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ORIGINAL PAPER

Prosthetic joint infection following total hip replacement: results of one-stage versus two-stage exchange

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Abstract
Purpose Prosthetic hip joint infection remains a challenging socio-economic problem. Curative treatment is usually a one- or two-stage revision surgery, but neither of these options has yet emerged as the treatment of choice. The aim of this study was to evaluate which of these methods produced superior outcomes.
Methods A retrospective study was performed including 92 patients with deep infections after implantation of primary total hip arthroplasty (THA) who had undergone either one-stage or two-stage revision surgery at a single centre. Infections were classified according to McPherson and we evaluated the rate of persisting infection or reinfection after surgical intervention.
Results The two-stage revision surgery revealed superior outcomes for the analysed infection categories compared to the one-stage procedure except for the least serious category of infections (i.e. McPherson Stage I/A/1, early postoperative infection, no systemic comorbidities, local status uncompromised).

Eradication of prosthetic infection was achieved in 94.5 % (n=52) within the group of two-stage exchange, and 56.8 % (n=21) of patients treated with a one-stage procedure. Outcome of patients following a one-stage or a two-stage exchange was overall significantly different with $p<0.001$. Further deviations between the described two procedures were noted in the subgroups following the classification described by McPherson.

Conclusions Our results indicate superiority of two-stage revision surgery in case of serious infections. The authors believe that decisions on the surgical approach for the treatment of deep prosthesis infections should be made on the basis of standardized staging systems.

Keywords Total hip arthroplasty · Infection · Classification system · Outcome analysis

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Introduction

Prosthetic joint infections are the most undesired complications after reconstructive joint surgery [1–4] and remain a challenging socio-economic problem. In recent decades, the risk decreased by the use of laminar airflow, antibiotic prophylaxis, antibiotic loaded bone cement (PMMA), rigorous hygiene standards, and standardized surgical procedures [3, 5–7]. Despite these efforts, infection after implantation of total hip arthroplasty (THA) is still a serious problem for patients, physicians and the general public [2].

The surgeon might choose between the following treatment options: a one-stage revision surgery versus a two-stage revision, implant retention with or without surgical intervention, and salvage procedures, such as the Girdlestone operation. In general, a curative approach demands surgical treatment in terms of one-stage or a two-stage procedure and each treatment requires the complete removal of the infected implants and infected tissue. In case of a one-stage procedure, the removal of the infected implants is followed by debridement and irrigation and thereafter implantation of new sterile prosthetic implants is performed during the same surgical session. In a two-stage procedure, the infected implants are removed and an antibiotic augmented cemented spacer is implanted as a first step. At a later date, after eradication of the infection at the joint site, the new prosthetic components are implanted.

However, the different options of treating periprosthetic joint infection are discussed controversially [6, 8–13] and we still lack evidence of a clinical difference between one and two-stage revision surgery, despite a recent consensus statement [9, 14, 15]. The reason for this inconsistent data could be the comparison of a variety of different types and degrees of infections.

In order to elucidate the optimal treatment for infected THA, we performed a retrospective single-centre study evaluating our data from patients with prosthetic joint infections using a staging score for infection type, host grade, and local extremity grade, published by McPherson [16], to discriminate individual determining factors. The aim of this study was to evaluate whether one-stage or two-stage revision surgery would produce superior outcomes.

The hypothesis was that two-stage revision surgery would produce superior outcome in case of serious deep infections in contrast to one-stage surgery.

Material und methods

We performed a retrospective analysis of all patients having suffered from deep infections after THA who were treated between 1985 and 2004 at our department. Due to the retrospective nature of this study, approval by the local ethics committee was not necessary.

The clinical diagnosis of deep hip prosthesis infection was verified by the presence of leukocytosis, elevated C-reactive protein (CRP), local erythema, swelling, and warmth as well as aspiration of serous or purulent exudate and positive microbiology.

After a search of our hospital database, we included 92 patients (44 females and 48 males with a mean age of 64.45 years, range 21–89 years). Fourty-eight patients suffered from deep infections of a left THA and 44 of the right THA. Of the total of 92 patients, 37 had undergone a one-stage THA revision surgery (19 women, 18 men). Twenty-two patients had undergone a one-stage THA replacement of the left hip and 15 of the right hip. Fifty-five had undergone two-stage THA replacement (26 women, 29 men). Of these 55 patients, 26 had a two-stage left-sided and 29 a two-stage right-sided THA replacement. This is further illustrated in Table 1.

We divided our patients in two groups for further analysis: group one, including 37 patients who had undergone a one-stage procedure and group two, including 55 patients, who had had a two-stage procedure. We classified the hip infections according to the system by McPherson et al. [7, 8] (Table 2). This classification distinguished three main factors: the type of infection, the systemic comorbidities, and the local status. The types of infection were therefore classified as early postoperative infections occurring within four weeks after primary implantation; acute hematogenous infection, which might last up to four weeks; and the chronic late infection which lasts longer than four weeks. Systemic comorbidities are classified as no compromising systemic factors (A), up to two systemic factors (B), and more than two (C). The local status is given as unremarkable in group 1, up to two pre-existing factors in group 2, and clearly poor condition with more than two factors in group 3. This classification allows objectively quantifying the patients' risk with a standardized approach.

Table 1 Demographic data of 92 patients having undergone one-stage or two-stage revision surgery after infection of primary total hip arthroplasty (THA)

Characteristic		One-stage-exchange	Two-stage-exchange
Total		37	55
Side	Right	22	29
	Left	15	26
Age	Mean	67	60.4
Sex	Female	19	26
	Male	18	29

One-step revision

In case of one-step revision surgery, the patients were operated in a supine position. Explantation was performed after washing three times under sterile conditions and by using sterile coverage. Intra-operatively, the infection was verified by an instantaneous section with help of the pathologist. After

Table 2 Classification system of prosthetic joint infection according to McPherson et al. [10]

Category	Grade	Description
Infection type	I	Early postoperative infection (<4 weeks postoperative)
	II	Hematogenous infection (<4 duration)
	II	Late chronic infection (>4 weeks duration)
Systemic		comorbidities
	A	Uncompromised (no compromising factors)
	B	Compromised (1–2 compromising factors)
C		Significantly compromised (>2 compromising factors) or one of the following: • Absolute neutrophil count <1000 • CD4 T cell count <100 • Intravenous drug abuse • Chronic active infection, other site • Dysplasia or neoplasm of immune system
Local status	1	Uncompromised (no compromising factor)
	2	Compromised (1–2 compromising factors)
	3	Significantly compromise (>2 compromising factors)

explantation and generous debridement, jet lavage was performed, followed by a lavage with Betaisadona® (povidone-iodine, at least for five minutes). New sterile drapes were applied and a new set of sterile instruments was set out.

After further jet lavage and Betaisadona baths, a new, sterile, uncemented THA system was implanted. Microbiologists where consulted for targeted antibiotic treatment, which was administered for at least six weeks in total or two weeks after normalized laboratory parameters.

Two-step revision

The procedure is equal to the one-step revision until the step of re-implantation of the uncemented THA. Instead of doing so, an antibiotic spacer consisting of antibiotic-augmented bone cement and a bipolar endoprosthesis is implanted. In 18 cases, a Girdlestone situation was created and the bone defect in the acetabulum was filled with antibiotic-augmented bone cement. This cement is normally augmented with gentamycin. In addition 1 g vancomycin was added to 40 mg Palacos® (Heraeus Medical GmbH Wehrheim, Germany) cement or another antibiotic depending on the antibiogram, in selected cases.

Standard infection diagnostics involved an intra-operative smear and removal of three tissue samples for microbiological examination. Any tissue suspected of being infected was sent to pathology for final analysis.

After surgery, patients were followed weekly with a clinical exam, laboratory testings, and CRP, as well as regular aspiration of the operated hip and microbiological examination of the aspirate. Implantation of the definitive THA as the second step was not performed before having had the aspirate sterile three times, the parameters of inflammation unremarkable three times, and a negative leukocyte scintigraphy.

Follow-up analysis

Regular follow-up evaluations were performed at our department at six weeks, three months, six months, and yearly after revision surgery.

After two years of follow-up, we observed five reinfections in the two-stage procedure group and four reinfections in the one-stage procedure group. Only two of 94 patients were lost at follow-up of two years.

Results

In the first group, 37 patients (19 women and 18 men) had undergone a one-step procedure. Of those 37 patients, 24 (64.9 %) had suffered from an early postoperative infection (infection type I), one (2.7 %) from an acute hematogenous infection (type II), and the remaining 12 patients (32.4 %) had suffered from a type III infection (Table 3).

In the second group, 55 patients (26 women and 29 men) had undergone a two-step procedure. This group showed a stronger tendency toward type III infections. Only six patients (10.9 %) were classified as category I and 1 (1.8 %) as category II. The remaining 48 patients (87.3 %) were classified as category III. We observed a considerably higher percentage of patients having undergone a two-step procedure with a chronic late infection (87.7 %) than in the one-step procedure group (32.4 %).

With respect to potential concomitant morbidities, in the one-step group there were 13 (35.1 %) patients with no such disorders (McPherson A), while 24 (64.9 %) patients had two or more compromising factors: 18 (48.6 %) had up to two such factors (B) and six (16.2 %) had more than two (C).

In the two-step procedure group, 37 (67.3 %) of 55 patients could be evaluated for systemic comorbidities, whereby 29 (52.7 %) were classified as B according to McPherson and eight (14.5 %) in category C. No systemic comorbidities were found in the remaining 18 (32.7 %) patients.

Comparing the two groups with respect to local status showed the following: In the one-step group there were 15 (40.5 %) patients with an unremarkable local situation but there were only five (9.1 %) such patients in the two-step group. In the one-step group, 17 (45.9 %) patients fell into category 2, and five (13.5 %) into category 3. In contrast, in the two-step group, there were 30 (54,5 %) patients in category 2 and 20 (36.4 %) in category 3. Direct comparison of the outcome between one- and two-step procedures showed the following: With the one-step procedure, eradication could not be achieved in 16 patients (43.2 %). In comparison, the two-step procedure showed much more successful eradication with no success in three patients only (5.5 %). Therefore the two-step procedure was successfully performed in the 52 patients

Table 3 McPherson classification (infection type, systemic host grade, and local extremity grade) [10] of one-stage versus two-stage revision surgery in 92 patients with infection of primary total hip arthroplasty (THA)

McPherson classification	One stage group $n=37$	Two stage group $n=55$	p
Infection type I	24 (64.9 %)	6 (10.9 %)	$p<0.001$
Infection type II	1 (2.7 %)	1 (1.8 %)	
Infection type III	12 (32.4 %)	48 (87.3 %)	
Systemic host grade A	13 (35.1 %)	18 (32.7 %)	$p=0.958$
Systemic host grade B	18 (48.6 %)	29 (52.7 %)	
Systemic host grade C	6 (16.2 %)	8 (14.5 %)	
Local extremity grade 1	15 (40.5 %)	5 (9.1 %)	$p=0.001$
Local extremity grade 2	17 (45.9 %)	30 (54.5 %)	
Local extremity grade 3	5 (13.5 %)	20 (36.4 %)	

Table 4 Outcome of the two surgery procedures in the McPherson classification [10] groups

McPherson classification		One-stage		Two-stage		
Infection type	Outcome	*n*	%	*n*	%	*p*
I (early)	No eradication	6	25.0	0	0.0	0.302
	Eradication	18	75.0	6	100.0	
II (hematolog)	No eradication	1	100.0	0	0.0	>0.999
	Eradication	0	0.0	1	100.0	
III (late chron)	No eradication	9	75.0	3	6.2	<0.001
	Eradication	3	25.0	45	93.8	
Systemic host grade						
A	No eradication	0	0.0	1	5.6	>0.999
	Eradication	13	100.0	17	94.4	
B	No eradication	10	55.6	0	0.0	<0.001
	Eradication	8	44.4	29	100.0	
C	No eradication	6	100.0	2	25.0	0.010
	Eradication	0	0.0	6	75.0	
Local extremity grade						
1	No eradication	6	40.0	0	0.0	0.260
	Eradication	9	60.0	5	100.0	
2	No eradication	5	29.4	2	6.7	0.081
	Eradication	12	70.6	28	93.3	
3	No eradication	5	100.0	1	5.0	<0.001
	Eradication	0	0.0	19	95.0	

(94.5 %) with clinical and serological freedom from infection. This difference is significant (p=0.001).

Comparison of infection types I and II with type III revealed a statistically significant difference in favour of the one-step procedure, as shown in Table 3 (p=0.12). In contrast, with the two-step procedure, p-value approaches 1 indicating no significant difference (p>0.999). The comparison of the systemic host grades is nearly the same. In the one-step procedure, the difference between grade A and grades B and C is statistically significant for outcome (p<0.01). But this is not the case with the two-step procedure (p>0.999). In summary, according to the McPherson classification, a higher infection type, a higher grade of systemic host, and a higher grade of local extremity revealed superior outcome in terms of a two stage revision procedure, which is illustrated in Tables 4 and 5.

Further, the one- and two-step procedures differ significantly in the comparison of local grade 1 versus 2 and 3 (p= 0.001) as well as in the comparison of local grade 1 and 2 versus 3 (p=0.18), as shown in Table 3.

Regular follow-up evaluations were performed at our department six weeks, three months, six months and yearly after revision surgery. After two years of follow-up, we observed five reinfections in the two-step procedure group and four reinfections in the one-step procedure group, corresponding to Grade 3 according to Goslings and Gouma, each [17]. Only two of 94 patients were lost at follow-up of two years.

Discussion

The aim of this study was to evaluate whether one-stage or two-stage revision surgery would produce superior outcomes. The authors performed a retrospective single-center study evaluating patients with prosthetic joint infections using a staging score for infection type, host grade, and local extremity grade, published by McPherson, to discriminate individual determining factors. The study hypothesis was that two-stage revision surgery would produce superior outcome in case of serious deep infections in contrast to one-stage surgery. We found that in case of serious and deep infections after THA,

Table 5 Outcome of the McPherson classification groups [10] in patients who underwent the one- and two-stage procedure

Procedure	Mc Pherson classification	No eradication		Eradication		Total		
		n	%	*n*	%	*n*	%	
One-stage	Infection type I+II	7	28	18	72	25	100	p=0.012
	Infection type III	9	75	3	25	12	100	
Two-stage	Infection type I+II	0	0	7	100	7	100	p>0.999
	Infection type III	3	6.25	45	93.8	48	100	
One-stage	Systemic host grade A	0	0	13	100	13	100	p<0.001
	Systemic host grade B+C	16	66.7	8	33.3	24	100	
Two-stage	Systemic host grade A	1	5.6	17	94.4	18	100	p>0.999
	Systemic host grade B+C	2	5.4	35	94.6	37	100	
One-stage	Local extremity grade 1	6	40.0	9	60.0	15	100	p=0.018
	Local extremity grade 2	5	29.4	12	70.6	17	100	
	Local extremity grade 3	5	100	0	0	5	100	
Two-stage	Local extremity grade 1	0	0	5	100	5	100	p>0.999
	Local extremity grade 2	2	6.7	28	93.3	30	100	
	Local extremity grade 3	1	5.0	19	95.0	20	100	

two-step revision surgery produced superior outcomes in contrast to one-step procedures.

Although the two-step procedures are technically more demanding for surgeons, psychologically more challenging for the patients, and reveal higher costs to the health care system, our data produced evidence that it might be the better method to eradicate a deep prosthesis infection with only infection type 1/A/I as the single exception. The authors believe that in case of type 1/A/I infections a one-step procedure is more suitable leading to less socioeconomic burdens.

However, the actual literature is very confusing with its wide variety of outcomes. In the present day, it is highly unusual that with meticulous medical research and evidence based medicine, such differences can be published for the different approaches to a given condition. Considering only the prosthesis replacement options compared in this study, eradication for deep prosthesis infections with one-step procedures is given as 86–92 % [9, 13, 18, 19]. On the other hand, eradication with the two-step procedure is given as 75–100 % [8, 9, 11, 12]. Large numbers of cases have been obtained by collecting data in meta-analyses and systematic reviews [20, 21]. Although great efforts were made in the comparison of large numbers of very different patients in the various studies it is questionable whether the published data, in spite of the best statistical concepts, can be collected this way and then be comparable [20, 21].

Infections are multifactorial events and have therefore be analysed and classified as such. The authors believe that a comparison of the oncological surgical approaches might be suitable in case of infection surgery [22]. The farther an infection has spread, the more difficult it will be to successfully eradicate it in total. In addition, the tissue and systemic factors of the patient such as diabetes can play a major role. It is a matter of fact that primary care units might admit their multimorbid patients to our department for further treatment, leading to a negative selection of these cases. Therefore, the course and treatment of such cases cannot be easily compared with early infections in younger, healthier patients [15]. It thus is essential to analyse patients precisely with respect to their infection risk and type. In 1999, McPherson published a staging system for patients with deep infections of THA and TKA [10, 16] and we used this algorithm in our study to classify our patients in order to achieve comparable data from defined patient groups.

Decisions regarding the surgical treatment of patients with deep prosthesis infections should be supported by a standardized staging system. Further studies based on such a staging system would be useful in defining a standardized and optimized interventional approach for deep infections of a hip total endoprosthesis [16]. According to our data, the one-step procedure, which is less stressful for the patient, is the method of choice for infection type 1/A/I. With all other categories in McPherson's staging system, the two-step procedure is superior for eradication of infections.

This study has potential limitations. First, it lacks further functional results, i.e. the comparison of the two procedures. However, our aim was to present a retrospective analysis of two different treatment methods for prosthetic joint infections and division in further subgroups with more than two different procedures was not possible due to the low numbers, which were included in this study. Second, we did not group the pathogenic germs with respect to a subgroup analysis, as the numbers were insufficient. In addition, the retrospective nature of this study results in a low level 3 of evidence. Last, we performed no sample size calculation, as we only evaluated retrospective data and the patients were operated on by different surgeons.

However, we want to underline the significant benefit that this study analyses a relatively large number of cases with a very low attrition, all treated at a single center and no meta-analysis of register datasets has been performed on this topic yet [23].

Conclusion

Our results indicate superiority of two-stage revision surgery in cases of serious infections. The authors believe that decisions on the surgical approach for the treatment of deep prosthesis infections should be made on the basis of standardized staging systems.

References

1. Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ (2009) The epidemiology of revision total hip arthroplasty in the United States. J Bone Joint Surg Am 91(1):128–133
2. Blom AW, Taylor AH, Pattison G, Whitehouse S, Bannister GC (2003) Infection after total hip arthroplasty. The Avon experience. J Bone Joint Surg (Br) 85(7):956–959
3. Bauer TW, Parvizi J, Kobayashi N, Krebs V (2006) Diagnosis of periprosthetic infection. J Bone Joint Surg Am 88(4):869–882
4. Parvizi J, Zmistowski B, Berbari EF, Bauer TW, Springer BD, Della Valle CJ, Garvin KL, Mont MA, Wongworawat MD, Zalavras CG (2011) New definition for periprosthetic joint infection: from the Workgroup of the Musculoskeletal Infection Society. Clin Orthop Relat Res 469(11):2992–2994
5. Evans RP (2011) Current concepts for clean air and total joint arthroplasty: laminar airflow and ultraviolet radiation: a systematic review. Clin Orthop Relat Res 469(4):945–953
6. Romanò CL, Romanò D, Meani E, Logoluso N, Drago L (2011) Two-stage revision surgery with preformed spacers and cementless implants for septic hip arthritis: a prospective, non-randomized cohort study. BMC Infect Dis 16(11):129
7. Dale H, Hallan G, Hallan G, Espehaug B, Havelin LI, Engesaeter LB (2009) Increasing risk of revision due to deep infection after hip arthroplasty. Acta Orthop 80(6):639–645
8. Bejon P, Berendt A, Atkins BL, Green N, Parry H, Masters S, McLardy-Smith P, Gundle R, Byren I (2010) Two-stage revision

for prosthetic joint infection: predictors of outcome and the role of reimplantation microbiology. J Antimicrob Chemother 65(3):569–575
9. Wolf CF, Gu NY, Doctor JN, Manner PA, Leopold SS (2011) Comparison of one and two-stage revision of total hip arthroplasty complicated by infection: a Markov expected-utility decision analysis. J Bone Joint Surg Am 93(7):631–639
10. McPherson EJ, Woodson C, Holtom P, Roidis N, Shufelt C, Patzakis M, Keck (2002) Periprosthetic total hip infection: outcomes using a staging system. Clin Orthop Relat Res 403:8–15
11. Fink B, Grossmann A, Fuerst M, Schäfer P, Frommelt L (2009) Two-stage cementless revision of infected hip endoprostheses. Clin Orthop Relat Res 467(7):1848–1858
12. Pignatti G, Nitta S, Rani N, Dallari D, Sabbioni G, Stagni C, Giunti A (2010) Two stage hip revision in periprosthetic infection: results of 41 cases. Open Orthop J 4:193–200
13. Wroblewski BM (1986) One-stage revision of infected cemented total hip arthroplasty. Clin Orthop Relat Res (211):103–107
14. Leopold SS (2014) Consensus statement from the international consensus meeting on periprosthetic joint infection. Clin Orthop Relat Res 471(12):3731–3732
15. De Man FH, Sendi P, Zimmerli W, Maurer TB, Ochsner PE, Ilchmann T (2011) Infectiological, functional, and radiographic outcome after revision for prosthetic hip infection according to a strict algorithm. Acta Orthop 82(1):27–34
16. McPherson EJ, Tontz W Jr, Patzakis M, Woodsome C, Holtom P, Norris L, Shufelt C (1999) Outcome of infected total knee utilizing a staging system for prosthetic joint infection. Am J Orthop (Belle Mead NJ) 28(3):161–165
17. Goslings JC, Gouma DJ (2008) What is a surgical complication? World J Surg 32(6):952
18. Winkler H, Stoiber A, Kaudela K, Winter F, Menschik F (2008) One stage uncemented revision of infected total hip replacement using cancellous allograft bone impregnated with antibiotics. J Bone Joint Surg (Br) 90(12):1580–1584
19. Raut VV, Siney PD, Wroblewski BM (1994) One-stage revision of infected total hip replacements with discharging sinuses. J Bone Joint Surg (Br) 76(5):721–724
20. Bedair H, Ting N, Bozic KJ, Della Valle CJ, Sporer SM (2011) Treatment of early postoperative infection after THA: a decision analysis. Clin Orthop Relat Res 469(12):3477–3485
21. Wolf M, Leithner A, Clar H (2012) Letter to the editor: treatment of early postoperative infections after THA: a decision analysis. Clin Orthop Relat Res 470(6):1792, author reply 1793–4
22. Wang J, Dang P, Raut CP, Pandalai PK, Maduekwe UN, Rattner DW, Lauwers GY, Yoon SS (2012) Comparison of a lymph node ratio-based staging system with the 7th AJCC system for gastric cancer: analysis of 18,043 patients from the SEER database. Ann Surg 255(3):478–485
23. Sadoghi P, Schröder C, Fottner A, Steinbrück A, Betz O, Müller PE, Jansson V, Hölzer A (2012) Application and survival curve of total hip arthroplasties: a systematic comparative analysis using worldwide hip arthroplasty registers. Int Orthop 36(11):2197–2203