CATASTROPHIC FAILURE OF THE POLYETHYLENE LINER
OF UNCEMENTED ACETABULAR COMPONENTS

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Ten cases are described of catastrophic failure of the polyethylene liner of three different designs of unce-mented acetabular component. Failure occurred as a result of either 'wearthrough' to the metal backing, liner fracture or a combination of both, at a mean of 4.6 years after implantation (2 to 7.6). At revision there was metallosis in all hips and osteolysis of the femur or the pelvis in six. Catastrophic failure was seen only in cups with a minimum polyethylene thickness of less than 5 mm.

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Finite element analysis provided the rationale for metal backing of the acetabular component of cemented total hip arthroplasty, and this feature has been incorporated into many designs (Carter, Vasu and Harris 1982; Vasu, Carter and Harris 1982). With the development of un cemented total hip arthroplasty, metal backing of the acetabular component gave the necessary metal surface for biological fixation. In some designs, the metal shell was used with modular polyethylene inserts to accommodate different sizes of femoral head and different degrees of build-up of the acetabular rim. Theoretically, such a liner could be exchanged if it wore out.

Uncemented metal-backed acetabular components, however, have several potential disadvantages compared with one-piece all-polyethylene cemented components.

For a given outside diameter and a given size of femoral head, the polyethylene thickness is necessarily decreased by the thickness of the metal backing and the locking mechanism. Thinner polyethylene is subject to a higher wear rate (Bartel, Bicknell and Wright 1986) and therefore more particulate debris will be generated that may initiate osteolysis (Harris et al 1976; Huddleston 1988; Maloney et al 1990). Thin polyethylene is also more likely to wear through completely or to fracture. Another potential problem is the introduction of another interface between the metal shell and the polyethylene liner at which polyethylene wear can occur.

We describe ten cases of catastrophic failure of the polyethylene liner in un cemented total hip arthroplasties.

PATIENTS AND METHODS

Our ten cases (in nine patients) occurred after primary total hip arthroplasty and were collected from two institutions, the Brigham and Women's Hospital and the Mayo Clinic. The mean age of the patients at the time of arthroplasty was 49.6 years (22 to 83); two were men and seven were women. Further details are given in Table I.

All the acetabular components had been implanted without cement and were of three designs. The Porous-Coated Anatomic component (PCA; Howmedica, Rutherford, New Jersey) is a factory-assembled non-modular prosthesis in which the porous-coated cobalt-chromium shell is fixed to bone by pegs; the liner is fixed to the shell by a central polyethylene locking peg. The polyethylene liners had not been heat-treated. The DePuy (Warsaw, Indiana) and Osteonics components (Allendale, New Jersey) had porous-coated titanium shells; modular polyethylene liners, fixed at the rim, were snapped into the shells at the time of the operation (Fig. 1). The outside diameters of the metal shells, the inside diameters of the polyethylene liners, and the minimum thickness of the polyethylene liners are listed in Table I.

Five different designs of femoral component had been used: PCA in two hips, Profile (DePuy, Warsaw, Indiana) in four, Technica Custom (Techmedica, Camarillo, California) in two, Omnifit (Osteonics, Allendale, New Jersey) in one, and a Zimmer Custom femoral component (Zimmer, Warsaw, Indiana) in one hip. In all of these, the femoral head was of cobalt-chromium alloy; the size used in each case is given in

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Table I. Details of ten patients in whom catastrophic acetabular polyethylene failure occurred after primary uncemented total hip arthroplasty

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Weight (kg)</th>
<th>Diagnosis</th>
<th>Acetabular component type</th>
<th>Metal shell outside diameter (mm)</th>
<th>Femoral head diameter (mm)</th>
<th>Minimum thickness of polyethylene liner (mm)*</th>
<th>Acetabular component opening angle (degrees)</th>
<th>Pain†</th>
<th>Time to failure (yr)</th>
<th>Mode of liner failure</th>
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<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>M</td>
<td>86</td>
<td>Hip dysplasia</td>
<td>PCA‡</td>
<td>46</td>
<td>32</td>
<td>3.8</td>
<td>43</td>
<td>Mild</td>
<td>7.2</td>
<td>Wearthrough</td>
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<tr>
<td>2</td>
<td>34</td>
<td>F</td>
<td>59</td>
<td>PVNS§</td>
<td>PCA</td>
<td>46</td>
<td>32</td>
<td>3.8</td>
<td>54</td>
<td>Mild</td>
<td>7.6</td>
<td>Wearthrough</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>M</td>
<td>100</td>
<td>Hip dysplasia</td>
<td>DePuy</td>
<td>54</td>
<td>32</td>
<td>2.6</td>
<td>62</td>
<td>Mild</td>
<td>4.0</td>
<td>Fracture</td>
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<tr>
<td>4</td>
<td>22</td>
<td>F</td>
<td>61</td>
<td>Osteoarthritis</td>
<td>DePuy</td>
<td>50</td>
<td>28</td>
<td>4.6</td>
<td>50</td>
<td>Severe</td>
<td>4.0</td>
<td>Wear/fracture</td>
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<td>5</td>
<td>22</td>
<td>F</td>
<td>61</td>
<td>Osteoarthritis</td>
<td>DePuy</td>
<td>48</td>
<td>28</td>
<td>1.9</td>
<td>42</td>
<td>Severe</td>
<td>4.0</td>
<td>Wear/fracture</td>
</tr>
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<td>6</td>
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<td>F</td>
<td>73</td>
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<td>DePuy</td>
<td>48</td>
<td>28</td>
<td>1.9</td>
<td>50</td>
<td>Mild</td>
<td>3.8</td>
<td>Wear/fracture</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
<td>F</td>
<td>58</td>
<td>Osteoarthritis</td>
<td>DePuy</td>
<td>50</td>
<td>28</td>
<td>4.6</td>
<td>50</td>
<td>Mild</td>
<td>4.0</td>
<td>Fracture</td>
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<tr>
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<td>59</td>
<td>F</td>
<td>55</td>
<td>Osteoarthritis</td>
<td>DePuy</td>
<td>50</td>
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<td>4.6</td>
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<td>28</td>
<td>4.6</td>
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<td>2.4</td>
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<td>F</td>
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<td>Mild</td>
<td>7.5</td>
<td>Wear/fracture</td>
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</table>

* minimum thickness according to the manufacturer; for all designs the thinnest polyethylene was near the rim
† before revision for polyethylene liner failure
‡ Porous-Coated Anatomic (Howmedica)
§ pigmented villonodular synovitis

![Fig. 1](image)

Cross-section of the discontinued DePuy acetabular component showing the thin polyethylene at the rim of the liner.

Table I. Only two of the ten femoral components were cemented (cases 6 and 9).

We measured the inclination of the acetabular component on anteroposterior radiographs as the angle subtended by a line between the lower end of the teardrop on both sides and a line along the lateral face of the component. The radiographs showed that the femoral component was not seriously malaligned in any patient.

RESULTS

Two types of catastrophic failure were identified: ‘wearthrough’ of the polyethylene to the metal backing (Fig. 2) and fracture of the liner (Fig. 3). In two cases, serial radiographs showed progressive liner wear and the operative findings confirmed it. In three cases, no wear was seen on radiographs before failure, and fractures of the liner were found in these three. In five cases, progressive wear was seen on the radiographs before catastrophic failure and the operative findings suggested that fracture had probably occurred through the thinned polyethylene before it had completely worn through.

At revision, the femoral heads were all found to be articulating directly with the metal shells of the acetabular components, and there was gross metallosis with staining of the synovium in all cases. The shell of the acetabular component was well fixed in nine of the ten cases and loose in one (case 1; Fig. 2). It was nevertheless removed in every case and replaced by another design. There was osteolysis around the acetabulum or the femur or both in six of the ten hips (cases 1, 2, 3, 4, 8 and 10; Fig. 2).

The diagnosis of liner failure was not difficult to make in most cases. Some patients reported clicking in the hip; the degree of pain experienced varied (Table I). Physical examination was not diagnostic but the radiographs all showed the femoral head to be located eccentrically in the socket.

Incidence. From 1983 to the end of 1990 a total of 4220 uncemented metal-backed acetabular components of many designs had been implanted at the Brigham and Women’s Hospital and at the Mayo Clinic. At the end of June 1993 we knew of 13 catastrophic liner failures among these cases: 10 of 477 DePuy sockets; 2 of 357 PCA sockets; and 1 of 496 Osteonics sockets. No failures occurred in liners with a minimum polyethylene thickness greater than 5 mm. The incidence of catastrophic failure in components with a minimum liner thickness of less than 5 mm was 10 of 126 DePuy sockets, 2 of 19 PCA sockets, and one of 48 Osteonics sockets. The mean time to recognition of catastrophic failure was 3.7 years (2.4 to
4) for the DePuy socket and 7.4 years (7.2 to 7.6) for the PCA socket.

DISCUSSION

Catastrophic failure of the acetabular component was rarely mentioned in the literature before the introduction of metal backing (Collins, Chetta and Nelson 1982; Harley and Boston 1985). We have identified two types of relatively early failure in three different designs, liner wearthrough and liner fracture. Similar types of failure have been reported in the metal-backed tibial and patellar components of total knee prostheses (Bayley et al 1988; Lombardi et al 1988; Stulberg et al 1988). We have not included discussion of catastrophic liner failures due to liner-shell dissociation or failure of the liner locking mechanism, which have been previously reported (Brien et al 1990; Kitziger, DeLee and Evans 1990).

The main design feature predisposing to catastrophic failure appears to be thin polyethylene. All the acetabular implants which failed had a minimum polyethylene thickness of less than 5 mm and the risk of this complication could probably be reduced if a femoral head size was used which allowed a thicker layer of polyethylene.

Some other factors may have contributed. Four of the patients (5 hips) were less than 40 years old and two weighed more than 80 kg. In five hips the inclination of the acetabular component was 50° or more. The more vertical the acetabular component the less well covered it is by polyethylene; the rim of the liner is closer to the line of action of the resultant joint force, and increased polyethylene stress may occur. Similarly, if the femoral component is in valgus alignment or has a valgus neck-shaft angle the polyethylene stresses are increased. Four hips had femoral components mated with acetabular components made by different manufacturers. Subtle differences in size tolerances between the two could predispose to high local stresses.

Design features which may have increased the risk of this complication include thin polyethylene at the socket rim and incongruity between the liner and the

Case 1. Figure 2a – Radiograph of a 31-year-old man seven years after un cemented total hip arthroplasty. The acetabular component is loose and there is osteolysis of the pelvis and proximal femur. The femoral head has migrated proximally. Figure 2b – The retrieved acetabular component showed complete wearthrough of the polyethylene liner.
metal shell. The acetabular components used in our patients have all now been withdrawn from the market by their manufacturers and have been redesigned. Although certain design features may increase the risk of liner failure, we believe that the problem is a fundamental one and that all such metal-backed uncemented acetabular components, especially those with thin polyethylene liners, are at risk. It seems likely that this problem will be seen with greater frequency in the future and that patients should be carefully followed so that revision, if it is needed, can be done with the minimum delay to avoid the ill-effects of particulate debris formation and osteolysis.

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REFERENCES


