Acetabular cement temperature in arthroplasty

Effect of water cooling in 19 cases

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In 19 patients who underwent total hip arthroplasty the temperature was studied at the bone-cement interface in the acetabulum during the polymethyl methacrylate curing process. To evaluate the effect of fluid cooling, the patients were randomized into two groups: one group with no irrigation, the other with continuous irrigation with Ringer solution during cement curing. The temperature was recorded with a thermocouple at the bone-cement interface. Without water cooling, the median maximum temperature was 49 (41–67) °C. In 9 out of 11 patients the temperature elevations were sufficient to cause impaired bone regeneration or thermal necrosis of bone. Continuous water irrigation reduced the amount of heat at the bone-cement interface; median maximum temperature was 41 (37–48) °C.

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The polymerization of methyl methacrylate produces considerable temperature elevations (Willert et al. 1974, Seidel et al. 1977, Mjöberg 1986, Toksvig-Larsen et al. 1991a). Thermal damage to bone results from the combined effect of the rise in temperature and the period during which the bone tissue is exposed to it (Krause et al. 1982). The threshold temperature for impaired bone regeneration has been found to be in the range of 44–47 °C for one minute exposure (Eriksson 1984).

Water irrigation has been successfully used to diminish temperature elevations during bone reaming in total hip arthroplasty (Wykman 1990). I recorded the effect of continuous water cooling on the temperature at the bone-cement interface in the acetabulum during total hip arthroplasty.

Patients and methods

Temperature elevations at the bone-cement interface were studied in 19 patients who underwent total hip arthroplasty for primary arthrosis. Precooled (+8 °C) polymethyl methacrylate bone cement (Palacos, Schering Corporation, Chicago) was used. After lavage of the bone bed, vacuum-mixed cement (Mitab AB, Sweden) was applied using pressurization technique. In all the patients, a Charnley polyethylene acetabular component without metal backing was used. The patients were randomized into two groups; one group had continuous irrigation with Ringer solution (temperature +21 ±2 °C) during the cement polymerization, the other group had no irrigation. Age distribution did not differ between the two groups. A flow rate of 80 to 100 mL/min was produced by a standard arthroscopy pump. The temperature was measured with a 2-mm Ni-Cr-Ni thermocouple connected to a digital thermometer (Tsuruga 3527, Svenska Termoinstrument AB, Sweden) with an accuracy of 0.1 °C and a response time of 0.5 s. The thermometer was connected to a pen-recorder. The thermocouple was introduced into a 2-mm drill hole in the peripheral bony rim of the acetabulum. Temperature was recorded at the very tip of the thermocouple which lay flush with the prepared bone surface, as in the technique described by Toksvig-Larsen et al. (1991b).

Results (Table 1)

The median ambient bone temperature was 33 (31–36) °C. At an average of 7.5 (6.0–8.4) min following the onset of mixing, the temperature started to rise. The temperature increase followed a sine-curve. Irrespective of cooling, maximum temperature was reached at an average of 10 min. In 9 out of 11 patients with no irrigation, 44 °C was exceeded during 2.7 (1.1–6.8) min. In 2 out of 8 patients with fluid irrigation, 44 °C was exceeded for 18 s and 46 s, respectively. Median maximum temperature during cement curing with no irrigation was 48.8 (40.5–67.3) °C. With continuous fluid irrigation the median maximum temperature was 40.9 (36.5-47.5) °C (P 0.007; Mann-Whitney U-test).

Table 1. Patients and results

Case	A	B	C	D	E	F	G
1	67	F		44.5	180	482	608
2	65	F	+	38	0	484	586
3	56	M		46.5	142	448	562
4	83	F	+	47.5	46	480	602
5	71	M	+	43	0	506	610
6	78	F		41.5	0	400	554
7	76	F		49	332	362	578
8	67	F		46.5	74	474	604
9	78	F	+	38	0	424	560
10	78	F	+	39.6	0	446	598
11	58	M		67.3	354	380	590
12	74	F		54.4	408	378	604
13	63	F	+	44.4	18	448	570
14	70	M		50	166	484	616
15	70	F		48.8	68	468	618
16	61	M		52.1	124	484	582
17	69	M	+	36.5	0	502	588
18	58	F	+	42.2	0	426	606
19	65	M		40.5	0	482	588

A Age
B Sex
C Irrigation
D Maximum temp., °C
E Seconds with temp. > 44 °C
F Time from start of mixing to start of temperature rise
G Seconds from start of mixing to maximum temperature

Discussion

Eriksson and Albrektsson (1983) have shown that heating up to 47 °C for 1 minute severely impairs bone formation; a temperature in the range of 44–47 °C was regarded as the threshold for impaired bone regeneration (Eriksson 1984). Toksvig-Larsen et al. (1991b) investigated the temperature in the bone-cement interface during hip arthroplasty. In their study, the mean maximum cement-curing temperature in the acetabulum was 43 °C while 5 out of 28 recordings were above 44 °C; two of these were above 47 °C.

The use of irrigation during osteotomy has been demonstrated, experimentally and in clinical studies, to reduce the temperature in the bone and on the saw blade during cutting or reaming (Krause et al. 1982, Toksvig-Larsen and Ryd 1989, Toksvig-Larsen et al. 1991b). Matthews and Hirsch (1972) reported that the use of irrigation limited temperature increases during drilling. In the present study, water cooling with a standard arthroscopy pump effectively reduced the bone hyperthermia to less harmful levels.

The temperatures recorded in my study were higher than those recorded by Toksvig-Larsen et al. (1991a). However, my thermocouples were introduced into drill holes where the cement could penetrate about 2 mm, thereby surrounding the tip of the thermocouple. Theoretically, the temperature could thus have been recorded in a small amount of cement close to the bone-cement interface and not exactly at the interface. Another possible explanation for higher curing temperatures could be that our precooled cement had a higher initial temperature — +8 °C, compared with +4 °C.

In the operations where continuous water irrigation was used, lower temperatures were recorded. Only in 2 out of 8 patients did the temperature at the bone-cement interface exceed 44 °C. The longest duration above 44 °C was 46 seconds.

The bone cement curing process as used during total hip arthroplasty may cause substantial heat trauma, which may contribute to loosening of the components. In the acetabulum, continuous water irrigation markedly reduces heat exposure to bone. During the operation, water cooling is easily achieved by the use of a standard arthroscopy pump.

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