INTRODUCTION

Magnetic resonance imaging (MRI) has been widely used in evaluating patients with lumbar spinal canal stenosis (LSCS). Conventional MRI is performed with the patient in a relaxed, supine position. However, this position results in an enlargement of the spinal canal dimensions, and may underestimate the LSCS, resulting in the failure to demonstrate dural sac compression. On the other hand, the positional change during LSCS can affect the severity of the clinical symptoms, such as back pain, sciatica, and neurogenic claudication. These symptoms are worsened by walking, standing, or hip extension, and are relieved by forward flexion, squatting, or lying supine with hip flexion.

Although conventional MRI allows the patient to be imaged in a less symptomatic position, it is reasonable that a more symptomatic position would yield more diagnostic information. Consequently, patients with significant symptoms may not demonstrate correspondingly severe imaging abnormalities during conventional MRI. Thus, the discrepancies between the radiological findings and the clinical symptoms cause difficulty in making accurate diagnosis and precise surgical decisions. The introduction of axial loaded MRI helped to overcome this limitation of conventional MRI. This study was conducted to validate the effectiveness of axial loaded MRI for making precise surgical decisions in patients with LSCS.

CASE REPORT

A 69-year-old woman presented with a 1-year history of pain in her lower back and both legs. She also had impaired motor and sensory functions in her legs when walking less than 100 m. These symptoms were aggravated during the month preceding her presentation to our clinic.

The patient underwent fusion surgery at L4-5 due to degenerative spondylolisthesis in 2001. After the surgery, she was pain-free for 10 years and worked full-time. But since then, she began to experience pain in her lower back and both legs, and the pain was aggravated by standing and, especially, by walking for longer than 5 minutes. The pain was relieved by squatting or lying in a supine position. The patient had taken medications and undergone active physiotherapy for the past year, but the symptoms persisted.

Upon admission, the patient’s physical examination revealed bilateral great toe dorsiflexion weakness (grade III). The patient had a good, bilateral pulse in her dorsalis pedis arteries. Conventional MRI showed LSCS at L1-2, L2-3, and L3-4, but discrepancies between radiological findings caused difficulty in choosing the precise surgical route. Consequently, axial loaded magnetic resonance imaging was performed, and it revealed the obvious cause of the patient’s symptoms. This information led to a 3-level decompression surgery with a successful outcome. In patients with unapparent lumbar spinal canal stenosis, axially loaded magnetic resonance imaging can be an important, noninvasive diagnostic tool that provides neurosurgeons with valuable information.

L3-4; cervical disc herniation at C4-5; and thoracic disc herniation at T7-8. The dural sac cross-sectional area (DCSA) was 93.75, 91.75, and 108.5 mm$^2$ at L1-2, L2-3, and L3-4, respectively. Each of these DCSA was measured using free line region of interest measurement of custom software (Piview; Infinitt Co., Seoul, Korea). Magnetic resonance myelography (MR myelography) also showed thecal sac compression at L1-2, L2-3, and L3-4, but the L3-4 compression was not prominent (Fig. 1, 2).

A diagnostic block was performed at the cervical and thoracic lesions to rule out imaging abnormalities not corresponding with the patient's symptoms. As expected, there were no changes or improvements in the patient's symptoms. However, difficulties in making precise surgical decisions remained because of the long LSCS, from L1-2 to L3-4, and the lack of prominent stenosis at L3-4. Therefore, axial loaded MRI was performed using a nonmagnetic compression device (DynaWell, DynaMed, Stockholm, Sweden). During this procedure, the patient's body weight was equally distributed to both legs. After a 10-minutes loading period, sagittal and axial T2-weighted sequences were acquired. Axial loaded MRI showed more aggravated stenosis at L1-2, L2-3, and L3-4. The sagittal image showed thecal sac indentation caused by buckling of the ligamentum flavum and the dorsal fat pad at L1-2-3-4. The axial image also showed a more constricted dural sac and aggravated, right paracentral disc protrusion at L1-2 and L2-3. In addition, aggravated dural sac compression, caused by buckling of the ligament flavum and dorsal fat pad, was found at L3-4. The DCSAs were 78.91, 80.08, and 96.22 mm$^2$ at L1-2, L2-3, and L3-4, respectively (Fig. 1, 2).

The patient underwent decompressive unilateral laminectomy for bilateral flavectomy at L1-2-3-4. As a result, both the patient's visual analogue scale (VAS) score for leg pain and her Oswestry Disability Index (ODI) score were improved relative to their preoperative values; the VAS score improved from 7 to 2 and the ODI score improved from 59% to 16% at the 3-month follow-up visit.

**DISCUSSION**

Previous studies have shown that axial loaded MRI can simulate the standing position and demonstrate morphological changes caused by compression of the lumbar spine, in...
cluding a bulging disc, a thickening of the ligamentum flavum, a change in the shape of the dorsal fat pad, or a deformation of the dural sac.\(^3\) Hansson et al\(^3\) reported that the ligamentum flavum contributed to 50-85% of the load-induced narrowing of the spinal canal, and the bulging of the ligamentum flavum seemed more likely to cause load- and motion-related symptoms than did a protruding disc.

The effects of axial compression on the lumbar spine have been focused on in the assessments of changes in DCSA.\(^1,3\) Danielson et al\(^2\) reported that significant decreases in DCSA during axial loading were more frequent among patients than among asymptomatic subjects. Decreases in DCSA from >100 mm\(^2\) to <100 mm\(^2\) were found in 24% of the patients, but in only 9% of asymptomatic individuals. Willén and Danielson\(^2\) assessed the effects of axial compression on patients with chronic lower back pain, neurogenic claudication, or sciatica. These authors reported that additional valuable information (AVI) could be obtained from compression studies. AVI was defined as a greater than 15 mm\(^2\) reduction in DCSA to levels below 75 mm\(^2\). AVI was obtained from 69% of patients with neurogenic claudication, 14% of patients with sciatica, but was not from patients with purely lower back pain. Another group\(^2\) compared the size of the dural sac between axial loaded MRIs and upright myelography images and concluded that dural sac size reductions, caused by axial loading, were more evident in patients with severe stenosis than in those with milder stenosis.

Hiwatashi et al\(^6\) reported that axial loaded MRI can affect decision making for symptomatic spinal stenosis. They showed that treatment decisions had been changed for 50% of LSCS patients after axial loaded MRI scans were obtained. Moreover, the treatment plan of 5 out of 20 patients changed from conservative management to surgery. Although there is not an absolute indication for symptomatic LSCS, many previous studies have suggested that a DCSA of 60-80 mm\(^2\) is the criterion for diagnosing significant stenosis.\(^3,7\) In addition, Hamanishi et al\(^8\) suggested that a cross-sectional area of <100 mm\(^2\), at more than 2 vertebral levels, was highly associated with the presence of neurogenic claudication.

In the present case, conventional MRI demonstrated central canal stenosis at L1-2, L2-3, and L3-4, but MR myelography did not show prominent dural sac compression at L3-4 and the DCSA of L3-4 was 108.5 mm\(^2\). Therefore, these results were insufficient to determine the need for surgical intervention. As a result of the axial loaded MRI, the DCSA decreased significantly from 108.5 to 96.22 mm\(^2\) at L3-4, and the DCSA of all 3 levels were <100 mm\(^2\). As these results more clearly indicated the cause of the patient’s neurogenic claudication, the decision of performing decompressive surgery at all 3 levels was made and the clinical outcome was satisfactory.

Myelography, in the upright position, has been frequently used to assess the effects of positional changes on the lumbar spinal canal. This technique is still sometimes important for making surgical decisions for patients with LSCS. However, it is an invasive procedure that does not provide any more detailed images than does MRI. Our experience has been that, in patients with unapparent LSCS, axially loaded MRI is an important and noninvasive modality that provides neurosurgeons with additional information that is valuable for making decisions relative to the best treatment for the patient.

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**Conflicts of Interest**

The authors report no conflict of interest. The authors alone are responsible for the content and writing of this paper.

**REFERENCES**