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TECHNICAL NOTE

Removal of infected cemented hinge knee prostheses using extended femoral and tibial osteotomies: Six cases

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Summary Extended femoral and tibial osteotomies were performed to remove infected cemented hinged knee prostheses in five patients (six knees) with a mean age of 72 years (44—85) and a history of multiple knee surgeries. A tibial osteotomy was used to mobilise the distal quadriceps insertion and to release the tibial extension. The femoral component was extracted by downward traction and its cement mantle was cleared through an anterior osteotomy (*n* = 4) or via the distal approach (*n* = 2). The bone flaps were re-approximated by wire cerclage over articulating acrylic spacers. Mean time to re-implantation of a new knee prosthesis was 11 months (6—24). Revision prostheses with cement fixation restricted to the epiphyseal-metaphyseal region were used. Infection recurred in two cases at 16 and 4 months after the prosthetic re-implantation, and was managed by joint fusion for one and irrigation/lavage for the other, respectively. At last follow-up after a mean of 53 months, the mean Parker score was 4 ± 2, the mean IKS knee score was 66 ± 25 (28—93), and the mean IKS function score was 7 ± 16 (0—40). This technique facilitates the removal of infected cemented components of hinge prostheses and of the cement mantle, most notably in the absence of loosening, without compromising re-implantation of a new knee prosthesis.

Introduction

The management of infected hinged knee prostheses remains of concern, as the risk of infection is higher with this design [1,2]. Routine removal of all the prosthetic material [3] is challenging due to difficulties in achieving synovectomy (absence of cleavage planes for dissection, repeated revision surgery complicating posterior synovectomy) and in extracting the implants (which requires anterior tibial

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Table 1 Demographic data of the five patients (six knees).

Patient No.	Age	ASA	No. of previous knee prostheses	Preoperative Parker score	Preoperative IKS knee score + function score
1	80	3	3	7	32 + 30
2D	72	3	2	4	30 + 30
2G	85	3	2	4	32 + 30
3	85	3	1	5	27 + 0
4	68	3	3	3	22 + 0
5	44	1	3	6	37 + 0

tuberosity osteotomy or more extensive osteotomies). Removal of the cement may require extended tibial and femoral osteotomies to facilitate clearance of the medullary cavity and, more specifically, extraction of a cement plug. These procedures were initially described for hip prostheses [4—7] and subsequently used at the knee.

We hypothesised that extended femoral and/or tibial osteotomies facilitated the removal of infected hinged knee prostheses without causing additional morbidity or preventing the subsequent implantation of another knee prosthesis.

Material and methods

Chronic infection of six cemented hinged knee prostheses in five patients was managed using extended osteotomies. Mean patient age was 72 years (range 44—85 years). The causative organism was a methicillin-resistant *Staphylococcus* in five cases (*Staphylococcus aureus* in three and coagulase-negative *Staphylococcus* in two) and a streptococcus in one case. Multiple procedures had been performed on all six knees, including arthroscopic joint lavage in all cases and at least two previous arthroplasties in five cases (Table 1). The ASA score was 3 in four of the five patients.

Extended osteotomies were performed in order to control the infectious process, as one patient had systemic evidence of infection, another was scheduled for heart valve surgery, and the other three had symptoms related to previous failed procedures intended to eradicate the infection (including dislocation of a rotating hinge prosthesis in one patient and pain due to tibial loosening in another). The length of the osteotomies was determined based on preoperative templating to ensure exposure of the cement mantle to the tip of the stem. The procedure was performed without using a pneumatic tourniquet for preventive haemostasis.

The tibial osteotomy was performed with the prosthesis in place, flush with the anterior aspect of the stem, using a saw and working in the medial to lateral direction. The anterior bone flap thus released had a mean length of 15 cm (range 10—18 cm) and was pedicled with the anterolateral leg muscles. Before the osteotomy, drill holes were made to mark the boundaries (hole allowing free passage of the drill bit) and to avoid accidental fracturing. Then, the tibial stem was extracted from the diaphysis by anterior traction (Fig. 1) and the femoral component was removed by downward traction. Both parts of the tibia were debrided using bone chisels and curettes, taking care not to fracture the remaining diaphysis. One of the flaps broke into two fragments.

In four cases, the femoral cement was not loosened and seemed to extend too far proximally to allow extraction via the distal route. Consequently, an anterior femoral osteotomy was performed. Mean femoral flap length was 10 cm (range 8—12 cm). The cut was made in the medial to lateral direction under the vastus medialis to preserve the continuity of the extensor apparatus, which was reflected with the tibial bone flap from medial to lateral, taking care not to cause accidental fractures. The medullary cavities were cleaned and the osteotomies re-approximated using cerclage wires or screws over an articulating acrylic spacer [8] with the goal of improving functional tolerance given the uncertain feasibility of subsequent arthroplasty.

The spacers were fashioned using plastified moulds (Biomet, Warsaw, Indiana, USA) and antibiotic-impregnated cement (Palacos Gentamycine^{TM}, Heraus Kulzer GmbH, Hanau, Germany). Joint stabilisation was achieved by adjusting the thickness of the tibial spacer. Extension stems were connected to the spacers and oriented in order to restore femoro-tibial alignment. Mean blood loss was 2 L (range 1.5—3 L) as estimated according to Gross [9], and heterologous blood transfusions (two to eight red blood cell packs) were required.

Two antibiotics selected by discussion with the bacteriology team were given intravenously for 15 days then orally until normalisation of the C-reactive protein (CRP) value, which required 2 months on average (range 45 days to 3 months). Levofloxacin and rifampin were used for the staphylococcal infections and amoxicillin in the patient with a streptococcal infection. The drains were removed when the daily drainage volume fell below 50 mL for three consecutive days, which required 10 days on average. Drainage fluids were sterile in all six cases. Secondary CRP elevation did not occur in any of the cases, and consequently aspiration was not performed. In the youngest patient, implantation of a new prosthesis was performed on principle. In the remaining five cases, prosthesis implantation was performed as late as possible, the reasons being mechanical complications (tibial fracture in one case and fracture of the femoral spacer in two cases) or poor functional tolerance of the spacer (painful instability in two cases).

With the spacers, weight bearing was limited for 2 months by using a walker or two forearm crutches. Isometric

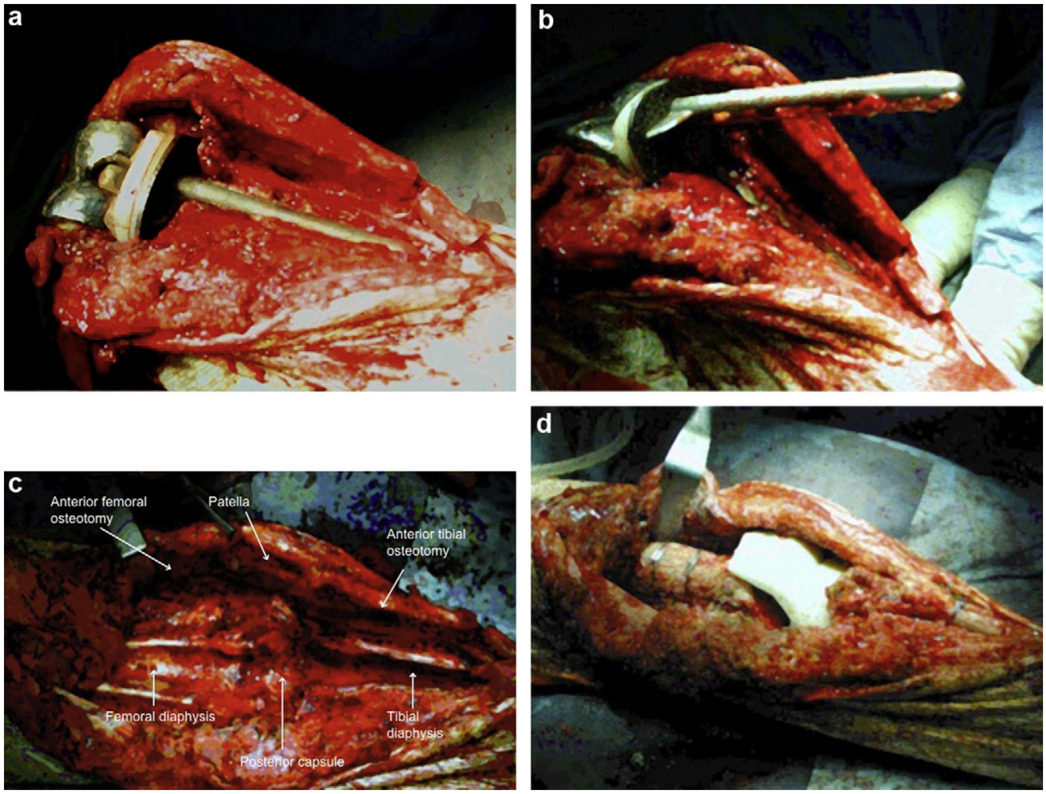

Figure 1 Steps of the procedure for extracting a hinged knee prosthesis: (a) tibial osteotomy, (b) extraction of the prosthesis, (c) femoral osteotomy, and (d) re-approximation of the osteotomies using cerclage wires over acrylic spacers.

quadriceps contractions were started rapidly, as well as passive mobilisation without exceeding 90° of flexion to avoid adverse effects on healing, as range of motion was not the primary concern in these patients with a history of multiple knee surgeries.

Mean time since osteotomy at re-evaluation was 53 months (range 15—98). The International Knee Society (IKS) score [10] and Parker score [11] were determined.

Results

No intra-operative complications occurred; more specifically, there were no injuries to nerves or blood vessels. None of the patients experienced systemic complications during the postoperative period. In one case, a diaphyseal postoperative fracture occurred at the distal part of the tibial flap (Fig. 2). A medial gastrocnemius flap was required in two cases to achieve wound healing.

Mean time to knee prosthesis implantation was 11 months (range 6—24 months). In most instances, a posterior-stabilised prosthesis with a raised cam was used, with sufficient constraint given the development of fibrotic tissue surrounding the spacer and, in some cases, with an offset stem (Nexgen LCCK prostheses in four cases and the Natural Knee revision prosthesis in one case; Zimmer, Warsaw, USA). In a single case, a hinged prosthesis (RHK, Zimmer, Warsaw, USA) was required as the very long stems needed were available only with this design. Exposure required tibial tuberosity osteotomy in a single case, in which healing occurred normally, and V—Y quadricepsplasty in another case. Metallic distal femoral wedges measuring 10 mm were used consistently and 5-mm tibial wedges in one case. Cement was applied only in the epiphyseal-metaphyseal region. The healed bone flaps were bypassed by extension stems, as the severity of the metaphyseal-epiphyseal bone damage precluded the use of shorter stems. Prophylactic antibiotics (intravenous vancomycin and gentamicin) were started after local specimen collection and continued for 48 hours. Culture of local specimens harvested during prosthesis reinsertion were consistently negative.

Recurrent infection due to different organisms from those identified initially developed in two cases. After 16 months, *Morganella* infection was diagnosed in one case, requiring prosthesis removal followed by fusion, which failed to heal. Early *Enterobacter faecalis* in another patient was managed with lavage, an insert change, and appropriate antibiotics; 2 years later, radiographs showed evidence of tibial plateau loosening, whereas the femoral component seemed stable, without secondary mobilisation.

At last follow-up, the mean IKS knee score was 66 ± 25 (28—95) and the mean IKS function score was 7 ± 16 (0—40). Mean range of flexion was 80° (65—95°), i.e., $30 \pm 20°$ (5—52°) less than preoperatively (Table 2). The mean Parker mobility score [11] was 4 ± 2 (1—6). Extension lag greater than 20° was noted in four cases including the case with non-union and the youngest patient, in whom necrosis and infection of the patella required patellectomy. In addition, in one case (No. 5), abnormal mobility occurred in the

Figure 2 Radiographs in case No. 1 obtained (a) before surgery and (b) after surgery with implantation of an articulating acrylic spacer; (c) a fracture at the tibial osteotomy site required implantation of a new knee prosthesis; (d) the tibial fracture was stabilized by the prosthesis stem.

coronal plane due to subsidence of the tibial component. The other five knees were stable in extension and X-rays showed stable components.

Discussion

The technique described here facilitates cleansing of the femoral and tibial diaphyses in the absence of loosening. However, re-implantation was followed by infection in two cases, although the organisms differed from those identified initially. Recurrent infection is common in patients with high ASA scores such as those in our case series [12]. The risk of recurrent infection underlines the need for eradicating potential organism reservoirs in the upper airways, gastrointestinal tract, or skin. However, no definite conclusions can be drawn from our small case series regarding the potential benefits of extended osteotomies in terms of eradicating the infection.

A substantial period was spent with the articulated spacers, underlining their good functional tolerance, in keeping with earlier data [13]. Spacers should be equipped with intramedullary stabilisers to prevent dislocation [8]. Although the bone flaps healed, circumferential healing was not assessed by computed tomography and we consequently took the precaution of bypassing the osteotomies area during re-implantation. Cement was used to secure the new prostheses only in the epiphyseal-metaphyseal region, in order to minimise surgical difficulties should the infection recur.

Table 2 Results and techniques.

Patient	Technique	Time to re-implantation (months)	Total follow-up since prosthesis removal (months)	Complication	IKS at last follow-up knee score + function score
1	FO + TO	6	57	Dehiscence managed with a local flap; tibial fracture	66 + 0
2D	FO + TO	16	98	Recurrent infection managed with fusion	59 + 0
2G	FO + TO	8	71		95 + 0
3	TO	24	60		93 + 40
4	FO + TO	8	27	Recurrent infection managed with lavage Recurring tibial loosening	28 + 0
4	TO + patellectomy	6	15		53 + 0

FO: femoral osteotomy; TO: tibial osteotomy.

Extended osteotomies result in substantial blood loss, as reported previously for osteotomy confined to the tibial tuberosity [12,14]. However, cement extraction via the intramedullary approach also carries a risk of complications, including incomplete resection, cement migration, and increased bone tissue loss [15]. Extended osteotomies are used for salvage surgery, when absolutely necessary, and avoid joint fusion (which is difficult to achieve in these knees with major bone tissue loss) but result in motion range limitation and weakness of the extensor apparatus.

Disclosure of interest

P. Massin has received royalties from Zimmer. P. Boyer, M. Sabourin, and C. Jeanrot have no conflicts of interest.

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