INTRODUCTION
The results of a Smith and Robinson fusion for cervical radiculopathy are generally excellent. Long-term follow up, however, does show recurrent pain in one third of patients undergoing the procedure, necessitating surgery in many of these patients at adjacent levels. Some authors believe the adjacent segment changes that developed are a consequence of the initial fusion, while others consider that these changes are a result of progression of the natural degenerative process [1]. The rationale for plate supplementation following anterior cervical discectomy and fusion is to provide immediate segmental stability for earlier mobilization, to prevent graft extrusion and collapse, and to improve fusion rates because of the increased local rigidity. Whether the addition of instrumentation to an anterior cervical fusion results in accelerated degenerative changes at adjacent segments is unclear. The aim of this study is to determine whether plate supplementation affects mechanical behavior at adjacent segments. We do this by comparing 1) kinematic behavior, and 2) the central and peripheral intradiscal stresses of adjacent segments following anterior cervical discectomy and fusion, with and without anterior plate supplementation.

METHODS
Five fresh cadaveric cervical spine specimens (C2-T1) were retrieved and stored at –20°C. The specimen was potted in dental cement exposing from mid-vertebral body of the C3 to that of C7. A six-degree load cell was mounted in series under the inferior vertebra to verify the moments and forces applied. Two disc-shaped miniature pressure sensors (1.5mm diameter and 0.3mm thickness) were implanted within the intervertebral discs of C4-C5 and C6-C7, respectively. One sensor was located centrally in the region of the nucleus pulposus, and the other was situated peripherally in the lateral annulus fibrosus. Flexion, extension, lateral bending, and torsion loads with a maximum magnitude of 2.5 Nm were applied to the cranial end of the construct in five steps. Unconstrained three-dimensional range of motion at C5-C6, the level above and the level below was recorded with a three-camera motion analysis system (VICON 370). Each specimen was tested in three stages: 1) Intact; 2) Anterior discectomy and grafting at C5-C6 using allograft bone plug; 3) Application of the anterior cervical plate. The segmental motion of the intact spine, discectomy and grafting, and plating were compared. The peak pressure sensor outputs were normalized with respect to the intact spine, and changes in annulus stress at C6-C7 and C4-C5 with graft alone and with supplemental plate were compared. Statistical analysis included one-way ANOVA and post-hoc t-test.

RESULTS
Range of Motion: At the surgical level, reduction following discectomy and grafting was observed in all loading directions, ranging from 53-75%. All were statistically significant except in extension. Further reduction after plating was found in flexion (40%, p<0.02) and lateral bending (26%, p=0.01). However, at the levels above and below the surgical level, the range of motion remained virtually unchanged following the two procedures except a slight increase in both levels in flexion after discectomy and grafting and again after plating. None of the increases was statistically significant.

Intradiscal Stress: For all loading directions, the general trend was that greater intradiscal stresses were generated at the level above the surgical level compared to the level below. Loading in flexion and extension caused higher stresses in the cervical spine compared to the lumbar spine. The increased local rigidity of the cervical spine is sensitive to the degenerative conditions of the disc, which may account for the large variations in our results. Larger sample size and proper degeneration grading scheme will be implemented in the future studies.

DISCUSSION
The issue of biomechanical changes at the levels adjacent to a spinal fusion has been investigated in the lumbar region in several studies. Increases in both kinematics and intradiscal pressure at adjacent segments following instrumented fusion have been reported [2-4]. These findings indicate a fusion-initiated biomechanical causative factor in the accelerated adjacent disc degeneration observed clinically. Very few biomechanical studies have been conducted in the cervical spine despite the belief that similar phenomena are present for instrumented cervical fusion. This is the first experimental study to address the changes in kinematics as well as intradiscal stresses at adjacent segments following cervical fusion and plating. Our results indicate different mechanism at work in the cervical spine compared to the lumbar spine. The clinician observed degenerative changes at adjacent segments in the cervical spine are more likely to be attributed to natural progression of the spondylotic process, instead of the altered biomechanical environment with an instrumented fusion. We also found that the intradiscal stress measurement in the cervical spine is sensitive to the degenerative conditions of the disc, which may account for the variations in our results. Larger sample size and proper degeneration grading scheme will be implemented in the future studies.

REFERENCES

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