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Prediction of Postoperative Pain Intensity after Lumbar Spinal Surgery Using Pain Sensitivity and Preoperative Back Pain Severity

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Abstract

Objectives. To investigate the role of preoperative pain sensitivity and preoperative symptom severity for prediction of postoperative pain intensity after lumbar spine surgery.

Methods. This study consisted of two groups who underwent decompression surgery alone (62 patients) or decompression with fusion surgery (37 patients) for lumbar spinal stenosis (LSS). Pain Sensitivity Questionnaire (PSQ) and visual analog pain scale (VAS) for back pain and leg pain were collected preoperatively with detailed medical history. The assessment was performed immediately after surgery when the patients had completely recovered and regained their complete consciousness from general anesthesia (H0) and subsequently 4, 8, 18, 30, 48, and 72 hours (H4, H8, H18, H30, H48, and H72) thereafter as they recovered.

Results. Both groups showed a decrease in back pain and leg pain with the time postoperatively. In fusion group, preoperative VAS for back pain was significantly correlated with postoperative VAS for back pain at H0, H4, H8, and H18, and PSQ minor/total PSQ also showed a significant correlation with postoperative back pain at H48 and H72. In contrast, only total PSQ and PSQ minors were significantly correlated with postoperative back pain at H18 and H30 in decompression group. Hierarchical regression analysis finally showed that each preoperative back pain and PSQ minor was predictive of immediate postoperative back pain (from H0 to H18) in fusion group and delayed postoperative back pain (H18, H30) in decompression group.

Conclusions. The study highlights that each preoperative back pain and individual pain sensitivity could predict the different aspects of postoperative pain after lumbar surgery.

Key Words. Postoperative Pain; Preoperative Back Pain; Pain Sensitivity; Pain Sensitivity Questionnaire; Lumbar Spinal Surgery

Introduction

Proper and adequate treatment for postoperative pain still remains elusive [1,2], even though many researchers have underscored the importance of proper management of postoperative pain and have used multimodal techniques [3–9]. Previous studies have demonstrated that severe postoperative pain has been the predictor of development of persisting chronic pain after surgery [4,5,8,9]. Therefore, insufficient treatment of postoperative pain can lead to a harsh postoperative course with

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prolonged rehabilitation and poor surgical outcomes [6,7].

For these reasons, it would be desirable to predict the intensity of postoperative pain for each patient. Identification of patients at risk of severe postoperative pain will allow more individualized and effective pain management. Therefore, previous studies have suggested gender, age, and psychological states as predictive factors of postoperative pain [10–12]. Recently, the preoperative pain severity and the pain sensitivity of individuals have also emerged as the paramount predictive factors to postsurgical clinical pain from various surgery types [13–16].

Even though there have been many studies regarding the surgical outcomes after spine surgery [17–19], predictive factors for postoperative pain intensity following the spine surgery have not previously been studied. In the current study, we hypothesized that individual pain sensitivity and preoperative pain intensity can influence the intensity of postoperative pain after lumbar surgery as other types of surgeries [13–16]. In order to assess the amount of the general pain sensitivity, the validated version of Pain Sensitivity Questionnaire (PSQ) was used [20–22]. Therefore, the purpose of this study is to investigate the role of preoperative pain sensitivity and preoperative symptom severity for prediction of postoperative pain intensity after lumbar spine surgery.

Methods

Study Design and Setting

The study was approved by the hospital institutional review board. The present study was prospectively designed. Initially, 117 patients that met the inclusion criteria were enrolled between September 2012 and January 2013. The inclusion criteria were 1) being diagnosed as LSS and scheduled to undergo spine surgery for lumbar spinal stenosis (LSS) and 2) the diagnosis for LSS symptoms required one or more of the following symptoms with radiological stenotic lesion in lumbar spine: pain, numbness and neurological deficits in the lower extremities and buttocks, and bladder/bowel dysfunction. Patients were excluded for the following criteria: if they had severe pain or disability at other joints; a history of psychiatric disorders or peripheral vascular disease; and any concurrent serious medical condition causing disability and general health status including sepsis or cancer. Finally, 18 patients were excluded, and the remaining 99 patients were included in the study. For difference of postoperative pain intensity, the enrolled patients were divided into two groups. One group (decompression group) consisted of the patients with LSS who underwent only decompression surgery without fusion, while the other group (fusion group) consisted of patients who underwent decompression surgery with fusion for LSS.

Patients

There were 42 male and 57 female patients. In fusion group, 33 patients and four patients underwent one-level and two-level fusion surgeries, respectively. In decompression group, 51 patients and 11 patients underwent one-level and two-level decompression surgeries, respectively. A series of questionnaires, including PSQ and visual analog pain scale (VAS) for back and leg pain, and preoperative medication for relief of pain were collected before operation by a clinical research assistant.

Data Collection and Analysis

The PSQ has been introduced previously and is composed of 17 life situations that are associated with pain [21,22]. The patient is asked to rate how painful this situation would be for him/her on a numeric rating scale ranging from 0 (not painful at all) to 10 (worst pain imaginable) (Table 1) [21,22]. Of the 17 situations, 14 would be rated as painful by majority of healthy subjects. These painful situations cover a range of painful stimuli such as hot, cold, sharp, and blunt in a variety of body parts including the head and upper and lower extremities. However, three of the 17 situations are normally not rated as painful by healthy subjects. These items were not included in the final score. Completion of the PSQ usually takes 15 minutes with assistance of a clinical researcher. In a previous study, two subscores consisting of the PSQ moderate score and the PSQ minor score were identified, each including seven 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) (Table 1) [22]. 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 in previous studies [21,22].

The VAS for back pain/leg pain was assessed using a bar of 100-mm line with one end (zero) indicating "none," while the other end (one hundred) stands for "disabling pain." The patients were supposed to place a mark on the 100-mm line for VAS for their back pain/leg pain, and the distance (mm) between the mark and zero point was considered as the score.

Postoperative Pain Monitoring and Management

In the postoperative period, a clinical research assistant, blinded to the study, assessed pain using VAS. This assessment was done immediately after surgery when the patient had completely recovered and regained complete consciousness from general anesthesia (H0) and subsequently 4, 8, 18, 30, 48, and 72 hours (H4, H8, H18, H30, H48, and H72) thereafter. The standard intravenous patient-controlled analgesia (PCA) was initiated; PCA was set to provide a continuous infusion at a rate of 1 mL/h (fentanyl 1,500 μg + normal saline 100 mL), with an on-demand bolus infusion of 2 mL with a 20-minute lockout period. The infused PCA pump volume was used to calculate the amount of fentanyl administered at the designated time intervals (analgesic use on postoperative H4, H8, H18, H30, H48, and H72).

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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").

Statistical Analysis

Because the postoperative pain was assessed in fusion group and decompression group, respectively, demographic data, PSQ scores, and pre/postoperative VAS for back/leg pain were analyzed as the baseline data between fusion group and decompression group using an independent *t*-test. A Pearson correlation test was used for analysis of the relation between PSQ scores and preoperative symptom severity. The correlations between predictive factors/demographic variables and postoperative back/leg pain intensities over postoperative time (from H0 to H72) were also analyzed using a Pearson correlation test. Finally, in each fusion and decompression group, hierarchical multiple regression analysis were performed in order to control for the effect of covariates such as age, sex, body mass index (BMI), and the amount of administered fentanyl which could reveal the effects of both predictors (preoperative back pain and PSQ) independent of the influence of covariates. In the first step, confounding variables were entered including age, sex, BMI, and the amount of administered fentanyl. Secondly, either preoperative VAS for back pain or PSQ scores entered based on the results of Pearson correlation test and multicollinearity statistics which indicated a problem when preoperative VAS for back pain and PSQ were entered simultaneously in a single analysis. All statistical analyses were performed using the SPSS 20.0.0 statistics package (SPSS, Inc., Chicago, IL, USA). A value of $P < 0.05$ was accepted as significant.

Results

Preoperative Data in Both Groups

Mean ages (standard deviation [SD]) in fusion and decompression group were 63.51 (10.63) and 62.68 (16.00), respectively. Mean BMI and symptom duration were also not significantly different between both groups. However, the preoperative mean VAS for back pain (SD) was significantly higher in fusion group (68.52 [25.60]) than that of decompression group (55.00 [25.61]), while the preoperative leg pain was similar between both groups. Mean total PSQ and PSQ minor were not different between both groups either (Table 2).

Postoperative Back Pain and Leg Pain in Both Groups

Both groups showed a decrease in back pain and leg pain with the time postoperatively (Figure 1a,b). Postoperative VAS for back pain decreased from 88.18 and 75.75 at H0 to 62.00 and 60.00 at H72 in fusion group and decompression group, respectively (Figure 1a). Postoperative VAS for leg pain decreased from 41.25 and 30.58 at H0 to 28.67 and 32.73 at H72 in fusion group and decompression group, respectively (Figure 1b). There was no difference of postoperative leg pain at all assessment periods between fusion and decompression group, while the postoperative back pain demonstrated a significant difference at H0, H4, H18, H30, and H48 (Figure 1).

Correlations among Variables in Both Groups

In fusion group, there was multicollinearity between preoperative back pain and pain sensitivity. Preoperative VAS for back pain was significantly correlated with both total PSQ and PSQ minor. In decompression group, PSQ minor and total PSQ also had a significant correlation with preoperative VAS for leg pain (Table 3).

In fusion group, preoperative VAS for back pain was significantly correlated with postoperative VAS for back pain at H0, H4, H8, and H18, while preoperative leg

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Table 2 Demographic data, preoperative symptom severity, and pain sensitivity in patients

	Fusion	Decompression	*P*
N	37	62	
Age (years)	63.51 (10.63)	62.68 (16.00)	0.756
BMI (kg/cm^2)	25.95 (3.61)	25.79 (2.78)	0.699
Symptom duration (months)	16.35 (6.33)	15.31 (9.49)	0.142
Number of segments	One segment: 33 Two segments: 4	One segment: 51 Two segments: 11	
Preoperative medication (n)			
NSAID and/or acetaminophen alone	11	17	
Opioid alone	9	20	
NSAID and opioid	17	25	
Preoperative VAS for back pain	68.52 (25.60)	55.00 (25.61)	**0.018**
Preoperative VAS for leg pain	73.97 (24.18)	71.30 (25.99)	0.631
Total PSQ	12.24 (3.63)	12.33 (3.24)	0.921
PSQ minor	5.44 (2.22)	5.41 (2.02)	0.950

Values are mean values (SD) or numbers. The value in bold means statistical significance. BMI = body mass index; NSAID = non-steroid anti-inflammatory drug; PSQ = Pain Sensitivity Questionnaire; SD = standard deviation; VAS = visual analog pain scale.

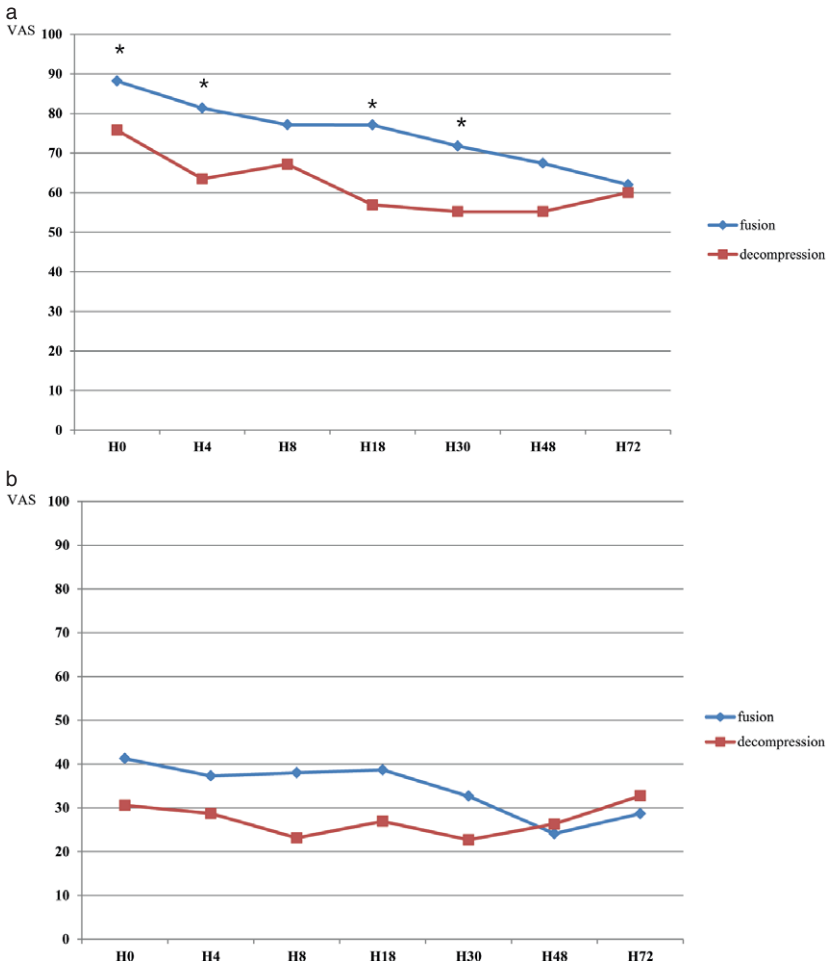

Figure 1 Changes of postoperative pain with the postoperative time course (asterisk [*] means *P* value < 0.05). (a) Postoperative visual analog pain scale (VAS) for back pain in fusion and decompression group. (b) Postoperative VAS for leg pain in fusion and decompression group. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

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Table 3 Correlation between preoperative symptom severity and PSQ scores in patients

			Preoperative VAS for Back	Preoperative VAS for Leg
Fusion	PSQ minor	*R*	**0.706**	0.360
		P value	**<0.001**	0.060
	Total PSQ	*R*	**0.708**	**0.387**
		P value	**<0.001**	**0.042**
Decompression	PSQ minor	*R*	0.172	**0.409**
		P value	0.248	**0.004**
	Total PSQ	*R*	0.183	**0.367**
		P value	0.217	**0.011**

Values are mean values (SD). The values in bold means statistical significance. PSQ = Pain Sensitivity Questionnaire; SD = standard deviation; VAS = visual analog pain scale.

pain showed no correlation with postoperative VAS for back pain over time. PSQ minor and total PSQ showed a significant correlation with postoperative back pain at H48 and H72 after operation in fusion group (Figure 2a). In decompression group, preoperative back pain and leg pain were not correlated with the postoperative back pain. Only PSQ minor and total PSQ were significantly correlated with postoperative back pain at H18 and H30 (Figure 2b). However, in both groups, any predictive factors such as preoperative back pain/leg pain and total

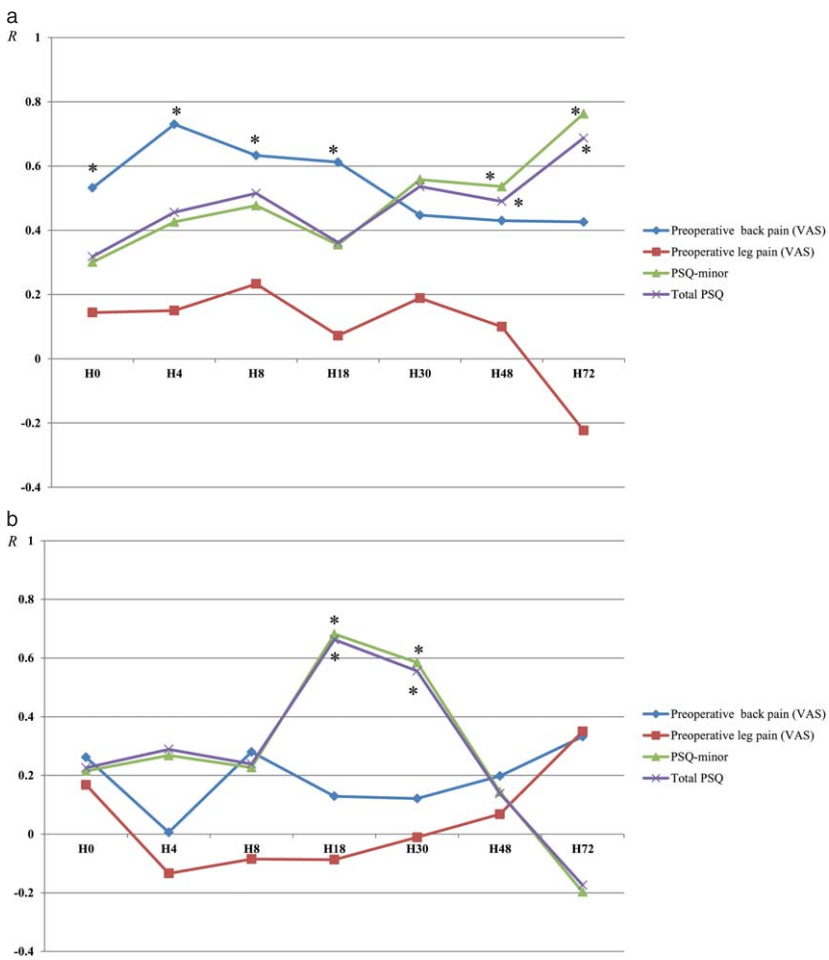

Figure 2 Changes of correlation coefficient (*R*) between predictive factors and postoperative visual analog pain scale (VAS) for back pain with the postoperative time course. (a) Fusion group. Asterisk (*) means that *P* value was statistically significant (preoperative back pain; 0.002, <0.001, 0.005, and 0.001 at H0, H4, H8, and H18, Pain Sensitivity Questionnaire [PSQ] minor/total PSQ; 0.015/0.028 and 0.006/0.019 at H48 and H72). (b) Decompression group. Asterisk (*) means that *P* value was statistically significant (PSQ minor/total PSQ; <0.001/0.001 and 0.009/0.013 at H18 and H30). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

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Table 4 Results of hierarchical multivariate regression models for prediction of postoperative back pain in fusion group

		R^2	F	Standard β	P
H0	Step 1	0.19	0.90		0.501
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Step 2	0.43	2.22		0.048
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Preoperative VAS for back pain			0.793	0.014
H4	Step 1	0.20	0.45		0.804
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Step 2	0.84	7.17		0.007
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Preoperative VAS for back pain			1.136	< 0.001
H8	Step 1	0.49	1.36		0.343
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Step 2	0.93	12.32		0.004
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Preoperative VAS for back pain			1.185	0.001
H18	Step 1	0.27	1.18		0.363
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Step 2	0.56	3.24		0.030
	Sex, age, BMI, preoperative VAS for leg pain, PSQ minor, the amount of fentanyl use				
	Preoperative VAS for back pain			0.835	0.006
H48	Step 1	0.28	1.36		0.299
	Sex, age, BMI, preoperative VAS for leg pain, the amount of fentanyl use				
	Step 2	0.37	1.54		0.246
	Sex, age, BMI, preoperative VAS for leg pain, the amount of fentanyl use				
	PSQ minor			0.424	0.191
H72	Step 1	0.34	1.02		0.448
	Sex, age, BMI, preoperative VAS for leg pain, the amount of fentanyl use				
	Step 2	0.70	2.97		0.132
	Sex, age, BMI, preoperative VAS for leg pain, the amount of fentanyl use				
	PSQ minor			0.882	0.055

BMI = body mass index; PSQ = Pain Sensitivity Questionnaire; VAS = visual analog pain scale.

PSQ/PSQ minor failed to show correlations with postoperative VAS for leg pain with the postoperative time course.

Hierarchical Multiple Regression for Prediction of Postoperative Back Pain

Tables 4 and 5 show all regression models for predicting postoperative back pain at each postoperative time in fusion and decompression group, respectively. Considering the multicollinearity between preoperative back pain and PSQ scores, either PSQ scores or preoperative VAS for back pain and other potential predictors were entered in the model.

In fusion group, the demographic covariates, the amount of administered fentanyl, and other potential

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Table 5 Results of hierarchical multivariate regression models for prediction of postoperative back pain in decompression group

		R^2	F	Standard β	P
H18	Step 1 Sex, age, BMI, the amount of fentanyl use, preoperative VAS for back pain	0.36	2.24		0.110
	Step 2 Sex, age, BMI, the amount of fentanyl use, preoperative VAS for back pain	0.53	3.36		0.031
	PSQ minor			0.61	0.035
H30	Step 1 Sex, age, BMI, the amount of fentanyl use, preoperative back pain	0.38	2.16		0.127
	Step 2 Sex, age, BMI, the amount of fentanyl use, preoperative back pain	0.54	3.07		0.048
	PSQ minor			0.45	0.049

BMI = body mass index; PSQ = Pain Sensitivity Questionnaire; VAS = visual analog pain scale.

predictors included in step 1 accounted for 19.0%, 20.0%, 49.0%, 27.0%, 28.0%, and 34.0% at H0, H4, H8, H18, H48, and H72, respectively. The models in step 1 did not show the statistical significance at the postoperative time of H0, H4, H8, H18, H48, and H72. When preoperative VAS for back pain was entered in step 2, this contributed to another 24.0%, 64.0%, 44.0%, and 29.0% to the predicted variance at the postoperative time from H0 to H18 (Table 4), and these models were statistically significant. Hierarchical linear regression analysis with preoperative back pain as independent variables, controlling for the effects of demographic variables, other potential predictors, and the amount of administered fentanyl, indicated that immediate postoperative back pain was significantly predicted by preoperative VAS for back pain ($\beta = 0.793$; $P = 0.014$, $\beta = 1.136$; $P < 0.001$, $\beta = 1.185$; $P = 0.001$, $\beta = 0.835$; $P = 0.006$ at H0, H4, H8, and H18, respectively). At H48 and H72, PSQ minor was entered in step 2, which contributed to another 9.0% and 36.0% to the predicted variance. However, the models were not statistically significant, and any variables did not explain the postoperative back pain at H48 and H72 (Table 4).

In decompression group, the demographic covariates, other potential predictors, and the amount of administered fentanyl included in step 1 accounted for 36.0% and 38.0% at H18 and H30, respectively, but the models in step 1 were not statistically significant. When PSQ minor was entered in step 2, this contributed to another 17.0% and 16.0% to the predicted variance, and multiple regression models were statistically significant (Table 5). Hierarchical regression analysis with PSQ minor showed that each PSQ minor ($\beta = 0.61$; $P = 0.035$) was significantly associated with postoperative back pain at H18. Results of the variables at H30 were almost similar with those at H18 (Table 5).

Discussion

The current study was designed to evaluate the predictive values of pain sensitivity and preoperative pain severity for postoperative pain intensity after lumbar surgery. These factors were selected because recent studies have been reported as potential reliable factors for predicting postoperative pain intensity after other types of surgery [13–16]. Furthermore, PSQ was used for assessing individual pain sensitivity instead of experimental study.

Both pain sensitivity and preoperative pain severity were correlated with the postoperative pain intensity. As a predictive factor for postoperative back pain, preoperative back pain severity showed a significant correlation with acute postoperative back pain at the time from H0 to H18 following surgery in fusion group, and hierarchical regression model also indicated the significant predictive value of preoperative VAS for back pain at the time from H0 to H18 after controlling demographic variables, other predictors, and the amount of administered fentanyl. These findings can be explained by the fact that preoperative back pain would be related with central and/or peripheral sensitization [9,16]. A previous study demonstrated that preoperative pain intensity was one of the best predictors of severe pain in the early postoperative period through a sensitization mechanism [16]. Not only does sensitization stand for an increase in the excitability of neurons, but it also makes it more sensitive to stimuli or sensory inputs [23]. Therefore, it could be assumed that chronic noxious afferent input from the area to be operated upon has produced neuroplastic changes in the nervous tissue (sensitization by up-regulation of receptor subsystems) that become manifest as a relatively hyperpathic state in the postoperative period [16,23]. However, there was no correlation between preoperative back pain and postoperative

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back pain in decompression group. This would be related with the difference of preoperative back pain between two groups. In the decompression group, most patients had only mild or moderate back pain, although of intractable leg pain that was caused by neurogenic claudication; the mean VAS for preoperative back pain was 55.00 in the decompression group, while the mean VAS for preoperative back pain was 68.52 in the fusion group. Therefore, relatively lower VAS for preoperative back pain in the decompression group would not cause sensitization in the operated area, lower back. For this reason, preoperative back pain did show no predictive value for postoperative back pain in decompression group. Furthermore, the current result shows the moderate postoperative back pain still remain at 72 hours after surgery even in the decompression group. This is the reason why the mean VAS for back pain at the time H72 was greater than preoperative back pain in the decompression group.

Contrarily, the pain sensitivity showed a significant predictive power for postoperative back pain only in decompression groups. Even though there were significant correlations in both groups between PSQ scores and postoperative back pain (Figure 2), hierarchical multiple regression demonstrated that PSQ minor and total PSQ were significantly predictive of postoperative back pain at the time of H18 and H30 only in decompression group (Table 5). According to a previous study, PSQ scores had significant high correlations with experimental pain intensity ratings, but no correlation with experimental pain thresholds [22], in which pain intensity rating means the subjective intensity rating of supra-threshold painful stimuli [24]. Furthermore, previous studies also reported the predictive role of supra-threshold pain sensitivity for postoperative pain [13,25]. From previous studies, it could be hypothesized that PSQ score seemed to be only predictive of postoperative pain intensity (not supra-threshold pain), which was supported by the present findings. Therefore, the results can be interpreted as two aspects. First, as shown, individual pain sensitivity can also play the role of prediction of postoperative pain after lumbar decompression surgery. Second, the result corroborates a previous assumption that PSQ may be useful for predicting postoperative pain [22].

Likewise, inconsistency in the postoperative periods and groups when both predicting factors (preoperative back pain and PSQ) showed correlations with postoperative back pain means that each factor reflects the different sides of individual pain perception. Preoperative back pain was significantly more predictive of postoperative back pain in earlier postoperative periods than PSQ. Therefore, based on the current results, preoperative back pain is a better predictor for the susceptibility for more severe postoperative pain than pain sensitivity measured by PSQ. However, PSQ had correlations with postoperative back pain at the delayed H18, H30 postoperative time only in decompression group, and this suggests that PSQ can be predictive of less level of postoperative pain than preoperative back pain.

This study has several limitations. First, the present work did not deal with psychological factors including catastrophizing and/or personal psychological traits that can influence postoperative pain [13,26]. However, the subjects with a history of psychological disorder such as depression, psychosis, and somatization disorder were excluded in the current study. Second, the current study should be interpreted in the context with multicollinearity between preoperative back pain and pain sensitivity. Because each preoperative back pain and pain sensitivity reflected the different aspect of postoperative pain in the present study, both factors were entered in the regression models. Furthermore, as it has not yet been known whether PSQ is a "cause" or a "consequence" of increased preoperative back pain, adjusting simultaneously for both variables would probably result in multicollinearity and/or overadjustment issues. Therefore, two predictors were entered in the "step 1" regression models separately.

In conclusion, the present study suggests that each preoperative back pain and individual pain sensitivity can predict postoperative pain intensity after lumbar surgery. Therefore, the subject who had severe back pain or increased pain sensitivity may require more active postoperative pain management after spine surgery. In addition, PSQ can be a useful measure for predicting postoperative pain.

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