Indications for prophylactic lumbar decompression at the L3/4 level in patients with L4/5 responsible lumbar spinal canal stenosis

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Abstract:

Introduction: Lumbar spinal canal stenosis (LSS) is a very common disease. When the responsible level is considered to be L4/5 despite the appearance of double-level (L3/4 and L4/5) stenosis on magnetic resonance imaging (MRI), it is difficult for spinal surgeons to decide whether prophylactic decompression should be performed at the L3/4 level. The purpose of this study was to investigate the relationship between the dural sac cross-sectional area (DCSA) at the L3/4 level and clinical symptoms in patients with double-level stenosis.

Methods: Thirty-five patients with double-level stenosis were registered in this study. All patients underwent decompression surgery at the L4/5 responsible level. The severity of patients' symptoms was evaluated by the Japanese Orthopaedic Association (JOA) score and its rate of recovery. A measurement program on MRI was used to determine the DCSA.

Results: The clinical course of LSS according to the JOA score recovery rate at the final follow-up revealed that the good group (≥50%) included 27 patients, and the poor group (<50%) included 8 patients. In the good group, the mean DCSA at the L3/4 level was 72.3 ± 32.1 mm^2 preoperatively and 71.3 ± 29.0 mm^2 at the final follow-up. In contrast, in the poor group, the mean DCSA at the L3/4 level was 49.1 ± 23.8 mm^2 preoperatively and 40.6 ± 14.1 mm^2 at the final follow-up. Significant differences were observed in the preoperative and final follow-up DCSAs at the L3/4 level between two groups.

Conclusions: Considering the present results, prophylactic decompression surgery at the L3/4 level should be performed for patients with double-level stenosis and DCSA <50 mm^2 at the L3/4 level.

Keywords:
lumbar spinal canal stenosis, double-level stenosis, dural sac cross-sectional area, prophylactic decompression surgery, Japanese Orthopaedic Association score

Spine Surg Relat Res 2017; 1(4): 191-196
dx.doi.org/10.22603/ssrr.1.2016-0032

Introduction

Lumbar spinal canal stenosis (LSS) is a very common disease among older people, and causes neurogenic intermittent claudication, motor and sensory disturbances, and radicular pain in the lower extremities[1)]. To evaluate the spinal canal in patients with LSS, imaging studies including myelography, computed tomography (CT), and magnetic resonance imaging (MRI) are performed. In particular, MRI is less invasive and more precise than the other modalities, and is therefore widely used to diagnose LSS and evaluate the spinal canal.

Multiple-level canal stenosis could be observed in many patients, and double-level stenosis in patients with lumbar spondylosis were associated with the occurrence of cauda equina symptoms[2,3)]. Previous experimental studies have showed that more pronounced changes can be induced with double-level compression, compared with single-level compression[4-6)]. Sato and Kikuchi[3)] reported that most patients with double-level (L3/4 and L4/5) stenosis had symptoms induced by compression at the L4/5 level only. It is uncommon for both stenotic levels to be symptomatic in patients with double-level (L3/4 and L4/5) stenosis. Based on neurologic examinations, a selective nerve root blockade, and radiograph findings, the responsible level for LSS can usually be decided in clinical situations. When the responsible

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Received: December 28, 2016, Accepted: May 14, 2017

level is thought to be L4/5, despite the appearance of double-level (L3/4 and L4/5) stenosis on MRI, it is difficult for spinal surgeons to decide whether prophylactic decompression should be performed at the L3/4 stenotic level.

Recently, to evaluate the severity of LSS, some researchers measured the dural sac cross-sectional area (DCSA) on the axial view of an MRI. According to previous studies, DCSA values below 75 mm^2 indicate absolute stenosis, those below 100 mm^2 indicate relative stenosis, and those below 130 mm^2 indicate early stenosis[7-10]. These cut-off values are widely accepted for evaluation of LSS. However, it remains controversial whether the DCSA is useful for evaluating the severity of LSS. Although many researchers have analyzed the relationship between the DCSA and the severity of clinical symptoms in patients with LSS, most researchers reported there was no significant correlation between them[11-13]. Meanwhile, Ogikubo et al.[14] reported that the DCSA was correlated with walking ability, severity of preoperative leg and back pain, and quality of life in patients with LSS. In a longitudinal cohort study of more than 10 years, Minamide et al.[15] found that the DCSA in worsening patients was <50 mm^2 at the initial examination. Furthermore, some patients underwent the decompression surgery during their observation period, and had DCSA <40 mm^2 at the initial examination.

Although many reports have been demonstrated the relationship between the DCSA and the severity of clinical symptoms in patients with LSS, there are no reports about the relationship between the DCSA at the L3/4 level and the postoperative symptoms in patients with double-level stenosis. The purpose of this study was to investigate the relationship between the DCSA at the L3/4 level and the clinical symptoms in patients with double-level (L3/4 and L4/5) stenosis who underwent decompression surgery at the L4/5 responsible level.

Materials and Methods

Consecutive patients with LSS were referred to our institution. Informed consent was obtained from all patients to undergo the examinations and surgery. Decompression surgery (partial laminectomy) was prospectively performed at only a single level from April 2006 to October 2009, even if lumbar MRI indicated multilevel lumbar stenosis. Thirty-five patients (17 females and 18 males) with double-level (L3/4 and L4/5) stenosis were registered in this prospective study. The mean age of the patients was 71.1 years (range: 57-81 years) at surgery. The preoperative diagnosis of LSS was based on neurologic examinations and clinical symptoms, and confirmed by spinal imaging examinations including plain radiography, CT, and MRI. The diagnosis was confirmed by two orthopedic surgeons authorized by the Japanese Orthopaedic Association (JOA). The responsible level for the neurologic symptoms in the double-level (L3/4 and L4/5) stenosis was determined by neurologic examinations (e.g., deep tendon reflex, manual muscle testing, sensory disturbance testing) and a selective nerve root blockade. LSS was classified into intermittent claudication type, radicular type, and mixed type, based on the symptoms[16]. The exclusion criteria included previous lumbar spine surgery, pyogenic spondylitis, destructive spondyloarthropathy, degenerative spondylolisthesis, spondylolysis, scoliosis, osteoarthritis of the lower extremity joints, polyneuropathy, and arteriosclerosis obliterans of the leg.

The clinical and functional outcomes were evaluated by the JOA score, which consists of four categories and has a maximum score of 29 points[17]. Previous studies have demonstrated the validity of the JOA scoring system[18]. The recovery rate of the JOA score was calculated by the Hirabayashi method[19]. The clinical results were classified into two groups according to the recovery rate of the JOA score: good group (≥50%) and poor group (<50%).

The MRI examinations were conducted on a 1.5 Tesla system (Gyroscan Intera 1.5T Nova; Philips, Best, the Netherlands) using a surface coil. The patients were examined with sagittal, coronal, and axial T1- and T2-weighted spin-echo or turbo spin-echo sequences with 4-mm slices. The box for transverse slices was placed parallel to each disc. All MRI examinations were performed with the patients in a psoas-relaxed position.

The DCSA was determined on axial T2-weighted images using a measurement program in the MRI unit (VOX/BASE II; J-MAC Systems Inc., Sapporo, Japan). The measured image was the smallest area of the dural sac on each disc level (Fig. 1). The DCSA was measured three times on each image, and the mean value was calculated. The data for the DCSA at the L3/4 level were investigated preoperatively, at 1 and 3 years postoperatively, and at the final follow-up examination, while those for the JOA score were evaluated preoperatively, at 1 year postoperatively, and at the final follow-up examination.

The differences between the two groups were determined using a paired *t*-test, Mann-Whitney U test, or Fisher's exact test. Values of $P<0.05$ were considered significant. Data input and analysis were performed with SPSS version 12.9 J (SPSS Inc., Chicago, IL).

Results

The mean follow-up period was 51.7 months (range: 36-84 months) after decompression surgery at the L4/5 responsible level. Two patients had cerebral infarction, and eight patients had diabetes mellitus in this study. They had no paralysis and no numbness at their upper and lower extremities preoperatively. Therefore, the presence of them did not influence the clinical prognosis of LSS. Of the 35 patients, 31 patients (88.5%) had intermittent claudication type, 1 patient (2.8%) had mixed type, and 3 patients (8.5%) had the radicular type. All patients had double-level (L3/4 and L4/5) stenosis with lumbar spondylosis, according to their MRI and myelography images. In the total population, the mean DCSA at the L3/4 level was 66.9 ± 31.7 mm^2 preopera-

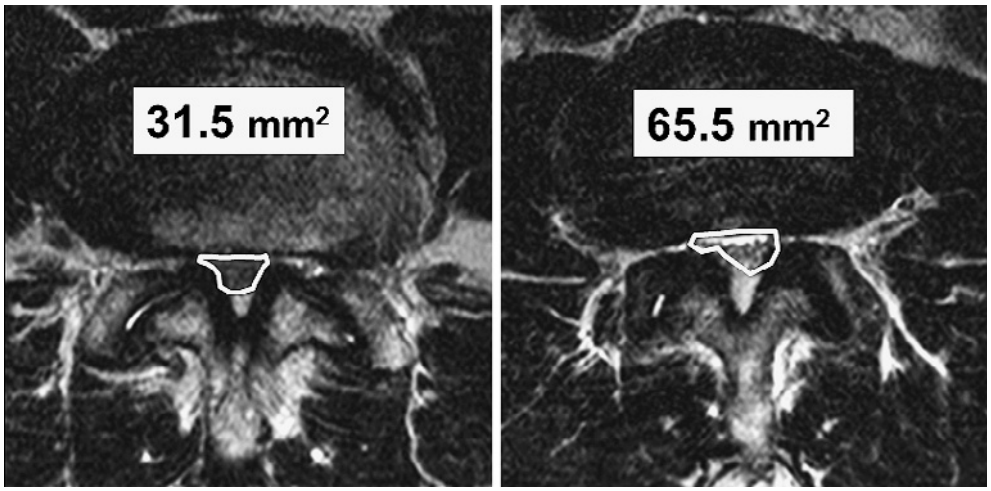

Figure 1.
Measurements of dural sac cross-sectional area (DCSA) on axial T2-weighted images. The white lines indicate the outlines of the DCSAs.

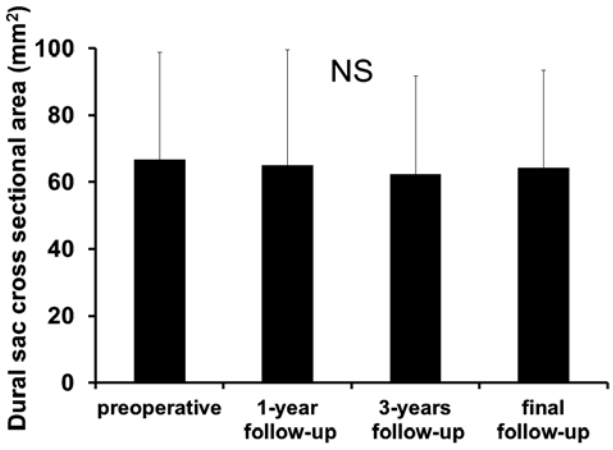

Figure 2.
Comparisons of the dural sac cross-sectional area at the L3/4 level in patients with double-level (L3/4 and L4/5) stenosis between the preoperative value and the value at each postoperative time-point. Data represent means±SD. NS, not significant

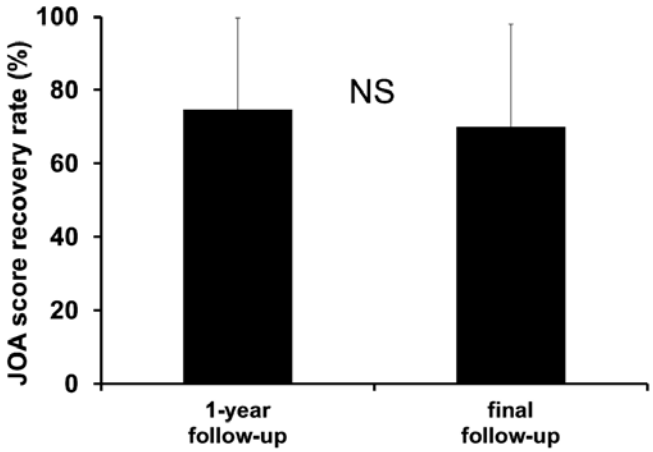

Figure 3.
Comparisons of the JOA score recovery rate between the 1-year follow-up and the final follow-up after decompression surgery at the L4/5 level. Data represent means±SD. NS, not significant; JOA, Japanese Orthopaedic Association

tively, 65.2 ± 34.3 mm^2 at the 1-year follow-up, 62.4 ± 29.3 mm^2 at the 3-year follow-up, and 64.3 ± 29.2 mm^2 at the final follow-up. There was no significant difference in the DCSA at the L3/4 level between the preoperative value and the value at each postoperative time-point (Fig. 2). The mean JOA score was 10.4 ± 4.4 points preoperatively, 24.0 ± 5.4 points at the 1-year follow-up, and 23.4 ± 5.2 points at the final follow-up. The mean JOA score recovery rate was 74.8 ± 24.7% at the 1-year follow-up and 70.0 ± 30.7% at the final follow-up. No significant difference was observed in the recovery rate between at the 1-year follow-up and the final follow-up (Fig. 3).

The clinical course of LSS according to the JOA score recovery rate at the final follow-up revealed that the good group (≥50%) included 27 patients and the poor group (<50%) included 8 patients (Table 1). No significant difference was observed in the baseline characteristics or symptoms between the two groups. In the good group, the mean DCSA at the L3/4 level was 72.3 ± 32.1 mm^2 preoperatively and 71.3 ± 29.0 mm^2 at the final follow-up. In contrast, in the poor group, the mean DCSA at the L3/4 level was 49.1 ± 23.8 mm^2 preoperatively and 40.6 ± 14.1 mm^2 at the final follow-up. There was a significant difference in the preoperative DCSA at the L3/4 level between the two groups. Furthermore, there was a significant difference in the final follow-up DCSA at the L3/4 level between the two groups (Fig. 4). No significant difference in the JOA recovery rate at the 1-year follow-up was observed between the two groups. In the poor group, 3 patients underwent decompression surgery at the L3/4 level during the observation period. The preoperative DCSA <50 mm^2 at L3/4 level could detect the poor outcome with 50.0% sensitivity / 74.0% specificity, and also with 36.3% positive predictive value / 83.3% nega-

Table 1. Comparisons of the Baseline Characteristics and the Symptoms.

	Good group	Poor group
No. of patients	27	8
Sex (F:M)	12:15	5:3
Mean age (yr)	70.1	74.5
Duration of symptoms (mo)	44.2	56.8
Preoperative JOA score (points)	10.1	11.2

No significant differences were observed in the baseline characteristics or symptoms between the two groups.
JOA, Japanese Orthopaedic Association.

tive predictive value.

Discussion

The results of this study revealed the relationship between the DCSA at the L3/4 level and the clinical outcome of patients with double-level (L3/4 and L4/5) stenosis who underwent selective decompression surgery at the L4/5 level and were followed for over 3 years. In previous studies, DCSA values below 75 mm^2 indicated absolute stenosis, those below 100 mm^2 indicated relative stenosis, and those below 130 mm^2 indicated early stenosis[7-10]. All of the patients in the present study met these diagnostic criteria for LSS. Many previous reports demonstrated that poor correlations were observed between the DCSA measured on MRI and the severity of symptoms[11-13]. In this study, there were no patients who had any symptoms caused by compression at the L3/4 level preoperatively, despite the appearance of compression at the L3/4 level on MRI.

Some reports revealed the natural course of LSS[16,20]. Longitudinal investigations of patients with LSS were followed for more than 10 years by Minamide et al.[15]. They demonstrated that the symptoms improved in approximately 30% of patients, remained unchanged in 30%, and worsened in 30% during their observation period. In addition, the DCSA in both the unchanged group and the worsened group was significantly smaller than that in the improved group at the initial examination. In the worsened group, the DCSA at the initial examination was <50 mm^2. Moreover, the DCSA of some patients who underwent surgery during their observation period showed severe narrowing (<40 mm^2) at the initial examination. In our study, the mean DCSA in the poor group (JOA recovery rate: <50%) was 49.1 mm^2 preoperatively. Considering these results, it may be better to perform decompression surgery in patients with DCSA <50 mm^2 at the L3/4 level, even if the patients do not clearly exhibit symptoms caused by the L3/4 stenosis.

Sato and Kikuchi[3] investigated the clinical features of two-level stenosis, and reported that a cauda equine syndrome was frequently induced by two-level stenosis, compared with one-level stenosis. They also described that selective decompression at the responsible level alone improved the symptoms in all patients. In our study, the clinical results were sufficient at 1 year after selective decompression of the L4/5 responsible level. However, the clinical results according to the JOA score recovery rate at the final follow-up revealed that the poor group (<50%) included 8 patients. In the poor group, the mean DCSA at the L3/4 level was 49.1 ± 23.8 mm^2 preoperatively, and 3 patients underwent the decompression surgery at the L3/4 level during the observation period. These results may justify the indication for prophylactic surgery at the L3/4 level when patients undergo decompression surgery at the L4/5 responsible level.

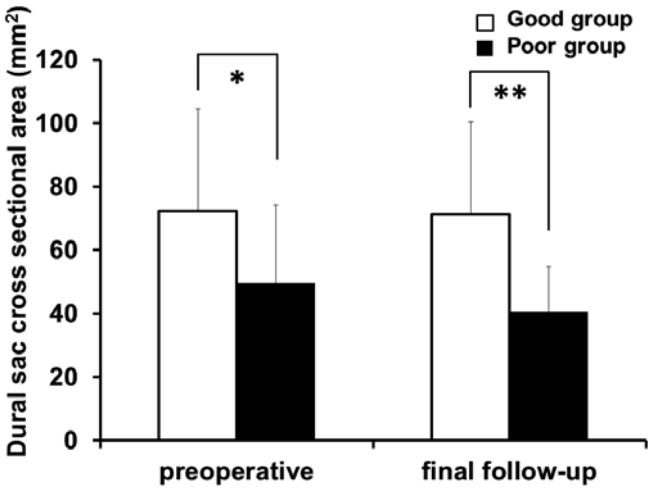

Figure 4.
Comparisons of the dural sac cross-sectional area (DCSA) at the L3/4 level between the good group and the poor group. There are significant differences in the preoperative and final follow-up DCSA at the L3/4 level between the good group and the poor group. Data represent means±SD. *P <0.05; **P <0.01.

Several limitations have to be considered in this study. There may be small number of samples for deciding the indication for prophylactic decompression surgery. However, the postoperative results were followed for over 3 years, and therefore these data are thought to be helpful for spinal surgeons when they consider whether decompression should be performed at only L4/5 or both L4/5 and L3/4. Furthermore, many factors, for example, the presence of disc degeneration[21] and the spinal sagittal balance[22] can influence the clinical outcomes or low back pain after decompression surgery at L4/5. In this study, we focused only DCSA at L3/4 level, and therefore future study should be needed to consider them.

Sato and Kikuchi[3] emphasized that precise diagnosis of the responsible level based on neurologic examinations, especially the gait load test, was very important, because the morphogenic changes did not always reflect neural function. They reported that changes in the neurologic condition before and after the gait load test were observed in 4 of 28 patients with two-level stenosis. We did not perform the gait load test, and diagnosed the responsible level only based on neurological evaluations involving manual muscle testing, deep tendon reflexes, sensory disturbance tests, and func-

tional diagnosis with a selective nerve root blockade. However, in our study, the clinical results of all patients were sufficient at 1 year after selective decompression at the L4/5 level. Therefore, the diagnosis of the responsible level was thought to be precise in this study. It would be better to investigate the gait load test to achieve a more strict diagnosis.

Recently, some researchers have reported a device that can apply axial loading to the lumbar spine of patients in the supine position during MRI[10,23-26]. Use of the device could induce significant narrowing of the spinal canal and provide valuable information that was not detected by conventional MRI[23-26]. Kanno et al.[27] described that the DCSA on axial-loaded MRI was significantly correlated with the severity of the symptoms. In addition, changes in the DCSA on axial-loaded MRI, which were not detected on a conventional MRI, were significantly correlated with the severity of the symptoms. Although axial-loaded MRI is undoubtedly very useful, it is actually uncommon. In the future, axial-loaded MRI would help us to detect the responsible level more precisely, and further help us to determine the levels for performance of decompression surgery.

In conclusions, off 35 patients with double-level (L3/4 and L4/5) stenosis who underwent decompression surgery at the L4/5 responsible level, 8 patients (22.9%) showed a poor clinical outcome (JOA recovery rate: <50%) at the final follow-up. Their mean DCSA at the L3/4 level was 49.1 ± 23.8 mm^2 preoperatively and 40.6 ± 14.1 mm^2 at the final follow-up.

Considering these results, in patients with double-level (L 3/4 and L4/5) stenosis and DCSA <50 mm^2 at the L3/4 level, the clinical results can gradually worsen. Therefore, prophylactic decompression surgery at the L3/4 level should be performed for patients with double-level (L3/4 and L4/5) stenosis and DCSA <50 mm^2 at the L3/4 level.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

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