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Failure of Irrigation and Débridement for Early Postoperative Periprosthetic Infection

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Abstract

Background Irrigation and débridement (I&D) of periprosthetic infection (PPI) is associated with infection control ranging from 16% to 47%. Mitigating factors include organism type, host factors, and timing of intervention. While the influence of organism type and host factors has been clarified, the timing of intervention remains unclear.

Questions/Purposes We addressed the following questions: What is the failure rate of I&Ds performed within 90 days of primary surgery? And what factors are associated with failure?

Methods We performed a multicenter retrospective analysis of I&D for PPI within 90 days of primary surgery. We included 86 patients (44 males, 42 females) with an average age of 61 years. Failure was defined as return to the operating room for an infection-related problem. We determined the failure rate of I&D within 90 days of primary surgery and whether the odds of rerevision for infection were associated with Charlson Comorbidity Index, age, sex, joint, organism type, and timing. The minimum followup was 24 months (average, 46 months; range, 24–106 months).

Results 54 of 86 patients (63%) failed. Eight of 10 (80%) failed within the first 10 days, 32 of 57 (56%) within 4 weeks, and 22 of 29 (76%) within 31 to 90 days postoperatively. No covariates were associated with subsequent revision surgery for infection.

Conclusions I&D for PPI is frequently used in the early postoperative period to control infection. While it is assumed early intervention will lead to control of infection in most cases, our data contradict this assumption.

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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.
Data were collected at each institution. Data analysis was conducted at OrthoCarolina Research Institute, Charlotte, NC, USA.

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

Introduction

Periprosthetic infection (PPI) is a devastating complication of arthroplasty. While a variety of treatment options is available, irrigation and débridement (I&D) is a frequently utilized option despite rates of failure of 53% to 84%, depending in part on the definition of failure (Table 1). It is not difficult to understand why such use of I&D persists given the emotional investment in dealing with this complication by both patient and surgeon. Therefore, an attempt to "save the implant" through I&D appears well intentioned despite an overall reported failure rate via meta-analysis of 68% [37]. While high failure rates have been consistently reported, the literature has also clarified its inability to control chronic infections (100% failure rate) [10], infections caused by resistant organisms (89% failure rate) [4], and even infections from susceptible organisms such as *Streptococcus* (69% failure rate) [30]. Perhaps the most compelling evidence to discourage its use is a 34% failure rate of two-stage reimplantation after a failed I&D [36].

An exception may be the use of I&D in the early postoperative period. An early postoperative PPI has been defined as one that occurs in the first 4 weeks postoperatively [41]. In contrast to other categories of PPI, the date of inoculation is well defined and early postoperative I&D should improve infection control because intervention may occur before the establishment of drug-resistant biofilm on the implant or before osteomyelitis becoming entrenched in periprosthetic bone. While one might assume early intervention would control the infection, the reported rates of failure to control infection vary from 0% to 79% in small series (Table 2).

We therefore posed the following questions: What is the failure rate of I&Ds performed (1) within 3 months, (2) within 30 days, and (3) between 31 days and 90 days of the primary surgery? And (4) what factors are associated with failure?

Patients and Methods

We performed a multicenter retrospective review of all 95 patients undergoing an I&D for a PPI after total joint arthroplasty within 90 days of the index arthroplasty between March 1995 and July 2009. Cases were identified by queries of institutional practice management systems and prospective total joint registries. To minimize selection bias, patients with less than 2-year followup were contacted by mail and/or telephone a minimum of three times before categorized as lost to followup. We included patients diagnosed with a PPI within 3 months of the primary arthroplasty treated with an I&D with or without a polyethylene exchange. We excluded patients who underwent I&D after revision surgery, underwent index arthroplasty at

Table 1. Failure of open irrigation and débridement for periprosthetic knee infection (acute, chronic, and perioperative)

Study	Number of failures/patients	Definition of failure	Resistant organisms
Hartman et al. [17] (1991)	20/33 (61%)	ROI with prosthesis removal	NR
Schoifet and Morrey [34] (1990)	24/31 (77%)	ROI	26%
Burger et al. [6] (1991)	32/39 (82%)	Clinical or radiographic signs of infection	18%
Deirmengian et al. [12] (2003)	20/31 (65%)	ROI	15%
Teeny et al. [40] (1990)	15/21 (71%)	ROI	NR
Rand [32] (review) (1993)	267/377 (71%)	ROI	NR
Bradbury et al. [4] (2009)	16/19 (84%)	Subsequent infection at surgery	100%
Marculescu et al. [26] (2006)	53/99 (53%)	ROI	2%
Silva et al. [37] (2002)	357/530 (67%)	ROI	NR
Brandt et al. [5] (1997)	21/33 (64%)	ROI (same organism strain)	3%
Ivey et al. [18] (1990)	7/10 (70%)	Clinical or radiographic signs of infection	NR
Deirmengian et al. [11] (2003)	20/31 (65%)	ROI	15%
Odum et al. [30] (2011)	104/150 (69%)	Subsequent infection at surgery	76%
Total	956/1403 (68%)		

Review of the orthopaedic literature was performed using the PubMed search engine; individual search terms included total knee infection, total knee débridement, and total knee two-stage; studies not adhering to the treatment protocol (open irrigation and débridement OR removal of the prosthesis, placement of either static or articulating antibiotic spacer, minimum 4 weeks of intravenous antibiotics, and subsequent reimplantation) and those in languages other than English were excluded from this review; ROI = recurrence of infection; NR = not reported.

Table 2. Failure of open irrigation and débridement procedures performed within 4 weeks of the index arthroplasty

Study	Number of failures/ patients (%)
Aboltins et al. [1] (2007)	1/9 (11%)
Azzam et al. [2] (2010)	21/41 (51%)
Bradbury et al. [4] (2009)	1/9 (11%)
Choi et al. [7] (2011)	4/6 (67%)
Crockarell et al. [10] (1998)	15/19 (79%)
Estes et al. [14] (2010)	0/2 (0%)
Gardner et al. [16] (2011)	5/10 (50%)
Hartman et al. [17] (1991)	3/11 (27%)
Ivey et al. [18] (1990)	1/2 (50%)
Klouche et al. [22] (2011)	0/2 (0%)
Koyonos et al. [24] (2011)	36/52 (69%)
Krasin et al. [25] (2001)	2/7 (29%)
Mont et al. [28] (1997)	0/10 (0%)
Rasul et al. [33] (1991)	4/6 (67%)
Segawa et al. [35] (1999)	5/10 (50%)
Tsukayama et al. [41] (1996)	10/35 (29%)
Van Kleunen et al. [42] (2010)	5/13 (38%)
Wasielewski et al. [43] (1996)	2/8 (25%)
Total	159/288 (55%)

These early postoperative cases were extracted from larger reported series that may have included a longer duration of time between the index arthroplasty and the open irrigation and débridement procedure.

an outside institution, and were infected with multiple or unidentified organisms. Of the 95 patients, seven patients died after 2 years with adequate clinical followup. Nine (9.5%) patients had inadequate data at 2 years and were categorized as lost to followup. Therefore, the final data set included 86 patients. Of these 86 patients, there were 44 males (51%) and 42 females (49%). The average age at the time of I&D procedure was 61 years (range, 17–89 years). Forty-six of the 86 cases (53%) were knees and 40 (47%) were hips. The majority of cases included a liner exchange (98% of knees, 71% of hips). The minimum followup was 24 months (mean, 46 months; range, 24–106 months). Each of the seven participating centers obtained institutional review board approval.

Prophylactic antibiotics were the standard of care at the time of the index arthroplasty at our institutions. Generally, a first-generation cephalosporin was used. Vancomycin was used if a penicillin allergy was present. The initial infection was diagnosed from a variety of laboratory assessments obtained preoperative to the I&D. These diagnostic laboratory tests included C-reactive protein values, erythrocyte sedimentation rate, synovial fluid analysis, and cultures. Gross purulence within the joint was documented and intraoperative histologic sections were analyzed for acute inflammation. Therefore, diagnostic protocols varied across institutions. Additionally, there was no standard surgical technique implemented for the I&D procedure or uniform postoperative antibiotic treatment regimes across centers due to the retrospective design.

Postoperative clinical followup varied slightly across centers. Patients returned to the clinic for a clinical and radiographic examination within 2 to 3 weeks after the index, primary arthroplasty procedure. Subsequent followup visits occurred between 2 and 3 months after the arthroplasty. Any patient with a wound problem identified by a physical therapist or home health professional was promptly examined by the surgeon.

We reviewed total joint registries and electronic health records at each institution to document sex, age at the date of the I&D, and age-adjusted Charlson Comorbidity Index (CCI). The dates of the index arthroplasty, I&D procedure, revision surgery, followup visit, and mortality were recorded. Causative organism at the time of the I&D procedure and any revision procedure were recorded and verified by pathology reports. The Social Security Death Index was used to validate mortality. The primary outcome variable was success or failure of the I&D procedure. Success was defined as no subsequent operative procedure to treat a PPI. Failure was defined as any subsequent operative procedure to treat a PPI of the same joint with any infecting organism or with the same infecting organism. Additional variables collected included sex, age, age-adjusted CCI, causative organism, and timing of the I&D. As with any retrospective analysis, there were missing data points. Two patients were missing age-adjusted CCI and one patient was missing the type of infecting organism. We did not believe it was necessary to perform any data imputations or to exclude these patients from the total analysis.

To determine the failure rates within each of the three defined time periods of 3 months, 30 days, and 31 to 90 days, proportions were calculated. To determine what independent factors were associated with failure, the dependent variable, a bivariate analysis was used. For the bivariate analyses, each factor was defined as a discrete category. Age was collapsed into two age groups: 65 years or younger and older than 65 years. Age-adjusted CCI was also collapsed into two categories: CCI of 1 to 3 and CCI of 4 or more. Timing of the I&D procedure was categorized as 30 days or less and between 31 and 90 days. The specific causative organisms were categorized as susceptible *Staphylococcus,* resistant *Staphylococcus,* and other. The category of other was used for any specific organism type with a frequency of seven or less. Chi square tests were then used to determine differences in proportions of failure between each categorical and/or dichotomous variable. A multivariate analysis using a multiple logistic regression model was used to determine whether failure was

associated with age, sex, CCI, organism, joint, and timing of I&D. To assess associations between the dependent variable failure and the independent factors, odds ratios and 95% CIs were calculated. We performed all statistical analyses using SAS® Version 9.2 (SAS Institute, Inc, Cary, NC, USA).

Results

Of the 86 patients who underwent I&D within 90 days of primary surgery, 54 (63%) required reoperation for infection at an average of 7.2 months postoperatively (range, 0.1–109 months). Twenty-nine (54%) of these 54 failures were reinfected with the same organism and 17 (31%) were reinfected with a different organism. The causative organism was unknown for three failure cases and laboratory assessments indicated no growth for the remaining five failure cases.

Of the 57 patients (27 hips, 30 knees) who underwent I&D within 30 days of primary surgery, 32 (56%) required reoperation for infection at an average of 7.2 months (range, 0.1–62 months). Nineteen of these 32 (59%) failures were reinfected with the same organism, nine were reinfected with a different organism, and four were either unknown or no growth.

Of the 29 patients (13 hips, 16 knees) who underwent an I&D within 31 to 90 days of primary surgery, 22 (76%) failed. Ten of these 22 (45%) failures were reinfected with the same organism, eight were reinfected with a different organism, and four were either unknown or no growth. Of the 10 patients who underwent I&D within 10 days of primary surgery, eight (80%) failed. Four of these failures were reinfected with the same organism, one was infected with a different organism, and three were either unknown or no growth.

We found no difference ($p = 0.08$) in proportions of failures with respect to timing of the I&D procedure (Table 3) (30 days or less versus 31 to 90 days). While I&Ds performed within 30 days of the primary surgery had a 64% lower odds of failure (odds ratio, 0.36; 95% CI, 0.12–1.04) compared to those cases performed between 31 and 90 days (Table 4), eight of 10 patients (80%) who underwent I&D within 10 days of primary surgery were subsequently revised for infection. The type of causative organism was not associated with failure in the bivariate analysis (Table 3) or the multivariate analysis (Table 4). The failures for nine specific infecting organisms are shown (Table 5). Of the 41 patients treated for infection due to a susceptible staphylococcal organisms, 26 (63%) failed. Of the 22 resistant staphylococcal infections, 14 (61%) failed. Of the 10 streptococcal infections, six (60%) failed. Host health did not make a difference in the failure rate in either the bivariate (Table 3) or multivariate (Table 4) analyses. The failure rate for patients with an age-adjusted CCI of 0 was 57% (16 of 28). Patients with an age-adjusted CCI of 1 to 3 had failure rates similar to those with a CCI of greater than 4. Of the 33 patients with a CCI of 1 to 3, 22 (67%) failed. Of the 25 patients with a CCI of greater than 4, 16 (64%) failed. Additionally, patient age, sex, and type of joint treated for infection were not associated with failure.

Table 3. Success and failure rates

Variable	Frequency		p value
	Success	Failure	
Age			0.697
0–65 years	20 (36%)	36 (64%)	
> 65 years	12 (40%)	18 (60%)	
Sex			0.052
Female	20 (48%)	22 (52%)	
Male	12 (27%)	32 (73%)	
Charlson Comorbidity Index			0.594
0	12 (43%)	16 (57%)	
1–3	11 (33%)	22 (67%)	
> 4	9 (36%)	16 (64%)	
Organism			0.833
Susceptible *Staphylococcus*	15 (37%)	26 (63%)	
Resistant *Staphylococcus*	8 (36%)	14 (64%)	
Other	9 (39%)	14 (61%)	
Joint			0.959
Hip	15 (37.5%)	25 (62.5%)	
Knee	17 (37%)	29 (63%)	
Timing			0.075
0–30 days	25 (44%)	32 (56%)	
31–90 days	7 (24%)	22 (76%)	

Discussion

I&D is a time-honored procedure when dealing with orthopaedic surgical-site infections. Unfortunately, the ability of this treatment option to control arthroplasty-related infections is unsatisfactory in more than 2/3 of patients (Table 1). An exception to this low rate of infection control may be the use of I&D in the early postoperative period. With this study, we sought to determine the failure rate of I&D performed within 3 months of index surgery and the factors associated with failure.

We recognize the limitations to this observational multicenter retrospective review. First, we included multiple surgeons using a variety of surgical techniques and diagnostic protocols. Second, each institution had different infectious disease consultants managing the post-I&D

Table 4. Results of logistic regression

Variable	β coefficient	Standard error	Wald χ^2	p value	Odds ratio	95% CI
Age						
> 65 years versus 0–65 years	0.070	0.528	0.018	0.894	1.073	0.381–3.018
Sex						
Female versus male	−0.475	0.250	3.606	0.058	0.387	0.145–1.031
Organism						
Susceptible *Staphylococcus* versus other	0.138	0.581	0.056	0.813	1.148	0.367–3.586
Resistant *Staphylococcus* versus other	0.482	0.674	0.511	0.475	1.619	0.432–6.071
Charlson Comorbidity Index						
1–3 versus 0	0.495	0.574	0.743	0.389	1.640	0.533–5.050
> 4 versus 0	0.350	0.628	0.311	0.577	1.420	0.414–4.862
Timing						
≤ 30 days versus 31–90 days	−0.517	0.274	3.565	0.059	0.356	0.122–1.040
Joint						
Hip versus knee	0.032	0.245	0.017	0.896	1.066	0.409–2.779

Table 5. Results by type of organism

Organism	Frequency		Time to revision (months)*
	Success	Failure	
Susceptible *Staphylococcus*	15 (37%)	26 (63%)	7.33 (0.23–62.43)
Resistant *Staphylococcus*	8 (36%)	14 (64%)	3.21 (0.1–15.42)
β-hemolytic *Streptococcus*	2 (29%)	5 (71%)	18.94 (0.13–109.18)
Non-β-hemolytic *Streptococcus*	2 (67%)	1 (33%)	26.76
Enterobacteriaceae	1 (25%)	3 (75%)	1.02 (0.36–2.24)
Enterococcus	2 (40%)	3 (60%)	2.78 (0.43–6.90)
Pseudomonas	2 (100%)	0 (0%)	NA
Acinetobacter baumannii	0 (0%)	1 (100%)	0.69
Diptheroids	0 (0%)	1 (100%)	0.30

* Values are expressed as mean, with range in parentheses; NA = not applicable.

antibiotic regimes. Therefore, these antibiotic regimes varied considerably across centers and over time. Third, since failure was only defined as a return to the operating room for an infection-related problem, this definition may underestimate the number of clinical failures and overestimate the success rate. Patients doing poorly clinically without a return to the operating room, patients on suppressive antibiotics, or those with limited followup who might recur later beyond the study period would be considered a success, given our definition of failure. Despite these limitations, we believe our study contributes to the body of knowledge and clarifies the limited efficacy of I&D even for the treatment of early postoperative PPI.

Our subsequent study questions relate to the timing of I&D in early postoperative infection. We theorized early intervention before the establishment of resistant biofilm or osteomyelitis becoming entrenched in the bone may improve the rate of infection control; that is, the sooner the I&D was performed relative to the index arthroplasty, the greater the likelihood of controlling the infection would be. It is important, however, when reviewing the I&D literature to break out those patients who are débrided in the first 30 days from their primary surgery. This group has been characterized as an "acute" perioperative infection by Tsukayama et al. [41] to distinguish these cases from those chronic infections or acute hematogenous infections under the assumption that the ability to control infection would differ. While many of the reports (Table 2) have a limited number of patients in this category, the mean findings from the study of these patients are not dissimilar from those reported here, 56% versus 58%. Recently Kim et al. [20, 21] in two different studies reported on perioperative I&D with much different rates of infection control: 109 of 128 hips (85%) and 27 of 32 knees (84%) were treated

successfully with a perioperative I&D. We have no explanation for the difference between these results and those reported here and in the majority of the literature. The fact that only 56% of patients undergoing I&D in the first month after index surgery failed compared to a 76% failure rate in the second and third months initially led us to believe such early intervention in the first month may have prognostic importance. However, 80% of those patients undergoing I&D in the first 10 days after index surgery also failed, tempering such an assumption.

We attempted to determine factors associated with the failure of I&D in the early postoperative period to control PPI. The CCI has been correlated with major complications in revision surgery [23], and we expected this index to affect our findings. We were surprised to find host health (as reflected in the CCI) did not affect the rate of infection control and found no correlation between type of organism and infection control. Sensitive *Staphylococcus,* resistant *Staphylococcus*, and *Streptococcus* organisms failed 63%, 61%, and 60% of the time, respectively. These findings are consistent with the previous report from our centers, which found similar failure rates regardless of organism type [30].

While a reported failure rate of any surgical procedure would be called into question if it failed 2/3 of the time, the use of I&D to treat an arthroplasty-related infection persists. This is probably related to the perceived radical option of implant removal in two-stage reimplantation to achieve control of the infection. While host factors and virility of the organism may play some role, the inability of parenteral antibiotics to penetrate the glycocalyx biofilm layer embedded on the implant may be the primary reason for the failure of this treatment option.

Biofilms are complex microbial communities containing bacteria that attach to a prosthetic surface. Structurally, they consist of bacteria embedded in a layer of sugars and proteins that protect the microorganisms from external threats [31]. Biofilms tend to form in stages. In the first stage, free-floating planktonic bacteria attach to the implant. Subsequently, the bacteria multiply, become more firmly attached, and differentiate by changing gene expression patterns to promote survival [13, 15, 31]. Once firmly attached, the bacteria secrete a protective matrix known as extracellular polymeric substance [31, 38]. Fully matured biofilms continuously shed bacteria, which can disperse and attach to other parts of the implant [9, 13]. The rate at which these biofilms form may affect the success or failure of I&D in PPI. In theory, if one can intervene before the biofilm becomes firmly attached to the implant, this treatment modality may be successful. Unfortunately, this window of opportunity is extremely short and may explain our observations. Free-floating planktonic bacteria typically attach to the implant within minutes and form strongly attached microcolonies within 2 to 4 hours. They develop a protective extracellular matrix within 6 to 12 hours, evolving into fully mature biofilm colonies that shed planktonic bacteria within 2 to 4 days. At this point, these mature biofilm colonies are extremely resistant to biocides such as antibiotics, antiseptics, or disinfectants and to inflammatory cells from the immune system [3, 8, 31]. After mechanical disruption by débridement, biofilms rapidly reform within 24 hours.

Given this information, the option of serial débridement may have a place in patients with early postoperative infection. In a few small studies with limited followup, the rates of infection control with and without antibiotic beads in the interim periods have been relatively high. Mont et al. [28] treated 10 early postoperative infections, performing multiple I&Ds in seven of the 10 patients. All were successful at limited followup. Estes et al. [14] performed a two-stage retention débridement protocol, leaving antibiotic beads and the prosthesis in place for 7 days before a second débridement. Eighteen of 20 patients were infection free at a mean of 3.5 years. Two of these were early postoperative infections, while 18 of the patients were acute hematogenous cases. Perhaps the repeated disruption of the biofilm layer through a serial débridement strategy led to these improved infection control. However, the mechanical disruption of biofilms can only be accomplished on the surface of the implant, leaving those areas behind a metallic implant or buried within the bone inaccessible to this treatment method.

Other strategies that may be effective are the use of intrawound vancomycin powder [39], resorbable antibiotic-impregnated calcium sulfate beads [27], or disinfecting detergents [29]. While these options have some theoretical advantages, their ability to penetrate and rid the implant of biofilm and their long-term efficacy in early postoperative infections remain to be demonstrated. In contrast, two-stage reimplantation even for an early postoperative infection should be considered based on its predictable, consistent results. Historically, this treatment protocol is successful 85% to 95% of the time [19]. Theoretically, if this two-stage procedure is performed perioperatively before bacteria become entrenched in the periprosthetic bone, the rate of infection control may be even better than those reported.

In conclusion, I&D for PPI after joint arthroplasty is a frequently used procedure in the early postoperative period to control infection. It is assumed early intervention will lead to such control in the majority of patients. Unfortunately, our findings are similar to those for I&D reported in the literature. The data suggest the ability of I&D to control infection even in the early postoperative period is limited.

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