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Overpowering the Previously Posterior Instrumented Cervical Spine With Cage-Assisted Anterior Cervical Discectomy and Fusion: A Cadaveric Study

Philip Saville, MD[a], Rikesh A. Gandhi, MD[a], Harvey E. Smith, MD[a], Vincent Arlet, MD[b,*]

[a]*Department of Orthopaedic Surgery, University of Pennsylvania, 3737 Market Street, 6th Floor, Philadelphia, PA 19104, USA*
[b]*Department of Orthopaedic Surgery, Comprehensive Spine Center, University of Pennsylvania, 235 South 8th Street, Philadelphia, PA 19107, USA*

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Abstract

Purpose: Cervical spines previously posteriorly instrumented and fused with a kyphotic deformity represent a surgical challenge. Current treatment strategies include C7 pedicle subtraction osteotomy or a posterior-anterior-posterior approach, which carry the risk of significant complications. The objective of this study was to attempt to achieve lordosis with multiple anterior cervical discectomy and fusion (ACDF) cages to overpower the posterior instrumentation.

Methods: Four adult cadaveric specimens were selected and underwent C3–C7 posterior laminectomy with posterior instrumentation in a kyphotic alignment using a 3.5-mm titanium screw-rod system. Next, ACDF from C3 to C7 was performed with 15° lordotic cages to restore cervical lordosis. Posterior instrumentation was then inspected for failure. Fluoroscopic images were obtained to calculate total construct lordosis and change in segmental lordosis. CT scans were obtained after ACDF to assess for loosening, instrumentation failure, endplate damage, or impaction. Bone mineral density was calculated on CT scans.

Results: Age ranged from 59 to 82, and all specimens were male. No gross instrumentation failure was observed. Mean pre-ACDF lordosis between C3 and C7 was 0° (−5° to 5°). Post-ACDF lordosis increased to 37° (35°–38°). Mean segmental lordosis achieved with no endplate destruction was 13.1° (8°–17°). T scores for the cadavers were −0.5, −0.5, −3.2, and −5.1. Two levels of impaction were observed (12.5%). Failure of bone screw interface occurred in the cadaver, with a T score of −5.1 in the middle of the construct.

Conclusion: Our study demonstrates the validity of overpowering posterior instrumentation through multiple level ACDF with lordotic cages. This may obviate the need to perform posterior-anterior-posterior procedures.

Level of Evidence: Level III

Keywords: Anterior cervical discectomy and fusion; Lordotic cages; Spinal fusion; Cervical deformity; Cervical kyphosis

Introduction

Cervical spines previously posteriorly instrumented and fused with a kyphotic deformity represent a surgical challenge. Options to correct the kyphotic deformity are focused around three column osteotomies in the cervical-thoracic junction, which are technically demanding, result in significant blood loss, and intrinsically carry a significant complication rate [1-3]. The alternative option is to lengthen the anterior column and shorten the posterior column, which requires a posterior-anterior-posterior procedure where the intact posterior instrumentation is removed, anterior release and decompression is obtained, and then repeat posterior

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All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Cadaveric specimens and spinal instrumentation were provided by NuVasive Inc.

*Corresponding author. Departmental of Orthopaedic Surgery, University of Pennsylvania, Comprehensive Spine Center, 235 South 8th Street, Philadelphia, PA 19107, USA. Tel.: (215) 829-3073; fax: (215) 829-3493.

E-mail address: Vincent.Arlet@uphs.upenn.edu (V. Arlet).

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instrumentation is applied [4,5]. This requires repositioning the patient multiple times and necessitates increased anesthesia time. We have previously shown the successful use of hyperlordotic anterior lumbar interbody fusion cages in overpowering the posteriorly instrumented lumbar spine in both cadavers and in a series of adult patients as a staged anterior and posterior fusion [6,7]. The objective of this study was to achieve lordosis with multiple anterior cervical discectomy and fusion (ACDF) cages to overpower the previously posteriorly instrumented cervical spine without instrumentation removal. The authors present their experience with this novel technique in 4 cadavers, and evaluate its preliminary feasibility.

Materials and Methods

Ten adult fresh-frozen cadavers from the human tissue lab from the manufacturer of ACDF cages (NuVasive Inc, San Diego, CA) were available at the time of this study. Using lateral and AP C-arm fluoroscopy, all 10 cadaveric cervical spines were screened for prior cervical spine trauma or cervical spine surgery. Cadavers were excluded if evidence of prior cervical spine trauma or cervical spine surgery was noted on fluoroscopy. Four suitable cadavers were identified.

All four specimens underwent C3–C7 posterior laminectomy with posterior instrumentation via a posterior midline approach. Polyaxial lateral mass screws were placed following the Magerl technique [8] in C3–C6, and polyaxial pedicle screws were placed into C7. During the posterior instrumentation, an aggressive bump was placed under the specimens' sternum to purposely induce a kyphotic deformity, and the 3.5-mm titanium screw-rod system was secured in this position. Following fluoroscopic confirmation of posterior instrumentation placement, the cadavers were flipped supine and ACDF from C3 to C7 was performed.

ACDF Surgical Technique

With the cadavers supine, a mechanical advantage was gained using a bump between the shoulders, and the bed was broken such that the head was suspended 2 inches above the table. ACDF was then conducted sequentially from distal to proximal at all disc spaces from C6–C7 to C3–C4. Annulotomy was conducted with a No. 15 blade. Caspar pins were placed into the superior and inferior vertebral bodies, and gentle distraction was applied. Cervical curettes and rongeurs were used to conduct a complete discectomy. In all specimens, the PLL was released with a Size 1 Kerrison. After sufficient discectomy, a paddle distractor was placed into the disc space and on fluoroscopy confirmed to reach the posterior one-third of the vertebral body. This was then used to generate distraction. To amplify the effect and produce lordosis, gentle pressure was applied to the specimens' forehead, which was suspended as described previously. After distraction, successive trials of 15° lordotic cages were used until an adequate fit was achieved. The final implant was then impacted to restore cervical lordosis.

Following implantation of all cages, the specimens were placed prone, and the original posterior instrumentation was examined for integrity. This involved visual inspection for hardware failure, and lifting the specimen with a rod holder. Two cadavers were instrumented by a senior academic surgeon with more than 25 years of experience, and two were instrumented by a senior orthopedic resident.

Radiographic Analysis

Fluoroscopic images were obtained after posterior instrumentation, and again after ACDF was performed. All specimens also obtained computed tomography (CT) scans of their cervical spine following ACDF.

On lateral images, total construct lordosis was measured between the superior endplate of C3 and the inferior endplate of C7 with the Cobb method. Change in segmental lordosis was measured according to the Ferguson method. We used this method for several reasons:

1. Multiple cages implanted in the spine risked damaging endplates and confounding measurements on subsequent levels.
2. Even without frank impaction present, the soft cadaveric bone may conform to the cage and confound measurements.
3. Measuring the lordosis between the adjacent endplates would likely result in measuring cage angle alone.

All measurements were competed using Surgimap software [9]. A positive value represented lordosis, and a negative value represented kyphosis. Measurements were made by two independent observers and checked for interobserver reliability. Measurements with a variability of greater than 2° were repeated with both observers present to reach agreement. Finally, images were assessed for impaction of cages. We defined impaction as evidence of the cage markers being inside either endplate.

Axial and sagittal reconstructions of the CT scans were reviewed to look for loosening, instrumentation failure, endplate damage, or impaction. Loosening was defined as lucency at the bone screw interface, or obvious migration of instrumentation. Hounsfield unit (HU) measurements were done at the level of the T7 vertebral bodies to evaluate osteoporosis. Three measurements from three different levels of axial cuts at the T7 vertebral body of each cadaver were averaged, per the technique described by Schreiber et al. [10]. The HU value was compared against vertebral- and age-matched controls from those described by Patel et al. [11].