Stability of midface fracture repair using absorbable plate and screw system with pilot holes drilled at acute angles

ABSTRACT

Aim: To determine if the KLS Martin Sonic Weld ™ system provides plate-screw construct stability in human skulls even when placed at acute angles at the midface buttresses. The strength of the construct will be compared to similar absorbable miniplates with screws placed at 90degree angles.

Background: Conventional plating systems use titanium plates for fixation of fractures. The benefits of titanium include its strength and biocompatibility. However, one of its weaknesses is that titanium plates require that screws be placed at a 90 degree angle to the pilot holes. This can become problematic in certain locations such as the midface, where raising a flap tethered superiorly creates a situation where drilling a 90 degree pilot hole with parallel screw placement extremely difficult. Today, a variety of craniomaxillofacial osteosynthesis systems are available on the market, including resorbable plating systems. Specifically, the KLS Martin Sonic Weld system ultrasonically fuses the plate and the head of the pin when placed. This system also ultrasonically vibrates the pin to fill the pilot hole grooves created by the drill. It will fill them completely even at angles of less than 90degrees. This situation would provide a tremendous advantage in hard to reach areas because pilot holes may be drilled at angles of less than 90 degrees, requiring less periosteal elevation, and the plate screw construct will maintain stability, unlike its titanium counterpart.

Hypothesis: Ultrasonically vibrated pins placed into absorbable miniplates at angles of less than 90 degrees with the Sonic Weld ™ system will tolerate the same amount of stress as the Sonic Weld system placed at a 90 degree angle before demonstrating plate-screw construct failure.

Methods: Testing was performed at the Wayne State University Bioengineering test laboratories. Twenty skulls were prepared by creating osteotomies in the midface buttresses bilaterally. Fractures were created at the nasomaxillary butress, zygomaticomaxillary buttress and zygomaticofrontal suture. We also tested the the zygomatic arch by creating a fracture at its midpoint.
Twenty specimens were plated on one side of the midface with the KLS Martin Sonic Weld system with pilot holes and pins placed at 90 degrees. On the contralateral side, the butressess were plated with the KLS Martin Sonic Weld ™ system at angles of 75, 60, 45, 30 degrees. The data was compared as matched pairs within each specimen and statistically analyzed. The specimens were tested in conjunction with faculty from the Wayne State University Department of Biomechanical Engineering using an Instron deviceat a low-speed/quasistatic loading. The fracture fixation was tested by creating tension across the fracture. Shearing forces were applied using ¼" bolt. Failure

defined as a decrease in load and occurred due to pin failure, plate failure or bone fracture.
Equipment required: 1) Instron device 2) High-speed camera 3) TDAS Data Acquisition system.

Data Analysis: A statistical analysis was conducted utilizing Predictive Analytic SoftWare (PASW 18) created by SPSS (Chicago, IL). One tailed, paired T-tests were conducted using the ideal fixation on the left hemiface (90° angle) as the control and the opposite right hemiface fixation as the test. Due to the limited number of tests, a bootstrapping test was also conducted to validate the T-tests. .

Results : A total of 57 paired tests were collected (114 total). Three tests could not be included due to a lack of failure in the test system. Twenty failures were due to bone breakage while the remaining 94 tests failed as a result of the plate-screw construct breaking. Comparison between the 57 available paired fixations provided a statistically significant difference between the test and the control groups ($p = 0.025$). The mean failure load for all the sites on the test group was greater than 240 N, except for the Fronto-Maxillary site at 30 degrees (197.9 N).

Conclusion: The main force acting on the zygomaticomaxillary complex is the masseter muscle. The masseter of an adult with facial fracture can generate a force of 25 to 250 N. This study shows that screws inserted at 90 angle have plate failure loads above the loads generated by the masseter muscle, and should be safe to use in the middle third of the face. Acute angles, < 90 are associated with worse failure loads than 90 screws, but still can stand loads above 250 N. In cases of difficult access, plating at angles < 90 is a viable option with the use of the Sonic Weld System.