Low polymerization temperature with Boneloc®

In vivo measurements in 11 hip replacements

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We investigated the thermal properties of a new bone cement, Boneloc®, during total hip replacement, using a thermocouple connected to a digital thermometer. In 10 of 11 cases the maximum temperature was below 43 °C at the bone-cement interface in the acetabulum. This is a considerable reduction in the polymerization temperature in comparison with earlier studies of conventional bone cement. We found no difference regarding the setting time of the cement.

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Addition of heat sinks—e.g., titanium dioxide (Homsy et al. 1972), crystalline monomers (Lee and Turner 1977), reduction of the ambient temperature by precooling of the cement or the implant (Meyer et al. 1973, DiPisa et al. 1976) or water cooling (Wykman 1992)—have, inter alia, been suggested in order to reduce the exothermic temperature.

A bone cement, Boneloc®, with a new composition has been developed. In vitro studies of this new cement have shown a reduction in the polymerization exotherm compared to standard PMMA-cements. We measured in vivo the polymerization exotherm at the bone-cement interface in the acetabulum during hip arthroplasty.

Patients and methods

In the recently introduced Boneloc® cement (Boneloc Polymers Reconstructive A/S), half of the MMA-monomer has been replaced by DMA/IBMA (n-decyl-methacrylate/isobornyl methacrylate). In the polymer powder MMA/BMA (methyl-methacrylate/butyl-methacrylate), copolymers have been chosen. The accelerator system has also been changed by applying a mixture of 0.5% DMPT (N,N, dimethyl-p-toluidine) and 1.0% DHPPT (dihydroxy-propyl-p-toluidine).

Using precooled (+8 °C) cement, we studied the temperature elevations at the bone-cement interface in 10 patients who underwent total hip arthroplasty for primary arthrosis. 1 patient underwent bilateral arthroplasties performed on 2 occasions. After lavage of the bone bed, cement was applied using the pressurization technique. In all the patients, a Charnley polyethylene acetabular component without metal backing was employed. The temperature was measured with a 2 mm Ni-Cr-Ni thermocouple connected to a digital thermometer (Tsurunga 3527, Svenska Terminstrument AB, Sweden), with an accuracy of 0.1 °C and a response time of 0.5 sec. The thermometer was introduced into a 2 mm hole in the peripheral bony rim of the acetabulum. The temperature was recorded at the very tip of the thermocouple which lay flush with the prepared bony surface, as in the technique described by Toksvig-Larsen et al. (1991) and Wykman (1992).

Results

The median ambient bone temperature was 35 (32–37) °C. At an average of 7 (5–8) minutes following the onset of mixing, the temperature started to rise. The temperature increase during cement curing followed a sine curve and reached a maximum of 41 (38–48) °C after 11 (9–13) minutes (Figure 1). In 10 of 11 cases the maximum temperature was below 43 °C, while the polymerization exotherm in one case exceeded 44 °C, and eventually reached a maximum of 48 °C (Table 1).

Discussion

Eriksson and Albrektsson (1983) have shown that heating up to 47 °C for 1 minute severely impaired new bone formation. A temperature in the range of 44–47 °C was regarded as a threshold temperature for impaired bone regeneration (Eriksson 1984). We

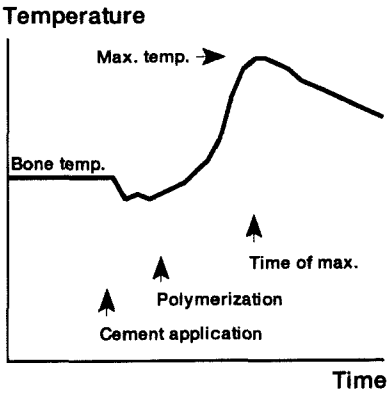

Figure 1. The polymerization temperature curve.

Table 1. Patients and results

Case	Sex	Age	Tm (°C)	Δtp (sec)	ΔtTm (sec)
1	m	73	39.0	494	754
2	f	66	41.0	506	782
3	f	68	42.7	504	720
4	f	75	42.0	424	728
5	f	70	38.0	416	692
6	f	58	38.5	456	676
7	m	56	40.5	318	600
8	m	53	38.0	436	550
9	m	84	41.0	496	632
10	f	78	47.8	450	536
11	f	68	41.1	388	548

Tm maximum temperature, Δtp time from start of mixing to start of rise in temperature, ΔtTm time from start of mixing to maximum temperature.

have earlier, using conventional PMMA cement, found in the acetabulum a maximum cement curing temperature of 49 (41–67) °C; 9 of 11 recordings were above 44 °C, and 3 of these exceeded 47 °C (Wykman 1992). The maximum temperature was reached after an average of 10 minutes. In that study water irrigation was successfully used to restrict the increase in temperature.

A new cement, Boneloc®, developed to keep down the exothermic temperature, to reduce leakage of chemical compounds, to improve polymerization, while retaining physical properties has been introduced to the market. Laboratory tests regarding compressive strength, 4-point bending strength, tensile strength, shear strength, fatigue life, and fracture toughness have shown that the physical properties of the Boneloc cement are on a level with conventional PMMA cements (Kindt-Larsen et al. 1995). An in vitro study of Boneloc® cement, performed in accordance with the standards for acrylic resin cements, has shown a reduction in the polymerization exotherm to 58 °C, which is 12–33 °C lower than in PMMA-cements (Kindt-Larsen et al. 1995). Other studies have confirmed this (Thanner et al. 1995).

In the same study, Kindt-Larsen et al. (1995) have shown a shortened setting-time than in conventional cements, as also suggested by the manufacturer. In our in vivo study, the Boneloc® cement in general showed considerably lower exothermic temperatures during polymerization, than in a previous study of a standard PMMA bone cement (Palacos®) (Wykman 1992). The risk of initial necrosis of bone due to thermal damage is thereby reduced. However, in 1 patient there was a markedly higher polymerization exotherm. The reason for this might have been an ambient temperature in the higher range in combination with a thicker cement mantle in the area of the probe, as shown by measurements on the postoperative radiographs.

The setting time for the Boneloc® cement was similar to that for the Palacos® cement used in the previous study. Our study confirms the laboratory results of a lower polymerization temperature for the Boneloc® cement. Whether this has any clinical implications concerning the risk of implant loosening has yet to be shown.

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