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High Infection Control Rate and Function After Routine One-stage Exchange for Chronically Infected TKA

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Abstract

Background Many surgeons consider two-stage exchange the gold standard for treating chronic infection after TKA. One-stage exchange is an alternative for infection control and might provide better knee function, but the rates of infection control and levels of function are unclear.

Questions/Purposes We asked whether a one-stage exchange protocol would lead to infection control rates and knee function similar to those after two-stage exchange.

Methods We followed all 47 patients with chronically infected TKAs treated with one-stage exchange between July 2004 and February 2007. We monitored for recurrence of infection and obtained Knee Society Scores. We followed patients a minimum of 3 years or until death or infection recurrence.

Results Three of the 47 patients (6%) experienced a persistence or recurrence of the index infection with the same pathogen isolated. Three patients (6%) had control of the index infection but between 6 and 17 months experienced an infection with another pathogen. The 3-year survival rates were 87% for being free of any infection and 91% for being healed of the index infection. Twenty-five of the 45 patients (56%) had a Knee Society Score of more than 150 points.

Conclusions While routine one-stage exchange was not associated with a higher rate of infection recurrence failure, knee function was not improved compared to that of historical patients having two-stage exchange. One stage-exchange may be a reasonable alternative in chronically infected TKA as a more convenient approach for patients without the risks of two operations and hospitalizations and for reducing costs. The ideal one stage-exchange candidate should be identified in future studies.

Level of Evidence Level IV, therapeutic study. See the Instructions for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
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Introduction

Infection after TKA is a devastating complication that threatens both life and function [8]. With modern prophylactic measures, a low incidence of 1% to 2% is to be expected [19]. However, with the increasing number of TKAs performed, the number of infected TKAs will increase in proportion [17]. Control of an infected TKA

generally requires surgery. Some authors believe débridement should be performed only in the early stage of infection [22]. When the infection is chronic, Parvizi et al. [18] considered prosthesis removal mandatory. Reimplantation of a new TKA is generally performed in a subsequent stage after a variable period of time (two-stage protocol) and initial control of the infection [24]. The period without any implant in place theoretically allows a better control of the infection by general antibiotic treatment, at the expense of functional impairment during the waiting period despite the use of fixed or articulating spacers. Furthermore, two-stage procedure increases inconvenience to patients and family and may involve more time off from work (if the patient is not retired) and the complication rates may be higher because of two hospitalizations and anesthesias; thus, additional direct and indirect costs may overcome the theoretical advantage of better infection control.

One-stage reimplantation of THA was proposed by Wroblewski [25]. The theoretical advantage was to reduce the waiting period before delayed reimplantation and to improve hip function. It also eliminated the need for a second demanding procedure with inherent complication risk, including the occurrence of a new infection. However, there might be a higher risk of persistence or recurrence of the index infection due to a deficient débridement or insufficient antibiotic treatment. Some authors consider two-stage protocols for control of infections in total joint arthroplasty the gold standard [10, 18]. Kalore et al. [11] suggested one-stage protocols were contraindicated or should be reserved for selected patients (no fistula, no severe bone damage, known pathogen with high sensitivity to antibiotics, etc). At our institution, a routine one-stage protocol is applied for all patients with chronically infected TKA, except for fungal infections and repeat failures of at least two previous infection treatments. However, it is unclear whether the rates of infection control and levels of function are similar with one-stage and two-stage procedures for an infected TKA.

We therefore asked whether a one-stage exchange protocol would lead to (1) rate of control of infection similar to those published after two-stage exchange and (2) knee function at least as good as that previously reported with two-stage exchange.

Patients and Methods

We retrospectively identified all 49 patients with chronically infected TKA treated at our referral institution between July 2004 and February 2007 from the institutional database. We suspected the diagnosis of infection was positive if any of the following criteria was present: chronic fever of more than 38°C with knee pain and without any other explanation, presence of abscess or fistula, early prosthesis loosening without mechanical reason, or positive bacteriologic documentation after aspiration. Diagnosis of infection was eventually confirmed by positive intraoperative cultures. The indication for a one-stage exchange was suspicion or diagnosis of chronic infection. The contraindications were fungal infections and repeat failures of previous infection treatments. During the study period, we treated one patient with resection arthroplasty because of four previous repeat failures with a multiresistant organism and excluded one patient as the reconstruction was delayed because of extensive bone loss requiring a custom-made reconstruction prosthesis; thus, 47 patients were included in the study. There were 27 women and 20 men, with a median age of 72 years (range, 45–93 years). The median BMI was 30 kg/m^2 (range, 19–45 kg/m^2). The median delay between index implantation and occurrence of the infection was 30 months (range, 1 month to 18 years). The median delay between the occurrence of infection and the current treatment was 10 months (range, 1–61 months). Twenty-two patients had an unsuccessful operative procedure to treat the current infection before referral, including 17 débridements, two one-stage exchanges, and three two-stage exchanges. Acute infection signs (fever, abscess) were present in 15 patients. A fistula was present in 20 patients. No patients were lost to followup. All patients were recalled specifically for this study; data from the deceased patient were obtained from medical record and radiographs. We had prior approval by the local institutional review board.

There were 25 patients with American Society of Anesthesiologists (ASA) scores [20] of 2 or less and 22 patients with ASA scores of greater than 3. The median preoperative Knee Society (KS) Score [9] was 55 points (range, 28–94 points). All patients had substantial pain complaints; the median preoperative KS pain score was 20 points (range, 0–45 points). The median preoperative flexion angle was 90° (range, 20°–120°). The median preoperative KS function score was 42 points (range, 0–95 points). A prosthetic loosening was present in 21 patients. Substantial bone defects were present in 10 patients. The median preoperative C-reactive protein (CRP) level was 41 mg/L (range, 5–250 mg/L). The preoperative samples were negative in 15 patients (Table 1).

All patients were operated on by two senior surgeons (JYJ, CB) experienced in knee surgery and infection treatment with a consistent surgical approach: skin incision using the previous scar and approach with tibial tubercle osteotomy if necessary, excision of the fistula when present, careful soft tissue débridement, complete prosthesis removal, and complete bone débridement, including intramedullary reaming. We performed a tibial tubercle osteotomy to complete débridement in 24 patients. Four to eight bacteriologic samples were taken from the débrided

Table 1. Isolated pathogens

Pathogen	Preoperative samples	Intraoperative samples
Staphylococcus aureus sensitive to methicillin	10	13
Staphylococcus aureus resistant to methicillin	4	3
Staphylococcus epidermidis sensitive to methicillin	9	22
Staphylococcus epidermidis resistant to methicillin	1	2
Streptococcus	5	7
Enterococcus	1	3
Pseudomonas aeruginosa	2	4
Other	1	5
All sterile	15	0

tissues and bone. Pulsatile irrigation was used after having completed the débridement. Draping, gloves, and instruments were changed. The reconstruction was performed with a standard implant in nine patients, a posterostabilized implant with stem extension in 20 patients, and a hinged prosthesis in 18 patients owing to ligamentous laxity and substantial bone destruction. All implants were fixed with commercially available gentamicin-loaded cement. Bone defects were filled with allograft (11 patients) or metallic augments (eight patients) according to the surgeon's preference. A pedicled musculocutaneous flap (medial gastrocnemius or medial soleus muscles) was performed immediately in five patients. Suction drains were left in 39 patients for 48 hours according to the surgeon's preference.

We observed a variety of responsible pathogens (Table 1). All 47 patients had at least one positive sample. Infection was monobacterial in 36 patients and multibacterial in 11. There were differences between preoperative and intraoperative samples in 20 patients: in five, the intraoperative sampling gave different results from the preoperative one; in 15 patients, the preoperative sampling was negative, but the intraoperative sampling was positive.

Antibiotic treatment was initiated intraoperatively as soon as the samples were taken, according to the preoperative documentation, and adapted to the findings of both pre- and intraoperative samples, according to the standard sensitivity tests and following internationally accepted guidelines [5]. Parenteral antibiotics were given during a mean period of 3.5 weeks (range, 1–16 weeks), mostly with two (35 patients) or three (nine patients) antibiotics; most frequently used intravenous antibiotics were vancomycin (26 patients) and teicoplanin (20 patients). Antibiotics were given orally as soon as possible, for a median total treatment period of 12 weeks (range, 3–16 weeks), mostly with two antibiotics (32 patients); most frequently used oral antibiotics were rifampicin (28 patients), levofloxacin (14 patients), and clindamycin (11 patients). Total duration of antibiotic treatment was based on tolerance of treatment, CRP level, and clinical symptoms. Fourteen patients experienced adverse effects from the antibiotic treatment: diarrhea in nine, fungal infection in three, and allergic or toxic reaction in two.

Postoperative rehabilitation followed the standard protocol used at our institution for primary TKA: immediate weightbearing with crutches as tolerated and early mobilization under supervision of a physical therapist with daily continuous passive motion without angular restriction. However, mobilization was delayed for 1 week by patients with a musculocutaneous flap.

One patient required above-the-knee amputation for end-stage arterial occlusion after 3 months without any evidence of knee infection. One patient died after 6 weeks because of poor general condition without any evidence of knee infection. The 45 remaining patients were followed for a minimal period of 3 years or until evidence of repeat infection, with a median of 33 months (range, 5–76 months). These patients were prospectively followed at 6 weeks, 12 weeks, 3 months, and 12 months by the operating surgeon until control of the infection was suspected or when postoperative infection was diagnosed. All living patients were reexamined for the purpose of the study by an independent observer (BB). We recorded the following data: complication and repeat surgery, KS Scores at the latest available examination, presence of abscess or fistula, presence of loosening and/or bone defect, CRP level at the last visit, and bacteriologic documentation when available. Presence of infection was diagnosed if any of the following criteria was present: chronic fever of more than 38°C with knee pain and without any other explanation, presence of abscess or fistula, early prosthesis loosening without mechanical reason, and positive bacteriologic documentation after completion of the antibiotic treatment. Recurrence of the index infection was diagnosed if the same pathogen as in the preoperative or intraoperative period was isolated; occurrence of a new infection was diagnosed if a pathogen other than that in the preoperative or intraoperative period was isolated. From the medical records, we recorded the following: previous surgery for infection, presence of fistula, ASA score of 3 or more, negative preoperative samples, presence of gram-negative pathogens or *Staphylococcus* resistant to methicillin, multibacterial infection, use of a muscular flap, use of bone graft or substitute, and volume and constraint level of the reimplanted TKA. We considered the primary goal of the treatment was achieved if the patient had a global KS Score of more than 150 points and the absence of knee infection.

The survival rate was calculated for all included patients in an intention-to-treat manner according to the

Table 2. Patients with recurrent infection

Patient	Initial symptoms	Initial radiographic results	Initial pathogens	Delay of recurrence (months)	Pathogens at recurrence	Treatment	Final result
1	Pain + fistula	Osteolysis	*Streptococcus* *Staphylococcus aureus* resistant to methicillin	6	*Escherichia coli*	Suppressive antibiotics	Contained
2	Pain	Loosening	*Enterococcus faecalis* *Corynebacterium* *Peptostreptococcus*	9	*Escherichia coli*	One-stage exchange	Success
3	Pain	Osteolysis	*Pseudomonas aeruginosa*	14	*Pseudomonas aeruginosa*	Two-stage exchange	Failure
4	Pain	Osteolysis	*Enterobacter*	17	*Escherichia coli*	Open débridement + suppressive antibiotics	Success
5	Pain + fistula	Loosening	*Staphylococcus aureus* sensitive to methicillin	5	*Staphylococcus aureus* sensitive to methicillin	Débridement + suppressive antibiotics	Contained
6	Pain	Osteolysis	*Staphylococcus aureus* sensitive to methicillin	18	*Staphylococcus aureus* sensitive to methicillin	One-stage exchange	Success

Kaplan-Meier method [12], considering three different analyses: (1) occurrence of any infection, (2) occurrence of a technical failure of one-stage exchange and/or recurrence of the index infection, and (3) occurrence of a new infection.

Results

Considering all included patients in an intention-to-treat analysis at last followup (before a repeat revision when necessary), 41 of 47 patients (87%) were free of any knee infection, and the 3-year survival rate for being free of any knee infection was 87% (95% CI, 75%–94%). Forty-four of 47 patients (94%) were healed after the index infection, and the 3-year survival rate for being healed of the index knee infection after successful one-stage exchange was 91% (95% CI, 79%–97%). Forty-four of 47 patients (94%) were free of a new infection, and the 3-year survival rate for being free of a new knee infection after control of the index infection was 93% (95% CI, 82%–98%). Of the 45 patients followed, 25 (56%) had a KS knee score of more than 150 points; 24 (53%) achieved the primary goal of the protocol (a KS knee score > 150 points and absence of any infection); and 27 (60%) achieved the secondary goal of the protocol (a KS knee score > 150 points and control of the index infection). Forty-one patients had an uneventful initial healing of the knee. Six patients required repeated débridement with prosthesis retention within 2 postoperative weeks because of persistent discharge (five patients) or skin necrosis (one patient); all samples remained sterile by reoperation, and these patients were not considered failures. Three patients had persistence or recurrence of the index infection with the same pathogen isolated; these patients were treated by repeat one-stage exchange (one), two-stage exchange (one), and débridement and suppressive antibiotic treatment (one) (Table 2). Three patients were healed from the index infection but later developed a new infection with another pathogen isolated; these patients were treated by open débridement and suppressive antibiotic treatment (one), repeat one-stage exchange (one), and suppressive antibiotic treatment (one) (Table 2).

At latest followup of the 42 patients without a repeat revision, the median KS knee score was 85 points (range, 10–100 points). The median KS pain score was 45 points (range, 10–50 points). The median flexion angle was 100° (range, 60°–130°). The median KS function score was 78 points (range, 0–100 points).

Discussion

Many surgeons consider two-stage exchange as the gold standard for treating chronic infection after TKA. One-stage exchange might be an alternative for infection control and better knee function. We asked whether a one-stage exchange protocol would lead to (1) infection control as measured by survival rate similar to the published rates after two-stage exchange and (2) knee function at least as good as that previously reported with two-stage exchange.

Our study has some limitations. First, it is an observational, cohort study, without any control or comparative group. Second, the number of patients was too small to perform an adequately powered analysis of prognostic factors. However, the number of included patients is higher

than in most other studies [1, 2, 7, 16, 20, 23] reporting one-stage exchange of infected TKAs. Further, no patient was lost of followup. Third, the minimum followup was 24 months, and the infection rate might increase in the future due to additional new infections. The median time to reinfection might be as high as 4 years [13]. Although no patient was lost of followup, some low-grade infections might have been missed. Fourth, the study reflects the experience of one surgical team during a single period and may not be transferrable to others. However, except for the patients with multiple failures selected for resection arthroplasty, it represents an unselected series.

The 3-year survival rate for being free of any knee infection in this series of infected TKAs treated by one-stage exchange and prolonged oral antibiotic treatment was 87%. Reports in the literature [10] about two-stage exchange are mostly from short- to intermediate-term studies with few patients that include different protocols (fixed or articulating spacers, local and general antibiotic treatment, interim period, etc), making it virtually impossible to average the findings (Table 3). However, a reinfection rate between 0% and 30% may be expected [10]. One-stage exchange is generally considered either fully contraindicated or reserved for selected patients operated on by experienced surgeons [15]. To the best of our knowledge, no prospective study comparing one- and two-stage exchange has been published. One retrospective study failed to detect any difference between one- and two-stage exchange [1]. Another, older study was too underpowered to draw an adequate conclusion [21]. Most authors supporting two-stage exchange rely only on Level IV studies [3, 14]. Consequently, there is no evidence-based data to support the choice of two-stage exchange as the gold standard. Few papers have reported findings after one-stage exchange of infected TKA. A recent systematic review of the literature [9] retrieved only four studies [2, 7, 16, 23], some of them limited to fewer than 20 TKAs and with only one published in the last decade [2], collecting in total 152 TKAs. Von Foerster et al. [23] published the study with the largest number of TKAs (104) available for followup and reported a rate of infection control of 73% after one-stage exchange and fixation of the new prosthesis with antibiotic-loaded cement. However, there was no routine additional intravenous or oral antibiotic treatment, which does not fit the current standard of care. Buechel et al. [2] reported the most recent series following modern standard of care. Twenty-two consecutive TKAs were treated by one-stage exchange, with fixation of the new prosthesis with antibiotic-loaded cement and prolonged postoperative antibiotic treatment. At an average followup of 10 years, 20 (91%) were free of infection. Control of the index infection was obtained in 94% of our patients, and 85% were free of any knee infection after 3 years. These figures are comparable to those of other one- [1, 2, 7, 16, 21, 23] and two-stage studies [1, 3, 21, 22, 24] considering control of infection. Several factors may have contributed to our encouraging success rate at 3 years: high number of methicillin-sensitive organisms, systematic use of antibiotic-loaded cement, and prolonged oral antibiotic regimen according to well-proven protocols [5]. Based on these findings, there seems to be no clear advantage to the two-stage strategy for controlling the index infection or avoiding a new infection.

We found a median KS knee score of 85 of 100 points and a median knee flexion angle of 100°. Again, these results are in line with the other one-stage studies and also with two-stage studies [4, 11] (Table 3). In the series by Buechel et al. [2]

Table 3. Summary of quoted literature (excluding literature analyses)

Study	Strategy	Number of patients	Mean followup	Infection healing rate (%)	Mean Knee Society knee score (points)	Mean Knee Society function score (points)
Bauer et al. [1]	1 stage	30	52 months	67	75.5	62.5
Buechel et al. [2]	1 stage	22	10.2 years	90.9	79.5	
Göksan and Freeman [7]	1 stage	19	4.6 years	89		
Lu et al. [16]	1 stage	8	20 months	100		
Scott et al. [21]	1 stage	10		70		
Von Foerster et al. [23]	1 stage	104	5–15 years	73		
Bauer et al. [1]	2 stage with or without spacer	77	52 months	67	74.8	62.5
Cuckler [3]	2 stage with spacer	44	5.4 years	98		
Scott et al. [21]	2 stage	7				
Sherrell et al. [22]	2 stage (after failed débridement)	83	50 months	66		
Westrich et al. [24]	2 stage with spacer	72	52.4 months	90.7	90.1	90.0

reporting the results of one-stage exchange, KS knee scores averaged 80 points, with 86% satisfactory results. After two-stage exchange, a mean KS clinical score of between 64 and 89 points and a mean flexion of between 83° and 112° have been reported [10, 15, 24]. The KS Score may have some limitations in evaluating knee function after revision TKA [6]; however, there is no universally accepted rating system. Our findings do not support the notion that one-stage exchange has the potential to allow better functional knee outcome than two-stage exchange, especially when the latter procedure is associated with articulating spacers. In a systematic review of the literature, Jämsen et al. [10] stated no factor could be reliably related to improved postoperative knee function probably because too many confounding factors cannot be controlled. Our findings are also similar to those reported for revision TKA for reasons other than infection [4, 8]. This confirms the one-stage strategy is able to offer reasonable knee function but with decreased quality compared to primary TKA.

Our data suggest routine one-stage exchange may represent a valuable option for chronically infected TKA. While we performed no cost analysis, there is little doubt the one-stage strategy involves lower costs than the two-stage strategy, primarily due to the avoidance of the second stage with additional surgery and hospitalization. As the failure and rerevision rates do not seem different, it might be assumed the one-stage strategy is more cost-effective. In addition, during the interim phase (which may last 6 weeks to 12 months) even with articulating spacers, the patient may suffer from knee pain when moving or walking, may not be able to bear weight on his or her leg, and must use supports to walk. These adverse effects, which may definitely affect quality of life during this period, disappear completely with the one-stage strategy. Our data can provide a standard against which to compare the effectiveness of other treatment protocols. Further studies may allow defining appropriate selection criteria for the one- or two-stage strategy, thus improving the efficiency of infection treatment.

References

1. Bauer T, Piriou P, Lhotellier L, Leclerc P, Mamoudy P, Lortat-Jacob A. [Results of reimplantation for infected total knee arthroplasty: 107 cases] [in French]. *Rev Chir Orthop Reparatrice Appar Mot*. 2006;92:692–700.
2. Buechel FF, Femino FP, D'Alessio J. Primary exchange revision arthroplasty for infected total knee replacement: a long term study. *Am J Orthop*. 2004;33:190–198.
3. Cuckler JM. The infected total knee: management options. *J Arthroplasty*. 2005;20(4 suppl 2):33–36.
4. Deehan DJ, Murray JD, Birdsall PD, Pinder IM. Quality of life after knee revision arthroplasty. *Acta Orthop*. 2006;77:761–766.
5. Drancourt M, Stein A, Argenson JN, Roiron R, Groulier P, Raoult D. Oral treatment of *Staphylococcus* spp. infected orthopaedic implants with fusidic acid or ofloxacin combination with rifampicin. *J Antimicrob Chemother*. 1997;39:235–240.
6. Ghanem E, Pawasarat I, Lindsay A, May L, Azzam K, Joshi A, Parvizi J. Limitations of The Knee Society Score in evaluating outcomes following revision total knee arthroplasty. *J Bone Joint Surg Am*. 2010;92:2445–2451.
7. Göksan SB, Freeman MA. One-stage reimplantation for infected total knee arthroplasty. *J Bone Joint Surg Br*. 1992;74:78–82.
8. Insall JN. Infection in total knee arthroplasty. *Instr Course Lect*. 1986;35:319–324.
9. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of The Knee Society clinical rating system. *Clin Orthop Relat Res*. 1989;248:13–14.
10. Jämsen E, Stogiannidis I, Malmivaara A, Pajamäki J, Puolakka T, Konttinen YT. Outcome of prosthesis exchange for infected knee arthroplasty: the effect of treatment approach: a systematic review of the literature. *Acta Orthop*. 2009;80:67–77.
11. Kalore NV, Gioe TJ, Singh JA. Diagnosis and management of infected total knee arthroplasty. *Open Orthop J*. 2011;5:86–91.
12. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. *J Am Statist Assoc*. 1958;53:457–481.
13. Kubista B, Hartzler RU, Wood CM, Osmon DR, Hanssen AD, Lewallen DG. Reinfection after two-stage revision for periprosthetic infection of total knee arthroplasty. *Int Orthop*. 2012;36:65–71.
14. Lentino JR. Prosthetic joint infections: bane of orthopedists, challenge for infectious disease specialists. *Clin Infect Dis*. 2003;36:1157–1161.
15. Leone JM, Hanssen AD. Management of infection at the site of a total knee arthroplasty. *J Bone Joint Surg Am*. 2005,87:2335–2348.
16. Lu H, Kou B, Lin J. One-stage reimplantation for the salvage of total knee arthroplasty complicated by infection. *Chin J Surg*. 1997;35:456–458.
17. Oduwole KO, Molony DC, Walls RJ, Bashir SP, Mulhall KJ. Increasing financial burden of revision total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc*. 2010;18:945–948.
18. Parvizi J, Zmistowski B, Adeli B. Periprosthetic joint infection: treatment options. *Orthopedics*. 2010;33:659.
19. Phillips JE, Crane TP, Noy M, Elliott TS, Grimer RJ. The incidence of deep prosthetic infections in a specialist orthopaedic hospital: a 15-year prospective survey. *J Bone Joint Surg Br*. 2006;88:943–948.
20. Saklad M. Grading of patients for surgical procedures. *Anesthesiology*. 1941;2:281–284.
21. Scott IR, Stockley I, Getty CJ. Exchange arthroplasty for infected knee replacements: a new two-stage method. *J Bone Joint Surg Br*. 1993;75:28–31.
22. Sherrell JC, Fehring TK, Odum S, Hansen E, Zmistowski B, Dennos A, Kalore N; Periprosthetic Infection Consortium. The Chitranjan Ranawat Award. Fate of two-stage reimplantation after failed irrigation and débridement for periprosthetic knee infection. *Clin Orthop Relat Res*. 2011;469:18–25.
23. Von Foerster G, Kluber D, Kabler U. Mid- to long-term results after treatment of 118 cases of periprosthetic infection after knee joint replacement using one-stage exchange surgery. *Orthopade*. 1991;20:244–252.
24. Westrich GH, Walcott-Sapp S, Bornstein LJ, Bostrom MP, Windsor RE, Brause BD. Modern treatment of infected total knee arthroplasty with a 2-stage reimplantation protocol. *J Arthroplasty*. 2010;25:1015–1021.
25. Wroblewski BM. One-stage revision of infected cemented total hip arthroplasty. *Clin Orthop Relat Res*. 1986;211:103–107.