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*Original Article*

# Risk of same-level recurrent stenosis requiring surgery after laminectomy for lumbar spinal stenosis

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**Abstract:** Purpose: Same-level recurrent stenosis requiring surgery (SLRS-S) may occur after laminectomy for lumbar spinal stenosis (LSS), leading to significant discomfort and radicular pain. The purpose of this study was to indentify factors independently associated with SLRS-S after laminectomy for LSS. Methods: With a case-control analysis nested in a historical cohort of patients who had laminectomy for LSS between January 2006 and December 2010, we identified 64 cases with SLRS-S. To identify the risk factors for SLRS-S, we selected 64 control patients who were matched in a 1:1 manner to the SLRS-S patients according to age, sex, decompressed segments, and follow-up duration. Univariate analysis and a multivariate logistic regression were performed. Results: Multivariate logistic regression analysis indicated that higher body mass index (BMI, odds ratio [OR]=1.157, 95% confidence interval [CI]=1.034-1.294, P=0.011), preoperative facet joint degeneration on computed tomography examination (OR=3.282, 95% CI=1.745-6.172, P=0.000), and a smaller relative cross-sectional area (rCSA) of the paraspinal muscle preoperatively (OR=0.136, 95% CI=0.042-0.438, P=0.001) were significant factors for predicting SLRS-S. Conclusion: The SLRS-S after laminectomy for LSS is most likely multifactorial, and is associated with a higher BMI, preoperative facet joint degeneration on computed tomography examination, and a smaller rCSA of the paraspinal muscle preoperatively.

**Keywords:** Decompression, lumbar spinal stenosis, muscle atrophy, risk factors, reoperation, stenosis

## Introduction

Lumbar spinal stenosis (LSS) is a lumbar degenerative disease that is a major cause of lumbar-related discomfort and radicular pain. Decompressive laminectomy for LSS is the most common operation performed in this population, with favorable surgical outcomes reported in many studies [1-3]. However, up to 20% of patients undergoing primary decompressive surgery for LSS do not experience sustained symptomatic pain relief [4]. The reasons for repeat surgery vary, but reoperation is generally an undesired event. Reoperations are often performed because of postoperative complications or technical errors, as well as progressive degenerative changes such as same-level recurrent stenosis, spinal instability, adjacent segment disease, or a combination of the aforementioned factors. While several prior studies have examined factors predicting adjacent segment disease [5, 6], little is known about which factors are independently associated with same-level recurrent stenosis requiring surgery (SLRS-S).

The psoas muscle and paraspinal muscle emerge as critical players in the role of spinal stability. Numerous studies have shown that atrophy of psoas and low back musculature is one of the causes of low back pain, creating a restriction of spinal movement. Moreover, Onesti [7] reported that paraspinal muscle atrophy, which occurs after lumbar spinal fusion surgery, causes failed back surgery syndrome. However, to our knowledge, no studies have analyzed the relationship between preoperative paraspinal muscle size and SLRS-S.

In this study, we aim to identify patient characteristics and radiological parameters including psoas and low back musculature that are inde-

**Table 1.** Criteria for grading osteoarthritis of the facet joints

| Grade | Criteria |
|---|---|
| 0 | Normal facet joint space (2-4 mm width) |
| 1 | Narrowing of the facet joint space (<2 mm) and/or presence of small osteophytes and/or mild hypertrophy of the articular process |
| 2 | Narrowing of the facet joint space and/or moderate osteophytes or moderate hypertrophy of the articular process and/or mild subarticular bone erosions |
| 3 | Narrowing of the facet joint space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and/or subchondral cysts |

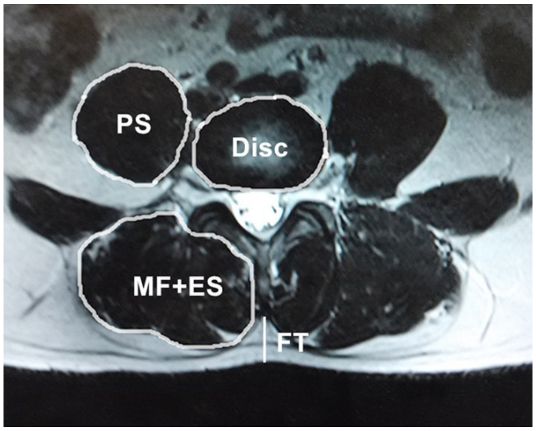


**Figure 1.** Cross-sectional area of muscles and subcutaneous fat thickness. T2 axial images obtained at L4-5 intervertebral disc level showing the lumbar paraspinal muscles. MF, multifidus muscle; ES, erector spinae muscle; PS, psoas muscle; FT, fat thickness.

pendently associated with SLRS-S following lumbar decompressive laminectomy on a large cohort of LSS patients using multivariate analysis.

## Materials and methods

*Study design and patient population*

We retrospectively evaluated the results of 480 posterior lumbar decompressive laminectomy performed at our institution for the treatment of LSS between January 2006 and December 2010. The mean follow-up duration was 73.0 months (ranging from 60-102 months). We excluded patients treated with other spinal procedures including lumbar fusion and minimally invasive lumbar surgery. We also excluded patients undergoing urgent or emergent surgery, or those with non-degenerative conditions, such as trauma, tumor, infection, or inflammation, and those who had undergone previous spinal surgery.

All patients continued to experience significant back and radicular leg pain, with a significant restriction of daily activities. All patients underwent a standard conservative treatment for at least 6 months before surgery including medication and physical therapy. The patients were recommended for a surgical procedure after failing to respond to a standard conservative treatment. In each patient, the index laminectomy had been performed for those spinal segments corresponding to clinical and radiological findings of neural compressive lesions. In some cases, we preoperatively performed diagnostic selective nerve root block or electromyography study to determine the decompression level.

SLRS-S was defined as: (1) prior lumbarde compressive laminectomy; (2) magnetic resonance imaging (MRI) evidence of same-level recurrent stenosis; and (3) presence of mechanical back and radicular leg pain requiring surgery.

Among these 480 patients, sixty-four cases with SLRS-S were identified. To identify the risk factors for SLRS-S, we selected a control group from the decompressive population who were matched in a 1:1 manner to the SLRS-S patients according to age, sex, decompressed level, and follow-up duration. The medical records and radiological study findings of the SLRS-S and control groups were retrospectively reviewed.

*Clinical evaluation*

Clinical outcomes were measured with the visual analogue scale (VAS) for back and leg pain and collected before initial lumbar laminectomy.

*Radiographic evaluation*

In this study, we assumed that risk factors on preoperative computed tomography (CT) and MRI would include facet joint degeneration, paraspinal muscle size, psoas major muscle size, paraspinal muscle fatty degeneration and subcutaneous fat thickness.

**Table 2.** Comparison of patient characteristics between SLRS-S and control groups

| Variable | SLRS-S (n=64) | Control (n=64) | *P*-value |
|---|---|---|---|
| Age at initial surgery (yr) | 62.4 ± 9.1 | 62.5 ± 8.8 | 0.985 |
| Sex (n, %) | | | |
| Male | 30 (46.9%) | 31 (48.4%) | 0.860 |
| Female | 34 (53.1%) | 33 (51.6%) | |
| Smoker (n, %) | 18 (28.1%) | 15 (23.4%) | 0.544 |
| Comorbidities (n, %) | | | |
| Cardiovascular | 18 (28.1%) | 27 (42.2%) | 0.699 |
| Pulmonary | 7 (10.9%) | 7 (10.9%) | 1.000 |
| Diabetes | 10 (15.6%) | 5 (7.8%) | 0.169 |
| Carcinoma | 0 (0%) | 1 (1.6%) | 1.000 |
| Back pain intensity (0-10 scale) | 5.2 ± 1.1 | 5.0 ± 1.0 | 0.267 |
| Leg pain intensity (0-10 scale) | 7.1 ± 1.4 | 6.8 ± 1.5 | 0.342 |
| BMI (Kg/m$^2$) | 25.6 ± 3.1 | 24.0 ± 4.4 | 0.019 |
| Follow-up (mo) | 72.2 ± 10.7 | 73.9 ± 10.8 | 0.370 |
| No. of decompressed segments | 1.6 ± 0.7 | 1.6 ± 0.7 | 1.000 |

SLRS-S: Same-level recurrent stenosis requiring surgery; BMI: Body mass index.

Facet joint degeneration on CT axial was rated from grade 0 to 3 according to the criteria of Weishaupt et al [8] (**Table 1**). All patients underwent high-resolution MRI with a 1.5-T system (Siemens Magnetom Symphony) before surgery. MRI of the lumbar spine were obtained using a spin echo sequence system for T1-weighted images (T1WIs) and a fast spin echo sequence system for T2-weighted images (T2WIs). It was difficult to separate the multifidus and erector spinae muscles in captured MRI images, so the multifidus and erector spinae muscles were measured together as the paraspinal muscles in this study. The cross-sectional area (CSA) was measured by manually tracing the fascial boundary of the paraspinal muscles and psoas major muscles bilaterally on axial T2-weighted MRI using the region of interest (ROI) of the picture archiving and communication system program and was calculated in mm$^2$. The thickness of the psoas major muscle was largest at L4-5 intervertebral disc level, whereas the maximum anatomical CSA of multifidus and erector spinae muscles was located between L3-4 and L4-5 intervertebral disc levels in the neutral posture [9]. Therefore, we calculated the mean CSA of both sides of the paraspinal muscles and the psoas major muscles by drawing their outlines using the ROI at the L4-5 intervertebral disc level. The CSA of the disc was measured at the same cut as that taken for the measurement of the muscle areas (**Figure 1**). Thereafter, we calculated the relative cross-sectional area (rCSA), which is the ratio of the CSA of muscles to that of the disc at the same level. This ratio was used to eliminate biases arising from variations in patient build. For subcutaneous fat, the shortest distance between spinous process and the skin was used due to the absence of a clear boundary of fat tissue as seen in muscle fascia on axial MRI. As seen in **Figure 1**, a line connecting the shortest distance from the spinous process to the skin at the L4-5 intervertebral disc level was used to calculatefat thickness. Fatty degeneration of the paraspinal muscles was estimated according to the method of Ranson et al [10]. The percentage of fat infiltrated area was measured using a pseudo-coloring technique. In this technique, the bright pixels of the fat tissue in the MRI were colored red using the pseudo-coloring tool of the program. Thereafter, the percentage of red area in the muscle compartment was read. The images were adjusted with the image processing software (ImageJ, version 1.48, National Institutes of Health, Bethesda, Maryland, USA). All muscle measurements were obtained by two of the investigators (X.D. and L.Z.) who were unaware of the patients' clinical details.

*Statistical analysis*

Descriptive analysis for the patient population was conducted using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Inferential statistics were performed to assess the association between the independent risk factors and SLRS-S using independent Student t-tests for continuous variables and chi-squared or Fisher's exact tests to analyze categorical variables. Factors with a *p*-value of less than 0.05 in univariate analysis were entered into the multivariate logistic model. The confidence interval (CI) of the odds ratio (OR) was 95%. To verify the reliability of the

**Table 3.** Comparison of radiologic characteristics between SLRS-S and control groups

| Variable | SLRS-S (n=64) | Control (n=64) | *P*-value |
|---|---|---|---|
| Preoperative facet joint degeneration grade on CT | 1.4 ± 0.9 | 0.9 ± 0.5 | 0.000 |
| Preoperative paraspinal muscle fatty degeneration degree (%) | 19.1 ± 8.5 | 16.3 ± 6.3 | 0.037 |
| Fat thickness (mm) | 43.8 ± 17.2 | 39.5 ± 16.0 | 0.144 |
| Paraspinal muscle rCSA | 1.7 ± 0.3 | 1.9 ± 0.4 | 0.002 |
| Psoas major muscle rCSA | 0.82 ± 0.37 | 0.84 ± 0.31 | 0.785 |

SLRS-S: Same-level recurrent stenosis requiring surgery; CT: Computed tomography; rCSA: relative cross-sectional area.

**Table 4.** Risk factors of SLRS-S after lumbar laminectomy: multiple logistic regression analysis

| Variable | OR (95% CI) | *P*-value |
|---|---|---|
| BMI | 1.157 (1.034-1.294) | 0.011 |
| Preoperative facet joint degeneration | 3.282 (1.745-6.172) | 0.000 |
| Paraspinal muscle rCSA | 0.136 (0.042-0.438) | 0.001 |

BMI: Body mass index; rCSA: relative cross-sectional area; OR: Odds ratio; CI: confidence interval.

measured data, the intra-observer and inter-observer correlations were checked using a Kappa coefficient test. A value of $P<0.05$ was considered to represent a statistically significant difference. All analyses were performed using SPSS software (version 21.0; SPSS Inc., Chicago, IL, USA).

## Results

The Kappa coefficient test showed that the data used for this study was reliable (0.83 and 0.84, respectively).

A summary of the demographic characteristics and radiographic data before initial decompression surgery for SLRS-S and control groups is presented in **Table 2**. The mean age at time of surgery was 62.4 years for the SLRS-S group and 62.5 years for the control group, with no significant difference between the two groups (P=0.985). The average follow-up duration was 72.2 months for the SLRS-S group and 73.9 months for the control group, with no significant difference between the two groups (P=0.370). The average BMI for the SLRS-S group was higher than that for the control group (25.6 kg/m$^2$ vs. 24.0 kg/m$^2$; P=0.019). No significant differences were observed between the two groups in terms of sex, smoker, comorbidities, back and leg pain intensity, and number of decompressed segments.

With regard to the radiological parameters, the average facet joint degeneration grade was grade 1.4 in the SLRS-S group and grade 0.9 in the control group (P=0.000). The mean rCSA of the paraspinal muscles was significantly smaller in the SLRS-S group than in the control group (1.7 vs. 1.9; P=0.002). However, the mean rCSA of the psoas major muscle was not significantly different between the two groups (0.82 vs. 0.84; P=0.785). The degree of fatty degeneration in the paraspinal muscle was significantly greater in the SLRS-S group than in the control group (19.1% vs. 16.3%; P=0.037). The mean fat thickness was not significantly different between the two groups (43.8 mm vs. 39.5 mm; P=0.144; **Table 3**).

A multivariate logistic regression analysis demonstrated that higher BMI (OR=1.157, 95% CI=1.034-1.294, P=0.011), preoperative facet joint degeneration on CT examination (OR=3.282, 95% CI=1.745-6.172, P=0.000), and a smaller rCSA of the paraspinal muscle preoperatively (OR=0.136, 95% CI=0.042-0.438, P=0.001) were significant factors for predicting SLRS-S (**Table 4**).

## Discussion

SLRS-S is important late complication following laminectomy for LSS. This study aimed to identify risk factors for SLRS-S after lumbar decompressive laminectomy. Multivariate analysis was used to test the association of patient characteristics and radiological factors with SLRS-S while controlling for potentially confounding variables. The results of this study showed that higher BMI, preexisting facet joint degeneration and smaller preoperative paraspinal muscle rCSA were significant independent risk factors for SLRS-S.

There is little information in the literature regarding factors affecting same-level recurrent stenosis after lumbar laminectomy. One previous single-cohort study by Mendenhall et al [11] reported revision neural decompression and instrumented fusion for same-level recurrent stenosis provides significant improvement in all patient-assessed outcome metrics. However, this study did not look at the risk factors associated with same-level recurrent stenosis.

Slightly more information is available on factors affecting adjacent segment disease after lumbar fusion surgery for LSS. Deyo et al [12] assessed the probability of revision surgery following operations for the treatment of lumbar stenosis and examined its association with patient age, comorbidity, previous surgery, and the type of surgical procedure. However, this analysis had been limited by the heterogeneity of initial surgery. Basques et al [13] recently reported factors that were independently associated with increased postoperative length of stay and readmission in patients who underwent elective laminectomy for lumbar spinal stenosis. However, readmission was defined as positive when a patient had an unplanned readmission one or more times and did not include revision surgery due to same-level recurrent stenosis.

In the present study, higher BMI patients were independently associated with SLRS-S following decompressive laminectomy for LSS. The negative impacts of higher BMI on musculoskeletal and spinal health have been well documented, with higher BMI contributing to degenerative disc disease, facet arthritis, and low back pain [14-20]. Moreover, a number of studies have demonstrated that higher BMI have a greater risk for complications following spinal surgery. Bohl et al [21] indicate that higher BMI is an independent risk factor for undergoing a revision procedure following a lumbar discectomy. In the present study, higher preoperative BMI was significant risk factors for revision surgery due to same-level recurrent stenosis.

Lee et al [22] reported that preexisting facet joint degeneration is associated with higher risk of adjacent segment disease after lumbar fusion. Kim et al [5] also reported that the occurrence of radiological adjacent segment degeneration is most likely multifactorial, and is associated with preexisting facet joint degeneration. In the present study, preexisting facet joint degeneration was significant risk factors for SLRS-S. Karavelioglu et al [23] reported that Ligamentum flavum thickening may occur independently or could be associated with facet joint degeneration. Postoperative changes in posterior elements of the spine such as thickening or hypertrophy of the ligamentum flavum may result in recurrent spinal stenosis.

In this study, we firstly found that a smaller rCSA of the paraspinal muscle was risk factor for SLRS-S. However, a smaller rCSA of the psoas major muscle, fatty degeneration of the paraspinal muscle and fat thickness were not significant risk factors after controlling for potential confounding variables. The spine consists of vertebral body, intervertebral disc, facet joint, spinal ligament and muscles. Similar to the other spine components, paraspinal muscles is important for maintaining lumbar segmental stability, and defects in the paraspinal muscles are believed to cause lumbar disc-degeneration. Paraspinal muscle atrophy is also an important independent risk factor of the presence and severity of low back pain [24, 25]. Kim et al [5] also reported that the occurrence of radiological adjacent segment degeneration after lumbar fusion is independently associated with paraspinal muscle atrophy. The psoas major muscle attaches directly to the lumbar vertebral bodies anterolaterally and acts as a primary flexor muscle of the hip joint. On the contrary, paraspinal muscle attaches directly to the lumbar vertebrae and acts as extensor muscle. Moreover, the psoas major muscle could function as a vertical stabilizer of lumbar global lordosis in the upright position [26, 27]. Verla et al [28] reported that the psoas muscle can be beneficial in postoperative rehabilitation with early ambulation and greater improvement in functional outcomes. We believe that the paraspinal muscle atrophy contributes more to the occurrence of same-level recurrent stenosis than the psoas major muscle atrophy. Increased loading of the lumbar spine also increases the load on spinal ligaments and the surrounding facet joints [29, 30]. Therefore, paraspinal muscle atrophy, with continuous increased spinal loading, could lead to spinal ligament hypertrophy and the progression of disc and facet degeneration, which would ultimately result in same-level recurrent stenosis. An abnormal increase in the movement of the spinal segments may occur in cases of severe degeneration of the disc, facet joints and posterior ligaments. A combination of the aforementioned factors finally resulted in revision surgery due to same-level recurrent stenosis.

There are several limitations that need to be considered in our study. First, the study was conducted retrospectively by case selection, and was not randomized. Second, our mean follow-up term was 73.0 months after initial surgery, indicating that the relationship between the predictive factors and long-term outcome of initial surgery could not be clearly established, although we could broadly predict the future condition from the trends observed.

The strengths of our study include the large volume of lumbar laminectomy surgeries performed at a single institution, allowing for a large sample and thereby increasing the power of analysis. This study is one of the first with enough power to conduct a multivariate analysis of risk factors to better assess their contribution to SLRS-S after lumbar laminectomy. The analysis first demonstrated risk factors of SLRS-S after laminectomy for LSS including new potential independent risk factors such as paraspinal muscle atrophy. Areas for continued study include biomechanical analysis concerning paraspinal muscles and psoas major muscles.

## Conclusion

The SLRS-S after laminectomy for LSS is most likely multifactorial, and is associated with a higher BMI, preoperative facet joint degeneration on computed tomography examination, and a smaller rCSA of the paraspinal muscle preoperatively.

## Disclosure of conflict of interest

None.

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