Standard bicortical screw fixation is not superior to monocortical fixation using mini-locking plates: a biomechanical study in a metacarpal fracture model

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Introduction: The use of locking plates with angular screw stability increases the primary strength, thereby reducing the rate of implant-related failures of large bone osteosynthesis. First biomechanical studies on miniplates in craniomaxillofacial fractures demonstrated a higher stability in 40% A monocortical fixation technique could avoid flexor tendon interfere and tendon ruptures in contrast to conventional bicortical fixation.

The purpose of this study was to determine strength and stiffness of angular fixed implants in a fracture model of metacarpal bone in comparison to standard titanium plates.

Materials and Methods: Fresh second metacarpal bones from domestic pigs (n=60) were used and divided randomized in 6 equal groups. Short transverse mid-shaft fracture was generated using standardized 3 point bending method. Load was applied apical distal (distance: Waste edge – point of force transmission 10mm) with a constant speed of 100mm/min until failure was noted . Specimens were fixed either with standard Leibinger-Stryker® 2.3mm plates and screws in a monocortical (group I, n=10) or bicortical (group II, N=10) technique. Newly designed locking plates (Leibinger- Stryker®) were used in the same manner (monocortical =group III, bicortical =group IV). Biomechanical testing was performed by using the Zwick/Roell® testing machine. For each study group a modified load to failure 3 point bending test was performed according to the described fracture setting. Ultimate strength was defined as the peak load proceeding a sharp decrease in the load-displacement curve. Load-deflection curves were continuously recorded, and the ultimate failure was measured as units of force (N). Stiffness was determined from the linear region of the load-displacement curves and recorded as N/mm. Additional cyclic loading was applied apical distal with a frequency of 1Hz, 1000 cycles and 20% of the maximum load to determine the displacement and load to failure after the cycles (group V bicortical standard, group VI monocortical angular fixed).

Statistical analyses were performed with SPSS® using the Mann-Whitney U Test for two independent specimens (p<0.05)

Results: A significant difference in maximum load between monocortical standard fixation (group I) and bicortical standard fixation (group II) was demonstrated (p < 0.01). The difference between monocortical (group III, 440±85N and 83±35N/mm) and bicortical (group IV, 378±116N and 70±31N/mm) angular fixed stabilisation was not significant in maximum load and stiffness. Significant differences, however, were found between stiffness (p=0.001) and maximum load (p=0.05) comparing standard and angular fixed plates in a monocortical fixation technique.

Discussion: The presented results show that the new generation of mini-implants as locking plate systems can be used to achieve a higher stability for fixation of metacarpal fractures. The ability of monocortical stable fixation can minimize the flexor tendon interference and probably reduce bone and soft tissue trauma.

Image 1: Maximum load of monocortical (group I, III) and bicortical (group II, IV) plate fixation.

The stability of monocortical angular fixed plates were even higher than the standard bicortical fixed plates (maximum load p=0.06, stiffness p=0.03).

After cyclic loading there was a comparable decrease of the maximum load in group V and VI (60% vs. 58%).

Discussion: The presented results show that the new generation of mini-implants as locking plate systems can be used to achieve a higher stability for fixation of metacarpal fractures. The ability of monocortical stable fixation can minimize the flexor tendon interference and probably reduce bone and soft tissue trauma.