Pain Physician 2013; 16:135-144 • ISSN 1533-3159

Retrospective Review

The Influence of Pain Sensitivity on the Symptom Severity in Patients with Lumbar Spinal Stenosis

Ho-Joong Kim, MD[1], Bo-Gun Suh, MD[1], Dong-Bong Lee, MD[1], Gun-Woo Lee, MD[1], Dong-Whan Kim, MD[1], Kyoung-Tak Kang, MS[2], Bong-Soon Chang, MD[3], Choon-Ki Lee, MD[3], and Jin S. Yeom, MD[1]

From: [1]Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bundang Hospital, Republic of Korea; [2]Department of Mechanical Engineering, Yonsei University, Seoul, Republic of Korea; [3]Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, Seoul, Republic of Korea

Address Correspondence:
Jin S. Yeom, MD
Spine Center and Department of Orthopaedic Surgery,
Seoul National University College of Medicine
Seoul National University Bundang Hospital
166 Gumiro, Bundang-gu,
Sungnam, 463-707,
Republic of Korea
E-mail: highcervical@gmail.com

Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: None.

Manuscript received: 10-03-2012
Revised manuscript received: 11-04-2012
Accepted for publication: 11-06-2012

Free full manuscript: www.painphysicianjournal.com

Background: The symptom severity of back pain/leg pain is not correlated with the severity of degenerative changes and canal stenosis in lumbar stenosis. Considering the individual pain sensitivity might play an important role in pain perception, this discordance between the radiologic findings and clinical symptoms in degenerative lumbar stenosis might originate from the individual difference of pain sensitivity for back pain and/or leg pain.

Objective: To determine the relationship among the clinical symptoms, radiologic findings, and the individual pain sensitivity in the patients with degenerative lumbar spinal stenosis.

Study Design: Retrospective analysis of prospectively collected data.

Setting: A spine center in the department of orthopedic surgery.

Methods: In 94 patients who had chronic back pain and/or leg pain caused by degenerative lumbar spinal stenosis, a medical history, a physical examination, and completion of a series of questionnaires, including pain sensitivity questionnaire (PSQ) [total PSQ and PSQ-minor], Oswestry Disability Index (ODI), Visual Analog Pain Scale (VAS) for back pain, and Short Form-36 (SF-36) were recorded on the first visit. Radiologic analysis was performed using the MRI findings. The grading of canal stenosis was based on the method by Schizas, and the degree of disc degeneration was graded from T2-weighted images with the Pfirrmann classification. The correlations among variables were statistically analyzed.

Results: Total PSQ and PSQ-minor were not dependent on the grade of canal stenosis after gender adjustment. VAS for leg pain and back pain was highly associated with the total PSQ and the PSQ-minor. Total PSQ and PSQ-minor were also significantly associated with ODI. Among SF-36 scales, the PSQ minor had significant correlations with SF-36 such as bodily pain (BP), Role-emotional (RE), and Mental Component Summary (MCS) after control of confounding variables such as body mass index (BMI), age, and the grade of canal stenosis/disc degeneration. Total PSQ was significantly associated with the SF-36 RP, BP, and RE. Furthermore, after adjustment for gender and pain sensitivity, there was no significant association between the grade of canal stenosis and VAS for back pain/leg pain and ODI, and no correlation was found between the grade of disc degeneration and VAS for back pain/leg pain and ODI, either.

Limitations: The multiple lesions of canal stenosis and/or disc degeneration and the grade of facet degeneration were not considered as a variable.

Conclusion: The current study suggests that the pain sensitivity could be a determining factor for symptom severity in the degenerative spinal disease.

Key words: Pain sensitivity, pain sensitivity questionnaire, lumbar spinal stenosis, visual analog pain scale, Oswestry disability index, Short Form-36

Pain Physician 2013; 16:135-144

It is generally stated that increased pain perception and sensitivity may constitute a risk factor for the development of chronic pain (1,2). Higher experimental pain sensitivity has been shown in a large number of chronic pain disorders including chronic tension-type headache, fibromyalgia, temporomandibular dysfunction, and chronic low back pain (3-6).

Chronic low back pain and radiating leg pain caused by various spinal degenerative diseases such as herniated nucleus pulposus, lumbar spinal stenosis, and internal disc derangement results in decreasing function and increasing physical impairment in adults (7-9). As people in the general population become older, degenerative spinal diseases potentially leading to painful and disabling conditions have been more prevalent (8,10). Therefore, an increasing number of patients are referred to spine specialists for degenerative spinal diseases. The availability of magnetic resonance imaging (MRI) allows the pathologies of degenerative spinal disease to be detected easily (7). Although MRI provides a noninvasive accurate morphologic assessment tool of the lumbar spine and permits an assessment for the relationship between morphologic findings and low back pain (11), the clinical significance of such findings is debatable, and many studies have reported that abnormal finds on the MRI are commonly found in asymptomatic individuals (11-15). Furthermore, the severity of back pain/leg pain, and/or functional disability are not correlated with the severity of degenerative changes and canal compromise (8,16).

Considering the individual diversity of pain sensitivity, the discordance between the radiologic findings and clinical symptoms in degenerative lumbar disease might originate from the individual difference of pain sensitivity for back pain and/or leg pain. Therefore, we hypothesized that the general pain sensitivity could influence the severity of back/leg pain and the level of functional disability caused by degenerative lumbar spinal stenosis. The purpose of this study was to determine the relationship between the clinical symptoms, radiologic findings, and the individual pain sensitivity in patients with degenerative lumbar spinal stenosis. In order to assess the amount of general pain sensitivity, we used the validated pain sensitivity questionnaire (PSQ) (1,17).

Methods

Study Design and Setting

The study was approved by the hospital institutional review board. This study included 94 patients with back pain and/or leg pain caused by degenerated lumbar spinal stenosis, who visited the outpatients' facilities of a spine center in the department of orthopedic surgery between April 2012 and September 2012. Inclusion criteria were patients from 45-years-old to 70-years-old without any acute or chronic disease, visiting the outpatients' facilities for chronic leg pain and/or back pain caused by degenerative spinal stenosis without any other musculoskeletal complaints, and having the stenotic lesion more than grade A of Schizas et al's classification in the lumbar MRI (7). Initially, 112 patients were collected consecutively between April 2012 and September 2012. Patients were excluded if they had only foraminal stenosis without central stenosis, if they had pain or disability at other joints,if their symptom duration was less than 3 months, if they had a history of psychological disorder or peripheral vascular disease, or if there was any concurrent serious medical condition affecting disability and general health status including sepsis or cancer. Thus, 18 patients were excluded, and finally 94 patients were included in this study.

Patients

Among 94 patients, 72 patients had central spinal stenosis without spondylolisthesis and 22 patients had grade I degenerative spondylolisthesis combined with spinal stenosis in the lumbar spine. Thirty-four patients were scheduled to undergo spine surgery, and 60 patients took conservative treatments including medication, physical therapy, and epidural steroid injection.

Data Collection and Analysis

Prospectively planned evaluations included a detailed medical history, a physical examination, and completion of a series of questionnaires, including PSQ, Oswestery Disability Index (ODI), and Visual Analog Pain Scale (VAS) for back pain/leg pain, and SF-36. All data were recorded at the first visit.

The PSQ has been introduced previously (1,17). It is composed of 17 items, each describing a daily life situation and asking the subject to rate how painful this situation would be for him or her on a numeric rating scale ranging from 0 (not painful at all) to 10 (worst pain imaginable) (Table 1) (1,17). Patients were carefully instructed to rate their own pain intensity, not the pain

Table 1. *Pain sensitivity questionnaire.*

Pain Sensitivity Questionnaire	
Pain sensitivity-minor	3. Imagine your muscles are slightly sore as the result of physical activity. 6. Imagine you have mild sunburn on your shoulders. 7. Imagine you grazed your knee falling off your bicycle. 10. Imagine you have a minor cut on your finger and inadvertently get lemon juice in the wound. 11. Imagine you prick your fingertip on the thorn of a rose. 12. Imagine you stick your bare hands in the snow for a couple of minutes or bring your hands in contact with snow for some time, for example, while making snowballs. 14. Imagine you shake hands with someone who has a very strong grip.
Pain sensitivity-moderate	1. Imagine you bump your shin badly on a hard edge, for example, on the edge of a glass coffee table. 2. Imagine you burn your tongue on a very hot drink. 4. Imagine you trap your finger in a drawer. 8. Imagine you accidentally bite your tongue or cheek badly while eating. 15. Imagine you pick up a hot pot by inadvertently grabbing its equally hot handles. 16. Imagine you are wearing sandals and someone with heavy boots steps on your foot. 17. Imagine you bump your elbow on the edge of a table ("funny bone").

aversiveness or the fear associated with the described situation by a clinical researcher. Fourteen of 17 items are simulated situations that are rated as painful by a majority of healthy subjects. The painful items covered a range of pain intensities; a variety of different types of pain such as hot, cold, sharp, blunt pain; and body sites including head and upper and lower extremity. However, 3 other items described situations that are normally not rated as painful by healthy subjects. These items were not included in the final score. Completion of the PSQ usually took 15 minutes with assistance from a clinical researcher. In the previous study (17), factor analysis identified 2 subscores of the PSQ, consisting of the PSQ-moderate score and the PSQ-minor score, each including 7 items that on average were rated as moderately painful (mean rating 4–6 on the 11-point scale, PSQ-moderate) or as causing minor pain (mean rating < 4, PSQ-minor) (17). In the present study, PSQ-minor and total PSQ score were presented because they were more correlated with the experimental pain sensitivity than the PSQ-moderate (1,17).

The ODI is a self-administered questionnaire measuring "back-specific function" on a 10-item scale with 6 response categories each. Each item scores from 0 to 5 and the summation of each item is transformed into a 0–100 scale. There is no unit of outcome, and no established value for a specific health status or change in health status (18,19). The VAS for back pain/leg pain was assessed using a bar with "none" on one end (zero) of a 100-mm line and "disabling pain" on the other end (100). The patient placed a mark on the 100-mm line for VAS for back pain/leg pain, and the distance (mm) at the mark from zero point was considered as the score. General health status was assessed with use of the Short Form-36 (SF-36). The raw scores for the 8 subscales and the 2 summaries of the SF-36 (Physical Function [PF], Role Physical [RP], Bodily Pain [BP], General Health [GH], Vitality [VT], Social Function [SF], Role Emotion [RE], and Mental Health [MH] / physical component summary [PCS] and mental component summary [MCS]) were transformed into norm-based scoring (20).

Radiological Analysis

Radiological analysis using the MRI findings was performed by an independent observer who was blinded to the purpose of this study. First, the grading of canal stenosis was based on the cerebrospinal fluid (CSF)/rootlet ratio as seen axial T2 images as the method by Schizas et al (7). Description of the grading is as follows. Grade A stenosis represents that there is clearly CSF visible inside the dural sac, but its distribution is inhomogeneous. A1 indicates the rootlets lie dorsally and occupy less than half of the dural sac area. A2 indicates the rootlets lie dorsally, in contact with the dura but in a horseshoe configuration. A3 indicates the rootlets lie dorsally and occupy more than half of the dural sac area. A4 indicates the rootlets lie centrally and occupy the majority of the dural sac area. Grade B stenosis means that the rootlets occupy the whole of the dural sac, but they can still be individualized. Some CSF is still present giving a grainy appearance to the sac. Grade C stenosis means that no rootlets can be recognized, and the dural sac demonstrates a homogeneous gray signal with no CSF signal visible. There is epidural fat present posteriorly. Grade D stenosis indicates there is no epidural fat posteriorly in addition to no rootlets being recognizable (7). Second, the degree of disc degeneration was graded from T2-weighted im-

ages with the Pfirrmann et al classification (21). Grade I indicates a normal shaped disc without horizontal bands and clear distinction between the nucleus and annulus. Grade II indicates an inhomogeneous shaped disc with horizontal bands and some blurring between the nucleus and annulus. Grade III indicates an inhomogeneous shaped and slightly decreased-height disc with blurring between the nucleus and annulus, but a still recognizable annulus shape. Grade IV indicates an inhomogeneous shaped and moderately decreased-height disc with hypointense signal, and indistinction between the nucleus and annulus. Grade V indicates the same as grade IV but with collapsed disc space.

Statistical Analysis

A Pearson correlation was used for comparison of variables between total PSQ/PSQ-minor and the symptomatic severity such as VAS, ODI, and SF-36. In order to control confounding biases including grades of canal stenosis, disc degeneration, age, and BMI, the partial correlation test was also used. One-way analysis of variance was used to assess differences of symptom severity related to the grade of canal stenosis and disc degeneration. Furthermore, for adjustment for the PSQ scores and gender, analysis of covariance (ANCOVA) was also used. Intraclass correlation coefficients (ICC model 3, 1) were used to describe the test-retest reliability of total PSQ scores. Repeated measurements of total PSQ scores showed high ICC (from 0.83 to 0.92). All statistical analyses were performed using the SPSS 12.0.0 statistics package (SPSS, Inc., Chicago, IL). A value of $P < 0.05$ was accepted as significant.

Table 2. *Baseline data in the patients. Values are mean values (SD).*

N	94 patients
Age (years)	61.24 (5.13)
Male : Female	31 : 63
BMI (kg/cm2)	25.85 (3.03)
Opioid use	12 patients for 3.4 (1.15) months
Symptom duration	13.5 (5.23) months
Diagnosis	Central spinal stenosis without spondylolisthesis; 72, Grade I degenerative spondylolisthesis with spinal stenosis; 22

BMI; body mass index, SD; standard deviation

Results

Variable Analysis

Table 2 demonstrates the baseline data of patients in the current study. Total PSQ scores and PSQ-minor had no correlation with age and BMI. However, total PSQ and PSQ-minor were significantly dependent of the gender. Women had higher total PSQ and PSQ-minor scores than men ($P < 0.001$, $P = 0.001$, respectively). After gender adjustment, total PSQ and PSQ-minor were not dependent of the grade of canal stenosis (Table 3). However, total PSQ was related with the grade of disc degeneration ($P = 0.023$).

VAS for back pain and leg pain was not correlated with age and BMI, while gender was associated with VAS for back pain (P = 0.006), VAS for leg pain (P = 0.003) and ODI (P < 0.001). The mean VAS for back pain, VAS for leg pain and ODI were 69.6 ± 21.32, 81.77 ± 15.75, and 49.86 ± 16.14, respectively in female, and the mean VAS for back pain, VAS for leg pain, ODI in male were 54.6 ± 25.23, 69.8 ± 16.90, and 35.58 ± 11.96, respectively..

Table 3. *Correlation between radiological severity and pain sensitivity. Values are mean values (SD).*

	PSQ-minor	*P*	Total PSQ	*P*
The grade of canal stenosis (n)				
A (26)	40.83 (12.25)	0.815	89.09 (21.50)	0.519
B (14)	36.31 (11.88)		80.77 (24.48)	
C (32)	41.13 (12.69)		92.13 (21.82)	
D (22)	42.41 (14.52)		95.91 (25.51)	
The grade of disc degeneration (n)				
III (17)	33.60 (13.30)	0.068	75.07 (23.33)	0.023
IV (33)	43.38 (12.03)		96.00 (21.16)	
V (44)	40.71 (12.58)		91.26 (22.34)	

PSQ; Pain sensitivity questionnaire, SD; standard deviation, P value; adjusted for gender with ANCOVA (Analysis of covariance)

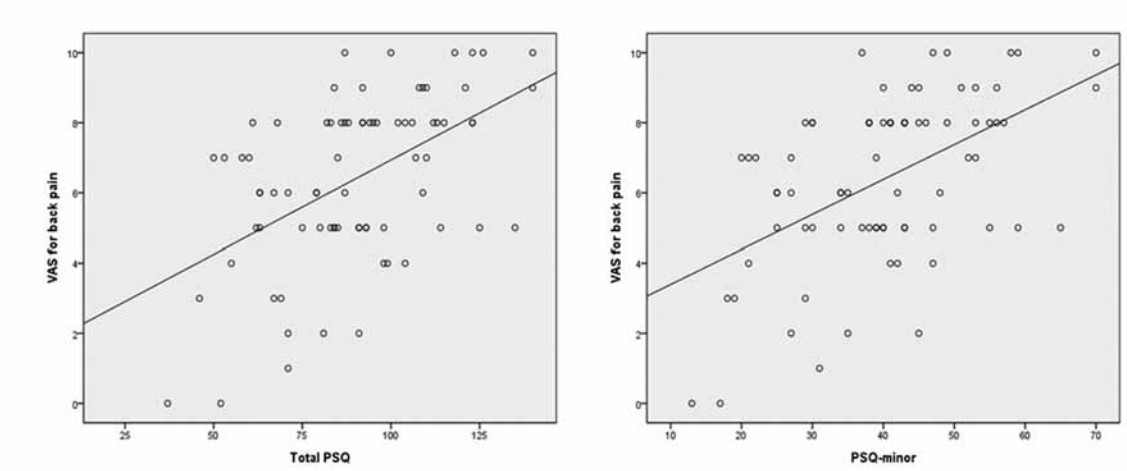

Fig. 1. *Correlation between PSQ scores and VAS for back pain (PSQ-minor; adjusted R = 0.530, Total PSQ; adjusted R = 0.510, R was adjusted for BMI, age, the grade of canal stenosis and disc degeneration)*

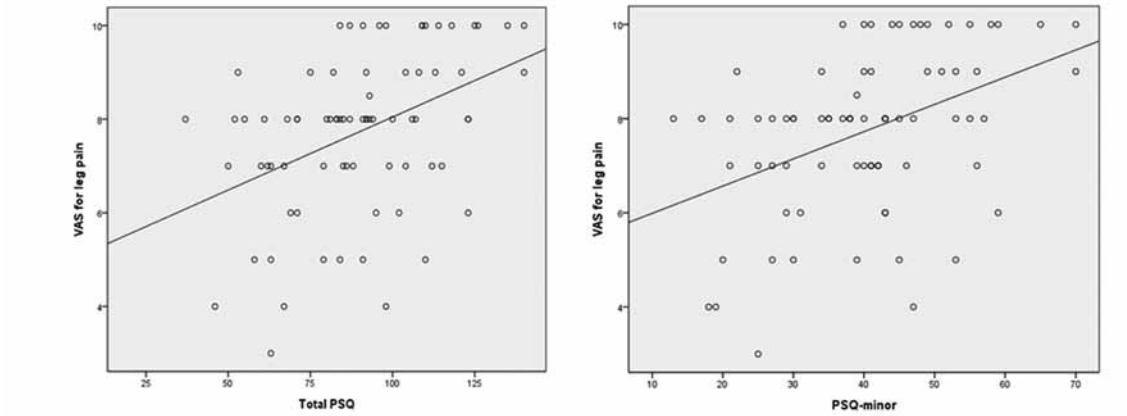

Fig. 2. *Correlation between PSQ scores and VAS for leg pain (PSQ-minor; adjusted R = 0.561, Total PSQ; adjusted R = 0.536, R was adjusted for BMI, age, the grade of canal stenosis, and disc degeneration).*

Correlation between PSQ-scores and Pain and Disability

VAS for back pain and leg pain was highly associated with the PSQ-score (Figs. 1, 2). Between the subscores of PSQ, the PSQ-minor was more correlated with the VAS for back pain ($P < 0.001$, R = 0.516) and leg pain ($P < 0.001$, R = 0.424). Additional adjustments for other possible confounders including age, BMI, the grade of canal stenosis, and disc degeneration did not change the associations, but rather resulted in higher correlation coefficients (R) with PSQ minor (PSQ minor; $P < 0.001$, R = 0.531, and 0.561 for VAS for back pain and leg pain, respectively) (Table 4). Total PSQ and PSQ-minor were also significantly associated with ODI (Fig. 3).

Correlations between PSQ-scores and General Health Status

Among SF-36 scales, the PSQ minor had significant negative correlations with SF-36 BP, RE, and MCS after control of confounding variables such as BMI,

Table 4. *Correlation between PSQ-scores and VAS for leg pain/back pain and ODI.*

		VAS for back	VAS for leg	ODI
PSQ-minor	R	0.516 (0.531)*	0.424 (0.561)*	0.378 (0.381)*
	P value	< 0.001 (< 0.001)*	< 0.001 (< 0.001)*	0.001 (0.012)*
Total PSQ	R	0.515 (0.510)*	0.422 (0.536)*	0.387 (0.380)*
	P value	< 0.001 (< 0.001)*	< 0.001 (< 0.001)*	< 0.001 (0.012)*

PSQ; Pain sensitivity questionnaire, R; correlation coefficient, * ; adjusted for BMI, age, the grade of canal stenosis and disc degeneration with partial correlation test

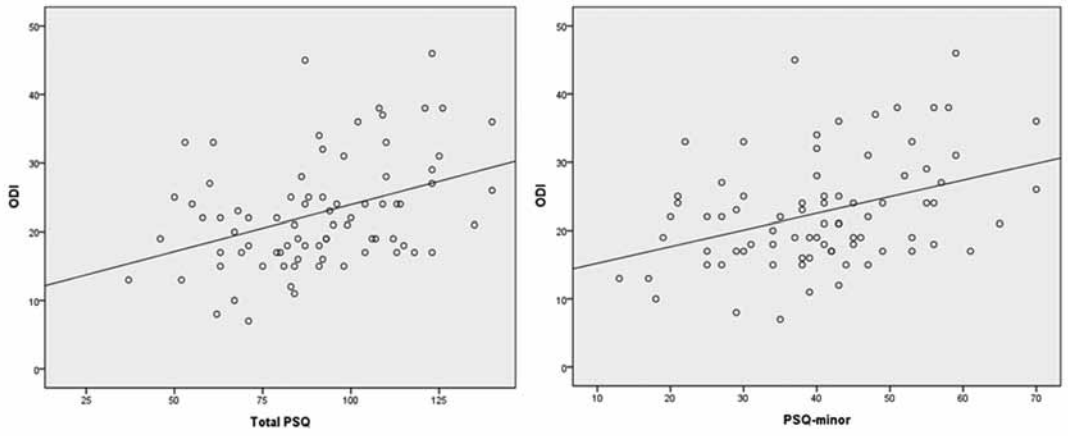

Fig. 3. *Correlation between PSQ scores and ODI (PSQ-minor; adjusted R = 0.381, Total PSQ; adjusted R = 0.380, R was adjusted for BMI, age, the grade of canal stenosis, and disc degeneration).*

age, and the grade of canal stenosis/disc degeneration. Total PSQ was significantly associated with the SF-36 RP, BP, and RE. SF-36 RE had the highest negative correlations coefficient with total PSQ and PSQ-minor among scales after control of confounding variables (Table 5). However, after taking away of the effect of VAS for back and leg pain, only SF-36 RE was found to be correlated with total PSQ and PSQ-minor (R = -0.429, *P* = 0.006 and R = -0.485, *P* = 0.002, respectively).

Relationship between Symptom Severity and the Grade of Canal Stenosis

If the patient had canal stenosis at multiple levels, the most stenotic level was taken into account for grading. Twenty-six patients were A grade of canal stenosis. B and C grade of canal stenosis was observed in 14 and 32 patients, respectively. Twenty-two patients were D grade of canal stenosis. There was no significant association between the grade of canal stenosis and VAS for back pain/leg pain. The ODI was not different among the grade of canal stenosis, either (Table 6). Even after adjustment for pain sensitivity and gender, no correlation was found.

Correlation of Disc Degeneration with Symptom Severity

The patient's disc degeneration grade was decided by taking into account the most degenerated disc. There was no patient with Grade I or II disc degeneration. The Grade III and IV degeneration was observed in 16 and 33 patients, respectively. Forty-five patients had grade V disc degeneration. After adjustment for gender and pain sensitivity, VAS for back pain and leg pain were not associated with the grade of disc degeneration, and no correlation was found between the grade of disc degeneration and ODI (Table 6).

Table 5. *Correlation between PSQ scores and SF-36.*

SF-36 scales and summaries		PF	R.P	BP	GH	VT	SF	RE	MH	PCS	MCS
PSQ-minor	R	-0.266	-0.243	-0.346	-0.292	-0.297	-0.242	-0.477	-0.118	-0.206	-0.350
	P value	0.089	0.121	0.025	0.061	0.057	0.123	0.001	0.455	0.191	0.023
Total PSQ	R	-0.261	-0.308	-0.345	-0.254	-0.295	-0.293	-0.445	-0.034	-0.269	-0.305
	P value	0.095	0.048	0.025	0.104	0.058	0.060	0.003	0.832	0.086	0.050

PSQ; pain sensitivity questionnaire, R; correlation coefficient, P value adjusted for BMI, age, the grade of canal stenosis and disc degeneration with partial correlation test

Table 6. *Relation between symptom severity and radiological findings. Values are mean values (SD).*

	VAS for back pain	*P*	VAS for leg pain	*P*	ODI	*P*
The grade of canal stenosis (n)						
A (26)	5.95 (2.31)	0.241 (0.470) *	7.98 (1.54)	0.326 (0.436)*	40.54 (12.14)	0.197 (0.562)*
B (14)	5.83 (2.95)		7.92 (1.31)		42.00 (14.60)	
C (32)	6.50 (2.12)		7.33 (1.96)		46.08 (17.72)	
D (22)	7.32 (2.36)		8.21 (1.55)		50.94 (18.47	
The grade of disc degeneration (n)						
III (17)	5.77 (2.46)	0.478 (0.726)*	6.77 (1.83)	0.034 (0.154)*	38.76 (15.54)	0.183 (0.909)*
IV (33)	6.33 (2.51)		8.22 (1.65)		43.18 (17.12)	
V (44)	6.68 (2.23)		7.80 (1.52)		47.70 (15.14)	

PSQ; Pain sensitivity questionnaire, SD; standard deviation, *; P value adjusted for gender and pain sensitivity with ANCOVA (Analysis of covariance)

Discussion

Pain is a critical symptom in patients with degenerative spinal disease seeking medical care and usually receives the immediate attention of most spine specialists (22-24). Most degenerative spinal diseases remain undiagnosed even in later stages of degeneration or severe canal narrowing if unaccompanied by pain. However, despite that crucial pain perception depends on a large individual difference in pain sensitivity, there has been little attention about pain sensitivity in the realm of degenerative spinal disease. Therefore, we intended to investigate the implication of pain sensitivity for pain severity, disability, and general health status in degenerative lumbar spinal stenosis, compared to the radiographic findings and severity.

As expected, the grade of canal stenosis was not correlated with symptom severity, represented by VAS and ODI. Furthermore, no relation was found between disc degeneration grade and clinical symptoms. Even after adjustments for the effect of pain sensitivity and gender, there were no correlations between the grade of canal stenosis/disc degeneration and clinical symptoms. This means that clinical symptoms appear to be connected with a more complex mechanism and not directly related to the grade of canal stenosis and disc degeneration. Previous studies fully corroborate this finding, demonstrating no relation between the canal narrowing/disc degeneration and clinical symptoms (8,13,16,25-27). In contrast, independent of radiographic findings, pain sensitivity was well correlated with the severity of back pain and/or leg pain in patients with lumbar spinal stenosis. There were significant positive correlations between VAS for both back pain/leg pain and total PSQ/PSQ-minor. These seem to be surprising because this correlation was statistically significant even without the adjustment for the effect of the radiographic severity including canal narrowing and disc degeneration which had been regarded as the main pathology of symptomatic degenerative spinal diseases (10). After control for MRI findings such as the severity of canal stenosis and/or disc degeneration, BMI, and age, an even higher correlation coefficient was found between total PSQ/PSQ-minor and VAS for back pain/leg pain. This might give us a clue

why MRI findings have low sensitivity and predictive values for clinical symptoms.

Radiographic findings in patients with degenerative lumbar spinal stenosis obviously reflect the pathological and anatomical deterioration related with degeneration. Therefore, radiological abnormality might be related with the clinical symptoms. However, the majority of previous studies have shown the discordance between radiologically abnormal findings and clinical symptoms (14,28). The possible explanation for this is that the chemical mediators such as tumor necrosis factor (TNF)–α and substance P may cause irritation of a nerve root but not be detectable on MRI (28). Second, the extent of canal narrowing is dynamic and is likely to be dependent on the posture of the patient. Back extension significantly decreases the canal area, while flexion has the opposite effect (8,29). Therefore, a static image of the canal dimensions on MRI may not be predictive of a patient's symptoms. In addition, the current study suggests another explanation. Radiographic findings, especially using MRI, provide the objective measure for pathology, but the VAS is a type of assessment tool that measures subjective complaints of pain severity. Therefore, it is a plausible assumption that this objective pathology in degenerative spinal stenosis could be expressed as clinical symptoms through the individual processing of nociceptive information, that is, pain perception (1,30). Outside the realm of the spine, many previous studies have also shown this discordance between subjective pain scales and physical or chemical causes of pain (22,31,32). In patients with rheumatoid arthritis, inflammation and other physiological parameters are poorly correlated with pain severity, and minimal association has been found between the extent of breast surgery and acute postsurgical pain (31,32). Similarly, the current study also demonstrated that individual pain sensitivity could influence VAS scores for leg pain and/or back pain, independently, in patients with degenerative lumbar spinal stenosis.

Our work also reveals that individual pain sensitivity can adversely influence the disability and general health status, measured by ODI and SF-36, respectively. SF-36 BP, RE, and MCS had significantly inverse relationships with the PSQ minor, and total PSQ had significant negative correlations with the SF-36 RP, BP, and RE. These correlations should be related with VAS as intermediaries. That is, the individual with increased pain sensitivity had a higher VAS by sensitive pain perception, which consecutively led to higher disability and lower general health status. This explanation could be verified by the partial correlation analysis as a means of controlling the effect of VAS for back and leg pain. This control for VAS resulted in no association between individual pain sensitivity and disability/general health status except with the RE scale. Previous studies have also consistently reported that lower back pain and leg pain is associated with a striking reduction in physical and mental quality of life, as well as functional status (33,34), and showed that the experimental pain sensitivity is significantly associated with functional status and pain in cases of chronic low back pain (35). Interestingly, SF-36 RE was most inversely correlated with pain sensitivity among the SF-36 scales. A low RE scale means that the subject has problems with work or other daily activities as a result of emotional problems (20). Therefore, the current result might imply that the individual with spinal stenosis who has increased pain sensitivity tends to have trouble with daily activities due to not only physical impairment, but also emotional problems. Previous studies clearly demonstrated the psychological process, that is, emotion could modulate pain, and vice versa (36,37).

In the medical field, it should be borne in mind that pain sensitivities are 2 sides of the same coin. As Nielsen et al (22) mentioned, it would be reasonable that low pain sensitivity could lead to delayed diagnosis and possibly to increased morbidity and mortality, whereas high pain sensitivity could result in increased use or cost of health care services and unnecessary and potentially harmful treatments. However, most musculoskeletal disorders including degenerative lumbar diseases are not life-threatening, but critically influence the quality of life. Therefore, pain sensitivity would have a different role from other medical diseases such as cardiovascular disorder and/or malignancy. Even though a recent report demonstrated that patients with spinal stenosis with greater than 12 months of symptoms had less improvement relative to those with less than 12 months (38), the clinical course of most degenerative spine diseases is benign, which is the main reason why early or preventive treatment (especially surgical treatment) should scarcely be warranted. On the other hand, because pain sensitivity could possibly influence not only initial symptom severity, but also outcomes of various treatments from conservative to surgical intervention for degenerative spinal stenosis, the influence of pain sensitivity on the treatment outcomes should also be the critical concern. Previous studies have reported that chronic pain patients who exhibit high experimental pain sensitivity

respond less well to treatment than those with lower experimental pain sensitivity (39-41). Furthermore, the dynamic change of pain sensitivity should be another consideration. Long-term treatment of chronic pain might change the pain sensitivity (42). Therefore, the present results leave a number of questions to be addressed in future work.

Limitations

The present study has certain limitations that need to be taken into account. First, for the assessment of radiological severity, the multiple lesions of canal stenosis and/or disc degeneration and the grade of facet degeneration were not considered as a variable, because the number of patients in the present study restricted the inclusion of this variable. Second, in general, clinical symptoms in degenerative spinal disease show a dynamic nature. That is, the pain that patients perceive is not constant, but should change in response to treatment or spontaneously without any treatment. Therefore, the symptom severity would have been dependent of assessment time. In order to eliminate this bias, the inclusion criteria were confined only to degenerative lumbar stenosis which tends to cause chronic pain rather than acute pain unlike herniated nucleus pulposus. Furthermore, the questionnaires from patients were collected at the first visit to the outpatient clinic, and symptoms at first visit had not changed for at least 2 months.

Conclusion

The present result could be interpreted differently. The increased pain sensitivity might not be the cause, that is, pre-existing and constituting a risk factor for the development of severe clinical symptoms in degenerative spinal disease, but could rather be considered as a result. This means that the increased pain sensitivity might be developed during the chronic course of the degenerative spinal disease (17). However, at least, the current study suggests that the pain sensitivity could be one of the determining factors for symptom severity in degenerative spinal disease.

References

1. Ruscheweyh R, Verneuer B, Dany K, Marziniak M, Wolowski A, Colak Ekici R, Schulte TL, Bullmann V, Grewe S, Gralow I, Evers S, Knecht S. Validation of the Pain Sensitivity Questionnaire in chronic pain patients. *Pain* 2012; 153:1210-1218.
2. Edwards R. Individual differences in endogenous pain modulation as a risk factor for chronic pain. *Neurology* 2005; 65:437-443.
3. Giesecke T, Gracely RH, Grant MA, Nachemson A, Petzke F, Williams DA, Clauw DJ. Evidence of augmented central pain processing in idiopathic chronic low back pain. *Arthritis Rheum* 2004; 50:613-623.
4. Lautenbacher S, Rollman GB, McCain GA. Multi-method assessment of experimental and clinical pain in patients with fibromyalgia. *Pain* 1994; 59:45-53.
5. Maixner W, Fillingim R, Sigurdsson A, Kincaid S, Silva S. Sensitivity of patients with painful temporomandibular disorders to experimentally evoked pain: Evidence for altered temporal summation of pain. *Pain* 1998; 76:71-81.
6. Schoenen J, Bottin D, Hardy F, Gerard P. Cephalic and extracephalic pressure pain thresholds in chronic tension-type headache. *Pain* 1991; 47:145-149.
7. Schizas C, Theumann N, Burn A, Tansey R, Wardlaw D, Smith FW, Kulik G. Qualitative grading of severity of lumbar spinal stenosis based on the morphology of the dural sac on magnetic resonance images. *Spine* 2010; 35:1919-1924.
8. Sirvanci M, Bhatia M, Ganiyusufoglu KA, Duran C, Tezer M, Ozturk C, Aydogan M, Hamzaoglu A. Degenerative lumbar spinal stenosis: Correlation with Oswestry Disability Index and MR imaging. *Eur Spine J* 2008; 17:679-685.
9. Kim H, Chun H, Han C, Moon S, Kang K, Park J, Moon E, Kim B, Sohn J, Shin S, Jang J, Lee K, Lee H. The risk assessment of a fall in patients with lumbar spinal stenosis. *Spine* 2011; 36:E588-E592.
10. Katz JN, Harris MB. Clinical practice. Lumbar spinal stenosis. *N Engl J Med* 2008; 358:818-825.
11. Kjaer P, Leboeuf Yde C, Korsholm L, Sorensen JS, Bendix T. Magnetic resonance imaging and low back pain in adults: A diagnostic imaging study of 40-year-old men and women. *Spine* 2005; 30:1173-1180.
12. Carragee EJ, Alamin TF, Miller JL, Carragee JM. Discographic, MRI and psychosocial determinants of low back pain disability and remission: A prospective study in subjects with benign persistent back pain. *Spine J* 2005; 5:24-35.
13. Borenstein DG, O'Mara JW, Boden SD, Lauerman WC, Jacobson A, Platenberg C, Schellinger D, Wiesel SW. The value of magnetic resonance imaging of the lumbar spine to predict low-back pain in asymptomatic subjects: A seven-year follow-up study. *J Bone Joint Surg Am* 2001; 83-A:1306-1311.
14. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am* 1990; 72:403-408.
15. Jensen MC, Brant Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. *N Engl J Med* 1994; 331:69-73.
16. Lohman CM, Tallroth K, Kettunen JA, Lindgren K. Comparison of radiologic signs and clinical symptoms of spinal stenosis. *Spine* 2006; 31:1834-1840.
17. Ruscheweyh R, Marziniak M, Stumpenhorst F, Reinholz J, Knecht S. Pain sensitivity can be assessed by self-rating:

Development and validation of the Pain Sensitivity Questionnaire. *Pain* 2009; 146:65-74.

18. Fairbank JC, Pynsent PB. The Oswestry Disability Index. *Spine* 2000; 25:2940-2952.
19. Carreon LY, Berven SH, Djurasovic M, Bratcher KR, Glassman SD. The discriminative properties of the SF-6D compared with the SF-36 and ODI. *Spine (Phila Pa 1976)* 2013; 38:60-64.
20. Ware J, Snow K, Kosinski M, Gandek B. SF-36 health survey manual and interpretation guide. New England Medical Center. The Health Institute, Boston, MA, 1993.
21. Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine* 2001; 26:1873-1878.
22. Nielsen CS, Staud R, Price D. Individual differences in pain sensitivity: Measurement, causation, and consequences. *J Pain* 2009; 10:231-237.
23. Hasselström J, Liu Palmgren J, Rasjö-Wråak G. Prevalence of pain in general practice. *Eur J Pain* 2002; 6:375-385.
24. BattiAok MC, Videman T, Gibbons LE, Manninen H, Gill K, Pope M, Kaprio J. Occupational driving and lumbar disc degeneration: A case-control study. *Lancet* 2002; 360:1369-1374.
25. Amundsen T, Weber H, Lilleås F, Nordal HJ, Abdelnoor M, Magnaes B. Lumbar spinal stenosis. Clinical and radiologic features. *Spine* 1995; 20:1178-1186.
26. Jönsson B, Annertz M, Sjöberg C, Strömqvist B. A prospective and consecutive study of surgically treated lumbar spinal stenosis: Part I: Clinical features related to radiographic findings. *Spine* 1997; 22:2932-2937.
27. Boos N, Semmer N, Elfering A, Schade V, Gal I, Zanetti M, Kissling R, Buchegger N, Hodler J, Main CJ. Natural history of individuals with asymptomatic disc abnormalities in magnetic resonance imaging: Predictors of low back pain-related medical consultation and work incapacity. *Spine* 2000; 25:1484-1492.
28. Beattie PF, Meyers SP, Stratford P, Millard RW, Hollenberg GM. Associations between patient report of symptoms and anatomic impairment visible on lumbar magnetic resonance imaging. *Spine* 2000; 25:819-828.
29. Penning L, Wilmink JT. Posture-dependent bilateral compression of L4 or L5 nerve roots in facet hypertrophy. A dynamic CT-myelographic study. *Spine* 1987; 12:488-500.
30. Edwards R, Sarlani E, Wesselmann U, Fillingim RB. Quantitative assessment of experimental pain perception: Multiple domains of clinical relevance. *Pain* 2005; 114:315-319.
31. Hagglund KJ, Haley WE, Reveille JD, Alarcón GS. Predicting individual differences in pain and functional impairment among patients with rheumatoid arthritis. *Arthritis Rheum* 1989; 32:851-858.
32. Katz J, Poleshuck EL, Andrus CH, Hogan LA, Jung BF, Kulick DI, Dworkin RH. Risk factors for acute pain and its persistence following breast cancer surgery. *Pain* 2005; 119:16-25.
33. Hicks GE, Gaines JM, Shardell M, Simonsick EM. Associations of back and leg pain with health status and functional capacity of older adults: Findings from the retirement community back pain study. *Arthritis Rheum* 2008; 59:1306-1313.
34. Vogt MT, Lauerman WC, Chirumbole M, Kuller LH. A community-based study of postmenopausal white women with back and leg pain: Health status and limitations in physical activity. *J Gerontol B Psychol Sci Soc Sci* 2002; 57:M544-M550.
35. Clauw DJ, Williams D, Lauerman W, Dahlman M, Aslami A, Nachemson AL, Kobrine AI, Wiesel SW. Pain sensitivity as a correlate of clinical status in individuals with chronic low back pain. *Spine* 1999; 24:2035-2041.
36. Rhudy JL, Meagher MW. The role of emotion in pain modulation. *Curr Opin Psychiatry* 2001; 14:241-245.
37. Price DD. Psychological and neural mechanisms of the affective dimension of pain. *Science* 2000; 288:1769-1772.
38. Radcliff KE, Rihn J, Hilibrand A, DiIorio T, Tosteson T, Lurie JD, Zhao W, Vaccaro AR, Albert TJ, Weinstein JN. Does the duration of symptoms in patients with spinal stenosis and degenerative spondylolisthesis affect outcomes?: Analysis of the Spine Outcomes Research Trial. *Spine* 2011; 36:2197-2210.
39. Edwards R, Doleys DM, Lowery D, Fillingim RB. Pain tolerance as a predictor of outcome following multidisciplinary treatment for chronic pain: Differential effects as a function of sex. *Pain* 2003; 106:419-426.
40. Granot M, Zimmer EZ, Friedman M, Lowenstein L, Yarnitsky D. Association between quantitative sensory testing, treatment choice, and subsequent pain reduction in vulvar vestibulitis syndrome. *J Pain* 2004; 5:226-232.
41. Edwards R, Haythornthwaite JA, Tella P, Max MB, Raja S. Basal heat pain thresholds predict opioid analgesia in patients with postherpetic neuralgia. *Anesthesiology* 2006; 104:1243-1248.
42. Wang H, Fischer C, Chen G, Weinsheimer N, Gantz S, Schiltenwolf M. Does long-term opioid therapy reduce pain sensitivity of patients with chronic low back pain? Evidence from quantitative sensory testing. *Pain Physician* 2012; 15:ES135-ES143.