CEMENT PENETRATION ASSOCIATED WITH PRESSURIZATION OF THE GLENOID IN TOTAL SHOULDER ARTHROPLASTY

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INTRODUCTION

Prosthetic replacement of the glenohumeral (shoulder) joint provides pain relief and improved function in patients with disabling arthritis. Premature implant loosening is a significant clinical concern with the glenoid at greatest risk. Most total shoulder replacement (TSR) designs have glenoid components that are cemented in place.

A stable cement-bone interface is derived from mechanical interdigitation of cement with the surrounding cancellous bone. The strength of that interface increases linearly with cement penetration depth (Askew et al. (1984)). Increased pressure during cement/implant insertion has been suggested as a means to facilitate cement penetration (Harris (1994)). Improved cementing techniques for total hip arthroplasty, including cement pressurization, are credited for increased survival rates compared with historical cementing techniques (Harris (1994)). We believe that similar results are attainable in the shoulder. The objective of this study is to analyze the effects of pressurizing cement into the glenoid cavity.

MATERIALS AND METHODS

The effect of pressurization on cement penetration was evaluated in three matched pairs of fresh-frozen cadaveric shoulders, age 60 and greater. This age range was chosen to represent typical TSR patients. Glenoid components were implanted using standard TSR surgical techniques. For each matched pair of shoulders, one received a component cemented in place using finger packing. On the opposite side, cement was injected under pressure using an instrument similar to a caulking gun. The type of cement (Howmedica Simplex P, low viscosity) and mixing technique were the same for both sides/treatments. Following cement insertion, a polyethylene glenoid component (Intermedics) with a keeled design was implanted in each shoulder.

A low speed saw was used to create a series of five slices through the bone and cement surrounding the polyethylene implant. Both surfaces of each slice were scanned and digitally analyzed to determine the cement penetration. Alizarin red biological stain was used to enhance contrast between bone and cement. Absolute penetration (P) and relative penetration (P*), as defined by Panjabi et al. (1983), were computed using the following equations:

$$P = (A2 - A1)\ \text{mm}^2$$

$$P^* = (A2 - A1)/(A3 - A1) \times 100\ \%$$

where A1 = cross-sectional area of the glenoid component, A2 = cross-sectional area occupied by the cement, including A1, and A3 = cross-sectional area within the cortical-cancellous bone boundary. Scanned images from paired shoulder specimens, depicting the influence of cement pressurization as well as the basis for area calculations, are shown in Figure 1.

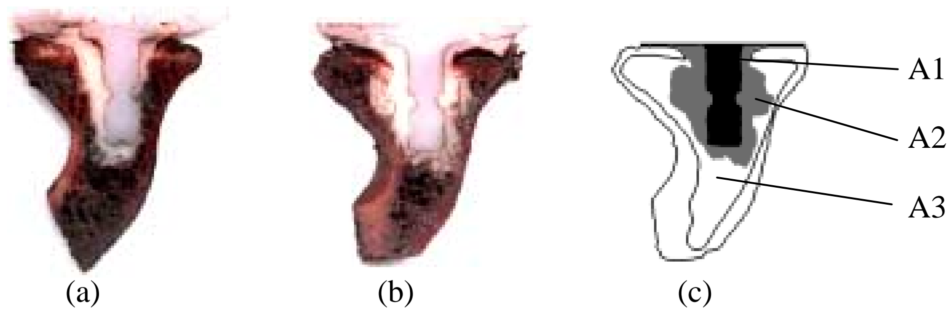

Figure 1. Representative sections through specimens with the glenoid component implanted using (a) finger-packed and (b) pressurized cementing technique. Schematic diagram (c) illustrates the boundaries of the areas corresponding to A1, A2, and A3.

RESULTS AND DISCUSSION

The highest values for absolute and relative penetration occurred in the pressurized specimens (P >100 mm^2, P* > 50%). An overall measure of the relative penetration for each specimen was obtained by calculating the mean and standard deviation of the individual slices (Table 1).

Table 1. Mean and standard deviation for relative cement penetration in %.

Specimen number	finger-packed	pressurized
1	28.9 ± 14.3	42.2 ± 6.2
2	30.8 ± 6.6	46.2 ± 4.5
3	25.6 ± 5.8	21.5 ± 5.7

In two of three matched pairs of shoulders, the mean penetration for the pressurized case was greater than that for the non-pressurized case, but it was slightly less in the third pair. Although both techniques exhibited considerable variability, smaller standard deviations for the pressurized case suggest a more uniform distribution of cement in these specimens. Comparison of absolute penetration values for matched pairs followed a trend similar to that for relative penetration.

Differences in penetration between pressurized and non-pressurized cementing techniques were evaluated as an indicator of implant stability. Overall, the effect of pressurization on cement penetration tended to be as good or better than the traditional non-pressurized approach. In the one case where penetration for the non-pressurized side exceeded that for the pressurized side, the posterior cortex was violated during pressurization. This complication, clearly undesirable, likely counteracted any positive effects of pressurization. Future testing will involve a larger sample size and statistical analysis.

REFERENCES

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