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Two-Stage Exchange Arthroplasty for Periprosthetic Joint Infection Following Total Hip or Knee Arthroplasty Is Associated With High Attrition Rate and Mortality

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ABSTRACT

Background: We sought to determine the ultimate fate of patients undergoing resection arthroplasty as a first stage in the process of 2-stage exchange and evaluate risk factors for modes of failure.
Methods: A retrospective case study was performed including all patients with minimum 2-year follow-up who underwent first-stage resection of a hip or knee periprosthetic joint infection from 2008 to 2015. Patient demographics, laboratory, and health status variables were collected. The primary outcome analyzed was defined as failure to achieve an infection-free 2-stage revision. Univariate pairwise comparison followed by multivariate regression analysis was used to determine risk factors for failure outcomes.
Results: Eighty-nine patients underwent resection arthroplasty in a planned 2-stage exchange protocol (27 hips, 62 knees). Mean age was 64 years (range, 43-84), 56.2% were males, and mean follow-up was 56.3 months. Also, 68.5% (61/89) of patients underwent second-stage revision. Of the 61 patients who complete a 2-stage protocol, 14.8% (9/61) of patients failed with diagnosis of repeat or recurrent infection. Mortality rate was 23.6%. Multivariate analysis identified risk factors for failure to achieve an infection-free 2-stage revision as polymicrobial infection ($P < .004$; adjusted odds ratio [AOR], 7.8; 95% confidence interval [CI], 2.1-29.0), McPherson extremity grade 3 ($P < .024$; AOR, 4.1; 95% CI, 1.2-14.3), and history of prior resection ($P < .013$; AOR, 4.7; 95% CI, 1.4-16.4).
Conclusion: Patients undergoing resection arthroplasty for periprosthetic joint infection are at high risk of death (24%) and failure to complete the 2-stage protocol (32%). Those who complete the 2-stage protocol have a 15% rate of reinfection at 4.5-year follow-up.

The gold standard for treatment of chronic periprosthetic joint infection (PJI) in the United States remains 2-stage exchange for surgically optimized patients [1,2]. After first-stage resection and antibiotic spacer placement, the second-stage revision rate has been shown to be 60%-82% [3–5]. The overall success rate of 2-stage revision arthroplasty has been shown to vary from 60% to 90% [5–8]. Both host and microbiologic factors influence the success rate of 2-stage exchange [5,7,9–14]. While previous studies have described risk factors for failure of 2-stage revision for PJI, little data exists pertaining to the fate of patients who undergo initial resection and antibiotic spacer implantation.

The factors associated with failure to ultimately achieve a successful second-stage revision after initial arthroplasty resection are not well understood. Our purpose is to determine the ultimate fate of patients who undergo resection arthroplasty as the planned first stage in a 2-stage exchange protocol and answer several specific questions. First, what are the failure rates after resection and antibiotic spacer placement for chronic PJI, defined as failure to achieve infection-free 2-stage revision, septic failure of second-stage reimplantation if performed, and mortality? Second, what risk factors are associated with the previously mentioned failure rates?

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Materials and Methods

Study Design

After institutional review board approval, we retrospectively reviewed our institutional database to identify all patients who underwent first-stage resection of a chronically infected total hip arthroplasty or total knee arthroplasty between the years 2008 and 2015 using Current Procedural Terminology codes. Operations were performed by 1 of 4 surgeons during the years analyzed, and all operations were performed as part of a planned 2-stage exchange protocol.

Patients

Patients were included if they underwent resection of a prosthetic knee or hip in the years analyzed and were 18 years of age or greater. All patients included had an infection diagnosed or diagnosable according to criteria set forth by the Musculoskeletal Infection Society (MSIS) [15]. For patients treated before MSIS criteria was published, patients were not included if they did not meet MSIS criteria retrospectively. Patients with a first-time diagnosis of chronic PJI undergoing initial resection and patients with history of resection or 2-stage revision were included to determine differences between these 2 subgroups of patients. Patients were excluded if they lacked minimum 2-year follow-up in the hospital database or if their infection did not meet or would not have met MSIS criteria for infection.

Two-Stage Exchange Protocol

Patients were diagnosed with chronic PJI according to MSIS criteria. After resection of components, irrigation and debridement, and high-dose antibiotic spacer placement, patients were treated with empiric antibiotics through a peripherally inserted central venous catheter that were narrowed to specific pathogen coverage for 6 weeks. Patients were a candidate for reimplantation if after a 2-week antibiotic holiday, all signs of infection were absent, if ESR and C-reactive protein (CRP) decreased by at least 50%, and joint aspirate, if performed, was not concerning for ongoing infection. If all these criteria were not met, the patient was a candidate for repeat resection.

Specifics of surgical approach of initial resection of knee or hip arthroplasty and reimplantation differed by surgeon but included a systematic approach. Resection of infected arthroplasty was performed with removal of all infected tissue and cement. Bone at the interface was routinely debrided with reaming and/or new cuts. To complete the workup, intraoperative cultures and pathology were also obtained from synovium, bone, and membranes at the time of resection. A thorough irrigation was performed in all cases, with differences based on surgeon preference in irrigation volumes and solution protocols including povidone-iodine and hydrogen peroxide. Both static and articulating antibiotic spacers were used for knees based on surgeon preference. Antibiotic type and dosing in cement varied by surgeon preference. Specific weight-bearing and rehab protocols differed between treating surgeons and on a case-by-case basis. Surgical approach of reimplantation varied by surgeon preference including specific implant device. All patients who underwent second-stage reimplantation underwent typical rehabilitation protocols at the individual surgeon's discretion.

Data Collected

Demographic data collected include age, sex, ethnicity, and insurance coverage. Preoperative surgical data collected included joint affected (hip or knee), the laterality, number of prior surgeries and arthroplasties, presence of a prior resection or exchange at another hospital, and whether the patient presented through the emergency room or semi-electively through clinic. Preoperative lab data collected include ESR, CRP, synovial total nucleated cell, synovial percent neutrophil, and preoperative culture characteristics including strain, resistance, and multiorganism infections. Patient comorbidity data collected included body mass index (BMI), presence or absence of HIV, metastatic cancer, mild liver disease, moderate liver disease, cancer, diabetes mellitus with/without end-organ damage, chronic kidney disease (CKD), hemiplegia, peptic ulcers, chronic lung disease, cerebrovascular disease (CVD), prior myocardial infection, congestive heart failure, peripheral vascular disease, and dementia. In addition, the patients' smoking status (never smoker, former smoker, current smoker) and HbA1c were also collected. Patients' comorbidities were used to determine McPherson host and extremity grade [10] and Charlson Comorbidity Index.

Outcomes

We measured 3 outcomes that focused on different definitions of failure. First, our primary outcome was defined as failure to achieve an infection-free 2-stage revision. This outcome included failure to undergo second-stage reimplantation as a result of death, patient preference, surgeon discretion, medical contraindication to second-stage, failure to clear infection after antibiotic spacer placement, and failure due to persistent or recurrent infection of the second-stage revision if performed. We chose to evaluate this outcome to identify overall rate of successful second-stage revision after initial resection and antibiotic spacer placement.

We then determined septic failure rate in those patients who successfully underwent the second-stage reimplantation operation. In this definition, failure occurred after the second-stage if a patient was diagnosed with PJI of the index joint, or if the patient had repeat surgery because of PJI. Repeat surgery for PJI included irrigation and debridement with polyethylene exchange, repeat resection with antibiotic spacer, knee fusion, above-knee amputation, and hip Girdlestone procedure. Diagnosis of recurrent infection was made according to MSIS criteria.

Finally, we used the Social Security Index database to determine the mortality rate of the entire cohort regardless of surgical history or success of the 2-stage process. We then determined risk factors by using univariate analysis, followed by multivariate analysis for our primary outcome.

Statistical Analysis

Rates of the before-mentioned outcomes and mortality were analyzed by calculating the cumulative incidence. Univariate followed by multivariate analyses were performed for studied variables to determine risk factors. We used chi-square test for univariate analysis to examine the association between collected variables and studied outcomes. Demographic variables were grouped by age (<60, 60-70, >70), BMI (<30, 30-40, >40), and smoking status (current smoker vs non−current smoker). Due to the predominance of white population in our study population, race was grouped as white vs non-white.

To limit the impact of confounding, we also performed a multivariate analysis using logistic regression on the outcome of failure to achieve an infection-free 2-stage revision, for potential risk factors that were found to be significant in univariate analysis. These risk factors were adjusted for age, gender and BMI, and operating surgeon. The risk factors associated with these outcomes were evaluated using odds ratios (ORs). ORs are reported with the

Table 1
Univariate Analysis of Risk Factors for Failure Outcome: Inability to Achieve Infection-Free 2-Stage Revision (Total 89 Patients).

Variable	Failure 2-Stage	No Failure	*P* Value
Age (y)			
<60	13	18	.9904
60-70	13	19	
>70	11	15	
BMI			
<30	14	18	.7134
30-40	14	24	
>40	9	10	
Charlson Comorbidity Index			
1-3	12	15	.8419
4-5	10	17	
>6	15	20	
Previous 2-stage			
Yes	11	7	.0597
No	26	45	
Race			
White	34	49	.6897
Non-white	3	3	
Gender			
Male	20	30	.7332
Female	17	22	
Host grade			
A	10	21	.4257
B	16	18	
C	11	13	
Extremity grade			
2	**22**	**43**	**.0149**
3	**15**	**9**	
Resistant strain			
Yes	14	15	.3724
No	23	37	
Smoking: current vs non			
Yes	3	3	.1406
No	18	65	
CRP			
0-3	21	28	.7856
>3	16	24	
Joint: hip vs knee			
1	22	40	.0774
0	15	12	
Prior resection			
Yes	**15**	**6**	**.0015**
No	**22**	**46**	
Presentation: ER vs clinic			
Clinic	30	44	.6607
ER	7	8	
Number of organisms on culture			
2	**17**	**6**	**.0003**
1 or 0	**20**	**46**	
Surgeon			
1	12	15	
2	6	5	
3	14	22	
4	5	10	.71

Bold indicates the significance of *P* value <.05. BMI, body mass index; CRP, C-reactive protein; ER, emergency room.

95% confidence intervals (CIs). All statistics were performed using SAS 9.4 (Cary, NC). Statistical significance was set at $P < .05$.

Results

We identified 89 patients who underwent resection of a prosthetic hip or knee in the first stage of a planned 2-stage exchange in the study period (27 hips and 62 knees) with greater than 2-year follow-up who met inclusion criteria. Mean follow-up for the entire cohort was 56.3 months. Average age of the population was 64 years (range, 43-84 years), and 39 (43.8%) were females. Average BMI was 33.6 kg/m^2 (range, 17.2-56.76 kg/m^2). The mean age-adjusted Charlson Comorbidity Index (CCI) was 5.1 (range, 1-16). McPherson grading revealed host grades of 35% grade A, 38% grade B, and 27% grade C, and extremity grades of 0% grade 1, 73% grade 2, and 27% grade 3. The most common cultured organism was coagulase-negative staphylococci at 34% (30/89 patients). Methicillin-resistant *Staphylococcus aureus* (MRSA) infections were present in 19% (17/89) of patients, with 11% (10/89) methicillin-resistant coagulase-negative *Staphylococcus* including all coagulase-negative *Staphylococcus* species such as *Staphylococcus epidermidis* and *Staphylococcus capitis*.

A total of 68.5% (61/89) of patients completed 2-stage revision after initial resection and antibiotic spacer placement. We were unable to clearly identify the specific reason for spacer retention in the majority of patients given the retrospective nature of the study. Only 58.4% (52/61) of patients achieved an infection-free second-stage revision with >2-year follow-up. Univariate analysis revealed multiple factors associated with failure to achieve an infection-free 2-stage revision: presence of polymicrobial infection ($P < .0003$), prior resection ($P < .0015$), and extremity grade 3 vs 2 ($P < .0149$; Table 1). The data from the univariate analysis were used to perform a multivariate analysis adjusting for age, gender, BMI, and operating surgeon, to identify risk factors for failure to achieve infection-free 2-stage revision. Risk factors for failure to achieve an infection-free 2-stage revision were as follows: presence of polymicrobial infection ($P < .004$; adjusted odds ratio [AOR], 7.8; 95% CI, 2.1-29.0), McPherson extremity grade 3 ($P < .024$; AOR, 4.1; 95% CI, 1.17-14.29), and a prior resection at another hospital ($P < .013$; AOR, 4.7; 95% CI, 1.36-16.39; Table 2). The MRSA cure rate in our study was 53%, 9 of 17 total MRSA infections; while 47% (8/17) of MRSA culture-positive infections failed to achieve an infection-free reimplantation ($P = .61$). Also, 63% of patients grew a single organism on culture, 26% of patients grew multiple organisms, and 11% were culture negative.

Of the 61 patients who completed a 2-stage protocol, 14.8% (9/61) were diagnosed with recurrent PJI (Fig. 1). Univariate analysis revealed factors associated with reinfection: a prior resection at an outside hospital ($P < .02323$), CKD ($P < .0448$), CVD ($P < .0198$), and presence of multiorganism infection ($P < .001$; Table 3).

Additionally, we performed a subanalysis excluding the 18 patients with prior resection or 2-stage revision, as we believed these 2 groups of patients could likely have different risk factors for failure. A univariate analysis on the 67 remaining patients without

Table 2
Multivariate Regression Analysis of Risk Factors for Failure Outcome: Inability to Achieve Infection-Free 2-Stage Revision (Total 89 Patients).

Variable	*P* Value	Adjusted *P* Value[a]	Adjusted Odds Ratio[a]	95% CI
McPherson extremity grade 3 vs 2	**.0236**	**.0224**	**4.10**	**1.17-14.29**
Positive history of resection	**.0125**	**.0150**	**4.72**	**1.36-16.39**
Polymicrobial infection	**.0036**	**.0021**	**7.802**	**2.096-29.049**
McPherson host grade A vs C	.7320	.6036	0.681	0.134-3.448
McPherson host grade B vs C	.8432	.7488	1.034	0.273-3.927
Current vs non–current smoker	.9919	.8650	0.679	0.032-14.197
Presentation via clinic vs ER	.9096	.8674	1.167	0.279-4.890
Charlson Comorbidity Index 1-3 vs >6	.5022	.2163	3.005	0.539-16.739
Charlson Comorbidity Index 4-5 vs >6	.7766	.4508	1.113	0.296-4.189
Methicillin-resistant organism	.6019	.6644	0.759	0.239-2.409
McPherson extremity grade 3 vs 2	**.0236**	**.0299**	**3.53**	**1.13-11.04**
Positive history of resection	**.0125**	**.009**	**5.01**	**1.50-16.78**
Polymicrobial infection	**.0036**	**.0009**	**8.14**	**2.35-28.16**

Bold indicates the significance of *P* value <.05. BMI, body mass index; CI, confidence interval; ER, emergency room.
[a] Adjusted for covariates age, gender, BMI, and surgeon.

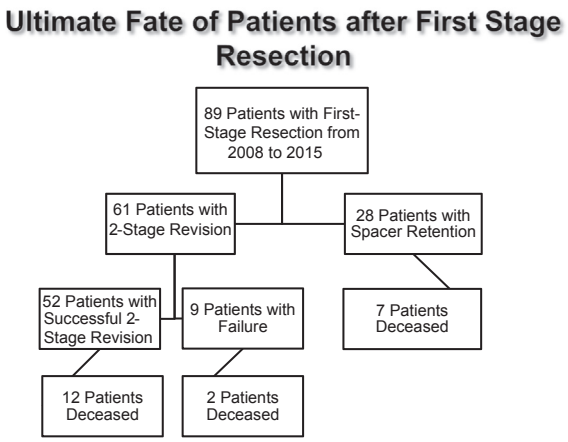

Fig. 1. Flow diagram of patient outcomes. Failure defined as diagnosis of recurrent infection via MSIS criteria. MSIS, Musculoskeletal Infection Society.

history of resection or 2-stage revision revealed the same factors associated with failure to achieve infection-free reimplantation: presence of polymicrobial infection ($P < .0001$) and extremity grade 3 vs 2 ($P < .0485$).

The mortality rate was 23.6% (21/89) of patients during the follow-up period. Factors associated with death during study period were host grade ($P < .0160$) and CCI ($P < .004$; Table 4). Among patients with McPherson host grade C, mortality rate was 37.5% (9/24 patients). Similarly, among patients with McPherson extremity grade 3, mortality rate was 37.5% (9/24 patients). Patients with an age-adjusted CCI >8 had a 56% (5/9) mortality rate. All deaths occurred after 2 years, as dictated by our inclusion criteria.

Discussion

In our institutional review, we found that of 89 patients undergoing implant resection for chronic hip or knee PJI, 68.5% (61/89) of patients completed the 2-stage protocol. Only 58.4% (52/89) of patients in the cohort achieved an infection-free 2-stage revision. Of those who completed the 2-stage protocol, 14.8% (9/61) of patients failed 2-stage revision with diagnosis of repeat or recurrent infection. Mortality rate was 23.6% after 2-year follow-up. Multivariate analysis identified the following as risk factors for failure to achieve an infection-free 2-stage revision: polymicrobial infection, McPherson extremity grade 3, and prior resection.

Our 2-stage revision rate of 68.5% is higher than the 60% 2-stage revision completion rate found in a study by Cancienne et al [3], but lower than the 82% rates cited by Gomez et al [4] and Wang et al [5]. We were unable to clearly identify the specific reason for spacer retention in the majority of patients given the retrospective nature of the study. The differences in observed reimplantation rates can likely be explained by a combination of baseline host factors, as some patients elect to not undergo reimplantation due to ongoing perioperative risk factors or satisfaction with initial resection, as well as surgeon discretion and different infection eradication rates among centers after first-stage resection. When failure was defined as failure to achieve an infection-free reimplantation at latest follow-up, our multivariate analysis revealed that patients who had a resection at another facility before our first-stage resection had nearly 5-fold greater likelihood of failure. Previous studies have found that surgeries or revisions before first-stage resection can alter the success rate ranging from 36% to 89% of 2-stage exchange [5,7,11,16,17]. A recent study identified both spacer exchange after initial spacer insertion and prior revision for aseptic failure to be risk factors for 2-stage revision failure [5]. While the present study did evaluate for repeat spacer exchange as a risk factor for failure, this did not meet statistical significance. Our data suggest that referring patients to a center equipped to perform complete 2-stage revision protocol rather than attempting resection before referral may result in increased chance at achieving an infection-free reimplantation. McPherson extremity grade 3 was associated with a 4-fold greater likelihood of inability to achieve an infection-free reimplantation, compared to patients with extremity grade 2. This study adds extremity grade to the list of risk factors. Therefore, in addition to systemic factors, the local joint environment also influences treatment outcome. We found that patients with a multiorganism infection had a nearly 8-fold greater likelihood of inability to achieve an infection-free reimplantation compared with patients who had single organism or culture-negative infections. Another study found that patients with mixed flora during first-stage resection had a greater likelihood of persistent infection

Table 3
Univariate Analysis of Risk Factors for Failure Outcome: Failure of 2-Stage Revision due to Reinfection (Total 61 Patients).

Variable	Failure 2-Stage	No Failure	*P* Value
Age			
<60	1	18	.2038
60-70	6	19	
>70	2	15	
BMI			
<30	2	18	.5230
30-40	6	24	
>40	1	10	
Charlson Comorbidity Index			
1-3	2	15	.2511
4-5	1	17	
>6	6	20	
Previous 2-stage			
Yes	2	7	.6094
No	7	45	
Race			
White	9	49	.4599
Non-white	0	3	
Gender			
Male	7	30	.2548
Female	2	22	
Host grade			
A	3	21	.4730
B	2	18	
C	4	13	
Extremity grade			
2	7	43	.6595
3	2	9	
Resistant strain			
Yes	3	15	.7852
No	6	37	
Smoking: current vs non			
Yes	0	2	1.0000
No	9	50	
CRP			
0-3	4	28	.7242
>3	5	24	
Joint: hip vs knee			
1	7	40	1.0000
0	2	12	
Prior resection			
Yes	**4**	**6**	**.0323**
No	**5**	**46**	
ER or clinic			
Clinic	9	44	.5911
ER	0	8	
Number of organisms on culture			
2	**6**	**6**	**.0010**
1 or 0	**3**	**46**	

Bold indicates the significance of *P* value <.05. BMI, body mass index; CRP, C-reactive protein; ER, emergency room.

Table 4
Univariate Analysis of Risk Factors for Failure Outcome: Alive vs Deceased (Total 89 Patients).

Variable	Deceased	Alive	*P* Value
Age			
<60	3	28	.6065
60-70	5	27	
>70	5	21	
BMI			
<30	7	25	.0848
30-40	6	32	
>40	0	19	
Charlson Comorbidity Index			
1-3	**1**	**26**	**.0040**
4-5	**3**	**24**	
>6	**9**	**26**	
Previous 2-stage			
Yes	2	16	1.0000
No	11	60	
Race			
White	11	2	
Non-white	72	4	
Gender			
Male	8	42	.6735
Female	5	34	
Host grade			
A	**2**	**29**	**.0160**
B	**10**	**24**	
C	**9**	**15**	
Extremity grade			
2	12	53	.0605
3	9	15	
Resistant strain			
Yes	6	23	.6535
No	15	45	
Smoking: current vs non			
Yes	3	3	.1406
No	18	65	
CRP			
0-3	12	37	.8259
<3	9	31	
Joint: hip vs knee			
1	12	50	.1533
0	9	18	
Prior resection			
Yes	6	15	.5640
No	15	53	
Presentation: ER or clinic			
Clinic	17	57	.7462
ER	4	11	
Number of organisms on culture			
2	8	15	.1423
1 or 0	13	53	

Bold indicates the significance of *P* value <.05. BMI, body mass index; CRP, C-reactive protein; ER, emergency room.

after 2-stage exchange [18]. Multiorganism infections are more difficult to treat as these organisms contribute to biofilm formation and the selected antibiotics may not be effective toward all the organisms in the infection [8]. Of particular interest in this study was that methicillin-resistant organisms were not found to be a risk factor for failure to obtain an infection-free reimplantation. Similarly, methicillin-resistant, coagulase-negative *S aureus* was not found to be an independent risk factor for failure ($P = .85$). The findings of the present study are in agreement with those of Wang et al [5] that did not find resistant organisms to be a risk factor for 2-stage failure after multivariate analysis. These results are in contrast to other studies specifically looking at MRSA as a risk factor for failure of PJI treatment [19,20]. It is possible that our study was underpowered to isolate antibiotic resistance as a risk factor. It is also possible that MRSA status was covariate with other important risk factors for failure, so its independent effect was impossible to parse out. Prior reports have described culture-negative infections to be associated with failure of 2-stage revision for PJI, but we also did not identify an association ($P = .78$) [11,21].

Of the 68.5% (61/89) of patients who completed the staged protocol, 85.2% (52/61) were free from septic failure with an average study follow-up of 56 months. This number is within the range of success rates published in other studies [5,11,22–27], including a recent study by Wang et al [5] reporting a 78.2% success rate in their cohort of 376 patients at 2-year follow-up. We identified several variables associated with failure due to infection after reimplantation: prior resection, CKD, CVD, and presence of multiorganism infection. Risk factors for failure of 2-stage exchange identified in previous studies include nicotine abuse, McPherson host stage, diabetes, BMI > 30, liver disease, organism type, prior resection, previous revision surgery, and operative time >4 hours [5,13,18,23,28]. In our study, the following variables showed no association with our 3 definitions of failure: age, gender, BMI, ethnicity, emergency room vs clinic referral, CRP, methicillin-resistant organisms, and insurance type. In this retrospective series, it is difficult to isolate all variables that influence outcome, including the various techniques and protocols of the different surgeons.

The mortality rate in this study was 23.6% (21/89) during the follow-up period. We observed a relatively high mortality rate in this study of 23.6% with an average follow-up of 56 months. The mortality rate in this study likely underestimates the true mortality rate of patients after first-stage resection for chronic PJI, as we only included patients with a minimum of 2-year follow-up for our study. Therefore, patients who were deceased before 2-year follow-up would not have been included. This rate is comparable to a recent study on patients undergoing initial 2-stage revision for total knee arthroplasty PJI, reporting 11% mortality rate at 2 years, but increasing to 45% by 15-year follow-up [7]. Risk factors meeting statistical significance for death in our study were host grade and CCI. In our study, patients who were McPherson host grade C at the time of resection had a 37.5% (9/24) mortality rate. Patients should be counseled that high CCI and host grade are associated with increased mortality rate after resection arthroplasty for PJI. Further research is required to determine all of the factors associated with mortality after 2-stage revision for chronic PJI and whether certain interventions can improve survival of patients with PJI.

There were several notable limitations to this study. First, this was a retrospective study and the data collected reflect what was recorded in medical records. Some patients may have had incomplete or missing data and it is possible that complete data would have revealed additional risk factors for our outcome studies. Another limitation is the relatively small sample size. Eighty-nine patients met inclusion and avoided exclusion criteria with a minimum of 2-year follow-up. The limited sample size from one institution may limit the ability to translate these results to other institutions. The specific treatment strategies including aspects such as dosing of antibiotics in cement, type of antibiotic spacer, and postoperative rehab differed among the 4 surgeons in this study and was not clearly stated in some patients. We did not observe any failure outcome differences among surgeons and could not make any conclusions as to specific protocols that resulted in different failure rates. Furthermore, while we did have a 2-year minimum follow-up in this series, the average follow-up of only 56 months is not long enough to capture long-term failure rates in these patients including rates of aseptic loosening, or even late PJI that has been reported in other studies as far as 15 years status post 2-stage revision [7]. The mortality rate in this study likely underestimates the true mortality rate of patients after first-stage resection for chronic PJI, as patients who were deceased before our minimum 2-year follow-up would not have been included. We chose to only include patients with a minimum of 2-year follow-up as this has become the gold standard for orthopedic outcome

studies, understanding that some patients who were deceased before 2-year follow-up would not be included. We believed including these patients in our relatively small cohort would skew our risk factor analysis to favor variables associated with mortality, a secondary outcome in our study rather than our primary outcome of failure to achieve an infection-free 2-stage revision. Finally, this study aimed to identify rates and risk factors for failure outcomes and did not include patient-reported or clinical outcomes.

Conclusions

In summary, we found that only 68.5% of patients with chronic hip or knee PJI complete the planned 2-stage protocol. For those patients who successfully completed the protocol, the cumulative reinfection rate was 15% at almost 6 years. McPherson extremity (grade 3), prior resection, and multiorganism infections were independent predictors for failure to achieve an infection-free 2-stage revision.

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