CEMENT-WITHIN-CEMENT REVISION HIP ARTHROPLASTY; SHOULD IT BE DONE?

A BIOMECHANICAL STUDY

P. L. S. LI, P. J. INGLE, J. K. DOWELL

From Broomfield Hospital and Anglia Polytechnic University, Chelmsford, England

The complete removal of the cement mantle at revision arthroplasty can be extremely difficult. Some authors advise a 'cement-within-cement' revision technique in which a new layer of cement is applied to the old before insertion of the femoral component. We could find no long-term clinical data regarding the success of this procedure.

In a simple biomechanical study, we examined the strength of the cement-to-cement interface in conditions likely to prevail in vivo. We found that the presence of a thin layer of blood and marrow debris at the interface weakened the cement-to-cement bond by 80% to 85%.

These biomechanical findings and additional photomicrographic evidence do not support the practice of cement-within-cement revision arthroplasty.

J Bone Joint Surg [Br] 1996;78-B:809-11.

Received 23 November 1995; Accepted 15 March 1996

Acrylic bone cement is difficult to remove during revision operations for aseptic loosening. Complications include femoral perforation or fracture, increased blood loss and prolonged operating times. Some surgeons have therefore recommended the technique of 'cement-within-cement' revision in which no attempt is made to remove the existing (secure) cement mantle, but a fresh layer of cement is applied to the old before insertion of a new femoral component (Greenwald, Narten and Wilde 1978; Lieberman et al 1993). We could find no long-term clinical reports on the success of this procedure.

Greenwald et al (1978) showed that if there was no blood

at the interface between the old and new cement, then the shear strength of this interface was similar to that of a uniform block of cement. In practice, however, blood, marrow fat and debris may be found in some areas of this new interface despite thorough lavage and drying. We have studied the effect of such a layer of blood and debris on the shear and tensile strengths of the cement-to-cement interface and correlated these findings with their photomicrographic appearance.

MATERIALS AND METHODS

Preparation of cement-to-cement composites. Uniform cylinders of cement 15 mm in diameter were made by pouring low-viscosity polymethylmethacrylate cement (Palacos; Schering-Plough, Bury St Edmunds, UK) into a metal mould after mixing for 90 s at a frequency of 1 Hz at room temperature (21°C) (Fig. 1). The cement was then allowed to cure at a temperature of 37°C. After four days, the cylinders were cut in half. The tips were then smoothed using a 240 µm grit wet-and-dry rotating emery disc to create an even interface for bonding with new cement. The cement-to-cement interface was either clean or contaminated by a thin layer of a mixture of blood with clots and marrow debris obtained from patients undergoing hip arthroplasty.

Fig. 1

The metal mould used to prepare cement cylinders.

P. L. S. Li, FRCS, Senior Orthopaedic Registrar
Norfolk and Norwich Hospital, Brunswick Road, Norfolk NR1 3SR, UK.

P. J. Ingle, MSc, Senior Lecturer
Anglia Polytechnic University, Victoria Road, Chelmsford CM1 1LL, Essex, UK.

J. K. Dowell, FRCS, Consultant Orthopaedic Surgeon
Broomfield Hospital, Court Road, Broomfield, Nr Chelmsford, Essex CM1 5ET, UK.

Correspondence should be sent to Mr P. L. S. Li.

©1996 British Editorial Society of Bone and Joint Surgery
0301-620X/96/51248 \$2.00

The half-cylinders were replaced in the metal mould, maintained at 37°C and a new layer of Palacos low-viscosity cement poured to fill the mould completely. Digital pressure was applied to the new cement layer when it reached the doughy stage. In the contaminated cylinders no attempt was made to clean the cement interface as most of the contaminated material was 'squeezed out' during pressurisation of the new cement. The cement-to-cement composites (Fig. 2) were allowed to cure for another four days before mechanical testing.

Mechanical tests. The interface shear and tensile strengths were measured with the cement cylinders warmed to 37°C.

Shear strength. This was measured by placing the cylinders in a Lloyds tensile testing machine (Warsash, Southampton, UK) adapted so that a shearing force was applied at the interface. The force F_s required to cause failure of the interface was recorded; the shear strength of the interface is F_s/A where A is the cross-sectional area of the cylinder.

Tensile strength. Using the same tensometer (Fig. 3), the tensile strength F_t of the interface was measured by applying a tensile force along the length of the cylinder until failure occurred. The tensile strength of the interface is then F_t/A .

RESULTS

Shear tests. Table I gives the shear strengths of the cement-to-cement interface and a uniform block of cement. The mean shear strength of a uniform block of polymethyl-methacrylate cement was 40 MPa (SD 4.4) which is comparable to previously published figures (Greenwald et al 1978). The clean cement-to-cement interface had a mean shear strength of 39 MPa (SD 2.4) which is marginally but not significantly less than that of a uniform block. In the contaminated cement-to-cement interface, however, the mean shear strength was significantly reduced to 6.2 MPa (SD 5.0) which represents a loss of shear strength of 85%. Photomicrographs of sections through a clean cement-to-

Fig. 2

A cement-to-cement composite with blood and bone marrow at the interface of the 'old' and 'new' cement.

Fig. 3

The Lloyds tensile testing machine. It has in this instance caused failure of the cement-to-cement bond in tension.

Table I. The mean ($\pm$ SD) shear strength (MPa) of clean and contaminated interfaces and of uniform blocks of cement

Interface	Shear strength
Uniform block (n = 74)	40 $\pm$ 4.4
Clean (n = 17)	39 $\pm$ 2.4
Contaminated (n = 18)	6.2 $\pm$ 5.0

Table II. The mean ($\pm$ SD) tensile strength (MPa) of clean and contaminated interfaces and of uniform blocks of cement

Interface	Tensile strength
Uniform block (n = 6)	13.2 $\pm$ 1.7
Clean (n = 13)	11.8 $\pm$ 2.8
Contaminated (n = 20)	2.7 $\pm$ 1.6

cement interface show that this interface is not visible under light microscopy (Fig. 4) suggesting that a chemical bond is formed at the interface between new and old cement. This type of bonding seems to be the likeliest explanation for the excellent shear strength noted between old and new cement.

Fig. 4

Fig. 5

Figure 4 – Photomicrograph of a 'clean' cement-to-cement interface showing obvious porosities. The interface is not visible indicating intimate bonding between the old and new cement (×50). Figure 5 – Photomicrograph showing that in the presence of blood and marrow debris, the interface between the old and new cement is clearly apparent. This accounts for the large decrease in shear and tensile strengths (×50).

By contrast, the interface was clearly visible in the presence of blood and marrow debris separating the new and old cement (Fig. 5). The thickness of the layer of contaminant was only 100 μm or less.

Tensile tests. Table II gives the results for tensile strength. The mean tensile strength of a uniform block of cement was 13.2 MPa (SD 1.7). For the clean interface, the mean tensile strength was 11.8 MPa (SD 2.8) which represents a reduction of 11%. For the contaminated specimens, the findings were similar to those for the shear experiments; the mean tensile strength was only 2.7 MPa (SD 1.6) which is a reduction of about 80% compared with that of a uniform block of cement.

DISCUSSION

Several authors have advocated cement-within-cement hip arthroplasty in which the old cement mantle is not completely removed and the new femoral component is inserted after application of a fresh layer of cement (Greenwald et al 1978; Lieberman et al 1993). Our experimental results do not support such practice.

When the cement-to-cement interface is spotlessly clean, the shear and tensile strengths of the interface are almost equal to those of a uniform block of cement and in these circumstances, cement-within-cement revision may be a sound procedure. In clinical practice, however, this is unlikely to be achieved despite modern lavage techniques. In revision surgery the bone bed tends to bleed even more than during primary arthroplasty making it almost impossible to achieve an old cement interface with an entirely clean surface area. Marrow fat is an additional contaminant

and previous studies have shown that this can weaken an interface even more than blood (Stone, Wilkinson and Stother 1989). If even a small area of the old cement is contaminated with blood and bone marrow debris, it will not bond adequately with the new cement layer. This will create a weak spot at that interface which can act as a stress concentrator and eventually lead to failure of the whole interface. The weakening effect of blood and marrow debris which we found was much greater than that suggested by Greenwald et al (1978). They noted a 37% reduction in shear strength of the cement-to-cement interface when blood was present. Our findings showed reduction of 85% in shear strength and of 80% in tensile strength. The reason for the difference is probably that Greenwald et al (1978) studied only the effect of blood and not of blood and marrow debris.

Conclusions. We have shown that the presence of blood and marrow debris dramatically reduces the strength of the cement-to-cement interface. If the entire old cement interface cannot be reliably cleared of blood and marrow fat during revision, all cement should be removed.

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

- Greenwald AS, Narten NC, Wilde AH. Points in the technique of recementing in the revision of an implant arthroplasty. *J Bone Joint Surg* 1978;60-B:107-10.
- Lieberman JR, Moeckel BH, Evans BG, Salvati EA, Ranawat CS. Cement-within-cement revision hip arthroplasty. *J Bone Joint Surg [Br]* 1993;75-B:869-71.
- Stone MH, Wilkinson R, Stother IG. Some factors affecting the strength of the cement-metal interface. *J Bone Joint Surg [Br]* 1989;71-B: 217-21.