ORIGINAL ARTICLE

Application of an articulating spacer in two-stage revision for severe infection after total knee arthroplasty

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Objective: To investigate the efficiency and safety of articulating spacer for severe infection after total knee arthroplasty (TKA) in patients with medical comorbidities and local sinus tracts.

Methods: Between January 2002 and March 2008, ten consecutive patients with late stage infected TKA complicated by local sinus tracts and medical comorbidities, were treated in our hospital by delayed two-stage reimplantation using articulating spacers. The modified Hospital for Special Surgery (HSS) knee scoring system was used to evaluate the results.

Results: One patient underwent knee fusion as the infection could not be controlled after first-stage surgery. Infection was eradicated in the other nine patients. The mean follow-up was 50 months (range, 24–90 months), no recurrent infection developing in these nine patients. The average modified HSS score was 48 points (range, 32–63) before the first-stage surgery, 79 points (range, 62–91) at the end of the spacer period, and 89 points (range, 74–95) at the latest follow-up, and the good to excellent rate was 0%, 80% and 100%, respectively. The average range of motion had improved to 8° to 93° at the end of the spacer period, and 3° to 110° at the last follow-up, compared to 13° to 70° preoperatively.

Conclusion: Delayed two-stage reimplantation using an articulating spacer is effective for treating infected TKA in patients with medical comorbidities or local sinuses.

Key words: Arthroplasty; Articulating spacer; Infection; Knee; Replacement

Introduction

Despite improvement in the surgical technique and the use of prophylactic antibiotics, infection after total knee arthroplasty (TKA) is not uncommon^{1–3}. Currently, the salvage options for an infected TKA include suppression with antibiotics, irrigation, open or arthroscopic debridement with prosthesis retention, resection arthroplasty, arthrodesis, amputation, one-stage reimplantation, and two-stage reimplantation (early or delayed)^{1,4,5}.

As is well known, delayed two-stage reimplantation (with an interval between stages of more than 6 weeks) provides the greatest chance of eradicating infection and preventing shortening of the affected limb. The final

outcomes are encouraging, as reported in previous publications^{6–11}. Recently, placement of an articulating antibiotic-laden spacer in the joint space at the first stage surgery has been recommended by a majority of surgeons^{12–15}. This protocol is aimed at delivering a high concentration of antibiotics, maintaining the joint space, preserving the soft tissues, and allowing early mobilization of patients. It has been reported that using an articulating spacer can achieve soft tissue compliance, allow for ease of operation, reduce postoperative pain, improve function, and eradicate infection as effectively as a static spacer^{13,14}.

Various medical comorbidities, such as diabetes mellitus, rheumatoid arthritis, poor nutrition, obesity, urinary tract infections, and the use of corticosteroids, are cited as either increasing the risk of reinfection or leading to a poor prognosis in infected prostheses^{16–19}. Furthermore, local sinuses in the affected knee make it more difficult to eradicate infection after TKA²⁰. Although two-stage reimplantation has shown excellent results, there have been no

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reports directly addressing the effects of two-stage reimplantation using an articulating spacer in patients with infected TKA, medical comorbidities and local sinuses. Therefore this retrospective study was undertaken to investigate the efficiency and safety of the articulating spacer for severe infection after TKA in patients with medical comorbidities and local sinuses.

Materials and methods

Patients

Between January 2002 and March 2008, ten consecutive patients with late stage infected TKA complicated by significant medical comorbidities and local sinus tracts, were treated in our hospital by delayed two-stage reimplantation using articulating spacers between the two stages. There were three men and seven women, aged from 23 to 73 years (mean, 63 years). Before the primary TKA, rheumatoid arthritis (RA) had been diagnosed in three cases, knee osteoarthritis with diabetes mellitus in six, and malignant giant cell tumor of the distal femur in one. Steroids drugs were taken periodically by the three patients with RA. Prior anti-infective measures, such as suppression by antibiotics, arthroscopic debridement and irrigation, had been taken in seven patients with unsuccessful results. The interval between the primary TKA and the onset of infection ranged from 9 to 20 months (mean, 13 months). Detailed information on the patients is shown in Table 1. This study was approved by the Ethics Committee of the hospital.

Identification of infection was based on the combined findings of clinical, serological, radiographic and bacteriologic evaluation. Typical manifestations of an infected knee, such as pain, swelling, redness and heat, were found in all patients. Compromised knee function was identified in each patient. Local synovial percutaneous fistulae with

continuous effusion were observed in all patients. Repeated serological tests on all patients revealed significant rises in white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) concentration. Repeated microscopic examinations and cultures of joint fluid aspirates of the affected knees were routinely performed. Positive cultures were observed in four cases, namely, methicillin-resistant *Staphylococcus Epidermidis* in two cases, methicillin-resistant *Staphylococcus Aureus* in one case, and *Enterococcus* in one case. Cloudy joint fluid and cocci with positive Gram-staining under microscopic examination were observed in one patient with a negative culture. Another five patients displayed a negative culture which may be due to the use of antibiotics prior to the culture (Table 1). Radiolucent lines or areas around the prosthetic components were observed on X-ray films of all patients (Fig. 1a).

Salvage strategy

The first-stage surgery involved resection of the local synovial percutaneous fistulae, debridement and irrigation of the joint space, removal of the infected prosthetic components, and implantation of an articulating spacer. After the infected prosthesis components had been removed, the femoral and tibial components were cleaned and then subject to autoclave sterilization. The cement and membrane attached to the bone surface were carefully curetted, and all non-viable soft tissue and bone were fully resected. The medullary canals were also thoroughly debrided. After extensive debridement had been achieved, irrigation was performed with 200 ml of 2% hydrogen peroxide solution, 300 ml of 0.25% PVP-I solution, and 1 liter of normal saline, in that order. The implanted articulating spacer consisted of the sterilized femoral component, a new tibial polyethylene insert (unless there was a large bone defect, in which case the sterilized tibial com-

Table 1 Physical data and infection information of all patients

Cases	Age	Sex	Diagnosis before pTKA	Side	Sinus tract	Organism	Gram-staining	Interval (weeks)
1	66	F	RA	L	Present	—	G+	13
2	61	F	RA	L	Present	MRSA	G+	12
3	71	M	OA, Diabetes Mellitus	L	Present	MRSE	G+	15
4	69	F	OA, Diabetes Mellitus	R	Present	EC	G+	12
5	23	F	Recurrent GCT	L	Present	MRSE	G+	11
6	71	M	OA, Diabetes Mellitus	R	Present	—	—	10
7	73	F	RA	R	Present	—	—	12
8	66	F	OA, Diabetes Mellitus	L	Present	—	—	13
9	68	M	OA, Diabetes Mellitus	R	Present	—	—	11
10	63	F	OA, Diabetes Mellitus	L	Present	—	—	10

Note: EC, *Enterococcus*; GCT, giant cell tumor; L, left knee; MRSA, methicillin-resistant *Staphylococcus Aureus*; MRSE, methicillin-resistant *Staphylococcus Epidermidis*; OA, osteoarthritis; pTKA, primary total knee arthroplasty; R, right knee; RA, rheumatoid arthritis.

Figure 1 A 69-year-old man was admitted with delayed infection of the right knee after total knee arthroplasty two years previously. (a) Radiolucent lines around the prosthesis components are visible on X-ray films. Two-stage reimplantation was performed on this patient. (b) A tibial polyethylene insert and (c) femoral component were used, with a large amount of antibiotic-impregnated cement around both components. (d) Radiographs of the articulating spacer show a large amount of antibiotic-impregnated cement around the tibial polyethylene insert. (e) X-ray film after second stage surgery showing that a new rotational hinged prosthesis has been implanted.

ponent was also used), and antibiotics-laden Palacos bone cement (1 g gentamicin in 40 g of Palacos cement) (Fig. 1b–d). A new patellar insert was also included where patella arthroplasty had been performed. The sterilized femoral component, tibial and patellar inserts were cemented in place with highly cured, antibiotics-laden Palacos bone cement. All bone mass deficiencies were fully filled with the cement. Generally, two packages of the cement were used. The articulating femur-to-tibia surface was thus composed of metal (the femoral side) and polyethylene (the tibial side). Then the limb was allowed to fully extend with correct alignment and tissue tension. Any excessive cement was removed along the edges of the components. After final curing of the cement, the joint space was irrigated with 1 liter of normal saline. After routine closure with drainage, the extremity was placed in a bulky compressive dressing.

After recovery, each patient was sent back to the ward for further care and treatment. Anti-inflammatory and analgesic drugs were administered. Antibiotic therapy was carried out based on the culture results. The appropriate antibiotics were used intravenously for more than 4 weeks, including the first postoperative day. Patients with a negative culture received intravenous vancomycin. Following this, broad-spectrum antibiotics were used for another 2 weeks. The drainage was removed on the post-

operative third day. Particular attention was paid to the clinical manifestations, including patients' complaints, basic life signs and the results of periodic laboratory tests.

During this period, patients received functional exercise of the treated knee, including active ambulation with partial weight-bearing and gentle, passive exercises over a full range of motion, under the guidance of an experienced physiotherapist. Patients were initially allowed 50% weight-bearing for ambulation with the assistance of a walker or crutches, and were encouraged to attempt more weight bearing thereafter.

Prior to the second-stage surgery for prosthesis reimplantation, absence of infection was required. Eradication of infection was considered to have been achieved when the knee was painless, the body temperature normal, repeated ESR was less than 20 mm per hour or ESR levels were progressively decreasing, and CRP was repeatedly negative (less than 10 mg/l) for at least 2 weeks after discontinuation of antibiotics. At the reimplantation procedures, the prior knee incisions were used. After achieving satisfactory exposure, the spacers were found to be correctly located; the soft tissues around the spacer appeared healthy and viable; and the bone mass seemed of good quality in all cases. The spacer was removed. After a thorough debridement and irrigation, a new rotational hinged prosthesis was implanted as planned preoperatively. All

prosthetic components were cemented to the bone surface with antibiotics-laden Palacos cement. Bone loss in the femur and the tibia were compensated for with cement (Fig. 1e).

Following the second-stage reimplantation surgery, patients received care and functional exercise as prescribed for the primary TKA, including active ambulation gradually to full weight-bearing and gentle, passive exercises through a full range of motion under the guidance of an experienced physiotherapist. After discharge, all patients were asked to attend for follow up at appropriate intervals at the clinic. All knees were evaluated by clinical signs, radiographic findings, ESR, and C-reactive protein. In addition, the modified Hospital for Special Surgery (HSS) knee scoring system was used to evaluate the clinical results.

Results

One patient underwent knee fusion as the infection could not be controlled after first-stage surgery; the serum

glucose was also not satisfactorily controlled in this patient. Infection was eradicated in the other nine patients.

For these nine patients, the average time between first-stage surgery and second-stage reimplantation surgery was 12 weeks (range, 10–15 weeks). After first-stage surgery, no case required additional surgeries before the reimplantation surgery. All patients were satisfied with the function of their surgically treated knees during the articulating spacer period. The mean follow-up was 50 months (range, 24–90 months), and no recurrent infection had developed by the last follow-up according to assessment of clinical manifestations, radiographic findings, and serological parameters. During the follow-up period, no signs of loosening of the prostheses were observed (Fig. 2).

The average modified HSS score was 48 points (range, 32–63) before the first-stage surgery, 79 points (range, 62–91) at the end of the spacer period, and 89 points (range, 74–95) at the latest follow-up, and the good to excellent rate was 0%, 80% and 100%, respectively. The

Figure 2 (a, b) A 23 year old woman with a giant cell tumor of the left distal femur underwent total knee arthroplasty and suffered delayed infection with sinus tract formation. The patient underwent two-stage reimplantation. (c) After first stage surgery, the infection was controlled and the sinus tract closed. (d) Eleven weeks later, second stage surgery was performed and a new rotational hinged prosthesis implanted. (e, f) There was no recurrent infection at the third postoperative year.

average range of motion was 13° to 70° before first-stage surgery, 8° to 93° at the end of spacer period, and 3° to 110° at the latest follow-up.

After reimplantation, good healing of the knee incisions was achieved in all patients, except for delayed healing in one patient with diabetes, in whom fluctuating blood glucose concentrations were observed. Deep venous thromboses were detected in three patients. There were no cases of pulmonary embolism, or complications related to the prosthetic components in this group of patients.

Discussion

Treatment of infected TKA

Deep infection after TKA is a surgical challenge which has potentially devastating consequences. There is a risk of severe morbidity, and loss of joint function is not uncommonly seen. Thus, eradication of infection is of crucial importance in these patients. Currently, the salvage options for infected TKA include suppression by antibiotics, irrigation, open or arthroscopic debridement with prosthesis retention, resection arthroplasty, arthrodesis, amputation, one-stage reimplantation, and two-stage reimplantation (early or delayed)^{1,4,5}. Among these options, delayed two-stage reimplantation has been proven to be the most successful treatment for chronic deep infections of TKA. The interval between stages is recommended to be more than six weeks by many previous studies^{6,10,11,21,22}. The state of art method of delayed two-stage reimplantation involves the following procedures: thorough and meticulous debridement, removal of the infected prosthesis, and insertion of a spacer fabricated of antibiotics-laden cement in the first-stage surgery; antibiotic therapy in the interval between stages; and removal of the spacer and reimplantation of a new prosthesis in the second-stage surgery.

Selection of a spacer

At present, implantation of an antibiotics-laden cement spacer plays a key role in the two-stage reimplantation protocol. There are two groups of spacers, namely, the block spacer and the articulating spacer. Borden and Gearen were the first to utilize antibiotic-laden cement block as a spacer in the interval between stages, with a 90% success rate⁷. Since then, some authors have reported success rates of 90–96% in controlling infection with the use of a block spacer^{9,11,21}. Despite the achievement of excellent success in eradicating infection, there remain several problems, including severe wound healing problems, significant bone loss, limited postoperative range of motion, and difficulty in the exposure for reimplantation surgery. However, the articulating spacer fully resolves

these problems while eradicating infection with a comparable success rate^{13,14}. In a study of 26 patients who were followed for an average of 30 months, Hofmann *et al.* reported that the average modified HSS score after revision improved to 87 points with 92% good-to-excellent results, and no recurrent infections were observed¹⁵. More recently, the articulating spacer has gained in popularity in the light of its advantages, such as facilitating reimplantation surgery and providing improvement in range of motion. The common design of the articulating spacer is an antibiotic-laden cement implant that delivers a high local concentration of antibiotics to the involved area while preserving a functional range of motion in the interval between stages. The first type of articulating spacer is made of metal and polyethylene components coated with antibiotic-laden cement¹², while the second type is made entirely of antibiotic-laden cement fabricated from particular molds¹³. The first type of articulating spacer is cheaper than the second, which is the reason it was chosen for this study. In this study, the articulating spacer was composed of metal (the femoral side), polyethylene material (the tibial side), and gentamicin-laden cement. Using this method, the final outcomes of an averaged 50 months follow-up were satisfactory, with a dramatic improvement in range of motion. Infection was eradicated in 90% of cases without recurrent infection. No complications except delayed incision healing in one case and deep venous thrombosis in three cases were found. The above results prove that the first type of articulating spacer is effective and satisfactory.

The influence of medical comorbidities on results

The general health and status of the local site of patients with infected TKA contribute to predicting the outcomes of treatment of infection. Patients with severe medical comorbidities or local sinuses are susceptible to having unsuccessful outcomes^{16–19}. A staging system for gauging periprosthetic joint infection has been developed by McPherson *et al.*²⁰ This system incorporates three areas of grading: the infection type (acute or chronic); grading of the overall medical and immune status of the host; and grading of the local site. As McPherson *et al.* have reported, patients with chronic infection, severe medical comorbidities, compromised immunity, or local sinus tracts, tend to experience poor outcomes²⁰. In this study, all patients had both local sinuses and medical comorbidities, yet achieved successful reimplantation without recurrent infection or severe complications in 90% of cases. The successful outcome suggests that two-stage reimplantation with articulating spacers is a powerful salvage option for infected TKA, and can be used in patients with medical comorbidities or local sinuses.

The successful outcome in the current series can be attributed to the following factors. First of all, the thorough irrigation and debridement in both stages of the procedure, and the use of the antibiotics, played a key role in the success. Secondly, the patients were relatively young despite the medical comorbidities and compromised immunity. Finally, in this series, the postoperative drainage which was placed in each patient alleviated swelling of the knee as well as diminishing the possibility of recurrence of infection by draining congested blood out of the joint space.

This study reports the present authors' experience. The major weakness is the limited number of cases included. Because salvage with two-stage reimplantation for infected TKA is rather expensive, some patients in our country can't afford it. Another weakness is the heterogeneity of the patients with respect to the age range, diagnosis before primary TKA, and prior unsuccessful surgical treatment for infection. However, the salvage protocol with two-stage reimplantation was identical in each patient.

In summary, delayed two-stage reimplantation using an articulating spacer is effective for treating infected TKA in patients with medical comorbidities and local sinuses.

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Disclosure

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