Introduction. Approximately 125,000 anterior cervical discectomies (ACD) are performed in the United States each year with the interbody space being filled with bone graft or a cage designed to promote fusion. The resulting longer lever arm produced by a fusion is widely believed to contribute to accelerated degeneration of adjacent cervical discs, a phenomenon that is observed in clinical practice. The mechanism of degeneration is thought to be multi-factorial, but the resultant increase in the stress on the adjacent discs may be partly responsible. However, little is known about the stress distributions within intervertebral discs of the intact cervical spine. The anatomy, function and kinematics of the cervical spine differ considerably from the lumbar spine and it is reasonable to hypothesise that the stress distributions within the intervertebral discs will also differ. The aim of this study was to explore for the first time the internal stress distribution of cervical discs in human cadaveric osteoligamentous specimens.

Methods. Six human cadaveric osteoligamentous cervical spines were prepared for biomechanical testing following storage at –20°C. Four specimens were male and two female with a mean age of 56 yrs (range 44-66 yrs). A section of spine including four intervertebral discs was prepared for testing, the vertebrae at the ends being secured in dental plaster within purpose-built cups. Using a Dartec hydrostatic materials testing machine and a variable angle plate, a load of 200N, intended to simulate intrinsic muscle forces experienced in vivo, was applied axially to each specimen for 20 seconds in neutral “posture”, 15° flexion, 10° extension and 10° lateral bending. A pressure transducer, side-mounted in a 0.9mm-diameter needle, was drawn through the disc in the mid-sagittal plane from posterior to anterior whilst the load was applied. Vertical compressive stress was recorded at 25 Hz, and the data transferred to a personal computer for analysis. “Stress profiles” were obtained for a total of 17 cervical discs. A 2-way ANOVA was used to examine the dependence of peak stress (recorded anywhere in the profile) on spinal level and posture.

Results. The maximum compressive stress measured in the neutral posture consistently diminished when moving from upper to middle, and middle to lower cervical discs (P<0.05). There was a non-significant trend for upper cervical discs (C2/3 to C4/5) to have maximum stress in extension, whereas lower cervical discs (C5/6 to C7/T1) had maximum stress in flexion. The mean stress decreased from 1.14 MPa at C2/3 to 0.78 MPa at C7/T1. Peak stress in 10° of lateral bending was significantly lower than in the neutral posture (p<0.05), according to a matched-pair, 1-tail t-test. In the neutral posture, stress profiles revealed a single peak located in the anterior annulus. Posture had little consistent effect on the size of the maximum stress, or its location within the disc, although in extension and lateral bending, the anterior portion of the disc tended to be relatively unloaded. Individual profiles are shown in Figures 1 and 2. In Figure 1 the peak stress is located anteriorly and there is no region of constant stress corresponding to a hydrostatic nucleus pulposus. In Figure 2 the peak stress has moved posteriorly. Again there is no region representing a hydrostatic nucleus.

Discussion. Although we could not apply pure bending moments to each motion segment, the experimental conditions aim to simulate the living state where angulation of the cervical vertebrae is not uniformly distributed, and coupled motion occurs. The generally lower stress peaks observed in the posterior region of the cervical discs in the neutral position may be explained by load being distributed through the uncovertebral joints which are more pronounced posteriorly. Loading of the uncovertebral joints would also account for the relative unloading of the discs seen at 10° of lateral bending. The decrease in peak stress at lower spinal levels corresponded with the increasing size of the vertebrae. The lack of a clearly defined hydrostatic nucleus pulposus in these cervical discs suggests that functionally they are different from lumbar discs of the same age. Recent anatomical studies confirm a more fibrous central region in cervical discs compared to lumbar discs.

Discussion. Stress distributions in cervical discs are sufficiently different from those of lumbar discs to justify further investigation. The data from these preliminary experiments will assist in assessing the effect of cervical spinal surgical constructs on adjacent cervical discs.

References.