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Original article

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Outcomes of two-stage revision arthroplasty in the treatment of patients with periprosthetic hip infection (retrospective cohort study)

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Abstract

Introduction Periprosthetic infection (PPI) is a serious challenge for orthopedic surgeons. Two-stage revision with an antibiotic-impregnated spacer is one of the most common methods for treating periprosthetic infection. **Purpose** To evaluate the functional results of the second stage of revision arthroplasty in patients with PPI and to determine the survival of the endoprosthesis components. **Materials and methods** We retrospectively studied the results of the second stage of treatment (removal of the spacer and installation of the endoprosthesis) in 23 patients admitted to the department for the period 2016–2019. All patients received a spacer during the first stage of treatment. The mean age of the patients was 53.7 ± 2.2 years. Males prevailed (91.3 %). **Results** Three patients developed infection recurrence in the follow-up period of 44.4 ± 1.9 months. The effectiveness of revision arthroplasty performed as the second stage of treatment was 87 %. The Harris Hip Score before the second examination was 42.3 ± 2.5 points, at the time of the last follow-up examination it was significantly higher, 78.32 ± 3.8 points (p = 0.000052; Z – 4.04). **Discussion** The success of two-stage revision arthroplasty is influenced by the factors associated with patients' co-morbidities, pathogenicity of the pathogen identified at the first stage, as well as the features of the implants used and surgical tactics. **Conclusion** The second stage of revision arthroplasty in patients who received a spacer with an antibiotic for the treatment of periprosthetic infection at the first stage significantly improved their functional state. The Kaplan-Meier implant survival rate was 77.5 %.

Keywords: periprosthetic infection, two-stage revision arthroplasty, articulating spacer, preformed spacer

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INTRODUCTION

Periprosthetic infection (PPI) after total hip arthroplasty is a serious challenge for orthopedic surgeons, while its treatment is a labor-consuming and expensive process. The goal of treatment is to attempt to preserve limb weight-bearing, eradicate infection, and restore joint function [1–3]. The most common treatment options for PPI are one- or two-stage revision (using a spacer impregnated with antibacterial agents). According to current data, the prognosis for infection control ranges from 84–100 % [3–6]. The use of a spacer in two-stage revision hip arthroplasty provides a higher level of comfort for the patient than a simple removal of the infected implant at the first stage [3, 7–9].

The data of the largest domestic registry show that for septic revisions, a two-stage method has been used in 78 %, and a one-stage method in 13 % of cases [10]. Two-stage revision is the method of choice in patients with a systemic nature of the infection, presence of a fistulous tract, extensive purulent lesions of the periarticular soft tissues, and a highly virulent pathogen [3, 11]. According to many researchers, the installation of a spacer impregnated with antibacterial drugs enables to achieve eradication of the infection, and the use of an articulating spacer improves functional results and reduces the number of complications [9, 11].

The purpose of the study was evaluation of the functional results of the second stage of revision arthroplasty in PPI and assessment of implant components survival.

MATERIALS AND METHODS

A retrospective study identified patients admitted to the department for the second stage of treatment between 2016 and 2019. All patients had previously received treatment for periprosthetic infection at the first stage including the removal of the implant, debridement, and spacer implantation. Patients who did not receive a spacer at the first stage were not included in the study. We adhered to the ICM 2018 diagnostic criteria approved by the Second International Conference on Musculoskeletal Infection to exclude PPI before performing the second stage. Exclusion criteria from the study were applied in the phases of

preoperative examination and the operation itself. Thus, if signs of infection were detected during the operation, the spacer was reinstalled, and this patient was excluded from the study. Thus, our retrospective cohort included 23 patients who were followed up in the postoperative period for at least two years (Fig. 1).

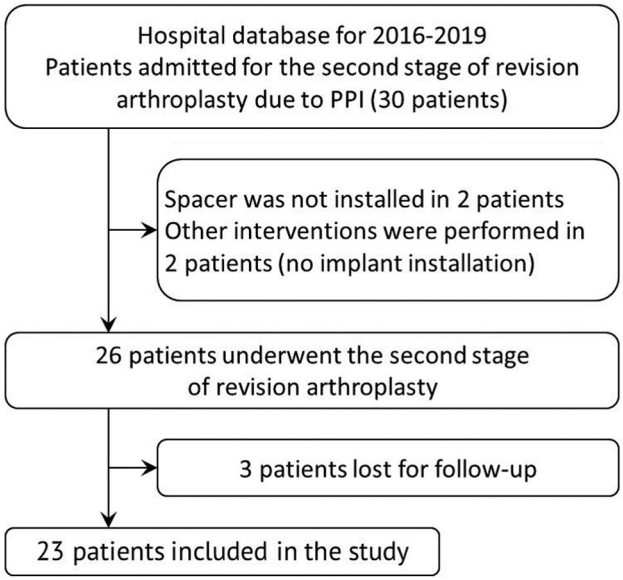

Fig. 1 Study design

Male patients prevailed in the study cohort (91.3 %). The average age of the patients was 53.7 ± 2.2 years (min – 37; max – 78). Eight patients (34.7 %) had a history of previous revisions for PPI. Fourteen interventions were performed under spinal epidural anesthesia; in nine patients, endotracheal anesthesia with catheterization of the epidural space was used. Key demographic characteristics of the patients are presented in Table 1.

Radiographic and functional study

Before and after the surgery, all patients underwent radiography of the pelvis and hip joint in two projections. If additional visualization of bone tissue defects was required, computed tomography was used. To assess the stability of the components of the endoprosthesis at the last follow-up examination in the postoperative period, radiography of the pelvis and hip joint was performed. The assessment of the clinical and functional state of patients was carried out using the Harris Hip Score (HHS).

Treatment

Before admission, a diagnostic puncture was performed in all patients; no growth of the pathogens was detected. The interval between the first and second stages averaged 13.3 ± 1.9 months. All operations were performed by two teams of surgeons.

Table 1

Main demographic data of the patients

Parameter	Findings
Number of patients	23
Age (years)	53.7 ± 2.2 (min – 37; max – 78)
Gender (males/females)	21 / 2
BMI (kg/m^2)	27.5 ± 1 (min – 20; max – 32)
ASA scale	I – 1 (4.3 %)
	II – 13 (56.5 %)
	III – 9 (39.1 %)
Previous revision for PPI	8 из 23 (35 %)
Time between 1st and 2nd stages (month)	13.3 ± 1.9 (min – 3.5; max – 45); CI (9.2;17.4)
Follow-up after the 2nd stage (months)	44.4 ± 1.9 (min – 26; max – 56); CI (38.7;47.2)
Associated diseases and premorbidity background	
Hypertension	15 (65 %)
Stomach or duodenum ulcer	4 (17.4 %)
Ischemic heart disease	3 (13.0 %)
Obesity (BMI > 30)	5 (21.7 %)
Diabetes mellitus	2 (8.67 %)
Hepatitis B or C	5 (21.7 %)
Anemia	3 (13 %)
ESR, mm/h	23.9 ± 5 (min – 2; max – 113); CI (13.2; 34.6)
CRP, mg/l	9.5 ± 1.6 (min – 0.6; max – 21); CI (6.2; 12.8)
Leucocytes, 10^9/l	7.4 ± 0.3 (min – 5.1; max – 10.6); CI (6.8; 7)
Hemoglobin, g/l	138 ± 5.6 (min – 104; max – 170); CI (125.2; 150.8)

Notes: BMI – body mass index; ASA – American Society of Anesthesiogists; CI – confidence interval; ESR – erythrocyte sedimentation rate; CRP – C-reactive protein

Table 2

Data on the 2nd stage revision

Parameter	Findings
Number of patients	23
Duration of the intervention (minutes)	214 ± 11 (min – 100; max – 315) CI (167;221)
Blood loss (ml)	788 ± 67 (min – 300; max – 1400) CI (650;927)
Blood transfusion	9 patients
Pathogenic agent revealed	*St. Aureus* + *St. epidermidis* – 1 (4.3 %)
	St. Iugdunensis – 1 (4.3 %)
	E. faecalis – 1 (4.3 %)
	Not dtected – 20 (87 %) cases

A direct lateral surgical approach was used to remove the spacer, to carry out debridement, and install a revision endoprosthesis. In 11 patients (48 %) in the study group, preformed spacers were implanted at the first stage. Articulating (30.5 %) and non-articulating spacers (21.5 %) were installed in seven and five patients, respectively. The material harvested during the surgical intervention was sent for microbiological examination. In 16 patients (69.5 %), impact bone grafting and tantalum augments were used to reconstruct the damaged structures and fill in the defects. Paprosky classification was used to classify acetabular and femoral defects (Table 3).

Table 3

Defects of the pelvis and femur

Parameter	Study group (23 patients)
Acetabular defect (Paprosky)	Type 1 – 2 patients
	Type 2A – 4 patients
	Type 2B – 7 patients
	Type 2C – 2 patients
	Type 3A – 5 patients
	Type 3B – 3 patients
Femoral defects (Paprosky)	Type 1 – 4 patients
	Type 2 – 10 patients
	Type 3A – 7 patients
	Type 3B – 2 patients

The implants were chosen in accordance with the preferences of the surgeon and individual characteristics of the patient. Among the implanted components, the cementless one prevailed, 17 cases (74 %). Cemented components were used in four operations (17.3 %), and dual mobility cemented cups in combination with a cementless stem were placed in two patients. Augmentation of acetabular defects was performed in 5 cases (21.7 %). Smith&Nephew, Zimmer, De Puy, and Implantcast implant systems were used. In three cases, extended cylindrical stems were used; in four cases, extended wedge-shaped stems were implanted; the remaining cementless femoral components were of standard length and wedge-shaped section. Antibiotic therapy was prescribed according to intraoperative test results of microbiological studies obtained during the installation of the spacer, and was subsequently adjusted after receiving microbiological tests during the last revision.

Postoperative care

We were able to track the treatment outcomes of 23 patients; the last follow-up was carried out in the period from 26 to 56 months (mean 44.4 ± 1.9 months; CI 38.7; 47.2). During the examination, the functional status was determined, signs of aseptic instability and infection were detected, and repeated interventions on the involved joint were recorded. The clinical and functional state of patients was assessed using the Harris Hip Score (HHS) questionnaire before surgery, then at one year after surgery, and at long-term follow-up.

Statistics

Data processing was performed using the Statistica-13 software (Statsoft, USA). Data were checked for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests, and then nonparametric statistics methods were used. To compare two dependent samples, the nonparametric Wilcoxon test was used. The Mann-Whitney test was used to compare independent samples, and the χ^2 test was used for categorical variables. We analyzed the survival of the implants installed at the second stage using the Kaplan-Meier method. Differences were considered statistically significant at $p \leq 0.05$.

RESULTS

The treatment was considered successful if the endoprosthesis was functioning at the time of the latest follow-up, and there were no symptoms of periprosthetic infection and aseptic instability. After the second stage, infection recurrence was detected in three patients (13 %). Those patients received treatment according to the protocol of a two-stage revision intervention, which was successful in one patient. In two other cases, the final outcome of treatment was resection arthroplasty. Four patients died in the postoperative period from the causes not related to articular pathology. Thus, the effectiveness of revision arthroplasty performed as the second stage of treatment was 87 %, and the survival rate of implants according to Kaplan-Meier was 77.5 % (Fig. 2).

We found that the presence of viral hepatitis B or C increased the likelihood of relapse (odds ratio – 11.3; CI 0.76; 168). Also, the pathogen St. Aureus ($p = 0.05$) and the history of septic revisions (OR, 3.14; CI, 0.28; 48.5) had an impact. BMI over 30 (OR – 1.16; CI 0.088; 15.458) and duration of exudation from the wound for

over 7 days (OR – 0.93; CI 0.071; 12.137) had no effect on the recurrence rate of infection in this study.

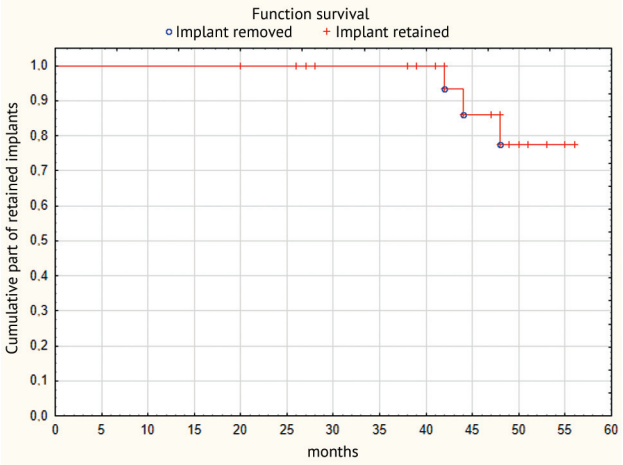

Fig. 2 Survival rate (Kaplan-Meier) of endoprostheses implanted at the second stage is 77.5 %. Follow-up period was 44.4 ± 1.9 months (min – 26; max – 56)

Before the second stage, the HHS was 42.3 ± 2.5 points (min – 20, max – 65; CI 37.7; 47). After the revision arthroplasty, the clinical and functional state of the patients improved significantly (p = 0.000052; Z – 4.04) and at the time of the long-term follow-up averaged 78.32 ± 3.8 points (min – 34.5, max – 94.8; CI 70.1; 85.3).

The Harris Hip Score in patients with articulating spacers implanted at the first stage was higher than in patients with non-articulating and preformed spacers. After the surgery, a significant difference (p = 0.045) was found between the groups of articulating and preformed spacers. Functional results after revision arthroplasty in patients with articulating spacers were not significantly higher than those in patients with non-articulating spacers, but there was a trend towards statistical significance (p = 0.052).

Table 4

Harris Hip Score before and after revision arthroplasty

Spacer type	HHS before the intervention (points)	HHS after the intervention (points)
Preformed spacers (11)	44.4 ± 2 (min – 31; max – 65); CI (41; 50)	70.1 ± 6.1 (min – 34.5; max – 94.8); CI (56.4; 84)
Articulating spacers (7)	47.5 ± 2.6 (min – 40; max – 60); CI (41; 54)	89.5 ± 2.12 (min – 80; max – 98); CI (56.4; 84)
Non-articulating spacers (5)	30.5 ± 3.5 (min – 20; max – 41); CI (20.9; 40.4)	78.5 ± 4 (min – 62.8; max – 84.1); CI (67.3; 89.6)

Repeated interventions and complications

Twenty out of 23 patients had infection arrest. Apart from infectious complications, such complications as intraoperative periprosthetic femoral fracture in two cases and two dislocations of the endoprosthesis head in the early postoperative period were observed. In both patients, the dislocation was reduced in a closed way; one of them had infection recurrence 3 weeks after the revision. In three patients with a recurrence of infection, a two-stage revision tactics was used; in all three, a spacer was installed after the removal of the implants. Microbiological tests of those patients revealed *St. Aureus*, one of them has a polymicrobial infection (*St. Aureus* and *Kl. Pneumoniae*). These pathogens were found at the first stage of treatment. In one case, the repeated revision was successful, but in the rest, resection arthroplasty was the final outcome.

DISCUSSION

Data from a meta-analysis of 60 studies (3,288 cases) state that the rate of reinfection after two-stage arthroplasty is 7.9 % [6]. There are many factors that influence the success of revision arthroplasty in patients who have a spacer implanted for periprosthetic infection. Those are the factors associated with the patient's comorbidity, the pathogenicity of the pathogen identified at the first stage, as well as the features of the implants used and surgical tactics [13, 15–17].

According to many authors, a high body mass index (BMI) increases the likelihood of infection recurrence [13, 18–20]. Some studies did not reveal such a relationship. However, our study, as some others [8], did not reveal such a relationship. In our study, the likelihood of infection recurrence was influenced by previous septic revisions and viral hepatitis B or C. The impact of chronic viral hepatitis was also confirmed by other studies. Bedair H.S. et al. found that patients treated for viral hepatitis had a lower incidence of perioperative infections than patients not receiving antiviral treatment [21, 22]. Our results are consistent with the data of Fagotti L. et al., who noted that if the initial causative agent of PPI was *St. aureus*, this increased the risk of infection in two-stage treatment [13].

Preformed, functionally articulating, and block-shaped spacers have been widely used [23, 24]. The results of numerous publications indicate greater patient satisfaction and reduction in the number of complications with the use of articulating spacers [3, 7, 8, 24, 25]. A systematic review of 25 articles found that infection control was comparable and ranged within 93–96 % with the use of preformed, functionally articulating, and custom-made (block-shaped) spacers, [24]. However, the results of their own work (conducted by those

authors) showed a significant difference in the obtained functional results and eradication of infection in patients with articulating and preformed spacers: 93 % versus 78 % [9]. In our study, if patients had good function before the second stage, then the final functional score after revision arthroplasty was also higher. Therefore, patients with previously placed articulating spacers had a higher function at the final follow-up.

The authors of a number of publications came to the conclusion that the survival rate of cementless stems after two-stage revision is higher than that of cemented stems [26–29]. In this regard, the studies that report a high rate of mechanical failures (looseness) of cement stems implanted during revision arthroplasty after removal of the spacer are of interest [11, 29]. The main reason, as considered, is thinning and sclerosis at the border of the bone and the cement spacer, which, in turn, prevents the penetration of cement into the cancellous bone damaged during revisions and worsens the fixation of the femoral component at the second stage [28, 29]. We relied on the above arguments, giving preference to cementless implants in our work.

Table 5 provides an overview of publications with the results of the treatment of periprosthetic infection by two-stage revision arthroplasty. In the articles cited, the rate of retained implants after the second stage was in the range of 70.8–100 %, which is comparable to our results.

The main limitations of this work are its retrospective design and a small number of cases, which may have influenced the results. The choice of implants was based on the preferences of the surgeon and the availability.

Table 5

Results of two-stage arthroplasty in patients with periprosthetic infection of the hip joint (literature data)

Author	Follow-up period (years)	Number of replaced joints	Time between the 1st and 2nd stage	Retained implants (including aseptic loosening), %	Infection arrest, %
Biring G.S., 2010 [7]	12	48	5 months	80	89
Leung F., 2011 [4]	4.8	38	6 months	n/a	79
Shen B., 2014 [11]	6	33	20 weeks	100	100
Tsung J. D., 2014 [30]	6.7	42	20 weeks	70.8	84
Marczak D., 2017 [3]	2	45	5.5 months	n/a	91
Včelák J., 2018 [25]	2	57		n/a	89.5
Chalmers B.P., 2018 [8]	5	131	n/a	77	88
Jones C.W., 2019 [12]	6.5	155	n/a	n/a	87

CONCLUSION

The second stage of revision arthroplasty in patients who had a spacer implanted at the first stage for treatment of periprosthetic infection resulted in a significant improvement in their functional state ($p = 0.000052$; $Z - 4.04$). The Kaplan-Meier implant survival rate was 77.5 %. Comparison of the final functional results showed that the use of articulating spacers at the first stage improves the functional state both during the period of waiting for revision arthroplasty and in the long-term postoperative period.

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