FAILURE OF THE CEMENT-BONE INTERFACE

A CONSEQUENCE OF STRENGTHENING THE CEMENT-PROSTHESIS INTERFACE?

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We report the early failure, at a mean of 37 months, of 17 femoral prostheses due to aseptic loosening at the cement-bone interface. In every case the prosthesis had been manufactured with a surface coating designed to enhance the strength of the cement-prosthesis interface.

It is postulated that improving the bond at the cement-prosthesis interface may transfer increased stress to the cement-bone interface and cause early failure at that interface.

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In an effort to improve the longevity of cemented femoral components, new methods of cementing have been introduced with promising results (Harris, McCarthy and O'Neill 1982; Roberts, Poss and Kelley 1986; Mulroy and Harris 1990; Barrack, Mulroy and Harris 1992). These techniques included distal canal plugging, endosteal curettage, pulsatile lavage, pressurised injection of cement, and cement centrifugation (Oh et al 1978; Krause et al 1982; Oh, Bourne and Harris 1983; Harris and McGann 1986). The design of components has also been altered, and attention has focused on the cement-prosthesis interface as the site of the first signs of failure (Jasty et al 1991). Cement precoating or porous coating of the femoral component was introduced to improve the resistance of the cement-bone interface to fatigue (Raab, Ahmed and Provan 1982; Ahmed, Raab and Miller 1984; Manley, Stern and Gurtowski 1985; Cook et al 1987; Stone, Wilkinson and Stother 1989).

We report 17 cases of early failure at the cement-bone interface of femoral components, the surfaces of which had been coated to enhance fixation to the cement. These incidents suggest that improving the cement-prosthesis bond may not increase the longevity of total hip arthroplasty.

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PATIENTS AND METHODS

We report 17 failed cemented femoral components, all manufactured with a surface coating designed to enhance the fixation of the prosthesis to the cement. Nine were precoated with polymethylmethacrylate (Harris Precoat; Zimmer, Warsaw, Indiana), seven were porous-coated proximally (6 Pennsylvania components; Biomet, Warsaw, Indiana and 1 PCA component, Howmedica, Rutherford, New Jersey), and one had proximal enhancement coating by 'surface roughening' (Mallory Head component; Biomet, Warsaw, Indiana). In every case separation had occurred at the cement-bone interface and was the cause for revision.

There were five men and 12 women; their average age was 71 years (40 to 85) and their mean weight was 158 lb (72 kg), ranging from 110 to 215 lb (50 to 98 kg). The preoperative diagnosis was osteoarthritis in 13 patients, hip fracture in two and avascular necrosis in two. Eleven patients were in Charnley class A and six in class B. In all cases, the cementing technique had included distal canal plugging, canal lavage and pressure injection of cement. In seven cases, the cement was centrifuged. The mean interval between implantation and revision was 37 months (11 to 76).

Radiographs taken at the time of arthroplasty and at revision were evaluated. Classification of the initial bone stock was according to Dorr et al (1990). In four patients it was type A and in 13 type B; there were no Dorr type C femora. We considered that the cementing technique was adequate – approximating to type B as defined by Barrack et al (1992). This implies good filling in the diaphyseal and metadiaphyseal regions, with cement extending at least 2 cm beyond the tip of the prosthesis and a cement mantle at least 2 mm thick. The cement did not necessarily extend through the cancellous bone to the cortex.

RESULTS

At the time of revision, the radiographs showed 100% demarcation at the cement-bone interface in every case (Figs 1 to 3). No radiolucencies were identified between the prosthesis and the coating in any case. The preoperative aspirates and intraoperative biopsy specimens were all negative to bacterial culture. At the time of revision,

Fig. 1a

Fig. 1b

Fig. 2a

Fig. 2b

Fig. 2c

Figure 2a – Postoperative radiograph of a cemented porous-coated titanium implant showing adequate cement fixation. Figure 2b – The lateral view confirmed good penetration of the cement. Figure 2c – Four years later there was complete demarcation at the cement-bone interface and subsidence of the femoral component, with its cement mantle.

Fig. 3

Cemented precoated cobalt-chromium prosthesis showing complete demarcation at the cement-bone interface just before revision.

loosening was demonstrable only at the cement-bone interface and in every case the prosthesis and its cement mantle were reviewed in one piece, the cement being still firmly bonded to the prosthesis. All the hips were revised using uncemented femoral components.

DISCUSSION

Our 17 revision cases were drawn from an unknown number of cemented primary total hip arthroplasties and we do not know therefore whether the incidence of loosening is higher when femoral components with coatings are used to enhance the cement-prosthesis interface. The phenomenon that we describe, early cement-bone interface failure, does invite speculation.

A recent observation by Jasty et al (1991) suggested that failure of cemented femoral components is initiated by debonding at the cement-prosthesis interface and it would seem logical that improvement in the strength of that interface, by precoating or porous coating, might

reduce loosening rates. Long-term clinical results are not yet available to confirm this theory.

Our 17 patients all had enhanced fixation at the cement-prosthesis interface; they experienced failure from early loosening at the cement-bone interface despite the fact that all the criteria for a long-lasting result appeared to have been met initially. The patients were not overweight and all had good bone stock. Modern cementing techniques had been used and apparently good fixation had been achieved radiographically. The cause of their early cement-bone interface failures is open to conjecture.

Crowninshield and Tolbert (1983), although they did not investigate the interface strains, showed that a good cement-prosthesis bond decreased strains within the cement. In contrast, Lu et al (1992) suggested from a finite element analysis, that perfect cement-prosthesis bonding increased cement strains. Mann, Bartel and Wright (1992) found that the addition of a proximal plasma-sprayed surface to a femoral component resulted in an increase in the normal stresses across the cement-bone interface. These authors speculated that "there may be an increased risk of cement-bone interface failure with the addition of a proximal plasma-sprayed surface. Similar results could be anticipated for stems with a proximal cement precoat . . .".

Perhaps improvement of the bond at the cement-prosthesis interface transfers increased stress to the cement-bone interface and thus promotes early failure at this interface. Further observations are needed to confirm or refute this speculation.

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