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Failed Two-Stage Exchange: Factors Leading to Unachievable Endoprosthetic Reconstruction After Multiple Revision Surgeries

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ABSTRACT

Background: Information about the outcome after failed 2-stage exchange is scarce. The aim of this study is to determine possible influencing factors leading to multiple revisions, resulting in a failed endoprosthetic joint reconstruction.
Methods: Medical records of patients (15 hip and 29 knee joints) who had undergone additional revision surgeries due to a failed 2-stage exchange were reviewed concerning infection parameters, number and type of procedure(s), current state of the revised joint, and whether failure of endoprosthetic reconstruction had occurred.
Results: Endoprosthetic reconstruction was achieved in 52.3% ($n = 23$) of the patients. About 36.4% ($n = 16$) of patients successfully reached the second stage of the initial 2-stage exchange. Half of the patients ($n = 22$) had to undergo spacer exchange in the initial interstage period. Five or more revision surgeries significantly increased the odds of failure of endoprosthetic reconstruction compared to patients with <5 revision surgeries (odds ratio 4.98, 95% confidence interval 1.34-18.4, $P = .016$). Patients with initial culture-negative revision surgery showed no significant differences in the odds of failure of endoprosthetic reconstruction (odds ratio 0.69, 95% confidence interval 0.20-2.43, $P = .567$).
Conclusion: Patients undergoing re-revision surgery due to a failed 2-stage exchange are very likely to ultimately experience a failed endoprosthetic reconstruction. The identification of the underlying pathogen does not influence the likelihood of a better outcome in terms of a successful endoprosthetic reconstruction.

Periprosthetic joint infections (PJIs) represent one of the major complications after total joint arthroplasty [1] and have a vast impact on a patient's quality of life, with the possibility of recurrent revision surgeries and long-term administration of antibiotics and prolonged periods of hospitalization [2,3]. A 2-stage exchange represents the current gold standard with success rates of approximately 90% [4–6]. Nevertheless, recent evidence suggests that these success rates have been overestimated due to the noninclusion of possible failure cases between the first and second stages [7]. Other treatment strategies involve 1-stage exchange or irrigation, debridement, and liner exchange with the retention of the prosthesis [8]. Only few studies have reported the outcome after failed septic revision due to persistent or new infections in re-revision cases [9–11]. The risk factors for multiple septic revisions involve female gender, heart diseases, and psychiatric disorders [10]. A substantial amount of patients with recurrent infections have to undergo multiple revision surgeries, ultimately resulting in resection arthroplasties, amputations, or arthrodeses with poor outcomes [12]. Kheir et al [12] demonstrated a success rate after failed 2-stage exchanges between 43% and 62% depending on the subsequent treatment strategy. The question is which factors lead to an increased risk of failed endoprosthetic joint reconstruction and limb salvage in patients with failed 2-stage exchange.

Therefore, we designed a retrospective study protocol to observe the clinical course and outcome, as well as the microbiological characteristics of patients with subsequent revisions after 2-stage exchange in total joint arthroplasty.

The purpose of this study is to determine the possible influencing factors leading to multiple revisions that may eventually

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result in a failed endoprosthetic joint reconstruction. We hypothesized that an increased number of re-revision surgeries leads to an increased probability of failure of endoprosthetic joint reconstruction.

Patients and Methods

After receiving the approval of the local ethics committee, medical records of patients who underwent a 2-stage exchange after total hip arthroplasty (THA) and total knee arthroplasty (TKA) in the period between 2000 and 2015 were retrospectively reviewed. From a total of 332 patients who underwent a 2-stage procedure, 44 patients (13.3%; 15 THAs and 29 TKAs) had to undergo additional revision surgeries due to a failed 2-stage exchange. Patients with a minimum follow-up of 24 months or a PJI-related mortality ($n = 4$) were included. Compromising host factors identified in the included patients were classified using the classification system by McPherson et al [13]. Patients with no compromising factors were classified as Systemic Host Grade A, patients with 1 or 2 compromising factors were assigned to Systemic Host Grade B, and patients with 3 or more compromising factors were classified as Systemic Host Grade C. Table 1 exemplifies the basic demographics of all the patients included in this study.

PJI was suspected preoperatively by the presence of leukocytosis, elevated C-reactive protein levels, pain, swelling, local erythema, and warmth. PJI was verified intraoperatively by positive microbiology and/or positive histopathological findings.

When an interim spacer was implanted, antibiotic bone cement containing 0.5 g gentamycin and 2 g vancomycin per 40 g bone cement (COPAL G+V 40; Heraeus, Wehrheim, Germany) was used. All patients received intravenously administered antibiotics 30 minutes prior to surgery and for at least 4 weeks postoperatively with 10-14 days intravenous administration. If patients were discharged before reimplantation, the antibiotics were switched to orally administered options in accordance with prior consultation with our specialist for infectious diseases. Reimplantation was planned following a minimum of 4 weeks from the date of explantation. During this interstage period, C-reactive protein level and leukocyte level were examined on a regular basis. If no constant decrease in those laboratory parameters was found or any clinical signs of persistent infection (pain, swelling, seromae) were present, joint aspiration was performed and a spacer exchange was planned instead of reimplantation. After reimplantation all patients received intravenous antibiotics for at least 7 days, which were then changed to oral antibiotics. These antibiotics were then administered for a period of time ranging from 21 days up to 5 weeks.

All the patients' medical records were reviewed for the aforementioned infection parameters, number and type of procedure, and current state of the revised joint. Additionally, it was recorded whether a failure of endoprosthetic reconstruction occurred. Failure of endoprosthetic reconstruction was determined as amputation, permanent resection arthroplasty (eg, Girdlestone situation), arthrodesis, or spacer retention due to recurrent/persistent infection.

Table 1
Demographics of All Patients Included in This Study.

Demographic Variable	Hip Joint	Knee Joint
Included patients ($n = 44$)	$n = 15$	$n = 29$
Sex	Male: 46.7% ($n = 7$) Female: 53.3% ($n = 8$)	Male: 69% ($n = 20$) Female: 21% ($n = 9$)
Age	Mean: 65.8 y (range 50-84)	Mean: 65.6 y (range 42-83)
Systemic host factor (McPherson et al)	*A*: 13.3% ($n = 2$) *B*: 53.3% ($n = 8$) *C*: 33.3% ($n = 5$)	*A*: 13.8% ($n = 4$) *B*: 82.8% ($n = 24$) *C*: 3.4% ($n = 1$)

Statistical Analyses

To evaluate potential differences of the scrutinized parameters in the study group and the control group, 2-sample *t*-tests for numerical variables, and chi-square and Fisher's exact test for binary variables were applied. The odds ratios (OR) were calculated to compare the risk of failure of endoprosthetic joint reconstruction with an increasing number of re-revision surgeries.

For all statistical analyses, a *P*-value of .05 was considered as statistically significant. All statistical calculations were performed using SPSS software version 23.0 (SPSS Inc, Chicago, IL).

Results

From the 44 included patients with a failed 2-stage exchange, it was possible to achieve endoprosthetic reconstruction in 52.3% ($n = 23$) of cases (Fig. 1, Table 2) at the end of the observational period (mean follow-up 56.3 months).

In 36.4% ($n = 16$) of the patients it was possible to perform the consecutive reimplantation during the initial 2-stage exchange. Successful endoprosthetic reconstruction could be maintained in 12 of these 16 patients even though all had to undergo further revision surgeries.

Twenty-two patients (50%) had to undergo spacer exchange during the interstage period. Successful endoprosthetic reconstruction was achieved in 10 of these patients with initial interstage spacer exchange.

About 6.8% ($n = 3$) of the patients were initially treated by irrigation & debridement with spacer retention due to suspected early superficial wound infection. Ultimately, one of these patients reached successful reimplantation, whereas the other 2 patients were considered as failed endoprosthetic reconstructions (1 amputation, 1 Girdlestone situation).

For a further 6.8% ($n = 3$) of the patients the spacer was removed leaving a dead space/Girdlestone situation. Even though all these patients underwent further surgeries, endoprosthetic reconstruction could not be achieved (1 retained spacer, 1 amputation, 1 Girdlestone situation).

In 2 of the patients positive histological results following reimplantation were attained and oral suppressive antibiotics were subsequently administered for 4.5 and 8 months, respectively. One of these patients needed additional surgery but it was possible to maintain endoprosthetic reconstruction. The other patient died due to multiple organ failure.

Throughout the cohort, an average number of 5.2 (range 3-11) re-revision surgeries was observed. No differences in the odds for failed endoprosthetic reconstruction were found between THA and TKA (OR 1.07, 95% confidence interval [CI] 0.31-3.72, $P = .919$).

We found that $\geq$5 revision surgeries (including the initial septic revision surgery) significantly increased the odds for the failure of endoprosthetic reconstruction when compared to patients with $\leq$4 revision surgeries (OR 4.98, 95% CI 1.34-18.4, $P = .016$; Fig. 2). Figures 3 and 4 depict details regarding the current state of the revised joint in relation to the number of revision surgeries. Patients undergoing spacer exchange during the initial 2-stage exchange show significantly higher odds for a failure in endoprosthetic reconstruction when compared to patients who reach the second stage without spacer exchange (OR 4.64, 95% CI 1.19-18.1, $P = .027$). A pathogen was detected in 81.8% (n = 18) of patients who had to undergo spacer exchange during initial interstage period ($n = 22$).