**Introduction:** The intervertebral disc (IVD) works synergistically with the posterior elements of the spinal motion segment to support compressive loading. The nucleus pulposus (NP) is constrained both caudally and cephalad by the cartilaginous endplate and laterally by the annulus fibrosus (AF). The mechanics of loading inside the disc are sophisticated. One of the primary roles of the spinal motion segment in humans is to withstand the ever-present compressive loading. With an increase in compressive loading: 1. disc height is reduced; 2. there is an interaction between the NP and the AF as the NP bulges radially and is constrained by the AF; and 3. the NP bulges into central endplate causing the endplate to bulge into the vertebra. The NP acts hydrostatically with a linear proportional increase in intradiscal pressure corresponding to the increase in compressive load. Considering the complexity of these load carrying mechanisms, it is useful to isolate dominant tissue characteristics in order to investigate the effects of tissue changes, whether endogenously or exogenously derived, on the overall load-sharing properties of the disc.

The annular stresses included in this present analysis include: circumferential (CT), radial compression (RC), axial tension (AT), and axial compression (AC). In this study we used two methods to simultaneously quantify transverse plane internal and external deformations: a sonographic imaging technique and a custom-made non-contacting laser contour measurement machine. A sonographic machine directly measured the internal deformation of AF while disc bulge was simultaneously measured by a custom-made laser contour measurement machine. The sonographic machine used for this study was a standard ultrasound equipment and the frequency was 7.5 MHz (mega hertz).

**Materials and Methods:** This study included a total of 4 bovine lumbar spinal motion segments. Specimen preparation involved cutting the pedicles and removing the posterior processes. The test unit consisted of hemi-vertebrae, potted in polyurethane, and the intervening disc. During the dissection and removal of the soft tissue around the disc, great care was taken to maintain disc hydration using a saline mister at regular intervals. The specimens were soaked for 2 days at room temperature in their respective solutions before being tested.

A 75 N tare load was applied to the specimens at a loading rate of 25N/sec by the Instron material testing system 8512 and held in situ for 10 minutes (Figure 2 and 3). The specimens were then loaded to 750 N with the same ramping rate as for applying the tare load and then held in situ for a 1-hour period. The disc height was recorded by the Instron machine with a data acquisition rate of 10 Hz.

We measured the external surface contour of transverse plane IVD and the internal deformation of AF at three timing points: 1. immediate after the tare load was applied. 2. immediate after the 750N ramp down. 3. after an hour of creep loading but before ramping up. The external surface contour of transverse IVD was measured by a custom-made contour measurement machine containing a rotating mounted laser displacement sensor (Keyence NJ, USA, LK-081). The rate of data acquisition was 20 Hz with 800 data points for a 360 degree complete circle. The internal deformation of IVD was measured by a brightness mode (B-mode: a two-dimensional ultrasound image display composed of bright dots representing the ultrasound echoes) of ultrasound imaging machine (Johnson & Johnson 280SL) with a linear array, 7.5 MHz (mega hertz) mechanical sector probe. The probe was applied to the anterior surface of the disc, each time with the same positioning for each measurement.

**Results:** In the radial compressive strain measurements, the internal deformation measurements taken by a sonographic image was 2.43 ± 0.80% when the specimen was measured immediately after axial loading. After an hour of creep loading, the strain was 7.25 ± 2.37%. In the axial compressive strain was 13.41 ± 1.79% when only loaded to 750N from the tare load. After a one-hour creep, it was 36.47 ± 1.46. In the radial tensile test, the bulging strain was 2.41 ± 1.18% when simply loading the specimens from the tare load to 750N. The circumferential tensile strain was 3.90 ± 2.84% after an hour of 750 N creep loading. In the axial tensile strain measurement, the strain was 8.73 ± 4.01% when the specimen was measured immediately after axial loading. After an hour of creep loading, the strain was 13.42 ± 13.00%.

By applying the modulus data in our previous study, the stress was then calculated and analyzed. The axial compressive stress measurement, when ramping to 750 N, was 0.46. After a one-hour creep at 750N constant load, it became 1.25. The radial compressive stress when ramping to 750N was 0.03. After a one hour creep at 750N, it was 0.09. The circumferential tensile stress was 0.47 at during the time when ramping to 750N. After one hour creep at 750N constant load, it became 0.77. The axial tensile stress at the time when ramping to 750N was 0.16. After a one-hour creep at 750N constant loading, it became 0.25.

**Discussion:** We measured, in this study, the four different AF deformations simultaneously which can enable integrated data analysis during loading and avoid some of the variability and errors associated with collecting different individual data sets with different tests and specimens at different time. The technique used to measure internal deformations of RC deformations using ultrasound equipment has not been reported previously. The normalized standard deviation of the measurement was about 30%. The localization of the margin between the nucleus and the annulus was by eye which may be a possible source of error, although this is the standard ultrasound procedure in the hospital.