Case Report

Consideration to a New Standard for the Diagnosis of Lumbar Central Canal Stenosis by Quantitative MRI Assessment

Motoyuki Iwasaki, Izumi Koyanagi and Kiyohiro Houkin

Abstract

The first aim of this study is to assess the Dural Sac Cross-sectional Area (DSCA) of the lumbar spinal canal in healthy young individuals with the appropriate posture when using MRI. A secondary aim was to determine if obtained DSCA values are correlated with each symptom. The group of 15 healthy individuals (group I) were scanned in the flexed and extended knee posture. The DSCA and Spinal Canal Cross-sectional Area (SCCA) were measured at the center of the pedicle level of each vertebral body. A group of 42 symptomatic patients (group II) were scanned, and the correlation with each symptom was statistically evaluated. In group I, the mean DSCA was 178 ± 5.1 mm² in the flexed posture and 158.9 ± 5.6 mm² in the extended knee posture. At each level, there was a significantly smaller DSCA in the extended posture. In group II, the mean DSCA was almost two-third of that in group I. The DSCA at L1/2 and L2/3 showed a mild correlation with the Japanese Orthopedic Association score - IV (JOA - IV) (urinary disturbance score) (r² = 0.278). The number of inter vertebral levels with severely and moderate stenosis was assessed and a significant negative correlation was found with JOA - IV (p = 0.0046 and 0.0275, r² = 0.184 and 0.116, respectively).

It should be noted that these imaging values should be always considered with matched lumbar symptoms.

Keywords: COSMIC, Dural sac cross-sectional area; Healthy young individual; Lumbar canal stenosis; Quantitative assessment

Introduction

Previously, many morphologic spinal canal studies have been done using a plain radiograph or CT with or without a contrast medium [1-4] and cadaver [5]. Recent advancements in radiological techniques have enabled us to perform a faster and less invasive diagnosis, which resulted in the development of a new assessment method for the spinal canal with magnetic resonance imaging [6-12]. Fat - suppressed three - dimensional Coherent Oscillatory State acquisition for the Manipulation of Image Contrast (COSMIC) is a sequence based on fast imaging employing steady - state acquisition, which can easily produce various thin sliced planes. COSMIC images are obtained from reconstructed original 3D scanned images, which can easily produce various thin sliced planes.

Several previous studies also measured anteroposterior diameter of the lumbar spinal canal or Dural Sac Cross-sectional Area (DSCA) of patients involved disc level, and then attempted to apply the numerical data to lumbar symptoms statistically, which resulted in no correlation (Table 1) [2,13-16]. However, the previous studies' designs may have negatively affected the results. Moreover, some studies use upright MRI and axial loading of the spine [2,8,11,13,14]. Those studies suggest the importance of a more appropriate condition while taking images despite whether or not it is an expensive and complicated method. We decided on a unified, reasonable, and easy posture while taking images to avoid variable values in the same individual without using upright MRI or axial loading of the spine for daily clinical decisions.

Previous standards for lumbar central canal stenosis were <75 mm² or 100 mm² in the DSCA [2,3,15,16], which clinicians might not recognize as “lumbar canal stenosis” at a glance. Those standards could lead to many unimproved cases after decompression surgery. Furthermore, clinicians have to realize there may be coexisting stenotic lesions along with spinal canal stenosis when making decisions, as the Spine Patient Outcomes Research Trial (SPORT) study suggested [17]. This study might help achieve better patient outcomes when we decide to surgically treat lumbar central canal stenosis with decompression.

Objective

Clarifying the correlation between lumbar symptoms and 3 - dimensional radiographical data leads to clinical decision making for all the spine surgeons.

Material and Methods

Fifteen healthy Japanese individuals and 16 patients with lumbago and/or leg pain were examined in two separate studies. A MRI was taken in the supine position by using the three - dimensional COSMIC method without axial loading.

Abbreviations

COSMIC: Fat - suppressed three - dimensional Coherent Oscillatory State acquisition for the Manipulation of Image Contrast
DSCA: Dural Sac Cross - sectional Area
JOA: Japanese Orthopedic Association score
SCCA: Spinal Canal Cross - sectional Area

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Group (I) was 15 healthy individuals (mean age: 36.3 ± 3.3 years, 7 men and 8 women) who were scanned in the flexed and extended knee posture with L1/2 - L5/S1 in the extended knee posture (p = 0.041). The mean DSCA at each disc level was not significantly different between postures and the differences gradually decreased as the disc level moved caudally. The DSCA was significantly different at all disc levels in the flexed knee posture compared to the extended knee posture (p = 0.0002 at L5/S1), which resulted in a significantly decreased DSCA value at each level in the extended knee posture. Although the mean DSCA between each disc level did not reveal any statistically significant differences in the flexed knee posture, the Tukey-Kramer method was used. When investigating the correlation between graphical parameters and outcome measures, Pearson’s correlation was used. The level of significance was set at 0.05.

**Results**

**Group (I)**

A typical sample of COSMIC images is shown in figure 1. The total mean DSCA was 178 ± 5.1 mm² in the flexed knee posture and 158.9 ± 5.6 mm² in the extended knee posture (Table 2). The mean DSCA at each disc level was not significantly different between postures and the values gradually decreased as the disc level moved caudally. The DSCA was significantly different at all disc levels in the flexed knee posture compared to the extended knee posture (p = 0.0196 at L1/2, 0.0017 at L2/3, 0.0002 at L3/4, <0.001 at L4/5, and 0.0002 at L5/S1), which resulted in a significantly decreased DSCA value at each level in the extended knee posture. Although the mean DSCA between each disc level did not reveal any statistically significant differences in the flexed knee posture, the mean DSCA at L1/2 was significantly larger compared to L5/S1 in the extended knee posture (p = 0.041). Moreover, the mean difference between DSCA in the flexed and extended knee posture was the largest at L5/S1 (29.33), which suggests that L5/S1 would be more influenced by dynamic spinal factors.

### Table 1: Recent representative studies of lumbar canal stenosis.

<table>
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<tr>
<th>Author</th>
<th>Country</th>
<th>Year</th>
<th>Modality</th>
<th>Up/AxL</th>
<th>Posture</th>
<th>Range</th>
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<th>Classification (mm²)</th>
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<th>Pain</th>
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### Statistics

JMP 8 statistical software was used for statistical analysis in the study. When investigating the difference between groups, the Tukey-Kramer method was used. When investigating the correlation between graphical parameters and outcome measures, Pearson’s correlation was used. The level of significance was set at 0.05.
The total mean SCCA was 203.6 ± 7.1 mm², and the mean at each mid pedicular level was similar and gradually decreased, which resulted in significantly smaller L5 SCCA compared to L1 (p = 0.0484) (Table 2). The mean DSCA and SCCA at each vertebral level for group (I) are shown in Table 3.

Upon receiving the results of group (I), we decided to only measure the DSCA in the extended knee posture because the extended posture is suitable for the diagnosis of lumbar canal stenosis. The mean DSCA of all the lumbar spinal level was 104.4 ± 4.0 mm² and the mean SCCA was 196.5 ± 3.5 mm² (Table 2). The DSCA at L1/2, 2/3, and 5/51 was also larger compared to L3/4 and 4/5 (p < 0.005) (Table 3). Other patients' demographic data were shown in Table 4.

When considering the relationship between disc level and each symptom, the DSCA value at L1/2 and 2/3 was significantly correlated with the JOA - IV (urinary disturbance score) (p = 0.0078 and 0.0022), however, showed only mild correlation (r² = 0.16 and 0.21).

The mean minimum DSCA was 47.6 ± 4.7 mm². There were no significant correlations between the minimum DSCA and VAS, total JOA, JOA - IA, and JOA - IV (p = 0.3345, 0.1634, and 0.0715, respectively). However, a significant correlation was found between minimum DSCA and JOA - IC and IV (p = 0.0003, r² = 0.278) (Table 5); therefore, the patient who had a lower minimum DSCA was more likely to have intermittent claudication.

The relationship between symptoms and the number of intervertebral levels with severely stenosis (DSCA < 40 mm²) was assessed. As a result, no correlation was found between VAS, total JOA, and JOA - IA (p = 0.6515, 0.1681, and 0.4186, respectively); however, a significant negative correlation was found with JOA - IC and IV (p = 0.0046 and 0.0275, r² = 0.184 and 0.116). The results show that the number of severely narrowed (DSCA < 40 mm²) levels is significantly related to intermittent claudication and urinary disturbance. Subsequently, the number of intervertebral levels with moderate stenosis (DSCA < 80 mm²) was assessed. The data revealed the correspondence with those of the number of severely affected levels (Table 5).

**Group (II)**

Upon receiving the results of group (I), we decided to only measure the DSCA in the extended knee posture because the extended posture is suitable for the diagnosis of lumbar canal stenosis. The mean DSCA of all the lumbar spinal level was 104.4 ± 4.0 mm² and the mean SCCA was 196.5 ± 3.5 mm² (Table 2). The DSCA at L1/2, 2/3, and 5/51 was also larger compared to L3/4 and 4/5 (p < 0.005) (Table 3). Other patients' demographic data were shown in Table 4.

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Discussion

Previous studies of lumbar canal stenosis attempted to assess the relationship between symptoms and acquired values using various imaging modalities. There were some reports that found negative results [2,13-16]; however, we thought that the presence of more accurate study conditions when assessing the acquired values would lead to less pseudo-negative results, which would benefit clinicians who have to accurately diagnose conditions in outpatient settings daily.

In the group (I) session, healthy young Japanese individuals had almost the same DSCA (mean: 158.9 ± 5.6 mm²) regardless of the intervertebral level, except for between L1/2 and L5/S1 in the extended knee posture. We thought the constant DSCA value could be acceptable as a definition when assessing spinal canal stenosis. To regulate the settings conveniently when taking an MRI, the knee posture was assessed. The extended knee posture significantly made the DSCA narrower compared to the flexed knee posture. The extended knee posture was thought to be ideal due to its convenience without using either axial loading or upright MRI. Moreover, the COSMIC method always provides an accurate cross-sectional plane by using 3D remodeling. Previous reports did not necessarily specify the posture when taking images and the precision of the angle of the acquired plane. Recently, the cross-sectional area can be instantly measured by drawing the contour of the dural sac without any formula, such as Haminishi et al., [9,12,16,18].

In the group (II) session, each patient’s minimum DSCA did not correlate with low back pain scores or urinary disturbance, such as VAS and JOA-IA/IV, but did correlate with JOA-IC, which indicates that even one level severe stenosis could cause gait disturbance as expected. Sigmundsson et al., reported that minimal DSCA did not correlate with estimated walking distance as a preoperative status [10]; however, this quantitative parameter does not accord with neurointermittent claudication, which indicates that further research is needed.

It is known that some patients with radiographic spinal stenosis remain asymptomatic [19,20]; however, some patients have symptoms such as neurological claudication or pain. Ishimoto et al., reported that severe central stenosis was significantly associated with clinical symptoms, but only 17.5% of participants with severe central stenosis were symptomatic [21]. It is unclear why such differences are seen. We should also clarify the definition of “spinal stenosis.” The Wakayama Spine Study qualitatively rated canal stenosis according to the classification included in a general guideline [22]. Until recently, a Spine Study qualitatively rated canal stenosis according to the following criteria: severity 1, 2, 3 or 4. The number of affected levels was correlated with intermittent claudication. Since the results of our study and the SPORT may have analyzed the same phenomenon from a different aspect.

Throughout the present study, total JOA and JOA - IA (low back pain) never correlated with DSCA. A few authors stated that total lumbar JOA scores were significantly correlated only with postoperative lower extremity VAS scores but not with the preoperative VAS and for low back pain [24], which corresponds with our results. Low back pain occurs from various pathologies; therefore, we believe the total JOA score, including lumbar pain, is less likely to be associated with the radiographical values.

There were few reports that mentioned the relationship between the degree of dural sac compression and bladder symptoms. Tsai et al., concluded that anteroposterior diameter of the dural sac on an MRI was correlated with the American Urological Association Symptom Score [25]. Previous research has reported that the incidence of urinary disturbance was significantly higher in patients with disc herniation at L1/2 and 2/3 compared to lower levels (L3/4 - L5/S1) [26], which is similar to the result of the current study.

Finally, it should be noted that from a spine surgeon perspective, the decision for surgery will never be based on some DSCA value, but rather on both imaging data and clinical presentation because our study could not show the moderate/strong correlation between any imaging value and symptoms.

Conclusion

The COSMIC method is a useful, fast, and noninvasive technique to quantify the lumbar canal and dural sac. When researching spinal stenosis, the posture used when performing MRI has to be specified to obtain accurate numeric values. The patient analysis revealed that upper lumbar stenosis was correlated with urinary disturbance, neurogenic claudication was correlated with the minimum DSCA. The number of affected levels was correlated with intermittent claudication and urinary disturbance. The JOA and VAS of leg pain never correlated with radiographical stenotic values.

References


