Lateral Mass Versus Hybrid Construct for Cervical Laminectomy and Fusion

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abstract

Spine stabilization after C3-C7 laminectomy can be accomplished with many instrumentation options. A hybrid construct using lateral mass screws from C3 to C5 and pedicle screws at C7 can potentially maximize strength and solve the spatial constraints introduced by the placement of C6 lateral mass screws and C7 pedicle screws. Seven cadaveric cervical spines from C2 to T2 were potted in a custom testing apparatus. Differential variable reluctance transducers were placed on C6 and C7 to measure linear displacement. Specimens were loaded in flexion, extension, lateral bending, and axial torque at 1.5 Nm. A wide laminectomy was then performed, and specimens were randomized to first receive either the bilateral C3-C7 lateral mass screw construct or a hybrid construct with C3-C5 lateral mass screws and C7 pedicle screws. All specimens were tested with both constructs. Normalized deformation (mean ± SD) for the lateral mass screw vs the hybrid pedicle screw constructs in the sagittal plane was 7.46% ± 5.48% vs 5.68% ± 3.67%, respectively (P = .237). Coronal deformation for lateral mass screw vs the hybrid pedicle screw constructs was 19.2% ± 10.9% vs 13.6% ± 9.53% (P = .237). Axial rotation deformation for lateral mass vs pedicle screw constructs was 85.9% ± 83.3% vs 74.7% ± 58.1%, respectively (P = .868). Despite data reported in the literature indicating a higher pullout strength of pedicle screws and improved strength of hybrid pedicle screw constructs compared with lateral mass screw constructs, a hybrid construct taking spatial constraints and increased danger of pedicle screw placement above C7 into account showed no improvement in motion compared with a lateral mass screw construct.
Surgical treatment for multilevel compressive spondylotic cervical myelopathy can be accomplished using a variety of options. Anterior approaches allow for the restoration of spinal column height and lordosis but have a high risk of pseudarthrosis, and the number of accessible levels is limited. Posterior approaches for decompression via laminectomy allow access to all involved levels. Laminectomy without instrumentation results in decreased stiffness compared with intact specimens and those having undergone laminoplasty. In addition, when performed alone, laminectomy carries the risk of causing postlaminectomy kyphosis. Laminoplasty can prevent postlaminectomy kyphosis and spares motion but results in a high axial neck pain rate. Lastly, laminectomy and instrumented fusion allows wide decompression of multiple levels and preserves sagittal alignment but leads to loss of motion.

Instrumentation options for posterior cervical laminectomy and fusion include wiring, hooks, lateral mass screws, and pedicle screws. Several biomechanical studies have shown that pedicle screws have a greater fatigue strength and less sensitivity to pullout in bones with low bone mineral density. However, placing pedicle screws in the cervical spine is technically challenging and time-consuming and carries a higher complication risk, with a critical breach rate of 6.7% to 65% depending on technique. Pedicles screws are the largest and best suited placement at C7 and then decrease in size cranially. Conversely, lateral masses are largest at C4 and decrease in thickness, progressing caudally.

Two types of stabilization constructs are currently commonly used. The first construct type uses bilateral lateral mass screws at C3, C4, and C5 that are connected to bilateral pedicle screws at C7. Primarily due to spatial constraints, C6 is not instrumented. The second construct type uses lateral mass screws bilaterally at every segment from C3 to C7. Currently, no biomechanical studies have compared the stability achieved by these 2 constructs. The authors biomechanically tested these 2 constructs for allowed motion at C6-C7 to determine their ability to provide a biomechanically favorable environment for fusion.

**Materials and Methods**

Multiple cervical spine biomechanical studies have used the protocol developed by Panjabi for nonconstrained, nondestructive testing of cervical spine instrumentation, which is used in the current study. Crawford et al reported a custom-built construct that applied nonconstrained moments using a materials testing system machine and a custom-built pulley system (Figure 1). Seven fresh-frozen cadaver spines (C2-T1) (Maryland State Anatomy Board, Baltimore, Maryland) were thawed at room temperature for 16 hours and then dissected free of all muscular tissue, leaving all ligamentous and facet capsular attachments intact. C2 and T1 were potted in a custom testing apparatus and placed in the materials testing system machine for testing while intact. All specimens were tested within 24 hours of removal from the freezer.

Differential variable reluctance transducer linear displacement sensors (Microstrain, Williston, Vermont) were placed on the lateral masses of C6 and C7 bilaterally to test flexion, extension, and lateral bending. These devices have a resolution of 4.5 µm and an accuracy of ±1% for the 9-mm sensors. The C6-C7 level was chosen for testing because it is the most common fusion failure site. For axial rotation, the differential variable reluctance transducers were placed on the carotid tubercle and the anterior midline of the C7 vertebral body to measure linear motion between these 2 segments, with a range of 0.1 to 9 mm of accurate measurement (Figure 2). A 1.5-Nm torque was applied to each specimen in flexion, extension, left and right lateral bend, and left and right axial rotation. Three trials were performed for each motion, with the peak torque applied...
and held for 30 seconds. The mean of these 3 trials was used for calculations.

After measuring motions for the intact state, all specimens underwent wide laminectomy from C3-C7 with bilateral partial medial facetectomy at C6-C7. The facetectomy was made wide enough to allow the placement of a C7 pedicle screw. Each specimen was then instrumented with either bilateral C3-C7 unicortical lateral mass screws placed with a modified Magerl technique (lateral mass construct group) or bilateral C3-C5 unicortical lateral mass and C7 pedicle screws (hybrid pedicle screw group). Instrumentation used consisted of 3.5-mm commercially pure titanium rods and 3.5×14-mm screws for lateral masses and 3.5×22-mm screws for the pedicles (Vertex Reconstruction System; Medtronic Sofamor Danek, Sunnyvale, California). The specimens were randomized as to which instrumentation scheme they were tested in first to minimize bias from specimen fatigue.

After testing, the construct was removed and replaced with the other construct, and testing was performed again. Lateral mass screws at C3, C4, and C5 were left in place and not altered when the construct was changed. Linear deformation between C6 and C7 was recorded for each motion for the intact state, lateral mass, and hybrid pedicle screw constructs. All specimens were tested for failure at a supraphysiological 3.0 Nm of applied flexion moment (4 lateral mass screws and 3 pedicle screws).

**Statistical Analysis**

The authors used standard summary statistics and graphing techniques to describe the study variables. Comparisons between stability across the different constructs in sagittal, coronal, and axial planes were performed using the non-parametric Wilcoxon signed-rank test. A P value less than .05 was considered statistically significant, and all analyses were conducted using Stata version 12.0 software (StataCorp, College Station, Texas).

### Table 1

<table>
<thead>
<tr>
<th>Plane</th>
<th>Lateral Mass Screw</th>
<th>Hybrid Pedicle Screw</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal</td>
<td>0.028±0.020</td>
<td>0.027±0.025</td>
<td>.612</td>
</tr>
<tr>
<td>Coronal</td>
<td>0.135±0.052</td>
<td>0.098±0.065</td>
<td>.237</td>
</tr>
<tr>
<td>Axial Rotation</td>
<td>0.119±0.080</td>
<td>0.124±0.111</td>
<td>.735</td>
</tr>
</tbody>
</table>

### RESULTS

Mean±SD linear motion between C6 and C7 in combined sagittal motion was 0.028±0.020 mm for the lateral mass group and 0.027±0.025 mm for the hybrid pedicle screw construct group (P=.612) (Table 1). Mean deformation for coronal motion was 0.135±0.052 mm for the lateral mass construct group and 0.098±0.065 mm for the hybrid pedicle screw construct group (P=.237). Mean deformation with axial rotation was 0.119±0.080 mm for the lateral mass construct group and 0.124±0.111 mm for the hybrid pedicle screw construct group (P=.735) (Figure 3).

The normalized deformations (experimental/intact×100=normalized %) as a percentage of intact range of motion are shown in Table 2. Mean±SD for the lateral mass vs hybrid pedicle screw construct group in sagittal deformation was 7.46±5.48% vs 5.68±3.67%, respectively (P=.237). Coronal deformation for the lateral mass vs hybrid pedicle screw construct group was 19.2±10.9% and 13.6±9.53%, respectively (P=.237). Axial rotation deformation for the lateral mass vs hybrid pedicle screw construct group was 85.9±83.3% vs 74.7±58.1%, respectively (P=.868)
No failures occurred at 3.0 Nm of applied flexion moment.

**Discussion**

Previous biomechanical research has shown that a hybrid pedicle screw construct applied at the caudal subaxial spine is superior to a lateral mass screw construct in terms of allowed motion. However, placing pedicle screws in the upper subaxial spine is associated with significant risks to the vertebral artery. To limit risks while maximizing stability, using a hybrid technique can potentially produce an ideal construct.

The current results show no significant difference in allowed motion, in absolute terms or relative to the intact state, between a lateral mass construct and a hybrid pedicle screw construct. Both constructs effectively reduced allowed motion relative to the intact cervical spine in the sagittal and coronal planes. Both constructs effectively restored rotational stability to at least the intact state, a finding similar to previous biomechanical studies. The authors were concerned that the lack of instrumentation at C6 with the hybrid construct would result in increased displacement between C6 and C7, thereby contributing to pseudarthrosis. The current results show that instrumenting C6 is not necessary if the cranial and caudal levels are rigidly affixed.

The use of direct measurement of the linear displacement between C6 and C7 shows minimal motion between levels with both techniques tested. Given the relative lack of motion, it is likely that both versions of fixation provide a reasonable biomechanical environment for fusion and that the choice of fixation after a wide laminectomy from C3-C7 should depend on surgeons’ comfort with each approach and the anatomic constraints.

The current study had significant limitations. Few specimens were studied, which reduces the power of the study. To obtain a power of 80% to detect a significant difference, a post hoc power analysis indicated that 113 specimens are needed. However, even if more specimens were tested to provide greater statistical significance, it is doubtful that the clinical relevance of this study would be altered. The absolute mean difference in motion allowed between a lateral mass screw and a hybrid construct in the current study is on the order of microns, which is unlikely to affect gross stability of the spinal column or strain on fusion grafts to a significant degree. Another limitation was the lack of information about the specimens’ bone density, which made the authors use a randomization scheme to minimize. The authors used a laminectomy model rather than a 3-column injury model because a wide laminectomy is more likely to be encountered in practice and, therefore, is a more clinically relevant model. However, with the lack of a grossly destabilizing 3-column injury, the specimens may not have been unstable enough to observe a difference between the 2 constructs.

**Conclusion**

A hybrid construct consisting of C3-C5 lateral mass screws and C7 pedicle screws was not inferior to a lateral mass screw
construct in restoring stability to laminectomized cervical spine specimens.

REFERENCES


