DOES TORQUE DIRECTION AFFECT THE BIOMECHANICS OF DIRECT VERTEBRAL DEROTATION USING PEDICLE SCREWS?

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Introduction:
Surgical correction of scoliotic deformities has been improved since the introduction of thoracic pedicle screws in recent years. Thoracic pedicle screws are believed to have better vertebral rotation control and therefore achieve better segmental scoliosis correction compared to hook only or hooks-and-screws patterns. Thoracic pedicle screws have greater pedicle pullout strength than hooks1 but forces applied to correct the axial plane rotational deformity have been studied only in a limited fashion. Furthermore, the direction of the failure pattern of the vertebral body in axial plane torsion is important to evaluate to better understand the risk to neurological structures. Failure of the medial pedicle wall during forceful segmental derotation could have catastrophic neurological consequences due to impingement into the spinal cord. The purpose of this study is to examine biomechanical differences in transverse plane derotation maneuvers of thoracic pedicle screws in both medial and lateral directions.

Methods:
Vertebral bodies, T4 to L5, from twelve cadavers (mean age: 68, range: 39 to 87) were instrumented with pedicle screws of an appropriate length. Insertion torque during screw placement was measured at 10Hz utilizing a custom torque sensor (Futek, Irvine, CA) driver and custom acquisition software. Each body was anchored for independent loading in medial or lateral directions. Each screw was rotated around a rod using a constant length lever arm (30.5cm) with a tube rigidly attached to the screw head. This simulated the posterior vertebral derotation maneuver needed to correct the transverse plane deformity of scoliosis (Figure 1). Medial and lateral load directions were randomized for each vertebral body and yield torques (Nm) were analyzed between loading directions using a one-way ANOVA (p<0.05).

Results:
Yield torques for both medial and lateral directions of screw tip movement were significantly related to the insertion torque of the screw (both p<0.01) (screw insertion torque is known to correlate with bone density3). There were no statistical differences in failure load between medial (12.0+/-4.9Nm) or lateral (11.5+/-5.1Nm) directions (Figure 2).

Discussion:
While there were no differences in yield torque between medial and lateral directions of screw movement, the differences in failure mode provide interesting clinical information. In medial tests, where the screw shank was rotated towards the canal, there was bone failure in half the cases compared to the lateral test where nearly 2/3 of the failure modes occurred in the lateral wall of the vertebral body. This may indicate that the dense cortical bone surrounding the canal protects the neural structures. This is again supported by the percentage of screws (42%) that bent in the body rather than suffered structural failure of the bone. From these data, if a surgeon were to perform direct vertebral derotation using a lever that was approximately 300mm (12”) long, the force required to fail the pedicle would be near 40N or 18lbs. Adolescent patients, however, will likely tolerate a greater force without bone failure than the older cadavers used in this study. Extreme caution is required to prevent the screw from being “rotated” into the canal or outside the vertebral laterally into the chest.

References:

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