Charnley low-friction arthroplasty in teenage patients

THE ULTIMATE CHALLENGE

B. M. Wroblewski, B. Purbach, P. D. Siney, P. A. Fleming

From Wrightington Hospital, Wigan, England

Increasing follow-up identifies the outcome in younger patients who have undergone total hip replacement (THR) and reveals the true potential for survival of the prosthesis. We identified 28 patients (39 THRs) who had undergone cemented Charnley low friction arthroplasty between 1969 and 2001. Their mean age at operation was 17.9 years (12 to 19) and the maximum follow-up was 34 years. Two patients (4 THRs) were lost to follow-up, 13 (16 THRs) were revised at a mean period of 19.1 years (8 to 34) and 13 (19 THRs) continue to attend regular follow-up at a mean of 12.6 years (2.3 to 29). In this surviving group one acetabular component was radiologically loose and all femoral components were secure. In all the patients the diameter of the femoral head was 22.225 mm with Charnley femoral components used in 29 hips and C-stem femoral components in ten. In young patients who require THR the acetabular bone stock is generally a limiting factor for the size of the component. Excellent long-term results can be obtained with a cemented polyethylene acetabular component and a femoral head of small diameter.

When Charnley introduced low-frictional torque arthroplasty of the hip (LFA) into routine clinical practice in November 1962, he was cautious in selecting patients for the operation. Four years later, when 1321 LFAs had already been undertaken at Wrightington Hospital without a single revision for loosening of the acetabular component or loosening or breakage of the stem, he concluded that this procedure was especially suitable in patients with gross disability resulting from rheumatoid arthritis who were bed-ridden or nearly bed-ridden, or in those with monoarticular osteoarthritis who were 70 years of age and over. In addition, he considered the procedure to be absolutely indicated in conditions in which the alternative treatment would have been an excision arthroplasty.1

By the end of 1979, 12 525 primary LFAs had been carried out at the Wrightington Hospital. Charnley wrote of the particular concerns when patients between 45 and 50 years of age were considered for LFA since all technical advances needed to be harnessed to offer a reasonable chance of trouble-free activity for 20 years or more. He highlighted that it was not in a young patient's interest for a surgeon to count on a successful revision should mechanical failure occur prematurely.2 More recently it has been suggested that modern metal-on-metal hip resurfacing techniques should be used in young patients with osteoarthritis as the results in these patients have not been encouraging, even with improved fixation and bearing surfaces.3 This opinion was based on the outcome at a mean follow-up of 3.3 years (1.1 to 8.2) of 446 resurfacings which had been undertaken in patients with osteoarthritis who were under the age of 55 years.

Increasing the follow-up clarifies the age at which young patients may be accepted for an LFA and we have recently reported good results in a group of patients with a mean age of 43.3 years at a mean of 32.3 years (30.0 to 50.4).4 The ultimate challenge of a follow-up of 50 to 60 years will require patients to be about 20 years of age or younger at the time of operation.

The literature contains some reports of total hip replacement (THR) undertaken in young adults and teenagers. One of the earliest publications was by Morris, Ansell and Arden5 who reported good results in 81 patients (135 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 29 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 39 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 39 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 39 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 39 patients (33 THRs) with juvenile polyarthritis and a mean age of 22.5 years at a mean follow-up of 6 years. Chandler et al6 in a study of 39 patients (33

THE JOURNAL OF BONE AND JOINT SURGERY
follow-up of 5.4 years (1 to 12). There was one dislocation and one loose stem. The results of Learmonth et al\textsuperscript{8} which were published in 1989 were less encouraging. They described 14 patients with a mean age of 16 years (12 to 22) and a mean follow-up of 8.5 years (4 to 11). Although there had been no revisions eight patients had radiological evidence of loosening of both components. In 1991 Witt, Swann and Ansell\textsuperscript{9} described 54 patients with juvenile idiopathic arthritis (96 THRs) at a mean age of 16.7 years (11.25 to 26.6) and a mean follow-up of 9.5 years; 24 hips had been revised and a further 17 showed radiological signs of loosening of components, representing a failure rate of 42.7%.

McCullough et al\textsuperscript{10} used hydroxyapatite (HA)-coated custom-made femoral components in 25 young adults (42 THRs) with inflammatory polyarthropy, of whom 21 were affected by idiopathic arthritis. The mean age at surgery was 21 years (11 to 35) and the mean follow-up 11.2 years (8 to 13). Two stems required revision and two were radiologically loose. Two acetabular components needed revision for loosening and a further three were loose. Four ultra-high-molecular-weight polyethylene (UHMWPE) liners had been revised, one on two occasions.\textsuperscript{10} The survivorship was 71.4\% at 12 to 13 years for the THR and 83\% at 13 to 14 years for the custom-made stem, although the numbers involved were not really appropriate for survivorship analysis.\textsuperscript{11} The conclusion was that the results of the HA-coated stems were better than those of the cemented femoral stems.\textsuperscript{10}

We now present our results of the use of the cemented Charnley LFA and C-stems (both DePuy International, Leeds, United Kingdom) in patients under the age of 20 years who underwent THR between 1969 and 2001.

**Patients and Methods**

Regular and indefinite follow-up for all patients under the age of 50 years was introduced as routine in 1974.\textsuperscript{12} Clinical assessment used the score of Merle d’Aubigné and Postel\textsuperscript{13} as modified by Charnley,\textsuperscript{14} and radiological evaluation included an anteroposterior view. Assessment of the interface of the acetabular component was performed according to Hodgkinson, Shelley and Wroblewski.\textsuperscript{15} The appearance of the femoral stem was documented according to Harris, McCarthy and O’Neill.\textsuperscript{16} Wear measurements of the UHMWPE acetabular component were carried out by one author (PDS) as described by Griffith et al.\textsuperscript{17}

There were 28 patients, 22 girls and six boys (39 LFAs) in the study. Their mean age at operation was 17.9 years (12 to 19) and their mean weight 50 kg (32 to 69); 11 had bilateral replacements. The underlying pathology is shown in Table I. In 15 hips other procedures had pre-dated the THR. These included six intertrochanteric osteotomies, five interventions of various types for developmental hip dysplasia, three soft-tissue procedures and one fixation of a fracture. In one patient radiotherapy had been administered for a giant-cell tumour involving the neck of the femur which subsequently fractured. A total of 15 patients were receiving steroids. All operations were carried out in a Charnley-Howorth clean-air enclosure using total-body exhaust suits. Exposure by trochanteric osteotomy was combined with a Zirconia ceramic head. Post-operative assessment used the score of Merle d’Aubigné and McCarthy and O’Neill.\textsuperscript{16} Wear measurements of the acetabular component were carried out by one author (PDS) as described by Griffith et al.\textsuperscript{17}

<table>
<thead>
<tr>
<th>Number</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose acetabular component</td>
<td>9</td>
</tr>
<tr>
<td>Loose acetabular and femoral component*</td>
<td>5</td>
</tr>
<tr>
<td>Gross wear of the acetabular component</td>
<td>1</td>
</tr>
<tr>
<td>Periprosthetic fracture of the femur</td>
<td>1</td>
</tr>
</tbody>
</table>

* one low friction torque arthroplasty was revised at another centre, infection and removal of the implant was the outcome.

**Results**

Two patients (4 LFAs) were lost to follow-up despite attempts at tracing them with the assistance of the Office of National Statistics. Their follow-up was 4.5 and 8.5 years, respectively. In 13 patients (16 LFAs) revision was required at a mean of 19.1 years (8 to 34). The indications for revision are shown in Table II. The mean total linear wear (penetration) in this group was 2.44 mm (0.4 to 7.0) and the mean linear wear rate was 0.15 mm/year (0.03 to 0.21).

In 13 patients (19 LFAs) revision has not been required and they have continued to attend for follow-up. Their mean follow-up was 12.6 years (2.3 to 29.0). The mean total linear wear (penetration) for this group was 1.61 mm (0.4 to 2.9) with a mean wear rate of 0.1 mm/year (0.01 to 0.21). Of this group there was no pain associated
with 12 LFAs, occasional discomfort in three and pain on activity in four. Function was considered to be normal or nearly normal in ten patients (10 LFAs) and nine LFAs have full or an almost full range of movement. The mean post-operative modified Merle d’Aubigné and Postel score for pain, function and movement for the five patients (9 hips) with juvenile idiopathic arthritis was 5.1 (4 to 6), 3.1 (1 to 4) and 2.9 (1 to 4), respectively and for the eight (10 hips) with other disorders 5.9 (5 to 6), 5.8 (5 to 6) and 5.6 (5 to 6), respectively.

Wear of UHMWPE acetabular component. For the 13 stainless steel femoral heads articulating against UHMWPE, at a mean follow-up of 14.5 years (2.3 to 29) the total mean penetration was 1.5 mm (0.4 to 3) and the mean linear wear rate was 0.08 mm/year (0.03 to 0.2). For the five Zirconia femoral heads articulating against UHMWPE at a mean follow-up of 7.8 years (2.5 to 11.3) the total mean penetration was 0.5 mm (0.4 to 0.8) and the mean linear rate was 0.1 mm (0.04 to 0.16) consistent with the early, high-rate, bedding-in patterns as previously reported. 20

The single Zirconia femoral head articulating against Hylamer UHMWPE had a total penetration of 2.9 mm at 13.4 years and a linear wear rate of 0.22 mm/year.

Radiological assessment. One acetabular component is loose and three show full demarcation of the cement-bone interface of less than 1 mm in width. They are classed as being stable. One stem shows demarcation in zones 3 and 4. All the other stems have no demarcation, cavitation or cement fracture. There is no evidence of osteolysis in any of the zones of Gruen, McNeice and Amstutz. 21

Discussion
Charnley’s cautious selection of patients in the early years of the LFA, was clearly justified. However, the clinical results do not always reflect the mechanical state of the implant. 22 In our group of teenage patients no revisions were required in the first seven years of follow-up. However, their life expectancy, and at times level of activity, is reflected in the wear and loosening of the UHMWPE acetabular component. This may have been further compounded by the relatively limited acetabular bone stock in those patients. Long-term successful results occur in patients with low wear rates of the UHMWPE acetabular component. In this context the combination of the use of the Charnley stem with a low frictional torque 22 and an alumina ceramic femoral head matched with a cross-linked polyethylene acetabular component with a reported mean penetration rate of 0.02 mm/year and a total penetration not exceeding 0.41 mm, 23 is proving to be beneficial in the long-term. The activity level achieved is not a characteristic of a particular type of hip replacement; it is a reflection of patient selection for the operation.

The purpose for the continuing follow-up is to establish the patterns of failure which will vary with the design, materials and methods of fixation and to intervene early in cases of impending failure because of loss of bone stock. This will avoid the need for more complex revisions. The knowledge gathered should be used to introduce evidence-based improvements in order to extend the survival of THR especially in younger patients.

This research was supported by the Peter Kershaw Trust and the John Charnley Trust. We thank the Office of National Statistics in Southport, United Kingdom for its help in tracing patients. The author or one or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article.

References