Screw Pull-Out Force is Dependent on Screw Orientation in an Anterior Cervical Plate Construct

Christian P. Dipaola, MD, Rochester, NY (n), Justin A. Jacobson, MD, Rochester, NY (n), Hani Awad, PhD, Rochester, NY (n), Bryan P. Conrad, MEng, Gainesville, FL (n), Glenn R. Rechtine, MD, Rochester, NY (n)

INTRODUCTION: One of the commonly held justifications for orienting cervical screws in an angled direction to the midline and/or cephalad/caudal, is to increase pull-out strength of the construct. Screws may also be angled to the midline to allow use of longer screws due to vertebral anatomy. This concept is widely taught and has guided implant design recently so that many manufacturers offer plating systems that only allow specific angulation and orientation of the screws. This assertion however, has never been tested and validated from a biomechanical perspective. Manufacturers also offer “variable angle” vs. “fixed angle” systems which may offer an advantage in terms of construct strength. The purpose of our study is to test the influence of screw orientation and plate design on the maximum screw pull-out load in a biomechanical screw pull-out model.

METHODS: Saw bones™ sections were used to simulate osteoporotic cervical vertebral bone (method validated in a previous study). A custom made mount allowed plate pull-off with an Instron DynaMight™ 8841 servohydraulic testing machine. A Medtronic Atlantis™ single level anterior cervical plate was centered and affixed to the sample. This plate design allows either fixed or variable angle screws to be used and has a set screw at each paired level to restrict back-out. Variable and fixed angle 4.0x15mm and 4.0x13mm self tapping screws were used. The fixed angle screws can only be placed properly at 12° convergent to the midline and 12° in the cephalad/caudal (12° up and in) direction (Fig. 1). Three groups were tested: 1. fixed angle, all screws at 12° up and in, 2. variable angle, all screws at 12° up and in, 3. variable angle, all screws at 90° to the plate. Peak screw pull-out force was measured as the machine pulled the plate off at a rate of 1mm/min. Five samples were tested for each condition.

RESULTS: No significant difference was detected in this anterior plating system when comparing group 1, the fixed angle construct = 288.4± 37.7N (mean±SD) vs. group 2, the variable angle screw construct = 297.7± 41.31N p≤ .73 (Fig. 2)

A significant difference was found in favor of group 3, the all 90° screw orientation = 415.2 ±17.4N, compared to group 2, all screws 12° “up and in”
There was a significant increase in maximum pull-out force to failure for the construct with all screws at 90° to the plate. When group 3 (all 90°) was tested using 13mm screws, there was still a trend toward better pull-out strength, compared to group 2 (all screws 12° “up and in”) with 15mm screws (345.2±20.5 vs. 297.4±41.3, p≤.06).

CONCLUSIONS: In this particular plating system, using a direct plate pull-out model, we have shown that screw orientation does influence maximum force to failure for the entire construct. When all four screws are oriented 90° to the plate the construct has the greatest ability to resist pull-out. We also showed that 13mm screws all at 90° perform just as well (and possibly better) than 15mm angled screws. This is counter to current teaching practices and cervical plating system recommendations. There was no difference in fixed vs. variable angle construct performance. It is important to emphasize that these results represent findings for one plate design.
Fig. 2

Comparison of Medtronic Variable vs. Fixed Angle Plate Construct

![Comparison of Medtronic Variable vs. Fixed Angle Plate Construct](image)

$p \leq 0.73$

Fig. 3

Comparison of Medtronic Variable Angle Screws All at 90 degrees vs. All 12 degrees "Up & In"

![Comparison of Medtronic Variable Angle Screws All at 90 degrees vs. All 12 degrees "Up & In"](image)

$p \leq 0.0016$
References


If noted the author indicates something of value received. The codes are identified as  a - research or institutional support; b - miscellaneous funding; c - royalties; d - stock options; e - consultant or employee; n - no conflicts disclosed and * disclosure not available at the time of printing. For full information, refer to inside cover.