INTRODUCTION:
Comminuted fractures of the olecranon remain complex entities. The optimal method of fixation has not yet been determined. The purpose of this study was to compare the stability of dual medial and lateral plating and posterior plating, with and without an intramedullary screw, in a cadaveric model simulating a highly comminuted olecranon fracture. The null hypothesis was that there was no significant difference in the stability of these constructs.

METHODS:
18 cadaveric elbows from donors averaging 64 years of age were sectioned from fresh frozen upper extremities at the mid arm and distal forearm. Each specimen was examined clinically and radiographically to rule out pathology of the distal humerus, proximal radial and proximal ulna.

Each elbow was then randomly assigned to one of three groups. Group 1 was fixed with dual medial and lateral 3.5mm dynamic compression plates (Synthes), using 2 cancellous screws per plate (Fig. 1). This was the maximum number of screws that could be predictably placed in the segment, site resulted in 4 bicortical cancellous screws in the proximal ulna. Each of the plates was then fixed to the ulna shaft with three bicortical screws each, for a total of 6 screws. Group 2 was fixed with a posterior 3.5mm dynamic compression plate with a 3.5 mm intramedullary “homerun” screw (Fig. 2). This screw (50 mm length) was placed through the plate, across the fracture gap and into the ulnar shaft. Two other cancellous screws were placed around the long lag screw into the proximal ulnar fragment. Three distal bicortical screws secured the plate to the distal ulnar fragment. Group 3 was fixed with a posterior 3.5mm dynamic compression plate in identical fashion except that the intramedullary screw was replaced with a shorter screw which remained in the proximal fragment and did not traverse the osteotomy site (Fig. 3).

The plate(s) were first placed on the intact ulna and then removed in order to create a fracture. Then the proximal ulna was osteotomized with an oscillating saw using a custom made jig to produce a 7 mm full-thickness segmental defect in the middle third of the olecranon. Once the segment was excised, the plates were repositioned and no contact occurred between the proximal and distal fragments, simulating a highly comminuted fracture without cortical continuity.

Specimens were then tested using a cyclical loading protocol with a servohydraulic test machine (MTS machine, Instron Corporation). Force was applied to the distal most posterior aspect of the ulnar shaft, distal to the end of the plate. This force was applied in an anterior direction in line with the elbow’s motion axis to create 3 point bending of the construct.

Ten cycles were performed at each force level with incremental increases of 20 N. The force was increased until each specimen failed catastrophically (i.e. proximal fragment pull-out). Gap displacement was measured using photoreflective markers (PC Reflex). Failure was defined as 3 mm of displacement at the posterior aspect of the fracture site or catastrophic failure, whichever came first. The results were analyzed by analysis of variance with post-hoc Tukey test. All differences were considered to be significant at a probability level of 95% (p>0.05).

RESULTS:
With failure defined as either 3 mm of displacement at the posterior aspect of the fracture site or catastrophic failure, the mean bending moment at failure for specimens with a posterior plate but without an intramedullary screw was 17.4 ± 10.2 Nm. The mean bending moment at failure for the dual medial/lateral plated specimens was 19.9 ± 5.6 Nm. This difference was not statistically significant (p > .05). The mean bending moment at failure for specimens with a posterior plate and an intramedullary screw was 44.5 ± 6.9 Nm, which was significantly greater than for specimens with either dual plating or posterior plating without an intramedullary screw (p = 0.01 for each). The intramedullary screw increased the stiffness of the posterior plate construct 256%.

Focusing on only catastrophic failure, the mean bending moment at catastrophic failure for the posteriorly plated specimen without intramedullary screws was 20.6 ± 11.0 Nm. The mean bending moment for the dual medial/lateral plated specimens was 26.1 ± 8.2 Nm. This difference was not statistically significant (p > .05). The mean bending moment at catastrophic failure only for the posteriorly plated specimen with intramedullary screws was 45.2 ± 6.3 Nm, which was significantly greater than for specimens with either dual plating (p =.05) or posterior plating without an intramedullary screw (p = 0.01).

DISCUSSION:
To our knowledge, the biomechanical importance of the intramedullary screw placed through the most proximal hole of the posterior plate has not yet been evaluated. Placement of an intramedullary screw may limit options for placement of posterior screws in cases of extreme comminution. Therefore, its importance to the strength of the fixation construct should be known.

In this cadaveric model simulating highly comminuted olecranon fractures, there was no statistically significant difference in bending strength between specimens fixed with a posterior plate without an intramedullary screw and dual medial and lateral plating. Based upon our observations, the posterior plate’s ability to act as a tension band device compensated for its lesser number of screws in the proximal fragment, as well as the unicortical nature of these screws. However, it seems that the most biomechanically significant event was the addition of the intramedullary “home run” screw. Clearly, the intramedullary “home run” screw is critical to the strength of fixation for highly comminuted olecranon fractures.

The posterior plate with intramedullary screw was the strongest construct in our testing protocol. The intramedullary screw rendered the posterior plate construct 2.5 times stiffer. This supports the fact that this intramedullary screw is critical to strong fixation of comminuted olecranon fractures.