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Custom-made hinged spacers in revision knee surgery for patients with infection, bone loss and instability

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ABSTRACT

Polymethyl methacrylate spacers are commonly used during staged revision knee arthroplasty for infection. In cases with extensive bone loss and ligament instability, such spacers may not preserve limb length, joint stability and motion. We report a retrospective case series of 19 consecutive patients using a custom-made cobalt chrome hinged spacer with antibiotic-loaded cement. The "SMILES spacer" was used at first-stage revision knee arthroplasty for chronic infection associated with a significant bone loss due to failed revision total knee replacement in 11 patients (58%), tumour endoprosthesis in four patients (21%), primary knee replacement in two patients (11%) and infected metalwork following fracture or osteotomy in a further two patients (11%). Mean follow-up was 38 months (range 24–70). In 12 (63%) patients, infection was eradicated, three patients (16%) had persistent infection and four (21%) developed further infection after initially successful second-stage surgery. Above knee amputation for persistent infection was performed in two patients. In this particularly difficult to treat population, the SMILES spacer two-stage technique has demonstrated encouraging results and presents an attractive alternative to arthrodesis or amputation.

1. Introduction

The management of infected metalwork around the knee is complex and not always associated with satisfactory outcomes. Resection arthroplasty [1] or above knee amputation [2] may facilitate infection eradication, but are associated with poor functional outcome. Consequently, two-stage exchange arthroplasty is the most commonly employed surgical approach used to manage infected total knee replacements [3,4]. During the first-stage procedure, microbiological specimens are obtained and the implants are removed. The joint is debrided and an antibiotic-loaded spacer is usually implanted. Provided there is no evidence of persistent infection, the definitive prosthesis is implanted after a period of antibiotic therapy. This approach is associated with the eradication of infection ranging from 41 to 91% of cases [4,5].

Conventionally, spacers consist of polymethyl methacrylate (PMMA) cement that elutes antibiotics, allows the patient to remain ambulant and lessens soft tissue contraction. Static spacers allow the surgeon to maintain the joint space in the presence of moderate bone loss but may be associated with extensor mechanism shortening, spacer related bone loss, instability, implant extrusion, overstuffing, and implant or peri-prosthetic fracture [6]. The use of articulating PMMA spacers may lessen these problems but such implants cannot be used if they do not provide the patient with a relatively stable knee. This is often the case when there is significant bone loss or ligamentous instability.

We report our early results using a custom-made cobalt chrome hinge spacer with antibiotic-loaded cement. The "SMILES spacer" was used at the first of two-stage revision knee arthroplasty for infection associated with significant bone loss due to trauma or failed endoprosthetic reconstruction.

2. Methods and materials

2.1. Patients

The study was approved by the joint Research and Ethics Committee of the Hospital Trust. A retrospective review of the cases notes and radiographs of 19 consecutive patients who underwent first-stage revision arthroplasty using the SMILES spacer prosthesis was performed. Surgery was undertaken at a single tertiary referral centre under the supervision of the five senior surgeons between September 2003 and August 2007. Patients with less than 2 years follow-up were excluded. All patients had deep infection involving the knee and associated with extensive bone loss or osteomyelitis.

There were 11 males and eight females with a mean age of 56 years (range 18–74). Fourteen patients had been referred to our

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unit from other centres and five had undergone their primary procedure at our hospital. Infection was diagnosed due to the presence of a discharging sinus (nine), positive cultures following aspiration (five), or raised inflammatory markers combined with high clinical suspicion (five). Infection had been present for a mean of 23 months (range 4–71) before the first-stage revision using the SMILES spacer. All of the patients had received either continuous or intermittent antibiotic therapy and repeated washouts and debridements without success. Each case was associated with extensive bone loss or osteomyelitis, and had previously been operated on a mean of 3.7 times (range 1–17 times, excluding simple debridements and washouts). Revision was performed for infection following revision knee replacement (11), tumour endoprosthetic reconstruction (four), primary total knee replacement (two), and infected metalwork with osteomyelitis (following fixation of a compound fracture of distal femur in one case and distal femoral osteotomy in one). Table 1 shows the patient demographics, including diagnosis at index procedure and the infected metalwork in situ.

2.2. Implant design

All of the implants were custom-made and manufactured by Stanmore Implants Worldwide (Middlesex, U.K). Pre-operative measurement radiographs and magnetic resonance imaging were used for implant design. The implant is based on the SMILES (Stanmore Modular Individualised Lower Extremity System) rotating knee hinge [7,8] but uses a fixed hinge, a smooth collar (rather than the usual hydroxyapatite coating) and polished intramedullary stems (Fig. 1a and b). All of the metal components were made of cobalt chrome, with ultra high molecular weight polyethylene bearing inserts. Femoral or tibial bodies were incorporated into the prostheses where the extent of metaphyseal and diaphyseal bone loss required it.

2.3. Surgical technique

Antibiotics were stopped at least a fortnight before surgery, to improve the chances of microbiological diagnosis. Surgery was performed under general anaesthesia with a high thigh tourniquet where possible. Previous skin incisions were excised and a medial parapatellar approach used. Sinuses, where present, were also excised. The infected prosthesis was removed and an extensive debridement of infected and necrotic tissue performed, including excision of membrane and any equivocal material: this usually included the cruciate and collateral ligaments if they had not already been excised. Multiple microbiological specimens were sent for culture and systemic antibiotics were administered.

The intramedullary canals were cleared using a combination of curettes, power lavage and flexible reaming. Callipers were used to measure the levels for tibial and femoral transection points to remove all abnormal bone seen on radiographs. Bone cuts were made using intramedullary (femur) and extramedullary (tibia) jigs. Gentamicin loaded cement (Palacos R + G, Heraeus Medical GmbH, Wehrheim, Germany) was wrapped around all static components of the implant (Fig. 2a). In cases in which the causative organism was known, appropriate additional antibiotics were added to the cement. The cement-prosthesis implant was then inserted and the first few centimetres only of the tibial and femoral stems were coated with cement. This was sufficient to provide rotational stability without complicating implant and cement removal at second-stage surgery. The hinge was coupled with a standard axle and locking cir-clip. Following tourniquet release and haemostasis, the wound was closed over a redivac drain.

2.4. Postoperative care

Following surgery, patients were allowed to mobilise fully weight bearing and encouraged to gain flexion from 0 to 90°. If not already present, a Hickmann line was sited to allow a minimum of 6 weeks intravenous antibiotic therapy.

Microbiological analysis of intra-operative samples consisted of a gram stain smear, incubation on horse-blood agar both aerobically and anaerobically, chocolate agar at CO_2 and Robertson's cooked-meat broth (enrichment cultures). Initial incubation was overnight and then, if negative, for a further 24 h. If the enrichment cultures were positive, they were further sub-cultured onto horse-blood agar both aerobically and anaerobically. Causative organisms were reported with associated sensitivities and these were used to guide appropriate antibiosis.

Patients were considered candidates for second-stage revision surgery if, after a minimum of 6 weeks, their inflammatory markers were within normal range and the soft tissues were in an appropriate condition. Further measurement radiographs were taken when required prior to second-stage surgery. A further radical debridement was performed and reconstruction accomplished using a variety of custom-made and modular endoprostheses (Fig. 2b).

Table 1
Patient demographics.

No.	Sex	Age	Diagnosis	Infected prosthesis	Previous ops	Causative organism	Follow-up (months)	Outcome
1	F	67	Osteoarthritis	Revision TKR	6	Coagulase negative staphylococcus	27	2nd Stage successful
2	F	65	Osteoarthritis	Revision TKR	5	Coagulase negative staphylococcus	30	Continued spacer infection
3	F	18	Osteosarcoma	Distal femoral replacement	17	Coagulase negative staphylococcus	38	2nd Stage successful
4	M	68	Osteoarthritis	Revision TKR	2	Coagulase negative staphylococcus	31	2nd Stage successful
5	M	61	Osteoarthritis	Revision TKR	3	Enterococcus	25	2nd Stage successful
6	M	58	Osteoarthritis	Revision TKR	2	Coagulase negative staphylococcus	44	2nd Stage successful
7	F	57	Osteoarthritis	Primary TKR	2	Coagulase negative staphylococcus	51	2nd Stage successful
8	M	41	Osteosarcoma	Distal femoral replacement	1	Coagulase negative staphylococcus	44	2nd Stage continued infection
9	F	43	Compound fracture	Metalwork (ORIF distal femur)	3	Enterobacter	37	2nd Stage successful
10	M	73	Osteoarthritis	Revision TKR	4	Coagulase negative staphylococcus	24	2nd Stage successful
11	F	62	Osteoarthritis	Revision TKR	2	Non-haemolytic streptococcus	28	2nd Stage successful
12	M	68	Osteoarthritis	Revision TKR	4	Enterococcus	28	2nd Stage continued infection
13	M	47	Chondrosarcoma	Distal femoral replacement	1	No organism identified	26	2nd Stage continued infection
14	F	27	Giant cell tumour	Proximal tibial replacement	1	Enterobacter	67	2nd Stage successful
15	M	74	Osteoarthritis	Revision TKR	3	Coagulase negative staphylococcus	35	Mobile + no infection on 'spacer' for 36 months
16	F	68	Osteoarthritis	Primary TKR	3	Coagulase negative staphylococcus	50	Above knee amputation
17	M	60	Peri-prosthetic fracture TKR for rheumatoid arthritis	Revision TKR	3	Group B streptococcus	29	2nd Stage continued infection
18	M	52	Rheumatoid arthritis	Revision TKR	3	Enterococcus	38	Above knee amputation
19	M	60	Osteoarthritis	Distal femoral osteotomy	6	Staphylococcus epidermis	70	2nd Stage successful