Autoclaved metal-on-cement spacer versus static spacer in two-stage revision in periprosthetic knee infection

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ABSTRACT
Background: Periprosthetic knee infection is troublesome for Orthopedic surgeons and a catastrophe for patients. Reported rates of periprosthetic joint infection following primary total knee arthroplasty (TKA) are 0.39–2%. Two stage revision arthroplasty, which has success rates exceeding 90%, has been the gold standard for treating subacute and chronic periprosthetic infection following TKA. Antibiotic spacers, a well established means of delivering local antibiotic therapy, maintain soft tissue tension during two stage revision arthroplasty. However, controversy remains around whether static or mobile antibiotic impregnated spacers are superior for treating infection following TKA. Various mobile spacers are available, including cement-on-cement, cement-on-polyethylene and metal-on-polyethylene. In this study, the efficacy of the modified metal-on-cement spacer, consisting of reininsertion of the autoclaved femoral component and implantation of antibiotic-loaded cement in the proximal tibia, is assessed. Materials and Methods: Records of 19 patients diagnosed as periprosthetic knee infection were reviewed in this retrospective study. Among these patients, 10 patients received first stage debridement with the autoclaved metal-on-cement spacer and 8 patients with the static spacer, who eventually underwent two-stage re-implantation, were listed in the final comparison. Patient demographics, infection eradication rates, average range of motion (ROM), surgical time and blood loss during the second-stage of the surgery, and Knee Society (KS) knee scores at last followup after revision total knee replacement were clinically evaluated. Results: At a minimum of 2-year followup after re-implantation, infection eradication rates, surgical times, blood loss during the second-stage of the surgery, and KS knee score after re-implantation were similar for the two groups. Patients receiving autoclaved metal-on-cement spacers had superior ROM after re-implantation compared to that of patients with static spacers. Conclusions: The autoclaved metal-on-cement spacer is an effective and simple method for two-stage re-implantation of a periprosthetic knee infection. Through this spacer, the good interim ROM can be achieved without the additional cost of prefabricated molds or new polyethylene tibial inserts. In addition, ROM after re-implantation is better than that with static spacers.

Key words: Mobile spacer, periprosthetic knee infection, two-stage re-implantation
MeSH terms: Arthroplasty, replacement, knee, knee joint, knee prosthesis, surgical infection

INTRODUCTION
Periprosthetic knee infection is troublesome for Orthopedic surgeons and a catastrophe for patients. Reported rates of periprosthetic joint infection following primary total knee arthroplasty (TKA) are 0.39–2%. As the number of patients undergoing primary TKA is increasing, there is an increase in the number of periprosthetic joint infection also.

Two-stage revision arthroplasty, which has success rates exceeding 90%, has been the gold standard for treating subacute and chronic periprosthetic infection following TKA. Antibiotic spacers, a well-established means of delivering local antibiotic therapy, maintain soft tissue tension during two-stage revision arthroplasty. However, controversy remains around whether static or mobile
antibiotic impregnated spacers are superior for treating infection following TKA.

Although static spacers deliver local antibiotic therapy, they markedly restrict knee motion. In contrast, mobile spacers, which allow mobility during the interim period between the first and second stage of revision arthroplasty, reportedly improve range of motion (ROM) after second-stage procedures. Various mobile spacers are available, including cement-on-cement, cement-on-polyethylene, and metal-on-polyethylene. Although each mobile spacer has its own advantages and advocates, commercial mobile spaces are not always affordable or applicable to each patient. Continued efforts are needed to develop temporary spacers for two-stage revision arthroplasty.

To the best of our knowledge, data regarding the effectiveness of metal-on-cement spacers are rare. In this study, the efficacy of the modified metal-on-cement spacer, consisting of reinsertion of the autoclaved femoral component and implantation of antibiotic-loaded cement in the proximal tibia, is assessed.

**Materials and Methods**

19 consecutive patients who were diagnosed with chronic periprosthetic knee infection and received two-stage debridement between February 1999 and February 2012 were assessed in this retrospective study. There were no exclusion criteria on the basis of the cause of infection. Review Board approval was acquired for this retrospective study of medical records and radiographs; that is data for treatment and followup were collected retrospectively from patient records.

There were 17 females and 2 males aged between 20 and 88 (mean 71.2 years) years. Indications for TKA were osteoarthritis (n = 16), rheumatoid arthritis (n = 2) and osteonecrosis of the femoral condyle (n = 1). 15 of 19 patients had at least one comorbidity. Diabetes mellitus was diagnosed in 11 patients. Latent osteoarticular tuberculosis infection, liver cirrhosis, and end-stage renal disease was diagnosed in three patients separately. Median time from the index operation and the first-stage operation was 55.7 months (range 9–145 months).

The diagnosis of infection was based on symptoms such as persistent pain, swelling, local warmth, restricted and painful ROM disproportionate to the expected recovery from the surgery. All infections were confirmed with joint fluid analysis and serological tests including C-reactive protein (CRP) levels, erythrocyte sedimentation rate (ESR) and leukocyte count. Bacterial cultures of synovial fluid samples or of perioperative specimens identified the pathogen in 11 patients [Figure 1].

**Treatment strategy and evaluation methods**

The two groups in this study were based on treatment protocols for two-stage revision [Figure 2]. Between February 1999 and June 2006, 10 patients were treated with static antibiotic-impregnated spacers [Figure 3]. Among these 10 patients, two patients did not undergo re-implantation (one died of pneumonia and the other refused re-implantation due to high mortality risk under anesthesia). Therefore, only eight patients who received second-stage revision could be included in the final comparison. Furthermore, among these eight patients, two patients had a recurrent infection during followup. These two patients then received two-stage revision again with mobile spacers.

After June 2006, 11 patients (including nine who had no previous debridement surgery and two who had previously failed two-stage revision surgery with static spacers) were treated with autoclaved metal-on-cement antibiotic-impregnated spacers [Figure 4]. However, among these 11 patients, one patient refused re-implantation because of satisfaction for the mobile spacer without motivation for revision. Therefore, only 10 patients who received re-implantation could be listed in the final comparison.

Successful two-stage re-implantation was defined as no evidence of infection for at least 2 years after revision TKA. Infection eradication rates, average ROM, surgical time, blood loss during second-stage procedure, as well as Knee Society (KS) knee score at last followup after revision TKA were compared. Knee ROM was examined through a goniometer, and clinical results were recorded by one Orthopedic surgeon (W-P H).

**Operative procedure**

All patients underwent two-stage revision surgery by one Orthopedic surgeon (W-P H). During the first-stage of surgery, all patients underwent extensive
debridement at the time of implant removal. A complete synovectomy was performed, and medullary canals were thoroughly debrided. Antibiotics were encased in the cement according to the sensitivity profile of the infecting organism or 2 g vancomycin/40 g bone cement powder was used for patients with negative preoperative culture results. Temporary spacer alternatives were static antibiotic-impregnated spacers and autoclaved metal-on-cement spacers. With the static spacers, antibiotic-loaded cement filled the extension gap after removal of all implants [Figure 3b].

For autoclaved metal-on-cement spacers, we prepared them as follows:

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**Figure 2:** Treatments and outcomes of patients treated for periprosthetic knee infection

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**Figure 3:** Anteroposterior radiograph of the knee of a 72 year old female with infection after total knee arthroplasty who was treated with the static spacer showing (a) loosening of implant (b) After static spacer insertion (c) After re-implantation of implant

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**Figure 4:** Anteroposterior radiographs of the knee of 88-year-old female with infection after total knee arthroplasty who was treated with the autoclaved metal-on-cement spacer. (a) Radiograph showing loosening of the prosthesis. (b) After autoclaved metal-on-cement spacer insertion. (c) After re-implantation
• Step 1: Preparation of the autoclaved femoral component:
The removed femoral component was cleaned to remove bone cement and debris, washed and sterilized in an autoclave for 7 min at 137°C in the operating room.

• Step 2: Preparation of the temporary tibial cement component:
A flexible template was utilized to enclose the space filled with antibiotic-loaded cement according to the size of the removed tibial plate [Figure 5a and b]. The autoclaved femoral component was then utilized to press onto the temporary tibial cement spacer before cement polymerization to ensure a smooth articulating surface between the metal and cement components [Figure 5c]. Excess cement was removed.

• Step 3: Reinsertion of the femoral and tibial components:
The femoral component was reinserted with antibiotic-impregnated cement first to restore its original joint height, according to reference from the epicondylar axis (average 23 mm from lateral epicondyle and 28 mm from medial epicondylar). Next, the tibial cement component was placed while the knee was in full extension position under gentle traction. The gap between the tibia cement component and tibia bone surface was filled with antibiotic-impregnated cement. All spacers were fixed loosely with antibiotic-impregnated cement during the near rubber phase of cement polymerization, in order to decrease infiltration of cement into the trabecular space of the bone surface and facilitate later removal. The effort was made to restore the original joint line and maintain proper alignment, as well as balanced soft tissue tension [Figure 5d].

After staged operations with static or mobile spacers, antibiotics were administered intravenously for 2 weeks according to the sensitivities of infecting organisms, followed by a 4-week course of oral antibiotics. After surgery, a temporary long leg splint was applied for 2 weeks in patients in the static group; while range of motion (ROM) of the knee was allowed after applying a knee brace in the mobile group. Weight bearing, when tolerated, was allowed in both groups.

The second-stage procedure was performed only when signs of infection were not present. Before the second-stage of revision, normal laboratory findings (ESR, CRP) were required for at least 2 weeks after withdrawal of antibiotics. The surgical approach for re-implantation followed the principles of revision TKAs. All prostheses were fixed with antibiotic-impregnated cement. Bone defects were filled with augments or bone grafts. After the operations, patients were clinically reviewed using ESR and CRP and for any signs of recurrent infection.

**Statistical analysis**
The primary outcome variables were infection eradication rate, perioperative ROM, and postoperative KS knee scores. The Mann–Whitney U-test was applied to compare variables. To compare categorical variables, the Chi-square test with Fisher’s exact test was used. \( P \leq 0.05 \) was considered statistically significant. Analytical results given are mean (range).

**Results**
All patients were followed up for at least 2 years after revision TKA. Ten patients in the modified mobile spacer group and eight in the static spacer group who underwent revision TKA were compared [Table 1]. No significant differences existed between the two groups for age, gender, and sites of a knee infection. Prior to the first operation, patients in the modified mobile spacer group achieved 40° (range 30–75°) ROM, compared with an average 38.1° (range 5–90°) of ROM for the static spacer group. Preoperative ROM between these two groups did not differ significantly. During the interim period between the first and second surgery, patients in the modified mobile spacer group achieved a 81° (range 45–100°) of ROM, compared with an average of 5° (range 0–30°) of ROM for the static spacer group. Average period between the first and second surgery was 135.9 days (range 61–296 days) and 155.8 days (range 49–420 days) in the mobile spacer group and static spacer group, respectively \( (P = 0.897) \). Notably, among the patients treated with the mobile spacer, five of 10 (50%) complained about knee instability while walking. All ten patients walked with the assistance of a knee brace.

**Figure 5** (a and b) Photograph showing antibiotic loaded cement preparation by removed tibial plate and flexible template (c) Photograph showing cement spacer being pressed by autoclave femoral component before cement polymerization (d) Peroperative photograph showing insertion of autoclaved femoral component and tibial cement component.
During the second operation, no differences existed between the mobile and the static spacer groups in terms of operative time (mean 173.7 vs. 183.1 min, $P = 0.562$) or the operative blood loss (mean 145 vs. 143.8 min, $P = 0.056$). Two patients in the mobile spacer group, and one in the static group needed V-Y quadriceps plasties for better exposure and lengthening of quadriceps tendon due to contracture. Further, no fracture of cement spacers was identified during re-implantation for these two groups. However, variance existed in terms of prosthesis used in revision surgery [Table 1].

At final followup after re-implantation, patients in the modified mobile spacer group achieved a 94.5° (range 70–125°) of ROM, compared with an average 74.3° (range 50–90°) of ROM for the static spacer group; these differed significantly ($P = 0.023$). The average KS knee scores in the modified mobile and static spacer groups were 74.7 (range 62–88) and 71.4 (range 60–81), respectively. No significant differences existed in scores at final followup ($P = 0.327$). Two-stage re-implantation without reinfection was successful in eight of 10 (80%) patients in the modified mobile spacer group and in six of eight (75%) patients in the static spacer group. Infection eradication rate between these two groups did not differ significantly ($P = 1$). Although the followup duration for the static spacer group (mean 40.8 months) was longer than that for the modified mobile spacer group (mean 32 months), the difference was not significant ($P = 0.056$). Besides, one patient’s postoperative course in the static spacer group was complicated by nonfatal deep vein thrombosis during the period between the two operations and needed anticoagulant therapy during the treatment course.

Two patients in the static spacer group were reinfected after followup for 12 and 23 months, respectively. The first patient had culture report of *Pseudomonas aeruginosa*, treated with quinolone group. The second patient failed to have positive culture report, empirically treated with vancomycin. These two patients with previously failed infection control subsequently received two-stage revision with autoclaved metal-on-cement mobile spacer. Fortunately, after followup for at least 2 years, there was no recurrence of infection. However, another two patients in the modified mobile spacer group were reinfected 11 and 15 months after re-implantation, respectively. Bacterial cultures yielded methicillin-resistant *Staphylococcus aureus* in the first patient but failed to yield organisms in the second patient. These two patients were all treated with vancomycin and underwent repeated debridement, eventually achieving infection control after followup for at least 1-year. No correlation between infection eradication rates, the yielding organism and giving antibiotics could be identified in these patients with recurrent infection.

**Discussion**

Periprosthetic knee infections are significant challenges for orthopedic surgeons. Even with successful eradication, these infections can be devastating and catastrophic, resulting in long term disability. Currently, two-stage revision with antibiotic spacers is commonly performed to treat an infection after TKA. However, debates remain as to which antibiotic spacers are ideal. The static spacer provides only temporary joint stability and is considered a simple procedure and an ideal antibiotic-delivery system. Nevertheless, concerns regarding static spacers have focused on spacer subluxation and dislocation, spacer fracture, bone erosion, as well as knee stiffness due to prolonged immobilization between stages. Instead, the mobile spacer has many advantages, including potentially

**Table 1: Patient demographics and clinical outcome of two-stage revision arthroplasty**

| Patient demographics | Mobile spacers (mean/range) (n=10) | Static spacers (mean/range) (n=8) | $P$ |
|----------------------|------------------------------------|-----------------------------------|-----|
| Age (in years)       | 68.9 (20-88)                       | 73.9 (63-82)                      | 0.857 |
| Gender               | 9 female, 1 male                    | 5 female, 3 male                  | 0.275 |
| Infected site        | 6 left, 4 right                     | 6 left, 2 right                   | 0.638 |
| ROM before first-stage surgery | 40° (30°-75°) | 38.1° (5°-90°) | 0.423 |
| Duration between first- and second-stage surgery (in days) | 135.9 (61-296) | 155.8 (49-420) | 0.897 |
| ROM after first-stage surgery | 81° (45°-100°) | 5° (0°-30°) | 0.000 |
| Surgical time during second-stage surgery (min) | 173.7 (150-225) | 183.1 (150-220) | 0.562 |
| Blood loss during second-stage surgery (ml) | 145 (50-500) | 143.8 (50-300) | 0.503 |
| Prosthesis options for revision | PSA (n=6); LCCK (n=4) | PSA (n=3); LCCK (n=5) | |
| ROM after second-stage surgery | 94.5° (70°-125°) | 74.3° (50°-90°) | 0.023 |
| Knee society knee score | 74.7 (62-88) | 71.4 (60-81) | 0.327 |
| Infection eradication rate (%) | 8/10 (80) | 6/8 (75) | 1 |
| Followup after second-stage surgery (months) | 32 (24-46) | 40.8 (25-56) | 0.056 |
| Complications | V-Y quadriceps plasties (n=2); Wound dehiscence (n=1) | V-Y quadriceps plasties (n=1); Nonfatal DVT (n=1) | |

Patients who did not undergo a second-stage procedure are excluded. PSA=United Orthopedic’s U2 PSA Revision Knee system, LCCK=The Zimmer NexGen Legacy Constrained Condylar Knee system, DVT=Deep vein thrombosis, ROM=Range of motion, PSA=Prosthetic specific antigen

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Chen, *et al.*: Autoclaved metal-on-cement spacer in two-stage revision for infected total knee replacement
The relative small sample size is the main limitation in our study. It is also limited by the biases inherent to a
Conflicts of interest

There are no conflicts of interest.

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