Biomechanical Comparison of Three Different Olecranon Fracture Fixation Methods

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INTRODUCTION: Olecranon fractures are common injuries and account for approximately 1% of all fractures and 10% of those around the elbow[1,2]. Traditional treatment modalities include conservative treatment and use of tension band wires (TBW). More recently, locked plating (LP) and intramedullary nailing (IMN) have been gaining popularity. This biomechanical study investigated and compared fracture gapping, construct stiffness, and yield strength of these three treatment types under dynamic loading in an obliquely osteotomized synthetic bone model.

METHODS: Twenty-five 4th generation composite ulnas (Sawbones) were cut to 180-mm length from the proximal end and further prepared depending on treatment type. For the <u>TBW treatment (n=5)</u>, fracture alignment was ensured by first inserting two .062” k-wires from proximal to distal, followed by removal of the wires and creation of a 60-degree oblique olecranon osteotomy. The wires were then re-placed, the osteotomy reduced with pointed forceps, and a standard tension band wire construct created using 18-gauge cerclage wire, following the technique described by Hammond[3]. For the <u>LP treatment (n=5)</u>, a 3-(shaft) hole Olecranon Plate (Acumed) was used. To ensure fracture alignment, the plate was preliminarily secured with two unicortical screws proximally and a single bicortical screw through the distal end of the plate’s reduction slot. The hardware was then removed to create the above-described osteotomy, before being re-positioned to align with the previously created holes. Finally, the osteotomy was reduced as described above and the plate fixation completed per surgical technique, filling all eight plate holes with appropriately sized screws (locking (lkg) 3.5 mm, bicortical, except for lkg 2.7 mm bicortical in proximal cluster, lkg 3.5 mm unicortical for “homerun” screw across osteotomy and 3.5 mm non-lkg bicortical for reduction slot). For the <u>IMN treatment (n=15)</u>, alignment was ensured by drilling and reaming to 3.1-mm diameter and preliminary insertion of a 3.0 mm x 120 mm Straight Ulna Nail (Ulna Nail 2, Acumed), including bicortical drilling of the first proximal interlocking hole, using the included targeting arm. Osteotomy and reduction were then performed as described above and nail fixation completed per surgical technique, including use of four interlocking screws. Three different interlocking screw types/methods were tested as part of the IMN group: 3.5 mm *headed* screws (HS, n=5) and 3.5 mm *headless* screws with (HLSC, n=5) and without (HLS, n=5) near-cortex countersinking.
For <u>all treatment groups</u>, proximal and distal ends were then potted with PMMA in custom fixtures, covering any exposed hardware with modelling clay to allow unrestricted movement after PMMA application. Finally, a miniature DVRT displacement sensor (LORD) was mounted to bridge the osteotomy gap posteriorly. The constructs were then mounted horizontally in a servo-hydraulic load frame (Instron 8874), the trochlear notch supported by a cylinder simulating the distal humerus (Fig. 1). Triceps tendon pull was simulated by applying a compressive load in the opposite direction above the tendon insertion point. Dynamic loading was applied at a physiologic magnitude of 200 N[4], and an R-ratio of 0.1 (20 N min. load) for 10,000 cycles, followed by dynamic loading at a 500-N magnitude (R = 0.1), for 1,000 cycles. Finally, a quasi-static ramp load to 1,000 N was applied at a rate of 5 mm per minute. Statistical comparisons were done using a One-Way ANOVA with Tukey post-hoc test (α= .05). Sample size was estimated via power analysis of pilot test data.

RESULTS: All constructs withstood the full dynamic loading regimen without catastrophic failure. Average gapping at 200 N/500 N load levels was 0.98 ± 0.16 mm/2.87 ± 0.43 mm for <u>TBW</u>, 0.09 ± 0.04 mm/0.26 ± 0.09 mm for <u>LP</u>, and between 0.43 ± 0.19 mm/1.38 ± 0.39 mm (HLSC) and 0.51 ± 0.22 mm/1.65 ± 0.41 mm (HS) for <u>IMN</u> constructs with different screw fixation types (Fig. 2). At both load levels, there were statistically significant differences (p<.05) between TBW, LP, and IMN, but not between different screw types within IMN.
Post-cyclic static loading resulted in yield strengths of 594 ± 19 N for <u>TBW</u>, 813 ± 80 N for <u>LP</u>, and between 655 ± 54 N (HLSC) and 724 ± 41 N (HLS) for <u>IMN</u> constructs with different screw fixation types (Fig. 3). LP was statistically significantly stronger (p<.05) than all other fixations, except for IMN with HLS; and TBW was significantly weaker (p<.05) than IMN with HS and HLS, but not HLSC. Post-cyclic stiffness values were 815 ± 79 N/mm for TBW, 1,118 ± 183 N/mm for LP, and between 640 ± 108 N/mm (HS) and 674 ± 102 N/mm (HLSC) for IMN constructs with different screw fixation types. LP was significantly stiffer (p<.05) than all other fixation types; and there was no significant difference (p>.05) among TBW and IMN regardless of screw fixation type.

DISCUSSION: The presented study provides valuable information regarding the ability of commonly used fracture fixation types to provide stable fixation of simple, oblique Olecranon osteotomies and Schatzker Type C fractures. Tension band wiring has long been considered the gold standard for surgical fixation of simple Olecranon fractures but is associated with a high incidence of construct failure and migration. Locked plating can address some of these concerns but may result in palpable hardware prominence. Intramedullary nailing presents a possible alternative, and in this study provided comparable or better fixation strength than tension band wires, but less than locked plating.

SIGNIFICANCE/CLINICAL RELEVANCE: While biomechanical test results are not always predictive of clinical performance, this study provides valuable insights into the comparative fixation strength and stiffness provided by three different treatment modalities for Olecranon fractures.

REFERENCES: [1] Duckworth et al.: The epidemiology of fractures of the proximal ulna. Injury, 2012;43(3):343-6; [2] Rommens et al.: Olecranon fractures in adults: factors influencing outcome. Injury, 2004;35(11):1149-57; [3] Hammond et al.: Biomechanical analysis of a transverse olecranon fracture model using tension band wiring. J Hand Surg Am, 2012;37(12):2506-11; [4] Nowak et al.: Locking-plate osteosynthesis versus intramedullary nailing for fixation of olecranon fractures: a biomechanical study. Int Orthop, 2013;37(5):899-903.

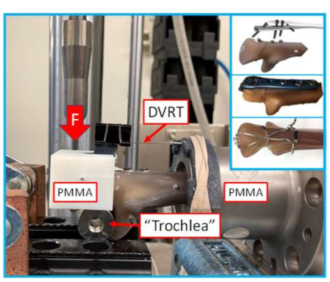

Figure 1: Test setup and illustration of Olecranon fixation devices tested.

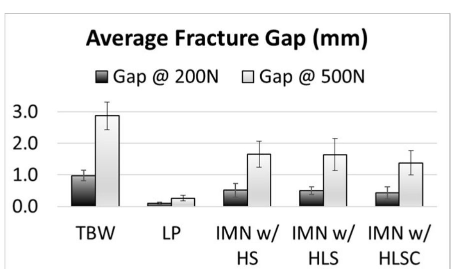

Figure 2: Average gapping of the osteotomy during cyclic application of 200 N and 500 N loads.

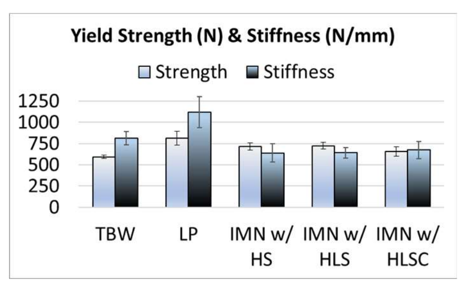

Figure 3: Yield strength and stiffness of the Olecranon fixation devices post cyclic testing.