■ THE INFECTED KNEE ARTHROPLASTY

Articulating antibiotic impregnated spacers in two-stage revision of infected total knee arthroplasty

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Antibiotic impregnated articulating spacers are used in two-stage revision total knee arthroplasty to deliver local antibiotic therapy while preserving function. We have observed infection control in greater than 95% of cases with functional outcomes approaching those seen in revision for aseptic loosening. Higher failure has been observed with methicillin resistant organisms.

Antibiotic spacers are a well-established means of delivering local antibiotic therapy while maintaining soft-tissue tension during two-stage revision total knee arthroplasty (TKA). Static spacers deliver local antibiotic therapy but do not allow knee motion and limit function. Articulating spacers are designed to allow mobility and protected weight bearing while maintaining soft-tissue tension and joint stability.

The PROSThesis of Antibiotic-Loaded Acrylic Cement (PROSTALAC) knee spacer (Fig. 1) was first used in 1987, consisting of a handmade replica of a conventional prosthesis made of highly antibiotic-loaded cement. This was improved in 1991, by using flexible polyethylene molds to create smooth articular surfaces on the femoral and tibial components. The current PROSTALAC spacer was introduced in 1994 with modifications to improve performance and stability. It has femoral and tibial components both made with antibiotic-loaded acrylic cement. Each component is cast in size specific molds. The tibial mold allows adjustment of the thickness of the spacer to assist in restoration of bone loss and joint stability. It has a post-cam mechanism formed from cement, between two inlay polyethylene (PE) plateaus. The femoral component incorporates small metal runners linked by a posterior cross bar to prevent posterior dislocation, thus creating a metal on PE bearing surface with a posterior stabilized system.

While there are several benefits to one-stage direct exchange for patients with little comorbidity and an identified susceptible organism, two-stage revision remains the gold standard in the treatment of chronic infection in TKA in North America and many centres worldwide. We present a review of our experience with articulating antibiotic impregnated spacers.

Patients and methods

In one of our earliest reviews of the PROSTALAC spacer published in 2000, Haddad et al¹ reported outcomes for 45 consecutive patients with infected TKA treated between April 1987 and March 1996. All patients were treated with intravenous antibiotics for six weeks. Patients were assessed at a mean of 48 months (20 to 112) using the Hospital for Special Surgery (HSS) score at baseline and follow-up to establish functional outcomes.

In 2003, Meek et al² reported outcomes for a subsequent series of 58 patients treated between January 1997 and December 1999. Radiological assessment of bone was used to classify osteolysis occurring during treatment. The functional assessment was measured by employing several quality of life (QOL) scores: WOMAC osteoarthritis index, Oxford-12, SF-12 and a satisfaction score. In a separate study using the same patients and published in 2004, Meek et al³ compared functional outcomes in the infected group to 125 patients who underwent revision TKA for aseptic loosening. There was remarkable similarity between the groups.

Finally in 2011, Gooding et al⁴ reported outcomes for our largest cohort of 115 infected TKA managed with the PROSTALAC spacer between September 1996 and January 2004. A total of 32 patients died with a mean follow up for surviving patients of nine years (five to 12). All patients were allowed to partial weight bear with crutches and encouraged to start range of motion and quadriceps strengthening exercises. Intravenous antibiotics were prescribed for a minimum of five weeks. For reimplantation, patients required resolution of inflammation and normalisation of the C-reactive protein (CRP) with a downward trending erythrocyte

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Fig. 1

The current PROSTALAC articulating antibiotic spacer after manufacture in the operating room (left) and cemented loosely into the knee (right). Note the features designed to improve the articulating surface, provide stability and compensate for bone defects.

sedimentation rate (ESR). Patient-reported QOL scores, with validated outcome tools, were used to assess functional outcome. A review of factors predisposing to reinfection was also performed.

Results

Infection clearance for the earliest series in 2000 was 91% and in the 2003 study 96%. In the larger 2011 series the overall clearance rate with one procedure was 87%. Of the 14 cases of reinfection, 12 were subsequently cleared with a repeat two-stage procedure giving an eventual control rate of 98%. The two failures were infected with Methicillin-resistant Staphylococcal organisms.

Functional advantages were apparent from the beginning. Relief of pain was noted in the early series and this improved further with the addition of a low friction bearing. The mean HSS score was 42.2 on presentation, 55.9 after the first stage and 71.4 at final review. These improvements were significant ($p < 0.0005$). Pre-operative range of motion improved from 71° to 95° at final follow-up with a reduction in extensor lag. When Meek et al³ compared functional results of revision for sepsis to aseptic revision they could not demonstrate a functional difference between the groups. In the septic group, mean WOMAC function was 68.9/100 and pain 77.1/100. Range of motion pre-operatively was 78° and 87° post-operatively. The final mean HSS score was 76. Finally, in the 2011 series slightly lower QOL scores were reported although there was still a significant improvement from the pre-operative scores. Final mean WOMAC function was 63.2/100 and pain 68.6/100.

Complications with the earlier designs included knee dislocation and instability. These were greatly reduced with addition of the post and cam mechanism and variable implant sizing to accommodate bone loss. While there were medical and wound complications in the latest series using the modern generation of the PROSTALAC, there was only

one fracture of the implant requiring repeat first stage and one case of instability. A reoperation rate after reimplantation of 11% was observed by Gooding et al⁴ similar to the findings of Meek et al.²

Infection due to methicillin resistant *Staphylococcus aureus* (MRSA) has increased in frequency. In the latest series (2011), eight of the 115 cases were due to MRSA, two of which failed treatment (25%), each requiring above-knee amputation to resolve the infection and achieve a useful limb.

Discussion

Articulating spacers have provided excellent control of infection with the added benefits of preserved range of motion and function during treatment. The success rate in our latest study was 87% after the first attempt. A repeat two-stage procedure was successful in 12 of the 14 failures. Other authors have reported similar rates of control using articulating spacers (Table I). Furthermore, there is no evidence of compromised infection control when comparing articulating spacers to static spacers⁵⁻⁷ or when using metal on polyethylene bearings.^{6,8}

Function during treatment is superior with articulating designs.⁷ Emerson et al⁶ reported significantly improved mean flexion after the second-stage when comparing static to metal on polyethylene articulating spacers (93.7° vs 107.8°). Park et al⁷ reported similar results comparing static to an all cement spacer (92° vs 108°). Jämsen et al⁸ compared all cement to metal on polyethylene spacers but did not show significant a significant difference in final motion or functional scores.

We found similar final range of motion and functional scores when comparing patients revised for septic and aseptic loosening. Baker et al⁹ reported functional outcomes for knees undergoing one-stage or two-stage revision for infection. They did not find a difference in patient derived outcome scores.

Table I. Reported control rates and functional outcome for two-stage treatment of infected TKA. C – cement, M – metal, PE – polyethylene, PROS – Prostalac.

Spacer	Reference	Number of knees	Infection control	Range of motion and functional outcome
Static vs C/C	Fehring et al 2000 ⁵	Static 25 C/C 30	Static 88% C/C 97%	ROM average 98° static and 105° artic. Static HSS score 83, Artic 84 points. Neither difference statistical significance
M/PE (PROS)	Haddad et al 2000 ¹	45	91%	ROM average at final follow up 94.5°. Average HSS score 71.5°.
Static vs M/PE	Emerson et al 2002 ⁶	Static 26 M/PE 22	Static 92% M/PE 91%	Static average flexion 93.7°. Articulating 107.8° (significance difference p=0.01)
M/PE (PROS)	Meek et al 2003 ²	47	96%	ROM 87° at final follow-up. WOMAC pain 68.9, WOMAC func 77.1 Oxford 67.3, SF-12 mental 53.7 physical 41.2.
C/C	Durbhakula et al 2004 ¹¹	24	92%	Average knee flexion post 2 nd stage. 104°. Average HSS score 82.
C on PE	Evans 2004 ¹²	31	94%	Average ROM of articulating spacer 10° to 80°. Average of 2 nd stage 0° to 130°.
C/C	Pitto et al 2005 ¹³	21	100%	ROM between stages 77°, final follow-up 94°, KSS score with spacer 74, 81 at latest fu. KSS func with spacer 75, 84 at latest fu.
M/PE	Cuckler 2005 ¹⁴	44	98%	Average ROM spacer 110, at final follow-up 112°. KSS score final follow -up 84.
M/PE	Hofman et al 2005 ¹⁵	50	88%	ROM with spacer -6° to 91°. At final follow-up ROM avg 4° to 104°. HSS score 89 points final follow-up.
C/C vs M/PE	Jämsen et al 2006 ⁸	C/C 10 M/PE 24	C/C 90% M/PE 83%	ROM with spacer C/C 44.3° with M/PE 87.3°. KSS score C/C pain 15, func 13, knee score 34. M/PE pain 19.1, func 17.9, knee score 40. ROM 2 nd stage C/C 92, M/PE 103 (not sig) KSS score C/C pain 46, func 53, knee score 79. M/PE pain 46.8, func 58, knee score 81.
Static vs C/C	Park et al 2010 ⁷	Static 20 C/C 16	Static 85% C/C 94%	Average flexion with spacer static 9 artic 80. At final follow-up ROM static 92, artic 108 significance difference (p = 0.04) HSS static 48.2, artic 57.2 and at final follow-up static 80 artic 87 (p=0.04)
C/C	Van Thiel et al 2011 ¹⁶	60	88%	Avg flexion 101.3 final follow-up. Avg KSS 79 final follow-up.
M/PE (PROS)	Gooding 2014	115	87% after first attempt, 98% after second attempt	ROM 93.2° at 2 years. WOMAC pain 68.6, WOMAC function 63.2 Oxford 60.8, SF-12 mental 55.4 physical 35.5.

While two-stage revision remains our preferred technique when treating chronic infection, one-stage revision is believed to decrease morbidity, mortality, and cost. One-stage revision is likely to be appropriate in the patient with a competent immune system, good bone stock, healthy soft tissue and a reconstruction using cemented fixation.¹⁰ A susceptible organism should be isolated. The failures in our series associated with MRSA indicate these patients are still most appropriately managed with two stage procedures.

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