Introduction
Intra-articular fractures of the distal humerus typically involve metaphyseal comminution and articular disruption. While relatively uncommon among joint injuries, complications associated with malunion, elbow stiffness, and subsequent decreased function are still relatively common. Dual plate fixation is the standard of care for biconcumbent distal humerus fractures. While no consensus exists regarding 90/90 plating vs. 180 plating, there is agreement that there should be one plate on each column. Pre-contoured pericarticular plates exist for fixation of distal humerus fractures reducing operative time by eliminating intraoperative contouring. They also allow for more fixation in the distal segment than standard small fragment plates. There is little data assessing the biomechanical stability of periarticular plating systems during physiologic loading. The study purpose was to determine the biomechanical stability and plate strains associated with two different types of periarticular systems for stabilization of complex segmental intra-articular fractures of the distal humerus.

Methods
Identical bi-columnar fractures with a segmental intra-articular component were created in ten epoxy composite left humeri. (Pacific Research Laboratories, Vashon Island, WA) using a custom cutting jig. Initial reduction was created with 4 Kirschner wires. An identical number of cortical screws were placed in the proximal aspect of each plate and the distal aspect of the medial plate. Due to plate design differences, screws through the distal aspect of the lateral plate differed accordingly. Based on the fracture pattern, the 180 degree plates (Acumed, Inc, Hillsboro, OR) allow 3 distal lateral to medial screws across the trochlea to the humeral column. (Figure 1) The 90 degree plates (Zimmer, Inc, Warsaw, IN) had 6 potential screw holes, but to achieve similar screw constructs, 3 of these holes were filled with lateral to medial screws. (Figure 2)

Lateral plates were then instrumented with single T-rosette 120ohm strain gages (Tokyo Sokki Kenkyujo, Tokyo, Japan) to allow recording of strain in both the longitudinal and transverse directions. Gages were applied as close to the end of the plate as possible (1.5cm for Zimmer, 2.5cm for Acumed). For flexion and extension testing, specimens were mounted horizontally in an MTS 858 bi-axial testing machine. (Eden Prairie, MN) The specimens were linked to the piston actuator with a custom designed ulno-humeral joint. The piston applied ±100N at 0.5mm/sec for 20 cycles. A same procedure was used for varus/valgus stiffness with the humerus rotated 90 degrees. For axial compression and torsion testing, the specimen was mounted parallel to the loading axis of the piston. For torsion, axial moments were applied for 20 cycles between ±2Nm at 0.5 deg/sec using the same custom joint. In compression, the piston applied compressive loads from 10-100N at 0.1mm/sec for 20 cycles. Data for displacement (mm), force (N), angle (radians), torque (Nm), and longitudinal/transverse plate strain (microstrain) were collected at 10Hz for the duration of each test. Construct stiffness and strains in both directions for each test were evaluated using a one-way ANOVA (p<0.05).

Results
There were no differences in physiologic stiffness between plating systems across tests. (Figure 3) However, the Zimmer system approached statistically significant increased stiffness in both flexion (p=0.1) and torsion (p=0.1). There were no differences in longitudinal strains between constructs for torsion (p=0.9) and varus/valgus (p=0.8). However, the longitudinal strains for the Zimmer construct approached significantly less strain in flexion/extension (p=0.1) and were significantly lower in axial compression (p<0.05). (Figure 4). For transverse strain, there were no differences between systems for flexion/extension, axial compression or varus/valgus. However, the Acumed system demonstrated significantly lower transverse strains compared to the Zimmer construct (p<0.04). (Figure 5).

Discussion:
The Zimmer plating system generally had increased stiffness compared to the Acumed system with significantly less strain during axial compression. However, the Acumed system had significantly less strain in the transverse direction during torsion. While both systems appear to adequately stability this fracture pattern, the 90 degree offset system may allow for stabilization of small lateral fragments due to the increased number of holes in this area.

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