Preservation of the original femoral cement mantle during the management of infected cemented total hip replacement by two-stage revision


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The removal of all prosthetic material and a two-stage revision procedure is the established standard management of an infected total hip replacement (THR). However, the removal of well-fixed femoral cement is time-consuming and can result in significant loss of bone stock and femoral shaft perforation or fracture. We report our results of two-stage revision THR for treating infection, with retention of the original well-fixed femoral cement mantle in 15 patients, who were treated between 1989 and 2002. Following partial excision arthroplasty, patients received local and systemic antibiotics and underwent reconstruction and re-implantation at a second-stage procedure, when the infection had resolved.

The mean follow-up of these 15 patients was 82 months (60 to 192). Two patients had positive microbiology at the second stage and were treated with six weeks of appropriate antibiotics; one of these developed recurrent infection requiring further revision. Successful eradication of infection was achieved in the remaining 14 patients.

We conclude that when two-stage revision is used for the treatment of peri-prosthetic infection involving a THR, a well-fixed femoral cement mantle can be safely left in situ, without compromising the treatment of infection. Advantages of this technique include a shorter operating time, reduced loss of bone stock and a technically more straightforward second-stage procedure.

The current standard management of peri-prosthetic infection involving a cemented total hip replacement (THR) is a two-stage revision procedure. The first-stage procedure involves the removal of all prosthetic material, including the implants and cement from both the acetabulum and femur. When the femoral cement mantle is loose the decision to remove it is easy, but a well-fixed cement mantle presents the surgeon with a dilemma. Logic dictates that all the cement should be removed, as it forms part of the prosthetic construct and acts as a potential source of continuing infection. However, it can be argued that an osseo-integrated cement-bone interface is not part of the effective joint space and is inaccessible to infecting organisms. The surface of cement adjacent to the prosthesis is potentially contaminated and requires burring and thorough lavage. During this process, antibiotic encased in the original cement mantle will become available for elution.

Removal of well-fixed cement is technically demanding and may be associated with complications such as excessive blood loss, bone loss and femoral fracture. In addition, at the second-stage procedure to re-implant a cemented prosthesis where cement has been removed, techniques such as impaction grafting may be required to treat bone loss, further adding to the complexity and risks of the revision surgery.

The necessity of removing all the femoral cement at the time of revision surgery for aseptic loosening was first questioned over 30 years ago. Cemented femoral implants can be relatively easily removed from the surrounding cement mantle and new implants successfully re-implanted into the original cement mantle by a cement-in-cement revision technique. We have successfully used the femoral cement-in-cement technique in our practice to facilitate access to the acetabulum during revision surgery since 1989. As it has been shown that well-fixed femoral cement does not need to be removed in the aseptic revision setting, it is logical to question whether the same is true for infected cases.

We present a series of patients who had a two-stage revision for infected THR where the femoral cement mantle at the first-stage procedure was well-fixed and left in situ. After the treatment of infection, cement-in-cement insertion of a femoral prosthesis into the previous cement mantle was carried out at the second-stage procedure.
Patients and Methods

Patients included in the study had established infection and were treated in a specialist arthroplasty unit between 1989 and 2002. Clinical and operative data were recorded prospectively using specially designed data-capture forms and entered into our database. Pre- and post-operative clinical evaluation was carried out using the grading system of Merle D’Aubigné and Postel as modified by Charnley, as well as the Oxford (OHS) and Harris hip scores (HHS).

All patients were reviewed clinically and radiographically at six weeks, six months, and then every two years. An assessment of the Barrack grade of the femoral cement mantle on the radiographs before the first-stage of the revision was recorded. Only patients with Barrack A or B mantles were appropriate for inclusion in the study. The most recent radiographs taken at latest review were assessed for the presence of radiolucent lines (RLLs) and osteolysis.

A clinical and radiological picture consistent with infection was present in all cases. Raised inflammatory markers were considered to be a CRP of > 10 mg/l (normal range 0 mg/l to 5 mg/l) or an ESR of > 30 mm/hr (normal range 0 mm/hr to 15 mm/hr). Pre-operative joint aspiration was carried out in cases where there were raised inflammatory markers but where doubts persisted regarding the diagnosis of infection. The hips of patients presenting with acute sepsis or those with discharging sinuses were not aspirated. At the time of surgery, fluid was taken from the joint for microscopy, gram staining and culture. In addition, multiple tissue samples were taken from around the joint and placed in individual sterile containers and sent to the microbiological studies. A minimum of five tissue samples were acquired from each patient and all samples underwent extended culturing. A positive diagnosis of infection was established if the same organism was grown from two different samples on microbiological culture.

Patients were considered to be potential candidates for preservation of the femoral cement if the pre-operative radiographs, reviewed by the operating surgeons, showed a well-fixed Barrack Grade A or B cement mantle. The operations were performed either by consultants (AJT, GAG) or fellows working within the arthroplasty unit and involved a posterior approach to the hip, exposure of the joint and removal of the femoral component. The neck of the femur was re-cut to remove 1 mm or 2 mm from the proximal surface in order to allow assessment of the integrity of the cement bone interface. The cement was considered well-fixed if a scalpel could not be passed between it and bone. Femora with a small amount of loose proximal cement were accepted, provided that the cement–bone interface was in a pristine condition above the level of the lesser trochanter.

The acetabular component was then removed along with all acetabular cement and tissue specimens were sent for microbiological assessment. Systemic antibiotics were then given, consisting of 1 g vancomycin by intravenous infusion, and a cement ball was prepared and placed in the acetabulum. The cement used was one of two proprietary bone cements, either Simplex P containing colistin and erythromycin (Howmedica, Limerick, Ireland) or Palacos R containing gentamicin (Heraeus Medical, Newbury, United Kingdom), depending on surgeon preference. Additional heat-stable antibiotic powders were added to the cement on an individual basis, depending on the microbiological characteristics of the infection. Most commonly these were vancomycin and gentamicin, either alone or in combination, usually 3 g of vancomycin and/or 2 g of gentamicin being added to each mix of cement.

The femoral cement mantle was carefully reamed to remove membrane and debris and to expose a fresh surface of cement, with the intention of liberating further antibiotics from the existing mantle. The cement bone interface was left intact and thorough lavage of the canal was carried out after reaming. At the discretion of the operating surgeon, the canal was then filled with either a cement cylinder containing antibiotics as described above, or with beads of gentamicin loaded cement. If a custom-mixed antibiotic cement cylinder was used, this was done when the cement had reached the dough phase. The intention was for the cement cylinder to deliver high levels of antibiotics to the local environment without binding to the existing mantle, so that it could be removed with ease at the second stage.

Post-operatively, systemic antibiotic treatment was guided by the sensitivities of the organisms. Patients were generally treated with six weeks (minimum three) of appropriate antibiotics administered intravenously or orally. The decision to change from intravenous to oral antibiotics was multi-factorial but was dependent on a good clinical response to treatment, a reduction of the CRP to < 50 mg/l and the availability of a suitable alternative oral antibiotic.

Patients were encouraged to mobilise during the interval between the two stages of their treatment. The excision arthroplasty meant that they were unable to bear weight on the affected side and required two crutches or a walking frame for mobilisation. Patients were allowed home after they had been started on oral antibiotics and their response to treatment was assessed by regular checks of their inflammatory markers, co-ordinated by their family doctor.

Satisfactory treatment of infection was established by the absence of clinical evidence of ongoing sepsis and normal blood inflammatory markers (CRP or ESR). The decision to proceed to second-stage surgery was made by the consultant responsible for the patient.

After eradication of infection, the second-stage involved posterior approach to the hip and removal of the cement spacer. Fluid from the hip and a minimum of five tissue samples were then sent for microbiological examination, followed by the administration of intravenous antibiotics. Early in the study period 1.5 g of cefuroxime and 500 mg of metronidazole were administered by intravenous infusion. The antibiotic policy of our unit changed in 1999 as a result of concerns over Clostridium difficile infection associated with cephalosporins. Vancomycin 1 g with gentamicin 160 mg were subsequently given intravenously.
Acetabular reconstruction was carried out as appropriate for each patient and involved either an uncemented component or a cemented component with impaction grafting. An assessment was made to check the femoral cement-bone interface, followed by cement-in-cement revision on the femoral side, with an Exeter Universal femoral stem (Stryker Orthopedics, Mahwah, New Jersey). Proprietary bone cements were used, either Simplex P or Palacos R as used in the first stage depending on surgeon preference. Additional heat stable antibiotic powder was added on a case-by-case basis to the cement, generally consisting of 1 g of vancomycin powder for each 40 g mix of cement. Post-operative antibiotics were directed by the previous sensitivities of the organisms and continued until the extended microbiological results were available. If positive cultures were obtained at the time of the second-stage procedure antibiotic treatment continued for six weeks.

If there was recurrent infection, a further first-stage revision procedure was carried out involving removal of all prosthetic material including the implants and cement from both the acetabulum and femur.

### Results

During the period studied a total of 131 patients underwent treatment for peri-prosthetic infection of the hip. Of these, 15 had a well-fixed femoral cement mantle suitable for retention at the first stage and were included in the study. Details of the patients and time frame of their operations are shown in Table I. The mean follow-up of these patients was 82 months (60 to 192). The organisms cultured at the time of the first-stage procedure are shown in Table II. One patient who was included in this study had no positive microbiology at the time of first-stage revision. The diagnosis of infection was made clinically on the basis of a large suppurative collection in the wound and hip and grossly elevated inflammatory markers (CRP > 110 mg/l). Pre-operatively he had been on antibiotics for a chest infection.

The pre-operative Barrack grades of the radiographs showed nine with Grade A and six with Grade B. An example of a well-fixed femoral cement mantle left in situ throughout treatment is shown in Figure 1. At five years post-operatively, four patients had developed a slight lucency around part of their cement mantle, but without osteolysis. All prostheses were classed as being well-fixed on radiological assessment as discussed below. In all, 13 of the 15 patients in this study had an Exeter stem removed at the first stage, one had a CPT stem (Zimmer Inc., Warsaw, Indiana) removed and the stem details for the other patient, who had an excision arthroplasty performed at another hospital, are unknown.

The median clinical scores before first-stage revision operation and at most recent review using the Charnley modification of the Merle d’Aubigné and Postel scoring system, as well as the OHS and HHS are shown in Table III.

Two patients had positive cultures at the time of the second-stage procedure. Both were treated with six weeks of appropriate antibiotics. One patient was infection-free at most recent review, five years after second-stage surgery. The other developed recurrent infection at three years post-operatively. This patient, unusually for a patient with a peri-prosthetic infection, developed septic shock shortly after being hospitalised with the primary hip infection. *Staphylococcus aureus* was responsible for the septicaemia as well as a peri-prosthetic infection. Following the first stage, six weeks of antibiotics were given with a satisfactory clinical response. At the second stage carried out eight months later, coagulase-negative *Staphylococcus* was cultured. Antibiotic treatment was continued for six weeks, as recommended under these circumstances.

Unfortunately after a further six months there was recurrent infection. At the subsequent further revision all prosthetic materials, including the implants and acetabular and femoral cement, were removed and the joint was found to be infected again with coagulase-negative *Staphylococcus*. After a further six months a repeat second-stage revision was carried out and at most recent review, 42 months post-operatively, there was no evidence of infection. Further details of patients who had complications after the second-stage procedure are shown in Table IV. Successful eradication of infection was achieved in 14 of 15 patients at a minimum of five years after the second-stage procedure. Three patients have died since the completion of the study, at 77, 82 and 85 years after the second-stage procedure.

### Discussion

In our study, 14 of the 15 patients had successful treatment of peri-prosthetic infection using the technique of leaving a...
well-fixed femoral mantle *in situ*. Our success rate in eradicating infection in this study is comparable to other studies using two-stage revision techniques.\(^{17-19}\) One patient developed recurrent infection that required a further revision necessitating removal of all prosthetic materials to eradicate the infection. At 42 months after that operation, there was no evidence of recurrent infection.

The other patient who had positive microbiology at the time of second-stage revision surgery was also treated with six weeks of post-operative antibiotics.\(^{16}\) There was no evidence of infection at latest review at five years.

As with other studies on the treatment of peri-prosthetic infection, we used strict criteria to establish the diagnosis of infection.\(^{14,17}\) In all but one patient an organism was cultured in at least two of multiple samples taken at the time of the first-stage procedure. The one exception was a patient who presented with a collection of pus around their hip wound shortly after being an in-patient for treatment of a chest infection. Prior to orthopaedic admission the patient had been on antibiotics for at least one week. At the first-stage procedure there was frank pus in the hip but no organism was cultured, probably due to the recent course of antibiotics. In view of the florid clinical picture, the patient was deemed appropriate for inclusion in the study, despite the lack of a cultured organism.

A potential criticism of our study is the small number of patients involved. During the study period, around 1500 revision procedures were carried out in our unit. Of these, 130 were carried out for infection. Only the 15 patients reported here had a femoral cement mantle that was sufficiently well-fixed at the time of surgery to be included in the study. The other patients treated for

### Table III.
The median clinical scores (range) before first-stage operation, and at most recent review using the Charnley modification of the Merle d’Aubigné and Postel scoring system and the Oxford and Harris hip scores

<table>
<thead>
<tr>
<th>Charnley category</th>
<th>Number of THRs</th>
<th>Pain</th>
<th>Function</th>
<th>Movement</th>
<th>Oxford hip score (0 to 48 worst to best)</th>
<th>Harris hip score</th>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td>Charnley score (each subscore from 0 (worst) to 6 (best))</td>
<td>Pain (0 (worst) to 10 (best))</td>
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<tr>
<td>Before 1st stage revision</td>
<td></td>
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<td></td>
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<tr>
<td>A</td>
<td>4</td>
<td>1 (1)</td>
<td>1.5 (1 to 2)</td>
<td>3 (3)</td>
<td>8 (8)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>1 (0 to 2)</td>
<td>1 (0 to 2)</td>
<td>4 (4 to 6)</td>
<td>10 (6 to 20)</td>
<td>10 (0 to 40)</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>3 (3 to 5)</td>
<td>3 (2 to 4)</td>
<td>4 (4 to 6)</td>
<td>24 (19 to 31)</td>
<td>20 (20)</td>
</tr>
<tr>
<td>At most recent review</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>5.5 (5 to 6)</td>
<td>6 (6)</td>
<td>5.5 (5 to 6)</td>
<td>40 (40)</td>
<td>30 (30)</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>5 (4 to 5)</td>
<td>5.5 (5 to 6)</td>
<td>5 (4 to 6)</td>
<td>35 (22 to 47)</td>
<td>30 (30 to 44)</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>5.5 (4 to 6)</td>
<td>1.5 (1 to 4)</td>
<td>5.5 (4 to 6)</td>
<td>30 (23 to 44)</td>
<td>44 (20 to 44)</td>
</tr>
</tbody>
</table>
infection had a two-stage revision procedure in which all prosthetic material was removed and a full excision arthroplasty performed. The small number of patients treated in this fashion reflects the strict selection of cases for the technique, which the authors feel is vital for its success.

A slightly unusual spectrum of infecting organisms (Table II) was found in our study compared with other studies reporting the organisms causing peri-prosthetic infection.20,21 We found a higher proportion of pyogenic infections and a relatively small proportion of coagulase-negative Staphylococcus infection than reported in other larger series.20,21 This might be due to the relatively small number of cases in this series. However, it is possible that acute, pyogenic infections present earlier, before the cement mantle has loosened, whereas slow, indolent infections cause gradual loosening of the mantle, thus excluding them from treatment in this way.

Prior to the first-stage procedure radiological evidence of a well-fixed femoral cement mantle was essential for inclusion in the study. It is important to note that both anteroposterior and lateral radiographs are required for assessment of the integrity of the cement-bone interface, before the mantle can be deemed to be well-fixed. Using the Barrack grading system12 for assessing cemented femoral components, all patients in this study had either a Grade A (n = 9) or Grade B (n = 6) cement mantle (Table III). The authors recognise that the Barrack grading system was developed for the assessment of radiographs taken immediately after primary surgery, as a way of judging results of the cementing technique. Although it was not originally described for the assessment of the cement-bone interface in the long-term, the authors nevertheless found it to be useful when selecting cases that may be appropriate for cement-increment revision. At most recent review, at least five years after the second-stage procedure, there had been some change in the radiographs of four patients. The lucency noted around the femoral components could be explained by the phenomenon of cortical thinning and endosteal expansion of the femur sometimes observed with increasing age of the patient.22 Despite the lucency around the femoral component the cement mantle remains well fixed to the femur and it has been shown histologically that a ‘neocortex’, not visible on radiographs, supports the cement mantle and the lucent area is filled with trabeculae that traverse to the receding endosteal surface of the femur.23

The low pre-operative hip scores confirm the incapacity caused by the septic implants. After the successful treatment of peri-prosthetic infection the hip scores improved as function was restored, with the most recent scores improved to a level almost comparable to the scores observed after primary THR and documented in previous studies using the Exeter Universal hip replacement.24

In all, 14 of the 15 patients in this study had a polished tapered stem removed at the first stage. The stem details of the last patient are not known. The polished tapered design is easy to remove leaving a cement mantle which approximately matched the shape of the stem used at the second stage, making the cement-in-cement technique easy to perform. We acknowledge that if we had been faced with removing short or curved stems at the first stage, we would have been required to perform additional work on the cement mantles to allow insertion of our chosen prosthesis at the second stage.

We conclude that when two-stage revision is used for the treatment of peri-prosthetic infection around a THR, a well-fixed femoral cement mantle can be safely left in situ at the time of the first stage. Our results show that using this approach does not compromise the treatment and eradication of infection, as long as strict selection criteria are adhered to. Re-implantation of a femoral stem into the remaining cement mantle can be performed safely at the time of the second-stage procedure using a cement-in-cement technique.7

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References

Table IV. Complications after second-stage surgery

<table>
<thead>
<tr>
<th>Problem</th>
<th>Number of patients</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive microbiological cultures at second-stage revision and subsequent recurrent infection after second-stage revision</td>
<td>1</td>
<td>Treatment with appropriate antibiotics for six weeks post-operatively. Recurrent infection 36 months after initial second-stage revision. Further debridement and excision of all prosthetic material and femoral cement. Had further second-stage revision after six months and had been clear of infection for 42 months at latest review.</td>
</tr>
<tr>
<td>Positive microbiological cultures at second-stage revision</td>
<td>1</td>
<td>Treatment with appropriate antibiotics for six weeks post-operatively. No subsequent evidence of recurrent infection at review 60 months after surgery.</td>
</tr>
<tr>
<td>Dislocation</td>
<td>1</td>
<td>41 days post-second-stage revision. Closed reduction: no further problems. Had acetabular impaction grafting at second-stage revision. Fell 44 days after second-stage revision resulting in sudden failure of acetabular fixation. Further revision of acetabulum to an uncremented acetabular component. No problems at most recent review.</td>
</tr>
<tr>
<td>Failure of acetabular fixation</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>