium acnes* | 4 (5.3%) | 2 (7.1%) | 2 (4.2%) | ns |
| Other | | | | |
| *Corynebacterium* spp. | 2 (2.6%) | 1 (3.6%) | 1 (2.1%) | ns |
| *Prevotella* spp. | 1 (1.3% | 0 | 1 (2.1%) | ns |
| *Candida albicans* | 1 (1.3%) | 0 | 1 (2.1%) | ns |
| Polymicrobial[a] | 27 (35.5%) | 10 (35.7%) | 17 (35.4%) | ns |
| Positive blood culture[b] | 16 (21.1%) | 5 (17.9%) | 11 (22.9%) | ns |

Data are expressed as the number (%) unless otherwise indicated

ET extended treatment, ESBL extended-spectrum beta-lactamase, FQ-S fluoroquinolone susceptible, ST short treatment

[a] Polymicrobial: isolation of two or more bacteria from deep samples

[b] Positive blood culture: isolation of the same bacteria in blood as in deep samples

**Table 4** Notable characteristics of the 11 patients with acute spinal implant infection failing treatment

| Patient sex, age | Underlying condition | Time from diagnosis to DAIR, days | First isolated agent | Empirical antibiotic therapy | Adjusted antibiotic therapy | Category of failure | Time from DAIR to failure, weeks | Microorganism at second surgery |
|---|---|---|---|---|---|---|---|---|
| M, 59 | Malignancy | 1 | *K. pneumoniae* | Beta-lactam | Ciprofloxacin | Reinfection | 4 | *MRSA* |
| F, 65 | Deformity | 7 | *MSSA + E. coli* | Cefepime | Levofloxacin + Rifampin | Reinfection | 4 | *Prevotella bivia* |
| F, 71 | Degenerative | 1 | *P. mirabilis + E. cloacae* | Carbapenem | Levofloxacin | Reinfection | 6 | *MRSA* |
| F, 61 | Deformity | 0 | *M. morganii + P. aeruginosa* | Ceftazidime | Ciprofloxacin | Reinfection | 50 | *Bacteroides* sp. |
| M, 55 | Deformity | 2 | *C. freundii + K. pneumoniae* | Carbapenem | Ciprofloxacin | Reinfection | 14 | *MRSA* |
| F, 45 | Deformity | 4 | *CoNS + Corynebacterium* sp. | Vancomycin | Linezolid | Reinfection | 25 | *MRSA* |
| F, 35 | Fracture | 6 | *K. pneumoniae + E. coli* | Beta-lactam | Beta-lactam | Reinfection | 52 | *C. freundii* |
| M, 46 | Malignancy | 16 | *AmpC E. cloacae* | Carbapenem | Ciprofloxacin | Relapse | 8 | *AmpC E. cloacae* |
| F, 61 | Degenerative | 9 | *E. coli* | Ceftriaxone | Ciprofloxacin | Relapse | 12 | *E. coli* |
| F, 76 | Degenerative | 2 | *ESBL E. coli* | Carbapenem | Carbapenem | Relapse | 13 | *ESBL E. coli* |
| F, 68 | Deformity | 10 | *MRSA* | Daptomycin | Cotrimoxazole + Rifampin | Relapse | 48 | *MRSA* |

AmpC AmpC β-lactamase; DAIR debridement, antibiotics, and implant retention; ESBL extended-spectrum beta-lactamase; F female; M male; MRSA methicillin-resistant *Staphylococcus aureus*; MSSA methicillin-susceptible *Staphylococcus aureus*

*S. aureus* was mainly present as a monobacterial infection, and only 9.2% were methicillin-resistant *S. aureus* (MRSA). MRSA is a proposed risk factor for relapse, but this risk has not been observed in hip and knee infections when rifampin is administered [24, 25]. In our series, 35% of infections were polymicrobial. Unlike *S. aureus*, which was mainly found alone, 50% of the gram-negative bacteria isolated were in polymicrobial infections. As has been reported by Dubeé et al. [10], and in contrast to other authors [11], polymicrobial etiology was not related to a higher risk of relapse.

Of note, regarding *P. aeruginosa*, all cases but one involving this microorganism were treated with extended antibiotics, likely because certain *P. aeruginosa* strains are known to produce biofilm and may be difficult to eradicate [26]. Some authors have reported no differences in the outcome of infection due to *P. aeruginosa* compared to that of other microorganisms, in particular when treated with ciprofloxacin [10, 12, 15]. As almost all our *P. aeruginosa* cases received extended therapy, we can provide no conclusions on shorter courses for these infections.

*E. faecalis* was always identified in polymicrobial infections together with other gram-negative bacilli, and all cases were treated with shorter courses. In our experience in prosthetic joint infection (PJI), shorter treatment duration does not usually lead to a less favorable outcome [27]. Of particular note, four patients had acute infection due to *C. acnes*, which is usually described as a slow-growing bacterium causing chronic infection [28]. Nonetheless, other cases of acute infection by *C. acnes* have been described elsewhere [29, 30].

As this is an observational study, the antibiotic treatment regimen was not randomized. ST patients mainly received shorter courses because of intolerance or poor vascular access, with a lack of alternative oral antibiotic options. Hence, after prompt debridement and completion of 8 weeks, treatment was discontinued and patients were closely followed up. There are no studies directly assessing antibiotic courses in acute SII. However, a recent study reported comparable outcomes in patients treated during 6 weeks [12]. Furthermore, there is evidence that shorter antibiotic courses are effective in PJI [12–14]. A multicenter observational study reported similar results in patients with gram-negative PJI treated with DAIR and a short course of antibiotics including ciprofloxacin (for susceptible microorganisms), compared to longer courses [15]. As is recommended, a 2-week tailored intravenous antibiotic regimen followed by an oral antibiofilm antibiotic was used in our patients, whenever possible. Even though the antibiotic schemes varied, more that 70% of patients received anti-biofilm agents, which we believe is a key factor in decreasing treatment duration, together with prompt, accurate debridement.

Cure rates were similar in the two groups, and the overall 84% is comparable to the 71 to 88% of cure rates reported in similar patients [9–11]. Due to the limited sample, we were unable to perform multivariate analysis to identify risk factors for relapse and reinfection.

This is a single-hospital-based study with a small sample, and being retrospective, patients were not randomized treatment. This could imply selection bias in which difficult-to-treat patients and those with optimized treatment were selected to an ST scheme. In addition, our short-course results do not apply to infections caused by *P. aeruginosa*. Despite these limitations, the strength of our study is that patients were followed by a single multidisciplinary team with broad experience in treating these infections.

In conclusion, the results of this study suggest that the antibiotic treatment can be shortened to 8 weeks in patients with acute SII; when prompt DAIR is ensured, a proper wound healing is observed and tailored antibiotics including anti-biofilm agents can be given.

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## Compliance with ethical standards

**Conflicts of interest** The authors declare that they have no conflict of interest.

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