

Biomechanical Testing of 2.8 Dorsal Olecranon Plates

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Introduction

Fractures of the proximal ulna vary from simple olecranon fractures to complex transolecranon fracture-dislocations [1]. Olecranon fractures, which account for approximately 10% of all elbow fractures and 20% of proximal forearm fractures, are the most common type of proximal ulna fracture in adults [2], [3]. The surgical treatment of simple olecranon fractures can be performed with tension band techniques or plating, while locking plates are particularly beneficial in multifragmentary or osteoporotic olecranon fractures, e.g. Monteggia fractures, as they can reduce fixation failure [4]. Dorsal locked plating enables the surgeon to safely stabilize fractures, e.g. in association with a posteriorly dislocated radial head, and achieve early joint movement with good functional results [4], [5].

With the introduction of the 2.8 TriLock Dorsal Olecranon plates, Medartis now offers the first dorsal plating system using exclusively 2.8 mm screws. Other dorsal olecranon systems use 3.5 mm screws in the shaft and either 3.5 mm or reduced diameter screws in the epiphysis. A reduced screw diameter in the proximal ulna requires a second set of drills and screwdrivers, which might complicate the surgical use of the system. In addition, the use of 3.5 mm screws reduces the number of available screw trajectories for capturing complex proximal fracture patterns. Therefore, it may be advantageous to offer a system that utilizes a reduced screw diameter in both the shaft and the metaphyseal section of the plate.

Using a reduced screw diameter raises the question of whether such a construct can be stable enough to fix complex fractures of the ulna. Biomechanical testing compared the fatigue strength of the Medartis 2.8 TriLock Dorsal Olecranon plate and screw construct with a leading competitor's construct using 3.5 mm shaft screws.

Materials and Methods

A construct test (screws and plate) was performed with a bone model simulating a complex olecranon fracture, similar to what occurs in a Monteggia-like lesion. Both the Medartis plate and the competitor's plate have comparable clinical indications and are used for dorsal plating of olecranon fractures. Six Medartis constructs and six competitor constructs were tested for comparison. The 3D-printed substrate simulates a V-shaped fracture (A) in the proximal epiphysis and a butterfly fragment (B) in the diaphysis (see Figure 1, top).

The test setup is based on an in vivo load case and represents a worst-case load situation where the plates' weakest cross-sections are in the loa-

ded area. The loaded area affects a section of the plate that contains 2.8 mm screws in the Medartis construct, but 3.5 mm screws in the competitor construct. The load is transferred to the midpoint between the two fractures A and B (see Figure 1, bottom).



Figure 1: Test set-up (top: fracture lines, bottom: test set up on the machine)

Figure 2 shows the screw arrangement in both constructs, optimized to stabilize the different bone fragments. The number of shaft screws used was kept the same for both constructs, resulting in three unused screw holes in the Medartis construct.



Figure 2: Screw configuration (top: Medartis 2.8 TriLock Dorsal Olecranon Plate, indicating unused screw holes (circled in red), bottom: competitor)

The constructs were subjected to fatigue testing. A cyclic load was applied at 5 Hz according to a staircase loading scenario, consisting of 50,000 cycles with an initial load of 200 N, after which the load was increased by 15%. This load increase was then repeated every subsequent 10'000 cycles until failure of the construct.

Results

Figure 3 provides an overview of the results. Statistical analysis (two-sided t-test) shows that the fatigue strength of the Medartis 2.8 TriLock Dorsal Olecranon screw and plate construct is superior to the competitor's (95% confidence

interval, $p < 0.01$). The Medartis construct demonstrated an average load of 601 ± 51 N, compared to 486 ± 29 N for the competitor, indicating a 32% improvement. Additionally, the Medartis construct withstood 13% more cycles before failure. The Medartis construct failed due to screw head shear-off, while the competitor's construct failed due to a plate fracture at the edge of a 3.5 mm locking screw hole. The 3.5 mm locking screw requires a larger hole in the plate than a 2.8 mm TriLock screw. Consequently, the plate in the predicate system failed at a lower load than in the Medartis system.

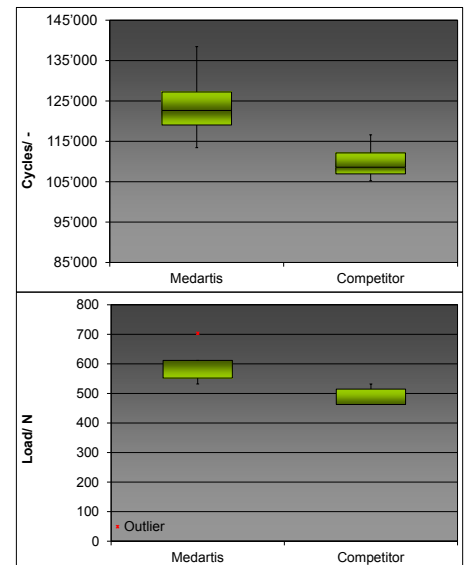


Figure 3: Results of the fatigue test (top: load cycles, bottom: failure load)

Conclusion

Based on the above results, it can be stated that the Medartis construct using exclusively 2.8 mm screws is significantly stronger than a competitor construct using 3.5 mm screws in the shaft section of the plate using the testing apparatus described. The Medartis construct withstands higher loads and more load cycles than a construct with 3.5 mm screws.

Literature

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- [2] Cantore et Al., JSES International 2022; V6: 309
- [3] Sahajpal et Al., J Hand Surg 2009;34A:357
- [4] Siebenlist et Al., EFORT Open Rev 2019;4:1-3
- [5] Xiao et Al., Hand Surg Am.2021;46(11):1006-1015