Does Sagittal Pedicle Screw Insertion Angle Influence Axial Compressive Strength of the Construct?

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INTRODUCTION
While neutral screw orientation (parallel to endplates) is generally considered optimal, it has been suggested that cranial or caudal angulation may have mechanical benefits. However, no previous report of the effects of sagittal screw orientation could be found. Hypothesizing that downward-angled screws would provide greater resistance to compressive loads, it was the authors’ purpose to test the influence of sagittal screw angulation on axial construct stability.

METHODS
Screws were inserted into 21 human vertebrae in one of three orientations (neutral, angled-up 15-20 degrees, angled-down 20-30 degrees). Screws were then connected to a single longitudinal rod rigidly fixed to a synthetic, nondeformable caudal vertebra to simulate an axially unstable post-corpectomy segment. Next, the construct was axially loaded to failure using a servohydraulic testing apparatus. The maximum force ($F_{max}$) and maximum displacement ($D_{max}$) were recorded and analyzed using a multivariate-ANOVA. To account for possible morphological differences, measurements from upper (T12-L1) and lower (L2-L5) vertebrae were considered separately.

RESULTS
T12-L1: $F_{max}$ was 223, 187, 340N for neutral, angled-up, and angled-down screws. Comparison of up versus down groups demonstrated a statistically significant difference ($p=0.01$). $D_{max}$ was 1.72, 1.06, and 2.15mm, respectively. There was a significant difference between the neutral and angled-down versus the angled-up group ($p=0.03$, 0.05, respectively).
L2-L5: $F_{max}$ was 247, 228, 309N for neutral, angled-up, and angled-down screws and $D_{max}$ was 1.60, 1.63, and 2.07mm, respectively. No statistically significant differences were detected (range, $p=0.14-0.70$).

DISCUSSION
These data suggest that downward screw angulation can improve resistance to axial loads in upper lumbar vertebrae. Angled-up screws fail after less displacement, starting closer to the superior endplate than neutral or angled-down screws. Screw angulation does not appear to have a significant effect in lower lumbar vertebrae. Notwithstanding other factors (e.g. facet joint injury), angled-down pedicle screws may have advantages in constructs that end at the T12/L1 level.