Impaction Grafting for Repair of Proximal Humeral Fractures with Hemiarthroplasty: Thermal and Biomechanical Implications

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BACKGROUND

Proximal humeral fractures are common osteoporosis related fractures, with most occurring in patient populations greater than 60 years of age. Greater tuberosity malunion subsequent to hemiarthroplasty is often met with poor clinical results, including decreased functionality and patient dissatisfaction. While tuberosity failure involves several factors, it is known that thermal injury to bone occurs with the curing of methylmethacrylate cement used for implant fixation. Prior studies have shown thermal injury to bone is initiated at 47°C. This complication may be avoided using an impaction grafting technique, consisting of cementing the implant stem distally and the use of impacted bone graft proximally. To date, neither the thermal consequence nor the biomechanical stability of this construct has been validated in a controlled laboratory setting.

METHODS

Surgical neck fractures were created in matched pairs of cadaveric humeri (n=7). Each was instrumented with a hemiarthroplasty stem and randomized to: (1) a cement group receiving full cementation or (2) an impaction grafting group receiving only cement distally and bone graft proximally. During instrumentation, thermocouples measured cortical temperature at the stem tip (representing the cement mantle), 2.5 cm distal to the surgical neck (representing the cement-graft interface in Group 2) and at the surgical neck (tuberosity interface). Torsional loading was applied in 2.5 N-m increments up to 10 N-m to evaluate relative micromotion between the implant stem and humeral shaft.

RESULTS

Thermal data demonstrated no significant difference in mean baseline temperature at any position between the groups (Table 1). A significant decrease in the maximum-recorded temperature at the surgical neck was observed in Group 2 (39.7 +/- 4.1°C) when compared to Group 1 (55.7 +/- 9.1°C, p=0.005), with no difference between maximum-recorded temperatures at the cement mantle between the groups (p=0.451). Biomechanical data demonstrated increased relative micromotion at baseline (2.5 N-m) in Group 2 (1.4 +/- 0.6°) compared to Group 1 (0.3 +/- 0.1°, p=0.002). Relative micromotion was also significantly increased at maximal torsion (10 N-m) in Group 2 (5.8 +/- 2.0°) compared to Group 1 (1.7 +/- 0.6°, p=0.002).

CONCLUSIONS

The exposure of bone to elevated temperature produces well-known detrimental effects and may contribute to tuberosity malunion following proximal humeral fracture repair with hemiarthroplasty. This study offers significant laboratory-based evidence indicating impaction grafting of hemiarthroplasty stems may aid in avoiding tuberosity thermal damage elicited by the use of methylmethacrylate bone cement. However, this potential benefit may come at the expense of acute construct stability, thus adding further insight for the clinical and surgical management of these fractures.

REFERENCES