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Thermal Analysis of Cementing in Hip Arthroplasty

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Abstract

Background:

Since the advent of hip replacement surgery in the late 1800's, the procedure has evolved into one of the most successful and commonly performed elective operations in the world. The use of Polymethyl methacrylate, otherwise known as bone cement, in hip arthroplasty was first described in 1958. Polymethyl methacrylate polymerises through an exothermic reaction, yielding temperatures that exceed the threshold for thermal osteonecrosis. A paucity of *in vivo* data exists, describing the thermal effects of this exothermic reaction. This study aimed to analyse the thermal changes that occur during cementing in hip arthroplasty.

Methods:

Temperature trends were evaluated over a twelve-minute period in patients undergoing primary total hip arthroplasty.

Infrared thermometry was used to measure the temperatures at the femoral stem and the bone-cement interface or the bone-implant interface in cemented and uncemented hip arthroplasty respectively.

Confounding variables were controlled as cemented and uncemented hip arthroplasty thermal dynamics were compared, to isolate the thermal effects of cementing in hip arthroplasty.

Results

During uncemented hip arthroplasty, the highest bone temperatures were at the time of implant insertion. In contrast, during cemented hip arthroplasty, the lowest bone temperatures were recorded at the time of implant insertion, as this subsequently increased. Bone temperature in the cemented group was persistently and significantly higher than the uncemented counterparts for 8 minutes during the observed period.

In cemented hip arthroplasty, implant temperature raised by 19.7°C and bone temperature raised by 10.9°C and from their respective initial temperatures. The maximum recorded implant temperature was 46.8°C in the cemented group and 33.4°C in the uncemented group. The maximum recorded bone temperature was 41.1°C in the cemented group and 34.4°C in the uncemented group. The median peak temperature difference between cemented and uncemented hip arthroplasty was 14.5°C at the implant and 8.6°C at the bone interface.

Conclusion

Thermal dynamics *in vivo* differ from those described in literature, *ex vivo*. The exothermic reaction of bone cement causes significant increases in temperature of both the bone and implant. During cemented hip arthroplasty, bone is exposed to temperatures of sufficient intensity and duration to cause thermal osteonecrosis. The clinical significance of these findings is yet to be determined. Further research is needed to enhance our understanding of cementing in hip arthroplasty and to explore measures of modulating heat energy during the procedure.

Keywords

Hip arthroplasty, Hip replacement, Polymethyl methacrylate (PMMA), Bone cement, Exothermic, Thermal, Osteonecrosis

Level of evidence

- Level 2c