A Novel Radiographic Indicator of Developmental Cervical Stenosis

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Introduction

- Developmental cervical stenosis (DCS) predisposes patients to neurologic compression and loss of function through cervical cord neurapraxia\(^1-4\), spinal cord injury\(^5,6\), and myelopathy\(^7,8\).

- The historical plain film measurement to assess DCS, the Torg ratio, has been shown to provide high sensitivity, but low specificity for identifying DCS\(^3,4,9\).

- The goal of this study is to develop an objective novel radiographic index, that is both sensitive and specific, for indicating DCS.

- The hypothesis of this study is that a ratio utilizing the spinolaminar line to lateral mass distance will provide a sensitive and specific index for DCS.

- This would provide physicians a simple tool to assess for DCS and prompt cross sectional imaging or referral to a surgical specialist.
Methods

- **Study type:** Radiographic study, n=150, average age 53.5±11.4 years

- **Inclusion:** Adult patients with plain film cervical spine lateral radiographs and cervical spine lateral CT radiographs. Patients had no previous cervical spine surgery. No further clinical information was reviewed to associate symptomatology or underlying diagnosis.

- **Exclusion:** Patients with severe spondylosis limiting resolution of the measurement parameters, OPLL, or inadequate lateral films, were not used. Rotated films were not used as they limit interpretation of the lateral mass posterior cortex. (see Figure)
Methods

- **Measurements:** Cervical levels C3-C6 were measured on plain films for multiple dimensions: spinolaminar line-lateral mass (SL) distance [A], lateral mass-vertebral body (LM) [B] distance, spinolaminar line-vertebral body (canal diameter, CD) [C] distance, and vertebral body (VB) diameter [D]. Measurement points were set at the cortical margins. Corresponding true canal anterior to posterior diameter was measured at levels C3-6 for each patient using CT mid-sagittal sections [E,F].

- All measurements had confirmed excellent intra- and inter-observer reliability (all > 0.960).

- Ratios of measurements taken to eliminate effects of magnification. These were: SL/CD, SL/FB, FB/CD, SL/VB, CD/VB, and FB/VB.
Results

- Plain film measurements CD and SL correlated significantly to sagittal CT canal diameter at all levels (CD: r= 0.73-0.81; SL: r=0.48-0.68) (p<0.001).

- LM and VB distances had poor correlations to CT canal size at all levels (LM: r=0.14; VB: r=0.04 at C5 level) (p=ns for both).

- Ratios of the plain film dimensions and their correlation coefficients to the true sagittal CT canal diameter were calculated.
  - Many of the ratios correlated significantly with the true canal diameter. Strongest correlations were present at the C5 level. (see examples in the Figure)
Results

- Receiver operating characteristic (ROC) curve analysis was performed with true canal stenosis defined as <12mm.
  - All cervical levels demonstrated statistical significance, but optimal statistics were produced at the C5 level.

- The ROC curve analysis identified that a ratio of $\text{LM/CD} > 0.735$ at C5 indicates cervical spinal canal diameter less than 12 mm with sensitivity of 83% and False positive rate (1-specificity) of 25%.

- Only the LM/CD ratio, but none of the other ratios tested (including Torg-Pavlov ratio or ratios based on the SL distance) provided appropriate statistical strength to indicate DCS.

This slide illustrates the ROC curve analysis with the C5 level showing the most significant results. The graph displays the sensitivity and 1-specificity for different cervical levels, with C5 LM/CD showing the highest value.

Diagonal segments are produced by ties.
Results

- Further ROC curve analysis was performed with the LM/CD ratio at C5 to determine if it could indicate the presence of cervical stenosis at any level in the cervical spine C3-C6 (any level less than 12 mm on the CT).

- This ROC curve analysis showed that the ratio **C5 LM/CD > 0.735** indicates cervical stenosis at any level C3-C6 with sensitivity of 76% and False positive rate of 20%.

- The **odds ratio (OR)** for indicating developmental cervical stenosis at any level when the C5 level LM/CD > 0.735 is **12.36 (95% CI, 5.38-28.38)**.

- The true negative rate for C5 LM/CD < 0.735 is 0.88.
Results

- Other ratios, including the CD/VB (Torg-Pavlov ratio) and the hypothesized SL ratios all generated curves that were on or below the diagonal reference line of the ROC space, therefore demonstrating a poor (or worse than random) ability to indicate cervical stenosis with any statistical strength.

- The accuracy of the LM/CD ratio to indicate DCS was not affected by skeletal size or patient gender.

- Furthermore, patients with LM/CD ratio > 0.735 (n=28) also had on average less space available for the cord on MRI both at narrowest mid-vertebral level (p=0.033) and trending towards statistical significance at the disc level (p=0.083) in comparison to patients with FB/CD < 0.735 (n=32).
Conclusion

- This analysis identified a novel index for DCS, the C5 LM/CD ratio.

- Measuring C5 LM/CD > 0.735 indicates developmental cervical stenosis (cervical canal sagittal diameter <12mm) occurring anywhere from C3-6 with a favorable statistical profile: sensitivity (76%), specificity (80%), odds ratio of 12.36 and true negative rate of 0.88.
  - The accuracy is not affected by patient gender or skeletal size.
  - The LM/CD ratio is also suggestive of reduced space available for the cord from combined skeletal and acquired soft tissue canal stenosis as observed on MRI.

- The LM/CD ratio represents an excellent radiographic index to indicate developmental cervical stenosis in the adult population and can be used as a screening tool to prompt cross sectional imaging or surgical referral.
References


