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Spacer prostheses in two-stage revision of infected knee arthroplasty

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Abstract At present, no consensus exists on the best spacer alternative for the management of two-stage exchange arthroplasty of infected knee arthroplasties. In this retrospective study, patient records of 24 patients, who had undergone two-stage revisions in which resterilised prosthetic components were used as spacers, were reviewed. The outcome was compared to that of operations performed during the same period (1993–2003) using cement spacers (n=10). With an average follow-up of 32 months, control of infection was achieved in 26 cases (76%), with good or excellent clinical outcome in 19 cases (56%). Treatment failed and resulted in amputation at the level of the thigh before reimplantation in one case. Three patients did not undergo reimplantation. In four cases (12%) infection relapsed. The reinfection rate did not differ between the two spacer groups. Patients treated with resterilised components had a superior range of motion during the period between the two stages. Operative time was shorter and there was less blood loss in the reimplantation arthroplasty when a prosthetic spacer was used. We consider resterilised prosthetic components a safe and effective alternative to cement spacers in the management of infected knee arthroplasties.

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Résumé Il n'existe pas actuellement de consensus sur les meilleurs spacers à utiliser dans le traitement des reprises en deux temps des prothèses totales du genou infectées. Dans cette étude rétrospective, 24 patients ont été évalués, patients ayant bénéficié d'un changement prothétique en deux temps, le spacer utilisé pouvant être les composants prothétiques stérilisés. Nous avons comparé le devenir de cette série (1993–2003) à une autre série traitée pendant la même période et en utilisant un spacer en ciment (10 patients). Le délai moyen était de 32 mois et la guérison de l'infection a été obtenue dans 76% des cas (26) avec un excellent ou un bon résultat dans 19 cas (56%). Les échecs du traitement sont secondaires à une amputation de cuisse avant la réimplantation (un cas). Trois patients n'ont pas eu de réimplantation et dans 4 cas (12%) l'infection a récidivé. La récidive de l'infection n'est pas différente entre les deux groupes de patients quelle que soit la nature du spacer. Les patients traités avec des composants prothétiques re-stérilisés ont eu une meilleure mobilité pendant la période intermédiaire. Le temps opératoire et les pertes sanguines sont significativement diminués lorsque le spacer utilisé est la prothèse re-stérilisée. Nous considérons en conclusion, que la re-stérilisation du composant prothétique est une méthode sure, efficace et une bonne alternative au spacer en ciment lors du traitement des prothèses totales du genou infectées.

Introduction

Two-stage exchange arthroplasty with delayed reimplantation remains the gold standard in the treatment of infected total knee replacements [13]. Several spacer types have been introduced [2, 5, 6, 8, 11, 13] in order to prevent scarring and soft tissue contraction and to allow mobilisation of the patient during the interim period between the operations.

Molded, articulating cement spacers have been developed, but they do not seem to improve the postoperative range of motion compared to regular cement block spacers [5]. In another study [4], superior range of motion was

achieved with resterilised prosthesis spacers compared to cement block spacers. These comparative studies used historical controls, which introduces a period effect as a confounding factor. Thus, the superiority of mobile over static spacers remains to be proven. This study reports the results achieved with resterilised prosthesis spacers compared with the results in patients with cement spacers treated during the same period.

Materials and methods

The study cohort consisted of 34 consecutive two-stage exchange arthroplasties performed for infected total knee replacement in 32 patients in 1993–2003. There were no exclusions on the basis of presentation (acute or chronic) or cause of the infection. Data concerning the treatment and follow-up were collected retrospectively from the patient records and the infection register of the hospital. The patients who had not attended follow-up visits for the last 1.5 years were invited for follow-up (n=7) or interviewed by phone (n=1). Preoperative and latest postoperative radiographs were analysed. Data concerning previous operations and eventual reoperations performed elsewhere in Finland were retrieved from the Finnish Arthroplasty Register.

The mean age at the first-stage operation was 68±11 years (39–85) for 21 women and 11 men. The average body mass index was 30.1±4.8 kg/m^2 (19.1–41.7). Twenty-five patients had osteoarthritis and seven patients had inflammatory arthritis. In the majority of the knees (n=30) the previous operation was primary total knee replacement, which in two patients had been simultaneously bilateral. Four patients had a history of two or more previous knee replacements, and one of them had previously had a two-stage procedure for infection. The median time between the index operation and the first-stage operation was 13.5 months (0.7–123.2).

Sufficient data to calculate the Knee Society pain score and function score before surgical treatment of the knee infection were available in 24 and 19 cases, respectively. The median pain score was 10 (0–45) and the median function score 0 (0–60). Median preoperative range of motion (recorded in 22 cases) was 82.5° (0–120). Extension lag of up to 20° or less was present in six knees. One knee was in ankylosed in 30°. The average tibiofemoral alignment was 3.0° of varus (ranging from 15.3° of varus to 4.7° of valgus). Osteolysis was found in eight cases.

The diagnosis of infection was based on symptoms, clinical status, C-reactive protein, and erythrocyte sedimentation rate and/or leucocyte count. Bacterial cultures of synovial fluid samples or of perioperative specimens revealed the infecting pathogen in 30 cases. *Staphylococcus aureus* (n=11) and coagulase-negative staphylococci (n=9) were the most common findings. In four cases, more than one bacterial species was identified. The time between the onset of symptoms and the first clinical examination was less than a week in 12 cases.

Treatment

Before the resection arthroplasty an attempt to control the infection with débridement was made in ten cases. The treatment consisted of resection arthroplasty with thorough débridement, high-pressure saline lavage [7], and synovectomy followed by intravenous and oral antibiotics and delayed reimplantation. The temporary spacer alternatives were (1) the removed and cleaned femoral component after resterilisation with resterilised or new tibial polyethylene insert (resterilised prosthesis spacer, n=24) and (2) cement spacer that was manually molded to allow the movement of the knee (n=10). The decision on the type of spacer was made perioperatively according to the surgeon's preference. All spacers were loosely fixed with antibiotic-impregnated cement to facilitate later removal.

All patients received parenteral antibiotics for at least two weeks followed by oral antibiotics. The total length of antibiotic treatment was a minimum of five weeks. An infectious diseases specialist was consulted about antibiotic treatment. In nine cases, a redébridement (removal of the spacer and débridement and lavage of the joint) was needed to control the infection. In one life-threatening infection, amputation was performed at the level of the thigh.

The second-stage procedure was performed when no signs of infection were present, on average 5.2±2.1 months (2.1–9.6) after the first stage. After removal of spacers, débridement and high-pressure saline lavage, a condylar (Total Condylar III or posteriorly stabilising, n=25) or hinged prosthesis (n=5) was implanted. All prostheses were fixed with antibiotic-impregnated cement. Bone defects were filled with augments or bone grafts. Allogeneic femoral head grafts were used in a cement spacer case. Tibial tubercle osteotomy was performed for exposure in two cases and quadriceps snip in one. In one case the second-stage procedure was not performed due to the high risk of reoperation and in two cases because the patients were satisfied with their prosthetic spacers and refused to have a new operation.

Analyses

The main outcome variables were reinfection rate, postoperative range of motion, and postoperative Knee Society knee and function scores [10]. Normally distributed variables were compared using Student's t-test. The Mann-Whitney U test was used for skewed variables. For comparison of categorical variables the chi-square test with Fisher's exact test, when necessary, was used. Statistical analyses were performed using SPSS for Windows 10.1 statistical software package and p values of 0.05 or less were considered statistically significant. Results are given as mean±standard deviation (range) or as median (range).

Table 1 Patient demographics and preoperative clinical setting presented by the type of spacer

	Type of spacer		*p* value
	Resterilised components (*n*=24)	Cement spacer (*n*=10)	
Patient demographics			
Age at first-stage operation, years	68±10 (43–80)	70±11 (43–85)	0.561
Gender			0.232
Female	18	5	
Male	6	5	
Diagnosis			0.754
Osteoarthritis	18	8	
Inflammatory arthritis	6	2	
Body mass index, kg/m^2	30.5±4.5	29.3±5.5	0.541
Preoperative clinical setting			
Type of previous operation			0.444
Primary total knee arthroplasty	22	8	
One-stage revision arthroplasty	1	2	
Two-stage revision arthroplasty	1	0	
Time since previous operation, months	15.3 (0.9–123.2)	9.4 (0.7–117.1)	0.849
Duration of symptoms <1 week	10	2	0.473
Knee Society score			
Pain score	19.1±14.5 (0–45)	15.0±9.3 (0–30)	0.787
Function score	17.9±22.7 (0–60)	13.0±18.9 (0–45)	0.964
Knee score	40.1±16.2 (10–73)	34	0.465
Mean range of motion, degrees	87.3±17.5 (55–120)	44.3±32.7 (0–95)	0.007

Results

Infection-free knee prosthesis with a Knee Society score of 70 or more was defined as success in the treatment. This was achieved in 19 cases at the latest follow-up, on average 31.6±26.8 (2–86) months after the reimplantation. Reinfection occurred in four cases, in two cases by the same infecting organism as that causing the previous infection. The earliest of the reinfections occurred half a month after the reimplantation in an obese patient with rheumatoid arthritis and it resulted in above-the-knee amputation. A late staphylococcal infection, occurring 69 months after the index operation, was treated successfully with long-term antibiotics. The two remaining reinfections were diagnosed after 15 and 54 months of follow-up and were managed with a new two-stage exchange arthroplasty. All patients were followed-up for 12 months or more for implant survival, based on the data of the Finnish Arthroplasty Register, and there were no re-revisions for reasons other than infection.

Radiolucent lines were visible in the latest radiographs around the femoral component in two cases, around the tibial component in one case, and around both components in one case. The average tibiofemoral alignment was 0.4° of varus (ranging from 5.6° of varus to 4.4° of valgus). Bone grafts had incorporated well and there were no signs of graft resorption. Migration of a spacer was observed in five cases, but this was associated with bone loss in only one case.

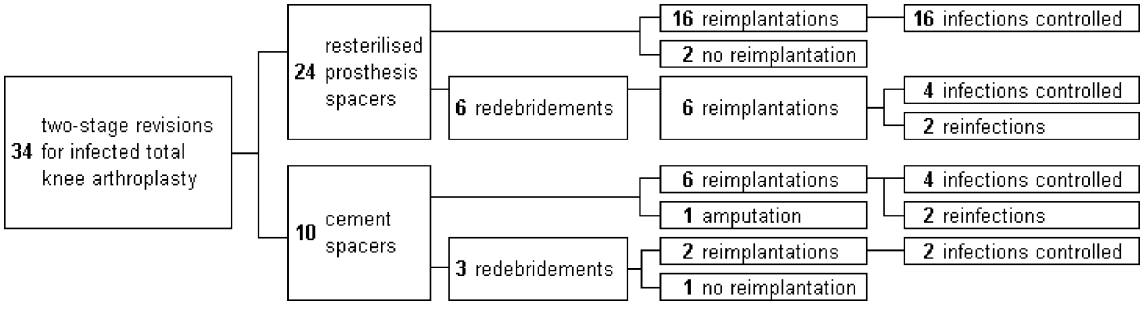

Fig. 1 Treatment and outcome in the eradication of infection with the use of resterilised prosthesis spacer and cement spacer

Table 2 Clinical outcome of two-stage exchange arthroplasty. Patients who did not undergo a second-stage procedure are excluded

	Type of spacer		*p* value
	Resterilised components (*n*=22)	Cement spacer (*n*=8)	
Length of follow-up, months	25.0±21.8 (2–68)	48.9±32.1 (2–86)	0.075
Infection-free at last follow-up	20 (91%)	6 (75%)	0.144
Pain score	46.8±7.8 (20–50)	46.0±8.9 (30–50)	0.654
Function score	58.7±26.0 (0–100)	53.0±17.2 (40–80)	0.044
Good or excellent result (>70)	11	1	0.046
Knee score	81.6±12.8 (56–99)	79.3±13.0 (67–97)	0.254
Good or excellent result (>70)	16	3	0.027
Range of motion, degrees	103.7±12.1° (80–120)	92.0±31.1° (40–120)	0.143

Effect of spacer type

Except for the range of motion, there were no significant differences in demographics, preoperative variables, or pathogens between the two groups (Table 1). Neither did the reinfection, amputation, and redébridement rates differ. The course of treatment and the outcomes achieved are presented in Fig. 1.

The average times between resection and reimplantation procedures were 170±60 (range: 63–288) and 128±56 (range: 69–223) days in resterilised prosthesis spacer and cement spacer groups, respectively (p=0.058). When a resterilised prosthesis was used as spacer the duration of the second-stage operation was shorter (mean 185±33 vs 247±88 min, p=0.008) and there was less blood loss [median 425 (50–2,200) vs 1,500 (120–4,200) ml, p=0.008], but there were no differences in the total operative time (the sum of operative time in first- and second-stage procedures and eventual redébridement, p=0.289) or the total blood loss (p=0.174).

Clinical data from the interim period between the two stages were available in approximately half of the cases. Patients with resterilised prosthesis spacers had a greater range of motion (mean 89±18 vs 17±13°, p<0.001) than patients with cement spacers. They also tended to score higher in Knee Society knee [median 64 (0–78) vs 17 (1–58)] and function (mean 15±14 vs 4±10) score but the differences were not statistically significant.

At the last follow-up examination, the proportion of excellent or good results according to the Knee Society knee (p=0.027) and functional (p=0.046) score was higher in the resterilised prosthesis group. Knees treated with prosthetic spacers had a slightly but not significantly greater range of motion than cement spacer knees (Table 2).

Effect of redébridement

Redébridement was required in nine cases to control the infection. Enterococci were more prevalent among these patients (33 vs 4%, p=0.019) than among the straightforward revision cases. Redébridement presaged a worse outcome in Knee Society knee score (mean 63±19 vs 81±13, p=0.026) and range of motion (mean 80±27 vs 101±19°, p=0.042). It also lengthened the total operative time (mean 414±53 vs 321±80 min, p=0.004) but did not increase the total blood loss. The reinfection rates did not differ.

Discussion

Although the two-stage exchange of infected knee prostheses is usually successful in eradication of infection, its clinical results are often poor, compared to results of revisions performed for aseptic reasons [1, 15]. This is probably related to the need for two (or more) surgical operations with a prolonged immobilisation during the interim period. In theory, an articulating spacer, by allowing movement of the knee, could prevent scarring

Table 3 Previous results with resterilised prosthetic spacers. *HSS* Hospital for Special Surgery knee score, *KSS* Knee Society knee score

Authors	Publication year	Number of patients	Average length of follow-up (months)	Reinfection rate (%)	Proportion of good or excellent results (%)	Average flexion (°)
Hofmann et al.	1995	26	30	0	92 (HSS)	106
Emerson et al.	2002	22	46	9	–	108
Hofmann et al.[a]	2005	50	73	12	90 (HSS)	104
Present series	2005	22	25	9	71 (KSS)	104

[a]The later report by Hofmann et al. includes the 26 patients already reported in 1995

and soft tissue contractures in and around the involved joint, and therefore result in easier reimplantation and superior clinical outcome compared to conventional static spacers. However, on the basis of the two reports [4, 5] comparing articulating spacers to historical controls with static spacers it seems that also the type of an articulating spacer matters.

In this study, resterilised prosthesis spacers were compared to manually molded mobile cement spacers and were found to give slightly better functional scores without increasing the risk for reinfection. Our results with this type of spacer were poorer than or at their best equal to those described in earlier series (Table 3). The inferiority of our results compared to this earlier series may result from different types of infections treated: in this series acute infections with symptoms for less than a week formed almost half of the cases, while all infections in Hofmann et al.'s series [8, 9] were chronic. This suggests that acute infections may complicate two-stage revisions for infected knee arthroplasties. Different types of infections could also explain why there has been no need for redébridement operations in the earlier series, but in this study were required in almost 25% of the cases. As these patients required extensive extra resources for their treatment and had worse clinical outcome compared to straightforward revisions, it is evident that demand for redébridements should be minimised. The persistence of infection is often caused by formation of bacterial biofilms resistant to host immune defence and antibiotics [3]. Prosthetic spacers serve as good substrate for bacterial adherence, but it has also been demonstrated that *Staphylococcus aureus* and *Pseudomonas aeruginosa* can form biofilms even on antibiotic-loaded bone cement in vitro [12, 14]. In this series, the redébridement rates did not differ between the spacer groups, which suggests that the use of prosthetic spacers does not compromise the outcome of treatment.

Two theoretical advantages of mobile spacers, namely, ease of reimplantation and superior functional capacity of the patient during the interim period, were demonstrated in our study. Similar results have been reported also with another type of mobile spacer, the PROSTALAC (DePuy, Warsaw, IN, USA) spacer [6]. The two patients with temporary prosthetic spacer who did not undergo reimplantation but are still satisfied with their knees represent an additional advantage of this type of spacer over static cement spacers. These findings may have important applications when different ways to reduce the enormous costs of two-stage revisions are considered.

This study has certain limitations that make it difficult to draw very far-reaching conclusions. Knee Society scores from the follow-up and interim period between the stages could not be recorded in all cases. It is possible that some differences escaped noticed due to lack of study power (type II error). Selection of the type of spacer according to the surgeon's preference instead of randomisation may have introduced a selection bias in favour of the resterilised prosthesis spacer. Considering that the number of reinfections increases with time [4], the follow-up of some patients may be too short to be sure about the success of the treatment even though the survival data were ensured from the nationwide Arthroplasty Register. On the other hand, the inclusion of a consecutive series of patients regardless of the cause or presentation of infection, and a thorough and complete follow-up for implant survival, improve the reliability of the results. We consider it safe to conclude that good functional outcome can be expected with the use of a resterilised prosthesis as spacer. In comparison to mobile cement spacers, they seem to ease the reimplantation procedure without impairing the postoperative knee function or bone stock.

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