ARTHROPLASTY
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Original Research

Articulating vs Static Spacers for Native Knee Infection in the Setting of Degenerative Joint Disease

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ABSTRACT

Background: Patients with advanced knee arthritis who develop a septic joint are not adequately treated with irrigation and debridement and intravenous antibiotics because of antecedent cartilage damage. The gold standard treatment has been a 2-stage approach. The periprosthetic joint infection literature has demonstrated the superiority of articulating spacers, and metal-on-poly (MOP) spacers are being used with increasing frequency. The purpose of this study was to compare the postoperative outcomes of patients with infected, arthritic knees treated by a 2-stage approach to those of patients who received single-stage treatment with a MOP spacer.
Methods: Sixteen patients with native knee septic arthritis treated with an antibiotic spacer between 1998 and 2019 were reviewed. Demographic data, clinical data, knee motion, Knee Society score, Timed-Up-and-Go, and pain scores were collected. Survivorship of final implants was compared.
Results: Six of 16 knees (38%) received single-stage treatment, and 10 received 2-stage treatment (62%). Five of 6 MOP spacers (83%) were retained at a mean follow-up of 3 ± 1.2 years. Nine of 10 (90%) receiving static spacers had subsequent reconstruction, with 9 (100%) surviving at mean follow-up of 7 ± 3.2 years. The patients who received MOP spacers trended toward greater terminal flexion, higher Knee Society score, and faster Timed-Up-and-Go at final follow-up.
Conclusion: Infection in a native, arthritic knee may be effectively treated using single-stage MOP spacer. Postoperative outcomes of single-stage MOP spacers compare favorably to staged static spacers and with those undergoing revision surgery for other indications. Longer follow-up is needed to evaluate durability of MOP spacers.
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Introduction

Septic arthritis is an orthopedic emergency requiring prompt treatment because of the potential for serious morbidity and mortality [1-4]. The mainstay of treatment for patients with healthy joints before infection is timely irrigation and debridement of the joint followed by targeted intravenous antibiotics with the goals of infection eradication and cartilage preservation.

For patients with advanced knee arthritis who develop a septic joint, however, a surgical irrigation and debridement and intravenous antibiotics may adequately address the infection, but not their antecedent pain and deformity. This patient group often has a difficult course because of pre-existing medical comorbidities and the substantial pain and disability associated with accelerated joint degeneration [5,6].

Once the infection is adequately treated, these patients continue to be a clinical conundrum. Postinfectious joint degeneration may be associated with severe deformity, increasing the complexity of a future arthroplasty. These patients are also at an increased risk for periprosthetic joint infection (PJI) after primary arthroplasty with studies demonstrating an 8%-10% infection rate in this patient population [7-9].

Treatment with a static antibiotic spacer and staged knee arthroplasty is effective [10-13]. The PJI literature has demonstrated articulating spacers to be superior [14,15] and supports using articulating spacers whenever the remaining bone and soft tissue allow. The use of single-stage metal-on-poly (MOP), or functional

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prosthetic, spacers for PJI has become more common with encouraging results [15,16], yet there are no reports of this technique used to treat septic native arthritic knees. We present outcomes of patients treated with a one-stage functional prosthetic spacer compared with those who received a two-stage treatment.

Material and methods

After obtaining institutional review board approval, an institutional database was queried to identify patients with infected, arthritic knees who were treated with placement of an antibiotic prosthesis between 1998 and 2019 at an academic, tertiary care medical center. Initial procedure of "placement of antibiotic spacer, knee" was used as the search criteria. Thorough analysis of each patient's medical records and radiographs was performed to rule out other diagnoses and procedures. In all, 16 of the originally identified 600 patients were included; the other 584 patients represented patients who underwent explant and spacer placement for PJI after primary total knee arthroplasty (TKA) performed at an outside institution. The clinical records were retrospectively reviewed for demographic information, infection details, antibiotic

treatment, complications, reoperations, revisions, and clinical outcomes. Clinical outcome scores were measured using Knee Society scores (KSS), Timed-Up-and-Go (TUG), visual analog score (VAS) for pain, and range of motion at final follow-up.

Sixteen patients met inclusion criteria: 5 females (31%) and 11 males (69%), with a mean age of 64.2 ± 11.3 years and a mean body mass index of 26.3 ± 3.8 kg/m^2 (Table 1 and 2). A comparison of comorbidity burden between the 2 groups can be found in Figure 1. To better stratify the overall health, limb status, and comorbidities, the patients were given scores based on the McPherson classification system with 2 (13%) grade II infections and 14 (87%) grade III infection (Table 3) [17]. Eight (50%) were grade A hosts, 6 (38%) were grade B hosts, and 2 (14%) patients were grade C hosts. One (6%) patient was extremity grade 1, 10 (63%) were extremity grade 2, and 5 (31%) were extremity grade 3.

The identified patients were treated by one of 2 methods: a two-stage protocol with a static antibiotic spacer followed by TKA vs formal arthrodesis, or a single-stage protocol with a functional prosthetic spacer. Surgeries were performed by one of 3 surgeons fellowship-trained in hip and knee arthroplasty (two-stage: J.I.H., S.B.G.; one-stage: D.F.A.). Spacer type was chosen by surgeon

Table 1
Demographic data.

Patient	Laterality	Sex	Age	BMI	Surgical/infectious history
1	Left	Male	75	22.7	• Femur and tibia fractures 1992 MCA s/p partial removal of tibial hardware • 2017 *Staphylococcus aureus* infection s/p removal of femur IMN and IV antibiotics
2	Left	Male	71	27.5	• May 2018 CS injection into knee • June 2018 aspiration: *Streptococcus viridens* • June 2018 arthroscopic irrigation and debridement, PO keflex
3	Left	Male	63	26.6	• Longstanding history of erosive arthritis • Acute development of swelling, pain, and elevated inflammatory markers
4	Left	Male	48	21.2	• Diagnosed with disseminated coccidioidomycosis • Episodic painful effusions since 2003
5	Right	Male	49	20.1	• August 2008: knee arthroscopy c/b persistent pain and effusion • February 2009: distal femur/proximal tibia osteomyelitis, septic arthritis diagnosed by aspiration
6	Left	Female	60	25.8	• August 2009: tibial plateau fracture s/p ORIF • October 2011: I&D and removal of hardware • Recurrent effusion and lab abnormalities
7	Left	Female	55	34.1	• April 2009: MRSA bacteremia during admission for ARDS • July 2009: multiple operative I&D left knee • August-October 2009: multiple operative I&D left knee • December 2009: diagnosed with postinfectious inflammatory arthropathy, abx discontinued • October 2011: repeat operative I&D for osteomyelitis proximal tibia and distal femur
8	Right	Male	73	27.4	• May 2009: right knee arthroscopy, open right fibular procedure • July 2011: admitted for septic shock
9	Right	Female	62	28.3	• January 2008: right knee arthroscopy • April 2008: right knee arthroscopy aborted "tibial erosions"" seen, cx MSSA
10	Right	Female	85	25.4	• 2007: right tibial plateau fracture s/p ORIF • May 2010: worsening knee pain, hardware prominence • June 2010: I&D right knee, ROH • September 2010: right knee acute swelling, aspiration cx MSSA
11	Left	Male	71	21.5	• 1965: knee dislocation with multiligamentous injury, distal 1/3 tibial shaft fracture treated nonop, subsequent posttraumatic arthritis • April 2016: I&D of native knee
12	Left	Female	59	29.0	• 2000: ACL, MCL, medial meniscus injury • 2001: ACL reconstruction • 2002: Revision ACL • 2003: Removal of hardware • Progressive instability, intermittent swelling
13	Left	Male	67	22.4	• April 2016: CS injection in Belize • April 2016: I&D left knee via small medial and lateral arthrotomies (Belize) • April 2016: arthroscopic I&D (USA) ×2 • Developed draining sinus, unable to bear weight
14	Left	Male	42	31.6	• Multiple remote knee arthroscopy • Presented to ED with fever, swelling, pain ×4 days
15	Right	Male	77	26.9	• 2015-2016: Multiple right knee arthroscopic and open I&Ds without resolution of symptoms
16	Right	Male	70	30.3	• April 2015: native knee septic arthritis s/p I&D ×2 • June 2015: repeat knee I&D

ACL, anterior cruciate ligament; ARDS, acute respiratory distress syndrome; BMI, body mass index; c/b, complicated/by; CS, corticosteroid; ED, emergency department; I&D, irrigation and debridement; IMN, intramedullary nail; IV, intravenous; MCA, motorcycle accident; MCL, medial collateral ligament; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; ORIF, open reduction internal fixation; PO, per oral; ROH, removal of hardware; s/p, status/post.

Table 2
Infectious data.

Patient	Known organism	Prespacer antibiotics	Date of surgery	Spacer type	OR cultures	Postspacer antibiotics	Treatment duration	Infection recurrence	Chronic oral suppression
1	MRSA	IV cefazolin	11/3/17	Static	No growth	PO cephalexin	14 d	No	None
2	Streptococcus viridens	PO cephalexin	9/28/18	Static	No growth	IV vancomycin	42 d	No	None
3	NA	None	9/22/19	Static	MRSA	IV vancomycin	15 d	No	None
						PO doxycycline	23 d		
						PO trimethoprim/ sulfamethoxazole	3 d		
						PO clindamycin	33 d		
4	Coccidioides	PO fluconazole	10/28/10	Static	Coccidioides	PO fluconazole	25 d	No	Yes[a]
						PO itraconazole	42 d		
						PO fluconazole	258 d		
5	MSSA	PO trimethoprim/ sulfamethoxazole	3/4/09	Static	MSSA	IV vancomycin	1 d	No	None
						IV nafcillin	63 d		
						IV vancomycin/IV zosyn	4 d		
						IV daptomycin	60 d		
6	Staphylococcus lugdunensis	PO cephalexin	3/22/12	Static	Staphylococcus lugdunensis	IV ceftaroline/IV zosyn[b]	61 d[b]	No	None
7	Oct 2011: Staphylococcus epidermidis	2009: IV vancomycin 2011: IV Daptomycin and PO rifampin	4/4/12	Static	No growth	IV daptomycin	73 d	No	None
						PO trimethoprim/ sulfamethoxazole	50 d		
8	NA	None	1/12/12	Static	No growth	IV daptomycin/PO ciprofloxacin	22 d	No	None
						IV ceftaroline	91 d		
9	MSSA	IV vancomycin PO Bactrim	12/23/08	Static	No growth	IV vancomycin/IV zosyn	3 d	No	None
						IV cefazolin/PO rifampin	43 d		
10	MSSA	IV vancomycin/IV nafcillin/IV cefazolin	9/10/10	Static	MSSA	IV vancomycin	76 d	No	None
11	Group C/G Streptococcus	None	5/13/16	Functional prosthetic	No growth	IV ceftriaxone	54 d	No	None
12	NA	None	11/3/16	Functional prosthetic	No growth	IV vancomycin/IV zosyn	20 d	No	None
13	Enterobacter cloacae	IV ertapenem/PO ciprofloxacin	5/24/16	Functional prosthetic	No growth	IV ertapenem	42 d	No	None
14	Group B Streptococcus	None	6/22/19	Functional prosthetic	No growth	IV ceftriaxone	33 d	No	None
						PO clindamycin	11 d		
						IV cefazolin	3 d		
15	MSSA	IV cefazolin	8/15/16	Functional prosthetic	Coagulase negative Staphylococcus[c]	IV vancomycin[c]	36 d[c]	Yes	None
						IV daptomycin[c]	14 d[c]		
16	MRSA	IV vancomycin	10/1/15	Functional prosthetic	No growth	IV vancomycin	42 d	No	None

IV, intravenous; MRSA, methicillin-resistant Staphylococcus aureus; MSSA, methicillin-sensitive Staphylococcus aureus; NA, not available; PO, per oral; OR, operating room.

[a] On chronic oral fluconazole for disseminated coccidioidomycosis before placement of knee spacer.

[b] Antibiotic therapy after static spacer exchange.

[c] Culture result and antibiotic therapy after conversion of functional prosthetic to static spacer.
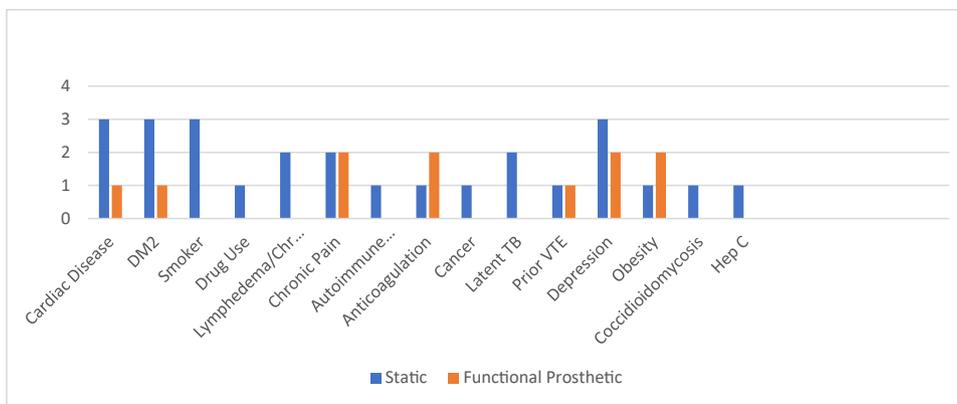
Figure 1. Comparison of comorbidity burden by spacer type demonstrating higher overall prevalence of medical comorbidities.

preference. Ten (63%) patients received 2-stage treatment consisting of thorough irrigation and debridement, distal femur and proximal tibial bone resection, and placement of a static antibiotic cement spacer. Patients were kept toe touch-weight-bearing while the static spacer was in place. Six (38%) patients received one-stage treatment, consisting of irrigation and debridement, primary TKA bone cuts, and implantation of a functional prosthetic spacer: a cobalt chrome primary TKA femoral component and an all-poly tibial component (Triathlon knee system; Stryker, Mahwah, NJ). TKA components were cemented according to pressurized third-generation cement technique. No additional hardware was used to augment the spacer fixation. For all patients, each bag of cement was augmented by organism-specific antibiotic agents or broad-spectrum antibiotics. The ratio of antibiotics to cement was chosen according to surgeon preference and was not standardized among the 3 surgeons. Survivorship was compared for the two-stage and one-stage procedures. Endpoints were defined as unplanned return to the operating room for any reason related to the affected joint and recurrence of infection as defined according to the 2018 Musculoskeletal Infection Society Guidelines [18].

Continuous data are presented as mean and standard deviation. Categorical data are presented as number and percent. Kaplan-Meier survivorship curves were constructed to estimate the survivorship free of revision or reoperation [19]. To estimate survivorship at 1 and 3 years, 95% confidence intervals (CI) were added. Statistical significance was set at a *P* value of .05.

Table 3
McPherson patient classification

Patient	Infection grade	Host grade	Extremity grade
1	III	A	C
2	III	A	B
3	II	B	B
4	III	C	B
5	III	A	B
6	III	B	C
7	III	B	B
8	III	B	B
9	III	B	B
10	III	B	C
11	III	A	B
12	III	A	C
13	III	A	C
14	II	A	A
15	III	A	B
16	III	C	B

Results

One patient (6%) was infected with a fungal organism. Twelve patients (75%) had bacterial organisms diagnosed before spacer placement; of these 12, 10 received prior antibiotic therapy (83%). Nine patients (56%) never had growth of any organism from operating room cultures at the time of spacer placement. Two patients (13%) never had an organism identified at any point in their clinical course, including aspirations and operative cultures from procedures before spacer placement. One patient (6%) had a different organism identified at the time of spacer placement compared with what was identified at the time of prior unsuccessful debridement at an outside facility. Of the patients with identified bacteria, 2 had methicillin-sensitive *Staphylococcus aureus* (13%), one had methicillin-resistant *Staphylococcus aureus* (6%), one had group B *Streptococcus* (6%), and one had group C/G *Streptococcus* (6%; Table 2).

Fourteen patients (88%) were treated with intravenous antibiotics after spacer placement. One patient received an oral antibiotic (6%), and one received an oral antifungal agent (6%). Therapy was directed by an infectious disease fellowship-trained physician (S.K.). One patient (6%) resumed his chronic suppressive therapy for disseminated coccidioidomycosis after second-stage surgery. No additional patients were placed on long-term oral antibiotic suppression therapy (Table 2).

In the static spacer group, one patient (10%) never had a second-stage procedure. The survivorship free of any revision was 100% (CI: 100%-100%) for the 9 (90%) patients who went on to second-stage surgery at both 1 and 3 years. No patient has required reoperation at mean follow-up 7 ± 3.2 years (Fig. 2). Of those who have had second-stage procedures, 3 (33%) underwent arthrodesis, and 6 (67%) went on to the second-stage TKA at mean 159 days after the index surgery. The 3 patients who received arthrodesis had extensive bone and/or soft tissue deficiencies identified during spacer placement. No patient had a static spacer dislodge. Of those 3 patients, one was noted to have an extensor mechanism disruption at the time of initial spacer placement. This patient and one other both had a prior history of periarticular trauma about the knee and associated bone loss. The third patient had disseminated coccidioidomycosis affecting the knee and longstanding bone and soft tissue destruction before spacer placement. One patient who ultimately received the second-stage required repeat irrigation and debridement and spacer exchange; at the time of initially planned reimplantation, the tissue appearance was concerning for persistent infection, and the decision was made intraoperatively to abort the planned reimplantation. Of the 6 patients who went on to the second stage, one (17%) received primary posterior-stabilized implants (Zimmer-Biomet, Warsaw, IN). The rest
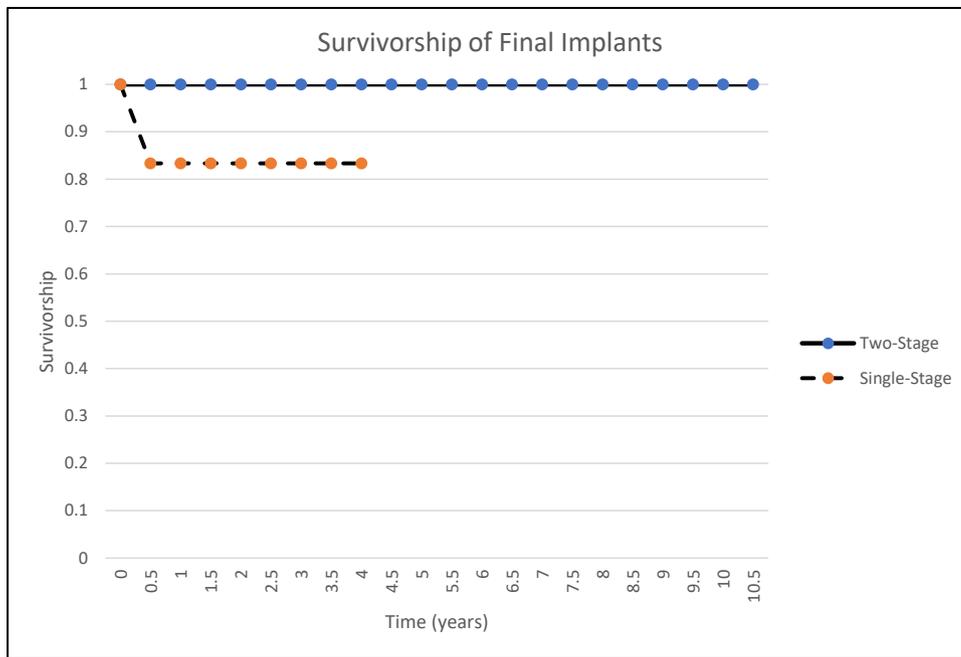
Figure 2. Survivorship curve of final implants in both cohorts demonstrating 100% survivorship of the second stage and arthrodesis at final follow-up and 86% survivorship of single-stage functional prosthetic spacers at final follow-up.

(83%) received stemmed implants with varus-valgus constraint (LCCK; Zimmer-Biomet, Warsaw, IN).

The patient (10%) in the 2-stage group who never had a second procedure developed PJI in the contralateral knee with a draining sinus and extensor mechanism disruption. This patient also has significant bilateral lower extremity weakness due to cervical spinal cord compression. Further treatment of the knee with the primary static spacer has been deferred in light of this complicated situation.

In the group that received one-stage functional prosthetic spacers, the survivorship free of any revision was 83% (CI: 82%-89%) at both 1 and 3 years (Fig. 2). The one patient (17%) who required additional surgery had persistent drainage after functional spacer placement. This patient was taken back to the operating room 16 days later for implant removal, repeat irrigation and debridement, and static spacer placement. Once the infection was cleared, 200 days after index spacer placement, the patient underwent spacer explant, irrigation and debridement, and placement of a rotating hinge prothesis (Stryker, Mahwah, NJ). This patient later sustained a fall that disputed the extensor mechanism and subsequently underwent mesh reconstruction (Marlex; CR Bard, Murray Hill, NJ) [20,21] 403 days after index spacer placement.

One patient in the one-stage functional prosthetic spacer group developed a nonhealing wound on the ipsilateral distal tibia. Pathological examination demonstrated that the wound had transformed into squamous cell carcinoma. This lesion has now been resected to negative margins, and required microvascular reconstruction with free gracilis muscle transfer and associated split-thickness skin graft. The knee has remained asymptomatic and is functioning well.

For all patients, the mean VAS was 0.6 ± 0.93. Stratifying the two-stage and functional prosthetic groups demonstrated a mean VAS of 0.4 ± 0.8 for the two-stage group and a mean VAS of 0.8 ± 1.07 for the one-stage functional prosthetic group ($P = .450$). Three patients of the 12 (25%) who received an articulating prosthesis had flexion contractures at final postoperative follow-up. Two patients in the two-stage group had flexion contracture equal to 10°, and one patient in the one-stage functional prosthetic spacer group had a flexion contracture of 20° (Incidentally, this patient failed one-stage functional prosthetic spacer placement.). The mean terminal flexion for all 12 patients with articulating prostheses was 101 ± 22°, 96 ± 27° in the two-stage group, and 107 ± 14° in the one-stage functional prosthetic spacer group ($P = .449$; Table 4).

Considering all patients, the mean KSS was 83 ± 13. The mean KSS for the two-stage group was 82 ± 12. Within the two-stage group, the mean KSS for the 3 patients (30%) with formal arthrodesis and the one patient (10%) with retained static spacer was 72 ± 6, and the mean KSS for the 6 patients (60%) with the second stage was 89 ± 10. In the one-stage functional prosthetic spacer group, the mean KSS was 84 ± 15. The patient who required

Table 4
Outcome scores*

	VAS	Flexion contracture	Terminal flexion	KSS	TUG (sec)
Two-Stage	0.4			82	22
TKA	0.7	2/6	96°	89	20
Arthrodesis	0	–	–	72	24
Functional Prosthetic	0.8	1/6	107°	84	11.5
Total	0.6	3/12	101.5°	83	17.8

TKA, total knee arthroplasty, VAS, visual analog scale; KSS, Knee Society score; TUG, timed up-and-go.
* All values reported as means except for flexion contracture, which is reported as number of patients.

further surgery reported a KSS of 52; the mean KSS considering only patients with retained functional spacers was 91 ± 6 (Table 4). There was no statistically significant difference between Knee Society scores when comparing the 2-stage and one-stage groups as a whole (*P* = .766).

The mean TUG time for all the patients was 18 ± 10 seconds. For all patients who received two-stage treatment, the mean TUG time was 22 ± 10 seconds. The mean TUG time for the arthrodesis and retained static spacer patients (40%) was 24 ± 4 seconds, and the mean TUG time for the two-stage TKA patients (60%) was 20 ± 12 seconds (*P* = .615). The mean TUG time for patients with retained one-stage functional prosthetic spacers (83%) was 9 ± 3 seconds. The patient who failed one-stage functional prosthetic spacer reported a TUG time of 26 seconds (Table 4). Comparing the patients with retained functional prosthetic spacer with those who received two-stage TKA, there was a trend toward faster mean TUG time, but this was not statistically significant (*P* = .087).

Discussion

Treatment of advanced knee arthritis in the setting of infection is a clinical challenge. The mainstays of treatment for infection in the nonarthritic knee (surgical debridement, lavage, and intravenous antibiotics) do not sufficiently address any resulting cartilage damage or deformity [22-24]. Although this situation is rare compared to the frequency of PJI, it is important to optimize treatment for these patients, as patients with a history of infection about the knee are often more likely to develop PJI after primary TKA, especially if infectious treatment history information is limited [7-9,25,26].

Our data show that both two-stage protocol with a static spacer and single-stage protocol with a functional prosthetic spacer are acceptable treatment options for this population. By the Delphi criteria [27], successful treatment of infection was achieved in 100% (9/9) of patients who received two-stage treatment and in 83% (5/6) who received one-stage treatment. The one-stage functional prosthetic spacer has demonstrated excellent survivorship in the limited series of patients that received it. The patient who failed treatment with one-stage functional prosthetic spacer failed early because of inadequate treatment of infection, rather than failing late because of mechanical reasons. The single-stage patients trended toward greater terminal flexion and a faster TUG test. KSSs were similar for patients who received a single-stage spacer and two-stage TKA. The reported KSSs were similar to those reported by other authors for patients with infection in the native arthritic knee [7,10,13] and also similar to those reported for patients after treatment for PJI [28,29].

Classically, this patient population has been treated with 2-stage arthroplasty [10,12,13,30,31]. Indeed, in our series, the patients who received two-stage treatment have demonstrated a 100% survivorship rate. There have also been reports of successful treatment using a one-stage approach [8,25,26,32,33]. Similar to the patients in the cohort studied by Bauer et al. [32], our patient population included those with quiescent and evolutive infections. Treatment protocols were determined as per surgeon preference, rather than by infection chronicity, which led both types of patients treated according to both protocols. Our results indicate that one-stage arthroplasty using a functional prosthetic spacer is an acceptable treatment for both evolutive and quiescent infections.

A recent multicenter randomized controlled trial of articulating and static cement spacers found articulating spacers to be associated with improved outcomes in the treatment of PJI after TKA [14]. Compared with articulating cement spacers, the use of functional prosthetic spacers allows infection to be treated in a single stage, which is particularly attractive for patients with a septic process

about a native, arthritic knee. Functional prosthetic spacers have been shown to be effective for treatment of PJI [15,16,34-37]. The described benefits of this protocol compared with traditional two-stage approach include lessened patient morbidity, earlier mobility, and potential for decreased costs [34,38-41]. However, several prior studies have reported mixed results on retained spacers placed with highly concentrated antibiotic cement. A retrospective review by Petis et al. [36] found a 21% cumulative revision rate for retained knee spacers at 2-year follow-up. Choi et al. [37] reported 83% success rate for unplanned spacer retention at a mean follow-up of 43 months, and reasons cited for retention were satisfaction with pain and level of function. Siddiqi et al. [16] demonstrated that a single-stage treatment with functional prosthetic spacer was not inferior to traditional two-stage treatment for PJI considering infection clearance, reoperation, and overall success rates.

The 3 patients who received two-stage treatment with eventual arthrodesis represent the patients with the most severe combined soft tissue and bony deficits. In our series, they reported minimal pain but lower KSS and slower TUG than the patients who received articulating implants. The mean pain scores and KSS reported in our series were superior to what were reported in the literature [42], perhaps reflecting that the patients in our cohort had fewer total surgical procedures than those who had arthrodesis procedures after failing two-stage treatment for PJI recurrence [42].

This study is not without limitations. First, this study represents a small series of patients. The studied patients do represent an uncommon clinical situation and include all who were treated at our institution over a 20-year period. We attempted to mitigate this issue by reporting on means and trends in the data, rather than assigning definitive statistical significance. In addition, most patients included in this study were initially treated at outside institutions, and detailed surgical data, culture reports, and antibiotic therapy records before treatment at our institution were often incomplete or unavailable. Thus, we are unable to make specific comments about the role of antibiotic therapy agents or treatment duration in the management of these patients. Finally, the short follow-up for the functional spacer cohort precludes us from commenting on the cost-effectiveness of this treatment, as we cannot predict which of these patients will need revision in the future.

Conclusions

This is the first report of functional prosthetic spacers used in the treatment of infection about the native degenerative knee. Our results indicate that one-stage functional spacers are not inferior to the gold-standard two-stage treatment. Our data indicate that patients who are successfully treated with one-stage functional prosthetic spacers may have superior functional ability indistinguishable from a reimplanted knee replacement after treatment. Further study of a larger cohort of these complex patients with longer follow-up is needed to corroborate our findings.

Conflict of interest

J. I. Huddleston is in the editorial/governing board of Journal of Arthroplasty and is a board member/made committee appointments for AAHKS. S. B. Goodman is in the speakers' bureau of/gave paid presentations for Merck; is a paid consultant for Depuy Synthes Joint Reconstruction, J&J Medical Device Companies, Pluristem, Wishbone, and Volt Medical; has stock or stock options in Accelalox and Arquos; is in the editorial/governing board of Journal of Arthroplasty, Journal of Orthopedic Research, and Biomaterials; and is a board member in/made committee appointments for Journal of Orthopedic Research and Biomaterials. D. F. Amanatullah is a paid consultant for Exactech, Stryker, Zimmer-Biomet, Depuy,

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