Lumbar Spine Hypoplasia and Adult Degenerative Disc Disease

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PURPOSE:

This analysis is an attempt to prove or disprove the hypothesis that even minor lumbar vertebral body hypoplasia that results in only a few millimeters of endplate length discrepancy (EPD), has a strong correlation with disc pathology.

INTRODUCTION:

Variation of lumbar spine morphology is common (1). The intuitive presumption that large discrepancies in adjacent vertebral endplates correlates with degenerative disc disease should be easily evaluated using MRI. To our knowledge, no prior study addresses this issue. Most spine studies evaluated prominent bone dysplasias or lumbar biomechanics and/or disc morphology. Craniocaudal measurement of disc and vertebral bodies and critical stenosis of canal and foramina have been calculated. The anteroposterior (AP) width of vertebral bodies is analyzed by a few investigators, but with no correlation to the disc width or health (2, 3, 4). The sagittal tomographic technique of MRI allows assessment of small differences in endplate AP length across the entire transverse width of adjacent vertebral bodies.

MATERIALS and METHODS:

We evaluated 102 consecutive symptomatic patients who had lumbar spine MRI exams, with identical imaging parameters. There were 65 males and 37 females ages 17 to 78 (average = 43, median = 41). A 1.5 Tesla Philips NT MR system performed all exams. Sagittal 4.0/0.4mm T1 (600/18) and turbo spin echo T2 (3000/120) weighted images used a 358 X 512 matrix & 40cm FOV. Para-axial T1 (500/16) 4.0/0.4 mm images covered L3-4 to L5-S1 with 20cm FOV & 218 X 256 matrix. Vertebral endplates/discs were assessed at L3-4, L4-5, and L5-S1 in each patient (n=306 levels). Images were magnified 1.4 for visual interpretation on "12 on 1" standard films. Endplate/disc ROI linear measurement was performed by an experienced technologist (E.M.) on T2 images, after 3X on screen magnification (200% of anatomic size), with available "side-by-side" comparison of T1 sagittal views. These were acquired on the slice closest to midline and 3 slices (13-14mm) to the left and right. The endplate/discs were visually assessed by MRI trained radiologists (PW & SC). They estimated (nearest mm) EPD, if any, and assessed posterior disc projection and shape/classification. No measuring devices were used for estimates (to simulate normal clinical radiologic assessment). Abnormal disc morphology was defined as disc projection ≥ 2 mm beyond the margin of the larger endplate. Disc signal was classified as normal or with mild/heterogenous, moderate, or prominent decreased T2 signal. Disc morphology was assessed as normal, bulge, protrusion or extrusion (5). Post-surgical discs (25 of 306) were considered abnormal, but not used when measuring disc projections.

RESULTS:

Overall, 24% were noted to have a midline EPD of ≥ 2mm. Of these, 83% had abnormal disc signal or morphology or both. At individual levels, EPD of ≥ 2 mm at midline correlated with abnormal discs in 84% at L3-4 (16 of 19), 89% at L4-5 (25 of 28), and 78% at L5-S1 (28 of 36). With an EPD ≥ 2 mm, discs were normal or nearly so in only 17%. Most (89%) of these did have mild heterogeneous decreased disc signal. There was also positive correlation between disc abnormalities and a 1mm estimated EPD (71%). Paramidline endplate discrepancies judged less than 1 mm correlated with intervening disc abnormalities in only 33%. Additional data is summarized in Table 1.

TABLE 1: Abnormal Discs

	EPD≥2mm	EPD=1mm	EPD=0mm	EPD≥2mm& Bulge >2mm
L3-4	84%	69%	27%	57%
L4-5	89%	74%	37%	62%
L5-S1	78%	70%	35%	55%

ABNL Disc is > Moderate Desiccation, Protrusion, or ≥ 2 mm Bulge

ROI measurement reliability index (90 measurements, 1.0mm tolerance) was 86%. The interobserver agreement for detection of midline EPD was 76%, and 87% for abnormal discs.

DISCUSSION:

The strong correlation between disc abnormalities and EPD is not surprising. What is striking is the minor nature of the discrepancy correlating with this degree of disc pathology, frequently at an early age. One reason such high percentages are demonstrated is inclusion of moderately desiccated discs as abnormal. However, irrespective of disc signal or classification, over 55% with EPD ≥ 2mm had a disc projection 2mm or more beyond the larger endplate. This information may be of utility for clinical decision-making, whether to perform chemonucleolysis, microdiscectomy, or fusion in symptomatic young individuals. Our younger patients (≤ 30) had a high incidence of DDD and higher rate of EPD than expected (50% at one or more levels). Although dorsal concavity of vertebral bodies is normal, a difference in AP lengths of adjacent vertebrae may cause abnormal mechanical stress on the discs. The disc size generally correlates with that of a larger endplate and thus is not fully "supported" by adjacent bone. There is resulting subtle lordosis in most patients. The mechanical force transmitted to the disc via the endplate almost certainly causes abnormal deformation under the circumstances of EPD. Increased shearing forces and locally increased pressure would likely occur within the posterior annulus in the position of extension. We did not evaluate any patient in other than a neutral supine position.

Study Deficiencies: There are many problems with this study in progress. A partial list includes (1) incomplete assessment of reproducibility and observer variance, (2) less than maximal spacial resolution, (3) inadequate correction for osteophytes, and (4) strong potential for visual assessment bias. Data concerning endplate lengths in lateral locations was not included in this report as limited inter and intraobserver reproducibility study gave poor results. Lordotic angulation and any form of listhesis creates minor optical illusions of EPD on visual inspection. Endplate analysis by visual inspection may be biased in favor of the hypothesis, as identification of an abnormal disc often results in more careful analysis of adjacent endplates. This increases the detection of small endplate discrepancies. Use of only T1 images would decrease this tendency. These potential errors were partially addressed by use of magnified views and ROI measurement by a separate individual. Interobserver measurement difference was often only 1mm, which can lead to significant statistical changes in the data categories presented. The overall correlation was good.

The natural history of this apparent accelerated disc degeneration process needs to be studied further to allow intelligent clinical decision-making concerning this common morphologic variant. This study included only symptomatic individuals evaluated at a single point in time. A longitudinal study of both symptomatic and asymptomatic patient's lumbar endplate and disc morphology is needed to draw further conclusions.

CONCLUSIONS:

1. A high percentage of patients with lumbar spine symptoms have small discrepancies in the AP length of adjacent endplates.
2. There is a strong correlation between minor endplate discrepancies and significant degeneration of the intervening disc.

REFERENCES:

1. Southworth, JD and Bersack, SR; AJR 64(4), 624-34, 1950.
2. Saraste H, Brostrom LA, Aparisi T, et al, *Spine*, 10, 3, 1985.
3. Gower DJ, Culp P, Marshall B, Surg Neurol 27, 316-18, 1987.
4. Aharinejad, S., Bertagnoli, R., Wicke, K.,et al, *Amer. Journal. Anat.*, 189, 69-76, 1990.
5. Jensen MC, Brant-Zawadzki MN, Obuchowski N, et al NEJM 331(2), 69-73, 1994.