BIOMECHANICAL ANALYSIS OF SUPRACONDYLAR HUMERUS FRACTURE PINNING FOR SLIGHTLY MALREDUCED FRACTURES

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Introduction: Treatement for displaced Type II and III supracondylar humerus fractures may require closed reduction followed by percutaneous pinning. Due to potential ulnar nerve damage, optimal pin configuration is debated. Previous biomechanical work has suggested that two crossed pins resist torsion better than the purely lateral configurations. Some authors have advocated the use of three pin configurations to maximize stability. A recent study examined the effect of medial column comminution on biomechanical stability. However, no previous study has tested stability when complete anatomic reduction is not achieved. Slight internal rotations are difficult to diagnose on plain radiographs, and dispose patients to distal fragment tilt in the coronal plane and subsequently cubitus varus. We hypothesized that internally rotated humerii would be less stiff than anatomically reduced humerii, and investigated whether increasing pin number or using a crossed pin configuration would create stability equivalent to a stable anatomically reduced two pin construct.

Materials and Methods: 64 synthetic humerii (Pacific Research Laboratories, Vashon Island, WA) were sectioned through the olecranon fossa to simulate a transverse fracture. Humerii were then randomized to either an anatomic reduction or a malreduction with 20 degrees of internal rotation. Fractures were stabilized using 1.6mm wires into one of four pin configurations: two lateral pins and one medial pin, three lateral pins, two crossed pins or two lateral divergent pins (n=8/group). Pins were inserted via a custom pin guide to ensure reproducibility. Specimens were then tested in varus, valgus, and extension loading at 0.5 mm/s between 5N and 50N of load for 10 cycles. Internal and external rotations were tested at 0.5 deg/s between ±1N for 10 cycles. All tests employed custom molds of the articular surface to ensure that all motion occurred across the facture. Data for displacement and force or rotation and torque were sampled at 10Hz and stiffness values for the loading phases of each test calculated. These stiffness values were then compared using 2x2x2 three way ANOVA ($p<0.05$) with a Tukey's post hoc individual comparison test.

Results: There were no instances of permanent displacement of the fracture resulting in loss of fixation or pin deformation either with or without anatomic alignment. Stiffness in varus loading was significantly greater for three pin constructs compared to two ($p<0.05$), and significantly less for malreduced specimens compared to anatomically reduced ($p<0.001$) but was not significantly affected by configuration (crossed vs all lateral). There was not a significant interaction nor did any of the malreduced three pin configurations reach stability equivalent to anatomically reduced 2 laterally divergent pins. In valgus loading, three pin constructs were significantly stiffer than two pin constructs ($p<0.02$) but malreduction and configuration had no significant effect. All malreduced three pin constructs had stiffness values equivalent to anatomically reduced 2 laterally divergent pins. For extension, the number of pins and the configuration and the interaction term favoring two lateral pins and three crossed pins were all significant ($p<0.01$, $p<0.05$, $p<0.05$ respectively). The three pin malrotated groups had similar stability to anatomically reduced two lateral pin group. For both internal and external torsion, malreduced specimens were significantly weaker than anatomically reduced specimens ($p<002$, $p>0.001$ respectively). In internal rotation, three pins were significantly stiffer ($p>0.05$) than two, but configuration and interaction were not significant. For external rotation, pin number and configuration both significantly affected stiffness ($p<0.01$ and $p<0.01$). In both internal and external rotation, the malreduced 3 pin constructs had stability comparable or better to the anatomically reduced two lateral pin.

Discussion: Three pin constructs were shown to be stiffer in physiologic loading for all loading directions investigated. Malreduction decreased stability significantly in both rotations and varus loading. However, the malreduced three pin constructs were shown to have equivalent stiffness to the anatomically reduced two lateral pin constructs in all loading modes but varus. While every attempt to properly reduce fractures should be made, internal rotation of the fracture fragment may be difficult to diagnose especially when comminution disguises key radiographic signs of malrotation such as fish-tail. Though medial tilt is unacceptable due to the propensity of cubitus varus to follow, some level of error is unavoidable due to the difficulty of visualizing the true position of the fracture. When rotation is suspected, fixing fractures more rigidly using an increased number of pins may reduce the incidence of cubitus varus. Constructs using lateral pins had stability equivalent to crossed pin ones in varus and valgus loading and internal rotation. This leads the authors to believe that adequate fixation can be obtained with lateral constructs.

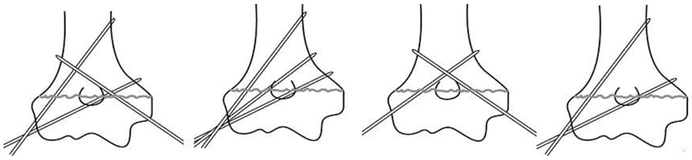

Figure 1: Pinning configurations.

Figure 2: Positions of anatomically reduced (left) an malreduced (right) fractures.

TABLE 1: Stiffness	**ANATOMIC REDUCTION**				**MALROTATION**			
In N/mm or Nmm/deg	THREE CROSSED	THREE LATERAL	TWO CROSSED	TWO LATERAL	THREE CROSSED	THREE LATERAL	TWO CROSSED	TWO LATERAL
VARUS (N/mm)	21.3 ±5.9	20.8± 6.1	11.8 ±2.4	22.0 ±3.3	13.1 ±2.6	15.5 ±2.3	12.8±2.3	12.0±2.4
VALGUS (N/mm)	15.8±4.8	14.3±6.4	11.4±3.8	14.7±3.1	13.9±3.0	15.9±3.5	9.9±1.2	13.0±3.5
EXTENSION (N/mm)	10.4±2.2	13.1±3.1	6.9±1.4	12.5±2.2	13.7±3.3	13.7±2.4	7.3±1.7	11.3±2.4
INTERNAL ROTATION (Nmm/deg)	133±35	128±26	106±46	103±36	118±35	101±27	83±38	84±14
EXTERNAL (Nmm/deg)	163±35	142±17	110±53	137±26	142±43	127±30	85±12	85±17