

Oversizing pedicle screw diameter relative to pedicle width improves fixation strength: A cadaveric pull-out and toggling study

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Introduction

Pedicle screw loosening remains a major complication in spinal fusion. The standard implant sizing strategy (screw diameter (SD) $\approx 0.8 \times$ pedicle width (PW)) may be overly conservative. We investigated whether screws exceeding this ratio improve fixation strength in ex vivo vertebrae under two biomechanical test conditions.

Materials and Methods

A biomechanical cadaveric study was conducted using nineteen human vertebrae. In a paired cadaveric design, each vertebra received a standard screw (SD/PW ≈ 0.8) on one pedicle and an oversized screw (SD/PW ≥ 1.0) on the contralateral side. Two biomechanical setups were tested: uniaxial pull-out testing, and toggling testing with perpendicular cyclic loading. Screw stability was assessed by measuring the achieved maximum pull-out force for pull-out testing and the failure force for toggling testing.

Results

Oversized screws increased median failure force in both trials. For the pull-out testing, the median increase in pull-out force with oversized screws was 58.4% (interquartile range [IQR] 21.4%–97.8%; $p = 0.019$; effect size $d = 1.40$). For the toggling testing, the median increase in failure force with oversized screws was 12.4% (IQR -6.4%–42.8%; $p = 0.054$; effect size = 0.59), which did not reach significance. However, when only intact pedicles were included ($n = 9$ pairs), a median increase of 21.3% (IQR 12.4%–47.6%; $p = 0.023$; effect size = 0.93) was achieved, showing significance.

Conclusion

Pedicle screw diameter is a key parameter for fixation strength, but the currently adopted “one-size-fits-all” 0.8 SD/PW recommendation does not yield optimal biomechanical results. These findings support moving toward biomechanics-based, patient-specific screw diameter selection rather than relying on a uniform 80% pedicle width recommendation.