A BIOMECHANICAL COMPARISON OF TECHNIQUES OF FIXATION OF PATHOLOGIC FRACTURES OF THE DIAPHYSEAL HUMERUS

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INTRODUCTION
The humerus ranks second, after the femur, in frequency of involvement by metastatic bone disease. At present, several fixation methods are used to stabilize pathological humeral fractures. However, to our knowledge, no biomechanical testing has been done to assess these techniques for fixation of pathological fractures. The purpose of this study is to compare the biomechanical parameters of five reported techniques of fixation of pathologic humeral fractures.

METHODS
Forty adult left synthetic humeri (Pacific Research Labs, WA, USA) were reamed initially to simulate osteoporotic bone seen in patients with metastatic bone disease. A 2 cm, 50 % hemicylindrical defect centered in the middle third was then created in each specimen. A transverse fracture was produced in the centre of each defect. The bones were randomly assigned to five groups of eight specimens each (Figure 1). Group A was fixed with standard 10 hole DCP plates (Zimmer Inc.) centered over the defect with 5 screws inserted on either end. In group B, the screw holes were injected with bone cement and then the screws and plate were reapplied while the cement was still soft. The defect was also filled with cement. Group C was fixed by injecting the cement into the entire intramedullary canal. The fracture was then reduced and the screws and plate were applied once the cement had hardened. In group D, the specimens were fixed with locked antegrade IM nail (Zimmer Inc.) with one proximal and one distal interlocking screw. Group E was same as D except that the defect was filled with cement. Each specimen was tested in external rotation to failure by fracture.

RESULTS
The statistical analysis of torsional stiffness values demonstrated that there were no significant difference between groups B, C, and E (P>0.16), whereas there were differences between all other group pair-wise comparisons (P<0.001) (figure 2). Groups B, C, and E were of highest stiffness, followed by A, and then D. Regarding the failure torque levels, there were no significant differences between groups A and B (p=0.99) and between groups D and E (p=1.0), whereas there were statistical differences for all other pair-wise comparisons (p<0.001). Group C had the highest maximum failure torque, followed by A/B and then D/E.

One–way analysis of variance was performed on torsional stiffness, failure torque and total energy absorbed. For values of a significance level of p<0.05, post hoc pair-wise multiple comparisons were made utilizing Tukey's honestly significant difference test.

DISCUSSION
Although dynamic compression plate fixation has become the standard surgical treatment for diaphyseal humeral fractures, intramedullary nails are still frequently utilized for pathologic fractures. The advantage of this fixation technique is that the entire bone is stabilized in the case of development of subsequent metastases in the same bone. We have developed a technique (Group C) whereby the entire intramedullary canal of the humerus is filled with polymethylmethacrylate cement, the cement is allowed to harden with the fracture reduced, and a standard broad dynamic compression plate is utilized to fix the fracture. This technique provides stabilization of the entire bone in the same manner as an intramedullary nail. The main goal of surgical management of pathologic fractures is immediate, unrestricted activity of the injured extremity, to allow for maximal quality of life for the patient who usually has a limited life expectancy. The results from this study demonstrate that, in a model of a fracture through a hemicylindrical defect in the mid-diaphysis of the humerus, fixation with a broad 10-hole dynamic compression plate after filling the entire medullary canal with cement is associated with the highest torque to failure and energy to failure with torsional forces. This fixation technique may best accomplish the clinical goal of maximal initial stability.

Figure 3 shows the total cumulative energy to failure for each group. There were no differences between pair combinations of groups A, B, D, and E (p<0.236). However, total energy to failure for group C was statistically greater than each of B, D, and E (p<0.005), but was not different from A, though it approached significance (p=0.057).

** No Statistically Significant Differences (p > 0.16)

C > B, D, and E (p < 0.005)
C not different than A (p = 0.057)

Figure 3. Total energy to failure results

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