Biomechanical Effects of Calcar Screws, DLS® and Bone Block Augmentation on Medial Support in Locked Plating of Proximal Humerus Fractures

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Disclosures:

Introduction: Proximal humeral fractures are the third most common bone fractures, occurring predominantly in the elderly [1]. Common treatments of displaced fractures are plate osteosynthesis and intramedullary nailing, depending on bone quality and fracture complexity. Although they are clinically established, complications after osteosynthesis require additional intervention in 14-20% of all cases [2]. Medial cortical comminution is regularly associated with varus deformities, subsidence of the fracture, and screw cut-out [3]. Inferomedial calcar screws and fibular allograft have been used to obtain medial support and recreate a buttress in clinical practice. Biomechanical evidence regarding medial support in locked plating of proximal humeral fractures is sparse. Aim of this study was to investigate the biomechanical effects of medial support with different screw configurations, types and additional application of a corticocancellous bone block in locked plating of proximal humeral fractures.

Methods: Human proximal humeri (n=32) from female donors were screened for bone irregularities. All were osteotomized, resulting in a 10mm gap at the surgical neck distal to the humeral head. Subsequently, they were randomly assigned to 4 treatment groups, with all groups featuring an angular stable plate (PHILOS®, Synthes) with varying screw configurations and types (Fig. 1C). Group I reassembled a basic setup of conventional locking screws, which was supplemented by additional calcar screws (Group II). In group III, screws in the humeral head were replaced by dynamic locking screws (DLS; Group III). Group IV had the same screw configuration as group II, featuring an additional cortical bone block.

Biomechanical testing was performed in a MiniBionix 858 (MTS) with a custom setup (Fig. 1A+B). A torsional load was applied at 0.1deg/sec with a load limit of ±3.5Nm. Specimens were then loaded axially and in 20deg of abduction/adduction with a 0.1mm/sec displacement control protocol and a load limit of 200N followed by cyclic loading. Load to failure experiments were subsequently performed at the same speed. Displacements in the gap were determined three dimensionally with an ultrasound device (CMS 20S, Zebris Medical). The resulting stiffness, fracture gap deflection and ultimate load were determined and compared between groups, utilizing ANOVA with Bonferroni-corrected post-hoc tests (α=0.05).

Results: Torsional stiffness was neither affected by screw configuration, nor by bone block insertion (Fig. 2B). Stiffness measured at the fracture gap showed no statistically significant differences between screw configurations (group I-III) in any direction (Fig. 2A). However, insertion of a cortical bone block significantly increased axial stiffness (group I, II, III vs IV) and stiffness in adduction (group I vs IV), by between 107% and 203%. There was an unexpected slight trend for increasing stiffness with DLS. Ultimate load to failure results showed no significant differences between screw configurations, but there was a significant increase with bone block insertion (Fig. 2C).

Discussion: The aim of this study was to determine whether the insertion of additional calcar screws affects the primary stiffness and stability of plating proximal humeral fractures. Varying screw configurations and types (DLS) only had a marginal effect; however, insertion of an additional cortical bone block significantly increased stiffness and stability. In case of severe cortical comminution with loss of medial contact, further augmentation is desirable as calcar screws alone cannot provide additional stability from a biomechanical point of view. Medial corticocancellous bone block augmentation seems to be a reliable alternative to fibular allografts. Clinical studies may show different conclusions, as we cannot illustrate the effect of additional medial support on fracture healing.

Significance: Decrease of complication rate after locked plating of proximal humeral fractures is mandatory. Biomechanical findings concerning additional medial cortical support could help to reduce varus malformation and its concomitant problems in clinical practice.

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Fig1: A) Mechanical setup for axial load with transducers for gap measurement. B) Mechanical setup for torsional load. C) Screw configuration in humerus: (I) 3 screws in the shaft (yellow), 6 angular stable screws in the head (green); (II) same as (I), with 2 additional interfemoral cancellous screws (purple); (III) 3 screws in the shaft (yellow), 6 dynamic locking screws in the humeral head (green) with 2 additional dynamic locking interfemoral cancellous screws (purple); (IV) same as (II), with additional femoral head allograft cortical bone block (orange) inserted in the gap.

Fig2: Results of biomechanical tests: A) Axial stiffness of the different groups subject to direction of loading; B) Torsional stiffness; C) Ultimate load to failure.