Treatment of deep infection of the hip associated with massive bone loss

TWO-STAGE REVISION WITH AN ANTIBIOTIC-LOADED INTERIM CEMENT PROSTHESIS FOLLOWED BY RECONSTRUCTION WITH ALLOGRAFT

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We have carried out in 24 patients, a two-stage revision arthroplasty of the hip for infection with massive bone loss. We used a custom-made, antibiotic-loaded cement prosthesis as an interim spacer. Fifteen patients had acetabular deficiencies, eight had segmental femoral bone loss and one had a combined defect.

There was no recurrence of infection at a mean follow-up of 4.2 years (2 to 7). A total of 21 patients remained mobile in the interim period. The mean Merle D'Aubigné and Postel hip score improved from 7.3 points before operation to 13.2 between stages and to 15.8 at the final follow-up. The allograft appeared to have incorporated into the host bone in all patients. Complications included two fractures and one dislocation of the cement prosthesis.

The use of a temporary spacer maintains the function of the joint between stages even when there is extensive loss of bone. Allograft used in revision surgery after septic conditions restores bone stock without the risk of recurrent infection.

Two-stage revision arthroplasty is an effective treatment for deep infection of implants in the hip.¹⁻⁷ The function of the hip may be severely restricted between the stages. The second operation can be a technically-demanding procedure. This is made worse when there is major loss of bone because of severe leg-length discrepancy, soft-tissue shortening, distorted tissue planes and disuse osteoporosis.^{4,8} Re-infection of massive allografts used for the reconstruction of the joint has also been a concern.^{9,10}

In 1996, we began to use a two-stage protocol of surgical treatment in a series of patients who had deep infection around their hip prosthesis. The unique feature was the use of a custom-moulding method for the manufacture of an antibiotic-loaded cement prosthesis to give the patient a functional joint between the stages. This technique is especially useful when there is extensive loss of bone. The second-stage was undertaken with the use of large bone allograft when there was no clinical or laboratory evidence of residual infection.

Patients and Methods

Between 1996 and 2001, 142 consecutive patients who had chronic, deep infection around a total hip arthroplasty (THA) were treated using the two-stage protocol. We were able to identify 24 with a minimum follow-up

of two years in whom infection was associated with massive bone loss which required the use of a structural bone allograft. There were 17 men and seven women with a mean age at the first stage of 59 years (34 to 69) (Table I).

The diagnosis of infection was made if there was a chronic discharging sinus communicating with the joint; frank purulent fluid or pus found on operative exploration; a level of C-reactive protein (CRP) of more than 20 mg/l and the presence of more than five polymorphonuclear leucocytes per high-power field on histological examination of tissues obtained at the time of operation.¹¹ The infection was confirmed by positive cultures of biopsy specimens obtained at the time of the first procedure in all hips.

The bony deficiency was carefully assessed using the pre-operative radiographs and the findings at the first operation. Fifteen patients had a massive acetabular defect, eight had segmental femoral bone loss and one a combined deficit. The bony deficiencies were classified according to the system proposed by the American Academy of Orthopaedic Surgeons (AAOS) (Table II).^{12,13} Twelve acetabular defects were classified as type III and four as type IV. Six femoral defects were of type III and three of type I. The mean length of the segmental femoral allograft was 14.5 cm (9 to 17).

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©2005 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.87B6.15411 \$2.00

J Bone Joint Surg [Br]
2005;87-B:770-5.
Received 18 February 2004;
Accepted after revision
13 July 2004

Table I. Details of the 24 patients

Mean age in yrs (range)	59 (34 to 69)
Men: women	17:7
Diagnosis of infection	
Discharging sinus	9
Purulent fluid or pus	17
High CRP* with positive pathology	20
Previous surgery	
Revision THA†	19
Primary THA	3
Hemiarthroplasty	2

* CRP, C-reactive protein

† THA, total hip arthroplasty

Table II. The classification of the American Academy of Orthopaedic Surgeons^{12,13} of acetabular and femoral deficiencies in THA*

Acetabulum		Femur	
I	Segmental deficiencies	I	Segmental deficiencies
II	Cavitary deficiencies	II	Cavitary deficiencies
III	Combined deficiencies	III	Combined deficiencies
IV	Pelvic discontinuity	IV	Malalignment
V	Arthrodesis	V	Femoral stenosis
		VI	Femoral discontinuity

* THA, total hip arthroplasty

Table III. The antibiotics used in the bone cement at each stage

	First stage	Second stage
Vancomycin + piperacillin	14	3
Vancomycin	5	16
Vancomycin + aztreonam	3	2
Teicoplanin	1	2
Aztreonam	1	1

Protocol of treatment

First stage. This consisted of excision of the sinuses, drainage of all abscesses and removal of all components, cement, foreign materials and any potentially infected tissues. Three sets of deep cultures (aerobic and anaerobic) were taken from the joint fluid, soft tissue and bone at the time of debridement.

We used custom-made metal moulds to form the cement prosthesis (Fig. 1). These were made of stainless steel and could be sterilised for repeated use. They were available in three different diameters and lengths (11/150, 13/180 and 15/220 mm) with a femoral head of 46 mm in diameter. The doughy cement, mixed with antibiotics, was introduced into the mould using three large Kirschner wires as an endoskeleton. After polymerisation the femoral component was removed from the mould and implanted into the femoral canal. The cement prosthesis was anchored in the remaining proximal femur with a collar of antibiotic-loaded cement. The cement acetabular component was shaped by the use of a retrieved unipolar cup.

The choice of antibiotics in the cement was determined according to the results of bacterial cultures obtaining from the draining sinuses or pre-operative joint aspirations

(Table III). We added 8 g of antibiotic powder to each package of 40 g of cement polymer (Surgical Simplex, Limerick, Ireland). If the infecting micro-organism could not be found pre-operatively or if infection was an unexpected finding, we used a combination of 4 g of vancomycin and 4 g of piperacillin.

Interim period. All patients were given intravenous antibiotics for two weeks. The selection was determined according to the microbiological assessment before operation and modified according to the results from the operative cultures. Oral antibiotics were prescribed for a further four weeks. The patients were encouraged to mobilise with toe-touch weight-bearing. The CRP was checked every two weeks to evaluate the control of the infection.

Second stage. The second-stage procedure was carried out when the wound had healed, the CRP had returned to normal and surgery was medically feasible. The interim prostheses were removed by fragmentation of the cement. For acetabular defects, cryopreserved (-80°C) allogenic cancellous bone was made into chips of approximately 1 cm³. They were pressed into the acetabular cavity and carefully impacted. A metal ring (Protek AG, Berne, Switzerland) or cage (Sulzer Orthopedics, Austin, Texas) was then positioned and fixed to the pelvis by multiple cancellous-bone screws. A polyethylene cup was cemented into the metal cage (Fig. 2). Segmental femoral defects were reconstructed with allograft which was selected according to the diameter. A long revision stemmed endoprosthesis with extensive porous coating was cemented into the allograft and the composite implant inserted into the host femur without the use of cement. The allograft-host junction was secured by step-cut interlocking and with wires or cables (Fig. 3). Two sets of deep bacterial cultures were taken at the second stage. We added 2 g of antibiotics to each 40 g pack of cement used for fixation of the components.

Post-operative care. All patients were given intravenous antibiotics for one week after re-implantation. No oral antibiotics were given to any patient thereafter. The patients were examined at one, three, six and 12 months, and then annually. Pain at rest and elevation of the serum level of CRP were used as indicators of recurrent infection.

A research fellow (Y-HC), who was not involved in the care of these patients, carried out objective clinical and radiological evaluation. The function of the involved hips was assessed before the operation, during the interim period and at the latest follow-up according to the scoring system of Merle D'Aubigné and Postel.¹⁴ The radiographs were examined for evidence of union or resorption at the allograft-host junction and migration or loosening of the allograft-prosthesis composite. On the acetabular side, incorporation of the allograft was determined by the appearance of trabecular remodelling within the grafted area. On the femoral side, the host-allograft junction was considered to have healed when stress-orientated callus had formed and the gap between the host and allograft had disappeared.

Fig. 1a

Fig. 1b

Photographs showing a) the metal mould and the unipolar cup used to make the cement prostheses and b) the femoral cement prosthesis.

Fig. 2a

Fig. 2b

Fig. 2c

Radiographs of a 47-year-old woman who had infection of a left total hip arthroplasty showing a) a type III acetabular defect, b) an antibiotic-loaded cement prosthesis three months after the first-stage surgery and c) three years after re-implantation with allograft reconstruction and a metal ring.

Fig. 3a

Fig. 3b

Fig. 3c

Radiographs of a 58-year-old woman showing a) septic loosening of a right total hip arthroplasty, b) four months after the first-stage operation with acetabular and femoral defects and a fracture of the proximal part of the femoral cement prosthesis and c) two years after revision with reconstruction of the acetabulum by allografts supported by a metal ring. The femur was reconstructed by an allograft-prosthesis composite.

Table IV. Micro-organisms isolated during resection arthroplasty

<i>Staphylococcus aureus</i> , oxacillin-resistant	9
<i>Staphylococcus aureus</i> , oxacillin-sensitive	5
<i>Staphylococcus epidermidis</i>	2
Coagulase-negative staphylococcus	2
<i>Pseudomonas aeruginosa</i>	1
<i>Escherichia coli</i>	1
<i>Enterobacter cloacae</i>	1
Unidentified gram-negative bacillus	1
Mixed	5

Results

Gram-positive micro-organisms were responsible for the infection in most hips (Table IV). At the second stage there was no visible evidence of infection and the cultures were all negative. We had no recurrence of infection in any patient at a mean follow-up of 4.2 years (2 to 7).

The mean Merle D'Aubigné and Postel hip score improved from 7.3 points (5 to 11) before operation to 13.2 points (11 to 16) between stages and to 15.8 points (14 to 18) at the latest follow-up. Statistical analysis showed a significant improvement at each stage (Wilcoxon signed-rank test, $p < 0.001$). The mean duration between stages was 13.6 weeks (11 to 17). Although weight-bearing on the involved limb was restricted in order to protect the temporary cement prosthesis and the remaining bone stock,

21 of the 24 patients could walk using a walker or crutches in the interim period.

Radiographically, there was no migration of the components or progressive radiolucency in the allograft-cement-prosthesis composite.

All the allografts appeared to have united to the host bone. In one patient, a screw used for fixation of the acetabular reinforcement ring was seen to be broken two years after operation. However, the patient had an excellent clinical score when followed up at four years and further surgery was not required.

Complications which were specific to the use of the cement prosthesis included two fractures of the cement femoral stem and one dislocation. These were treated conservatively by immobilisation and skin traction and usually resulted in a shortened interim period. Complications after re-implantation included a dislocation which occurred after three months and required a further revision at six months. No further dislocation occurred after this procedure.

At the most recent follow-up, two hips required re-operation because of complications other than infection. One was the recurrent dislocation described above. In the other, a periprosthetic fracture of the femur occurred 16 months after acetabular reconstruction with allograft and a cementless, non-grafted femoral revision. Further revision using a longer uncemented stem was required because of loosening of the femoral component.

Discussion

The management of deep infection with extensive loss of bone after arthroplasty of the hip is challenging. The goal of treatment is the eradication of infection and restoration of durable joint function. In our series, we showed that such patients could be managed successfully in two stages using a custom-cement prosthesis as an interim spacer and structural allograft for reconstruction. Use of the cement prosthesis has improved the comfort of the patient between stages, as reflected by a significant increase in the hip score from 7.3 to 13.2 points before re-implantation. Most patients were also mobile despite extensive loss of bone stock. Because they had better hip function and mobility, they usually had more patience and had more confidence during the flexible schedule of the next procedure.

The use of antibiotics in bone cement has made the interim spacer an antibiotic delivery system. In an *in vivo* human study, Masri, Duncan and Beauchamp¹⁵ showed that, with the use of at least 4.6 g of antibiotic powder (3.6 g of tobramycin and 1 g of vancomycin) per package of bone cement, elution of therapeutic levels of antibiotics from a prosthesis of antibiotic-loaded acrylic cement (PROSTALAC, Vancouver, Canada) could last for several months. In our series, we aimed to provide the hip with a high local level of antibiotics at the site of the infection. To each package of 40 g of cement polymer we added 8 g of antibiotic powder to fabricate the spacer prosthesis because we found this to be the highest mixture ratio which could be introduced into the mould and formed into a prosthesis without difficulty. Although measurement of the concentration of antibiotic was beyond the scope of our study, we consider this to be an important contribution to the successful eradication of infection in such complicated cases.

The use of a spacer to manage the patient between stages is not a new idea,¹⁶⁻²¹ but handmade cement spacers may cause pain and further loss of bone in the acetabulum if the patient bears weight. Since fixation of the femoral component is achieved by cementing to the remaining femur rather than using press-fit, a large variety of sizes of moulds is not necessary.

Complications which were specific to the use of the custom-cement prosthesis included two fractures of the cement femoral stem and one dislocation. Other authors have reported such complications.^{4,7,19}

Some authors have advocated a one-stage or direct exchange arthroplasty for the treatment of infected hip replacements.^{22,23} The one-stage revision is an attractive technique because it has the potential to lower the patient's morbidity, decrease the cost and avoid the technical difficulties of revision surgery. However, only a few cases meet the strict criteria for this type of surgery and currently it has a limited role.²⁴ We are aware of only one study by Loty et al²⁵ which indicated that the use of bone allografts in direct exchange arthroplasty was not associated with an increased rate of failure. Most other authors have found that massive

bone loss requiring reconstruction with allograft has a higher risk of re-infection and is contraindicated.^{23,24,26}

The use of bone allografts is a biological reconstruction having the potential for restoration of bone stock and possible re-attachment of the soft tissues. Many authors have supported the use of allograft. Berry, Chandler and Reilly²⁷ reported 18 staged revisions using morsellised or bulk allograft and found two cases of recurrent infection at 4.2 years. In a similar study, Wang and Chen³ noted that 91% of their patients were free from infection at four years. Alexeeff et al²⁸ and Ilyas and Morgan²⁹ evaluated the use of structural allograft in the revision of septic hip arthroplasty and reported no recurrence of infection at 47.8 and 65 months respectively. Our results indicate that the use of massive bone allograft and the delayed re-implantation of the infected hip arthroplasty did not increase the incidence of recurrent infection, provided that this had been eradicated at the first-stage.

The custom-made, antibiotic-loaded cement prosthesis affords the benefits of two-stage exchange without the functional disadvantages of an excision arthroplasty even when the bone stock is severely deficient. It can be produced by a simple moulding method and provides comfort and mobility for patients in the interim period and the potential for the eradication of infection.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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