Two-stage revision arthroplasty in the treatment of periprosthetic hip infections with severe bone loss: Results from 182 cases

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Abstract

The optimum treatment for periprosthetic joint infection (PJI) of the hip with substantial bone defects remains controversial. A retrospective assessment was performed for 182 patients treated for PJI with a two-stage protocol from 2005 to 2015. Implant removal and debridement were followed by Girdlestone arthroplasty or spacer implantation. The results of the Girdlestone and spacer groups were compared. There were 71 cases that received spacers, and 111 Girdlestone procedures were performed. After the first stage, 26.37% of cultures were negative, and among patients with a detected pathogen, methicillin-sensitive *Staphylococcus aureus* was the most common organism (41.79%). Acetabular and femoral bone defects, according to the Paprosky classification, were more severe in the Girdlestone group (P<0.05). During the follow-up (mean, 5.95 years), the overall incidence of complications was 21.42%. The mean Harris hip score was significantly lower in the Girdlestone group (68.39 vs 77.79; P<0.0001). The infection recurrence rate reached 8.79%. Despite satisfactory infection control, the number of complications and poor functional outcomes associated with resection arthroplasty indicate the necessity for development of different approaches for patients with advanced bone loss.

Introduction

Infections after hip arthroplasty pose a serious medical problem because they thwart the expected positive outcome of surgical treatment and often prevent successful recovery. Periprosthetic joint infection (PJI) is the third[1] most frequent type of complication after primary hip replacement and is found in approx. 0.3-2.9% [2] of patients who underwent surgery. It is also the second most common cause for revision procedures.[3] Treatment of PJI is aimed at eradicating infection, eliminating pain, and restoring joint function.[4]

There are no randomized clinical trials revealing direct indications or contraindications for using either of the aforementioned methods.[5-18] Comparison of cost and efficacy among specific strategies has proven difficult.[5,6] While the two-stage protocol with spacer implantation remains most widely accepted, the use of a spacer itself may be problematic in patients with poor bone stock and vast bone defects.

Thus, this retrospective study was performed so that the authors can present their experience in the treatment of periprosthetic hip infections with two-stage arthroplasty in a cohort of difficult patients.

Materials and Methods

After receiving institutional review board approval, the institutional registry was consulted to identify patients treated for periprosthetic hip infection at the Orthopaedics Department of the Centre of Postgraduate Medical Education between 2005 and 2015. The database was queried for patients admitted for explantation, followed by revision arthroplasty. The main criteria of eligibility for the study were diagnosed late periprosthetic joint infection and follow-up time of at least 2 years. Late PJI was defined based on major and minor criteria (Table 1) and at least 6 weeks of symptom history. Patients who did not meet the inclusion criteria, and with a history of failed previous two-stage or one-stage septic revisions, were excluded from the cohort. The final number of cases included in the study was 182.

During the first stage, all surgeries were performed from the posterolateral approach. After resection of scars and sinus tracts, and removal of prosthesis with all foreign material, tissue samples from the acetabulum and femoral canal were collected for histopathology and cultures, and radical debridement of inflammatory tissues that were changed or necrotic was performed. Depending on patient status and the condition of soft tissues and bone stock, spacer implantation or resection arthroplasty (Girdlestone procedure) was performed. The implants used were prefabricated, non-articulating, gentamicin-impregnated spacers (Spacer G; Tecres, Verona, Italy) available in 6 sizes (46, 54, and 60 mm heads were available with two stem variants). In cases of the Girdlestone procedure, a local antibiotic was delivered by use of a lyophilized collagen implant impregnated with gentamicin (Collatamp®/ Garamycin®; EUSA Pharma). In all cases, closed suction drainage for 24-48 hours was applied. The postoperative antibiotic therapy protocol included intravenous antibiotic administration for 10-14 days followed by oral antibiotics for another 4 weeks. Initially, the selection of antibiotics was based on previous cultures results (if available) or included combinations of broad-spectrum antibiotics. Empiric therapy was converted to targeted treatment as soon as intraoperative cultures were available. All patients received standard anticoagulation prophylaxis according to current indications. Based on general and local status, patients were encouraged to ambulate within the first 24-48 hours after the surgery.

The presence of clinical improvement combined with negative c-reactive protein

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(CRP, <10 mg/L) and normal erythrocyte sedimentation rate (ESR, <30 mm/h) values were factors that allowed reimplantation. In case of any doubt, preoperative joint fluid aspiration for cultures was performed. As a standard procedure, plain radiograms and computer tomography were performed in order to assess the acetabular and femoral bone loss according to the Paprosky Classification (Table 2). Similarly to 1st stage surgery, a posterolateral approach was used for reimplantation. Before arthrotomy, joint fluid was aspirated for cultures and, in particular cases, for intraoperative Gram-staining. Resection of scar tissue and thorough debridement were mandatory. Once again, tissue samples were obtained for histopathology and cultures.

In the vast majority of cases, cementless implants were used, but the implant type and additional elements (inserts, grafts, and augments) were selected on an individual basis according to existing bone defects. Gentamicin-impregnated collagen implants were additionally utilized with the cementless technique. Extended antibiotic therapy, initially based on cultures obtained in the 1st stage and then on intraoperative material results obtained during reimplantation, was used for 6 weeks. Antibiotics were administered intravenously for 10 to 14 days. Closed suction drainage was used for 24-48 hours after the procedure. Anticoagulation prophylaxis was applied for up to 6 weeks. If possible, patients began ambulation within 24 hours after revision surgery and weight-bearing was modified depending on the revision implant setting. During hospitalization, postoperative CRP monitoring was introduced at 2-day intervals. In cases showing prolonged clinical and laboratory symptoms of an infection, another revision was performed along with hip joint debridement.

Upon completion of the 2nd stage of treatment and resolution of general and/or local complications, secondary revisions were registered. The follow-up schedule consisted of outpatient visits after 6 weeks, 6 months, and then once a year. Additionally, over the first 6 weeks after discharge, infection parameters were monitored every 2 weeks (CRP and ESR). The functional outcome was measured according to the Harris hip score.

The Shapiro-Wilk W test was used to test the normality of distribution. The Wald-Wolfowitz runs test was used to calculate the significance of differences regarding age, number of prior surgeries, and follow-up time between the Girdlestone and the spacer group. The M-L chi-square test was used to compare the overall acetabular and femoral defects, repeated revision rate, and overall complication rate. Other comparisons between the groups were performed using Student's *t*-test for independent samples. Tests results were defined as statistically significant with $P<0.05$. Analyses were performed using Statistica for Windows.

Results

There were 93 women and 89 men in the study group, and the mean age was 61.37 years (range, 18 to 87; SD 13.10 years). The mean follow-up period was 5.95 years (range, 3.92 to 9.26; SD 1.43 years). In the 1st stage surgery, 71 (39.01%) patients received a spacer, and 111 underwent the Girdlestone procedure (60.99%). A total of 153 (84.07%) cases underwent the primary procedure outside our facility, and 29 (15.93%) primary hip replacements were performed in our hospital; 122 patients treated away from our facility underwent multiple revision procedures for the examined hip (range, 1 to 8; mean 1.82), and 151 received extended antibiotic therapy before the 1st stage of the treatment. The mean number of previous procedures was insignificantly lower in the spacer group (1.59 vs 1.96, p=0.248). The average time interval between the primary arthroplasty and the 1st stage of treatment was 2.4 years (range, 48 days to 12 years).

The average interstage interval was 9.2 months (from 26 days to 2.2 years). The extent of acetabular and femoral bone deficiencies according to the Paprosky Classification is presented in Table 2. Of the femoral defects, 59.89% were type IIIA and IIIB. Type IIB and IIC were the most common types among acetabular defects (34.07% and 22.53%, respectively). In general, bone defects were found to be more

Table 1. PJI Diagnosis Criteria.

Major criteria – 1 out of 3 must be met	Minor criteria – 2 must be met
Joint fistula	Hip joint pain after hip replacement
Positive hip fluid culture	CRP levels >10 mg/L and ESR rate >30 mm/h
Intraoperative infection symptoms	

Table 2. Bone defects according to the Paprosky Classification.

Paprosky Defects	In total N=182	Girdlestone Group N=111	Spacer Group N=71	P-Value
Acetabulum				
I	38 (20.88)	5 (4.50)	33 (46.48)	<0.0001
IIA	18 (9.89)	1 (0.90)	17 (23.94)	<0.0001
IIB	62 (34.07)	43 (38.74)	19 (26.76)	0.0935
IIC	41(22.53)	39 (35.14)	2 (2.82)	<0.0001
IIIA	23 (12.64)	23 (20.72)	0 (0.00)	<0.0001
Femur				
I	12 (6.59)	0 (0.00)	12 (16.90)	<0.0001
II	61 (33.52)	18 (16.22)	43 (60.56)	<0.0001
IIIA	95 (52.75)	80 (72.07)	16 (22.54)	<0.0001
IIIB	14 (7.14)	14 (12.61)	0 (0.00)	0.0047

The values are given as the number of cases, with percentage in parentheses.

severe in the Girdlestone group, and the difference was statistically significant for the acetabulum (P<0.001) and femur (P<0.001).

The microorganism profile is presented in Table 3. After completion of the 1st stage of the treatment, cultures were negative in 26.37% of patients. Among patients with detected pathogens, Gram-positive cocci constituted 94.03% of infections, with methicillin-susceptible *Staphylococcus aureus* (MSSA) as most common strain. As 16 cases of intraoperative cultures were found to be positive after the 2nd stage, the infection recurrence rate reached 8.74%. Although it was higher in the Girdlestone group, the difference was statistically insignificant (P=0.5).

Complications and treatment failures, as well as the summary of the patients' characteristics, are presented in Table 4. The overall complication rate was 21.42%. There was a trend towards a higher complication rate within the Girdlestone group (26.13 vs 14.08%; P=0.6). Among 15 reported intraoperative femur fractures, 1 was diagnosed postoperatively and required the revision procedure, and 1 was associated with a patient's death in the early postoperative period. Eleven of 12 dislocations occurred in the Girdlestone group, and 4 of them required repeated revision. The overall revision rate in the study cohort was 9.34%. The revision rate was higher in the Girdlestone group (10.81 vs 7.04%), but the finding was statistically insignificant (P=0.7). There were 6 repeated two-stage procedures and 3 debridement, antibiotics, and implant retention (DAIR) surgeries due to recurrence of infection (in one case, the DAIR procedure was unsuccessful and was followed by a two-stage surgery). The remaining two DAIR procedures were performed due to prolonged wound drainage. The revision rate due to infection recurrence after completion of the two-stage protocol was 4.97% (9/181 - the patient who died during the in-hospital stay was excluded). The mean Harris hip score after 181 patients completed treatment was 71.69 points (fair). The average score was significantly higher in the spacer group (77.79 vs 68.39 pts, P<0.001).

Discussion

Due to the study group's characteristics and the experiences of the authors, two-stage revision allowing bone stock preservation and sufficient time for soft tissue regeneration was the treatment of choice in our institution.

The duration of the interval between the first and second stage, as well as the legitimacy of using spacers, still remain disputable aspects. Time intervals between particular stages ranging from 3 weeks to

Table 3. Microorganism profile.

Pathogen	Number after 1st stage N=134	Number after 2nd stage N=16
S. aureus MSSA	56 (41.79)	4 (25.00)
S. epidermidis	49 (36.57)	7 (43.75)
S. salivarius	0 (0.00)	1 (6.25)
Streptococci	9 (6.72)	0 (0.00)
Enterococci	12 (8.96)	1 (6.25)
Anaerobes	4 (2.99)	0 (0.00)
Mixed flora	4 (2.99)	0 (0.00)
A. baumani	0 (0.00)	1 (6.25)
P. fluorescens	0 (0.00)	1 (6.25)
Micrococcus spp.	0 (0.00)	1 (6.25)

The values are given as the number of cases, with percentage in parentheses.

Table 4. Results and complications following 2nd stage surgery.

Measure	In total N=182	Girdlestone N=111	Spacer N=71	P-Value
Age°	61.37±13.10	62.69±13.91	59.31±11.53	0.1334
Surgeries prior to 1st stage†	1.82±1.30	1.96±1.36	1.59±1.18	0.2479
Follow-up (yrs)†	5.95±1.43	6.04±1.56	5.81±1.18	0.5957
Positive cultures after 2nd stage*	16 (8.79)	11(9.91)	5(6.94)	0.4820
Complications - overall*	39 (21.42)	29 (26.13)	10 (14.08)	0.0595
Intraoperative fractures	15 (8.24)	11(9.91)	4 (5.63)	0.4551
Prosthesis dislocations	12 (6.59)	11 (9.91)	1 (1.41)	0.0514
Repeated revisions*	17 (9.34)	12 (10.81)	5 (7.04)	0.6906
DAIR	5 (2.75)	2 (1.80)	3 (4.23)	0.6095
Two-stage septic revision	6 (3.30)	4 (3.60)	2 (2,82)	0.8921
Revision due to fracture	1 (0.55)	1 (0.9)	0 (0.00)	0.8213
Revision due to dislocation	5 (2.75)	4 (3.60)	1 (1.41)	0.6753
Patient's death	1 (0.55)	1 (0.90)	0 (0.00)	0.8213
Harris hip score°	71.69±9.60	68.39±9.40	77.79±7.48	<0.0001

*The values are given as the number of cases, with percentage in parentheses. °The values are given as the mean ± standard deviation.

9.2 months do not seem to affect the final outcome of the two-stage procedure in the hip.[19,20] Aalirezaie *et al.*[21] concluded that the length of the inter-stage interval (mean of 100.2 days) has no statistical significance in predicting failure of two-stage exchange.

Romano *et al*. emphasized the positive impact of using spacers on the functional outcome of two-stage post-infectious arthroplasties, which is comparable to the results of one-stage revision arthroplasty in aseptic failures.[9] Marczak *et al.* reported a significant difference in terms of functional improvement (according to the Harris hip score) between their spacer and a non-spacer cohort treated with two-stage replacement due to PJI.[24] The same authors reported an infection recurrence rate of 9.2% that was comparable in the two groups.

The use of spacers is also advantageous because of the local release of antibiotics in high, bactericidal concentrations,[15] which may lead to increased systemic antibiotic efficacy and higher rates of eradication,[17] in the two-stage procedure. However, the prolonged use of spacers may lead to spacer dislocation, fractures, bone stock defect progression,[11,12] and possible emergence of bacterial resistance.[13,14] Petis *et al.*[16] reported high complication rates after hip spacer retention. In their study, the estimated cumulative incidence for revision for any reason was 13.4% (95% CI 0%-29.1%) at 1 year and 27.6% (95% CI 0%-51.4%) at 4 years, mainly due to mechanical failures such as component loosening with migration, femoral stem loosening, and spacer dislocation. Additionally, four deaths were recorded during a mean 6-year follow-up.

Wroblewski[22] and Sharma[10] described possible indications for the Girdlestone procedure. Both authors mention inadequate bone stock to be an important factor in decision-making. In addition, a difficult to treat infection may be considered as another indication for resection arthroplasty.[29,30] Besides infections caused by Enterococci, methicillin-resistant *Staphylococcus aureus* and rifampicin-resistant strains, rare cases of fungal PJI may also be included to a difficult to treat group. A systematic review performed by Shoof *et al.*[27] suggests that two-stage revision may be considered the gold standard in the treatment of fungal PJI. In the majority of analyzed studies, resection arthroplasty was performed as the first stage of the treatment.

In the trial group, the mean time interval between stages was 9.2 months, which resulted because there are a limited number of facilities capable of treating periprosthetic infections in Poland. Additionally, advanced acetabular and femoral defects before the 2nd stage according to the Paprosky classification (Table 2) reflect significant bone stock deficiencies in the cohort. The predicted prolonged time to reimplantation combined with substantial bone defects might have led to mechanical complications associated with the use of spacers and resulted in the Girdlestone procedure becoming the treatment of choice in our institution.

Reports from European facilities list coagulase-negative Staphylococci (30-43%) followed by *S. aureus* (12-23%) as the most frequent causes of periprosthetic infections. The incidence of mixed infections is estimated at 10-11%, whereas in 10-30% of cases, the culture results are negative.[7,8] The data presented in the current study indicating MSSA as the most common etiological agent are better correlated with reports from facilities in the USA.[7,23] At the same time, the administration of antibiotics in suspicion of early postoperative PJI delays proper treatment and may contribute to a higher percentage of late *S. aureus* infections.

Two separate, high patient-volume database reviews were conducted to assess mortality and morbidity associated with the two-stage protocol. Browne compared 90-day morbidity and mortality between patients who underwent total hip arthroplasty (THA) implant removal (10,386 cases) and those after coronary artery bypass grafting, carotid endarterectomy, prostatectomy, pancreatoduodenectomy (Whipple procedure), and kidney transplant.[26] Major complications were seen in 15.1% of cases, and morbidity was found to be higher with most of the studied procedures. Ibrahim reported morbidity of 23% at midterm follow-up.[25] According to a retrospective cohort study published by Sigmund *et al.*,[28] morbidity associated with two-stage revision may be even higher when the resection arthroplasty was performed as the first stage of the treatment. Among the group of 93 patients, the authors reported at least one local complication in 76% of cases and at least one systemic complication in 24% of cases. Moreover, a higher incidence of complications was observed with increasing severity of acetabular bone defects. These results correspond with the outcomes presented in our study.

Despite the heterogeneity of the listed reports, high morbidity might be considered to be an integral element of two-stage revision arthroplasty.

Conclusions

Despite difficult conditions defined by delayed diagnosis and advanced bone defects, two-stage replacement with or without spacer implantation may be recognized as a successful method of infection control in the treatment of PJI of the hip. The number of associated complications and poor functional outcomes associated with resection arthroplasty as the 1st stage procedure indicates the necessity for development of a different approach to patients with advanced bone stock deficiencies.

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