LONG-TERM RESULTS OF REVISION HIP ARTHROPLASTY
SURVIVAL ANALYSIS WITH SPECIAL REFERENCE TO THE FEMORAL COMPONENT

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We report a clinical and radiological survival analysis of 148 consecutive revisions of hip arthroplasties. All patients referred were offered revision if it was indicated and they were medically fit. About one-third (32%) had had at least one previous revision, and about one-third had an established deep infection. The revisions were performed in ultra-clean air with body-exhaust suits. The usual method of fixation was by contained and pressurised cement of standard viscosity, to which appropriate antibiotics had been added in infected cases. Some patients had cementless revision.

Clinical failure meant that one or both of the implants had been removed; radiological failure was assessed from serial radiographs. The clinical survival at ten years was 95%. The Merle D'Aubigné and Postel rating for pain improved from a mean of 2.9 to 5.2; and in Charnley group A and B cases, walking ability improved from 2.3 to 4.3. In contrast to some reports we also found good radiological survival; this was 90.5% for cemented femoral stems. Isoelastic revision stems inserted without cement gave poor results.

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Table 1. Clinical diagnosis before the original hip replacement

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of hips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary osteoarthritis</td>
<td>114</td>
</tr>
<tr>
<td>Osteoarthritis secondary to</td>
<td></td>
</tr>
<tr>
<td>Dysplasia</td>
<td>2</td>
</tr>
<tr>
<td>Congenital dislocation</td>
<td>4</td>
</tr>
<tr>
<td>Fracture/dislocation</td>
<td>6</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>13</td>
</tr>
<tr>
<td>Juvenile rheumatoid arthritis</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
</tr>
</tbody>
</table>

The published results of hip revision surgery have varied greatly, due probably to lack of homogeneity in the patient groups operated on and the variety of procedures carried out. The patients' state of health and level of function, the number of previous operations on the hip, and the presence or absence of infection and bone destruction all influence the outcome, as do the revision techniques used.

Attempts have been made to clarify the situation by reporting revisions for aseptic and for septic failure separately. Reports of revisions for sepsis, however, have usually concentrated on the cure of infection rather than on the long-term outcome (Morschel, Babst and Jenny 1990). Overall, the results have been discouraging, either because of loosening or threatened loosening (Callaghan et al 1985; Kavanagh, Ilstrup and Fitzgerald 1985; Retpen, Varmaken and Steen Jensen 1989), poor clinical function (Pellicci et al 1985; Kershaw et al 1991) or radiological evidence of early subsidence (Franzén, Mjöberg and Önnerfält 1992). These reports outweigh the few encouraging ones (Marti et al 1990; Harris, personal communication 1991). Only Retpen et al (1989), Marti et al (1990) and Kershaw et al (1991) have used survival analysis to assess their results. We have, therefore, reviewed our results and subjected them to survival analysis.

PATIENTS AND METHODS

We studied the first 148 consecutive total hip replacements (144 patients) revised in our unit. The first revision operation was in March 1982 and the most recent in the series was in January 1989. Four patients had bilateral revisions; these were performed at different times. The mean age at revision was 67.2 years (19 to 82). Table 1 gives the original diagnoses.

All patients presenting to the unit were offered a revision if it was indicated and if the patient was well enough to survive the operation and to benefit from improved hip function. No patient was rejected on technical grounds alone. Eighty-five hips had had only one previous operation, 36 had had two, 15 three, and 12 four or more (maximum 8). Thirty hips had been revised on a previous occasion
(including conversions to a Girdlestone pseudarthrosis), and 16 had been revised twice or more (maximum 4).

To determine the presence or absence of deep infection before revision we depended on a complete history (including whether or not the original replacement had been carried out in ultra-clean air and what had been the subsequent postoperative course), the ESR, and radiography. Sequential technetium/gallium radionuclide scanning was also performed on all patients. A decision was then made as to whether the loosening was aseptic or there was any possibility of infection. In 96 patients there was doubt and in these a tissue biopsy was taken under general anaesthesia, the specimen was cultured and the sensitivity of the organism or organisms determined. Further specimens were taken during the revision operation (Wootton, Northmore-Ball and Morris 1991).

On the basis of these findings and particularly of the bacteriology, the hips were grouped into those definitely infected and those definitely not. A third group consisted of those in which some degree of doubt remained. This group included those hips with all the hallmarks of infection including a discharging sinus but persistently negative cultures, and hips in which the bacteriology was unexpectedly positive. We subdivided this third group into those in which infection seemed almost certain and those in which it was only a possibility. The final groupings were: definite infection (n = 42) 28%; infection almost certain (n = 15) 10%; infection possible (n = 10) 7%; no infection (n = 81) 55%. Of the infected cases, 26 had a discharging sinus at the time of revision. All these hips had one-stage revisions.

The operations were all carried out by one of the authors (MDN-B) in a Charnley-Howorth vertical down-draught, laminar-flow, ultra-clean air enclosure using body-exhaust suits. The patient was supine and trochanteric osteotomy was performed except when the trochanter had already been excised or when excision was intended. The implants and all previous cement were removed, the debridement being particularly painstaking when we thought that there was infection. Inaccessible intrapelvic cement was occasionally left in cases believed to be aseptic. The cement was usually removed from the proximal end of the femur; fenestration of the shaft was necessary on only two occasions.

In 132 hips, Charnley components (De Puy Thackray, Leeds, UK), two of them of the resection type, were used for the revision. In nine hips a cementless RM-Isoclastic prosthesis (Robert Mathys Co, Bettlach, Switzerland) was used. In three hips which required resection of the upper femur, AO tumour prostheses (Stratec Medical GB, Welwyn Garden City, UK) were used. Two hips required saddle prostheses (Waldemar Link, GmbH & Co, Hamburg, Germany) and two custom-made total femoral replacements were used. Bone grafting, either autogenous or from the hospital bone bank, was often used in aseptic cases if there was much bone destruction.

The components were fixed with standard viscosity cement containing 0 to 5 g of gentamicin per 40 g (Palacos; Schering, Bury St Edmunds, UK) firmly impacted into a closed cavity. Antibiotics chosen according to the core biopsy were added in infected hips, up to a maximum of 4 g per 40 g of cement. Pre-existing defects in the femur (present in 32 cases) were blocked before final cementing by either a small preliminary cement mix, bone graft, wire mesh, digital obturation, or some combination of these. The distal femoral canal was blocked by a Hardinge plug (De Puy Thackray, Leeds, UK) supplemented (in 44 cases) by the temporary placement of a transverse Kirschner wire to prevent its distal migration (Northmore-Ball, Narang and Vergroesen 1991). The lesser trochanter, when still present, was excavated as a cement fixation hole (Wroblewski, personal communication 1982).

Similar techniques were used for the acetabular component. AO or Eichler rings (Stratec Medical GB, Welwyn Garden City, UK) were used in 18 cases either to stabilise a large graft or because the acetabulum was destroyed to such an extent that a closed cavity for adequate cement impaction could not be produced.

The bone surfaces were washed and dried and the femoral cement was inserted with a gun (Howmedica UK Ltd, London, UK), pressurisation being achieved by sealing the femur around the gun nozzle with glove rubber and a swab. The pressure was maintained until the cement had cured. In the acetabulum the Exeter cement pressuriser (Howmedica) was used and the Charnley cups (De Puy Thackray) were of the flanged type.

In 130 hips (88%) both components were replaced. In two cases, only the acetabular component was changed, and in 16 only the femoral component. All these 18 hips had aseptic loosening.

Systemic antibiotics were started intraoperatively after bacteriological specimens had been taken. Cefuroxime was normally used in aseptic hips, followed by oral cephradine. In infected hips, the antibiotic regime was chosen according to the core biopsy result. Antibiotics were altered or discontinued when the final bacteriological result from the operative specimens became available. In infected hips an appropriate antibiotic was then continued for six weeks to three months. In some patients they had to be stopped much earlier than this for medical reasons, but there were no apparent ill-effects from shorter courses.

Assessment. The patients were reviewed at yearly intervals for up to three years and at two-yearly intervals thereafter. Radiographs were taken, and function was scored according to Charnley’s modification of the Merle D’Aubigné and Postel system (1954). For the purposes of this study, we made efforts to trace all patients who had been lost to follow-up or who had not been recently reviewed. Eight patients who were either too ill to attend the hospital or who lived too far away were evaluated by postal questionnaire only.

A total of 27 patients had died, three in the immediate postoperative period and a further 18 before the end of the second postoperative year. The exact cause of death was not always known, but we were able to establish that none died as a direct result of the revision procedure. The mean follow-up time for the patients who were still alive and not lost to
review was 6.5 years (2 to 11).

Clinical survival. The criterion for clinical survival of an arthroplasty was that neither component had been removed from the patient (Dobbs 1980; Dorey and Amstutz 1986; Nelissen, Brand and Rozing 1992).

Radiological survival. The diversity of the primary implants, the presence of grafts, rings, and screws, and the frequent absence of cement meant that we could not use a classification based entirely on radiolucent lines. We also observed that, despite cement pressurisation, a localised radiolucency at some part of the interface was occasionally present on the immediate postoperative films. This was probably due in the femur to a pocket of blood, and in the acetabulum to a retained piece of membrane deep within a previous cement fixation hole. In such cases the remainder of the interface might be quite devoid of radiolucent lines, indicating sound fixation. We also found, as noted by Kavanagh et al (1985), that variations in rotation, X-ray beam angle and penetration could make considerable differences, sometimes causing apparent disappearance of a definite radiolucent line. We therefore used the following classification for mechanical integrity of the fixation:

Grade 1. Serial radiographs showed good interfaces with no detectable change over a period of (about) two years. The presence of a small localised non-progressive defect on the immediate postoperative film did not necessarily exclude a hip from this group.

Grade 2. Serial radiographs showed small radiolucent areas not present on the postoperative film, but with no subsequent progression (Fig. 1).

Grade 3. Serial radiographs showed progressive increase in radiolucency or component migration, or both. The criterion for radiological survival was that the radiographs fell into grades 1 or 2.

Life-tables as described by Armitage and Berry (1987) were constructed. The number of hips at risk was calculated from the start of each postoperative year and the probability of survival of the hip at that follow-up time was determined. The notional date for final review was 31 October 1992. During each yearly interval after the index revision, some hips failed and others were withdrawn, leaving a reduced number at risk at the start of the next interval. A hip was withdrawn if the observation time since revision was insufficient to reach the start of the next interval and the hip was known not to have failed, or if the patient had been lost to follow-up or had died. The hips withdrawn were not statistically different from the rest in terms of age, sex, original diagnosis and type of prosthesis used for revision. We therefore assumed that the probability of failure in these two groups was the same (Nelissen et al 1992).

Figure 1a – Radiograph six years after a one-stage exchange operation for a proven Staphylococcus epidermidis infection in an active 68-year-old man. A previous revision had already been performed before referral to us, leaving two substantial perforations in the posterior femoral cortex and extruded cement. There was also a large defect in the anterior cortex proximally. The perforations were blocked with a preliminary cement mix before definitive cementing. Figure 1b – The same hip after eight years’ follow-up. The thin, incomplete radiolucencies have not progressed. The patient had had a revision of the other hip in the interim, for mechanical loosening, and was rated as group B (right) 544, (left) 544.
RESULTS

Clinical survival. The life-table for clinical survival is shown in Table II and Figure 2. The probability of clinical survival was 95% at ten years.

Figure 3a shows a comparison of the Merle D’Aubigné and Postel ratings for pain before (mean 2.9) and after (mean 5.2) the index revision for the 130 patients for whom both figures were available. The mean figure for range of motion improved less, from 3.5 to 4.7. In those 96 patients in whom hip function was considered to be the main determinant of mobility, that is excluding Charnley group C patients, the mean score for walking ability rose from 2.3 before revision to 4.3 at review (Fig. 3b).

Clinical failure occurred in five patients. One required very early acetabular revision for mechanical loosening due to a technical error, in which an AO ring, not fixed with screws, did not sink properly into the acetabulum during cementation. The other four failures were from infection.

Two of these failed in the 3- to 4-year and 5- to 6-year intervals and were probably infected at the time of revision but were treated without complete debridement. One was probably infected intraoperatively; this patient had severe

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Table II. Life-table for clinical survival of 144 patients (148 hips) who underwent revision arthroplasty

<table>
<thead>
<tr>
<th>Elapsed time since index revision (yr)</th>
<th>Number withdrawn</th>
<th>Number of failures</th>
<th>Number at start of interval</th>
<th>Adjusted number at risk</th>
<th>Probability of failure in each interval</th>
<th>Probability of survival in each interval</th>
<th>Total survivors (per cent)</th>
<th>Standard error (per cent)</th>
<th>95% confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1</td>
<td>13</td>
<td>148</td>
<td>141.5</td>
<td>0</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1 to 2</td>
<td>12</td>
<td>1</td>
<td>135</td>
<td>129</td>
<td>0.007</td>
<td>0.992</td>
<td>99.22</td>
<td>0.79</td>
<td>97.7 to 100</td>
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<td>2 to 3</td>
<td>6</td>
<td>122</td>
<td>119</td>
<td>0</td>
<td>1</td>
<td>99.22</td>
<td>0.81</td>
<td>97.6 to 100</td>
<td></td>
</tr>
<tr>
<td>3 to 4</td>
<td>16</td>
<td>116</td>
<td>108</td>
<td>0.027</td>
<td>0.972</td>
<td>96.46</td>
<td>1.8</td>
<td>95.9 to 99.9</td>
<td></td>
</tr>
<tr>
<td>4 to 5</td>
<td>19</td>
<td>97</td>
<td>87.5</td>
<td>0</td>
<td>1</td>
<td>96.46</td>
<td>2</td>
<td>92.5 to 100</td>
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<tr>
<td>5 to 6</td>
<td>13</td>
<td>78</td>
<td>71.5</td>
<td>0.013</td>
<td>0.986</td>
<td>95.11</td>
<td>2.6</td>
<td>90.0 to 100</td>
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<td>6 to 7</td>
<td>18</td>
<td>64</td>
<td>55</td>
<td>0</td>
<td>1</td>
<td>95.11</td>
<td>3.1</td>
<td>89.0 to 100</td>
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<td>7 to 8</td>
<td>12</td>
<td>46</td>
<td>40</td>
<td>0</td>
<td>1</td>
<td>95.11</td>
<td>3.6</td>
<td>88.0 to 100</td>
<td></td>
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<tr>
<td>8 to 9</td>
<td>23</td>
<td>34</td>
<td>22.5</td>
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<td>1</td>
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<td>6.3</td>
<td>82.8 to 100</td>
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<td>9 to 10</td>
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<td>7</td>
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<td>95.11</td>
<td>12.1</td>
<td>71.4 to 100</td>
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<td>10 to 11</td>
<td>3</td>
<td>3</td>
<td>1.5</td>
<td>0</td>
<td>1</td>
<td>95.11</td>
<td>-</td>
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</table>

Graph of clinical survival with 95% confidence intervals.

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protrusio acetabuli due to rickets. There was a serious intraoperative haemorrhage which required vascular repair. The operation was successfully completed but with temporary breakdown of complete laminar flow asepsis. The other patient had excellent function for three years, during which time the opposite hip was revised, and we believe that late infection was haemagenous.

Four of the above five failures were re-entered into the study after a second revision. The patient with a vascular injury had a conversion to a Girdlestone pseudarthrosis.

The distribution of hips within the three radiological grades was found to be: grade 1, 
(n = 95) 64%; grade 2, 
(n = 40) 27%; grade 3, 
(n = 13) 9%.

Radiological survival. Radiological survival is shown in Table III and Figure 4. There were 13 radiological failures, a survival of 85% at ten years. Five of these 13 were the clinical failures referred to above. Of the remaining eight, five had cementless RM-Isolastic prostheses. There was no significant difference in timing between these failures and those of the cemented hips. Thus, we have a very high radiological failure rate (over 50%) for this cementless prosthesis. For cemented stems, the radiological survival rate was 90.5%.

All patients had healed wounds at review and none of the radiological failures appeared to be infected. There was no clinical evidence of infection in any of the remaining patients.

DISCUSSION

Our results give grounds for optimism about the results of revision surgery in both aseptic and infected hip arthroplasties, and in particular about the results of cemented fixation using standard viscosity cement by the method described. Although the numbers at risk in the 9- to 10- and 10- to 11-year intervals are small, no significant deterioration in results was seen after the third year. The one failure in the 5- to 6-year interval resulted from pre-existing infection rather than mechanical failure.

This optimistic view is reinforced by our radiological study, since the survival figures remained almost stable after the fifth year. We cannot ignore the possibility of a dramatic increase in the late failure rate, but the results so far suggest that, except for hips which develop a new infection, potential failures are ‘weeded out’ in the early years after revision. Furthermore, the patients’ ordinary functional activity is
likely to decrease with increasing age. In this connection, the high mortality rate in the first two years after revision, from causes unrelated to the operation, is noteworthy.

The RM-Isolastic prosthesis was used in younger patients with severe bone destruction who required large grafts, particularly in the femur. The conditions of its use were therefore demanding. Nevertheless, our results with it were very poor, and this prosthesis is no longer used in our unit.

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.

REFERENCES


