INTRODUCTION Accurate morphometric characterization of the lumbar spinal canal is important in understanding low back disorders such as lumbar spinal stenosis. Current conventional methods measuring the AP diameter of the canal, a common parameter for defining the canal, use practical and clinically available methods where patient CT scans are analyzed in 2D. This method, however, does not take into account the obliquity of the spine potentially omitting the fact that the AP diameter might not lie in an arbitrarily predefined anatomical plane (e.g. sagittal or coronal), leading to less accurate measurements. The purpose of this study was to utilize a novel 3D CT-based measurement approach to account for the obliquity of the spine and obtain a more accurate measurement of the lumbar spinal bony canal.

METHODS This IRB-approved study used CT derived 3D geometry from 90 subjects (48 M, 42 F, ages: 20-59 yrs, 58 symptomatic for low back pain) to create vertebral point cloud models of the lumbar spine using a segmentation and reconstruction software package (Mimics, Materialise, Inc., Leuven, Belgium). The data was post-processed to obtain the point-cloud data set of each segmented vertebral body. A custom-written Visial C++ program computed eigenvectors of the posterior walls that were then utilized as reference planes to measure the AP diameter of the bony canal. Two points (A & B) were set along the approximate inferior and superior ends of the posterior wall in 3D space. Along this axis line, canal cross sections were determined and normalized to 1/100 increments. At each intersection point of the axis line and each cross-section (O), a spherical coordinate system was established to act as a centered pivoting point for a virtual cone with a vertex angle of 10°. The boundary of the bony canal. AP diameter of the canal was defined as the least distance within this boundary (Fig. 1). For each subject, the minimum AP, maximum, and average AP diameters of the bony canal were calculated at levels L1-L5. Intervertebral discs were graded according to the Pfirrmann MRI scale. Statistical significance was set at p<0.05 and determined with ANOVA.

RESULTS Symptomatic subjects had significantly smaller min. AP diameters than asymptomatic subjects (Fig. 2). Minimum diameter also decreased with increasing grade of disc degeneration. Discs with grade 1 degeneration had significantly larger minimum diameters than grade 5, and discs with grade 2 degeneration had significantly larger minimum diameters than grades 3, 4, and 5. Across levels, L1 had significantly larger minimum diameters than L2-L5, and significantly larger average diameters than L2 and L3. Males had significantly smaller minimum and average diameters than females. There was no significant difference between age groups.

DISCUSSION The study found significant differences in AP diameter between low back pain patients and healthy individuals that could implicate the narrowing of the spinal canal to the etiology of chronic low back pain, which has not been reported before. The finding that greater disc degeneration showed smaller minimum diameters is consistent with the findings in the cervical spine by Morishita et al. that smaller than average cervical spinal canal diameters may put an individual at a greater risk for development of pathological changes in the disc. The finding also is consistent with the literature suggesting degenerative changes in the intervertebral disc can cause narrowing of the spinal canals from mechanical changes occurring in the 3-joint complex. Future studies utilizing this technique may lead to more accurate findings and a greater understanding of the anatomical factors related to low back pain and other disorders of the lumbar spine.

SIGNIFICANCE This study describes a novel 3D imaging technique used to accurately describe the morphometry of the lumbar spinal bony canal compared to conventional 2D techniques, where obliquity of the spine is not taken into account and there are often interobserver reliability problems. 3D imaging techniques are essential in aiding clinicians to make accurate diagnoses.

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REFERENCES


Fig. 1(left) Determination of tubular cross sections using point cloud data and a spherical coordinate system. Fig. 1(right) Cross-section boundary and min. AP and max. diameter on a L1 3D model.