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ORIGINAL ARTICLE

Lumbar foraminal stenosis causes leg pain at rest

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Abstract
Purpose Lumbar intra-spinal canal stenosis is characterized by leg pain that intensifies during walking and intermittent claudication, while leg pain at rest is a characteristic neurological symptom of lumbar disc herniation. Until now, a correlation between leg pain at rest and symptomatic foraminal stenosis has not been reported. This is a prospective and comparative study of unilateral leg pain from L5 nerve root compression due to spinal canal stenosis to determine clinical characteristics of lumbar foraminal stenosis.
Methods Clinical and neurological findings were compared among 38 patients receiving L5–S1 transforaminal lumbar interbody fusion for L5–S1 foraminal stenosis (FS group) and 60 patients receiving L4–5 decompression or/and fusion for L4–5 intra-spinal canal stenosis (CS group).
Results The only significant difference between the FS and CS groups in demographic clinical data was leg pain at rest. The prevalence of leg pain was significantly higher in the FS group compared to the CS group (76 vs. 35 %). The visual analogue scale for leg pain at rest was also significantly higher in the FS group than in the CS group (6.6 ± 3.1 vs. 1.3 ± 1.9).
Conclusions Leg pain at rest is characteristic of L5–S1 foraminal stenosis.

Keywords Lumbar foraminal stenosis · Spinal canal stenosis · Leg pain · Dorsal root ganglion

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Introduction

Lumbar foraminal stenosis is often difficult to diagnose, contributing to an unfavorable prognosis after routine surgical treatment of lumbar spinal canal stenosis [4, 9, 13]. In their review of failed back surgery syndrome, Burton et al. [4] considered foraminal stenosis to be the cause of pain in nearly 60 % of patients with persistent postoperative symptoms. The prevalence of lumbar foraminal stenosis has been reported to be 8–26 % [1, 9, 13]. Specifically, L5 nerve root disorders due to L5–S1 foraminal stenosis have been reported to account for 75 % of all cases of foraminal stenoses [9]. L5 nerve root disorders can be divided into L4–5 intra-spinal canal stenoses and L5–S1 foraminal stenoses. However, few studies have examined the differences in clinical features between these two L5 nerve root disorders.

The study presented here was undertaken to compare clinical symptoms of patients with L5–S1 foraminal stenosis with those of patients with L4–5 intra-spinal canal stenosis, focusing on the association between leg pain at rest and lumbar foraminal stenosis. The comparison between patients with these two L5 nerve root disorders allowed us to isolate clinical features unique to foraminal stenosis.

Patients and methods

A questionnaire survey, including assessment of leg pain at rest using the visual analogue scale (VAS), was administered in 2006 and thereafter to 172 patients visiting our hospital with the chief complaint of unilateral leg pain that temporarily disappeared in response to an L5 selective nerve root block. All patients surveyed were consistently examined by magnetic resonance imaging (MRI), myelography, computed tomography after myelography, and nerve root infiltration, and from these radiographic findings, had diagnoses of L5–S1 foraminal stenosis and/or L4–5 intra-spinal canal stenosis that were treated surgically.

Of the 172 patients surveyed, 74 patients meeting any of the following exclusion criteria were not included in the study: (1) evident disc hernia mass on MRI ($n = 19$), based on the definition of disc herniation reported by Milette et al. [14] and Fardon et al. [6]; (2) previous lumbar surgeries ($n = 16$); (3) multiple sites decompression ($n = 26$); (4) showing 70 % or less postoperative improvement in VAS score for leg pain ($n = 4$); (5) failure to complete pre- and postoperative questionnaire surveys ($n = 4$); and (6) failure to return for follow-up for more than 1 year after surgery ($n = 5$).

The remaining 98 patients were divided into two groups, the FS group (foraminal stenosis: patients having undergone surgery for L5–S1 alone based on the diagnosis of L5–S1 foraminal stenosis; $n = 38$) and the CS group (canal stenosis: patients having undergone surgery for L4–5 alone based on the diagnosis of L4–5 intra-spinal canal stenosis; $n = 60$). All 38 patients with L5–S1 foraminal stenosis (FS group) received a thorough decompression of the foraminal area by total facetectomy on the symptomatic side and transforaminal lumbar interbody fusion (TLIF) of L5–S1. All 60 patients with L4–5 intra-spinal canal stenosis (CS group) underwent decompression of L4–5 alone with ($n = 39$) or without ($n = 21$) L4–5 TLIF. In both the FS group and the CS group, disc herniation was not confirmed intraoperatively.

We obtained data for all cases, including age, gender, duration of illness, preoperative and postoperative Japanese Orthopaedic Association Scores (JOA scores), clinical findings (VAS score for leg pain at rest, VAS score for leg pain during exercise, VAS score for lower back pain, presence/absence of intermittent claudication, VAS score for postoperative leg pain, VAS score for postoperative lower back pain), and neurological findings (presence/absence of muscular weakness, straight leg raising (SLR) test results, and presence/absence of Kemp's sign: an exacerbation of leg pain by extension or posterolateral bending of the lumbar spine [12]). JOA score is JOA's clinical evaluation scoring system for lower back pain syndrome, including subjective symptoms, clinical signs, restriction of activities of daily living and urinary bladder function, and a normal score is 29 points.

Each of these demographic characteristics and clinical findings was compared between the FS and CS groups. Data were analyzed using the Student's t test and Fisher's exact probability test; $p < 0.05$ was regarded as statistically significant. The correlation between the VAS for leg pain at rest and the JOA score was calculated for the FS group.

Table 1 Comparison of patient characteristics, clinical findings and neurological findings between the L5–S1 foraminal stenosis (FS) group and the L4–5 intra-spinal canal stenosis (CS) group

	FS group ($n = 38$)	CS group ($n = 60$)	p
Patient characteristics			
Age (years)	68.6 ± 15.9	70.6 ± 11.3	0.93
Gender (male/female)	21/17	34/26	0.90
Duration of leg pain (months)	4.7 ± 3.1	6.4 ± 3.8	0.49
Preoperative JOA score (points)	10.2 ± 4.6	11.3 ± 5.1	0.31
Postoperative JOA score (points)	20.1 ± 5.2	21.6 ± 4.8	0.38
Clinical findings			
VAS of leg pain at rest (cm)	6.6 ± 3.1	1.3 ± 1.9	0.03*
VAS of leg pain at walking (cm)	7.4 ± 2.9	8.2 ± 3.4	0.27
VAS of low back pain (cm)	5.2 ± 2.0	4.5 ± 2.7	0.36
Prevalence of intermittent claudication (n)	17	32	0.09
Postoperative VAS of leg pain (cm)	2.2 ± 1.4	1.8 ± 1.5	0.29
Postoperative VAS of low back pain (cm)	2.6 ± 1.8	2.1 ± 1.6	0.42
Neurological findings			
TA or EHL power reduced (n)	11 (29 %)	23 (38 %)	0.23
SLR test (n)	7 (18 %)	13 (22 %)	0.35
Kemp's sign (n)	26 (68 %)	38 (63 %)	0.17

All values are mean ± standard deviation except gender, prevalence of intermittent claudication and neurological findings. Analyzed with the Student's t test or Fisher's exact probability test

JOA Japanese Orthopaedic Association, *VAS* visual analogue scale, *TA* tibialis anterior muscle, *EHL* extensor hallucis longus muscle, *SLR* straight leg raising

* Indicates statistical significance at $p < 0.05$

Results

There were no significant differences between the FS and CS groups in patient characteristics (age, gender, duration of illness, preoperative/postoperative JOA score) (Table 1). In the analysis of clinical symptoms, the VAS score for leg pain at rest was significantly higher in the FS group (6.6 ± 3.1 vs. 1.3 ± 1.9, $p = 0.03$). The prevalence of leg pain at rest was significantly higher in the FS group (76 vs. 35 %, $p = 0.04$). The correlation coefficient of the VAS for leg pain at rest with the JOA score in the FS group was −0.516 ($p < 0.01$). Other clinical symptoms did not differ significantly between the two groups. There were no significant inter-group differences in neurological findings, including muscular weakness, SLR test, and Kemp's sign.

Surgical outcomes were determined using the JOA score, VAS of leg pain at rest and walking, and VAS of low back pain (Table 1) at final follow-up (more than 1 year after surgery). In the FS group, the JOA score, the VAS score of the most intense leg pain in daily life (leg pain at walking), and the VAS score of low back pain improved from 10.2 ± 4.6 to 20.1 ± 5.2, from 7.4 ± 2.9 to 2.2 ± 1.4, and from 5.2 ± 2.0 to 2.6 ± 1.8, respectively, after surgery. On the other hand, in the CS group, the JOA score, the VAS score of the most intense leg pain in daily life (leg pain at walking), and the VAS score of low back pain improved from 11.3 ± 5.1 to 21.6 ± 4.8, from 8.2 ± 3.4 to 1.8 ± 1.5, and from 4.5 ± 2.7 to 2.1 ± 1.6, respectively, after surgery.

Discussion

It has long been reported that lumbar intra-spinal canal stenosis is characterized by leg pain which intensifies during walking and intermittent claudication [5, 10]. In contrast, Jonsson et al. [11], from their study of the correlation between SLR test results and pain-related symptoms involving lumbar disc herniation, reported that leg pain at rest is a characteristic neurological symptom of lumbar disc herniation. To date, there have been few reports containing sufficient data of any association between leg pain at rest and lumbar foraminal stenosis. Sato et al. [17] compared 38 surgically confirmed foraminal stenosis patients to 38 age- and sex-matched L4–5 intra-spinal canal stenosis patients. Without showing detailed data, they concluded the prevalence of leg pain at rest was significantly higher in foraminal stenosis patients (50.0 vs. 7.9 %, $p < 0.005$). Our study revealed that a high VAS score, 6.6 ± 3.1, for leg pain at rest is characteristic of symptomatic foraminal stenosis compared to that for intra-spinal canal stenosis, 1.3 ± 1.9. Kunogi et al. [13] reported a high incidence (84.6 %) of positive Kemp's sign in 26 cases of intraforaminal or extraforaminal lumbar disc herniations and foraminal nerve root entrapments. Our results, however, found no significant difference in the rate of positive Kemp's sign between the FS and CS groups (Table 1).

Several studies report swelling of the dorsal root ganglion (DRG) seen on MR images in patients with herpes zoster [3, 21]. Yoshimoto et al. [21] reported a case of herpes zoster in which enlargement of a DRG was detected by MRI. There are also several radiologic reports of nerve root swelling in patients with disc herniation [2, 19]. Swelling of the nerve was observed both proximally and distally to the disc herniation. Aota et al. [2] used magnetic resonance myelography (MRM) to assess swelling in the DRG and found the degree of swelling correlated well with severity of leg pain in patients with disc herniation. Disc herniation and herpes zoster are representative conditions that cause leg pain at rest. In another study using MRM, Aota et al. [1] observed nerve swelling specifically in patients with foraminal stenosis. In that study, edema was assessed in spinal nerves because the compression of the DRG made it difficult to determine swelling. Interestingly, swelling was never observed in patients with intra-spinal canal stenosis.

Animal studies have suggested that edema in the DRG underlies development of nerve root pain in patients with disc herniation [8, 16]. Acute compression of the normal DRG produces a neurophysiological response similar to the neural activity induced after chronic compression of the nerve or nerve root [8]. The association of spinal nerve swelling with DRG compression may be attributable to the histological properties of the DRG [8, 16]. Rydevik et al. [16] applied acute compression to rat DRGs and found an almost threefold increase in endoneurial fluid pressure. They suggested that this elevation in DRG pressure could be the mechanism underlying the genesis of nerve root pain. In a study using rats, Yabuki et al. [20] demonstrated that application of autologous nucleus pulposus to the nerve root caused edema in the DRG without direct compression. In chronic cauda equina or nerve root compression, however, edema in nerve roots was not a prominent feature [15]. Chronic compression of the DRG has been extensively studied by LaMotte et al. [18]. They hypothesized that chronic compression of the DRG after certain injuries or diseases of the spine may produce, in neurons with intact axons, abnormal ectopic discharges that originate from the ganglion and potentially contribute to low back pain, sciatica, hyperalgesia, and tactile allodynia. No reported studies to date describe edema in nerve tissue in chronic DRG compression models.

Thus, it seems likely that swelling of the DRG makes a major contribution to the leg pain at rest in patients with foraminal stenosis, lumbar disc herniation, and herpes zoster.

There are several limitations to our study. First, because the primary goal of our study is to characterize symptoms of lumbar foraminal stenosis by comparing it with intra-spinal canal stenosis, we needed to examine only surgically confirmed foraminal stenosis and intra-spinal canal stenosis patients in which the region of stenosis was limited to only one area. Consequently, the large number of patients with disc herniation ($n = 19$), decompression of both L4–5 intra-spinal canal and L5–S1 foramen ($n = 16$), and decompression of multiple sites at one time ($n = 26$) were excluded. This may have resulted in an increased prevalence (39 %) of foraminal stenosis in our study. Second, clinical severity and surgical outcome were assessed using only the JOA score and the VAS of leg pain. Although the JOA scoring system is not widely used outside Japan, significant correlations among the JOA Score, the Oswestry Disability Index, and the Roland–Morris Disability Questionnaire have been reported in a cross-cultural translation and cross-sectional psychometric testing study [7]. Third, unfortunately, we did not perform radiographical analyses in the present study, because the purpose of this study is purely to analyze symptomatologies of lumbar foraminal stenosis.

Our study found that leg pain at rest with high VAS is a characteristic clinical symptom of L5–S1 foraminal stenosis. When combined with recent advances in diagnostic imaging modalities, we believe that leg pain at rest may provide a differential diagnostic aid for improving diagnosis of symptomatic foraminal stenosis.

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Conflict of interest None.

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