Acetabular revision with impacted morsellised cancellous bone grafting and a cemented cup

A 15- TO 20-YEAR FOLLOW-UP


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This study presents the clinical and radiological results of 62 consecutive acetabular revisions in 58 patients, at a mean of 16.5 years follow-up (15 to 20). The Kaplan-Meier survivorship for the cup with end-point revisions for any reason, was 79% at 15 years (95% confidence interval (CI); 67 to 91). Excluding two revisions for septic loosening at three and six years, and one revision of a well-fixed cup after 12 years in the course of a femoral revision, the survivorship was 84% at 15 years (95% CI; 73 to 95). At review there were no additional cases of loosening, although seven acetabular reconstructions showed radiolucent lines in one or two zones. Acetabular revision using impacted large morsellised bone chips (0.7 cm to 1.0 cm) and a cemented cup, is a reliable technique of reconstruction, when assessed at more than 15 years.

Loss of bone stock compromises the outcome in revision of total hip arthroplasty. The long-term results of most techniques of acetabular revision remain unclear and few reports are available on the outcome beyond ten years. From a biological viewpoint the reconstruction of the bone stock with grafted bone is an attractive option.

Following the experience of Hastings and Parker5 and McCollum, Nunley and Harrelson6 with protrusio acetabuli, we have used a modified technique of bone grafting for acetabular revisions using tightly impacted morsellised bone chips and cemented cups. In 1998 we described the outcome of this technique in 60 procedures followed for more than ten years.7 We now report the outcome at 15 to 20 years.

Patients and Methods
Between January 1979 and March 1986, 62 acetabular revisions were performed using impacted morsellised bone grafts and a cemented cup in 58 patients with failed hip prostheses. The revisions were performed by four surgeons, although one (TJJHS) operated on half of the patients. At review, one patient was lost to follow-up, leaving 61 hips for study. Revision surgery was undertaken on 43 cemented and six uncemented total hip arthroplasties. The primary diagnosis had been primary osteoarthritis in 28 cases, secondary osteoarthritis in 29, mainly following childhood disorders, and rheumatoid arthritis in four. The indication for revision was aseptic loosening (57 hips) or septic loosening (four hips); two patients had had previous revisions, once and twice, respectively.

The group comprised 13 men and 44 women with a mean age at surgery of 59.1 years (23 to 82); 36 of the procedures were on the left side. At review in April 2001, 17 patients (18 hips) had died within 15 years of the revision operation. Nearly all the patients had been followed annually in detail. None had further revision surgery and the deaths were not related to the hip. One patient who had been lost in the previous review has now been traced, using modern computer techniques, and her clinical data are included in this update. Of the surviving 43 arthroplasties, 33 hips (31 patients) were examined and seen at a minimal and maximal follow-up of 15 and 20 years, respectively. Seven patients were interviewed by telephone and three (four hips) were reviewed by orthopaedic surgeons in other clinics. The Harris Hip Score (HHS) was used for clinical evaluation.

Radiological follow-up was complete for 50 hips, incomplete in ten hips and missing in one. Of those examined clinically, radiological data were available in 27. Anteroposterior (AP) views of the pelvis were assessed by three authors (SBTB, BWS, TJJHS) who made a consensus opinion. Acetabular defects were
<table>
<thead>
<tr>
<th>Details of 62 consecutive acetabular revisions</th>
<th>Acetabular revisions</th>
<th>Patients</th>
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<tbody>
<tr>
<td>Total studied between 1979 and 1986</td>
<td>62</td>
<td>58</td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Available</td>
<td>61</td>
<td>57</td>
</tr>
<tr>
<td>Died without further surgery</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Re-revisions</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>for septic loosening</td>
<td>2 (at 3 and 6 years)</td>
<td></td>
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<tr>
<td>for aseptic loosening</td>
<td>7 (between 6 and 14 years)</td>
<td></td>
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<tr>
<td>for mismatch during femoral revision</td>
<td>1 (at 12 years)</td>
<td></td>
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<tr>
<td>for wear done</td>
<td>1 (at 17 years)</td>
<td></td>
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<tr>
<td>Radiological loosening during follow-up</td>
<td>3 (all 3 died at 7, 13 and 14 years with minor symptoms)</td>
<td></td>
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<tr>
<td>who were not revised</td>
<td></td>
<td></td>
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<tr>
<td>Survival rate at 15 years with endpoint</td>
<td>79% (95% CI, 67 to 91)</td>
<td></td>
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<tr>
<td>re-revision for any reason</td>
<td></td>
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<tr>
<td>Survival rate at 15 years with endpoint</td>
<td>84% (95% CI, 73 to 95)</td>
<td></td>
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<tr>
<td>re-revision for aseptic loosening</td>
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Figure 1a – Pre-operative AP radiograph of the pelvis of a failed cemented cup which was inserted for secondary osteoarthritis after an acetabular fracture in a 53-year-old man. Figure 1b – A revision of both components was done in October 1982 with acetabular bone impaction grafting; two femoral heads were used. A metal mesh was placed on top of the bone graft (a technique no longer used). Figure 1c – Twenty years after the reconstruction, there are no signs of acetabular loosening. The cup is stable with radiological incorporation. During the 20 years of follow-up, this patient had two femoral revisions.
assessed comparing pre-operative and the first post-operative radiographs and the operation record according to the AAOS classification.\(^8\) There were 38 cavitory and 23 combined cavitory and segmental defects (ten central and 13 peripheral). The radiographs at the latest review were compared with films taken after operation, and at follow-up after one, five, ten and 15 years. Radiolucency was scored in the three zones of DeLee and Charnley,\(^9\) taking a line of more than 2 mm width as positive. Migration of the cup was estimated in relation to the line between the tear drops.\(^10\)

Clinical failure was defined as any need for revision of the acetabular component. Radiological failure of the reconstruction was defined as migration of more than 5 mm in any direction, or progressive radiolucent lines in all three zones on conventional radiographs.

For statistical analyses we used a Kaplan-Meier survivorship analysis.

**Results**

Three patients (three hips) died after the minimum follow-up period at 15, 15 and 17 years after revision, respectively. None had had further revision surgery. The mean HHS of the 28 patients with 30 acetabular reconstructions who were still living at a mean of 16 years and 5 months (15 to 20 years) after surgery was 86 (50 to 100).

Of the original group of 61 hips, 11 had been revised further (Table I). Two were for culture proven, septic loosening at three and six years after surgery and seven for aseptic loosening between six and 14 years. One well-fixed cup was changed at 12 years in the course of femoral revision for aseptic loosening. One cup was revised again after 17 years because of wear even though it was well fixed.

Most hips had a stable radiographic appearance with uniform radiodensity of both graft and host bone, even after 20 years of follow-up (Figs 1 and 2). In one hip, the acetabular component had migrated by 13 mm soon after the operation, but then remained in that position, and was not recorded as a radiological failure. The normal trabecular structure around the cups was seen in most cases within a year. Eight of the nine hips that were revised for septic or aseptic loosening had radiological signs of loosening in all zones. Three other hips showed radiological loosening at seven, 11 and 13 years after surgery but were not revised again because of the mild symptoms. All died subsequently at seven, 13 and 14 years after surgery. None of the 27 cases for which the radiographic data were available at a minimum of 15 years and who were still functioning showed radiological loosening. Twenty-one of the 27 (78%) appeared to be stable. Of the other six hips two had a stable radiolucent line in zone I, one had a progressive line in zone I and four had a progressive line in zone III.

No further acetabular reconstruction was necessary; two patients had dislocation after surgery, but these were treated conservatively. However, nine patients were reoperated upon for other reasons during follow-up. Of these, two were treated for superficial wound problems and a suspicion of infection. In one case heterotopic ossification was removed and one had an exploration of the sciatic nerve for entrapment. Three patients had femoral fractures during follow-up; two followed falls and one was caused by a metastasis. Three patients had a revision of the femoral component with acetabular revision during the period of study.

Using the Kaplan-Meier survival analysis at ten years, the survival of the cup with revision for any reason was 93% (95% CI; 86 to 100) and the survival of the cup, with aseptic loosening as the endpoint was 96% (95% CI; 91 to 100) (Fig. 3). At 15 years, these data were respectively, 79% (95% CI; 67 to 91) and 84% (95% CI; 73 to 95).

**Discussion**

We believe that bone defects encountered at revision surgery should be treated biologically using a bone graft to reconstruct the skeleton. We accept that all acetabular implants will fail in time. If the already damaged bone bed is not reconstructed by bone-graft techniques, the problems at a future revision are even worse. The survival of these cemented cups after a revision with this technique is very satisfying, even after a follow-up of 15 to 20 years. Both the radiological incorporation and the histological evidence from human biopsies confirm that bone stock is restored to a situation which is as close to nature as possible.\(^11\) This method uses conventional implants, as in primary procedures, which is cost-effective. The only major modification we have made during the years is that we no longer use a mesh on top of the graft.

Since our earlier report, we have encountered a new problem,\(^7\) in that we were unable to obtain a complete radiographic review as many of the patients are very old. However, the clinical outcome of all cases is known, including those who had died. Assessing the reliability of our study, in accordance with Murray, Britton and Bulstrode,\(^12\) the loss to follow-up quotient is 0.1, which is close to ideal. The worst-case survival scenario, considering all hips lost to follow-up as failures and including all acetabular revisions for any reason, is 77% at 15 years and 69% at 20 years. We observed a deterioration of the results with more acetabular re-revisions. However, the failure mechanism of these reconstructions seems to be comparable with cemented primary cups and is due to wear with associated osteolysis about the cup, which is often slow to develop.

Although Conn et al\(^13\) have suggested radiographic criteria for graft incorporation, it is difficult to interpret on radiographs. The process of incorporation of impacted morsellised bone grafts has been examined in animal experiments both in bone chamber models and in realistic models of the acetabulum and femur.\(^14\)\(^17\) We have recently reviewed 25 human biopsy specimens taken from 24 acetabular reconstructions in 20 patients with a follow-up after surgery of one to 170 months.\(^11\) In general, both in the
animal models and in the human biopsies, there was a rapid incorporation of bone graft. However, in the human study, some cases showed areas which were not incorporated, even after a long follow-up. In biopsies taken from reconstructions which were revised repeatedly for aseptic loosening, necrotic areas of previously incorporated graft were seen, probably related to the loosening process.

By using this bone impaction technique with a cemented cup, we were able to reconstruct the bone stock, provide a stable cup and restore the mechanics of the hip. The clinical outcome of revisions with this technique, four years after reconstruction, are comparable with the fourth-year scores after primary cemented hip arthroplasty. This is the only technique of reconstruction we have used for acetabular revision. The outcome in 70 revisions who all had a Paprosky grade 3A or 3B defect was recently reported. At a five-to-nine-year follow-up, only one cup was re-revised; the survival rate for aseptic loosening was 98%.
Another type of bone graft for revision is a structural allograft for which the head of the femur is most commonly used. Larger structural bone allografts incorporate incompletely even after a long period. This has also been observed when massive autologous femoral heads were used. In one series 20% had been revised at a mean follow-up of 11.8 years. However, Kerboull et al. presented a single-surgeon study of 60 consecutive acetabular revisions in 53 patients in which the revision was performed using bulk allograft bone, an acetabular reinforcement device and a cemented cup. All had a type-3 or type-4 bone defect according to the AAOS classification. The survival rate for the acetabular component was 92% at a mean follow-up of ten years, which is certainly a good result in this group with extensive bone defects.

Another option for acetabular revision is the cementless acetabular component. Although these are frequently used, long-term reports of more than ten years follow-up are few. Leopold et al. described 138 cases of cementless cup revision in 131 patients at a mean follow-up of 11.5 years. The endpoint for further revision (14 of 130 hips) for any reason was 89%, but there were no revisions of the cup for aseptic loosening. The worst case scenario including all acetabular revisions for any reason and cases lost to follow-up as failures showed a survival rate of 84%. These data are comparable with our results at the same follow-up. Bone defects in both studies seem to have been equal, but the patients in the cementless group were younger (mean, 50 years vs 59 years). However, new problems were observed in the last review of this cementless group, including pelvic osteolysis in 17% of the hips and shedding of metal from the back of the metal shell. If this pelvic osteolysis is progressive, the outcome in future years will be unfavourable. Templeton et al. reviewed 61 consecutive revisions performed on 55 patients by one surgeon; a porous-coated Harris-Galante component was used for the acetabulum. None of the acetabular components had required revision for aseptic loosening at a mean follow-up of 12.9 years. However, nine of the 55 hips (16%) underwent additional procedures on the acetabulum during a re-operation, or for stem-associated problems. Osteolysis of the pelvis was observed in 13% of the cases.

The technique of acetabular impaction grafting with cement is demanding, since impaction must be tight enough to create stability. The use of a bone mill is tempting, but most create bone chips of small dimensions which provide little stability. Even when using models of simple cavitory defects in experiments on axial loading, the stability of cemented cups in reconstructions with smaller bone grafts of 2 to 5 mm diameter were inferior to procedures in which larger chips were used. This may be the explanation for the ongoing migration observed in seven of 21 cups two years after surgery in a clinical radiostereophotogrammetric analysis. However, up to five years after surgery, no cup was re-revised. Every effort should be made to prevent inclusion of cartilage remnants, since these particles can interfere with the mechanical characteristics, and can hamper bone integration because they do not incorporate into bone.

The method of impaction is also important. We always used trial cups or specially designed impactors in combination with a hammer. However, some surgeons used a modified technique in which the bone grafts are impacted using an acetabular reamer in a reversed direction in combination with manual compression on the reamer. We compared the initial stability of the cemented cup in a simple cavitory defect model, using the same-sized bone chips both with the reversed reaming technique and the traditional method.
with impactors and a hammer; the former resulted in a significant higher migration of the cups.\textsuperscript{24} A major concern is the use of bone processed in different ways, since the mechanical and biological properties of freeze-dried or irradiated bone may not be comparable with that of the fresh-frozen grafts which we used. We did not wash the allograft prior to impaction, although this may be attractive. In the animal model, the incorporation of washed, impacted allografts was superior to those that were unwashed.\textsuperscript{17}

The optimum post-operative management is unclear. All our patients had strict bedrest for six weeks, but because of the high morbidity and the costs, we now mobilise most of our patients on crutches immediately and they use them for three months. Recently, by using roentgenstereophotogrammetric analyses, it was shown that, at least in cavitory defects, there were no significant differences in the migration pattern of the cups for loaded or restricted weight-bearing.\textsuperscript{18} However, the period of immobilisation or restricted weight-bearing in more extensive cases should be adjusted in relation to the original extent of the destruction.

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References