The Effect of Fixed Angle versus Variable Angle Plates and Screw Orientation on Biomechanical Strength of Fixation in Anterior Cervical Plate Constructs

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INTRODUCTION: Historical teaching for cervical spine surgery is that orientation of screws in an angled direction to the midline and/or cephalad/caudad, increases pull-out strength of the construct and allows the use of longer screws\(^2,3\). Furthermore, fixed-angle locking cervical plates are thought to provide increased stability. Despite these teachings, there is a paucity of supporting biomechanical evidence. This study evaluates the effect of screw orientation and plate type (fixed vs. variable angle) on biomechanical strength to failure.

METHODS: Two constructs, a fixed-angle (small stature CSLP\(^\text{TM}\)) and a variable angle CSLP\(^\text{TM}\), were tested for peak pull-out strength using Saw bones\(^\text{TM}\) sections (method validated in a previous study\(^1\)). 4.0x14mm and 4.0x16mm self tapping, locking screws were used. Screws were oriented in the fixed-angle plate as 12° convergent to midline and 12° cephalad in the proximal holes, and 12° convergent to midline and 0° cephalad/caudad in the distal holes (Figure 1). Screws in the variable plate were instrumented in 3 orientations: (1) identical to the fixed angle plate (“mixed orientation”), (2) all screws at 0° to midline and 0° cephalad/caudad (all 90° to plate), and (3) 12° convergent to the midline and 12° in the cephalad/caudad (all 12° “up and in”). Biomechanical testing was performed on an Instron DynaMight\(^\text{TM}\) 8841 servohydraulic testing machine and custom jig, measuring maximum pull-out load under a displacement-controlled pull-out rate of 1 mm/min. Five samples were tested per group.

RESULTS:
When all screws were placed 90° to the plate (412.8 ± 22.2 N) (mean ± standard deviation), there was a significantly increased peak pull-out strength compared to when all screws were placed 12° “up and in” (376.2 ± 24.3 N, p≤.03) (Figure 2). When the 14mm screws were oriented all at 90° and compared to 16mm screws oriented 12° “all up and in” there was still significantly better pull-out strength with the all 90° construct (434.2±28.7N vs. 376.2±24.3N, p≤.009). The fixed-angle plate had a significantly decreased peak pull-out strength (288.2 ±15.7 N) compared to the variable angle plate (416.6±12.6N) (p<0.00001) when the screws were placed in the same orientation (Figure 3). Overall, the variable
angle plate, despite orientation of screws, had a significantly greater pull-out strength than the fixed-angle plate ($p<0.001$).

CONCLUSIONS:

Our findings indicate that, in this system, a variable angle plate has greater pull-out strength than a fixed angle plate, regardless of the orientation of screws. With the variable angle plate, a construct of all screws $12^\circ$ “up and in” is the weakest configuration. We also found that 2mm shorter screws all oriented at $90^\circ$ to the plate still performed significantly better than longer convergent screws. These findings are remarkable because they contradict the current doctrine. This may be a function of plate dependent factors and should not be applied universally to all plate systems. Further study of additional plating systems is warranted.

Figure 1.
Figure 2.

Synthes All 90 Degrees (Str) vs. All up/in 12 Degrees (Div)

\[ p \leq 0.03 \]
Reference

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