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Clinical Study

Negative impact of spinal epidural lipomatosis on the surgical outcome of posterior lumbar spinous-splitting decompression surgery: a multicenter retrospective study

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Abstract

BACKGROUND CONTEXT: Spinal epidural lipomatosis (SEL) results from excess lumbar epidural fat (EF) accumulation that compresses the cauda equina or nerve roots. Guidelines for the therapeutic management of SEL are not currently available.

PURPOSE: To elucidate the efficacy of lumbar decompression surgery in SEL.

STUDY DESIGN: Multicenter retrospective study.

PATIENT SAMPLE: A total of 288 consecutive patients who underwent posterior lumbar spinous-splitting decompression surgery for lumbar spinal canal stenosis and followed up greater than 2 years at participating institutions were retrospectively reviewed.

OUTCOME MEASURES: Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ) and Roland-Morris Disability Questionnaire (RDQ).

METHODS: Participants were divided into two groups according to the ratio of EF to anteroposterior diameter of the spinal canal (EF/SC-L) at the spinal level with maximum dural tube compression. Patients with EF/SC-L of ≥0.6 and <0.6 were defined as those with SEL and non-SEL, respectively. We assessed whether surgical treatment was “effective” or “not effective” using the JOABPEQ based on the following: an increase of ≥20 points in the postoperative score compared with the preoperative score, or a preoperative score <90 with a postoperative score ≥90 points. We constructed a multiple Poisson regression model by adjusting for confounding factors, and determined estimated relative risk (RR) for “not effective” with surgical treatment using the JOABPEQ. Additionally, we selected age-, sex-, BMI-, and decompression levels-matched patients with non-SEL and compared the frequency of “not effective” between SEL patients (n=60) and non-SEL patients (n=60).

RESULTS: Analysis using the RDQ and JOABPEQ showed that the 1- and 2-year postoperative scores were significantly better than the preoperative scores in the both groups. Multivariable

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Poisson regression analysis demonstrated that SEL was significantly associated with “not effective” for decompression surgery in the 1-year postoperative outcomes of walking ability ([RR] 1.5, 95% confidence interval [CI] 1.0−2.2) and social life (RR 1.3, 95% CI 1.0−1.8) and the 2-year postoperative outcomes of walking ability (RR 1.6, 95% CI 1.2−2.3). Matching analysis showed that SEL was significantly associated with “not effective” with lumbar decompression surgery in the 2-year postoperative outcomes of walking ability (p=.02).

CONCLUSIONS: Patients with SEL exhibited significant improvements in surgical outcomes at 1 and 2 years postoperatively. However, compared with the non-SEL group, the efficacy of posterior lumbar spinous-splitting decompression surgery was worse in the SEL group, especially for walking ability. These results indicate that EF accumulation should be considered when planning treatment for patients with lumbar spinal canal stenosis and estimating the efficacy of lumbar decompression surgery.

Keywords: Epidural fat; Japanese Orthopedic Association Back Pain Evaluation Questionnaire; Lumbar decompression surgery; Lumbar spinal canal stenosis; Posterior lumbar spinous-splitting decompression surgery; Roland-Morris Disability Questionnaire; Spinal epidural lipomatosis; Surgical effectiveness

Introduction

Although spinal epidural fat (EF) is a normal finding in the lumbar region of healthy individuals, excessive EF accumulation, termed spinal epidural lipomatosis (SEL), can lead to compression of the cauda equina and nerve roots. As a result, patients with SEL often exhibit neurologic symptoms, including leg pain, numbness, intermittent claudication, motor deficits, sensory disturbances, and bladder and bowel dysfunction. In 1975, Lee et al. reported the first case of SEL in a patient receiving corticosteroids following renal transplantation [1]. SEL can occasionally develop in patients using corticosteroids and those with endocrine disorders associated with overproduction of endogenous corticosteroids [2−4]. Meanwhile, several studies found that SEL was common in male obese individuals [5−9]. Recent study demonstrated the significant association between metabolic syndrome and the development of SEL [10].

We previously reported that patients with SEL exhibited more severe pain and less walking ability than those with lumbar spinal canal stenosis (LSS) in the absence of SEL [11]. In a study examining surgical outcomes in seven patients with SEL, Ishikawa et al. showed that the rate of recovery was high according to the Japanese Orthopedic Association score [12]. Ferlic et al. recently showed that lumbar decompression surgery for SEL was associated with favorable outcomes based on the patient-reported questionnaires [13]. In addition, Bayerl et al. reported that surgical outcomes were comparable between patients with SEL and those with LSS in the absence of SEL [14]. However, these studies lacked control groups or did not otherwise provide detailed methods for the selection of control groups. Therefore, they may not provide definitive conclusions on the comparison of surgical outcomes between patients with and without SEL. Hence, we conducted a multicenter retrospective study to compare the efficacy of lumbar decompression surgery between patients with and without SEL among patients undergoing posterior lumbar spinous-splitting decompression surgery for LSS.

Materials and methods

Participants

We retrospectively reviewed 288 consecutive patients who underwent posterior lumbar spinous-splitting decompression surgery without spinal instrumentation for LSS from September 2008 to November 2016 and followed up for more than 2 years at participating institutions [15]. EF in decompression area was removed as much as possible during the surgical procedure. For each patient, the clinical data were collected using patient charts, imaging studies, and surgical records based on the institutional ethics guidelines (approval number: 20110142). All participants were presented with an opt-out option. The subjects were notified of the study, and the data of those who declined to participate were excluded from the analyses to comply with the ethical guidelines of all participating institutions. Surgery was recommended for patients displaying obvious symptoms of LSS, including leg pain and neurogenic claudication, who were resistant to conservative therapy. The LSS diagnosis was validated using magnetic resonance imaging (MRI). Patients with failed back surgery syndrome were excluded.

Data collection

All enrolled patients had complete data for the Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ) [16] and the Roland-Morris Disability Questionnaire (RDQ) [17] collected at preoperative and 1- and 2-year follow-up assessments. In addition, we collected the following data for each patient: age; sex; body mass index (BMI); perioperative factors, including the number of decompression levels, operating time, and amount of blood loss; and medical history, including diabetes mellitus, hypertension, hyperlipidemia, and heart disease.

Radiographic parameters

We recorded the following radiographic data from standing full-length spine radiographs: anterior percentage of slip, sagittal vertical axis (SVA), thoracic kyphosis (TK), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), and pelvic incidence (PI). In addition, we analyzed the spinopelvic alignment using PI-LL, SVA, TK, LL, PI, and PT, described previously [18]. We defined spondylolisthesis as ≥10% anterior slip of the upper vertebra and lumbar scoliosis as a Cobb angle ≥10°.

MRI

The anteroposterior distance and cross-sectional area of EF and the spinal canal (SC) from L1/2 to L5/S1 were measured using the axial images of lumbar MRIs (Fig. 1). The ratios of EF to SC in the anteroposterior distance and cross-sectional area were calculated (EF/SC-L and EF/SC-A, respectively) at each level. EF/SC-L exhibited a strong positive correlation with EF/SC-A (r=0.741, p<.001; Fig. 2). These results indicate that EF/SC-L can be a reliable indicator for SEL.

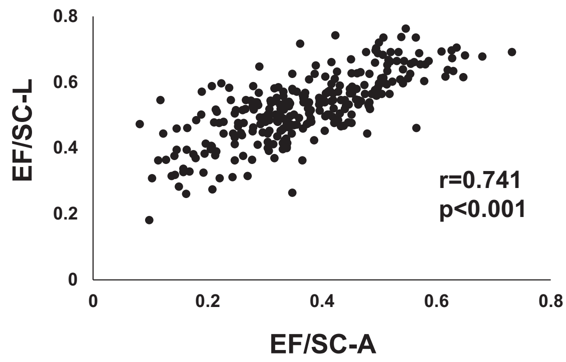

Fig. 2. Correlation between EF/SC-L (ratio of EF to SC in the anteroposterior distance) and EF/SC-A (ratio of EF to SC in the cross-sectional area). r, correlation coefficient.

Grouping of participants

Participants were divided into two groups according to the EF/SC-L at the spinal level exhibiting maximum dural tube compression. Based on our previous study [10,11,19], patients with an EF/SC-L ≥0.6 were categorized in the SEL group (group L), and those with an EF/SC index <0.6 were categorized in the non-SEL group (group N). Additionally, we selected age-, sex-, and BMI-matched patients without SEL (group SN). When selecting, we also tried to match the number of decompression levels of group SN with group L as much as possible.

Assessment of the therapeutic effect of lumbar decompression surgery

To elucidate the efficacy of lumbar decompression surgery in patients with SEL, we assessed whether surgical treatment was "effective" or "not effective" at 1 and 2 years postoperatively using the JOABPEQ based on the following: (1) an increase of ≥20 points in the postoperative score compared with the preoperative score, or (2) a preoperative score <90 with a postoperative score ≥90 points. If either (1) or (2) was satisfied, the treatment was determined as "effective" [16].

Statistical analysis

In this study, data were presented as means±standard deviation. We used Pearson's chi-square test (Tables 1−3, 5, and 6), Student's *t* test (Tables 1−3 and 5), the Mann-Whitney *U* test (Figs. 3 and 4), and Friedman's test (Figs. 3 and 4) for statistical analyses. For multiple comparisons, significance values were adjusted by Bonferroni correction (Figs. 3 and 4). We considered p<.05 to indicate statistical significance. To examine the association of SEL with "not effective" with lumbar decompression surgery based on the JOABPEQ, we constructed a multiple Poisson regression model including age, sex, BMI, hypertension, hyperlipidemia, diabetes mellitus, heart disease, operating time, the number of decompression level, SVA, LL, degenerative scoliosis, and presence of reoperation, and determined the estimated relative risks (RRs) and 95% confidence intervals (95% CI) for "not effective" with lumbar decompression surgery (Table 4). Multiple Poisson regression analysis was performed using the STATA14 software (Stata Corporation, College Station, TX).

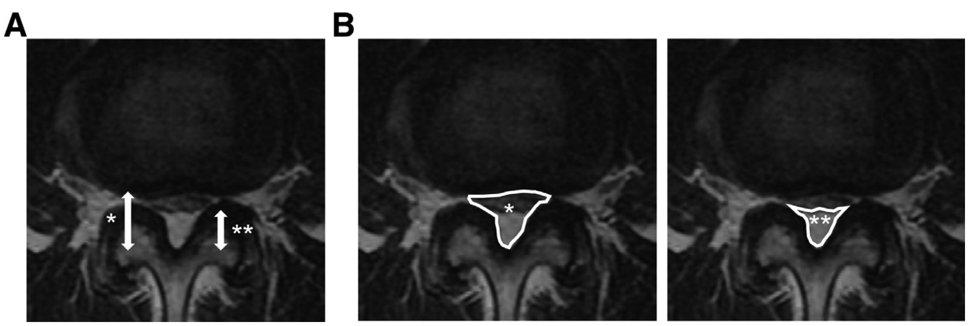

Fig. 1. Anteroposterior distance (A) and cross-sectional area (B) of the spinal canal (SC)* and epidural fat (EF)** in the axial images of lumbar MRIs.

Table 1
Baseline characteristics of the L group and the N group

		L (n=60)	N (n=228)	p Value
	Age	73.6±7.0	70.1±9.0	.006
	BMI	25.4±3.4	23.9±2.8	<.001
	% Male	42 (70.0%)	146 (64.0%)	.388
Medical history	Hypertension	27 (45.0%)	77 (33.8%)	.107
	Hyperlipidemia	5 (8.3%)	18 (7.9%)	.911
	Diabetes mellitus	10 (16.7%)	33 (14.5%)	.671
	Heart disease	7 (11.7%)	22 (9.6%)	.644

Chi-square test or *t* test.

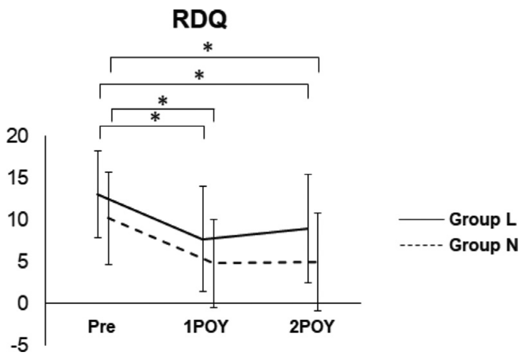

Fig. 3. The Roland-Morris Disability Questionnaire (RDQ) scores at baseline and follow-up after surgery (mean±standard deviation; n=288) in the spinal epidural lipomatosis (SEL [L]) and non-SEL (N) groups. *p<.05.

Results

Comparison of the clinical characteristics between the S and N groups

Overall, 60 and 228 patients were included in the L and N groups, respectively. The baseline characteristics of the study cohort, including the mean age, sex ratio, mean BMI, and prevalence of diabetes mellitus, hypertension, hyperlipidemia, and heart disease are summarized in Table 1. Briefly, the mean age and BMI were significantly higher in the L group than the N group (Table 1). Among the preoperative radiographic parameters, SVA was significantly larger in the L group than the N group (63.3±47.8 vs. 45.2±38.5; p=.002; Table 2). The values for LL (26.8°±13.4° vs. 34.0°±13.7°; p<.001) and SS (22.1°±9.8° vs. 25.4°±9.7°; p=.022) were significantly smaller in the L group than the N group (Table 2). The perioperative factors, summarized in Table 3, showed that the mean number of decompressed levels (2.1±0.8 vs. 1.7±0.7; p<.001) and the mean operating time (65.4±28.2 vs. 56.3±26.4 minutes; p=.020) were significantly higher in the L group than the N group.

Comparison of the surgical outcomes between the S and the N groups

Fig. 3 presents the preoperative and 1- and 2-year postoperative RDQ scores. In both groups, the 1- and 2-year postoperative scores were significantly better than the preoperative scores. In the L group, albeit not significant, the 2-year postoperative scores were worse than the 1-year postoperative scores. The scores of the L group were significantly higher than those of the N group at all time points (Fig. 3). Fig. 4 shows individual JAOBPEQ domain scores at preoperative and 1- and 2-year postoperative assessments. For all domains except for psychological disorder, the 1- and 2-year postoperative scores were significantly better than the preoperative scores in both the L and the N groups (Fig. 4). In psychological disorder, 2-year postoperative scores of the L group were comparable with those preoperatively (Fig. 4). Additionally, the preoperative scores of the L group were significantly lower than those of the N group in the domains for pain disorder (p=.02), lumbar function (p=.01), and walking ability (p<.01), but not social life (p=.10), and psychological disorder (p=.86).

Evaluation of the surgical efficacy in patients with SEL

A multiple Poisson regression analysis showed that SEL was significantly associated with “not effective” with posterior lumbar spinous-splitting decompression surgery in the 1-year postoperative outcomes of walking ability (RR 1.5, 95% CI 1.0−2.2) and social life (RR 1.3, 95% CI 1.0−1.8) and the 2-year postoperative outcomes of walking ability (RR 1.6, 95% CI 1.2−2.3; Table 4). In addition, after matching age, sex, BMI, the number of decompression levels, we compared these parameters between the L group (n=60) and the SN group (n=60). Although LL still showed a significant difference between the two groups (Table 5), SEL was significantly associated with “not effective” with lumbar decompression surgery in the 2-year postoperative outcomes of walking ability (p=.02; Table 6).

Discussion

In this multicenter retrospective study, we found that the patients with SEL who underwent posterior lumbar spinous-splitting decompression surgery exhibited a significant improvement in clinical outcomes at 1 and 2 years postoperatively, although they experienced worse surgical efficacy, especially regarding walking ability, compared with the

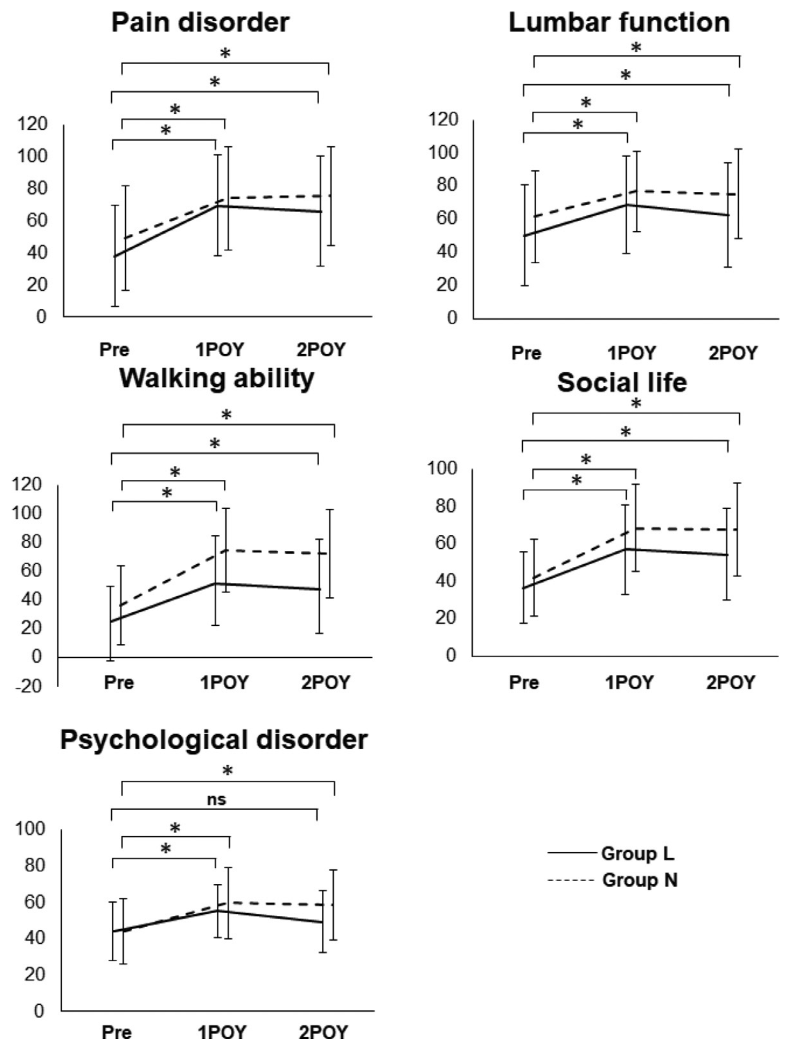

Fig. 4. The Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ) scores at baseline and follow-up after surgery (mean±standard deviation; n=288) in the SEL (L) and non-SEL (N) groups. *p<.05.

patients without SEL undergoing posterior lumbar spinous-splitting decompression surgery.

In the present study, SEL was defined as an EF/SC index of >60% at the lumbar spinal level as we reported previously [10,11,19]. Although the accumulation of EF tissue can be easily measured by MRI, the diagnostic criteria for SEL have not been determined. Ishikawa et al. classified SEL into three grades using a system based on sagittal and axial MRI scans, which, however, is a nonquantitative classification that cannot provide a precise assessment of the degree of EF accumulation [12]. Borre et al. classified the degree of EF accumulation into four grades according to the EF/SC index and showed that patients with an EF/SC ≥75% exhibited clear neurologic symptoms. In addition, they demonstrated that the prevalence of patients with an EF/SC ≥75% was 2.1% among those undergoing spinal

Table 2
Preoperative radiographic parameters of the L group and the N group

	L (n=60)	N (n=228)	p Value
Anterior slip (>10°)	7 (11.7%)	28 (12.3%)	
Degenerative scoliosis	7 (11.7%)	17 (7.5%)	
SVA (mm)	63.3±47.8	45.2±38.5	.002
TK (°)	24.7±12.0	25.5±11.8	.642
LL (°)	26.8±13.4	34.0±13.7	<.001
PT (°)	23.9±9.8	22.2±8.6	.210
SS (°)	22.1±9.8	25.4±9.7	.022
PI (°)	46.0±10.6	47.5±10.6	.345

SVA, sagittal vertical axis; TK, thoracic kyphosis; LL, lumbar lordosis; PT, pelvic tilt; SS, sacral slope; PI, pelvic incidence.

Chi-square test or *t* test.

Table 3
Perioperative factors of the L group and the N group

	L (n=60)	N (n=228)	p Value
The number of decompression level	2.1±0.8	1.7±0.7	<.001
Operating times (min)	65.4±28.2	56.3±26.4	.020
Blood loss (mL)	22.9±44.8	25.6±63.3	.756

Chi-square test or *t* test.

Table 4
Poisson regression analysis using JOABPEQ (''not effective'' with surgical treatment)

		SEL	Number of patients	Number of incidents	Rate of incidence (%)	Relative risk	95% CI		p Value
1-year postoperation	Pain disorder	−	228	97	42.5	Ref			
		+	60	23	38.3	0.9	0.6	1.4	0.68
	Lumbar function	−	228	134	58.8	Ref			
		+	60	34	56.7	1.0	0.7	1.3	0.85
	Walking ability	−	228	64	28.1	Ref			
		+	60	28	46.7	1.5	1.0	2.2	0.03
	Social life	−	228	98	43.0	Ref			
		+	60	35	58.3	1.3	1.0	1.8	0.05
	Psychological disorder	−	228	144	63.2	Ref			
		+	60	42	70.0	1.1	0.9	1.4	0.38
2-year postoperation	Pain disorder	−	228	88	38.6	Ref			
		+	60	27	45.0	1.2	0.8	1.7	0.45
	Lumbar function	−	228	129	56.6	Ref			
		+	60	36	60.0	1.0	0.8	1.4	0.73
	Walking ability	−	228	64	28.1	Ref			
		+	60	32	53.3	1.6	1.2	2.3	0.01
	Social life	−	228	103	45.2	Ref			
		+	60	35	58.3	1.1	0.8	1.4	0.54
	Psychological disorder	−	228	146	64.0	Ref			
		+	60	47	78.3	1.2	1.0	1.4	0.08

CI, confidence interval.

Adjusted by age, sex, BMI, hypertension, hyperlipidemia, diabetes mellitus, heart disease, operation times, SVA, LL, degenerative scoliosis, the number of decompression level, and presence of reoperation.

Lipomatosis was defined as was EF/SD index >0.60.

Table 5
Demographic data, preoperative radiographic parameters, and perioperative factors of the L group and the SN group

		L (n=60)	SN (n=60)	p Value
	Age	73.6±7.0	73.9±6.7	.853
	BMI	25.4±3.4	25.3±2.5	.951
	% Male	42 (70.0%)	42 (70.0%)	1.000
Medical history	Hypertension	27 (45.0%)	20 (33.3%)	.191
	Hyperlipidemia	5 (8.3%)	7 (11.7%)	.543
	Diabetes mellitus	10 (16.7%)	11 (18.3%)	.810
	Heart disease	7 (11.7%)	3 (5.0%)	.186
Radiographic parameters	Anterior slip (>10°)	7 (11.7%)	8 (13.3%)	.780
	Degenerative scoliosis	7 (11.7%)	10 (16.7%)	.432
	SVA (mm)	63.3±47.8	53.4±42.7	.237
	TK (°)	24.7±12.0	26.4±11.8	.427
	LL (°)	26.8±13.4	32.2±12.7	.025
	PT (°)	23.9±9.8	22.2±8.4	.311
	SS (°)	22.1±9.8	25.0±9.2	.098
	PI (°)	46.0±10.6	47.2±11.0	.551
Perioperative factors	The number of decompression level	2.1±0.8	2.0±0.8	.490
	Operating times (min)	65.4±28.2	62.8±29.6	.621
	Blood loss (mL)	22.9±44.8	37.6±72.1	.182

Chi-square test or *t* test.

MRI [20], indicating that patients with an EF/SC ≥75% were clinically too limited to clarify the impact of EF accumulation on clinical outcomes. In the previous study [19], histologic and molecular analysis showed that the character of EF from the patients with EF/SC >60% was significantly different from those with EF/SC ≤60%, indicating that EF/SC >60% is one of the candidates for diagnostic criteria of SEL. However, given that patients with an EF/SC index >60% can exhibit degenerative changes of the lumbar spine leading to canal stenosis in addition to SEL, the SEL group

Table 6
Comparison of frequency of ''not effective'' with surgical treatment between the L group and the SN group

		SEL	Number of patients	Number of incidents	Rate of incidence (%)	p Value
1-year postoperation	Pain disorder	−	60	24	40.0	.85
		+	60	23	38.3	
	Lumbar function	−	60	35	58.3	.85
		+	60	34	56.7	
	Walking ability	−	60	19	31.7	.09
		+	60	28	46.7	
	Social life	−	60	26	43.3	.1
		+	60	35	58.3	
	Psychological disorder	−	60	37	61.7	.36
		+	60	42	70.0	
2-year postoperation	Pain disorder	−	60	22	36.7	.35
		+	60	27	45.0	
	Lumbar function	−	60	37	61.7	.85
		+	60	36	60.0	
	Walking ability	−	60	19	31.7	.02
		+	60	32	53.3	
	Social life	−	60	32	53.3	.58
		+	60	35	58.3	
	Psychological disorder	−	60	44	73.3	.52
		+	60	47	78.3	

SEL was defined as was EF/SD index >0.60.
Chi-square test.

in the present study may not be completely homogenous. Future studies are therefore warranted to standardize the diagnostic criteria for SEL.

In the present study, the categorization of the patients into two groups according to the degree of EF accumulation revealed that the mean BMI and age were significantly higher in the SEL group than the non-SEL group. These results are partially consistent with past studies showing a significant association between obesity and SEL [5−9]. Conversely, in our previous study, age was not associated with SEL [10,11]. Although this discrepancy may be dependent on different datasets, the present result is in agreement with a previous report showing that advanced age was one of the risk factors for metabolic syndrome [21]. Among the parameters of sagittal spinal alignment, SVA, LL, and SS were significantly different between the two groups in the present study. Considering that advanced age causes an increase in SVA and decreases in LL and SS [22], the difference of these parameters between the two groups may be attributable to age. Among the perioperative factors, our analyses demonstrated that the number of decompression levels and the operating time were significantly higher in the SEL group than the non-SEL group. These results may be associated with previous studies reporting that excessive EF accumulation commonly occurred over multiple levels [13,14]. Because age, BMI, SVA, LL, degenerative scoliosis, the number of decompression level, operating time, and the presence of reoperation can affect the surgical outcomes of spinal lumbar surgery [23−25], we included these variables as confounding factors in the multivariable analysis for the efficacy of lumbar decompression surgery. In addition, we compared the surgical efficacy between the two groups after matching these confounding factors as much as possible.

Consistent with the previous studies by Ishikawa et al. [12] and Ferlic et al. [13], the present study showed that the parameters of both the RDQ and JOABPEQ in the SEL group were markedly improved at 1 and 2 years postoperatively, suggesting that lumbar decompression surgery offered adequate relief for symptoms in patients with SEL. However, the previous reports, which were based on a case series study, did not compare postoperative clinical outcome with the non-SEL patients [12,13]. In the present study, compared with the non-SEL patients, our results suggested a correlation between the presence of SEL and poor surgical efficacy based on the walking ability according to the JOABPEQ. Thus, excessive EF accumulation may exert an adverse effect on surgical outcomes in patients with LSS. Previously, we demonstrated that the expression levels of inflammatory cytokines, such as tumor necrosis factor-α and interleukin-1β, were increased in the EF tissues of patients with SEL [19]. These inflammatory cytokines were reported to regulate the expression of pain mediators [26,27]. In the present study, the HRQOL analysis revealed that patients with SEL had more severe neurologic symptoms than those without SEL, even preoperatively. These observations support our hypothesis that inflammatory cytokines in excessive EF accumulation may be partially involved in the neurologic pain caused by SEL [19]. In addition, both multivariable analysis and matching analysis showed that the walking ability of SEL patients in 2-year postoperation was worse than that in 1-year postoperation. Considering that all of the EF tissues cannot be completely removed by decompression surgery, these results suggest that chronic inflammation in the remaining EF tissues may exacerbate neurogenic pain and aggravate the walking ability in SEL patients with the passage of time. Meanwhile, reaccumulation of EF tissues which form postoperatively might be involved in the poor surgical efficacy of SEL patients. However, because of the lack of postoperative lumbar MRI data, we could not examine the postoperative status of the EF in the present study. To clarify the cause of poor surgical outcome in SEL patients, we need the future study including postoperative lumbar MRI of SEL patients.

Bayerl et al. reported that the surgical efficacy of microsurgical decompression for SEL patients was comparable to that for the patients with classical spinal stenosis [14]. They showed that demographic parameters such as age, gender, and BMI and radiographic parameters were similar between the SEL group and the classical spinal stenosis group. To remove the demographic difference between the non-SEL and SEL groups, we can use several methods, such as matching and multivariable analysis. In this study, we applied both multivariable analysis (Poisson regression model) and matching analysis due to adjustment for several possible confounding factors. In addition to a statistic method, there are the differences of surgical procedure, parameters of HRQOL, and diagnostic criteria between the two studies [14]. These differences may influence the results of surgical efficacy for SEL patients. Further investigation is warranted to provide the definitive conclusions on the surgical efficacy of patients with and without SEL.

This study has some limitations that should be addressed. First, the data were retrospectively collected from a limited number of patients who had complete datasets for the JOABPEQ and RDQ at preoperative and 1- and 2-year follow-up assessments. Second, the diagnostic criteria for SEL have not been defined. In the present study, the impact of degenerative changes in the lumbar spine causing canal stenosis on the surgical efficacy in patients with SEL might not have been excluded completely. Nevertheless, using the JOABPEQ parameters for SEL, the present study revealed that the excess EF accumulation contributed to the poor efficacy of posterior lumbar spinous-splitting decompression surgery, especially on walking ability, in patients with LSS. These findings might aid in establishing guidelines for the therapeutic management of SEL.

In conclusion, patients with SEL exhibit a marked improvement after surgery at 1 and 2 years postoperatively. However, compared with the patients without SEL, the efficacy of posterior lumbar spinous-splitting decompression surgery was worse in those with SEL, especially based on walking ability according to the JOABPEQ. These results indicate that EF accumulation should be considered when planning treatment for patients with LSS and estimating the efficacy of lumbar decompression surgery.

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