Cervical Spinal Canal Stenosis: Anatomic and Radiographic Analyses of Sagittal Canal Dimensions

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INTRODUCTION: Radiographic evaluation of cervical stenosis has traditionally been assessed with sagittal measurements of the spinal canal on lateral cervical spine radiographs. Most established methods of measuring the sagittal diameter of the canal include the anterior-to-posterior distance from the midpoint of the posterior vertebral body to the closest point on the anterior spinolaminar line. Based on observations of the normal concave contour of the posterior vertebral body in conjunction with the posteriorly-sloping contour of the posterior lamina, we hypothesized that the midpoint would not be the most stenotic level when measuring sagittal canal dimensions.

The four purposes of this study were: 1) to anatomically and radiographically determine the narrowest sagittal AP diameter along the spinal canal, 2) to determine the effects of age, gender, race, body mass index (BMI) and cervical spondylosis on sagittal canal dimensions, 3) to evaluate current radiographic methods of determining cervical stenosis, and 4) to propose a classification system of cervical spinal stenosis based on anatomic and radiographic observations.

METHODS: Forty-six lateral cervical spine radiographs of cadavers (24 males and 22 females) from the Hamann-Todd collection at the Cleveland Museum of Natural History were assessed for radiographic analysis. Two-hundred-and-thirty dry cervical vertebrae of the subaxial spine from the same forty-six cadavers were then assessed for analysis of sagittal bony anatomy. Measurements from both lateral cervical radiographs and bony cervical vertebrae were made with digital calipers and recorded in millimeters.

Six standard measurements were made from all lateral cervical spine radiographs (Fig. 1): 1) superior vertebral body AP sagittal diameter (SVD), 2) middle vertebral body diameter (MVD), 3) inferior vertebral body diameter (IVD), 4) superior canal diameter (SCD), 5) middle canal diameter (MCD), and 6) inferior canal diameter (ICD). ICDs were made from the posteroinferior-most aspect of the vertebral body to the caudal spinolaminar line if the measurement was less than the distance to the corresponding spinolaminar line at the same cervical level. Anatomic vertebral body measurements from cervical spines were made in a similar manner in the mid-sagittal plane. Spondylotic intervertebral...
levels were identified and recorded based on the presence of end-plate sclerosis and/or osteophyte formation.

Stratified analysis based on age, gender, race, and BMI were performed. Statistical analysis of data was performed using the t-test when comparing two independent samples, and ANOVA when multiple samples were being compared. Statistical significance was regarded as p<0.05.

RESULTS: Radiographically, the mean SVD, MVD, and IVD were 19.5±2.3mm, 18.3±1.9mm, and 20.5±2.2mm respectively (Fig. 2). The MVD was statistically smaller than both SVD and IVD (p<0.01). The mean SCD, MCD, and ICD were 16.0±2.3 mm, 16.9±1.9 mm, and 15.8±1.9 mm respectively. The MCD was statistically larger than both SCD and ICD (p<0.01).

Anatomically, the mean SVD, MVD, and IVD were 15.7±1.9mm, 15.2±1.7mm, and 16.2±1.0mm respectively (Fig. 2). The MVD was statistically smaller than both SVD and IVD (p<0.01). The mean SCD, MCD, and ICD were 14.5±1.5 mm, 15.3±1.5 mm, and 16.5±1.6 mm respectively. The SCD was statistically smaller than the MCD or ICD (p<0.01).

There was a statistically significant difference between SVDs of specimen ≤40 years old and >40 years old (16±2.1mm vs. 15.4±1.7mm; p<0.05). Fifteen of the 46 specimen (33%) demonstrated evidence of spondylotic degenerative changes. Analysis of gender differences revealed that males had larger VD and CD measurements at all three levels (p<0.01). No significant differences (p>0.05) were found in VD, CD, or TR measurements at any level between specimen from white and black populations. The mean CDs of specimen with BMI<20 were found to be significantly more stenotic than specimen with BMI>20 at all 3 levels (p<0.01).

Using mid-vertebral ratio values of <0.8 as radiographic criteria for the diagnosis of cervical stenosis, 36 of 230 measured cervical levels (16%) met the criteria. With TR <0.08 as the definition of stenosis, 19 of 46 cadavers (41% incidence) fit the criteria at the mid-vertebral level. When using an absolute mid-sagittal canal diameter <13 mm as radiographic criteria for the diagnosis of cervical stenosis, no measured cervical levels (0%) met the criteria.

CONCLUSIONS: The anatomic and radiographic data presented in this study clearly indicate that the mid-vertebral body is not the most accurate level to measure when screening for cervical stenosis. Results of both studies reveal that the mean mid-vertebral body sagittal diameter was significantly smaller than the diameters of the body at the superior and inferior endplates (p<0.01). Perhaps
more importantly, the sagittal canal diameter at the mid-vertebral body level is clearly not the most stenotic. The superior, most cephalad level was found to be the point of maximal stenosis.

We propose a new classification system of canal stenosis based on the etiology and extent of disease in the subaxial cervical spine. The main classification is based on the etiology of stenosis: Type 1 – DEVELOPMENTAL, Type 2 – SPONDYLOTIC, Type 3 – TRAUMATIC, Type 4 – PATHOLOGIC, and Type 5 – COMBINED. The second sub classification is based on the extent of the disease: FOCAL or DIFFUSE.

As far as we know, this study represents the first critical anatomic investigation of sagittal cervical canal diameters on cervical spines with accompanying lateral radiographs from the same specimens. We present data which confirm that the endplate level, not the mid-vertebral body level, is the anatomic region of greatest canal stenosis and propose a method to most accurately measure cervical canal stenosis. A classification system based on the etiology and extent of cervical canal stenosis is presented in order to ensure more accurate communication of this potentially debilitating condition.

**Figure 1.** Sagittal cervical spine measurements. SVD = Superior Vertebral Diameter; MVD = Middle Vertebral Diameter; IVD = Inferior Vertebral Diameter; SCD = Superior Canal Diameter; MCD = Middle Canal Diameter; ICD = Inferior Canal Diameter.
Figure 2. Mean sagittal AP diameters of radiographic vs. anatomic cervical spine dimensions (in mm). SVD = Superior Vertebral Diameter; MVD = Middle Vertebral Diameter; IVD = Inferior Vertebral Diameter; SCD = Superior Canal Diameter; MCD = Middle Canal Diameter; ICD = Inferior Canal Diameter.