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Biomechanical comparison of orthogonal versus parallel double plating systems in intraarticular distal humerus fractures

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ABSTRACT

Objectives: In intraarticular distal humerus fractures, internal fixation with double plates is the gold standard treatment. However the optimal plate configuration is not clear in the literature. The aim of this study was to compare the biomechanical stability of the parallel and the orthogonal anatomical locking plating systems in intraarticular distal humerus fractures in artificial humerus models.
Methods: Intraarticular distal humerus fracture (AO13-C2) with 5 mm metaphyseal defect was created in sixteen artificial humeral models. Models were fixed with either orthogonal or parallel plating systems with locking screws (Acumed elbow plating systems). Both systems were tested for their stiffness with loads in axial compression, varus, valgus, anterior and posterior bending. Then plastic deformation after cyclic loading in posterior bending and load to failure in posterior bending were tested. The failure mechanisms of all the samples were observed.
Results: Stiffness values in every direction were not significantly different among the orthogonal and the parallel plating groups. There was no statistical difference between the two groups in plastic deformation values (0.31 mm–0.29 mm) and load to failure tests in posterior bending (372.4 N–379.7 N). In the orthogonal plating system most of the failures occurred due to the proximal shaft fracture, whereas in the parallel plating system failure occurred due to the shift of the most distal screw in proximal fragment.
Conclusion: Our study showed that both plating systems had similar biomechanical stabilities when anatomic plates with distal locking screws were used in intraarticular distal humerus fractures in artificial humerus models.
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Introduction

Distal humerus fractures are relatively uncommon and comprise approximately 2% of all fractures.[1] Double plate osteosynthesis is accepted as the gold standard treatment of distal humerus fractures in the literature.[2–6] However, the optimal plate configuration remains controversial. Multiple biomechanical studies have compared these plating systems; however, a consensus has not been reached regarding which plating system is optimal.[7–16] Earlier biomechanical studies suggested to use orthogonal plating system in distal humerus fractures,[7] whereas more recent studies showed that the parallel plating system provided greater stability.[11–17] Comparing these studies is not possible because of many study differences, including test protocols, plate designs, screw types and count, and cadaver or sawbone usage. Most of the studies in the literature, parallel plates and orthogonal plates had different alloy.[11–18] Generally nonlocking plates were used as posterolateral plate and the fixation of the distal fragment could be inadequate with these plates if the fragment is small because of the lack of the screw holes in distal fragment. In the

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recent studies anatomic locking plates were compared however, all of the screw holes in distal fragment were not filled with screws and maximum stability could not be achieved.[12–19]

The purpose of the present study was to compare the similar anatomic locking plating system configurations maximum stabilities in distal humerus fractures biomechanically. We hypothesized that the orthogonal locking plating system provided as much stability as the parallel plating system.

Materials and methods

Specimens

The AO type 13-C2 fracture model was created in sixteen identical artificial humerus models[20] (3rd-generation sawbone, Sawbones, Malmö, Sweden). The bones were divided into two groups (8 per group), the parallel plating and the orthogonal plating group. Using a saw, a transverse osteotomy was made from the top of the olecranon fossa, leaving a 5-mm gap proximal to the osteotomy site to simulate the metaphyseal comminution.[10–19] This gap prevented bone contact at the osteotomy site during all of the biomechanical tests.

Preparation

In the parallel plating group, we first performed the medial part of the transverse osteotomy using a custom-made cutting guide. Then, we fixed the medial plate and completed the transverse osteotomy. After placement of the lateral plate, we pulled back the distal screws partially and performed the intercondylar osteotomy just in the middle of the trochlea using a 0.5-mm saw. Next, anatomic reduction was performed with a reduction clamp, and the distal screws were tightened again. In the orthogonal plating group, the lateral part of the transverse osteotomy was performed first, and the posterolateral plate was fixed. The remainder of the osteotomy and fixation procedure was performed as in the parallel plating group.

Plate configurations

Medial and lateral plates were used in the parallel group and medial-posterolateral plates were used in the orthogonal group. The Acumed elbow plating system (Acumed, Hillsboro, OR, USA) was used for all of the plates. In both groups, an 8-hole medial plate (88 mm) was used. A 10-hole lateral plate (100 mm) was used in the parallel group, and a 5-hole posterolateral plate (78 mm) was used in the orthogonal group. The medial and lateral plates were 11 mm wide and 2 mm at the thickest point. The posterolateral plate was 10.7 mm wide and 4.7 mm at the thickest point. All of the plates were titanium.

Only the medial plate was slightly bent using plate benders to adapt it to the medial cortex. Four 3.5-mm locking screws and two 3.5-mm cortical screws were used for the proximal fixation in each group. All of the proximal screws were bicortical. The distal fixation was accomplished using three 3-mm locking screws for the medial plate and four 2.7-mm locking screws for the posterolateral plate in the orthogonal group. Three 3-mm locking screws were used for the distal fixation of each plate in the parallel group. All of the distal screws were unicortical. Three screws in the orthogonal group and six screws in the parallel group passed the intercondylar osteotomy, and none of the screws passed the transverse osteotomy (Fig. 1).

Acumed's Tap-Loc system was used for the distal fixation of the medial and lateral plates. In this system, the distal locking screws may be angled up to 20° in each direction, thereby allowing surgeons to use the longer screws in distal fixation and to maximize the stability of the distal fragment. Plate positions, screw lengths and locations were determined in pilot preparations with X-rays then identical screw types and lengths were used in each sample. A targeted drill guide was used to standardize the direction of the distal screws. All of the samples were prepared by the same orthopedic surgeon.

Potting

All samples were cut 17 cm above the joint surface. The proximal 5 cm of the samples was potted into a plastic cup filled with polyester cement (DYO Chemical Inc., Izmir, Turkey) (Fig. 2). All samples were tested with an electrodynamic testing machine (MTS Acumen™ Electrodynamic Test Systems, Eden Prairie, MN, USA). The samples were fixed with a clamping device to apply force. To prevent the application of force to only one point, a custom ulnohumeral interface was made using polyester cement (Fig. 3).

Biomechanical testing

Stiffness tests were first performed in the axial, coronal (varus–valgus) and sagittal planes (anterior–posterior). Then, cyclic loading and load to failure tests were performed under posterior

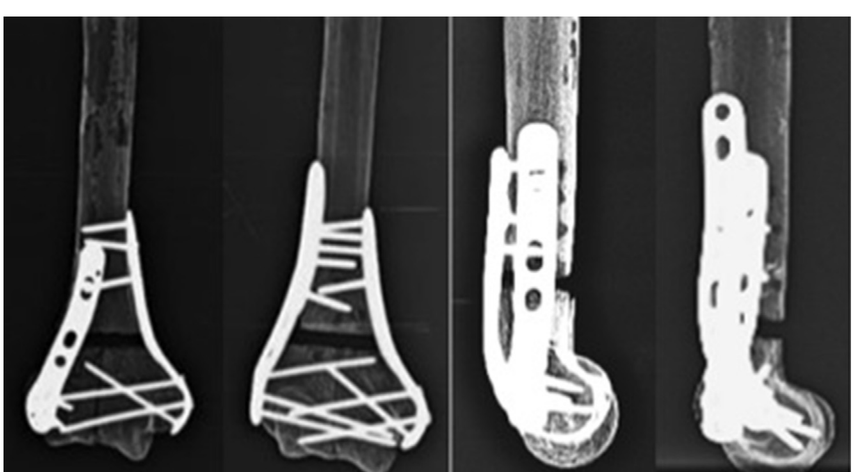

Fig. 1. Anteroposterior and lateral radiographs of the orthogonal and parallel plating samples.

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