THE STRENGTH PROFILE OF THE THORACOLUMBAR ENDPLATE REFLECTS THE SAGITTAL CONTOURS OF THE SPINE

*Bailey, CS; *Spovold, S; *Dvorak, MF; *Fisher, C; +*Oxlund, TR
University of British Columbia, Vancouver, Canada

INTRODUCTION:

The strength profile of the lumbosacral endplates has recently been mapped using regional indentation testing. The periphery of the endplate had higher failure loads than the centre, with the posterolateral aspect of the endplate being strongest. This knowledge can assist in preventing intervertebral implant subsidence by influencing the position and design of an implant. Intervertebral implants are commonly used in the reconstruction of the thoracolumbar spine (T9-L2). Therefore, a similar understanding of the thoracolumbar endplate strength profile is required. The purpose of this study was to map the strength profile of the thoracolumbar endplates using indentation testing to failure load. We hypothesized that the strength profile would vary with the sagittal contour of the spine, and would differ between levels. Thus, the strongest aspect of the endplate would be found posteriorly in the lumbar region and anteriorly in the thoracic region of the thoracolumbar spine.

METHODS:

Six fresh-frozen human cadaver thoracolumbar spines were utilized. Indentation testing using a materials testing machine (Dynamic, Instron Corporation, Canton, MA) was performed on the superior and inferior endplates of T9, T12, and L2. A minimum of twenty-five indentations was performed in a rectangular grid with seven columns and five rows, which corresponded to the lateral and AP dimensions of the endplate, respectively (Figure 1). Each indentation was referenced from the centre of the endplate, with the rows and columns spaced by 20% and 15% of the endplates anterior-posterior (AP) and lateral (LAT) dimension, respectively.

The indentor was hemispherical with a diameter of 3mm. The indentation was performed at 0.2mm/s to a depth of 3mm. In all cases the endplate failed beneath the indentor. Data was sampled at 10 Hz, from a standard 1000N capacity load cell. Failure load was interpreted as the first significant deviation from the linear portion of the load-displacement curve generated for each indentation test. Because the shape of the endplate varied between level and specimen, the number of indentations per endplate varied.

To maintain a consistency in the comparison, three analyses were performed: an AP analysis, LAT analysis, and maximum AP-LAT analysis (MAX). The MAX analysis represented the maximum number of indentations consistently performed on all endplates tested, which excluded the most anterior row and the most lateral two columns. The AP and LAT analysis were designed to address the strength of the endplate at its periphery. The AP analysis included all indentation tests within the three central columns. The LAT analysis included 7 indentations performed along the maximum lateral endplate dimension, located one row posterior to the centre. All three excursions were analysed using a repeated measures, multivariate ANOVA and post hoc Newman-Keuls mean comparison when required. To examine the influence of level, the ratio of the mean strength of the posterior row over that of the anterior row was examined using an ANOVA.

RESULTS:

MAX Analysis: The AP and LAT positions varied significantly (p<.0001). Post hoc comparison of means revealed that each row was significantly stronger than the rows anterior to it (range: p <.04), except for the most anterior column which was stronger than that directly posterior (p = .015) (Figure 2). The most lateral columns were stronger than the three in the centre (range: p = .04 - .0002). A significant 2-way interaction existed between AP and LAT position, in that the lateral sites on the most posterior and anterior rows were stronger than those in the central to lateral increase in strength (p<.036). L2 was significantly greater than both T9 and T12. The ratio for L2, T2, and T9 was 1.35, 0.97, and 0.91 respectively.

LAT analysis: The LAT position had a significant effect on the strength profile map (p<.024). Post hoc comparison of means revealed that the right most lateral site was significantly stronger than four of the more central sites (p<.04), and the opposite most lateral site tended to be similarly stronger than the more central sites, although not significantly so (p<.20).

AP ratio: The ratio of the mean strength for the posterior row compared to that of the anterior row was significantly different across level (P<0.036). L2 was significantly greater than both T9 and T12. The ratio for L2, T2, and T9 was 1.35, 0.97, and 0.91 respectively.

DISCUSSION:

The overall strength profile for the thoracolumbar endplate was similar to that for the lumbosacral spine in that the periphery was stronger than the centre. There was an incremental increase in the strength of each row moving anterior and posterior from the central row. The interaction identified between position and level, suggests that the relative strength of the anterior endplate becomes greater as you ascend rostral in the thoracic spine. The central to lateral increase in strength was not uniform across the endplate and occurred in the anterolateral and posterolateral aspect. Due to the endplate’s shape, more indentation sites were located on the endplate’s cortical margin at the anterior and posterior aspect, and may explain this pattern.

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