THE MANAGEMENT OF INFECTED TOTAL KNEE REPLACEMENTS

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A review of patients with an infected resurfacing prosthesis is presented. Eight patients with a loose infected prosthesis were treated by a one-stage exchange arthroplasty; six others with a well-fixed infected prosthesis were treated by drainage and antibiotics. All eight treated by exchange arthroplasty remained free of infection as did five of those treated by drainage. In four of these last five patients, the prosthesis was inserted without cement; the possible role of polymethylmethacrylate in the persistence of infection is discussed.

Infection after total knee replacement is thought to be a prelude to failure of the arthroplasty, and the appropriate management remains problematic.

Knee replacement began at The London Hospital in 1969; between then and 1975, 16 knees became infected and were treated by attempted arthrodesis. The results were poor: bony fusion occurred in only 62.5%, and even in them the prolonged duration of treatment and the resulting stiff knee, often in a patient suffering from rheumatoid arthritis, left much to be desired (Freeman, King and O'Riordan 1983). The percentage of successful fusions in the literature ranges from 25% to 100% (Deburge and GUEPAR 1976; Walldius 1960).

In view of this outcome and the encouraging results of one-stage exchange arthroplasty at the hip using antibiotic-impregnated cement (Buchholz et al. 1979, 1981), an attempt has been made since 1975 to treat loose infected total knee replacements by a similar one-stage procedure. Arthrodesis has been reserved for persistent infection after revision. Although there is now a substantial literature describing the success of one-stage exchange arthroplasty at the hip, there is little on its use at the knee. Insall, Thompson and Brause (1983) have reported success with a two-stage exchange arthroplasty, and we have received personal reports from colleagues of success with one-stage revision.

It is possible for a totally replaced knee to become infected without loosening of the prosthesis. Although in theory this could occur at any time after operation, our experience has always been that it occurred early. In these circumstances it is tempting to try to sterilise the prosthesis by drainage and antibiotics without removing it. Since 1976 we have tried to do this in suitable cases, although in view of the reports of failure at the hip (Fitzgerald et al. 1977) we were not at first hopeful of success.

MATERIAL AND METHODS

Fourteen patients with infection after knee replacement have, between 1975 and 1983, been treated by either a one-stage exchange arthroplasty or by drainage and antibiotics. Of these, eight (six women and two men) were treated by a one-stage exchange arthroplasty, and six (three women and three men) by drainage and antibiotics.

The patients' ages ranged from 47 to 78 years in the exchange arthroplasty group, and from 56 to 66 in the drainage group. The initial diagnosis was rheumatoid arthritis in six of the arthroplasty patients, and in four of those treated by drainage. The remaining four patients had osteoarthritis.

The initial procedure had been a total knee replacement using a Freeman-Swanson prosthesis in three patients, an ICLH prosthesis in four, and a Freeman-Samuelson prosthesis in seven. The time from the initial joint replacement to the treatment of the infection ranged from 6 to 51 months in those patients treated by arthroplasty, and from 2 to 8 months in those treated by drainage and antibiotics.

Polymethylmethacrylate without antibiotics was used for all components in five knees and for one component in three; no cement at all was used in five knees. In one patient, gentamicin-impregnated cement was employed for one of the components because of the poor condition of the skin and an intra-operative fracture of the tibia.

The length of follow-up after treatment of the infection was from 12 to 40 months in the arthroplasty group and from 12 to 18 months for those treated by drainage.

During the period of this study two patients died.
one from carcinoma of the bronchus, and the other from diabetes. Both had been treated by exchange arthroplasty; their clinical condition is reported at their latest review two years after treatment. One of these patients was reviewed radiologically at six months and the other at two years.

**Clinical presentation.** We have divided the patients into two subgroups: those who presented with an infection within one year of the initial arthroplasty were called "early"; those who presented after one year were called "late".

In the exchange arthroplasty "early" group, all patients gave a history that the knee had never been free of postoperative pain, and all presented with painful swelling of the joint. In the exchange arthroplasty "late" group, the knee had been symptomless for some time until pain developed and the joint then became swollen and painful. All six patients treated by drainage and antibiotics presented "early" as defined above.

The criteria for including 12 of the 14 patients in this series were a positive intra-operative culture combined with clinical and/or radiological signs of sepsis. The other two patients had negative intra-operative cultures but clinical and operative findings strongly suggestive of infection: both had received antibiotics before bacteriological investigation, and this might have been the reason for the sterile intra-operative culture.

Four patients who had exchange arthroplasty had had delayed wound healing after their initial replacement; two presented with an "early" infection and two with "late". Four patients treated by drainage and antibiotics had a serous fluid discharge after the initial arthroplasty, but subsequently healed; one patient never healed and the wound continued to discharge.

Seven patients were initially operated upon in conventional operating theatres; of these, three patients had prostheses which had, in part, been sterilised in ethylene oxide but then packaged in a possibly faulty manner. The remaining seven had been operated upon in ultraclean theatres, and two prostheses had had ethylene oxide sterilisation; thus, five patients, despite operations in "sterile" air and with correctly packed prostheses became infected; the infection rate for this group was approximately 2%.

**Surgical management.** In all cases the knee was aspirated before operation, in order to determine the infecting organism. The knee was then opened through the old incision. Swabs and tissue were taken for culture from the subcutaneous layers and from within the joint, and the prosthesis was examined to determine the strength of fixation. If the prosthesis was loose, the knee was treated by exchange arthroplasty; or if it was still firmly implanted, the knee was treated by drainage and antibiotics.

**One-stage arthroplasty.** The prosthesis and all tissue of doubtful viability were removed. Tissue from beneath the prosthesis was taken for both bacteriological and histological examination, while the prosthesis and any cement were sent for culture. The joint was washed with copious amounts of normal saline, and a new prosthesis was fixed into place, using gentamicin-impregnated cement (Palacos R). The wound was closed in layers, using non-absorbable deep sutures and nylon for the skin. Two large suction drains were placed into the knee. A padded plaster cylinder was applied and retained until the wound was dry and healing uneventfully. Gentle flexion was then encouraged, and the sutures were removed on the twelfth postoperative day.

**Drainage.** If the prosthesis was found to be firmly fixed, the knee was treated by drainage and antibiotics. In three patients this was combined with postoperative lavage of the joint. This practice was later abandoned, as it was difficult and its efficacy was questionable. Swabs were taken for bacteriological study, and the knee was then washed out with copious amounts of normal saline. When lavage was performed, an irrigation system using dilute chlorhexidine solution was set up. The wound was then treated like those in the exchange group.

**Antibiotic management.** In those patients undergoing exchange arthroplasty the infecting organism was a staphylococcus in all but two cases in which sterile cultures were obtained (the reason for this has been described previously). Antibiotics were given during the operation only after material had been obtained for culture. The choice of antibiotic given assumed that *Staphylococcus aureus* was the infecting agent; this was modified, if necessary, when the result of intra-operative culture was known. Treatment, initially intravenous, was later changed to oral and continued for not less than three months.

In all the patients treated by drainage, *Staphylococcus aureus* was the infecting organism, combined in one case with an anaerobic streptococcus. Antibiotic treatment followed the same lines as for the exchange group.

**RESULTS**

All patients were examined for signs of recurrence of infection. Our criteria for clinical absence of infection were:

1. The absence of rest pain.
2. The absence of warmth, tenderness or effusion.
3. The absence of pain (unless attributable to other factors).
4. Perfect wound healing.

The erythrocyte sedimentation rate was not helpful because so many of our patients had rheumatoid arthritis.

In 13 of the 14 patients there was no evidence of infection at their latest review, as judged by our criteria. Two patients had died. One, when reviewed two years after exchange arthroplasty, had no signs of infection. The other had had an amputation of his leg for diabetic gangrene before his death; the state of his knee at that time was not assessed by us but the last clinical review at
two years showed no signs of infection.

In one case infection persisted: this was a patient from the drainage group in which polymethylmethacrylate without antibiotics had been used to fix all three components. Inflammatory signs never fully resolved, and by one year the knee was clinically and radiologically infected and the prosthesis was loose; an arthrodesis was performed. At this operation the femoral and patellar components were both found to be completely loose. The tibial component had been cemented only under the medial half of the prosthesis and around the medial fixation peg, and the appearance of this part of the interface was similar to that of the femoral interface. In contrast, the lateral uncemented peg was well fixed and had to be extracted by hammering on a screw passed into the peg.

**Radiological results** (Table I). Radiologically our criteria for the absence of infection were: no increasing lucent lines; no lucent line greater than 2 mm; no signs of osteitis; no migration or loosening of the prosthesis.

Of the eight patients treated by one-stage exchange arthroplasty, no lucent line was seen on the most recent radiographs in five femoral interfaces and five tibial interfaces. A lucent line was seen at three femoral interfaces; one, occupying less than 20% of the interface and less than 1 mm thick, was seen in the initial radiograph and remained constant in all subsequent films. Another femoral interface had a lucent line extending over less than 50% and less than 1 mm thick; this patient died, but in the last available radiograph the lucency was still visible. A third patient developed a lucent line of less than 20% of the interface and less than 2 mm thick at six months: this remained constant until the latest radiograph one year after the exchange arthroplasty.

A lucent line was seen at two tibial interfaces. One, occupying less than 20% and less than 1 mm thick, was seen in the initial radiograph and increased to involve 40% of the interface at six months; thereafter the width remained constant. In a second patient a lucent line of less than 20% and between 1 and 2 mm in thickness remained constant from the immediate postoperative radiograph.

Four of the five patients whose prostheses were fixed without cement and who were subsequently treated by drainage had no signs of osteitis or of bone destruction (Table II). The one patient who received gentamicin-impregnated cement developed a 5% lucent line less than 1 mm thick at six months; this remained constant in follow-up examinations. In the one case already described in which cement without antibiotics was used, infection persisted and arthrodesis was performed.

**Function.** Only one patient complained of pain requiring analgesia. This patient suffers from generalised rheumatoid arthritis and has retropatellar pain but has no other stigmata of infection.

The distance the patient could walk improved in every case. Eight patients could walk for 30 minutes or more; the remainder, however, were restricted by their general condition rather than by the knee replacement. Every patient had an improvement in the range of knee flexion, and eight obtained more than 90° of flexion.

**DISCUSSION**

If "cure" may be defined as the absence of clinical and radiological evidence of infection for at least a year after revision and for nine months after cessation of antibiotics, then we have "cured" all eight patients with infection and a loose prosthesis. This was achieved by means of a one-stage exchange arthroplasty, using gentamicin-impregnated cement and subsequent antibiotic
therapy. Our findings are similar to those reported for the hip. However, our experience does not encompass infections with all organisms or with infected stemmed prostheses or in patients with gross inflammatory signs or systemic toxicity, so that our results cannot be extrapolated to these groups.

Nevertheless, our results are encouraging: only one patient with a revised knee required analgesia, six could walk for at least 30 minutes and none had less than 70 of movement. We therefore believe that a one-stage exchange arthroplasty is the treatment of choice for a loose infected knee prosthesis, especially if the organism is a staphylococcus and there is no gross inflammation or sinus formation; indeed, since 1978 we have not had to arthrodes an infected arthroplasty. This contrasts with the findings of Rand and Bryan (1983) whose overall success rate was 35% for a revision implantation. They did not use antibiotic-impregnated cement or long-term antibiotics, and we consider this to be the reason for the difference in success rates.

In a patient in whom the knee is infected but the prosthesis remains well fixed (a circumstance unlikely to occur except in the early postoperative course), it is tempting to try to eradicate the infection without removing the prosthesis. Disappointingly, this rarely, if ever, succeeds at the hip. We have, however, apparently "cured" proven Staphylococcus aureus infections in four patients with uncemented total knee replacements, and in one patient whose prosthesis was fixed with gentamicin-impregnated cement. We failed to cure one infection in a patient in whom polymethylmethacrylate without antibiotics was used. Clearly this outcome may be due to chance, but it does at least suggest that it may be the polymethylmethacrylate which makes cure difficult or impossible unless the prosthesis is removed.

Certain other observations support this view. First, it is possible to sterilise, at least clinically, an infected plated fracture, with the plate still in situ; this demonstrates that the presence of a well fixed metallic implant does not render cure of infection impossible. Secondly, experimental findings suggest that persistent infection is likely to occur after bacteriological contamination of a prosthetic interface if polymethylmethacrylate is present. Petty (1978b) showed that, in vitro, small concentrations of methylmethacrylate monomer depress the chemotactic factors derived from the compliment sequence, and that, if the monomer is added to suspensions of polymorphonucleocytes, it significantly reduces the migration of these cells. In the same year (1978a), he reported that methylmethacrylate monomer in concentrations as low as 0.156% significantly reduced the ability of leucocytes to phagocytose and kill strains of Staphylococcus aureus and Escherichia coli. Finally (1983) he reported a series of experiments based on this work: implants of high density polyethylene, stainless steel, chromium-cobalt alloy, and polymethylmethacrylate polymerised in situ were introduced into canine femora into which different dilutions of various bacteria had been instilled. It was found that polymethylmethacrylate reduced the infectious dose by two orders of magnitude.

Samuelson et al. (1983) reported the implantation of cemented and uncemented total knee replacements in opposite limbs of the same animal. Seven of the joints fixed with polymethylmethacrylate became infected: however, only two of the uncemented prostheses failed in this manner and both these infections followed infection of the contralateral (cemented) replacement.

In our one successful cemented case, the cement might still have been releasing gentamicin at the time of drainage (Wahlig and Dingeldein 1980) and this may have been sufficient to balance the harmful effect of polymethylmethacrylate which we now postulate. In our one unsuccessful case, it is significant that the only section of the interface that remained well fixed was the uncemented half of the tibial component, and that here the inflammatory features were minimal, both to the naked eye and histologically.

These observations, taken together, suggest that polymethylmethacrylate interferes with the capacity of the local tissues to destroy bacteria, perhaps because unpolymerised monomer is leached from the cement mass. As a consequence, contaminated cement usually, if not always, results in persisting infection, to cure which the contaminated polymethylmethacrylate must be removed. In contrast, we postulate that other implant materials (for example, metals) may sometimes be sterilised in situ by a combination of surgery and antibiotics, so that their removal is not mandatory. If further work substantiates this hypothesis, it may explain why special precautions are needed to eliminate bacterial contamination and to control sepsis rates in implant surgery using polymethylmethacrylate.

The sepsis rate for primary knee replacement implied by our study is high. We believe that this was due to two special circumstances: the absence of an ultraclean environment in some cases and the imperfect sterilisation of some prostheses. During this study, the main theatre used by the senior author had two periods when the positive pressure laminar flow ultraclean air system did not function and other rooms without one were used. During the first period there were three infections and during the second, four. A further hazard, not apparent until a later review, was that the ethylene oxide sterilisation of some of the femoral components was possibly faulty.

In conclusion we believe that, although the number of cases in this series is small, two points emerge. First, a loose total knee replacement of the resurfacing type infected with Staphylococcus aureus may be treated by a one-stage exchange arthroplasty using antibiotic-impregnated cement and long-term antibiotics. Secondly, it seems possible that an infected, well-fixed but uncemented resurfacing knee prosthesis can be successfully treated by simple drainage and antibiotics.
REFERENCES


