Effects of Kyphotic Malalignment of Cervical Fusion on Adjacent Level Disc Mechanics
Raj D. Rao, MD, Mei Wang, PhD, Manoj D. Singrakhia, MD, Linda M. McGrady, BS, Larry Macioleck, MD (Milwaukee, WI)

INTRODUCTION: The issue of appropriate disc height restoration during anterior cervical discectomy and fusion has been previously addressed in the literature [1]. Kyphosis at an operated cervical disc space occurs as a result of anterior cervical discectomy without fusion, inadequate graft height at surgery, or from settling of the structural allograft / autograft. We hypothesize that kyphotic alignment following anterior cervical discectomy and fusion will increase the stress at adjacent spinal segments and hasten degenerative changes at the adjacent segments.

METHODS: Six fresh cadaveric sheep cervical spines were retrieved for the study, and were divided into two groups: one group for the study of the superior adjacent segment, and one for inferior adjacent segments. Each spine was thawed and dissected into specimens containing two motion segments: the operative level C4-C5 and either superior or inferior adjacent segment. The specimen will be potted in dental cement exposing the mid-vertebral body of the inferior segment. It was mounted onto a customized spine-testing jig. Two disc-shaped miniature pressure transducers (1.5mm diameter and 0.3mm thickness) were implanted within the discs adjacent to the operative level. One transducer was located centrally in the region of the nucleus pulposus, and the other situated peripherally in the anterior annulus. Pure moment up to 4.5 Nm in flexion and extension was applied to the specimen in six steps. A six-axis load cell (Model MC3, AMTI, Watertown, MA) was mounted in series under the inferior vertebra to verify the moments and forces applied. A set of three reflective markers was on to each vertebral body. A motion analysis system (VOCON 370, Oxford Metrics, Oxford, England) was used to measure three-dimensional spinal motion at the segments. Each specimen will be tested in three stages: 1) normal; 2) following single-level anterior plated fusion in kyphotic alignment; 3) following single-level anterior plated fusion in normal alignment. Lateral radiograph of each spinal segment was taken after each plating procedure (Fig 1). Sagittal alignment angle was measured from radiographs based on the angle formed by tangent lines to the posterior edges of C4 and C5.

RESULTS: The average sagittal angle of the fused segment was 11.3 (range 7-16) degrees lordotic for the normally plated spines, and 8.5 (range 5-10) degrees kyphosis for the kyphotic group, making the difference of 19.8 (range 14-26)
degrees. The averaged adjacent segments motion and intradiscal pressure in flexion is presented in Fig. 2. At the superior adjacent disc, the intradiscal pressure increased 119% (normal plate) and 66% (kyphotic plating) over the normal disc during flexion, and 36% (normal plating) and 60% (kyphotic plating) during extension. At the inferior adjacent disc, the disc pressure increased slightly in flexion (36% and 9%) and decreased in extension (44% and 34%). In flexion, the intervertebral motion at the superior adjacent segment decreased 33% in the superior adjacent segment and 13% in the inferior adjacent segment for the normal plating group while remain unchanged in the kyphotic plating group. In extension, the motion maintained pre-operative level at both adjacent segments for both plated groups.

CONCLUSIONS: The effect of kyphotic malalignment of single-level cervical fusion on the disc mechanics of the adjacent segments was studied in a sheep cervical model. Sheep spines have been shown to have similar biomechanical properties to the human spine, and are frequently used to substitute for the human spine in biomechanical testing. The discs in sheep cervical spines show no significant degenerative changes or interspecimen variability. Our preliminary results show that in the non-degenerative spine, kyphotic alignment following anterior cervical discectomy and fusion results in significantly higher intradiscal stress at the adjacent segments, while maintaining intervertebral motion at the pre-surgical level. Restoration of appropriate graft height during surgery, and maintenance of this graft height during the healing phase is likely to result in decreased adjacent segment degenerative changes over the long term.

REFERENCES:
Intervertebral Motion of Adjacent Segments

Intradiscal Pressure of Adjacent Segments

Fig. 1: Lateral radiographs of the sheep cervical spine after anterior interbody fusion with plating at C4-C5. On the left, the normal lordosis angle was maintained with a 6-mm fibula allograft. On the right, the same spine was plated without the graft, simulating the kyphotic mal-alignment of the fusion segment. The inferior adjacent disc was...

Fig 2: The intervertebral motion (top) and intradiscal pressure in the nucleus (bottom) of the inferior and superior adjacent segments following anterior plated fusion during flexion. The measurement was normalized with respect to the intact spine. The 100% represents the value for normal intact spine. Error bars indicate the standard deviations.