First-time revision using impacted morsellised allograft bone with a cemented Exeter stem

RADIOSTEREOMETRIC ANALYSIS OF STEM MIGRATION OVER NINE YEARS

Previously, radiostereometric analysis following hip revision performed using impacted morsellised allograft bone and a cemented Exeter stem has shown continuous subsidence of the stem for up to five years. It is not known whether the subsidence continues thereafter. In our study, 17 of 25 consecutive osteo-arthritic patients with aseptically loose stems who underwent first-time revision using impacted morsellised allograft bone and a cemented Exeter stem were followed by yearly radiostereometric examinations for nine years. The mean subsidence at six weeks was 1.1 mm (0.1 to 2.3), from six weeks to one year 1.3 mm (0 to 2.6), from one to five years 0.7 mm (0 to 2.0), and from five to nine years 0.7 mm (0.1 to 3.1). That from six weeks to nine years was 2.7 mm (0 to 6.4) (95% confidence interval 2.0 to 3.5). The Charnley pain score significantly improved after revision, and was maintained at nine years, but walking ability deteriorated slightly as follow-up extended. Of the eight patients who were not followed for nine years, two had early subsidence exceeding 11 mm.

Our findings show that in osteo-arthritic patients who undergo revision for aseptic loosening of the stem using impacted morsellised allograft bone and a cemented Exeter stem, migration of the stem continues over nine years at a slower rate after the first year, but without clinical deterioration or radiological loosening.

The most common reason for revision of the femoral stem in total hip replacement (THR) is aseptic loosening, often associated with loss of bone stock in the proximal femur.1 Reconstruction may be undertaken by impaction of morsellised cancellous bone graft combined with a cemented stem.1 The developers of this technique used the double-tapered polished Exeter stem (Howmedica International, London, United Kingdom).1 Reports of revision THR using impaction bone grafting and a cemented Exeter stem, as well as impaction grafting in combination with other cemented stems, has shown good early and medium-term clinical and radiological results.1-3 Radiostereometric analysis (RSA) is a reliable method of assessing prosthetic micromovement.4,5 Marked subsidence detected by RSA has not only been associated with future loosening of the prosthesis, but also with fracture of the cement mantle.6-9

We have used morsellised allograft bone and a cemented Exeter stem in first-time revision THR and followed the patients by repeated RSA examination. Our findings at two and five years, reported previously, revealed that the migration of the Exeter stem is more pronounced at two years after revision and that minor migration occurs between two and five years after surgery without clinical deterioration.10,11 A recent long-term follow-up survivorship analysis of patients who had undergone revision by impaction bone grafting and the implantation of a cemented Exeter stem has shown a low rate of re-revision, but the pattern of migration of the stem has not been studied.12 We have therefore assessed the long-term subsidence of the stem in these patients.

Patients and Methods
Between January 1994 and December 1995, 25 consecutive patients with aseptic loosening of a femoral stem after primary cemented THR for osteoarthritis underwent revision with impacted morsellised allograft and a cemented Exeter stem. Our study was conducted in accordance with Swedish laws on ethics in medical research and informed consent was obtained from all the patients.

All revisions were performed by two surgeons who were not authors (MS, PS) using a...
standard technique. 

A posterolateral approach was used. Fresh-frozen femoral heads, thawed in saline (50°C to 60°C) for 20 minutes, were morcellised with the Tracer Bone Mill (Tracer Designs Inc., Santa Paula, California) producing bone chips of approximately 3 mm in size. The bone chips were compressed in a cotton cloth for delipidisation. The graft was impacted into the femur using the X-change revision instrument system (Howmedica International). Pre-chilled vacuum-mixed bone cement containing gentamicin was introduced with a cement gun. A standard collarless double-tapered polished Exeter stem was inserted.

RSA examination was performed within seven days of the operation and then at six weeks, three, six, 12, 18 and 24 months and annually thereafter for nine years. The series comprised 14 men and 11 women with a mean age of 74 years (60 to 84). Two patients died and one sustained a femoral fracture within five years. One declined and four were unable to continue participation because of old age or illness (one before the five-year and four before the nine-year examinations).

The remaining 17 patients, nine men and eight women, with a mean age of 75 years (64 to 84) were followed for nine years. The revision involved the right hip in 14 patients. Pre-operative deficiency of bone stock in the proximal femur on conventional radiographs was classified according to the criteria of Gustilo and Pasternak as grade I in five patients, grade II in nine and grade III in three.

Radiostereometric analysis. We used the standard technique. 

Tantalum markers 0.8 mm in diameter were implanted in the greater and lesser trochanters during revision. Migration of the stem along the longitudinal, transverse and sagittal axes was calculated as point movement: the displacement of the centre of the prosthetic head in relation to the tantalum markers in the femoral bone. No tantalum markers were present in the cement or morcellised bone. Therefore migration within the composite could not be calculated separately.

The accuracy of the method was determined by two repeated RSA examinations as described previously. Movements of the stem measuring at least 0.3 mm along the longitudinal, 0.5 mm along the transverse and 0.7 mm along the sagittal axes were considered to be detectable migration, with values lower than these not detectable.

Radiological assessment. Subsidence of the stem within the cement mantle was measured and voids in the mantle were recorded. Peri-prosthetic radiolucent lines were determined on the anteroposterior radiographs according to Gruen, McNeice and Amstutz.

Clinical assessment. All the patients were evaluated and categorised clinically according to the classification of Merle d’Aubigné and Postel as modified by Charnley.

The Charnley hip scores for pain, walking ability and range of movement were calculated pre-operatively and at follow-up.

Statistical analysis. We calculated the mean value, the range and the standard error of the mean (SEM) for migration along the three axes. The unsigned absolute migration values used in these calculations above each cardinal axis were summated. We calculated the mean difference in migration and the 95% confidence interval (CI) between the follow-up at six weeks, and at one, five and nine years. For the Charnley scores we calculated the mean and range for the pre-operative and the follow-up scores at two, five and nine years, and analysed the change in scores from pre-operatively to nine years using the Wilcoxon test. All statistical tests were two-sided and a p-value ≤ 0.05 was considered to indicate statistical significance.

Results

Migration of the stem. For the 17 patients who completed the nine-year follow-up, all the femoral stems had migrated in the distal, mediolateral, and posterocentral directions, with migration in the distal and posterior directions being more pronounced than in the mediolateral direction (Fig. 1). At six weeks the stems had subsided by a mean of 1.1 mm (0.1 to 2.3) and the mean subsidence from six weeks to nine years was 2.7 mm (0 to 6.4). That from six weeks to one year was 1.3 mm (0 to 2.6), from one year to five years 0.7 mm (0 to 2.0), and from five years to nine years 0.7 mm (0.1 to 3.1) (Table I).

For the 25 patients initially in the study, the mean subsidence at six weeks was 1.3 mm (0.1 to 4.8) and at one year 2.9 mm (0.1 to 17.9). For the two patients who died, the subsidence at their last follow-up was 1.9 mm (two years) and 6.4 mm (three years), respectively. For the patient who sustained a femoral fracture, the subsidence at four years was 11.8 mm. For the four patients unable to and the one patient who declined further participation, subsidence at their last follow-up was 1.7 mm (two years), 2.0 mm (six years), 2.5 mm (eight years), 2.9 mm (six years) and 24.1 mm (six years), respectively. The last patient had no signs of radiological loosening.

Radiological findings. All the 17 stems subsided between 1 mm and 5 mm within the cement mantle, most occurring within the first two years. Two stems had defects in the cement mantle that were present from the outset and eight had no cement beyond the tip of the stem. Of the 119 zones analysed in the 17 patients, radiolucent lines were observed in 25 zones in 12 patients (six zones between host bone and graft, 15 between cement and graft and four between cement and host bone).

Clinical findings. At the follow-up at nine years there had been no re-revisions. The mean Charnley score for pain had improved from 3.1 pre-operatively to 5.1 at nine years (Table II). In all, ten patients were free from pain, one had occasional slight pain, five had pain associated with physical activity but not at rest, and one patient who had a drop foot because of peripheral neuropathy following a viral infection and used a wheelchair reported severe pain on attempting to walk, preventing all activity. The mean Charnley score for walking ability at nine years was similar to that before revision (Table II). For nine patients the
Charnley category had worsened because of progression of osteoarthritis of the knee or contralateral hip, or other medical conditions. The mean Charnley score for the range of movement had improved from 4.3 before revision to 4.7 at nine years.

For the eight patients who were lost to follow-up before the nine-year review, the Charnley pain score recorded at their last follow-up was 6 in six patients and 4 in two, the walking ability score was 6 in one and ≤2 in seven patients and the range of movement score was 4 in four and 5 in

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Table I. Results (mean, range) of radiostereometric analysis for migration of the femoral component

<table>
<thead>
<tr>
<th>Direction</th>
<th>Migration (range)</th>
<th>Mean change (95% confidence interval) (n = 17)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>6 wks (n = 25)</td>
<td>1 yr (n = 25)</td>
</tr>
<tr>
<td>Distal</td>
<td>1.3 (0.1 to 4.8)</td>
<td>2.9 (0.1 to 17.9)</td>
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<tr>
<td>Mediolateral</td>
<td>0.5 (0.0 to 2.7)</td>
<td>0.7 (0.0 to 4.8)</td>
</tr>
<tr>
<td>Posteroanterior</td>
<td>1.1 (0.0 to 4.7)</td>
<td>2.7 (0.1 to 21.0)</td>
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</tbody>
</table>

Graphs of the mean (SEM) migration of 17 Exeter stems followed by annual RSA examinations for nine years after revision showing a) distal, b) mediolateral and c) posterior migration.
four patients. The patient with signs of major early migration of the stem, who was followed for six years, had a Charnley pain score of 4 and a walking ability score of 1.

Discussion

A recent long-term follow-up study of revision of the stem using impaction bone grafting and the cemented Exeter stem has shown excellent survival of 94% at 15 years,12 but little is known about the behaviour of the stem itself. Earlier RSA studies found continuous migration of the stem for up to five years after surgery, raising concerns about its future fixation.10 Our study showed that migration continued up to nine years after surgery, but no radiological loosening was seen, nor did the pain score deteriorate during this period.

RSA studies performed to investigate the initial migration after primary and revision surgery have concluded that early migration from six months post-operatively for up to two years increases the risk of revision.5,6 In a study by Kärrholm et al,5 subsidence of between 1 mm and 2 mm during the first two years was shown to imply an increased risk of future loosening. Our study with revision using morsellised bone grafts showed that despite a mean RSA-measured subsidence of 3.4 mm after two years and continued slow subsidence until nine years there was no radiological loosening.

The results of femoral impaction bone grafting with different types of cemented stem, both with and without a collar and with polished as well as with a textured stem, have been described as good in short- to medium-term follow-up.2,3,9,17-22 The type of stem used may not make a substantial difference, as suggested by Malkani et al,23 who believed that the grafting technique was more important than the design of the stem.

We have shown that subsidence of the cemented Exeter stem after impaction bone grafting occurs mainly during the first two years,11 but continued subsidence at a slower rate takes place for up to nine years. After the initial mechanical settling-in of the prosthesis,24,25 continuous migration may be a consequence of biological graft resorption/remodelling26-28 and/or other factors such as cement fatigue29,30 and femoral expansion.31-33

A limitation of our study is the lack of information in this small series about the long-term quality-of-life outcome. However, previously we have found favourable medium-term outcomes with impaction allografting34 and the long-term follow-up Charnley scores do not suggest substantial deterioration.

In conclusion, in osteo-arthritic patients with aseptic loosening of the femoral stem who were revised using impacted morsellised allograft bone and a cemented Exeter stem, we found that RSA-measured subsidence of the stem continued over nine years without clinical deterioration or radiological loosening.

Table II. Clinical outcome for the 17 patients followed for nine years

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative</th>
<th>Two years</th>
<th>Five years</th>
<th>Nine years</th>
<th>p-value (pre-operative to nine yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>3.1 (1 to 6)</td>
<td>5.6 (4 to 6)</td>
<td>5.4 (4 to 6)</td>
<td>5.1 (2 to 6)</td>
<td>0.001</td>
</tr>
<tr>
<td>Walking ability</td>
<td>3.1 (1 to 5)</td>
<td>4.4 (2 to 6)</td>
<td>4.3 (1 to 6)</td>
<td>3.2 (1 to 6)</td>
<td>0.91</td>
</tr>
<tr>
<td>Range of movement</td>
<td>4.3 (3 to 6)</td>
<td>4.6 (4 to 5)</td>
<td>4.4 (3 to 6)</td>
<td>4.7 (3 to 6)</td>
<td>0.11</td>
</tr>
</tbody>
</table>

* values are mean (range)
† Charnley category (n: A, B, C) had changed from (4, 12, 1) pre-operatively to (1, 8, 8) at nine years

References


