POLYETHYLENE WEAR IN UNCEMENTED ACETABULAR COMPONENTS

J. R. HERNANDEZ, E. M. KEATING, P. M. FARIS, J. B. MEDING, M. A. RITTER

From the Center for Hip and Knee Surgery, Mooresville, Indiana, USA

We measured polyethylene wear in 231 porous-coated un cemented acetabular cups. We divided the hips into two groups according to the fixation of the femoral component, by cementing (n = 97) or press-fit (n = 134). Follow-up was from three to five years. The patients in two subgroups were matched for weight, diagnosis, sex, age and length of follow-up.

The linear wear rate of cups articulated with un cemented femoral components (0.22 mm/year) was significantly higher than the wear rate (0.15 mm/year) of cups articulated within cemented femoral components (p < 0.05). These results can be compared with previously reported wear rates of 0.08 mm/year for cemented all-polyethylene cups and 0.11 mm/year for cemented metal-backed cups. The higher wear rates of un cemented arthroplasties could jeopardise the long-term results of this type of hip replacement.

Received 9 July 1993; Accepted 18 August 1993

Wear and debris-mediated osteolysis is considered to be one important reason for loss of fixation and failure of total hip arthroplasties (Mirra, Marder and Amstutz 1982; Howie 1990). The durability of implants may well be limited by bone destruction caused by the body’s response to minute wear particles (Nasser et al 1990; Schmalzried et al 1992). Reduction in the number of wear particles is important to increase the longevity of hip replacements.

Late failure of fixation of many cemented all-polyethylene acetabular components led to attempts to improve implant design and fixation. The metal backing of acetabular components was introduced with the aim of reducing stresses in cement, trabecular bone and the medial acetabular wall (Carter, Vasu and Harris 1982; Bartel, Wright and Edwards 1983; Carter 1983; Gonzalez, Glass and Mallory 1988). In theory, the dissipation of forces reduced periacetabular stresses and was expected to decrease aseptic loosening. The other advantage of metal backing was to allow a worn polyethylene liner to be changed without disrupting the cement-bone interface.

Despite early reports of success (Mattingly et al 1985; Harris and McGann 1986), the later results with cemented metal-backed cups were unsatisfactory (Ritter et al 1990). Harris and Penenberg (1987) found frank or impending loosening in 41% of cemented metal-backed acetabular cups. Ritter et al (1990) reported increased rates of complete radiolucency, migration and revision. Cates et al (1993) also found increased radiographic wear in cemented metal-backed cups compared with all-polyethylene components.

In un cemented metal-backed porous-coated prostheses at three to five years, migration of acetabular and femoral components has been reported, and localised loss of endosteal bone (Heekin et al 1993). Femoral endosteal lysis around the distal stem was reported in 22% in a 3.5-year follow-up of un cemented Harris-Galante arthroplasties (Woolson and Maloney 1992).

Uncemented metal-backed acetabular components are widely used despite these recent reports. To our knowledge there are no reports on the cause of the increase in osteolysis and failure rate. Since this may be a wear-mediated response, we measured the wear rate of this type of implant and compared it with previously reported wear rates measured in the same way for cemented all-polyethylene and for cemented metal-backed acetabular components.

MATERIALS AND METHODS

From January 1988 to June 1990, a total of 231 un cemented metal-backed acetabular cups were inserted in 203 patients, all as primary total joint replacements, and were reviewed after a minimum follow-up of three years (maximum five years).

All the acetabular prostheses were of the Universal cup design (Biomet, Warsaw, Indiana). This has a titanium shell with a plasma-sprayed porous coating and a conical,
machined polyethylene liner. Titanium alloy screws were used for initial fixation of the cup. The femoral component was the Bimetric Stem (Biomet, Warsaw, Indiana) which is of modular titanium construction. In 97 hips cement was used and 134 were inserted by the fit-and-fill method without cement. All the femoral components had plasmasprayed porous coating of the proximal third and were used with a modular titanium alloy head 28 mm in diameter.

A posterior approach to the hip without trochanteric osteotomy was used in all cases. Femoral cementing, where used, was by current techniques with low-viscosity cement, distal plugging, pulsatile lavage and brushing, neosynephrine sponges, canal drying and pressurisation of the cement. The uncemented femoral components were inserted after reaming the canal to 1 mm smaller than the component. Postoperatively, all patients had the same rehabilitation, and early partial weight-bearing was encouraged. All patients used crutches or a walker for the first two months.

For measurement we used anteroposterior pelvic radiographs taken on non-portable equipment by the same two technicians using a standard technique. We studied the latest postoperative film and the two-month postoperative film to determine polyethylene wear by the technique of Livermore, Ilstrup and Morrey (1990). Duration of implantation was rounded to the nearest half-year and all radiographic measurements were made by one individual (JRH). Each radiograph was measured twice to the nearest 0.05 mm using a Kanon Manual Kaliper (Model No. OL-150). The direction of polyethylene wear in the frontal plane was measured by reference to a line drawn through the centre of the femoral head at 90° to a line touching the ischial tuberosities. A computer software program (Advanced System Consultants, Indianapolis, Indiana) was developed to convert the radiographic measurements into linear wear rates after correction for magnification. Acetabular wear is cylindrical, and volumetric wear can therefore be calculated from the femoral head size and the linear wear (Charnley and Halley 1975; Dowling et al 1978). The volumetric wear rate can then be calculated.

From the two series of 97 cemented and 134 hybrid arthroplasties, we matched pairs of patients for age, sex, and weight ending with 58 patients (66 joints) with cemented femoral prostheses and 58 (65 joints) with uncemented femoral components (Table I).

Statistical analysis used Scheffe's test for multiple mean comparison for age, linear wear, volumetric wear, weight, linear wear rate, and volumetric wear rate.

RESULTS

Amount of wear (Table II). The mean linear wear for all the cups articulating with uncemented femoral components was 0.73 mm (0 to 4.21). In the matched sub-group of 65 hips, the mean linear wear was 0.72 mm (0 to 4.21).

The mean linear wear for all the cups articulating with cemented femoral components was 0.42 mm (0 to 2.75), and in the matched sub-group of 66 hips it was 0.47 mm (0 to 2.75). Both for the whole groups and for the matched groups, the difference in linear wear between those with cemented and uncemented femoral components was significant (p < 0.04).

Mean volumetric wear was, of course, in the same proportion. In the uncemented femoral component group it was 455 mm³ (0 to 2596); for the matched sub-group it was 449 mm³ (0 to 2596). In the cemented femoral group, mean volumetric wear was 259 mm³ (0 to 1692), and for the matched group 290 mm³ (0 to 1692). Again, the difference was significant (p < 0.04).

Wear rates (Table III). The mean linear wear rate for both the matched and unmatched groups with uncemented femoral components was 0.22 mm/year (0 to 1.41). For all those with cemented femoral components, the mean linear wear rate was 0.14 mm/year (0 to 0.92); for the matched sub-group it was 0.15 mm/year (0 to 0.92). The differences between the groups was statistically significant (p < 0.05). The volumetric wear rate followed the same pattern with similar results and statistically significant differences between cemented and uncemented groups (p < 0.05).
Table III. Mean (range) linear (mm/yr) and volumetric (mm³/yr) wear rates in all four groups of patients

<table>
<thead>
<tr>
<th>Femoral component</th>
<th>Uncemented</th>
<th>Cemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>0.22 (0 to 1.41)</td>
<td>0.15 (0 to 0.92)</td>
</tr>
<tr>
<td>Unmatched</td>
<td>0.22 (0 to 1.41)</td>
<td>0.14 (0 to 0.92)</td>
</tr>
<tr>
<td>Volumetric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>139 (0 to 865)</td>
<td>92 (0 to 564)</td>
</tr>
<tr>
<td>Unmatched</td>
<td>135 (0 to 865)</td>
<td>83 (0 to 564)</td>
</tr>
</tbody>
</table>

Table IV. Radiographic changes in 231 total hip replacements at three to five years

<table>
<thead>
<tr>
<th>Femoral component</th>
<th>Uncemented</th>
<th>Cemented</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetabular radiolucency</td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Femoral radiolucency</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Osteolytic lesion</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Cortical hypertrophy</td>
<td>19</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Subsidence</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Radiographic findings** (Table IV). Thirteen patients had radiolucent lines on the acetabular side; six with uncemented femoral components and seven with cemented components. On the femoral side, six hips showed radiolucent lines; five in the uncemented group and one in the cemented. There were osteolytic lesions in five patients; three in the cemented and two in the uncemented group. Nineteen hips showed cortical hypertrophy; all 19 were in the uncemented femoral component group. Only one cemented prosthesis had subsidence of the femoral component, and this hip also showed a fracture of the femoral cement mantle.

**DISCUSSION**

There are several reports of wear rates for cemented all-polyethylene and for cemented metal-backed acetabular components (Charnley and Halley 1975; Wroblewski 1985; Cates et al 1993), but we believe that ours is the first report of wear rates in uncemented cups. We used the technique of Livermore et al (1990) to measure radiographic wear; they reported an average accuracy of 0.075 mm. We attributed all measurable reductions in polyethylene thickness to polyethylene wear, not to creep (Rimmac et al 1988; Ritter et al 1990).

We divided our population into two groups depending on whether the femoral component was cemented or uncemented, although identical components were used in all. Sub-groups in our retrospective series were matched for age, sex, diagnosis and weight of patient and all were followed for at least three years, after operations by the same surgical technique and identical postoperative rehabilitation.

We found a statistically significant difference in wear between those with and without cement fixation of the femoral component. Furthermore, comparison of our results with those obtained by identical methods for cemented all-polyethylene cups showed a statistically significant difference (Fig. 1). Livermore et al (1990) reported a linear wear rate of 0.08 mm/year with a stainless steel femoral component and a cemented all-polyethylene cup. Cates et al (1993) found an identical linear wear rate of 0.08 mm/year with cemented all-
polyethylene cups, and 0.11 mm/year with cemented metal-backed cups, in both series the cups were articulating with a cemented titanium femoral component with a 28 mm titanium-alloy head. Our wear rates, 0.22 mm/year for the uncemented and 0.15 mm/year for cemented femoral components are considerably greater.

Several factors may be involved in these increased wear rates. Dalstra and Huiskes (1991) used a threedimensional model to show that there were increased stresses within polyethylene when it is metal-backed. The polyethylene used in our series was machined, and in Bankston et al (unpublished data 1994) we shall report a significant increase in wear in machined polyethylene as compared with moulded polyethylene. Cates et al (1993) studied the components of moulded polyethylene. We used modular titanium femoral components; there are several reports that the use of a titanium femoral component increases the wear of polyethylene (McKellogg et al 1981, 1990; Nasser et al 1989).

We found significantly less wear when the femoral component was cemented. We can only conjecture that the cement may help to absorb some of the stresses, and thus reduce the forces within the polyethylene. Cement also offers a better seal, not only against titanium particles which may act as third bodies for polyethylene wear (McKellogg et al 1990), but also against the access of polyethylene wear particles to the femoral endosteal surface.

Conclusions. Particulate polyethylene has recently been shown to be a cause of failure of total hip replacement. We found a significant increase in polyethylene wear in uncemented metal-backed acetabular components which was made worse when the femoral component was also uncemented. Increased wear must increase the number of polyethylene particles and therefore jeopardize the longevity of hip replacement. This raises questions about the continued use of uncemented acetabular components. A method of decreasing wear is needed to match or exceed the proven longevity of cemented all-polyethylene acetabular cups.

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


