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Clinical and Radiological Outcomes of Two-Stage Revision Knee Arthroplasty in Infected Primary Knee Arthroplasty

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ABSTRACT

Introduction: Two-stage revision arthroplasty is the gold standard treatment for infected knee arthroplasty. The primary objectives of this treatment approach are to eradicate the infection and restore a pain-free and well-functional joint. In this retrospective study of case series from a single center, we aimed to evaluate the clinical and radiological results of patients who underwent two-stage revision knee replacement with the diagnosis of infected knee prosthesis and share the results.

Methods: The data of patients between 2011 and 2016 were analyzed in this retrospective study. Twenty-four patients who were followed up for at least six months were included in the study. Infection markers, Knee Society Score (KSS), pain scores, range of motion (ROM), and flexion contractures were recorded before and after treatment. Radiologically, changes in the patellar tendon length, the Insall-Salvati (IS) ratio, and the joint line (JL) were evaluated.

Results: Sixteen female and eight male patients with a mean age of 68.0±8.6 years were studied. The patients were followed up for 31.0±18.9 months on average. The mean clinical KSS of the patients before and after treatment was 44.7 and 76.3, respectively, while the functional KSSs were 31.7 and 63.5, respectively. The patients had a mean ROM of 60.5° and 84.8°, pain score of 8 and 2.25, and knee flexion contracture of 1.38° and 0.21° before and after the treatment. Pre- and post-treatment IS and JL values did not have a statistically significant effect on the clinical and functional outcomes.

Conclusion: The early- tomid-term results of patients who underwent two-stage knee revision arthroplasty were satisfactory in terms of clinical and functional results. Postoperative JL position and IS ratio had no significant effect on functional outcomes. The use of dynamic spacers and the short time between two stages had a positive effect on the results.

Keywords: Infected knee arthroplasty, joint line, Knee Society Score, two-stage revision

Introduction

Due to the increase in the elderly population in parallel with the prolongation of life expectancy and high success rates, total knee arthroplasty is one of the most frequently performed orthopedic elective surgeries. It is estimated that the number of total knee replacements in the United States will increase by 85% by 2030 (1). Notably, instability, mechanical loosening, malposition of the prosthesis, dislocation, polyethylene abrasion, periprosthetic fractures, and infection are the predominant complications necessitating revision surgery after total knee replacement (2).

Infection, which has a prevalence of 0.5-2% after total knee replacement, draws attention as the most important complication with a long and costly treatment (3,4). It is anticipated that the increase in the estimated total number of knee replacements will also increase the number of patients with infections, which in turn will create a serious burden on the health system and the economy (5,6). Various treatment options are available for infected knee prostheses, including irrigation and debridement, one or two-stage revision arthroplasty, arthrodesis, amputation, and antimicrobial suppression without surgical intervention (7). The primary objectives of treatment encompass eliminating the infection and restoring a pain-free and well-functional joint. Two-stage revision arthroplasty is the gold standard in the treatment where the above goals are aimed (8-10). The first stage of the two-stage revision arthroplasty includes removing infected components, extensive debridement and

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tissue sampling, placing an antibiotic-loaded dynamic or static spacer into the joint followed by appropriate antibiotic treatment for the infection, and if necessary re-debridement to eradicate the infection, while revision procedures are performed in the second stage (11).

In this retrospective study of case series from a single center, we aimed to evaluate the clinical and radiological results of patients who underwent two-stage revision knee replacement with the diagnosis of infected knee prosthesis and share the results.

Methods

The data of patients who underwent two-stage knee revision arthroplasty with the diagnosis of an infected knee prosthesis in our clinic between 2011 and 2016 were retrospectively analyzed. Of the 28 patients identified, 24 who were diagnosed with an infection after primary knee arthroplasty were regularly followed up for at least six months, and patients whose laboratory tests and radiological images could be accessed were included in the study. Patients with a diagnosis of infected revision arthroplasty, who underwent arthrodesis or one-stage revision surgery, and without regular follow-ups were excluded from the study. The study was approved by University of Health Sciences Turkey, İstanbul Training and Research Hospital Institutional Ethics Committee (approval number: 936, date: 03.02.2017).

The physical examination findings of the patients were evaluated together with C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell levels, which are infection indicators. Microbiological studies were performed by aspiration of joint fluid from the patients. Standard radiographs were checked for septic loosening. Two-stage revision arthroplasty was planned for patients with confirmed infection according to Musculoskeletal Infection Society criteria (12). In the first stage, the implants were removed and extensive debridement was performed. Then, perioperative joint fluid and tissue samples were sent for culture. The first stage was completed by placing a dynamic or static spacer into the joint cavity with antibiotic-loaded cement, both for the treatment of infection and to obtain a functional joint after the treatment. After the first stage, specific antibiotic therapy was started for patients whose preoperative cultures had the causative microorganism. Broad-spectrum antibiotic therapy was initiated as empirical treatment for patients whose cultures did not yield any microorganisms. After the perioperative culture was concluded, appropriate antibiotic treatment was planned for all patients in consultation with the infection clinic. The patients received at least six weeks of intravenous and oral antibiotics. Between the two stages, the patients were allowed controlled joint movement with the use of an angle-adjustable brace. During antibiotic therapy, the CRP and ESR levels of the patients were monitored. A second stage was planned for revision arthroplasty for patients who showed no signs of infection and whose CRP and ESR levels were significant or regressed to normal. In the second stage, the spacer and cement were removed. Debridement, culture sampling, and synovial cell count were repeated during the operation, and revision arthroplasty was performed. After completion of the second stage, appropriate antibiotic therapy was administered empirically until the culture results were obtained. Subsequently, the patients were followed-up in the postoperative period using the same laboratory parameters.

The patients were evaluated both before and after treatment with the American Knee Society's clinical and functional scoring system [Knee Society Score: (KSS)] (13). Numerical pain scores, joint range of motion (ROM), flexion contractures, and complications were also recorded before and after treatment.

Patients were evaluated radiologically according to changes in the patellar tendon length (PTL), the Insall-Salvati (IS) ratio, and joint line (JL) before and after revision arthroplasty. On the lateral knee X-ray, the distance between the lower pole of the patella and the tibial tubercle was defined as PTL, the ratio between PTL and patella length was defined as IS ratio, and the distance between the head of the fibula and the lateral femoral condyle was defined as JL.

Statistical Analysis

SPSS 15.0 for Windows software was used for statistical analyzes. Descriptive statistics are given as the mean, standard deviation, minimum, and maximum for the numerical variables and as numbers and percentages for the categorical variables. Comparisons of the numerical variables without normal distribution in two independent groups were made using Student's t-test, whereas those with normal distribution were compared using the independent Mann-Whitney U test. The paired samples t-test was used when the differences of the numerical variables in dependent groups met the normal distribution criteria, whereas the Wilcoxon test was employed when the criteria were not met. The relationships between the numerical variables were analyzed with Pearson's correlation when the parametric test conditions were met and with Spearman's correlation when the conditions were not met. The difference in ratios in independent groups was analyzed by the chi-square analysis. The statistical significance level was set at $p<0.05$.

Results

Of the 24 patients included in the study, 16 (67%) were females and eight (33%) were males, with a mean age of 68.0±8.6 years (range: 46 to 82 years). The mean follow-up period was 31.0±18.9 months (range: 6 to 65 months). The cultures of 13 patients (54.2%) did not grow any microorganisms. In the cultures of the remaining 11 patients, *S. epidermidis* was observed in three (12.5%), MRSA in two (8.3%), *E. coli* in one (4.2%), *Pseudomonas aeruginosa* in one (4%, 2), *S. aureus* in one (4.2%), *Serratia marcescens* in one (4.2%), *S. haemolyticus* in one (4.2%) and *Enterococcus* + *S. epidermidis* in one (4.2%).

The mean ROM of the patients was 60.5°±15.0° (range: 0° to 80°) before the treatment and 84.8°±12.9° (range: 45° to 100°) after the revision arthroplasty. While the mean flexion contracture was measured at 1°±3.2° (range: 0° to 10°) before the treatment, it was measured at 0.2°±1.0° (range: 0° to 5°) after the revision arthroplasty. The mean numerical pain score before treatment was 8.0±1.3 (range: 6 to 10), whereas the score at the end of the follow-up was 2.3±1.3 (range: 0 to 5). The differences between the ROM, flexion contracture, and pain measurements before and after the treatment were statistically significant ($p<0.001$) (Table 1).

The mean duration of antibiotic use between the two stages was 10.8±7.4 weeks. When the duration of antibiotic use between the two stages of the patients and the KSSs were compared, a negative but insignificant correlation was found (Table 2).

During the first phase, the joint space was filled using dynamic spacers in 15 patients and static spacers in nine. We noted that the patients in whom dynamic spacers were used had higher ROM and clinical and functional KSSs after revision arthroplasty than those in whom static spacers were used. However, the difference was not statistically significant (p=0.676, p=0.232, and p=0.630, respectively) (Table 3).

The clinical and functional KSSs of the patients were evaluated before and after treatment. The mean clinical KSS before treatment was 44.7±10.6, while it improved to 76.3±10.4 at the end of the follow-up. Accordingly, the results of 23 patients (95.8%) were "poor" and one patient (4.2%) was "moderate" before the treatment, whereas the results were "excellent" in 10 patients (41.7%), "good" in eight (33.3%), and "moderate" in six (25%). The mean functional KSS was 31.7±17.2 (range: 0 to 60) before the treatment, whereas it was 63.5±20.1 (range: 20 to 90) at the end of the follow-up. The differences between the pre- and post-treatment measurements of the clinical and functional KSSs were statistically significant (p<0.001).

There was no statistically significant difference in the mean PTL, IS ratio, and JL measurements before and after revision arthroplasty (Table 4). The relationship between the IS ratio and JL measurements obtained from the knee radiographs of the patients after revision arthroplasty and the clinical and functional KSSs at the end of follow-up was also evaluated and no statistical significance was found (Table 4).

No additional complications were encountered in the patients during the first phase of the spacer application and until the pre-revision period. However, reinfection was observed in two patients (8.3%), knee instability in one (4.2%), and wound site infection in one (4.2%) during and after revision surgery.

Table 1. ROM, flexion contracture, and pain measurement results before and after the revision surgery

		Mean ± SD	p
ROM (°)	Pre-revision	60.5±15.0	<0.001*
	Post-revision	84.8±12.9	
Flexion contracture (°)	Pre-revision	1.4±3.2	0.068†
	Post-revision	0.2±1.0	
Pain score	Pre-revision	8.0±1.3	<0.001†
	Post-revision	2.3±1.3	

ROM: Range of motion, SD: Standard deviation, *Paired t-test, †Wilcoxon test

Table 2. Statistical relationship between the duration of antibiotic use and the clinical and functional KSSs after revision arthroplasty

	Duration of antibiotic therapy (weeks)	
	r	p*
Clinical KSS after revision	-0.367	0.078
Functional KSS after revision	-0.265	0.212

r: Correlation coefficient, KSS: Knee Society Score, *Spearman's correlation

Table 3. The relationships among the ROM and the clinical and functional KSSs after revision arthroplasty according to the type of spacer used

	Spacer type				p*
	Dynamic (n=15)		Static (n=9)		
	Mean ± SD	Median	Mean ± SD	Median	
ROM after revision	87.1±9.3	88.0	80.9±17.2	85.0	0.676
Clinical KSS after revision	78.1±10.5	80.0	73.3±10.1	74.0	0.232
Functional KSS after revision	65.3±20.2	65.0	60.6±20.7	60.0	0.630

KSS: Knee Society Score, ROM: Range of motion, SD: Standard deviation, *Mann-Whitney U test

Table 4. The mean PTL, IS ratio, and JL values and their statistical relationships before and after revision arthroplasty and the correlation of post-revision JL and IS values with the clinical and functional KSSs

		Mean ± SD		Min.-Max.	p
PL (cm)	Preoperative	4.41±0.56		3.05-5.20	0.322*
	Postoperative	4.28±0.75		3.25-6.00	
IS	Preoperative	1.10±0.22		0.74-1.45	0.127*
	Postoperative	1.04±0.17		0.76-1.40	
JL (cm)	Preoperative	1.04±0.41		0.38-1.95	0.182*
	Postoperative	1.21±0.57		0.51-2.71	
		JL after revision		IS after revision	
		r	p†	r	p†
Clinical KSS after revision		-0.217	0.359	-0.106	0.658
Functional KSS after revision		-0.286	0.222	-0.212	0.368

IS: Insall-Salvati ratio, JL: Joint line, KSS: Knee Society Score, Min-Max: Minimum-Maximum, PL: Patellar length, r: Correlation coefficient, SD: Standard deviation, *Paired t-test, †Spearman's correlation

Discussion

The aim of revision surgeries after infected knee arthroplasty is to obtain a painless and functional knee joint where the infection is eradicated. In our study, the results obtained after revision knee arthroplasty performed in two stages met these goals.

The debate is still on whether one- or two-stage revision arthroplasty should be performed after infected total knee replacement. Although a higher reinfection rate was reported in one-stage revision arthroplasty (0-11%) in a systematic evaluation compared to two-stage revisions (0-40%), the superiority of the two procedures over each other was not proven due to the lack of studies with sufficient evidence (14). In another systematic evaluation by Nagra et al. (15), the authors emphasized that one-stage revision surgery has better clinical results and lower reinfection rates in selected patients. Similarly, a recent systematic review showed no statistical difference between functional outcomes and eradication rates in one- or two-stage treatment (4). The largest case series study in the literature with a two-stage procedure was conducted in 2012 by Mahmud et al. (16). The authors performed two-stage revision surgery on 253 knees with an average follow-up of 48 months and observed reinfection in 16 patients (7%). The authors also reported that infection-free time after two-stage revision surgery was five years in 85% and 10 years in 78% of their patients. In our study, reinfection developed in two (8.3%) of our patients who were followed up for an average of 31 months. The clinical KSSs before and after the treatment were 44.7 and 76.3, and the functional KSSs were 31.7 and 63.5, respectively.

In a comparative study, Park et al. (17) used antibiotic-loaded static spacers in 20 knees and dynamic spacers in 16 knees and reported better functional scores and wider ROM in patients in whom dynamic spacers were used with no increase in reinfection rate and bone loss. In a systematic review published by Voleti et al. (18), a total of 1,526 patients who used static spacers in 654 knees and dynamic spacers in 872 knees were examined. There was no significant difference between the two groups in terms of reinfection. However, after the second stage, a significant difference in ROM was observed, especially in the group that used dynamic spacers. In addition, no significant difference was found in terms of clinical scores and wound-related complications (17). In our study, the ROM and clinical and functional KSSs were also higher after revision in patients to whom dynamic spacers were applied. The post-revision results of both groups support the literature and are satisfactory.

To obtain adequate alignment and function in both primary total knee prosthesis and revision knee prosthesis, kinematic reconstruction should be well understood (19-21). The importance of the JL and the restoration of patellar height in revision knee arthroplasty has been the subject of several publications. Malposition of the JL causes decreased extensor strength, patellar impingement syndrome, anterior knee pain, patellar instability, and decreased ROM (21-23). In revision knee arthroplasty, severe bone loss and changes in soft tissue pose a challenge for orthopedic surgeons in restoring the JL, adjusting the patellar height, and providing knee stability. The augments in modern revision arthroplasty systems have been the solution for restoring the JL by restoring the distal femoral bone loss (21). In a study evaluating the JL and patellar height after revision knee arthroplasty, 74 knees of 70 patients were examined (24). Forty-seven knees had to undergo a two-stage revision and 27 knees one-stage revision due to aseptic loosening. The mean JL lengths of all patients increased from 17.51 mm to 18.37 mm, while the IS ratio decreased from 0.98 to 0.92 and PTL from 42.92 mm to 39.45 mm. The authors observed that the JL and IS ratio had greater changes in the septic group. In addition, functional results were lower in the septic group than in the aseptic group. Finally, the researchers stated that the JL position and IS ratio did not correlate with functional scores. The values we found for the JL, IS ratio, and PTL were in similar ranges with the studies in the literature, and similarly there was no correlation between these values and post-treatment functional scores.

Study Limitations

Its retrospective design, the low number of cases, the lack of a control group, and the fact that it included a single surgical procedure can be considered the limitations of our study. The literature should be supported by comparative studies with a larger number of cases.

Conclusion

Two-stage revision arthroplasty after septic knee arthroplasty is a satisfactory intervention in terms of clinical and functional results. The use of dynamic type spacers and the short time between the two stages have a positive albeit statistically insignificant effect on the results.

Ethics Committee Approval: The study was approved by University of Health Sciences Turkey, İstanbul Training and Research Hospital Institutional Ethics Committee (approval number: 936, date: 03.02.2017).

Informed Consent: Retrospective study.

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