HIP

Comparison of total hip replacement with and without cement in patients younger than 50 years of age

THE RESULTS AT 18 YEARS

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There have been comparatively few studies of the incidence of osteolysis and the survival of hybrid and cementless total hip replacements (THRs) in patients younger than 50 years of age. We prospectively reviewed 78 patients (109 hips) with a hybrid THR having a mean age of 43.4 years (21 to 50) and 79 patients (110 hips) with a cementless THR with a mean age of 46.8 years (21 to 49). The patients were evaluated clinically using the Harris hip score, the Western Ontario and McMaster Universities (WOMAC) osteoarthritis score and the University of California, Los Angeles (UCLA) activity score. Radiographs and CT scans were assessed for loosening and osteolysis. The mean follow-up was for 18.4 years (16 to 19) in both groups.

The mean post-operative Harris hip scores (91 points versus 90 points), the mean WOMAC scores (11 points versus 13 points) and UCLA activity scores (6.9 points versus 7.1 points) were similar in both groups. The revision rates of the acetabular component (13% versus 16%) and the femoral component (3% versus 4%), and the survival of the acetabular component (87% versus 84%) and the femoral component (97% versus 96%) were similar in both groups.

Although the long-term fixation of the acetabular metallic shell and the cemented and cementless femoral components was outstanding, wear and peri-acetabular osteolysis constitute the major challenges of THR in young patients.

The results of total hip replacement (THR) with and without cement in young patients has been disappointing.1-3 Poorly designed implants, undersized femoral components, poor cementing technique, excessive wear of the polyethylene liner and peri-prosthetic osteolysis have led to an increased rate of aseptic loosening of the implants in older series.1,3 There is comparatively little information on patients < 50 years of age with contemporary cemented and cementless THRs,4-8 although a high rate of revision is projected for this group.9

We evaluated the clinical and radiological results, rates of revision, and the survival of hybrid and cementless THRs performed in patients < 50 years of age at a minimum 16 years’ follow-up.

Patients and Methods
We prospectively enrolled 166 patients (228 hips) who underwent primary THR between January 1991 and February 1993. All the operations were performed by one surgeon (YHK). There were 83 patients (114 hips) with cemented femoral components and 83 (114 hips) with uncemented components. Randomisation to a cemented or an uncemented component was by a number in a sealed envelope, which was opened in the operating room before the skin incision had been made. All patients in both groups received a cementless acetabular component. Among the 83 patients with a cemented femoral component, five (five hips) were lost to follow-up, leaving 78 (109 hips) available at a mean follow-up of 18.4 years (17 to 19). Among the 83 patients with a cementless femoral component, four (four hips) were lost to follow-up, leaving 79 (110 hips) available with a mean follow-up of 18.4 years (16 to 19, Table I). The study had ethical approval.

Two different implants were used. The Charnley Elite or Elite-plus stem (Ortron 90) (DePuy, Leeds, United Kingdom) was used in the cemented (hybrid) group and the Profile stem (DePuy) in the cementless group. A cementless Duraloc 100 or 1200 series acetabular component (DePuy, Warsaw, Indiana) was
used in all hips in both groups. Of the 62 Duraloc 1200 acetabular components used in both groups, 28 were fixed with one or two screws and the remaining 34 were press-fitted without using an additional screw.

The Charnley Elite or Elite-plus stem is straight and has a smooth surface (Ra, 0.6 μm). The cementless Profile femoral stem is an anatomical metaphyseal-fitting titanium stem, the proximal 30% of which is porous-coated, with an average pore size of 250 μm. A polyethylene liner made of ram-extruded 415 GUR polyethylene with an inner diameter of 22 mm was used in all hips in both groups. The polyethylene, whose average thickness was 11.0 mm in the cemented group and 10.7 mm in the cementless group, was irradiated in a vacuum and packaged in a vacuum state.

The cementless femoral components were inserted with a press-fit as determined by the pre-operative use of templates. At the time of the operation, an attempt was made to fill the femoral canal with the broach, leaving little cancellous bone remaining. When cement was used, it was applied using an intramedullary plug, pulsatile lavage, vacuum mixing, injection with a gun, a proximal rubber seal and a distal centraliser on the femoral component.

Clinical and radiological follow-up was carried out at three months and one year after the operation, and yearly thereafter. The Harris hip score (HHS) and the Western Ontario and McMaster Universities osteoarthritis index (WOMAC) were determined pre-operatively and at each follow-up. The patients subjectively evaluated pain in the thigh with use of a 10-point visual analogue scale (0, no pain; 10, severe pain). The chance-corrected κ coefficient was calculated to determine intra-observer agreement on the scores and the ranges of movement. The level of activity of the patients was further assessed using the University of California, Los Angeles (UCLA) activity score. All of the clinical data in the medical records from each follow-up assessment were compiled by one observer (JWP), who was not part of the surgical team.

The type of femur was determined on the pre-operative radiographs of all hips using the isthmus ratio of Dorr. Radiological evaluation was performed at each follow-up looking for radiolucent lines around the acetabular component in zones I, II and III according to the system of DeLee and Charnley, and for the femoral component in zones 1 to 14 according to Gruen, McNeice and Amstutz. The stability of the cementless femoral component was classified as with bone ingrowth, stable fibrous ingrowth, or unstable. The criteria used to define loosening of the cemented femoral component have been reported previously. Definite, probable and possible loosening of the acetabular components were considered. Definite loosening was diagnosed when there was a change in the position of the component of > 2 mm vertically and/or medially or laterally, or a continuous radiolucent line wider than 2 mm on both the anteroposterior and the lateral radiographs.

Linear wear of the polyethylene liner was measured with a software program (AutoCAD, Release 13; Autodesk, Sausalito, California). The differences in the rates of polyethylene wear between the two groups were determined. The location and extent of osteolysis were recorded in the zones around the acetabular and femoral components described above.

At the last follow-up, all patients underwent CT scans using a multislice scanner (General Electric Light Plus; GE Medical Systems, Milwaukee, Wisconsin) to determine osteolysis and the anteversion of the acetabular compo-
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nent. The scan sequence was between the posterior superior iliac spine and 10 cm below the tip of the stem using contiguous 2.5 mm slices. A further CT scan was carried out between the superior pole of the patella and the tibial tuberosity to determine the anteversion of the acetabular component. Osteolysis was defined as any non-linear region of peri-prosthetic cancellous bone loss with delineable margins. Osteolytic lesions > 0.5 cm² were identified on both radiographs and CT scans. One author (JHJ) examined all the radiographs and scans.

Statistical analysis. All analyses were two-tailed using SPSS statistical software version 15 (SPSS Inc., Chicago, Illinois). A p-value ≤ 0.05 was deemed to be significant. Continuous data were analysed using the Mann-Whitney U test and categorical data by the chi-squared test. Fisher’s exact test was used to compare non-parametric ordinal data. The paired t-test was used to compare the prevalence of osteolysis and Wilcoxon’s signed-rank-sum test was used to compare non-parametric ordinal data.

Results

The HHS, the incidence of thigh pain, the WOMAC score and the UCLA activity score were substantially improved after both hybrid and cementless THRs. We found similar mean pre-operative (44 points versus 48.8 points, p = 0.61) and post-operative HHSs (91 points versus 90 points, p = 0.71) in both groups. The prevalence of transitory pain in the thigh was 2.6% (2 of 78 patients) in the hybrid group up to six months after the operation, and 11.4% (9 of 79 patients) in the cementless group for up to one year (p = 0.042). No patient in either group had thigh pain at two years after operation. The mean pre-operative WOMAC score was 68 points (38 to 91) in the hybrid and 71 points (39 to 95) in the cementless group. The mean WOMAC score at the final follow-up was 11 points (4 to 33) in the hybrid and 13 points (4 to 33) in the cementless group. The mean post-operative UCLA activity score was 7.6 points (6 to 10) in the hybrid and 7.8 points (5 to 10) in the cementless group (Table II). The κ coefficient of intra-observer agreement regarding the hip scores and the range of movement was 0.85 to 0.95.

There were no differences between the two groups in the post-operative radiological assessment of the Dorr isthmus ratio (p = 0.162), stem alignment (p = 0.162, 0.168 and 0.153, respectively), acetabular component position (p = 0.917 and 0.926, respectively), radiolucent lines around the acetabular component (p = 0.926) and femoral component (p = 0.868), polyethylene wear (p = 0.478), and the incidence of acetabular and femoral osteolysis (p = 0.168 and 0.159, respectively) (Table III). The incidence of acetabular osteolysis (35 of 109 hips (32%) in the hybrid group; and 40 of 110 hips (34%) in the cementless group) and the incidence of osteolysis of the calcar of the femur (31 of 109 hips (28%) in the hybrid group; and 35 of 110 hips (32%) in the cementless group) were similar in the two groups (Fig. 1). The size of acetabular osteolyses ranged between 0.5 cm² and 1.8 cm × 1.1 cm in the hybrid group and between 0.5 cm² and 2.1 cm × 1.6 cm in the cementless group. The κ coefficient of intra-observer agreement on the measurement of the radiographs and CT scans was 0.79 to 0.91.

The revision rates of the acetabular and femoral components were not significantly different between the groups. In the hybrid group, 14 acetabular (13%) and three femoral

Table II. Clinical patients with cemented and cementless total hip replacements (THRs)

<table>
<thead>
<tr>
<th></th>
<th>Cemented THR (n = 78 patients)</th>
<th>Cementless THR (n = 79 patients)</th>
<th>p-value (Student’s t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Harris hip score (range)</td>
<td>44 (5 to 66)</td>
<td>48.8 (6 to 55)</td>
<td>0.61</td>
</tr>
<tr>
<td>Post-operative</td>
<td>91 (75 to 100)</td>
<td>90 (71 to 100)</td>
<td>0.71</td>
</tr>
<tr>
<td>Good (≥ 90 points) (n, %)</td>
<td>35 (46)</td>
<td>35 (44)</td>
<td>0.843</td>
</tr>
<tr>
<td>Fair (70 and 79 points) (n, %)</td>
<td>40 (51)</td>
<td>47 (62)</td>
<td>0.817</td>
</tr>
<tr>
<td>Poor (&lt; 70 points) (n, %)</td>
<td>3 (4)</td>
<td>2 (3)</td>
<td>0.235</td>
</tr>
<tr>
<td>Mean UCLA* activity score (range)</td>
<td>3.4 (1 to 5)</td>
<td>3.1 (1 to 4)</td>
<td>0.725</td>
</tr>
<tr>
<td>Post-operative</td>
<td>76 (6 to 10)</td>
<td>78 (5 to 10)</td>
<td>0.814</td>
</tr>
<tr>
<td>Thigh pain (until 1 year) (n, %)</td>
<td>2 (2.6)</td>
<td>9 (11.4)</td>
<td>0.042 (paired t-test)</td>
</tr>
<tr>
<td>Mean WOMAC† score</td>
<td>68 (38 to 91)</td>
<td>71 (39 to 95)</td>
<td>0.718</td>
</tr>
<tr>
<td>Pre-operative (range)</td>
<td>11 (4 to 35)</td>
<td>13 (4 to 33)</td>
<td>0.927</td>
</tr>
</tbody>
</table>

* UCLA, University of California, Los Angeles
† WOMAC, Western Ontario and McMaster Universities osteoarthritis index
components (3%) were revised, 11 between 12 and 19 years for polyethylene wear and osteolysis, two at one and two years for recurrent dislocation, and one at six weeks for infection. Revision for aseptic loosening was required for two femoral components at nine and 16 years, respectively, and in one for infection at six weeks. In the cementless group, 18 acetabular (16%) and four femoral components (4%) were revised. Between ten and 18 years 16 acetabular components were revised for polyethylene wear and osteolysis, one at one year for recurrent dislocation, and one at four weeks for infection. Revision for aseptic loosening was carried out for three femoral components at 14, 16 and 18 years, respectively, and in one at six weeks for infection.

The survival of the implants was similar in the two groups. In the hybrid group, the Kaplan-Meier survival analysis, with revision as the endpoint at ten years 93.6%, at 15 years 91.8% and at 20 years 87%. Five of the 83 patients were lost to follow-up. In the cementless group the Kaplan-Meier survival of the acetabular component at one year was 98.2%, at ten years 93.6%, at 15 years 89.1%, and at 20 years 84%. Four of 83 patients were lost to follow-up at 20 years.

Survival of the femoral component at 20 years’ follow-up in the hybrid group was 97% (95% CI 91 to 100) and in the cementless group 96% (95% CI 93 to 100).

The Kaplan-Meier survival with an endpoint of radiological failure showed 83% for the acetabular component (95% CI 75 to 91) in the hybrid group and 81% for the acetabular component (95% CI 75 to 89) in the cementless group. The survivorship of the femoral component at 20 years was 97% (95% CI 95 to 100) in the hybrid group and 96% (95% CI 93 to 100) in the cementless group.

**Discussion**

This study showed excellent results for the femoral component both with and without cement in patients < 50 years of age. We also found no difference in the functional scores for
the hybrid and cementless THRs. We believe that several factors were responsible for our excellent results, including good cementing technique (grades A, B and C18), the design of the cemented femoral component, better surgical technique for implantation of the cementless femoral component, the strong trabecular bone in the young patients, the use of a 22 mm femoral head with a low rate of volumetric wear of the polyethylene liner, and small and light patients. Since no acetabular component was revised for aseptic loosening, we are encouraged by the maintenance of the fixation of the cementless hemispheric porous-coated implants, but we experienced considerable problems with wear of the polyethylene.

Kim et al.6,7 Kim8 and Kim, Kim and Yoon21 described acetabular osteolysis in between 9% and 10.8% of young patients with contemporary modern cementless THR, including the Charnley Elite, Elite Plus and Profile stems (four patients from the series reported by Kim et al.7 were included in this present study). They encountered femoral osteolysis in up to 16% of young patients with a cemented THR and between 7% and 13% in those with a cementless implant. Callaghan et al.22 found a prevalence of femoral osteolysis of 20% after Charnley THR in young patients 23.3 years post-operatively. Smith, Estok and Harris23 reported a prevalence of femoral osteolysis of 32% after cemented THR at 18.2 years post-operatively. Archibeck et al.24 noted acetabular osteolysis in 16% and femoral osteolysis in 5% of patients after Multilock cementless THR (Zimmer, Warsaw, Indiana) at ten years after operation.

Although the wear rate of polyethylene was high, at 0.21 mm per year, in our study, the prevalence of osteolysis was relatively low in both groups. This can be attributed to

| Table III. Radiological results of patients with cemented and cementless total hip replacements (THRs) |
|-----------------------------------------------|-------------------------------------------------|-----------------|
|                                               | Cemented THR                                    | Cementless THR  |
|                                               | (n = 109 hips)                                  | (n = 110 hips)  |
|                                               | p-value                                         | (Student’s t-test) |
| Dorr isthmus ratio                            | 0.25 to 0.45                                   | 0.27 to 0.47    | 0.162 |
| Dorr type A femora (n, %)                     | 96 (88)                                        | 99 (90)         | 0.172 |
| Dorr type B femora (n, %)                     | 13 (12)                                        | 11 (10)         | 0.148 |
| Alignment of femoral component (n, %)         |                                               |                 |
| Neutral                                       | 102 (94)                                       | 100 (91)        | 0.162 |
| Varus                                         | 4 (4)                                          | 8 (7)           | 0.168 |
| Valgus                                        | 3 (2)                                          | 2 (2)           | 0.153 |
| Cementing technique (n, %)                    |                                               |                 |
| Grade A                                        | 103 (94)                                       | -               |       |
| Grade B                                        | 4 (4)                                          | -               |       |
| Grade C                                        | 2 (2)                                          | -               |       |
| Stem canal fill (n, %)                        |                                               |                 |
| Satisfactory fill in both coronal and sagittal planes | -                   | 105 (95)        | 0.926 |
| Satisfactory on coronal plane but not the sagittal plane | -                   | 5 (5)           |       |
| Position of the acetabular component (mean, range) |                                               |                 |
| Lateral opening                               | 41° (35° to 50°)                               | 43° (35° to 51°) | 0.917 |
| Anteversion                                   | 24° (19° to 28°)                               | 26° (25° to 32°) | 0.926 |
| Radiolucent line (1 mm) (n, %)                |                                               |                 |
| Acetabular component                          | 9 (8)                                          | 8 (7)           | 0.926 |
| Femoral component                             | 13 (12)                                        | 15 (14)         | 0.868 |
| Polyethylene linear wear per year (mm) (range) | 0.210 (0.10 to 0.361)                          | 0.217 (0.12 to 0.378) | 0.479 |
| Osteolysis (n, %)                              |                                               |                 |
| Acetabulum                                     | 35 (32)                                        | 40 (36)         | 0.168 |
| Femur (zone 1 and 7 only)                     | 31 (28)                                        | 35 (32)         | 0.159 |
| Revision (n, %)                                |                                               |                 |
| Acetabular component                          | 14 (13)                                        | 18 (16)         | 0.673 |
| Femoral component                             | 3 (3)                                          | 4 (4)           | 0.912 |
| Survival (20 years) (%)                       |                                               |                 |
| Acetabular component                          | 87 (95% CI 80 to 93)                           | 84 (95% CI 78 to 92) | 0.776 |
| Femoral component                             | 97 (95% CI 91 to 100)                          | 96 (95% CI 93 to 100) | 0.794 |

* CI, confidence interval
the short follow-up, good fixation of both components, low
wear of the polyethylene by using a small-diameter femoral
head, improved quality of the polyethylene, and light and
small patients. As the Duraloc 1200 acetabular compo-
nents have several screw holes, the incidence of acetabular
osteolysis in the hips with those components would be
expected to be higher than in those with Duraloc 100 com-
ponents without screw holes as the holes would act as a
conduit for polyethylene debris. Contrary to our expecta-
tions, the incidence of acetabular osteolysis was similar
between the hips with Duraloc 1200 acetabular compo-
nents (22 of 62 hips, 35%) and those with Duraloc 100
acetabular components (49 of 157 hips, 31%). This sugges-
ts that polyethylene debris can migrate into the aceta-
bulum in the absence of screw holes.

The revision rates of cemented THRs in young patients
have been variable. Chandler et al\textsuperscript{25} described a rate of re-
vision of the femoral component of 21% in patients aged
30 years or younger at only 5.6 years of follow-up. Dorr,
Kane and Conaty\textsuperscript{26} reported a rate of femoral revision in
patients \(\leq 45\) years of 44% at 16.2 years. Callaghan et al\textsuperscript{22}
noted a rate of femoral revision of 5% in patients whose
average age was 42 years at 23.3 years. Similar results were
reported by Smith et al\textsuperscript{23} at a 20-year follow-up using mod-
ern cementing techniques. Archibeck et al\textsuperscript{24} had revised
only one (1%) Multilock femoral component in patients
aged \(\leq 50\) years at a mean of nine years. In our study the
rate of acetabular revision was 13% in the hybrid group
and 16% in the cementless group. These rates are consis-
tent with those of other reports.\textsuperscript{8,21,27,28}

The survival of THRs in young patients is less than in
older patients. Young patients may have acquired hip dis-
ease from many different causes and have different levels
of activity. In our subset of patients with osteonecrosis of the
femoral head, the overall survival of the femoral stem was
96% at 20 years. The majority of patients in our series con-
tinue to participate in high-demand activities, including
moderate to heavy labour. The aetiology and the level of
activity did not seem to affect the longevity of fixation of
acetabular and femoral components. Wear and bearing fail-
ure remain a significant concern, and newer alternative
bearings would hold a promise of an increased lifespan
from the entire prosthetic unit. In young patients the sur-
vival rates of cementless femoral stems have proved supe-
rior to cemented implants.\textsuperscript{29-31} The average rate of failure
for porous-coated femoral components has been estimated
at 0.46% per year, whereas the average rate for cemented
femoral components was 3.5 times higher at 1.61% per
year.\textsuperscript{29} Our series would predict a failure rate of 0.2% per
year in both cemented and cementless femoral stems in
these difficult young patients.

There were limitations to this study. First, the implants
used were contemporary at the time they were implanted,
but are no longer used. Secondly, we recorded an annual
penetration rate of 0.21 mm per year, which is high com-
pared to that reported in other papers.\textsuperscript{22,23,29-31} The mea-

urements of penetration of the head into the polyethylene
with the specific software used, which measures the dis-
tance between the centre of the femoral head and the centre
of the acetabular component, may give higher values than
other methods.

Our results in patients \(\leq 50\) years of age suggest that
cemented and cementless femoral components provide out-
standing long-term fixation and significant pain relief well
into the second decade. Although the long-term fixation of
the acetabular metallic shell and cemented and cementless
femoral components was outstanding, wear and peri-
acetabular osteolysis constitute the major challenges in
hybrid and cementless THR in these young patients.

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