International Orthopaedics
https://doi.org/10.1007/s00264-026-06852-w

RESEARCH

Hofmann articulating spacer vs preformed cement spacer two stage revision in native septic knee arthritis: a comparative study

Luigi Zanna[1] · Gregorio Secci[2] · Francesco Raspanti[1] · Niccolò Giabbani[1] · Matteo Innocenti[2] · Letizia Attala[1] · Marco Mugnaini[1]

Received: 8 April 2026 / Accepted: 12 May 2026

Abstract

Purpose Septic arthritis (SA) of the native knee is a severe and increasingly prevalent condition, particularly among elderly and comorbid patients. When associated with end-stage degenerative joint disease, a two-stage total knee arthroplasty (TKA) with an antibiotic-loaded articulating spacer is commonly adopted. However, evidence directly comparing different spacer designs is limited. The aim of this study was to compare the clinical and functional outcomes of two two-stage strategies: a preformed cement articulating spacer and a Hofmann-type metal-on-polyethylene articulating spacer.

Methods We retrospectively reviewed 15 consecutive patients treated between June 2022 and December 2024 at a tertiary referralcentre. Inclusion criteria were native knee SA with end-stage arthritis managed with planned two-stage TKA and minimum 12-month follow-up. Seven patients received a Hofmann spacer and eight a preformed cement spacer. The primary endpoint was septic failure, defined as recurrent infection requiring surgical intervention; secondary endpoints included functional outcomes (Knee Society Score [KSS], Oxford Knee Score [OKS], Forgotten Joint Score [FJS]), pain (VAS), and range of motion (ROM) during the interstage period and after reimplantation.

Results Mean follow-up was 24.2 months. Infection eradication was comparable between groups, with one reinfection (6.7%) occurring in the cement spacer group ($p = 1$). During the interstage period, the Hofmann group demonstrated significantly superior KSS, OKS, FJS, VAS, and ROM ($p = 0.001$). After reimplantation, functional outcomes remained significantly better in the Hofmann group, with greater ROM and higher patient-reported scores. Two patients in the Hofmann group elected spacer retention due to satisfactory function.

Conclusion Both strategies achieved effective infection control. However, the Hofmann articulating spacer provided superior functional recovery without compromising septic eradication, supporting its use in selected patients with native septic knee arthritis and advanced degeneration.

Keywords Septic knee arthritis · Two-stage total knee arthroplasty · Articulating spacer · Hofmann spacer · Cement spacer

✉ Luigi Zanna
luigizanna90@gmail.com

Gregorio Secci
secci.gregorio@gmail.com

Francesco Raspanti
francesco.raspanti@uslcentro.toscana.it

Niccolò Giabbani
niccolo.giabbani@uslcentro.toscana.it

Matteo Innocenti
matteo.innocenti@unifi.it

Letizia Attala
letizia.attala@uslcentro.toscana.it

Marco Mugnaini
marco1.mugnaini@uslcentro.toscana.it

[1] Department of Orthopaedic and Traumatology, Ospedale Santa Maria Annunziata, Bagno a Ripoli, Florence, Italy

[2] Department of Orthopaedic, Azienda Ospedaliero-Universitaria Careggi, Florence, Italy

Published online: 15 May 2026

Introduction

Septic arthritis (SA) is a microbial infection of the joint space, most frequently involving the knee, accounting for 40% to 50% of reported cases [1, 2]. In Europe, the annual incidence of SA has been estimated to range between four and ten cases per 100.000 individuals [3]. SA incidence has steadily increased in recent decades, with over 54.000 cases identified in hospital data as reported by Rutherford et al. [4]. Overall rates rose by about 43% (from 5.5 to 7.8 per 100.000), with incidence doubling among patients older than 75 years. Although SA is still considered a relatively uncommon condition, these epidemiological trends suggest that its clinical impact may become increasingly relevant in the future. Population ageing appears to play a central role, as older individuals are at substantially higher risk compared with the general population. Alexandersson et al. reported an overall adult incidence of approximately four cases per 100.000 persons per year, rising sharply to 14 per 100.000 among individuals aged 80 years and older [5]. In addition to advanced age, the presence of comorbidities markedly increases susceptibility to SA. Aitkens et al. [6] demonstrated a markedly increased incidence among patients with end-stage renal disease undergoing dialysis, reporting approximately 515 cases per 100.000 persons per year-more than 50-fold higher than that observed in the general population. SA treatment usually begins with arthroscopic or open irrigation and debridement to clear infected material and lower the intra-articular bacterial load. Then, it is combined with appropriate antibiotic therapy to eradicate the infection. However, once infection control has been achieved, orthopedic surgeons are often required to address residual or progressive joint degeneration, either as a consequence of infection-related cartilage and bone damage or due to the progression of pre-existing osteoarthritis [7]. Management of postinfectious knee degeneration is particularly challenging, due to bone loss and deformity. In addition, a history of SA is associated with a periprosthetic joint infection (PJI) rates ranging from 8 to 10%, after TKA [8, 9]. For these reasons, a 2-stage revision, similarly to PJI protocol, may be considered [2]. As for PJI, static and articulating spacers were proposed [7, 10] as a strategy to treat post-septic knee arthritis. Hooper et al. reported that both spacers, static and articulating, were able to treat this complex disease without compromising the survival of the implant [7]. Moreover, articulating spacers allow improved interstage mobility and patient comfort and may also serve as a definitive treatment option without reimplantation in a 1.5-stage protocol [7]. Two major groups of articulating spacers are currently available: Cement-on-cement spacers and Metal-on-polyethylene [11]. Cement-on-Cement may be fabricated manually, formed using molds, or obtained as prefabricated units [11, 12]. Metal-on-polyethylene constructs, also known as Hofmann spacers according to the surgeon who first proposed them [13], consist of a femoral prosthetic component, which can be either newly manufactured or sterilized and reused [14], and a cemented polyethylene tibial component. Regardless of the design, all of these articulating spacers aim to replicate the geometry of a TKA. Despite the similarities between these two types of articulating spacers, they differ in aspects such as cost and the potential for use as a definitive treatment. To date, no studies have directly compared these spacers in the management of native knee SA, representing a clear gap in literature. The aim of this study was to compare the outcomes of two different 2-stage revision strategies for knee SA: preformed cement spacer versus Hofmann-type articulating spacer. The primary endpoint was septic failure, defined as recurrent infection requiring surgical intervention, while the secondary endpoint was the evaluation of functional recovery during the interstage period and after reimplantation. We hypothesized that the use of a Hofmann-type articulating spacer would provide superior functional outcomes without compromising infection control.

Materials and methods

We retrospectively reviewed all consecutive patients surgically treated for native septic arthritis at our tertiary referralcentre between June 2022 and December 2024. Informed consent was obtained from all individual participants, and data were collected and stored in anonymous digital form in accordance with institutional ethical guidelines. All procedures performed in this study were in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Inclusion criteria were confirmed SA of the native knee, radiographic evidence of end-stage degenerative joint disease, treatment with a planned two-stage TKA using either a preformed antibiotic-loaded cement spacer or a Hofmann articulating spacer and minimum follow-up of 12months. Patients with involvement of joints other than the knee, those, without advanced arthritis, treated with debridement alone, and patients with follow-up shorter than 12 months were excluded (Fig. 1). The diagnosis of SA was established based on clinical presentation (pain, swelling, erythema, and limited range of motion), elevated serum inflammatory markers (C-reactive protein [CRP] and erythrocyte sedimentation rate [ESR]), and synovial fluid analysis. All patients underwent preoperative joint aspiration including leukocyte count with differential (white blood cells [WBC] and polymorphonuclear cell percentage [PMN%] and Leucocyte esterase (LE), and microbiological cultures. Intraoperatively, at

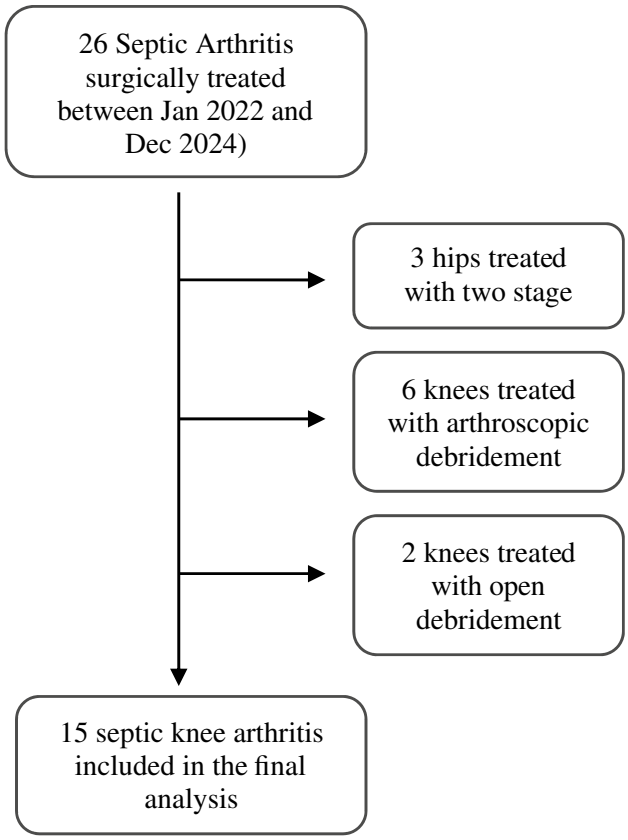

Fig. 1 Study design. This flowchart depicts patient acquisition in the current study, the number of exclusions

least five deep tissue samples were obtained prior to antibiotic administration. Diagnosis was confirmed according to established criteria for native joint septic arthritis [12, 15–17]. All patients were surgically treated with a standard two-stage protocol with either cement preformed spacer or Hofmann (metal on polyethylene) spacer during the first stage. Spacer selection was entirely surgeon-dependent, based on intraoperative technical factors not on patient characteristics. All patients entered a formal two-stage protocol with the a priori intent to proceed to definitive reimplantation. Postoperative antibiotic therapy was administered under infectious disease supervision and tailored to microbiological findings. Antibiotic therapy was continued throughout the interstage period without a planned antibiotic "holiday" prior to reimplantation in accordance with our institutional protocol and the literature [18]. However, comparable outcomes between continuous antibiotic therapy and a planned antibiotic holiday have been reported in the literature [19], and it should be acknowledged that continuous therapy may reduce the sensitivity of intraoperative cultures obtained at second-stage surgery, a recognized tradeoff inherent to this approach [20].

Surgical technique

All procedures were performed by experienced arthroplasty surgeons using a standard medial parapatellar approach. After arthrotomy, extensive synovectomy and radical debridement of all infected and necrotic tissues were performed, including removal of devitalized cartilage and compromised bone. Particular attention was paid to the posterior capsule and medial and lateral recesses. Multiple deep tissue cultures were obtained before antibiotic administration, five to eight [21–25]. In the cement spacer group, a commercially available articulating antibiotic-loaded cement spacer (Vancogenx®) was implanted according to the manufacturer's instructions. Standard distal femoral and proximal tibial bone cuts were performed as in primary TKA. Spacer sizing and positioning aimed to restore limb alignment, maintain joint space, and achieve balanced flexion and extension gaps. Stability was assessed intraoperatively. No additional fixation beyond cement interposition COPAL® G + V (Heraeus, Hanau, Germany), was used. In the Hofmann group, an articulating metal-on-polyethylene spacer was constructed using components of the Vanguard total knee system (Zimmer Biomet, Warsaw, IN, USA), following principles described for articulating spacers in infected arthritic knees. After radical debridement, standard distal femoral and proximal tibial bone cuts were performed as in primary TKA using intramedullary and extramedullary alignment guides. Care was taken to restore mechanical alignment and preserve collateral ligament integrity. On the tibial side, an all-polyethylene insert was cemented directly onto the resected tibial surface without implantation of a definitive tibial baseplate, with COPAL® G + V (Heraeus, Hanau, Germany). Before the implantation a 6.5 mm screw 55 to 65 mm long was fixed in the polyethylene (Fig. 2a), to provide more stability of the implant on the tibial side. On the femoral side, a Vanguard femoral component was cemented using high-dose antibiotic-loaded polymethylmethacrylate (Fig. 2b). During cement polymerization, the knee was gently mobilized to prevent rigid osseous interdigitation and to obtain a stable but removable press-fit interface. The final construct consisted of a metal femoral component articulating against a polyethylene tibial insert embedded in antibiotic-loaded cement (Fig. 2c). This configuration allowed maintenance of soft-tissue tension, preservation of joint mobility during the interstage period, and facilitated spacer removal at the time of reimplantation. Immediately during the first-stage procedure, after sampling of multiple deep tissue cultures, the patients received tailored intravenous antibiotic therapy according to the preoperative antibiogram of the identified microorganism for at least 2 weeks, followed by oral therapy. Antibiotic treatment was continued until the day

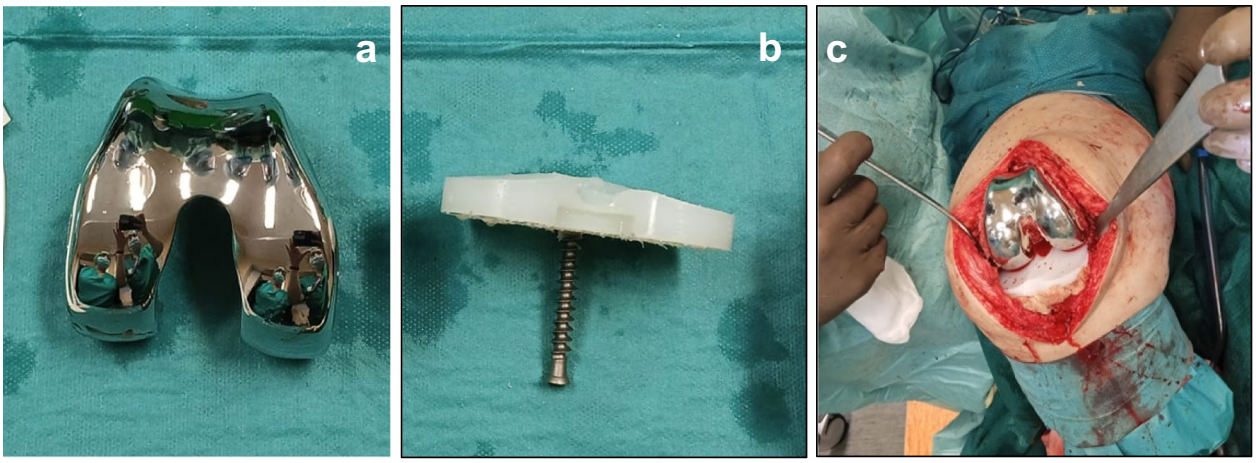

Fig. 2 (**a**) Femoral component of the Hofmann spacer, (**b**) Tibial component of the Hofmann spacer, (**c**) Intraoperative implant

of reimplantation, based on clinical evolution and serial inflammatory marker trends (CRP and ESR). Reimplantation was performed after clinical resolution of infection, satisfactory soft tissue condition, and normalization or significant reduction of inflammatory markers, between ten to twelve weeks after spacer placement. At the second stage, the spacer was removed through the previous approach, repeat synovectomy and multiple tissue samples were obtained, and definitive TKA implantation was performed according to bone loss and ligament stability. After reimplantation, antibiotic therapy was continued for an additional four to six weeks, according to infectious disease specialist indications. Treatment was initially administered intravenously and subsequently transitioned to oral therapy according to microbiological findings, clinical course, and inflammatory marker trends.

Postoperative management

During the interstage period, postoperative rehabilitation protocols differed between groups during the first postoperative month. In the Hofmann spacer group, weight bearing as tolerated with crutches was allowed from the first postoperative day. Unrestricted range of motion (ROM) exercises were encouraged under physiotherapist supervision, without use of a brace. In the preformed cement spacer group, partial weight bearing with crutches was prescribed until the first radiographic control atone month. ROM was limited to 0°−90° using a hinged brace during the early postoperative phase. After the first month, both groups followed equivalent progressive rehabilitation. Crucially, interstage functional assessment was performed at approximately ten to 12 weeks postoperatively immediately before reimplantation. The first outpatient evaluation was scheduled approximately three weeks after surgery for wound assessment, suture removal, review of definitive intraoperative cultures, and adjustment of antibiotic therapy when indicated. A second visit was performed at four to six weeks postoperatively and included clinical examination, radiographic assessment of implant positioning, and laboratory testing. Subsequent evaluations were conducted at approximately three, six, 12, 18, and 24 months after surgery. Clinical and functional outcomes included the Knee Society Score (KSS), Oxford Knee Score (OKS), Forgotten Joint Score (FJS), Visual Analog Scale (VAS) for pain, and ROM were measured with a goniometer. Spacer-related complications during the interstage period and septic and aseptic failures after TKA were recorded. Infection eradication was defined according to Delphi-based consensus criteria [26]. Septic failure was defined as recurrent infection requiring surgical intervention, and aseptic failure as revision for mechanical causes.

Statistical analysis

Statistical analysis was performed using SPSS statistics software version 25.0 for MACINTOSH (IBM, Armonk, NY). The normal distribution was tested with the Kolmogorov–Smirnov's (KS) test. Descriptive statistics (mean, standard deviation, etc.) were used to describe the patients' variables and clinical outcomes. Categorical variables, such as score, and complications were assessed using the Chi-square test or Fisher exact test for statistical significance. Continuous variables, such as KSS, OKS, FJS, VAS and ROM were compared using independent-samples t-test. To quantify the magnitude of between-group differences, effect sizes were calculated as Cohen's d with 95% confidence intervals for all primary interstage outcome measures, using the observed means and standard deviations from the

independent-samples t-test. All outcomes demonstrated large effect sizes (Cohen's d ≥ 2.1) with 95% CI lower bounds exceeding 0.8 (the conventional threshold for a large effect): KSS d = 5.18 [95% CI 2.94–7.41]; OKS d = 5.33 [95% CI 3.05–7.62]; FJS d = 6.45 [95% CI 3.77–9.13]; VAS d = 2.11 [95% CI 0.81–3.41]. Retrospective power exceeded 0.96 for all outcomes. No correction for multiple comparisons was applied, as each comparison was pre-specified and the two-group design does not require post-hoc multiple comparison procedures. *P*-values < 0.05 were considered statistically significant.

Results

According to the inclusion and exclusion criteria, 15 patients were enrolled for the final analysis: seven treated with a Hofmann spacer and eight with a preformed cement spacer. The main cause of infection was joint injection (9/15). No significant differences between the two groups were observed in terms of age, gender, side, Charlson Comorbidity Index (CCI), Body Mass Index (BMI), and cause of SA (Table 1). The mean follow-up after reimplantation was 24.5 months. Diagnostic criteria were comparable between the Hofmann and Cement groups. In synovial fluid analysis, the Hofmann group showed a higher mean white blood cell count (114.380,5 vs. 54.919,7), while PMN percentages were similar (89.9% vs. 89.1%). LE was strongly positive (3 +) in both groups. Fever at the time of diagnosis was observed in two patients in the Hofmann group and three in the cement group. Inflammatory markers were comparable, with CRP levels of 8.23 mg/dL and 8.49 mg/dL, and ESR values of 68.7 and 56.4 in the Hofmann and cement groups, respectively (Table 2). A sinus tract was present in one patient in each group. The distribution of microorganisms is reported in Fig. 3. During the interstage period, one patient in the cement spacer group experienced a dislocation and another reported severe pain until reimplantation; no significant complications were reported in the Hofmann spacer group. All patients in the cement spacer group underwent reimplantation, whereas five out of seven in the Hofmann group did so. Two patients reported a high level of satisfaction and chose to retain the spacers. After reimplantation, no aseptic failures occurred during follow-up, and one (6.7%) acute haematogenous reinfection was observed in the cement spacer group six months after reimplantation, caused by a different microorganism, with no significant difference in infection control between groups ($p = 1$). During the interstage period, patients with the Hofmann spacer reported significantly better functional outcomes in terms of KSS and OKS: 95.43 ± 6.05 vs. 40.12 ± 12.39

Table 2 Diagnostic criteria of the groups

	Hofmann Spacer Group	Cement Spacer Group
Synovial WBC	114380.5	54919.7
Synovial PMN%	89.9%	89.1%
Synovial LE	3 +	3 +
Fever at time of diagnosis	2/7 (28.6%)	3/8 (37.5%)
Blood CRP	8.23	8.49
Blood ESR	68.7	56.4
Sinus Tract	1	1

CRP (C-reactive protein), *ESR* (Erythrocyte sedimentation rate), *WBC* (Synovial white blood cells), *PMN% (*polymorphonuclear cell percentage), *LE* (Leucocyte esterase)

Table 1 Comparison of baseline data, medical data, causes of septic arthritis, spacers complication and postoperative failure between Hofmann spacer group and cement spacer group

	Hofmann Spacer Group	Cement Spacer Group	Total	*P* value
	7	8	15	
Age	66.2	67.9	67.2	0.41
Gender	F 2, M 5	F 3, M 5	F 5, M 10	1
Side	L 3, R 4	L 5, R,3	L 8, R 7	0.62
BMI	24.7	28.15	26.54	0.081
CCI	4.3	4.4	4.36	0.46
Causes of Arthritis	Injection 4, post-traumatic 3	Injection 5, post-traumatic 1, erysipela 2	9 Injection, 4 post-traumatic, 2 erysipela	0.56
Spacer Complications	0	1 dislocation, 1 sever pain	1 dislocation, 1 sever pain	
Reimplanted Patients	5/7 (71.4%)	8/8 (100%)	13	
Septic failure after reimplantation	0/7	1/8 (12.5%)	1/15 (6.7%)	
Follow-up after reimplantation	22.4 ± 6.89	25.7 ± 11.29	24.5 ± 9.97	0.29

F (Female), *M* (Male), *L* (Left), R (Right), *BMI* (Body Mass Index), *CCI* (Charlson Comorbidity Score). Significant values *P* < 05 are shown in italics

Table 3 Inter-stage clinical outcomes and Range of Motion

	Hofmann Spacer Group	Cement Spacer Group	*P* Value
VAS	0.71 ± 0.76	3.75 ± 1.83	*0.001*
KSS	95.43 ± 6.05	40.12 ± 12.39	*0.001*
OKS	44.4 ± 0.90	21.9 ± 5.32	*0.001*
FJS	79.34 ± 5.92	32.9 ± 7.31	*0.001*
ROM Extension	1.43 ± 2.26	6.25 ± 3.31	*0.001*
ROM Flexion	122.1 ± 4.52	68.75 ± 14.31	*0.001*

VAS (Visual Analog Scale), *KSS* (Knee Society Score), *OKS* (Oxford Knee Score), *FJS* (Forgotten Joint Score), ROM (Range of Motion). Significant values *P* <.05 are shown in italics

Table 4 Improvements in functional scores and pain between inter-stage period and after reimplantation (Δ) significantly greater in the cement spacer group than in the Hofmann group

	Hofmann Spacer Group	Cement Spacer group	*P* Value
ΔVAS	- 0.4	−2.25	*0.01*
Δ KSS	+3.8	+36.9	*0.001*
Δ OKS	+2.2	+15.9	*0.001*
Δ FJS	+14.3	+42.5	*0.001*

VAS Visual Analog Scale, *KSS* Knee Society Score, *OKS* Oxford Knee Score, *FJS* Forgotten Joint Score. P<.05 are sho in italics

Table 5 Post-operative clinical outcomes and Range of Motion

	Hofmann Spacer Group	Cement Spacer Group	*P* Value
VAS	0.6 ± 0.9	1.5 ± 0.9	0.06
KSS	97.4 ± 3.6	77 ± 6.2	*0.001*
OKS	46.4 ± 1.1	37.75 ± 5.6	*0.003*
FJS	91.4 ± 6.5	75.6 ± 8.03	*0.003*
ROM Extension	1 ± 2	4.4 ± 2.99	*0.003*
ROM Flexion	129 ± 2.74	104.4 ± 12.61	*0.001*

VAS Visual Analog Scale, *KSS* Knee Society Score, *OKS* Oxford Knee Score, *FJS* Forgotten Joint Score, Range of Motion (ROM) Significant values *P* <.05 are shown in italics

($p = 0.001$) and 44.4 ± 0.9 vs. 21.9 ± 5.32 ($p = 0.001$), respectively, for Hofmann and cement spacers. Furthermore, the Hofmann spacer resulted in lower awareness of the knee during daily activities, as reflected by FJS scores of 79.34 ± 5.92 vs. 32.9 ± 7.31 ($p = 0.001$) in the Hofmann and cement spacer groups, respectively, likely due to friction between cement components during flexion–extension in the cement spacer group. Moreover, pain and ROM were significantly better in patients with the Hofmann spacer. The mean VAS score was significantly lower in the Hofmann group compared to the cement spacer group (0.71 ± 0.76 vs. 3.75 ± 1.83, $p = 0.001$). ROM during the interstage period was also significantly superior in the Hofmann group, with a mean extension deficit of 1.4° ± 2.1° and mean flexion of 122.1° ± 7.3°, compared to 6.2° ± 3.8° and 68.7° ± 15.6° in the cement spacer group, respectively ($p = 0.001$ for both comparisons) (Table 3 and Fig. 4). Improvements in functional scores and pain were significantly greater in the cement spacer group than in the Hofmann group. The delta (Δ) KSS, OKS, FJS, and VAS were + 36.9 vs + 3.8, + 15.9 vs + 2.2, + 42.5 vs + 14.3, and −2.25 vs. −0.4 in the cement and Hofmann spacer groups, respectively (Table 4). However, after reimplantation, the Hofmann spacer group demonstrated significantly better knee functional outcomes, with a mean KSS of 97.4 ± 3.6 vs. 77 ± 6.2 in the cement spacer group ($p = 0.001$), a mean OKS of 46.4 ± 1.1 vs. 37.75 ± 5.6 ($p = 0.003$), and a mean FJS of 91.4 ± 6.5 vs. 75.6 ± 8.03

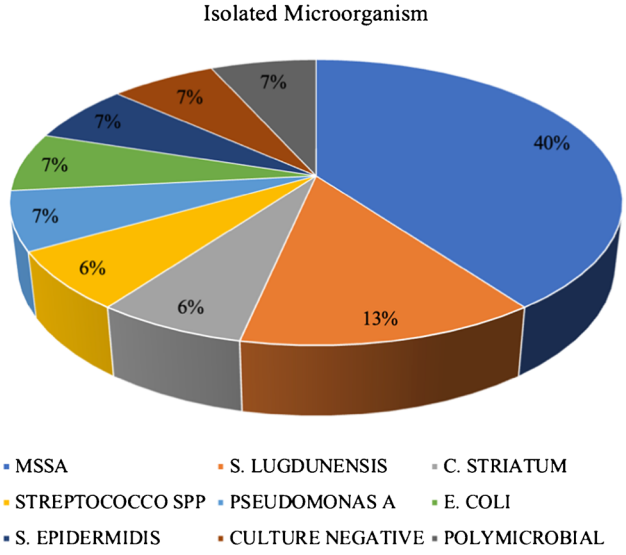

Fig. 3 Distribution of isolated microorganisms. Meticillin-Sensitive Staphylococcus aureus (MSSA)

($p = 0.003$), reflecting improved daily functional ability. These results indicate that the functional advantages of the Hofmann spacer persisted after reimplantation. Comparable VAS values were reported between the groups (0.6 ± 0.9 vs.

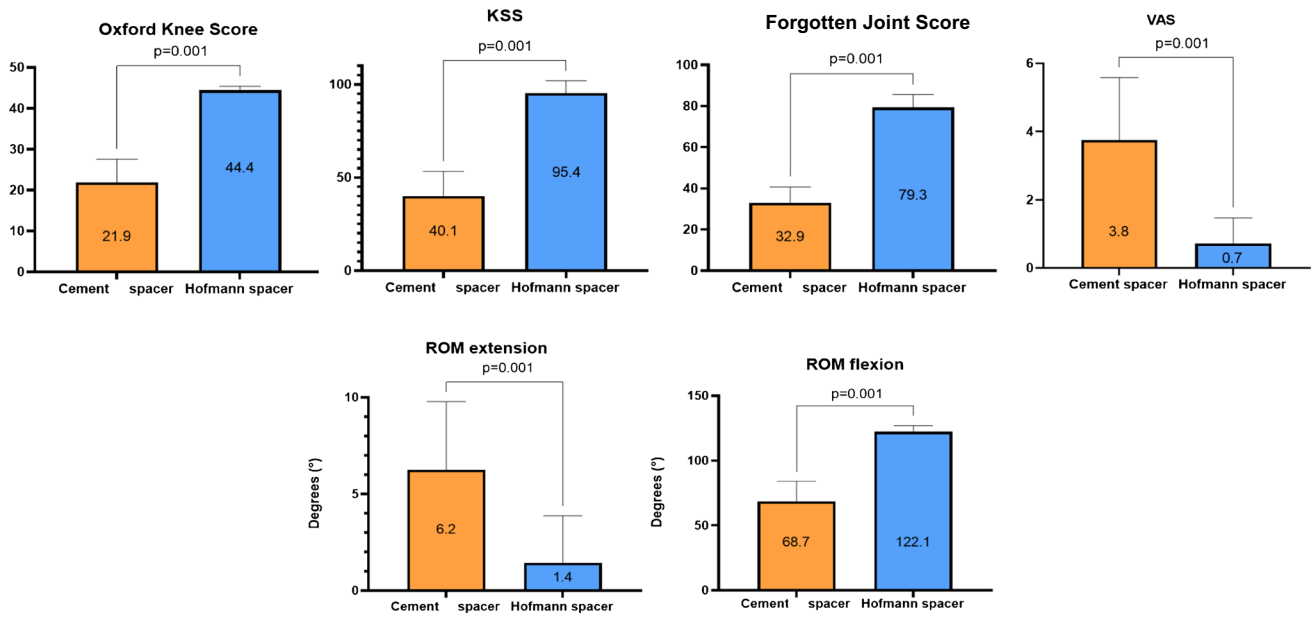

Fig. 4 Comparison of interstage period with spacer of Oxford Knee Score (OKS), Knee Society Score (KSS), Forgotten Joint Score (FJS), Visual Analog Scale (VAS) and Range of Motion (ROM) in both extension and flexion between Cement Spacer Group (orange) and Hofmann Spacer Group (blue). Data are expressed as mean values

1.5 ± 0.9, $p = 0.06$). Following definitive TKA reimplantation, ROM remained significantly superior in the Hofmann group, with a mean extension deficit of $1.0° \pm 2.0°$ and mean flexion of $129.0° \pm 6.5°$, compared to $4.4° \pm 3.2°$ and $104.4° \pm 18.7°$ in the cement spacer group, respectively. Patients in the Hofmann group also reported earlier weight-bearing tolerance and better overall mobility throughout the interstage period (Table 5 and Fig. 5).

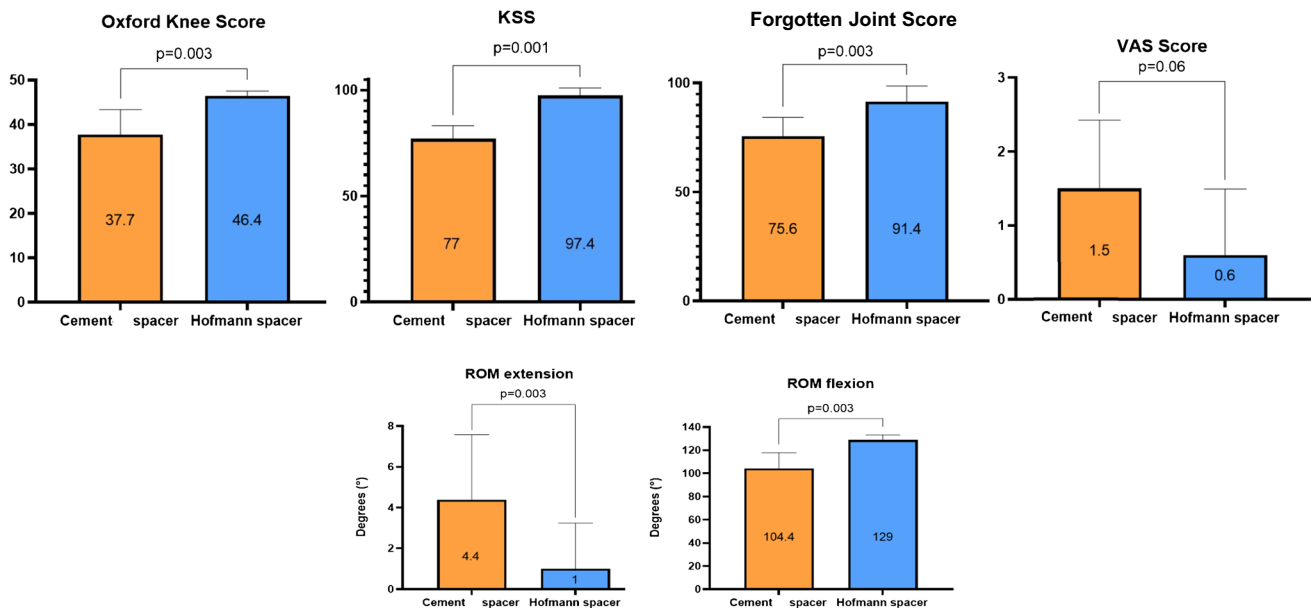

Fig. 5 Comparison of post reimplantation Oxford Knee Score (OKS), Knee Society Score (KSS), Forgotten Joint Score (FJS), Visual Analog Scale (VAS) and Range of Motion (ROM) in both extension and flexion between Cement Spacer Group (orange) and Hofmann Spacer Group (blue). Data are expressed as mean values

Discussion

The present study demonstrates a low overall septic failure rate of 6.7% following staged treatment of native septic knee arthritis associate with joint degenerative disease, confirming the effectiveness of the applied protocol in achieving infection eradication. This rate compares favourably with previously reported failure rates in the literature, which generally range from approximately 5% to 15% for staged arthroplasty procedures performed for native septic knee arthritis [27–30]. Within this context, the use of an articulating Hofmann-type spacer provided clear functional advantages over a dynamic preformed cement spacer, without negatively affecting infection control. Patients treated with the Hofmann spacer achieved superior knee function, lower pain levels, and greater ROM during the interstage period, and these benefits were largely maintained following definitive TKA. These findings are clinically relevant in the context of septic arthritis of the native knee, where maintaining joint mobility while ensuring infection control remains a major therapeutic challenge. An important characteristic of our cohort is that this study represents a specific clinical phenotype of native septic arthritis arising in patients with advanced osteoarthritis who had received intra-articular injections as part of conservative management. The disproportionate representation of injection-related SA in our series (9/15, 60%) reflects the referral pattern of our center, and stands in contrast with the broader literature on native septic arthritis, where haematogenous spread remains the predominant mechanism of infection, accounting for the majority of cases across general populations [3]. In this subgroup, direct inoculation of skin flora differs substantially from haematogenous SA, where Gram-negative and polymicrobial infections are more prevalent. This microbiological profile, dominated in our series by MSSA, *S. epidermidis*, is consistent with previously described injection-related SA cohorts [31–33]. Our findings should therefore be interpreted within this specific context and may not be directly generalizable to haematogenous, post-traumatic, or Gram-negative dominant SA populations. Infection eradication rates in the present series were high and comparable between the two spacer designs, with no statistically significant difference in septic failure. Only one reinfection was observed, occurring as an acute haematogenous event in the preformed cement spacer group and caused by a different pathogen. This finding is consistent with the literature, which suggests that reinfection after staged arthroplasty is more strongly associated with host-related factors and secondary bacteremia than with spacer design. Pietsch et al. [34] reported complete infection control using articulating spacers in infected arthritic knees, while Shaikh et al. [12] similarly observed no recurrent infections after reimplantation when an aggressive debridement and targeted antibiotic regimen were employed. More recent data from Ozdemir et al. [2] confirmed that functional articulating spacers do not increase reinfection risk compared with other spacer constructs, reinforcing the concept that controlled joint motion does not compromise septic eradication when surgical principles are respected. The most relevant differences between spacer types emerged during the interstage period. Despite being classified as dynamic devices, preformed cement spacers provided inferior functional outcomes compared with the Hofmann articulating spacer. Patients treated with the Hofmann spacer demonstrated significantly better clinical and patient-reported outcomes, including higher KSS, OKS, FJS, improved pain control, and substantially greater ROM. These findings are consistent with prior reports emphasizing that true articulating spacers better preserve soft-tissue balance and knee kinematics than cement-on-cement or semi-constrained dynamic spacers [35, 36]. Pietsch et al. [34] highlighted that metal-on-polyethylene articulating spacers allow more physiological motion and facilitate earlier mobilization, whereas preformed cement spacers, although permitting limited movement, often fail to reproduce normal knee mechanics. Ozdemir et al. [2] similarly discussed that functional articulating spacers provide superior interstage mobility and patient satisfaction compared with cement-based constructs, which may still be associated with pain, limited flexion, and mechanical issues. In the present study, mechanical complications such as spacer dislocation were observed only in the preformed cement spacer group, supporting previous observations that cement-based dynamic spacers may offer less intrinsic stability and kinematic reliability than true articulating designs [34, 36–38]. After definitive TKA reimplantation, patients previously managed with Hofmann articulating spacers continued to demonstrate superior functional outcomes and greater ROM compared with those treated with preformed cement spacers. These results support the concept that preserving joint motion and soft-tissue integrity during the interstage period positively influences postoperative recovery. Shaikh et al. [12] and Ni et al. [39] both reported that patients with better interstage mobility achieved improved final functional outcomes after reimplantation. Although, in our cohort, the absolute improvement from interstage to post-reimplantation was greater in the preformed cement spacer group, this likely reflects poorer interstage baseline function rather than superior final recovery. A further explanation lies in the ceiling effect of the outcome instruments: patients in the Hofmann group entered the post-reimplantation phase with near-optimal interstage scores (mean OKS 44.4/48; mean FJS 79.3/100), leaving limited arithmetical room for further improvement. The larger delta scores in the cement spacer group therefore represent catch-up recovery from a substantially lower baseline, not evidence of inferior outcomes in the Hofmann group. An additional and increasingly relevant finding of the present study is the feasibility of spacer retention as

a definitive or semi-definitive solution, supporting a 1.5-stage, patient-tailored treatment strategy. Two patients treated with the Hofmann spacer elected not to undergo reimplantation due to satisfactory pain relief and functional performance. This observation aligns with the discussion by Ozdemir et al. [2], who reported that a substantial proportion of patients with functional articulating spacers for native septic knee arthritis retained their spacers long term without increased infection risk [23]. Similar considerations have been raised in the periprosthetic joint infection literature [40, 41], where articulating spacers have been retained in elderly, low-demand, or medically fragile patients to reduce surgical burden while maintaining acceptable function and infection control [42]. These findings support a shift toward individualized treatment algorithms rather than rigid staging protocols. The decision to proceed with reimplantation should account for patient age, comorbidity burden, functional demand, and expectations, rather than being dictated solely by traditional two-stage principles. In this context, true articulating spacers should not be regarded merely as temporary devices, but as flexible tools that may serve as long-term solutions in carefully selected patients. This study has limitations. Its retrospective, non-randomized design and limited sample size (n = 15) reduce statistical power and introduce potential selection bias. Spacer selection was surgeon-dependent and not patient-driven, but residual confounding cannot be excluded without randomization; propensity score analysis was not feasible. Critically, rehabilitation differed between groups during the first postoperative month, representing a confounding variable that cannot be fully disentangled from the spacer design effect, even though interstage assessment was at 10 weeks after restrictions had resolved. No multiplicity correction was applied; all findings are hypothesis-generating. The predominance of injection-related SA (60%) reflects the specific phenotype studied and may limit generalizability to hematogenous SA populations. The lack of randomization introduces potential selection bias, and microbiological heterogeneity may have influenced outcomes. Nevertheless, these findings provide meaningful clinical insight into the advantages of true articulating spacers over preformed cement dynamic spacers and support a patient-centered, function-preserving approach in the management of chronic native septic knee arthritis.

Conclusion

Both approaches achieved high infection eradication, but the Hofmann articulating spacer provided significantly superior functional recovery, ROM, and patient-reported outcomes, including KSS, OKS and FJS, during both interstage period and after reimplantation. These findings support its use as a reliable option in selected patients with native septic knee arthritis and severe joint degeneration.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00264-026-06852-w.

Author contributions L.Z., G.S. and F.R made both the conception and the design of the work and drafted the first version of the manuscript. M.I. and N.G. contributed to the acquisition, analysis, or interpretation of data. L.A. and M.M. revised the final version of the work. Each author made substantial contributions to the design of the work as well as to the acquisition of data. All authors also substantively revised the work and approved the submitted version (and any substantially modified version that involves the author's contribution to the study), and agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even those in which the author was not personally involved, are appropriately investigated and resolved, and the resolution documented in literature. All authors read and approved the final manuscript.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

Data availability All data are available in the main text and tables. Additional information can be provided if solicited.

Declarations

Competing interests The authors declare no competing interests.

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