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Comparison of One-Stage Revision With Antibiotic Cement Versus Two-Stage Revision Results for Infected Total Hip Arthroplasty

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ABSTRACT

Eighty three patients of infected total hip arthroplasty (THA) treated by implant removal and staged revision were retrospectively analyzed. Clinical characteristics and treatment outcomes were compared between three groups: 17 one-stage revisions (one-stage group), 44 two-stage revisions with second stage reimplantation (two-stage reimplanted group), and 22 planned two-stage but no reimplantation (two-stage non-reimplanted group). The rate of infection control was 82% (14/17) in the one-stage group, 75% (33/44) in the two-stage reimplanted group, and 68% (15/22) in the two-stage non-reimplanted group ($P = 0.60$). The mean of latest Harris hip score was 77, 60, and 58 ($P = 0.14$), and the UCLA activity score was 4.0, 4.2, and 3.6 ($P = 0.74$) for each group, respectively. Results of this study suggest that one-stage revision arthroplasty can be a treatment option in selected cases of infected THA with a satisfactory infection control rate and functional outcomes comparable to those of two-stage revision.

Infection is a rare, but possibly devastating complication after total hip arthroplasty (THA). Of several treatment options, two-stage exchange arthroplasty with antibiotic-loaded temporary spacer has been considered a gold standard therapeutic approach [1–3]. However, prolonged treatment duration with interim functional disability, and necessity of additional major surgery are its drawback.

One-stage exchange arthroplasty, on the other hand, has advantages of decreased patient morbidity, no need for second stage major surgery, shorter treatment duration, and early functional recovery [4]. However, direct exchange arthroplasty has not been commonly used because of uncertainty of complete eradication of infection at the time of implant removal and surgeons' concern about recurrent infection [5].

Treatment of infection by one-stage exchange arthroplasty has been reported occasionally with relatively wide range of treatment success rates of 77%–100% [4,6–9]. It is also known to show less favorable infection control compared to the two-stage revision [3,10]. However, most of the direct exchange procedures have been applied for selected cases and there is a paucity of data regarding concurrent comparison between one- and two-stage revisions of infected THA [11].

The purpose of this study was to compare the patient characteristics and treatment outcomes between one- and two-stage revision procedures for infected THA.

Materials and Methods

This study has been approved by institutional review board (2008P002146). From January 1999 to December 2009, there were 93 patients with infected THAs treated by implant removal and planned two-stage revision arthroplasty at our institution. Of these, one patient died of reason unrelated to the surgery within one year after the surgery and nine patients were lost to followup. Excluding these 10 patients, 83 patients were included in this retrospective analysis. There were 44 males and 39 females, and the mean age at the time of surgery for infection at our institution was 65 years (range, 38–88 years). The mean followup period was 61 months (range, 12–132 months). Underlying diagnoses for the primary THA were osteoarthritis (n = 36), posttraumatic arthritis (n = 10), femoral neck fractures (n = 8), avascular necrosis (n = 7), rheumatoid arthritis (n = 7), sequela of developmental hip dysplasia (n = 6), and unknown (n = 9). Primary THA was performed at our institution in 31 hips, outside hospital in 43 hips, and uncertain in 9 hips.

In accordance with new definition for periprosthetic joint infection advocated by the workgroup of the musculoskeletal infection society [12], diagnosis of infection was made by presence of sinus tract communicating with the prosthesis; or growth of the microorganism from at least two separate tissues or joint fluids from the affected prosthetic joint; or when four of the following six criteria existed: elevated erythrocyte sedimentation rate (ESR, ≥ 30 mm/h) and C-reactive protein (CRP, ≥10 mg/L), elevated synovial white blood cell (WBC) count (≥2000/μL), elevated synovial neutrophil percentage (PMN%, ≥65%), presence of purulence in the affected joint, isolation of a microorganism in one culture of tissue or fluid, more than

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5 neutrophils per high-power field on histopathologic examination [12–15]. Infection was classified as early postoperative, acute hematogenous, and chronic infections based on the criteria of Tsukayama et al [16], and host condition was classified by McPherson classification [17]: uncompromised (Group A), compromised (Group B), and significantly compromised (Group C).

As a treatment option, 17 of 83 patients underwent implant removal and one-stage exchange arthroplasty (one-stage group) and 66 patients received implant removal with (n = 46) or without (n = 20) temporary spacer for two-stage revision (two-stage group). Of 66 two-stage group, 44 patients underwent second stage reimplantation (two-stage reimplanted group), but 22 patients did not undergo second stage reimplantation at the latest followup (two-stage non-reimplanted group) (Fig. 1). The final decision for one-stage exchange or two-stage revision was at the discretion of treating surgeons who considered all the particulars of the patient and conditions at surgical field. There were no standard criteria for selecting either treatment option during the period of this study and the rationale for choice of treatment option could not be ascertained from retrospective review.

The first stage operation consisted of implants removal and meticulous, thorough debridement of all foreign materials including cement, necrotic bone and soft tissues. Antibiotic-loaded cement (40 g of cement with 2.4 g of tobramycin and 1.0 g of vancomycin) was used for fixation of new implants (one-stage) or spacers (two-stage). In the one-stage group, after aggressive brushing and pulsatile lavage, antibiotic cement was packed into the medullary canal without cement plug. A new femoral stem (n = 17) and all-polyethylene cup (n = 16) or metal cup with polyethylene (n = 1) of appropriate size were coated with cement and carefully inserted with manual pressurization in proper anteversion and inclination when antibiotic cement reached a very doughy state. In the two-stage group, articulating spacers (n = 30) consisting of metallic femoral component and all polyethylene cup, or static cement spacer (n = 16) were inserted after removal of the implants. In 20 patients, no spacer was inserted.

Postoperatively, patients were treated with a six-week period of organism-sensitive intravenous antibiotic therapy in all groups. All patients were allowed to weight-bear as tolerated. Second-stage reimplantation was performed for the two-stage reimplanted group based on the patients' general condition and normalization of the laboratory data with the same criteria as initial diagnosis. The mean time interval between stages was 8 months (range, 6 weeks–72 months). The patients were followed up regularly in our clinic postoperatively at 2 weeks, 1 to 3 months, 1 year, and then every 2 to 3 years thereafter. Wound condition and hip function (Harris hip scores and UCLA activity scores) were evaluated with radiographic examination including pelvis AP, hip AP, and shoot-through lateral views.

Treatment was defined as successful if a patient did not receive any additional surgical procedure for persistent or recurrent infection after our initial surgical treatment. Treatment was defined as a failure if a patient necessitated any additional surgical procedure for infection control. The planned second stage reimplantation was not considered additional surgical procedure for infection control. Patient characteristics, laboratory findings, and treatment results were compared between the groups. As the two-stage non-reimplanted group had never undergone second stage reimplantation, being similar category as single stage treatment, they were separately compared with other groups.

Data were analyzed using SPSS Ver. 17.0 (SPSS, Chicago, IL). Chi-square test and Fisher's exact test were used to determine the differences in proportions for each variable between the one- and two-stage groups. The independent sample t-test was used to compare the means of continuous variables between the two study groups. P values of <0.05 were considered statistically significant.

Results

Baseline demographic data showed no significant difference between the one-stage revision and two-stage reimplanted group, and between the two-stage reimplanted and non-reimplanted group, except the higher incidence of draining sinus in the non-reimplanted group (Table 1). Preoperative laboratory data for WBC count, ESR, CRP, and joint aspirate WBC and differential count showed no significant difference between the groups, either (Table 2). Coagulase negative Staphylococcus was the most common pathogen in the one-stage and two-stage reimplanted group, and Staphylococcus aureus (S. aureus) was the most common organism in the two-stage non-reimplanted group (Table 3). The mean followup time was significantly shorter in the non-reimplanted group (42 months) compared to the one-stage (62 months) and the reimplanted group (70 months) ($P < 0.01$).

The rate of treatment success was 82% (14/17) in the one-stage group and 75% (33/44) in the two-stage reimplanted group, and 68% (15/22) in the two-stage non-reimplanted group ($P = 0.60$). In the one-stage group, three patients developed recurrent infection after exchange arthroplasty. One patient was treated by repeat one-stage

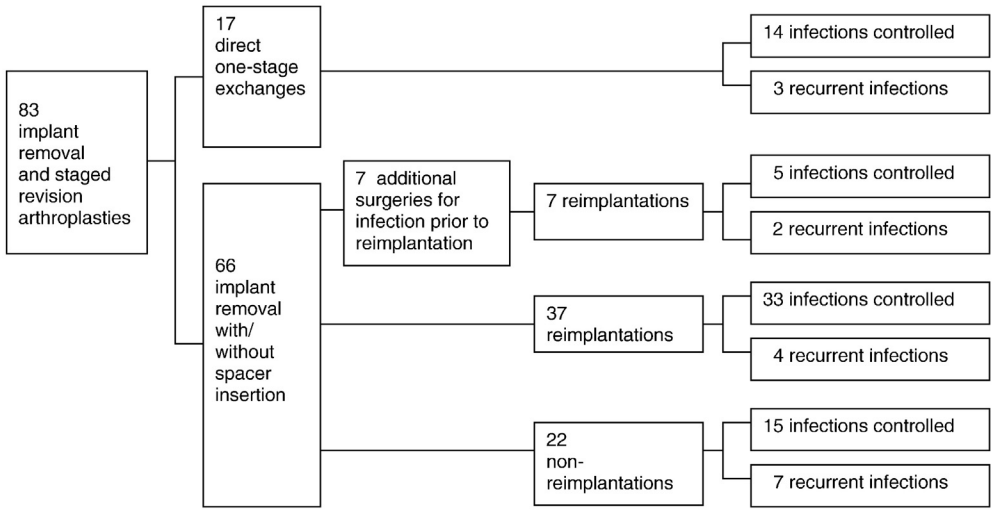

Fig. 1. Treatment methods and results for 83 infected total hip arthroplasties.

Table 1
Comparison of Baseline Demographic Data and Treatment Result.

Variables	*P* Value	One-Stage (n = 17)	Two-Stage	
			Reimplanted (n = 44)	Non-Reimplanted (n = 22)
Age at surgery, years	0.29			
≤65		5 (29%)	21 (48%)	7 (32%)
>65		12 (71%)	23 (52%)	15 (68%)
Gender	0.94			
male		9 (53%)	24 (55%)	11 (50%)
female		8 (47%)	20 (46%)	11 (50%)
Side	0.92			
left		6 (35%)	18 (41%)	9 (41%)
right		11 (65%)	26 (59%)	13 (59%)
Diabetes Mellitus	0.33			
yes		1 (6%)	9 (21%)	5 (23%)
no		16 (94%)	35 (79%)	17 (77%)
Prior tx for infection	0.75			
yes		5 (29%)	12 (27%)	8 (36%)
no		12 (71%)	32 (73%)	14 (64%)
Host condition	0.12			
uncompromised		5 (29%)	19 (43%)	4 (18%)
compromised		12 (71%)	25 (57%)	18 (82%)
Type of Infection	0.21			
early postoperative		0 (0%)	6 (14%)	0 (0%)
acute hematogenous		3 (18%)	8 (18%)	4 (18%)
chronic		14 (82%)	30 (68%)	18 (82%)
Draining sinus	0.02[c]			
yes		2 (12%)	6 (14%)	9 (41%)
no		15 (88%)	38 (86%)	13 (59%)
Microorganism[a]	0.62			
methicillin resistant		4 (29%)	15 (39%)	8 (42%)
methicillin sensitive		10 (71%)	23 (61%)	11 (58%)
Complication requiring surgery	0.10			
yes		0 (0%)	5 (11%)	0 (0%)
no		17 (100%)	39 (89%)	22 (100%)
Treatment result[b]	0.60			
success		14 (82%)	33 (75%)	15 (68%)
failure		3 (18%)	11 (25%)	7 (32%)
Followup, months	<0.01[c]	62 ± 32	70 ± 35	42 ± 21
Outcome scores				
Harris Hip Score (range)	0.14	77 ± 14 (46–94)	60 ± 30 (7–100)	58 ± 30 (30–98)
UCLA activity (range)	0.74	4.0 ± 1.4 (2–6)	4.2 ± 2.0 (1–10)	3.6 ± 1.1 (2–5)

Continuous data are mean ± SD.
[a] Patients with culture negative results are not included.
[b] Any additional surgery for recurrent or persistent infection was considered failure.
[c] Statistically significant.

exchange and another patient was treated by resection arthroplasty. The remaining patient was treated by two-stage revision, but infection was not controlled and the patient required ongoing treatment at latest followup. In the two-stage reimplanted group, 11 patients showed recurrent infection. Seven patients required additional surgeries for infection control prior to reimplantation: additional I/D (n = 3), resection arthroplasty (n = 3), and spacer exchange (n = 1). All seven patients underwent second stage reimplantation and two of them had a recurrent infection after reimplantation. One was treated by resection arthroplasty, and the other was receiving ongoing treatment at latest followup. Another 4 out of 11 recurrent infection showed recurrence after reimplantation, which were treated by I/D (n = 1) and repeat two-stage revision (n = 3). At latest followup, three patients had infection controlled, but one patient was receiving ongoing treatment. In the two-stage non-reimplanted group, 7 patients had a recurrent infection after the first stage procedures, which were treated by additional I/D (n = 5) or spacer exchange with repeat I/D (n = 2). Three patients required ongoing treatment for infection at latest followup. The reasons for not undergoing reimplantation in this group were uncontrolled chronic infection (n = 3), poor host condition (n = 8), and 11 satisfied hip joint function without implants (n = 11).

Table 2
Comparison of Preoperative Laboratory Data (Mean ± SD).

Variables	One-Stage (n = 17)	Two-Stage		*P* Value
		Reimplanted (n = 44)	Non Reimplanted (n = 22)	
serum WBC, /μL	9235 ± 2544	9051 ± 2811	9614 ± 4070	0.80
ESR, mm/h	69.1 ± 28.6	77.5 ± 39.3	71.8 ± 32.0	0.71
CRP, mg/L	29.0 (23.5–42.6)	51.6 (10.4–142.8)	50.0 (18.7–121.5)	0.41
Joint aspirate				
WBC ($\times 10^3$), /μL	39.2 (28.4–58.0)	42.2 (20.0–124.4)	34.5 (5.6–79.5)	0.80
Differential, %	95 (90–96)	95 (91–98)	88 (80–94)	0.19

WBC, white blood cell; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein. CRP and joint aspirate values are median (interquartile range) due to skewness.

For functional assessment at latest followup, the Harris hip score was 77 ± 14 points in the one-stage, 60 ± 30 in the two-stage reimplanted, and 58 ± 30 in the two-stage non-reimplanted group ($P = 0.14$). The UCLA activity score was 4.0 ± 1.4 points in the one-stage, 4.2 ± 2.0 in the two-stage reimplanted, and 3.6 ± 1.1 in the two-stage non-reimplanted group ($P = 0.74$) (Table 1).

Complication other than recurrent infection occurred in 5 patients of two-stage reimplanted group. Two patients of periprosthetic fractures were managed by open reduction and plate fixation and one patient of trochanteric nonunion was managed by internal

Table 3
Microbacterial Characteristics of 83 Hips.

Type of Microorganism	One-Stage (n = 17)	Two-Stage	
		Reimplanted (n = 44)	Non-Reimplanted (n = 22)
Gram-positive			
Staphylococcus aureus			
MSSA	1	3	2
MRSA	2	2	5
Coagulase negative Staphylococcus			
MSCNS	2	6	1
MRCNS	2	10	2
Streptococcus species	3	5	1
Propionibacterium acnes		1	
Peptostreptococcus		1	
Corynebacterium			1
Gram-negative			
Enterococcus	1	2	1
E. coli	1		1
Proteus mirabilis			1
Others			
Mycobacterium genavense			1
Polybacterial	2[a]	6[b]	5[c]
Microorganism unknown	2	8	1

MSSA; methicillin-sensitive Staphylococcus aureus.
MRSA; methicillin-resistant Staphylococcus aureus.
MSCNS; methicillin-sensitive Coagulase negative Staphylococcus.
MRCNS; methicillin-resistant Coagulase negative Staphylococcus.
[a] Proteus + Peptostreptococcus + Pseudomonas, MSCNS + anaerobic Gram positive rod.
[b] CNS + Peptostreptococcus + Propionibacterium acnes, E. coli + Proteus + Enterococcus, E. coli + Enterococcus, MSCNS + MRCNS, MRSA + MSSA + Propionibacterium acnes, MRSA + MSCNS.
[c] MSSA + Streptococcus, MSSA + Candida tropicalis, Peptostreptococcus + Corynebacterium, S. lugdunensis + MSSA + Streptococcus, MSCNS + Corynebacterium + MRCNS.

fixation with plate and cable wire. Two patients had a hematoma formation (one after spacer insertion and the other after reimplantation) due to prolongation of coagulation time and required surgical debridement.

Discussion

With the aging population and increasing numbers of THAs being performed, increased number of complication such as infection and revision surgery is expected. However, elderly patients' medical condition is not always suitable for repeated extensive surgery and many patients are not usually eager to undergo a two-stage procedure for treatment of infection. Therefore, when a revision surgery is planned, it would be reasonable for both surgeon and patient to select a method that is more conservative but highly successful. From this point of view, one-stage revision for infected THA can be an attractive option because no need for extensive second stage operation, decreased morbidity, less expenses, and early functional recovery are expected in direct exchange one-stage revision [1,4].

In a recent study of decision analysis, Wolf et al [11] demonstrated that direct exchange arthroplasty was favored over two-stage approach for many outcomes based on utilities such as interim functionality, recovery time, and probability of death, although the two-stage treatment yielded a higher probability of eradication of the infection [11]. In the present study, not only the functional outcome but infection control rate of the one-stage revision was comparable to that of the two-stage revision, which supports other previous studies with real data suggesting that there is a role of one-stage exchanges for revision in infected THA.

However, interpretation of results of one-stage revision should be done with caution because most of one-stage procedures were performed in properly selected patients [4,8,18,19]. Jackson and Schmalzried [4] reviewed literatures of direct exchange procedure and identified factors associated with a successful direct exchange: (1) absence of wound complications after the initial THA; (2) good general health of the patient; (3) methicillin-sensitive (MS) Staphylococcus epidermidis, S. aureus, and Streptococcus species; and (4) an organism that was sensitive to the antibiotic mixed into the bone cement, and factors associated with failure: (1) polymicrobial infection; (2) gram-negative organisms; and (3) certain gram-positive organisms such as methicillin-resistant (MR) Staphylococcus epidermidis and Group D Streptococcus.

Of many considerable variables, the presence of a discharging sinus is often regarded as a contraindication to one-stage revision [4,19,20]. However, Raut et al [21] reported an 86% success rate for infection control in their series of 57 infections with discharging sinuses at an average followup of 7.4 years. They concluded that a discharging sinus was not a contraindication to one-stage revision of a hip arthroplasty. In our series, there was higher incidence of draining sinus in the two-stage non-reimplanted group, but there was no difference between the one-stage and two-stage reimplanted group.

Emergence of antibiotic-resistant microorganism and evolution of surgical technique using antibiotic-impregnated cement are considered the two most important developments that influenced the choice of one- versus two-stage exchange [4]. Specifically, infection caused by methicillin resistant (MR) organism is a particular threat in periprosthetic joint infection and considered a contraindication for one-stage revision [4,8]. However, Yoo et al [19] reported successful control of infection in four patients of MR coagulase negative Staphylococcus, and Winkler et al [22] reported five MR S. aureus (MRSA) infections, which were treated successfully with a one-stage revision. In our series, methicillin resistance has not shown any effects on the treatment results. In terms of the use of antibiotic-impregnated cement, although there is a report of successful infection control with cementless direct exchange arthroplasty [19], implant fixation without cement may be a contraindication to one-stage revision, and antibiotic-impregnated bone cement was used in 99% of one-stage revision in a literature review [1,4,18]. A review of multiple series also revealed that direct exchange with use of plain bone cement was successful in 40 (60%) of 67 infected THAs, whereas success rate was 1352 (83%) of 1630 hips after use of antibiotic-impregnated cement [23]. In the present study, we also used antibiotic cement in all one-stage revisions while most reimplantation was undergone by cementless fixation in the two-stage revision. As it might be impossible to excise all contaminated bone at the time of prosthesis removal, use of antibiotic cement to eliminate remnant infection as well as implant fixation is strongly recommended in one stage exchange revision.

Results of our study showed that one- versus two-stage treatment had similar results in terms of patient characteristics and clinical outcomes including infection control. Furthermore, a large portion of patients who had a plan for two-stage revision but did not proceed with planned reimplantation (two-stage non-reimplanted group) were found to be functioning well without recurrence of infection. This finding suggests that these patients in the two-stage group could have benefited from one-stage procedure, which supports the argument that one-stage treatment in selected patient has the potential for optimal treatment outcome.

Limitations of this study include its retrospective study design. There was no protocol of selection criteria for each treatment option, and the final decision for treatment option was made by treating surgeons. However, analysis of comparing possible variables between the groups did not identify any factor that could be identified as a predictor of selection criteria. The only difference was presence of draining sinus. In order to identify selection criteria that can be applied for selecting one-stage procedure, further prospective controlled study is required. In addition, uneven distribution of number of cases and followup periods between the groups may also lead to potential bias.

Rate of infection control by one-stage revision arthroplasty was comparable to that of the two-stage revision with similar functional outcome. Although we could not identify specific patient characteristics which might contribute to successful application of direct one-stage exchange, this study may suggest that one-stage revision can be an effective treatment option for selected patients in revision THA for infection. Further prospective randomized study will be required.

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