Two-stage uncemented revision hip arthroplasty for infection

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We treated 50 consecutive patients with infected total hip arthroplasties according to a standard protocol. Previous surgery to eradicate the infection had been attempted in 13 patients and discharging sinuses were present in 20. Aspiration arthrography was routinely carried out before our interventions.

The first stage was a meticulous removal of all foreign and potentially infected material. Samples were taken for culture and a thorough lavage carried out. Antibiotic-loaded beads were placed in the femoral shaft and an antibiotic-loaded cement ball in the acetabulum. At the second stage an uncemented arthroplasty was introduced. Bone allograft was used in 18 patients. The interval between procedures was usually three weeks, but this was extended if the wound was slow to heal or there was extensive bony destruction. Appropriate antibiotics were given for three months.

At a mean follow-up of 5.8 years the rate of reinfection was 8% (4 patients). Two of these patients have had another, successful, two-stage revision. At this medium-term review, a satisfactory clinical and radiological outcome was obtained in all except two patients.

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The current incidence of infection after primary total hip replacement is under 1% in most large centres, but it remains a devastating complication for both the surgeon and the patient.¹⁻⁸ It is expensive, time-consuming to treat and usually results in a poor functional outcome.

The objective in these cases is the permanent eradication of infection and the restoration of function. To this end, several techniques have been proposed.^{5,6,9} These include antibiotic suppression,¹⁰ early debridement,^{11,12} one-stage revision to a cemented prosthesis with antibiotic-loaded cement,¹³⁻¹⁶ and two-stage revision, using either a cemented¹⁷⁻²⁰ or an uncemented component.²¹⁻²³ A number of alternative treatments are available for the interval period in two-stage protocols²⁴⁻²⁶ including specially designed antibiotic-loaded spacers.²⁷⁻²⁹ When treatment fails excision arthroplasty,^{30,31} arthrodesis³² or even amputation³³ may be required.

We have studied 50 consecutive patients all of whom were referred with an infected total hip replacement and treated using a standardised protocol for two-stage revision to an uncemented arthroplasty.

Patients and Methods

Between 1988 and 1992, we treated 27 women and 23 men with a mean age of 60 years (24 to 81). The mean follow-up was 5.8 years (2 to 8.7). The patients were predominantly tertiary referrals; 20 had discharging sinuses, 16 had infected revision total hip replacements and 13 had already undergone at least one attempt to eradicate the infection. All had cemented arthroplasties with sepsis presenting between two weeks and seven years after operation (Fig. 1). The original diagnoses are summarised in Table I.

The diagnosis of infection was based on the clinical presentation and confirmed by preoperative and intraoperative findings. All patients had at least one of the following: an organism cultured before open operation, systemic symptoms with a painful hip, a sinus communicating with the prosthesis, or purulent fluid at exploration. Only patients whose operative cultures were positive were included in the study. At least four samples were taken in every case, and the same organism had to be identified in two for a positive result.

The stage of infection, as defined by Fitzgerald et al.,³⁴ was as follows: stage 1, 12 patients; stage 2, 28 patients; stage 3, 10 patients.

All were investigated according to a defined protocol, including a full blood count and measurement of the ESR, C-reactive protein (CRP) and antistreptococcal and anti-

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Fig. 1

Anteroposterior radiograph of right total hip replacement complicated by infection.

Fig. 2

Anteroposterior radiograph (off traction) during the interval period between the two stages. A laminated cement ball can be seen in the acetabulum and antibiotic beads in the femoral shaft.

Table I. Indications for the initial total hip arthroplasty in the 50 patients

Indication	Number
Osteoarthritis	36
Developmental dysplasia/Perthes' disease	6
Rheumatoid arthritis	3
Osteonecrosis	2
Post-traumatic	2
Psoriatic arthropathy	1

staphylococcal titres. Standard weight-bearing anteroposterior and lateral radiographs were taken, supplemented by three-dimensional CT when there was loss of acetabular bone stock. Aspiration arthrography was carried out in every case. An ESR of greater than 40 mm/hr and a CRP of greater than 10 mg/l were considered to indicate infection. An aspiration was deemed positive if any of the cultures were positive, including late subculture.

The first stage of the surgery consisted of excision of sinuses, drainage of all abscesses and the meticulous removal of all foreign material, membranes, cement, plugs and any potentially infected soft tissue. An ultrasonic cement-removing device (Ultradrive; Biomet, Swindon, UK) was used, guided by intraoperative fluoroscopy. Antibiotic therapy was always stopped at least one week before

surgery, and withheld until samples were taken for both microbiological and histological analysis. These samples were taken before any cement was disturbed, lest it contain antibiotic, and swabs were taken from around the prosthesis. Both the femoral and acetabular implant sites were reamed thoroughly and washed using a pressurised pulsed lavage system. A laminated antibiotic-impregnated cement ball was placed in the acetabulum and similar cement beads into the femoral shaft (Fig. 2). The wounds were closed over suction drains.

After operation the patients were placed on skeletal traction. Antibiotics were given intravenously for at least five days and then orally. Antibiotic treatment was modified according to the microbiological result. Radiographs were also taken to reassess bone stock and plan the re-implantation. The second stage was usually carried out at three weeks, but in eight patients was delayed to allow wound healing or modification of the prosthesis, and in ten for 3 to 12 months because of medical co-morbidity, or poor bone stock. Further debridement was required in two patients, wound excision in one, and removal of gentamicin beads in one as an interim procedure. These patients were allowed to mobilise on crutches between operations.

The factors which influenced the timing of the second

stage included wound healing, the response to antibiotics, the patient's general wellbeing and bone stock, as judged at the time of the first stage and on subsequent radiographs. Haematological, serological and microbiological data were also available, but the ESR and CRP were not expected to return to normal. At the second stage the cement ball and beads were removed, further samples were taken for microscopy, culture and sensitivity, and a further lavage was undertaken. An uncemented arthroplasty was then introduced with morsellised femoral head allograft used on the acetabular side in 18 patients. The prostheses used included Harris-Galante stems and cups (Zimmer, Swindon, UK), Furlong HAC stems (JRI, London, UK), BIAS stems (Zimmer) and customised stems (Stanmore Implants Worldwide, Stanmore, UK).

All the patients were given antibiotics for at least three months after operation. Either flucloxacillin or vancomycin with fucidic acid was initially prescribed if no organism was identified. This regime was modified according to the results of cultures and histological examination. The ESR and CRP and the patient's nutritional status were studied in the postoperative period and were factors in deciding how long the treatment with antibiotics should continue. The patients were allowed to mobilise, touch weight-bearing for six weeks, and were reviewed clinically, radiologically and serologically at six weeks, three months, six months and yearly. Progressive mobilisation was adjusted according to the stability of the reconstruction and the clinical and radiological observations.

The outcome was measured by the hip score and patient satisfaction. Re-infection was defined as a recurrence of inflammation with a positive culture or clear radiological and serological evidence of sepsis. Functional outcome was assessed using the Harris hip score (HHS): an excellent outcome was an improvement in the score of over 40 points or an absolute score over 90. A good outcome was an increase of more than 30 points or a score of more than 80 and a fair outcome was a score of over 70 points or an increase of more than 20 points. Failure was defined as an improvement in the score of less than 20 points or a score of less than 70 at the time of review. Radiological outcome was assessed using the criteria outlined by Johnston et al.³⁵ An AP radiograph of the pelvis, a lateral view of the affected hip and AP and lateral views of the ipsilateral femur were obtained. The radiographs were classified according to the degree of subsidence or radiolucencies surrounding either component.

Table II. Organisms cultured from the 50 patients

Organism	Number
<i>Staphylococcus epidermidis</i>	23
<i>Staphylococcus aureus</i>	16
Coliforms	6
Beta-haemolytic streptococcus	4
<i>Pseudomonas</i>	3
Anaerobes	2
<i>Proteus</i>	1
Polymicrobial	5

Results

Preoperative investigations. The mean ESR was 59 mm/hr (11 to 110) and the mean CRP was 12 mg/l (2 to 56). We found the ESR to be more consistently increased (>40 mm/hr in 36 patients) than the CRP (>10 mg/l in 27 patients). The trend in the CRP was helpful between stages, although we did not follow this assiduously. The antistreptococcal and antistaphylococcal titres were positive in 14 patients but this observation did not alter the management.

Arthrography showed evidence of loosening and of bony defects in a number of patients. Saline infiltration/aspiration was used to enhance the microbiological study. There were only four dry taps after saline injection; it was therefore possible to assess samples in 46 patients and to compare them with the definitive culture from the operation specimens. The final organisms were identified from previous exploration in 21 patients, on the basis of the preoperative aspiration in 18, and after the first stage in the remainder.

The organisms cultured are summarised in Table II. There were five multiple infections. Staphylococci predominated, occurring in 39 patients, either in isolation, or in combination with other organisms (3). There were three late infections with *Streptococcus milleri* which occurred after dental and gastrointestinal interventions.

Operative findings. At exploration, neither component was loose in ten cases; 14 had a loose femoral component, six had a loose acetabular component and in the remainder, both components were loose. There were two cortical perforations on the femoral side observed during the first stage, but these did not alter the management and were bypassed by the prosthesis inserted at the second operation.

Control of infection. Cultures of tissue obtained at the second stage were negative in all patients. There were no wound problems which required reoperation after the second stage. During the period of follow-up, two patients died from unrelated causes without evidence of reinfection, at 30 and 36 months, respectively. Four patients had recurrent infection; three with *Staphylococcus epidermidis*, only one of which had originally harboured the same organism, and one with *Escherichia coli* after the eradication of an original infection with *Staphylococcus aureus*. It follows that only one of these is a persistent infection; the others are reinfections with different organisms. Of these four patients, three had undergone primary total hip replacement with antibiotic-loaded cement, three had already undergone a revision procedure and one suffered from rheumatoid arthritis and was taking corticosteroids. There was no significant difference between the serological results of these patients during the interval period and those of the rest of the patients. Two of these patients have been successfully treated by further two-stage revision and the other two have undergone excision arthroplasty.

The rate of eradication of infection following two-stage uncemented revision, at a mean of 5.8 years, was 92% (46 of 50 patients). If infection by a different organism is

Fig. 3a

Fig. 3b

Anteroposterior (a) and lateral (b) radiographs five years after reconstruction, showing a well-fixed prosthesis with no evidence of reinfection.

considered as a new infection occurring in a previously sterile joint then the rate of success was 98% (49 of 50 patients). No evidence of reinfection was seen in any of the 18 patients in which morsellised allograft was used.

Complications. Skeletal traction was well tolerated by the patients. No specific complications were observed although prolonged immobilisation may well have contributed to the early postoperative complications. These included cardiac failure (2), pulmonary embolism (1), haematemesis (2), infection of the urinary tract (9), palsy of the common peroneal nerve (1) which recovered, and four dislocations managed by closed manipulation.

Function. A full clinical assessment was possible in 48 patients. The mean HHS improved from 36 (7 to 61) to 78 (54 to 92); 29 patients achieved an excellent score, ten good, six fair and three poor. These figures include both patients who ultimately underwent excision arthroplasties.

Radiological outcome. Radiological review showed that there was no sign of persisting infection in the 46 patients who were considered free from sepsis at their last review (Fig. 3). There was no gross osteolysis. Two patients had radiolucent lines around the acetabular component, which have not progressed since the time of surgery, and four showed subsidence of BIAS femoral components reaching a stable, asymptomatic position without evidence of reinfection. Almost invariably there was a pedestal at the distal end of the BIAS prosthesis, and this was associated with

occasional thigh pain. When allograft was used in the acetabular reconstruction it incorporated well with no predisposition to recurrent sepsis.

Discussion

The operative treatment of infected total hip replacements continues to generate considerable debate.^{5,6} The protocol which we have followed raises several controversial issues. These include the use of a two-stage procedure, the type and duration of antibiotic therapy, the length of the interval period, the use of uncemented components at the time of reimplantation and the use of allograft in the reconstruction. Impressive early results of single-stage revision arthroplasty¹³ have been reported by Raut et al^{14,15} with a rate for eradication of infection of 84% to 86%, in spite of many discharging sinuses. Single-stage revision without antibiotic-loaded cement has also been associated with a high incidence of recurrent infection.³⁶ Hanssen and Rand⁶ summarised the results of single-stage exchange and found a cumulative success rate of 83% when antibiotic-loaded cement was used but of only 60% when it was not. Single-stage revision for infection therefore demands the use of cement impregnated with antibiotic.

Two-stage revision has the advantage of allowing uncemented reconstruction and, theoretically, provides a better environment for the eradication of infection. Organisms

may be cultured from tissues accessible only after removal of the implant, and the interval before reimplantation allows for further microbiological assessment and appropriate adjustment of antibiotic therapy. Augmentation with allograft may be carried out with greater confidence. A two-stage exchange programme is associated with increased eradication of infection when compared with one-stage protocols.^{5,6} Hanssen and Rand⁶ found that the cumulative rate of eradication was 82% when antibiotic-loaded cement was not used. This increased to 90% with antibiotic-loaded cement at the second stage, and increased further to 92% when local antibiotic delivery with beads or spacers was undertaken during the interval period.

Reports of high rates of aseptic loosening following cemented revisions for infection,³⁷ concerns about the adverse effects of cement on the immune system³⁸⁻⁴⁰ and the desire to take advantage of cementless fixation led the senior author (SKM-A) to the use of this technique. Our protocol combined the advantages of two-stage exchange with high local concentrations of antibiotic in the interval period and an uncemented reconstruction, which may have advantages over the use of cement both with regard to fixation and preservation of bone stock.

The ideal duration and route of administration of antibiotic therapy have not been determined. Most reported protocols advise four to six weeks of intravenous administration.¹⁸⁻²⁰ We gave intravenous antibiotics for only five to seven days after the first stage and in the immediate postoperative period after the second stage. Our patients were usually in hospital during the interval period and we were therefore able to monitor their compliance with oral antibiotic regimes. Several studies have demonstrated the efficacy of local antibiotic depots within beads and spacers^{41,42} suggesting that, in the presence of antibiotic-loaded cement, intravenous antibiotics are not essential during the interval period. Exceptions are made when the organism cultured is not sensitive to the antibiotic in the cement, when no appropriate oral antibiotic is available, or if the patient is unable to tolerate it.

The length of the interval period is variable and this has considerable economic implications. Lieberman et al¹⁸ reported results from a protocol of reimplantation, six weeks after removal of an infected prosthesis. They did not differ from the results in patients in whom reimplantation had been delayed for over one year.¹⁹ We have seen no increase in the rate of reinfection or other complications by reducing the interval period to three weeks in most cases. Moreover, a shorter interval to reimplantation facilitates the second-stage procedure.⁴³

There are few reports of two-stage revision to uncemented arthroplasties.^{21-23,36,44-46} Berry et al⁴⁴ used uncemented prostheses with allograft in 11 patients followed by reinfection in two (18%). Morscher, Babst and Jenny⁴⁷ reported a rate of reinfection of 30%. Our series provides the largest review of two-stage uncemented revision for infection. The high rate of eradication of infection and the

good fixation and function obtained, encourage the use of uncemented implants in a previously infected bed. This is particularly important in cases in which bone loss or altered anatomy will demand customised implants, or when the quality of the intramedullary cavity of the femur is such that adequate cemented fixation is unlikely. Moreover, uncemented fixation of an intramedullary stem of standard proportions avoids the problems presented in a reinfected, distally cemented prosthesis.

There has also been concern that allograft used in reconstruction after infection may be associated with a higher rate of recurrent sepsis by acting as a potential sequestrum. This is particularly important when considering the frequency of both femoral and acetabular erosion which occurs with an infected arthroplasty. Major bone loss has been regarded by some authors as a contraindication to reimplantation after infection²⁰ and a three-stage protocol has been proposed for bone grafting in the presence of infection.²³ We used morsellised allograft from a femoral head for acetabular reconstruction in 18 patients, none of whom suffered subsequent reinfection. This supports the findings of Nestor et al²³ and of Berry et al⁴⁴ who used various combinations of morsellised and bulk allografts in the second stage of revision for infection, and reported only two recurrent infections out of 11 at a mean follow-up of 4.2 years. Alexeeff et al⁴⁸ used massive structural allografts in the second stage of a two-stage procedure in 11 patients. They reported no further sepsis at a mean follow-up of four years. Wang and Chen⁴⁹ used a combination of morsellised and bulk allograft in 22 cases with a rate of eradication of infection of 91%. We conclude that two-stage revision with an uncemented prosthesis allows the use of allograft in the reconstruction, without prejudicing the outcome.

Management of the infected total hip replacement remains expensive, with a long and difficult course for the patient and frequently a poor functional outcome. The protocol which we describe for two-stage revision to an uncemented prosthesis includes a thorough debridement at the first stage and allows some flexibility in planning the second stage. It offers a high local concentration of antibiotic and a second opportunity for debridement. It also allows bone grafting in a safe environment. The results reported match those of the other described techniques for the eradication of infection, and confirm the safety and efficacy of uncemented reconstruction.

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