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ORIGINAL STUDY

Recovery of knee mobility after a static or mobile spacer in total knee infection

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The purpose of the study was to compare the recovery of knee mobility after two-stage revision of an infected total knee arthroplasty using a static or mobile spacer. At 12 months follow-up, none of the patients had a recurrent infection of their new prosthesis. Knee flexion was lower in the static spacer group at 3, 6 and 12 months postoperatively. Patients that received a mobile spacer had a better and faster recovery of their knee function. The operation time of re-implantation was shorter in the mobile spacer group than in the static spacer group. Our results suggest that patients treated with a mobile spacer have a faster recovery of the knee range of motion and a shorter operation time, including for the subsequent re-implantation of a prosthesis. Our results support the use of the mobile spacer in patients with an infected TKA that are treated with a two-stage revision of the prosthesis.

Keywords : knee prosthesis ; infection ; revision ; cement spacer ; range of motion.

INTRODUCTION

Total knee arthroplasty (TKA) is a frequently performed surgical procedure in orthopaedic surgery. Patients suffering from knee osteoarthritis benefit from this operation by reduction in perceived pain and improvement in function. However, a prevalent complication following TKA is the occurrence of infection. The reported incidence of infection has been reported to be approximately 1% after primary TKA, and 6% after revision TKA (*1,12,29*) and has been suggested to increase in the near future (*19*).

An infected prosthesis is a major problem for both patient and surgeon. Because many infecting organisms are able to adhere to the surface of the implant, thorough debridement and removal of the prosthesis are warranted (*4,6,30,32*), leading to an extensive re-operation, a long-term rehabilitation period, and associated costs (*15,20,25*).

A delayed two-stage exchange of the infected knee prosthesis is generally recognized as the preferable strategy for the treatment of infected TKA (*5,10,14,16*). The antibiotic spacer block technique has been used for many years. Since the

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spacer block allows no flexion of the knee between the two operative stages, its use has been associated with several disadvantages, such as muscle atrophy, bone loss, and a decreased range in motion. Encouraging results with the use of articulating spacers (*3,7-9,11,13,17,22,26,28*), that allow movement of the knee, gave reason to start using mobile spacers. Although the two-stage approach is currently recognized as the gold standard, the superiority of the mobile spacer remains to be further investigated. Many modifications of the temporary spacer have been studied, including different types and amounts of antibiotic cement (*21*), and different shapes and sizes of the spacer (*8,13,18,22,27,31*). The purpose of the present study was to compare the recovery of knee mobility between a static spacer block and a mobile spacer in patients after removal of an infected TKA. We retrospectively examined a cohort of patients with an infected TKA that were treated with a two-stage revision.

MATERIAL AND METHODS

Patients

Patients with a documented TKA infection that underwent a two-stage revision of both the femoral and tibial component of their TKA were included into this retrospective study. Between March 1993 and January 2009, all patients operated in our institution were included into the study.

The diagnosis of an infected TKA was based on the clinical presentation, the erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), radiographs, bone- and IgG-scans, and was tested with Gram stains and cultures of periprosthetic tissue. If possible, a punction of the synovial fluid was taken.

Exclusion

A total of 42 patients underwent a two-stage revision during the inclusion period of the study. Seven patients were excluded from the study : 4 patients received an arthrodesis in the second stage of the revision arthroplasty and 3 patients underwent a two-stage revision of only one component. This resulted in a total number of 35 patients who were treated with a spacer made of antibiotic-loaded acrylic cement. Nine patients were treated with a temporary static spacer block and 26 patients were treated with a temporary Prostalac® articulating spacer (Depuy, Warsaw, IND, USA).

Operation

All revisions were performed by, or under close supervision, of one of the senior staff members. All procedures consisted of 1) removal of the primary TKA and implantation of the temporary spacer, 2) treatment with antibiotics with the temporary spacer *in situ*, and 3) removal of the temporary spacer and re-implantation of a new TKA.

The temporary spacer was either a static spacer block or a Prostalac® articulating prosthesis. Both the static spacer block and the mobile Prostalac® spacer were made from antibiotic-impregnated acrylic cement (Simplex®, Stryker-Howmedica, Limerick, Ireland). The antibiotic cement used for the spacer block contained Gentamicin and the cement used for the Prostalac® spacer Erythromycin and Colistin sulphomethate. The static spacer block as well as the Prostalac® articulating spacer were made on a custom basis. A mold was used for both components of the mobile spacer and the resulting construct functioned similar to a conventional total knee replacement. After a period of six weeks to three months, the second stage was performed, in which the temporary spacer was removed and a new prosthesis was inserted.

Rehabilitation

After the implantation of the temporary spacer, patients were encouraged to mobilize from the second day post-operatively under supervision of a physical therapist. The knee joint of patients with a static spacer block was placed into a cast to avoid knee motion and patients were allowed to bear full bodyweight as tolerated. Patients with a mobile spacer were also allowed to bear full bodyweight as tolerated, but were also allowed full range of motion (ROM). In addition, they passively trained their knee function by using a CPM machine (Kinetec, Smith & Nephew, France). Postoperatively, intravenous or oral antibiotics were given for 6-weeks depending on the infecting organisms.

After re-implantation with the new prosthesis, both groups followed a similar rehabilitation program. The rehabilitation program started from the second day post-operatively and was supervised by a physical therapist. Patients were allowed full bodyweight bearing and mobilized with use of two elbow crutches. The ROM of the knee was actively trained by use of exercises and passively by use of a CPM machine.

Clinical assessment

Both study groups were evaluated at 3, 6 and 12 months postoperatively after the re-implantation of the new prosthesis. The mobility of the knee was assessed by an independent physician assistant. The range of motion was measured with use of a standard clear plastic goniometer referenced against anatomical landmarks.

Other operation related parameters, such as the number of tuberosity osteotomies, operation time, and implantation time of the spacer, were obtained from patient files and surgical reports.

Statistical analysis

Statistical analysis was performed using SPSS 16.0 (SPSS Inc., Chicago, Illinois, USA). Group differences in baseline characteristics were compared using unpaired *t*-tests. The Chi-Square test was used to compare differences in percentages between groups. When data did not follow a normal distribution, non-parametric Mann-Whitney U tests were performed. The recovery of knee mobility after surgery in the static spacer group and Prostalac® group was analyzed using a 2-way repeated-measures ANOVA with a between subject factor ('group' : static *versus* mobile spacer) and a within subject factor ('time' : baseline, 3, 6 and 12 months postoperatively). We considered a statistically significant effect at a two-sided *p*-value of less than 0.05.

RESULTS

Both groups had comparable characteristics at baseline. Both groups were of similar age ($p = 0.65$) and time of total knee arthroplasty *in situ* ($p = 0.83$). The time of the temporary prosthesis *in situ* was 15 weeks (range : 4-40) in the static spacer block group and 19 weeks (range : 7-66) in the Prostalac® group ($p = 0.41$) (Table I).

Recovery of knee mobility

Preoperatively, no statistically significant differences in ROM were found between both groups ($p = 0.15$). At 3, 6 and 12 months postoperative, the knee ROM of patients treated with mobile spacers was significantly higher than in the static spacer block group ($p < 0.05$) (Table II). The ROM of the knee joint increased significantly in both groups after implantation of the revision prosthesis (ANOVA, *time-effect ;* $p = 0.01$). We found a significant difference in mobility of the knee between groups

Table I. — Patients' characteristics

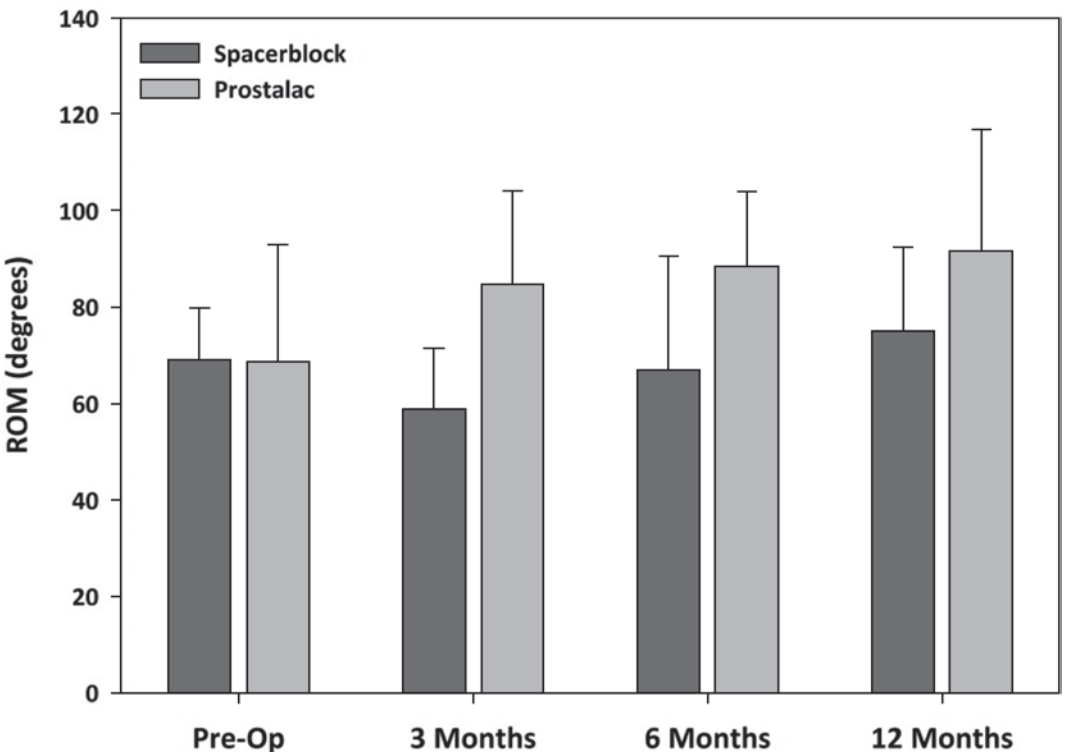
	Static Spacer block ($n = 9$)	Mobile Prostalac ($n = 26$)	*p*-value
Age (years)	61 ± 15	58 ± 13	0.65
Gender (male/female)	2 / 7	13 / 13	0.15
Primary diagnosis for TKA :			
Osteoarthritis	3	13	
Rheumatic disease	2	9	
Secondary osteoarthritis	2	4	
Unknown	2	2	
Total knee arthroplasty *in situ* (years)	5.2 ± 6.5	4.7 ± 5.2	0.83
Temporary spacer *in situ* (weeks)	15.5 ± 11.8	19.0 ± 10.6	0.41
Operation time of spacer (minutes)	116 ± 33	107 ± 26	0.37
Operation-time of re-implantation (minutes)	203 ± 28	155 ± 35	0.001
Tuberosity osteotomy at first-operation (number)	2 (22%)	13 (50%)	0.15
Tuberosity osteotomy at second-operation (number)	5 (56%)	19 (73%)	0.33

TKA = total knee arthroplasty.

Table II. — Joint mobility after two-stage revision of an infected total knee arthroplasty

	(n)	Revision with spacer block	(n)	Revision with mobile spacer	*p*-value
Preoperative ROM	8	52.5° ± 24.6°	29	69.0° ± 28.9°	0.15
ROM after re-implantation					
– 3 months postoperatively	8	65.6° ± 13.7°	26	83.8° ± 22.0°	0.03
– 6 months postoperatively	7	69.3° ± 21.5°	21	90.0° ± 16.0°	0.01
– 1 year postoperatively	8	73.8° ± 14.3°	22	96.4° ± 21.0°	0.01

ROM = range of motion.



ROM = range of motion, Pre-Op = preoperatively.

Fig. 1. — Recovery of knee motion after two-stage revision of an infected TKA

(ANOVA, *group-effect ; p* = 0.03), indicating that the ROM of the knee joint was lower in patients in the static spacer group than in the mobile spacer group. The recovery of knee ROM after implantation of the revision prosthesis was also lower in the static spacer block group than in the mobile spacer group (ANOVA, *time*group ; p* = 0.03) (Fig. 1).

Operation

During the implantation of the temporary spacer, an osteotomy of the tibial tuberosity was performed in 2 patients in the static spacer block group and in 13 patients in the Prostalac® group. During implantation of the revision prosthesis, an osteotomy of

Table III. — Infecting organisms

Organism	Frequency (%), (*n*)
Coagulase-negative staphylococci	11 (39)
– Staphylococcus epidermidis	6 (21)
– Staphylococcus capitis	1 (4)
– Staphylococcus warneri	1 (4)
– Staphylococcus haemolyticus	1 (4)
– Staphylococcus lugdunensis	1 (4)
– Unknown	1 (4)
Staphylococcus aureus	4 (14)
Propionibacterium species	5 (18)
Pseudonomas aeruginosa	1 (4)
Streptococcus species	2 (7)
– Streptococcus agalactiae	1 (4)
– Haemolytic streptococcus group G	1 (4)
Gram-positive rods	2 (7)
Micrococcus species	1 (4)
Spore formers	2 (7)

the tibial tuberosity was performed in 5 patients in the static spacer group and in 19 patients in the Prostalac® group. These differences were not statistically significant for implantation of the temporary spacer ($p = 0.15$) and re-implantation with the new prosthesis ($p = 0.33$). The duration of operation was comparable among groups during the first stage ($p = 0.37$). During the second stage, the duration of operation was shorter in the mobile spacer group than in the static spacer group ($p < 0.05$) (Table I).

Infection

No patients in either group showed any signs of a recurrent infection of their new TKA at 12 months follow-up. At the time of removal of the infected primary prosthesis, 5 patients in the static spacer group and 17 patients in the mobile spacer group had a culture proven infection (Table III). In the other cases, no specific infecting organisms could be detected, which does not prove the absence of an infection (*23,24*). In all cases however, the IgG-scan was positive for infection and the clinical observation showed redness, swelling, warmth, pain and dysfunction of the knee joint.

DISCUSSION

The purpose of the present study was to investigate the recovery of knee ROM in patients with an infected TKA treated with a two-stage revision using a temporary static spacer block or a mobile Prostalac® spacer. Our results show that patients with an articulating spacer have a better ROM at 3, 6, and 12 months postoperatively. In addition, the recovery of knee ROM is better with a mobile spacer after re-implantation of the new prosthesis.

We found no difference in infection control between both techniques. In both the mobile and static spacer group, the infection of the total knee arthroplasty was treated successfully. At 12 months follow-up, none of the patients had a recurrent infection. Our results suggest that mobile and static spacers are both good treatment options for treating an infected TKA, in line with previous reports (*7,26*).

In contrast to other studies that found a comparable operation time at the second stage operation (*8*), our results show a shorter operation time in the group that were treated with a mobile spacer. We assumed that is related with a lower amount of scar tissue formation and soft tissue shortening.

There were more osteotomies of the tibial tuberosity in the mobile spacer group that were performed during operation. A tuberosity osteotomy may be a disadvantage for knee motion recovery, if the knee is immobilized in a plaster cast for several weeks postoperatively. Although the mobile spacer group had a disadvantage on this respect, the recovery of the knee ROM was better. Therefore, we assume that differences in recovery of knee motion would have been larger if both groups had had a comparable proportion of tuberosity osteotomies.

The mobile spacer also appears preferable from a rehabilitation perspective. The mobility of the knee joint was better in the mobile spacer group at all follow-up times. At 6 months postoperatively, the mean flexion of the knee joint was 90° in the mobile spacer group, whereas mobility of the knee in the static spacer group reached only 69 and 74° flexion 6 and 12 months postoperatively. Reaching 90° of flexion is an important milestone during rehabilitation. At 90° knee flexion, patients are able to sit and rise from a chair more comfortably. In addition, a

normal walking pattern requires approximately 70°knee flexion during the swing phase (*2*). During the swing phase, the foot is lifted from the floor with a knee flexion of approximately 70°. When knee flexion is less, the patient is at risk of falling when for example passing a threshold.

A limitation of our study is the small number of patients in the static spacer group : we were able to include only 9 patients between 1993 and 2009. In the period before 1993, the knee mobility was not assessed in a standardized fashion during the outpatient visits. In addition, our department switched to the mobile spacer technique in 2002.

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