A Biomechanical Study in Fixation Technique on Comminuted Vancouver B1 Periprosthetic Femur Fractures

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INTRODUCTION:
Treatment of periprosthetic fractures with well-fixed femoral components may be difficult to manage and internal fixation is often necessary, though the optimal method of fixation has not been resolved. Currently, locking plates have been introduced as an alternative method of periprosthetic fracture fixation. However, some clinical reports have suggested that additional fixation should be used because a single locking plate may not offer the stable fixation needed for the proper reduction of Vancouver B1 periprosthetic femoral shaft fractures. The purpose of this study was to evaluate the stiffness of three different locking plate constructs for the fixation of comminuted Vancouver B1 periprosthetic femoral shaft fractures.

METHODS:
In this biomechanical study, ten synthetic femurs (Sawbones® Pacific Research Lab., Inc. Vashon WA) were implanted with a cemented femoral prosthesis. A simulated periprosthetic fracture was created distal to the implant. Three fracture fixation constructs were assessed (Figure 1). Construct A: A lateral 10-hole locked plate with 2 proximal unicortical locking screws, 2 proximal cables and 4 distal bicortical locked screws. Construct B: Construct A plus an anterior strut synthetic allograft with 4 cables. Construct C: Construct A plus an anterior 10-hole locking plate with 2 proximal unicortical locking screws and 3 distal bicortical locking screws. Axial stiffness (AS), lateral bending stiffness (BS), and torsional stiffness (TS) were measured by a material testing machine (Figure 2). Construct A was tested for all femurs, then either an allograft or a second plate was added and five construct B and five construct C were retested. Differences were determined with a one-way repeated measures ANOVA.

RESULTS:
Fixation technique was found to have a significant effect for all loading modalities. (AS, p<0.001, BS, p<0.001, TS, p<0.001)(Figure 3,4,5).

Construct C (AS 21,339 ± 2,906 N/mm; BS 10,071±1,729 N/mm; TS 6.5 ± 0.5 N-m/deg) was significantly stiffer than construct B (AS 11,682 ± 2,600 N/mm; BS 2,539 ± 281 N/mm; TS 5.6 ± 0.3 N-m/deg) which in turn was significantly stiffer than construct A (AS 4,804 ± 1,356 N/mm; BS 706 ± 65 N/mm; TS 4.5 ± 0.4 N-m/deg)

DISCUSSION:
This study demonstrated that a lateral locked plate plus an anterior locked plate with cable and locking screws provide the highest stiffness of the constructs examined for fixation of a comminuted Vancouver B1 periprosthetic femoral shaft fracture in axial, torsional, and bending loading tests. The greatest increase of stiffness was observed in the lateral bending test when supplements were added to a single plate. The reason for this result seems to be the geometry of the constructs and the direct lateral forces applied. Although in this study double locked plates had the highest stiffness, our results demonstrated that the use of an additional allograft strut demonstrated superior stiffness than a single locked plate alone. In addition, this may be a more viable treatment option when an area of bone loss is present because it may also serve to restore bone stock. Our results represented changes in construct stiffness with different construct types in a laboratory setting but care should be taken when applying these results to the clinical setting as this may not translate to improved clinical results. Thus, a further in vivo study is required to evaluate the appropriate stiffness required for optimal fracture union using locked plating technology.

CONCLUSION
A lateral locked plate plus an anterior locked plate with cable and locking screws provide the highest stiffness of the constructs examined for fixation of a comminuted Vancouver B1 periprosthetic femoral shaft fracture. A lateral plate with an allograft was also significantly stronger than locking plate alone and may be considered when areas of bone loss are present.

REFERENCE