Original research

Early to midterm results of “low-friction” articulating antibiotic spacers for septic total knee arthroplasty

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Background: Infection of total knee arthroplasty is a complex problem often resulting in multiple surgeries for the patient. We examined the early to midterm results of a retained cemented “low-friction” metal-on-polyethylene articulating antibiotic spacer in total knee arthroplasty.

Methods: We retrospectively reviewed patients with a total knee cemented articulating antibiotic spacer performed for joint sepsis. Patients were allowed full weight bearing and normal activities after eradication of the infection at 6 weeks postop. Two months later, patients were given the option of conversion to a revision implant vs retention of the spacer. We examined infection cure rate, mechanical failure, Knee Society Scores, range of motion, and patient factors associated with spacer retention.

Results: Fifty-five knees were studied with average follow-up of 1.8 years (0.2-8.4). Among patients choosing spacer retention (40%), the average follow-up time of the spacer was 3.3 years (0.6-8.4). Five patients (9.1%) required a repeat spacer for recurrent infection.

Conclusions: Usage of articulating cement antibiotic spacers with a metal-on-polyethylene bearing couple provides excellent infection eradication, while also resulting in good functional outcomes. Early evidence suggests that use of the implant can be extended beyond typical timeframes and, in certain patient populations, may be suitable for a single-stage procedure.

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Introduction

Infection is one of the most dreaded complications in total knee arthroplasty, and it is among the most common reasons for reoperation [1]. Its incidence in primary procedures is currently 0.4%-2%, with a societal cost approaching $1 billion [2-6]. As the expected number of total knee arthroplasty procedures continue to rise, periprosthetic joint infections (PJIs) will become more prevalent [5].

The principles of chronic PJI management involve removal of the infected component, thorough debridement of necrotic tissue and foreign debris, placement of a cement spacer or new components, and culture-directed antibiotics. Surgical decision-making often depends upon several factors including chronicity of infection, microorganism, health of the patient, fixation of the prosthesis, remaining bone stock, and surgeon preferences. When temporary spacers are placed, they are typically planned for a second-stage surgery with delayed removal and revision arthroplasty after eradication of the infection, typically around 6 weeks to 3 months after the first stage.

Since originally proposed by Insall et al [7] in 1983, 2-stage exchange arthroplasty has emerged as the gold standard for treatment in chronic PJI. With this technique, successful eradication of PJI with the addition of antibiotic cement and culture-directed antibiotic therapy averages 91% but has a range of 59%-100% [8].

During 2-stage exchange arthroplasty, there are several options: (1) resection arthroplasty, (2) static cement spacer, or (3) articulating “low-friction” metallic/polyethylene or articulating “high-friction” cement spacer [9]. The low-friction option has a new or
The antibiotic cement mixture protocol was to mix 1 bag (40 g) of Simplex (Howmedica, Rutherford, NJ) cement powder with the powdered antibiotics. For each 40 g bag of cement, one of the following powdered antibiotic options was added: (1) 4 g of vancomycin (Gram-positive organisms), (2) 4.8 g of tobramycin (Gram-negative organisms), or (3) 2.0 g of vancomycin and 2.4 g of tobramycin (mixed flora). In most cases, 1 batch of cement was utilized for the tibia and 1.5 batches for the femur. The decision of which combination to use was based on whether there was prior identification of the organisms preoperatively and whether they were Gram positive or Gram negative. In cases where identification was not possible or mixed flora was noted, a combination of vancomycin and tobramycin was noted. The cement was then mixed by...
hand with the monomer without any vacuum assistance. Care was taken to insure a homogenous mixture. Methylene blue dye was then added for identification of cement vs bone and removal of the cement upon possible revision procedure.

Postoperative protocol

Postoperatively, the patient was allowed touch down/foot flat weight bearing to the extremity and ambulation with a walker for 6 weeks to allow the soft tissues and the joint to rest. After 6 weeks, full weight bearing was allowed. Free active and passive ROM was instituted, unless limited by the soft tissue status immediately postoperatively from either soft tissue tension or muscle flap coverage as dictated by a plastic surgeon. The antibiotic regimen was managed by an infectious disease specialist. This usually included IV antibiotics for a minimum of 6 weeks followed by an oral antibiotic regimen for a variable amount of time at their discretion. The patients’ clinical follow-up schedule was 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and yearly thereafter. Plain radiographs were taken at every visit to evaluate for any signs of progressive radiographic loosening, cement fracture, or implant subsidence. If there were signs of continuing infection, a repeat antibiotic articulating antibiotic spacer was planned, provided there was appropriate bone support and soft tissue viability. After 6 weeks of IV antibiotics, an additional 6 weeks of oral antibiotics were occasionally given if warranted by infectious disease for an aggressive organism. An antibiotic-free interval of 6 weeks was instituted to evaluate adequacy of treatment. A preliminary check for eradication of infection consisted of an ESR and CRP. If the inflammatory laboratories were elevated then an aspiration was done, and this occurred in 8 patients.

Otherwise, if the inflammatory laboratories were normalized and the patient was doing well clinically with no pain or swelling, we determined that there was an absence of infection. With lack of implant failure and patient acceptance, the patient was given the option of retaining the spacer implant or converting to the “second stage” of the revision. If choosing to retain the implant they were followed every 6-12 months. If deciding to convert to the “second-stage” revision, they had the spacer removed and a revision prosthesis implanted at their convenience. The average time from initial placement of spacer to revision was 6 months. Standard preoperative medical workups were done and a preoperative joint aspiration was performed if we had any concern regarding possible recurrence. Intraoperative frozen sections were routinely done to ensure that there was no acute inflammation. Typically, 4 separate specimens are sent from different locations within the knee joint. If pathology was positive for acute inflammation, the patient underwent a repeat antibiotic articulating spacer.

Statistical analyses

Descriptive statistics are reported as frequencies and percentages for categorical variables and as means and standard deviations or medians and interquartile ranges, depending on the normality of the distribution. Bivariate comparisons were performed with Fisher’s exact test for categorical variables and t-tests or Wilcoxon rank-sum tests for continuous variables, where appropriate. A P-value less than .05 was considered statistically significant. All analyses were performed with STATA 15.1 (StataCorp LLC, College Station, TX).
Results

Overall, there were 55 knee procedures in 49 patients. The average age was 63 years (standard deviation 10), 41.8% were male, and average body mass index (BMI) was 33.0 (standard deviation, 7.6). In total, 26% were diabetic and 18.2% were smokers (Table 1). The average preoperative KSS was 62 (standard deviation 17). Postoperatively, the average KSS was 82 (37-103) and the flexion achieved averaged 87° (100-140°). The data were recorded from the last visit in the office if the spacer was currently in or the last visit prior to getting the spacer revised.

The mortality rate at the time of last follow-up was 11.8% (n = 6) (average follow-up of 1.8 years, range 0.2-8.4) (Table 1). Three of the deaths occurred in the retained spacer group and 3 occurred in the revision group. Regarding the timing of the 6 deaths, patients died at 13, 32, 39, 44, 52, and 69 months out from their spacer surgery. All patients died of causes unrelated to their prior spacer surgery.

The most common organisms identified from the index procedure culturing were methicillin-resistant Staphylococcus aureus (14.5%) and methicillin-susceptible S aureus (12.7%) (Table 2).

A total of 33 knees had removal of the spacer within 12 months: 26 of 33 (78.8%) were removed and underwent the second stage knee arthroplasty. Postoperatively, the average KSS was 82 (37-103) and the flexion achieved averaged 87° (100-140°). The ROM data were recorded from the last visit in the office if the spacer was currently in or the last visit prior to getting the spacer revised.

When we compared patients with retained spacers to those who were revised (Table 3), we found that the retained group tended to be slightly older (67 vs 61, P = 0.04), with lower BMIs (average of 30.1 vs 35.0, P = 0.02) and substantially lower incidence of obesity (BMI ≥30) (36.4% vs 67.7%, P = .03). When we compared KSSs and ROM, we found that the retained spacer group had significantly better ROM (100 vs 85, P = .053) and tended to have higher scores (both preoperatively and postoperatively) as well; however, the latter differences did not reach statistical significance (Table 3).

Discussion

Currently in the United States, the mainstay of treatment for established prosthetic joint infection is the 2-stage revision [7] with planned reimplantation after eradication of the infection. There is an abundance of clinical data to demonstrate the success of this method with either static or articulated spacers [20]. The benefits of a mobile spacer include improved maintenance of soft tissue tension and pliability with decreased bone loss at revision [7], increased performance scores and ROM after revision [14-16], as well as decreased surgical time and blood loss at revision [15]. In addition, these achieve equivalent or better eradication of infection in knees when compared to multiple prior studies [14-16,21,22].

With the advent of antibiotic-impregnated cemented spacers, there are options. One is cement-on-cement/high friction either premed or formed at the time of surgery. Another is low-friction articulation of the total knee implants, namely the femoral option is to utilize a brand new femoral implant articulating onto a mobile spacer include improved maintenance of soft tissue tension and pliability with decreased bone loss at revision [7], increased performance scores and ROM after revision [14-16], as well as decreased surgical time and blood loss at revision [15]. In addition, these achieve equivalent or better eradication of infection in knees when compared to multiple prior studies [14-16,21,22].

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Table 1
Patient characteristics and overall outcomes.

| Patient characteristics       | n (%)           |
|------------------------------|-----------------|
| Age, mean (SD)               | 63 (10)         |
| BMI, mean (SD)               | 33.0 (7.6)      |
| Sex: male                    | 23 (41.8)       |
| Diabetes                     | 14 (25.9)       |
| Smoking                      | 10 (18.2)       |
| Spacerc longevity            | 2 (2)           |
| Retained spacer              | 22 (40)         |
| Revision procedure           |                |
| ABX spacer                   | 5 (9.1)         |
| AK A                         | 1 (1.8)         |
| Resection arthroplasty       | 1 (1.8)         |
| TKA                          | 25 (45.4)       |
| TKA—Infection recurred       | 1 (1.8)         |
| None: retained spacer        | 22 (40)         |
| Preoperative KSS, mean (SD)  | 62 (17)         |
| Postoperative KSS, mean (SD) | 82 (15)         |
| Postoperative ROM, mean (SD) | 87 (30)         |
| Mortality                    | 6 (11.8)        |

Table 2
Species detected.

| Bacterial species                        | n (%)       |
|------------------------------------------|-------------|
| Staphylococcus (not otherwise specified) | 3 (5.4)     |
| Methicillin-susceptible Staphylococcus aureus | 7 (12.7)   |
| Methicillin-resistant Staphylococcus aureus | 8 (14.5)   |
| Methicillin-susceptible Staphylococcus epidermidis | 2 (3.6)   |
| Candida albicans                         | 1 (1.8)     |
| Escherichia coli                         | 1 (1.8)     |
| Enterococcus faecalis                    | 3 (5.4)     |
| Group B strep                            | 1 (1.8)     |
| Pseudomonas aeruginosa                   | 3 (5.4)     |
| Coagulase-negative staphylococci         | 2 (3.6)     |
| Propionibacterium acnes                  | 3 (5.4)     |
| Serratia marcescens                      | 1 (1.8)     |
| Gram-positive culture (not otherwise specified) | 3 (5.4)   |
| Culture negative                         | 10 (18.2)   |

Table 3
Retained vs revised characteristics/outcomes.

| Patient characteristics       | Retained (n = 22) | Revised (n = 33) | P value |
|------------------------------|------------------|------------------|--------|
| Age, mean (SD)               | 67 (12)          | 61 (8)           | .04    |
| BMI, mean (SD)               | 30.1 (6.0)       | 35.0 (8.0)       | .02    |
| Obese (BMI ≥30)              | 8 (36.4)         | 21 (67.7)        | .03    |
| Sex: male                    | 10 (45.4)        | 13 (39.4)        | .78    |
| Diabetes                     | 5 (22.7)         | 9 (28.1)         | .76    |
| Smoking                      | 4 (18.2)         | 6 (18.7)         | .99    |
| Preoperative KSS, median (IQR) | 65 (42-83)    | 63 (51-73)       | .92    |
| Postoperative KSS, median (IQR) | 93 (74-96)    | 82 (73-92)       | .19    |
| Postoperative ROM, median (IQR) | 100 (85-123)  | 85 (65-99)       | .053   |
| spacer duration (y), median (IQR) | 2.7 (1.4-4.7) | 0.6 (0.4-1.0)   | NA     |

ABX, antibiotics; AK A, above-knee amputation; SD, standard deviation; TKA, total knee arthroplasty.
the new polyethylene insert. Studies with long-term follow-up [14-16] demonstrate not only equivalent or superior functional outcomes and clearance of infection with low-friction spacers, but also increased ease of reimplantation at the second stage when compared to spacers constructed with cement-on-cement or high-friction bearing surfaces. Thus, as an extension of this, the possibility of prolonged use of this type of spacer with potential of full activity and weight bearing may allow adequate function without a second-stage revision.

The current study’s protocol uses a high dose of antibiotics equal to or greater than 4 g per batch of cement. This agrees with prior recommendations [22] for a similar dosing for therapeutic treatment infections. The theoretical reduction in cement strength did not cause any failures that required revision of the components, yet we exercise caution as this represents short to midterm follow-up only.

Currently, single-stage revision to treat an infected total knee is not commonplace in the United States. The results of this study support the possibility in which the metal-on-polyethylene bearing antibiotic cement spacer’s implanted longevity can be extended beyond the short-term use during the first stage of a 2-stage procedure. At the time of the last follow-up, the average implant longevity of the antibiotic spacer was 3.3 years in patients who retained their spacer. Many patients (40%) chose to retain their spacer indefinitely. Theoretically, this approach may be especially desirable for advanced age patients with multiple medical comorbidities. In this instance, a single surgery would be ideal, rather than exposing the patient to all the risks of surgical complications twice. Although we believe that this protocol would be particularly advantageous to older, less healthy patients, when we examined our own data, we found that, although they were slightly older, those who retained the spacer were generally also healthier (significantly lower BMI, lower incidence of obesity, slightly lower incidence of diabetes) and also tended to have higher postoperative KSS and significantly better flexion. The postoperative KSS difference did not reach statistical significance, but we believe that was likely attributable to the smaller sample size. Larger future studies are necessary to gain further insight into the outcomes associated with retained spacers, as well as patient factors that may be predictive of outcomes.

This study demonstrated similar infection cure rates and complications rates as compared to prior published data for mobile cement antibiotic spacers [9,10,14-16]. There were no late complications due to prolonged activity or weight bearing on the prosthesis. In addition, if there were late stage loosening, subsidence, or instability of the joint, it could be managed by the already anticipated second-stage revision procedure.

The weakness identified in this study is the retrospective nature of the review, as well as the smaller sample size. In addition, the decision of whether to proceed with the second-stage revision vs to opt out for the single-stage arm was not random as it was up to the patient’s discretion. Designing a prospective randomized protocol with specific exclusion criteria and standardizing all other parameters in the future would allow us to examine the functional, economic, and social outcomes in a more in-depth analysis.

Conclusions

This study was able to demonstrate the early to midterm results of low-friction articulating spacers in the treatment of PJIs. By lengthening the time of service of a prior published and successful technique [23], the “low-friction” antibiotic metal-on-polyethylene spacer can be retained by the patient without prolonged activity restriction, possibly postponing the second stage if they are doing well clinically, and still achieve good results.

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