MULTILEVEL ANTERIOR LUMBAR INTERBODY CAGES: AN IN VITRO BIOMECHANICAL ASSESSMENT

++Brodke, D S.; *Mohr, R A.; *Nguyen, B K N.; *Bachus, K N.
+*Orthopaedic Bioengineering Research Laboratory, Department of Orthopedics , University of Utah School of Medicine, 3B165 SOM. Salt Lake City, UT 84132, (801)581-5200, Fax: (801)581-3845, darrel.brodke@hsc.utah.edu

Introduction: While posterior instrumentation remains the most common fixation technique for lumbar fusion, threaded titanium interbody cages have become a popular alternative. Cages are commonly used for single-level fusion, occasionally for two-level fusion, and rarely for three-level fusion. Despite initial enthusiasm about multilevel cage constructs, there has been an increase in reported pseudoarthrosis rates and concern for stability. To date, no biomechanical studies have evaluated the stability of multilevel fusion constructs. This study was designed to assess the stiffness of multilevel cages alone and with additional posterior instrumentation. A comparison is made to single level constructs.

Materials and Methods: Six calf spines (L1-6) were used for this study. The spines were mounted in a custom pneumatic 4-axis spine simulator (Figure 1), designed to apply compressive axial loading to the specimen, as well as pure flexion/extension, lateral bending, and axial torsion moments. The spine simulator uses computerized pneumatic motors modulated by a feedback loop through a six-axis load cell to control all planes of motion simultaneously.

Non-destructive stiffness testing proceeded sequentially in flexion/extension, lateral bending, and axial torsion by applying a ± 5.0 Nm moment in one plane, while actively controlling the others at zero moment. A constant 50N axial load was maintained throughout testing. The spine simulator’s computer-controlled pneumatic actuators produce a nearly "pure moment" by allowing coupled motion without producing off-axis loads. Following testing of the intact specimen, the spines were prepared with sequential cage constructs (single level L3-4, two-level L3-5, and three-level L2-5), using BAK™ cages (Sulzer SpineTech, MN). Posterior instrumentation was then added at L2-5. Data were compared with six specimens that underwent 1, 2, and 3-level posterior pedicle screw instrumentation, using Silhouette System™ (Sulzer SpineTech, MN). Statistical analysis was performed using ANOVA and Fisher’s post hoc test.

Results: Single level cages, placed at L3-4, significantly increased the stiffness to lateral bending 6x over the control group, from 1.4 to 8.6 Nm/deg (p<0.01). Flexion-extension and torsional stiffness were increased 35% (10.7 to 14.4 Nm/deg) and 29% (8.3 to 10.7 Nm/deg) respectively, though these were not statistically significant. Single level posterior pedicle screw instrumentation yielded essentially similar results, though with significant increases in stiffness in all three bending planes (p<0.01) (Figure 2). In the two-level cage construct, L3-4 and L4-5, lateral bending stiffness was again significantly increased 4x, from 0.9 to 4.0 Nm/deg (p<0.005). Flexion-extension stiffness increased 37%, from 7.6 to 10.4 Nm/deg, while torsional stiffness was virtually unchanged, from 5.1 to 5.4 Nm/deg, with no statistical significance.

With the three-level cage construct, L2-3, L3-4 and L4-5, there were no significant differences from the control group. However, when posterior non-segmental instrumentation was added, flexion-extension stiffness increased from 3.5 to 52.6 Nm/deg, 15x over control and 8x over the cage construct alone (6.8 Nm/deg), (p<0.0001). Lateral bending stiffness increased from 0.5 to 15.3 Nm/deg, 30x over the control and 8x over the anterior cage construct (2.0 Nm/deg) (p<0.01). Torsional stiffness also increased significantly from 3.0 Nm/deg control and 3.7 Nm/deg with anterior cages, to 6.0 Nm/deg with the posterior construct (p<0.002).

Conclusion: In comparing single-level anterior cage constructs with multilevel cage constructs, the multilevel constructs showed progressively decreasing stiffness in all planes, flexion-extension, lateral bending, and torsion. Posterior instrumentation significantly increases stiffness in all planes over controls and cage only constructs. The addition of non-segmental posterior instrumentation to the 3-level anterior cage construct significantly increases all stiffnesses.


Acknowledgements: The authors would like to acknowledge the financial support of The Shriners’ Hospital For Crippled Children, the National Science foundation Equipment Grant #93-155, and the Department of Orthopaedics, University of Utah School Medicine. Special thanks to Sulzer SpineTech for the donation of the instruments.