LONG-TERM RESULTS OF CHARNLEY TOTAL HIP REPLACEMENT

REVIEW OF 92 PATIENTS AT 15 TO 20 YEARS

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We made a prospective study of 241 Charnley total hip replacements performed between 1968 and 1974. In 1990, we reviewed 92 patients with 103 hips (96.3% of surviving hips) at a mean follow-up of 17.6 years (15 to 20.6)

The clinical results were excellent, with Charnley scores of 4 or more for pain in 95% of the patients, for function in 73% and for movement in 93%. Of the whole series, 8.3% had been revised, and Kaplan-Meier survival analysis showed a probability of revision at 20 years of 10.7%.

These results are similar to those from the few other series with extended follow-up, and make it difficult to justify the present widespread use of uncemented hip prostheses. It would seem that some aspects of the design of the first-generation Charnley stem were beneficial for long-term survival of the arthroplasty. We found no correlation between the clinical results and radiological loosening on the Harris scale.

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From its introduction in 1962 until 1968 the Charnley prosthesis was reserved for use only at Wrightington Hospital. Our unit in the University Hospital in Odense was the first Danish orthopaedic department to adopt the Charnley total hip replacement (THR) in October 1968. From then until July 1974 all 241 hip replacements in our department were carried out by the senior author (KHS), following the original surgical technique advised by Charnley. There are a number of reports of good long-term results of the Charnley low-friction arthroplasty (Wroblewski 1986; McCoy et al 1988; Kavanagh et al 1989; Nicholson 1992; Older and Butorac 1992), but many of these studies were impaired by difficulties in locating all surviving patients and arranging their examination. Furthermore, in most series very few patients were operated on below the age of 60 years, because of uncertainty about long-term results. Therefore, surviving patients from early series are now very old and their number is rapidly diminishing. Even in 1979, Charnley considered that great care and informed judgement were needed before advising operation for patients between 45 and 65 years of age.

In Denmark, the Danish People’s Register makes it possible to obtain almost complete follow-up, and there is an established tradition of co-operation in such studies. We aimed to provide accurate data on the long-term survival of the cemented Charnley THR. In our series many patients had a THR at a relatively young age, and there is therefore a larger number of surviving patients at long term. All the data on these patients were prospectively recorded and all patients had a strictly standardised operation.

The increasing use of uncemented hip prostheses on the basis of short-term follow-up makes it important to establish the true results of cemented prostheses in centres other than the originating one.

PATIENTS AND METHODS

Between October 1968 and July 1974 we implanted a total of 241 Charnley THR in 211 patients; 240 were primary procedures and one was a revision. Twenty-nine patients had bilateral THRs as staged procedures. There were 109 women and 102 men; the median age at surgery was 62 years (34 to 79). Fifty-two of the patients (22%) were under 55 years of age.

The indications were osteoarthritis in 191 hips (79%), the sequelae of childhood hip disorders in 27 (11%), old fracture in 13 (5%) and avascular necrosis in 4 (1.6%). Only three (1.2%) had rheumatoid arthritis. Two had old septic arthritis and one an old dislocation. There had been previous surgery in 51 hips: 19 had intertrochanteric osteotomies (8%), 32 had other proce-
dures such as fracture fixation, infarction, hemiarthroplasty or arthrodesis.

Operating technique. Preoperatively, all patients were very carefully assessed and prepared. Any carious or infected teeth were treated, varicose veins were operated on and cardiopulmonary problems were treated. At this time we did not consider that obesity was a contraindication; 64 of the hips (26.6%) were implanted in patients 10% or more over their calculated ideal weight. Operation was in a conventional theatre which had been closed for 48 hours before hip surgery; no unnecessary movement was allowed in the theatre, and speeching was prohibited. The rate of air-change was only 10/hour, with non-laminar flow. Surgeons wore standard operating gowns, and antibiotic prophylaxis was not used either systemically or in the acrylic bone-cement.

The operation closely followed Charnley’s early recommendations, using a lateral approach through a trochanteric osteotomy. The trochanter was replaced by a standard technique using double vertical wires crossing a single horizontal wire. Cement was inserted by thumb-pressure only, but in contrast to the technique used by most surgeons at that time, insertion was delayed for five minutes after mixing to allow an increase in its viscosity. No medullary plug was used, but this rather firm cement could be pressurised to some extent. In the acetabulum, its viscosity made it less liable to escape into the interior of the pelvis or around the flanges of the cup. After the first 74 hips, a metal grid was used to cover the centering hole in the acetabulum. The newly cemented components were held steady with firm pressure until the cement had fully polymerised.

Few special components were used; there were 220 standard stems and 220 standard cups, 11 straight narrow stems and 10 extra small cups. Ten femoral components and 11 acetabular cups could not be identified with certainty at follow-up. All the femoral components had a polished surface and right-angled corners at the lateral surface, the so-called first-generation or ‘flatback’ design. The acetabular components all had the simple flange of first-generation components; none had a long posterior wall.

Postoperatively, the patients were isolated in a clean ward bay until drains were removed. No prophylactic antithrombotic drugs were given; all patients were kept in bed for ten days after operation.

Follow-up and review. All patients were examined at 6 months and at 2, 5 and 10 years after the operation. Standard forms were completed, radiographs were taken, and all records for this cohort were filed together.

During 1990, we made a special review of surviving patients, logging data, old and new, in a computerised database. All radiographs were reassessed. The records and radiographs of all patients who had died or were not available for follow-up were also reviewed and entered.

At clinical examination we used the Merle d’Aubigné and Postel (1954) scoring as modified by Charnley (1972). Preoperative severity of arthritis had been graded according to the Heripret scoring scale (Danielsson, Dymling and Heripret 1963). All complications were recorded.

Acetabular measurements
1) The angle of the cup to the vertical axis of the pelvis in the frontal plane and its anteversion or retroversion.
2) Migration, measured on the anteroposterior view in relation to the teardrop and to the lowest point of the sacroiliac joints.
3) The thickness of acetabular bone covering the cement.
4) Polyethylene thickness in the vertical axis through the femoral head, to allow an estimation of wear.
5) Radiolucency in the three DeLee and Charnley zones (1976) to give a loosening score similar to that of Harris, McCarthy and O’Neill (1982).

Femoral measurements
1) Valgus or varus position, and the distance from the highest part of the lesser trochanter to the base of the neck of the prosthesis medially.
2) Radiolucency in the frontal plane in the seven zones of Gruen, McNeice and Amstutz (1979).
3) Any cement fracture.
4) Evidence of loosening using the definitions of Harris et al (1982).
5) Trochanteric position and fixation, with time of union and any wire breakage.

All radiographic measurements were corrected for magnification by reference to the apparent size of the head of the femoral component. The probability of revision was estimated by the method introduced by Kaplan and Meier (1958), the endpoints being death or revision of one or both components.

RESULTS
Of the original 211 patients, 95 with 107 THRs (44.4%) had survived at least 15 years, and of these 92 with 103 hips (96.3%) were available for follow-up; 40 men and 52 women. The median follow-up time was 17.6 years (15 to 20.6) and the patients had a median age of 77.1 years (53.3 to 98.2) at the time of re-examination.

Three patients with four THRs were lost from follow-up because of severe incapacitating disease not related to the arthroplasty; earlier records from the previous examinations showed no signs of imminent failure. In all, 109 patients with 127 THRs had died, and seven with seven hips revised since 1974 were still alive. For the deceased patients the median time of survival after surgery was 12.5 years (1.1 to 21.9).

Of the 240 primary arthroplasties 230 had scores of 5 or more on the Heripret scoring-scale indicating severe arthritis. Preoperative Charnley scores are compared with those at follow-up in Figure 1: preoperatively, under 4% scored 4 or more for function or pain, but at latest review only 7% scored 3 or less for pain and movement. One-quarter of the hips scored poorly for function, but in this group many suffered from other disabling diseases.

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Postoperatively, deep venous thromboses (DVT) were diagnosed clinically in 20 patients, 14 in the operated leg. Minor pulmonary embolus was suspected in nine; 12 had pneumonia and 16 had urinary-tract infections. All these complications were treated successfully with no long-term sequelae and there were no deaths within the first year after operation. Some of the complications may have been related to the ten-day postoperative bed rest recommended at that time. One hip dislocated in the early postoperative period. After closed reduction it has remained stable. There were no late dislocations. Three patients (1.4%) required reoperation for problems related to the trochanteric osteotomy: one had refixation for detachment and two had removal of wires for pain.

Up to 1990, 20 of the original 240 THRs (8.3%) had had revisions. There were five deep infections, one early and four late at 0.9 to 4.7 years postoperatively. They were all treated by excision arthroplasty. Other than for infection, only one revision was performed before July 1974, to reposition a poorly placed femoral component.

There were five fractures of femoral components (2.1%) at a mean of 15.7 years (10.8 to 16.5). All five patients were male, with a mean age at surgery of 59.3 years (51.7 to 66.6). Only one of these patients was overweight, but the small numbers did not allow us to comment on the relation between weight and the time of fracture (Charnley 1975; Wroblewski 1982).

Eight hips were revised for aseptic loosening (3.3%), as proved by negative cultures at operation. In three both components were loose, in three the stem only, and in one the cup only. One had an excision arthroplasty because of loss of bone stock. One cup was revised after being loosened in a severe accident.

The probability of revision is shown in the Kaplan-Meier plot in Figure 2 and Table I. At 20 years this was 10.7%. Latest radiographs, however, showed that, on the Harris scale, 30 of the femoral components (30%) were 'definitely loose' (Table II), one was 'probably loose' and one was 'possibly loose'. Thus, two-thirds showed no signs of loosening. A cement fracture was visible in 12
Of the 30 'definitely loose' femoral components only 13 had a radiolucent line at the cement-bone interface: the other 17 were so graded because subsidence inside
the cement showed a 'black line' with no other radiographic or clinical signs of loosening (Paterson, Fulford and Denham 1986). Of the 13 cases with cement-bone radiolucency, this was present in only one of the Gruen zones in seven, in two zones in two, and in three zones in two. If subsidence had not occurred these 11 hips would not have been classified as loose.

**DISCUSSION**

Long-term follow-up studies often review procedures which have undergone major changes in intervening years and must be judged by earlier standards. The threshold for THR has changed; more younger patients with less severe symptoms now have operations. Almost all our patients had very severe osteoarthritis, too severe to advise the alternative of an intertrochanteric osteotomy. This was a genuine choice during the years under review; 385 osteotomies were performed for hip osteoarthritis in our department. Many of our patients had had previous surgery before THR or had sequelae of infantile hip disease. This would be expected to make the results worse since they add both to the technical difficulty and to the risk of infection or loosening.

The indications for surgery before 1975 excluded some patients who probably would be operated on today. Rheumatoid arthritis was considered to cause a high rate of loosening and young patients were seldom offered a THR. Our series differs from other contemporary series in this respect.

Our careful preoperative assessment, with the eradication of any treatable source of complications, and the meticulous perioperative regimen were expected to improve the final results. Total hip replacement was then far from a standard operation. The cementing technique was crude by modern standards and might be expected to lead to a high rate of loosening.

The very limited range of available components does not seem to have been a problem. Charnley intended to keep the number of variants as low as possible, but his original design of the femoral stem was altered in 1976 because of stem fractures; in our series the fracture rate was 2.1%. Anthony et al (1990) have suggested, however, that some of the details of the original stem were fortuitously desirable. The stems were polished, had no cobra flange, and had only one taper in the frontal plane. Some modern 'Charnley' stems have a double-taper which may reduce the ability to subside inside the cement. Dall et al (1988) have suggested that the first-generation Charnley stem may have been superior to the revised version. Although we found that 30 stems were loose, most showed few or no radiolucent lines at the cement-bone interface. More commonly, there was a gap between the cement and the proximal part of the stem (Fig. 3),

![Kaplan-Meier plot of the probability of revision of the cemented Charnley THR up to 20 years postoperatively.](image-url)

**Table I.** Probability of revision in 241 cemented Charnley THR

<table>
<thead>
<tr>
<th>Follow-up (yr)</th>
<th>Number at risk</th>
<th>Percentage</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>218</td>
<td>3.4</td>
<td>± 2.2</td>
</tr>
<tr>
<td>10</td>
<td>212</td>
<td>3.8</td>
<td>± 2.5</td>
</tr>
<tr>
<td>15</td>
<td>161</td>
<td>8.2</td>
<td>± 3.8</td>
</tr>
<tr>
<td>20</td>
<td>95</td>
<td>10.7</td>
<td>± 4.7</td>
</tr>
</tbody>
</table>

**Table II.** Number and percentage of radiologically loose prostheses at 15 to 20 years in 98 Charnley THR

<table>
<thead>
<tr>
<th>Cup</th>
<th>Stem</th>
</tr>
</thead>
<tbody>
<tr>
<td>No loosening</td>
<td>61 (62.8)</td>
</tr>
<tr>
<td>Possibly loose</td>
<td>20 (20.4)</td>
</tr>
<tr>
<td>Probably loose</td>
<td>11 (11.3)</td>
</tr>
<tr>
<td>Definitely loose</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Cement fracture</td>
<td>12 (12.2)</td>
</tr>
</tbody>
</table>

**Table III.** Mean Charnley scores in hips with definite loosening or cement fracture compared with the remainder

<table>
<thead>
<tr>
<th>Mean score</th>
<th>Pain</th>
<th>Function</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definite femoral loosening (n = 30)</td>
<td>6</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Definite cup loosening (n = 5)</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Cement fracture (n = 12)</td>
<td>5.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>All others (n = 63)</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
indicating subsidence inside the cement mantle, with the cement-bone interface intact. Some hips showed fractures of the cement at the tip of the prosthesis, confirming subsidence within the proximal part of the cement.

We found very little correlation between the Harris grade for loosening and the clinical findings: a better scale is needed, since this scoring assumes that any subsidence is a sign of failure. Certain types of ‘dynamic’ subsidence may be a good sign (Fowler et al 1988).

We saw only one early dislocation, and no other signs of instability; this may result from the correct use of trochanteric osteotomy. The prostheses did not allow for the intraoperative adjustment of soft-tissue tension that is possible with modular designs, but the gluteus medius could be tensioned by reattaching the trochanter more distally. Trochanteric osteotomy is often regarded as time-consuming and unnecessary, but there is evidence that its use improves stability. It has been shown that osteotomy may cause very few complications (Sørensen et al 1981), and it does allow optimal positioning of the cup (Lewinnek et al 1978; Wiesman et al 1978). Our experience emphasises the need for exact positioning of the cup, with a 45° angle in the AP plane, and no anteversion or retroversion.

Our postoperative complication rate reflects the long bed-stay that was used in the absence of antithrombotic prophylaxis. Our current lower rates of infection and venous thrombosis reflect the change to a short period of bed rest.

Our mean follow-up of 17.6 years showed better results for pain and range of movement than for function, a difference explained by the fact that the patients were elderly, and often otherwise disabled. Our high survival rate agrees with previous reports (Wroblewski 1986; Skeie et al 1991; Older and Butorac 1992) and confirms that good function without pain often coexists with radiographic loosening. Revision is required only for clinical indications, unless there is major loss of bone stock.

Like others, we assumed that patients who have died or have been lost to follow-up have the same probability of failure as those who have been re-examined. Older and Butorac (1992) make the point that there is no evidence of a dramatic increase in rates of failure or loosening with time; we have confirmed this – our failure rate is constant during the whole period of observation. The same operating technique was used throughout; no changes were introduced that could be expected to influence the failure rate in either direction. Table IV shows that the survival rates after 10 to 20 years are fairly uniform in many published series. Minor variations can be explained by differences in indications for primary and for revision procedures, but the clinical results are uniformly good. This also accords with the latest results from the originating unit at the Centre for Hip Surgery, Wrightington: 18 to 26 years after THR, 84% of patients were completely painfree and only 11% had occasional discomfort (Wroblewski et al 1992).

During the last decade, uncemented types of THR have become popular: many different new designs have been introduced after very short-term follow-up in the hope of avoiding some of the problems associated with cemented hips such as aseptic loosening, bone resorption and subsequent complicated revisions. Medium-term follow-up studies of uncemented THRs are now appearing, and they are revealing other complications, such as osteolysis (Kim and Kim 1993) or very early symptomatic loosening (Engh, Griffin and Marx 1990). The results are not as encouraging as was hoped (Duncan et al 1992). Like Older and Butorac (1992), we find it difficult to justify the widespread use of these implants. There may be some special indications but these have not been clearly defined, and more long-term follow-up is essential before they replace a well-proven, low-cost design. The designs of these new prostheses are frequently modified and therefore each is tested in relatively small numbers of patients. We believe that such designs should be regarded as experimental until long-term follow-up of larger series has been presented.
Table IV. Reported long-term results after Charnley THR with trochanteric osteotomy

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of hips</th>
<th>Follow-up (yr)</th>
<th>Revisions (percentage)</th>
<th>Survival (years)</th>
<th>Loosening (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charnley (1979)</td>
<td>302</td>
<td>12 to 15</td>
<td>&gt; 5.8''</td>
<td>11.3</td>
<td>29.9</td>
</tr>
<tr>
<td>Stauffer (1982)</td>
<td>207</td>
<td>10</td>
<td>10.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johnsson, Thorngren and Persson (1988)</td>
<td>204</td>
<td>14</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McCoy et al (1988)</td>
<td>35</td>
<td>15</td>
<td>15</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Kavanagh et al (1989)</td>
<td>81</td>
<td>15</td>
<td>15</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Ahnfelt et al (1990)</td>
<td>15520</td>
<td>10</td>
<td>&gt; 9.2''</td>
<td>10</td>
<td>92v</td>
</tr>
<tr>
<td>Carter, Pynsent and McMinn (1991)</td>
<td>?</td>
<td>20</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skeie et al (1991)*</td>
<td>629</td>
<td>13</td>
<td>8.1</td>
<td>13</td>
<td>92</td>
</tr>
<tr>
<td>Garcia-Cimbrelo and Munera (1992)</td>
<td>40</td>
<td>17</td>
<td>17</td>
<td>89.3 (cup)</td>
<td>18.9</td>
</tr>
<tr>
<td>Nicholson et al (1992)+</td>
<td>185</td>
<td>15 to 22</td>
<td>&gt; 13''</td>
<td>90.9 (cup)</td>
<td>17.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>88.1 (stem)</td>
<td>21.9</td>
</tr>
<tr>
<td>Older and Butorac (1992)+</td>
<td>388</td>
<td>17 to 21</td>
<td>6</td>
<td>20</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Neumann et al (1994)†</td>
<td>240</td>
<td>15 to 21</td>
<td>8.3</td>
<td>20</td>
<td>89.3</td>
</tr>
</tbody>
</table>

Z, total number of patients is 396 (94 followed for less than 11 years); Y, stem fractures not included; V, infections not included; U, aseptic loosenings only; I, infections estimated to be 1.2%

* osteoarthrosis only
† one surgeon only

A surgeon should justify his choice of technology by objective data: we believe that follow-up of the Charnley hip can provide such data. A 20-year survival rate of nearly 90% gives the implant a longer life expectancy than most of the patients who receive it. Our single-surgeon series may well produce better results than those from a group of surgeons, but later improvements such as clean-air theatres, prophylaxis against infection and thrombosis, improved cementing and better prosthesis design should allow similar or even better results.

Our study had a near complete follow-up with excellent results, and we commend the conservative attitude in Sweden, where uncemented hips were used in only 4% of the 9236 hip replacements performed in 1987 (Ahnfelt et al 1990). We see no reason whatsoever to use expensive, sophisticated, often poorly documented designs on the basis of short-term 'success'. Most patients who need a hip replacement will be well served by the excellent long-term results of the cemented Charnley prosthesis.

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


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