

## Comparison of Three Different Paraspinous Unilateral Approaches to the Spinal Canal for Lumbar Decompression-Minimally 2-Year Postoperative Evaluation

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### Abstract

**Background:** The purpose of this study is to investigate the differences of the clinical results and imaging findings among three different bilateral decompression via unilateral approach with a minimum 2-year follow-up period.

**Methods:** Thirty consecutive patients with lumbar spinal canal stenosis who had undergone bilateral decompression via 3 different unilateral paraspinous approaches with a minimum 2-year follow-up period were chosen retrospectively for groups A (conventional open surgery), B (mini open surgery), and C (micro-endoscopic surgery). The clinical results and imaging findings of these three groups were then investigated.

**Results:** A significant difference in length of incision and intraoperative blood loss per level decompressed was seen with group A>B>C. Operative time per level decompressed was longer in group C than in groups A or B. Japanese Orthopaedic Association (JOA) score recovery rate was lower in group B than in group C. The change ratios of cross-sectional area (CSA) of the ipsilateral and contralateral multifidus were smaller in group A than in groups B or C. Ipsilateral facet joint preservation was less in group A than group C, and contralateral facet joint preservation was less in group A than in groups B or C. The difference in change in slippage was greater in group A than in group C.

**Conclusion:** This study revealed that bilateral decompression via a unilateral approach using mini open or micro-endoscopic procedures could be better surgical interventions compared to a conventional unilateral open approach for paravertebral muscle and facet joint preservation for at least 2 years.

**Keywords:** Lumbar spinal canal stenosis; Decompression surgery; Less invasive surgery; Microendoscopic surgery

### Introduction

Lumbar decompression using a posterior approach is a commonly performed surgical intervention for Lumbar Spinal Canal Stenosis (LSCS), and there are various posterior approaches to reach the spinal canal. Less invasive spinal procedures have come into wide use, and previous studies have found that less invasive surgeries have equal or superior outcomes compared to conventional open surgery [1-8]. The purpose of this retrospective case-control study was to determine whether the differences among 3 paraspinous unilateral approaches for lumbar decompression would suggest that less invasive procedures would have superior outcomes compared to conventional procedures for at least 2 years. There are no studies comparing differences in clinical results and imaging findings among 3 different unilateral approaches to bilateral decompression that we examined.

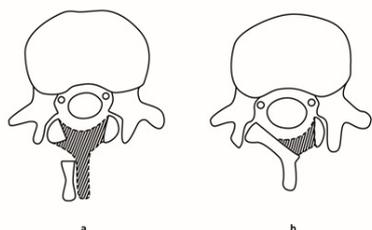
### Materials and Methods

In the present study, we investigated differences in clinical results and imaging findings among 3 procedures. Thirty consecutive patients

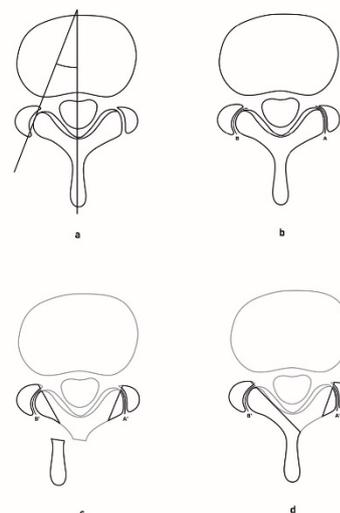
with LSCS who had undergone bilateral decompression via 3 different unilateral paraspinous approaches with a minimum 2-year follow-up period were chosen retrospectively for groups A (conventional open surgery), B (mini open surgery), and C (micro-endoscopic surgery). Decompression surgeries were performed before 2008 (group A), after 2008 (group B), and after 2011 (group C) by the first author. After 2011, micro-endoscopic surgery was indicated for within 2 levels decompression and mini open surgery for 3 or more levels decompression. To set the operation period among three groups close, every thirty patients were selected around 2007 in group A, 2008 in Group B, and 2011 in group C. Patients with a change in surgical site slippage more than 3 mm on preoperative lateral decubitus flexion-extension X-rays were excluded. Approach side was decided with consideration of the patient's anatomy and symptoms. All patients presented with cauda equine symptoms with or without radicular symptoms who did not respond to conservative treatments, and they were observed postoperatively for at least 2 years. All patients underwent upright X-rays with anteroposterior and lateral views of the whole spine, lateral decubitus flexion-extension views of the lumbar spine, magnetic resonance imaging (MRI) of the lumbar spine at 1.5 T, and computed tomography (CT) of the lumbar spine according to the

following schedule: before surgery (X-ray, MRI, and CT), 1 week after surgery (CT), and at final follow-up (X-ray and MRI).

Group A (16 men, 14 women) consisted of patients who had undergone loupe and a chisel decompression with cutting of the basal portion of the spinous process (e.g., for decompression of L3/L4/L5, the basal part of the spinous processes of L3, L4, and L5 were cut by chisel). The spinous processes with preserved ligamentous structures were not attached to their origins on closure. Group B (16 men, 14 women) consisted of patients who had undergone decompression using the same tools as those used in group A plus a retractor for mini open surgery, Quadrant (Medtronic Sofamor Danek, Tennessee, USA), without cutting the basal part of the spinous process. Group C (18 men, 12 women) consisted of patients who had undergone micro-endoscopic decompression using a high-speed drill without cutting of the basal part of the spinous process (Figure 1).



**Figure 1:** (a) In group A, the basal part of the spinous process is cut by a chisel, and the spinous process is retracted contralaterally to expose the interlaminar space. The caudal portion of the cranial lamina, cranial portion of the caudal lamina, medial portion of bilateral facet joints, and hypertrophied yellow ligaments are removed for decompression. (b) In groups B and C, the caudal portion of the cranial lamina and the cranial portion of the caudal lamina are removed by a chisel (group B) or a high-speed drill (group C) without cutting the basal part of the spinous process. Undercutting the contralateral laminae and removing the medial portion of the bilateral facet joints with hypertrophied yellow ligaments are performed for decompression.



**Figure 2:** (a) Preoperative facet joint sagittalization using the axial computed tomography (CT) obtained just above the pedicle (e.g., for evaluation of the L4/L5 facet, the axial CT obtained just above the L5 pedicle was used) is defined as the angle between 2 lines, 1 made between each edge of the facet joint, and the other made by visual observation of the midpoint of the vertebral body and spinal canal. The numerical value of the angle would be smaller according to the severity of facet joint sagittalization. (b-d) Facet joint preservation is defined as the postoperative length divided by the preoperative length (ipsilateral facet joint preservation:  $A'/A$ ; contralateral facet joint preservation:  $B'/B$ ).

This study was approved by the institutional review board of Izumi Municipal Hospital.

The clinical data investigated were age, body mass index (BMI), number of levels decompressed, length of incision, operative time, intraoperative blood loss, Japanese Orthopaedic Association (JOA) score recovery rate [9,10] between preoperative and final follow up, surgical complications, and total length of postoperative follow-up period. The imaging findings (Table 1) investigated included the cross-sectional areas (CSAs) of the subarachnoid space and bilateral multifidus at the middle of the decompressed intervertebral level, preoperative sagittalization of the facet joint, length of the facet joint, change in slippage, alignment of the lumbar spine (L1-L5) and surgical site (e.g., for decompression of L3/L4/L5, the angle of L3-L5 was measured), range of motion (ROM), and rotational angle.

	CSA: subarachnoid space	CSA: multifidus	Sagittalization of the facet joint	Length of the facet joint	Change of slippage	Alignment	ROM	Rotational angle
Level								
Each decompressed level	*	*	*	*	*	--	*	*
Surgical site	--	--	--	--	--	*	--	--

L1-L5	--	--	--	--	--	*	*	*
Modality	--	--	--	--	--	--	--	--
Upright anteroposterior view	--	--	--	--	--	*	--	--
Upright lateral view	--	--	--	--	--	* (kyphosis +, lordosis -)	--	--
Decubitus lateral flexion-extension view	--	--	--	--	*	--	*	--
MRI	*	*	--	--	--	--	--	*
CT	--	--	*	*	--	--	--	--
Calculation	--	--	--	--	--	--	--	--
The difference (post-pre)	--	--	--	--	*	*	*	*
The ratio (post/pre)	*	*	--	* (facet joint preservation)	--	--	--	--

CSA: Cross Sectional Area; ROM: Range of Motion

**Table 1:** The imaging findings.

Changes in imaging findings between preoperative and final follow-up studies (X-ray and MRI), or between preoperative studies and those at 1 week after surgery (CT), were compared. The difference (postoperative subtracted from preoperative measurement) or the ratio (postoperative divided by preoperative measurement) of these imaging findings was used to examine statistical significances among the 3 groups. The correlation between preoperative facet joint sagittalization and preservation (postoperative divided by preoperative length of the facet joint) was also investigated (Figure 2).

These imaging findings were measured by Synapse, ver. 3.2.1 (FUJIFILM Medical, Tokyo, Japan). The Tukey-Kramer multiple comparisons procedure was used to investigate statistical significance among the 3 groups by BellCurve for Excel, ver.2.00 (SSRI, Tokyo, Japan), and a p-value less than 0.05 was considered significant. Pearson's correlation coefficient was used to investigate the relationship between facet joint sagittalization and preservation by Office Excel 2007, ver.12.06755.50000 (Microsoft, Washington, USA).

## Results

### Clinical data

Preoperative JOA scores were higher in group C than in groups A and B. In comparing the results, no significant difference was observed among the 3 groups in age, BMI, or total length of postoperative follow-up period. Due to the retrospective nature of this study, a significant difference was seen between groups A and C in the number of levels decompressed. For comparison purposes, parameters for length of incision, operative time, and intraoperative blood loss were divided by the number of levels decompressed. A significant difference in length of incision and intraoperative blood loss per level decompressed was seen with group A>B>C. Operative time per level decompressed was longer in group C than in groups A or B. JOA score recovery rate was lower in group B than in group C (Tables 2 and 3).

Groups	Mean value (mean ± standard deviation)					
	A	B	C	A-B	B-C	A-C
<b>Clinical data</b>						
JOA score	12.9 ± 3.5	13.2 ± 4.8	16.9 ± 3.0	0.722	0.005*	0.000*
<b>Imaging findings</b>						
CSA of subarachnoid space (mm <sup>2</sup> )	60.9 ± 19.6	62.3 ± 27.4	61.5 ± 25.5	0.956	0.99	0.914
CSA of ipsilateral multifidus	413 ± 265	396 ± 121	382 ± 99	0.871	0.918	0.663
CSA of contralateral multifidus	392 ± 169	385 ± 118	387 ± 87	0.957	0.996	0.981

Ipsilateral facet joint sagittalization (degree)	27.1 ± 11.1	35.2 ± 11.6	33.8 ± 12.9	0.001*	0.828	0.011*
Contralateral facet joint sagittalization	26.1 ± 10.7	36.1 ± 11.7	33.3 ± 11.2	0.000*	0.414	0.003*
Length of ipsilateral facet joint (mm)	15.2 ± 3.0	14.1 ± 2.7	15.3 ± 2.9	0.23	0.238	0.995
Length of contralateral facet joint	15.4 ± 3.0	14.1 ± 2.7	15.2 ± 2.2	0.098	0.243	0.882
Change of slippage	0.35 ± 0.87	0.52 ± 0.92	0.67 ± 1.0	0.579	0.696	0.182
<b>Alignment (degree)</b>						
A-P: L1-L5	4.1 ± 5.0	2.5 ± 2.9	4.4 ± 5.6	0.394	0.257	0.958
A-P: surgical site	4.6 ± 4.6	2.9 ± 3.1	2.9 ± 2.4	0.138	0.997	0.16
Lateral: L1-L5	-19.8 ± 10.1	-25.6 ± 14.9	-27.1 ± 11.3	0.169	0.884	0.062
Lateral: surgical site	-14.7 ± 8.7	-19.9 ± 12.2	-18.1 ± 9.4	0.107	0.909	0.239
<b>ROM (degree)</b>						
Lateral: L1-L5	21.0 ± 10.1	19.1 ± 9.8	17.2 ± 8.8	0.717	0.733	0.281
Lateral: each level decompressed	4.8 ± 3.9	4.4 ± 3.6	6.6 ± 4.2	0.875	0.014*	0.038*
<b>Roatational angle (degree)</b>						
L1-L5	3.2 ± 3.3	3.1 ± 3.6	2.1 ± 2.5	0.992	0.471	0.401
Each level decompressed	2.2 ± 2.2	2.3 ± 2.0	2.0 ± 1.6	0.944	0.738	0.889
JOA: Japanese Orthopaedic Association; CSA: Cross Sectional Area; A-P: Antero-Posterior; ROM: Range of Motion; *p<0.05						

**Table 2:** Mean value and statistical analysis for preoperative clinical data and imaging findings.

Clinical data	Mean value (mean ± standard deviation)					
	Group A	Group B	Group C	Groups A-B	Groups B-C	Groups A-C
Age (years)	70 ± 10	72 ± 9	71 ± 8	0.662	0.955	0.832
BMI (%)	24.3 ± 3.0	22.8 ± 3.2	23.1 ± 3.2	0.169	0.93	0.317
Number of levels decompressed	2.2 ± 0.8	1.9 ± 0.8	1.50 ± 0.5	0.338	0.091	0.002**
*Length of incision (mm)	49.8 ± 13.9	25.3 ± 10.8	18 ± 0	0.000**	0.019**	0.000**
*Operation time (min)	57.3 ± 14.9	54.1 ± 22.3	101.6 ± 24.3	0.82	0.000**	0.000**
*Intraoperative blood loss (g)	165 ± 84	99 ± 87	27 ± 43	0.002**	0.001**	0.000**
Recovery rate of JOA score (%)	60.0 ± 26.4	53.0 ± 29.6	75.8 ± 24.5	0.578	0.004**	0.064
Postoperative follow up period (Month)	39 ± 8	42 ± 9	38 ± 8	0.21	0.124	0.96
<b>Imaging findings</b>						
Change ratio of CSA of subarachnoid space	2.8 ± 1.2	2.4 ± 1.0	2.4 ± 1.1	0.07	0.989	0.132
Change ratio of CSA of ipsilateral multifidus	0.82 ± 0.20	0.91 ± 0.18	0.97 ± 0.90	0.013**	0.204	0.000**
Change ratio of CSA of contralateral multifidus	0.89 ± 0.20	0.98 ± 0.14	0.99 ± 0.08	0.005**	0.959	0.004**
Ipsilateral facet joint preservation	0.80 ± 0.12	0.84 ± 0.14	0.86 ± 0.11	0.215	0.634	0.035**

Contralateral facet joint preservation	0.77 ± 0.12	0.94 ± 0.08	0.92 ± 0.09	0.000**	0.458	0.000**
Change of slippage (mm)	0.62 ± 1.22	0.20 ± 1.29	0.07 ± 0.72	0.103	0.842	0.036*
<b>Change of alignment (degree)</b>						
A-P: L1-L5	-0.07 ± 3.71	0.77 ± 2.69	1.50 ± 2.39	0.528	0.609	0.11
A-P: surgical site	1.03 ± 2.74	0.63 ± 3.03	0.80 ± 2.89	0.854	0.973	0.948
Lateral: L1-L5	-0.83 ± 9.85	-4.23 ± 7.86	1.03 ± 6.44	0.246	0.049**	0.72
Lateral: surgical site	-1.47 ± 7.94	-2.90 ± 6.77	0.83 ± 5.63	0.697	0.093	0.398
<b>ROM (degree)</b>						
Lateral: L1-L5	-0.47 ± 1.31	-0.80 ± 8.74	5.03 ± 7.51	0.991	0.07	0.093
Lateral: each level decompressed	-0.38 ± 2.86	-1.14 ± 2.93	0.67 ± 3.72	0.382	0.012**	0.198
<b>Rotational angle (degree)</b>						
L1-L5	-0.17 ± 2.51	0.40 ± 3.11	0.17 ± 2.38	0.693	0.94	0.881
Each level decompressed	0.66 ± 2.55	0.04 ± 2.67	0.62 ± 2.45	0.373	0.487	0.997
<b>r-value</b>						
Ipsilateral facet joint sagittalization - preservation	**r=0.32	r=0.23	r=0.17	-	-	-
Contralateral facet joint sagittalization - preservation	**r=0.48	**r=0.30	r=0.27	-	-	-
BMI: Body Mass Index; JOA: Japanese Orthopaedic Association; CSA: Cross Sectional Area; A-P: Antero-Posterior; ROM: Range of Motion; N.S.: Not Significant *Parameters were divided by the number of levels decompressed. **p<0.05						

**Table 3:** Results of mean value and statistical analysis for comparative study.

No complications, including dural tear, infection, hematoma, venous thrombosis, or neurological deficit, were found in the surgical or clinical records.

### Imaging findings

Preoperative ROM at each level decompressed was greater in group C than in groups A or B. Sagittalization of ipsilateral and contralateral facet joints was more severe in group A than in groups B or C. In comparing the results, no significant difference was observed among the 3 groups in the change ratio of the CSA of the subarachnoid space. The change ratios of the CSA of the ipsilateral and contralateral multifidus were smaller in group A than in groups B or C. Ipsilateral facet joint preservation was less in group A than group C, and contralateral facet joint preservation was less in group A than in groups B or C. The difference in change in slippage was greater in group A than in group C. No significant difference was observed in change of alignment, except for on the lateral view of the lumbar spine, which showed the difference was less in group B than in group C (group B: kyphotic change; group C: lordotic change). The difference in ROM at each level decompressed showed significance with Group B<C. No statistical difference was observed in rotational angle.

Pearson's correlation coefficient between preoperative facet joint sagittalization and preservation was the highest (r=0.48) in relation to

contralateral facet joint sagittalization and preservation in group A (Tables 2 and 3).

### Comparison of clinical results and imaging findings overall

The mean preoperative CSA of the subarachnoid space in all 3 groups was 62.0 mm<sup>2</sup> ± 25.4 mm<sup>2</sup> (average ± standard deviation), and the mean postoperative value was 142.4 mm<sup>2</sup> ± 44.3 mm<sup>2</sup>. The mean CSA value showed a significant improvement after surgery (P<0.05) [11]. Pearson's correlation coefficient was examined for all 3 groups (Table 4) to compare the following variables: age and preoperative JOA score, age and JOA score recovery rate, age and the number of levels decompressed, age and lowest CSA value among the levels decompressed, number of levels decompressed and preoperative JOA score, number of levels decompressed and JOA score recovery rate, preoperative JOA score and lowest CSA value among the levels decompressed, and preoperative JOA score and recovery rate of JOA score. Although all the correlation coefficients were relatively low, there was mild negative correlation between age and preoperative JOA score (r=-0.361), and between the number of levels decompressed and preoperative JOA score (r=-0.309).

Variables	r-value
Age-Preoperative JOA score	*-0.361

Age-JOA score recovery rate	-0.159
Age-Number of levels decompressed	*0.24
Age-Lowest CSA value among the levels decompressed	-0.168
Number of levels decompressed-Preoperative JOA score	*-0.309
Number of levels decompressed-JOA score recovery rate	-0.2
Preoperative JOA score-Lowest CSA value among the levels decompressed	0.023
Preoperative JOA score-JOA score recovery rate	*0.21
JOA: Japanese Orthopaedic Association; CSA: Cross Sectional Area; *p<0.05	

**Table 4:** The correlation of clinical and imaging data overall 3 groups.

## Discussion

Postoperative problems concerning posterior lumbar surgery mainly consist of paravertebral muscle damage and spinal degeneration, which could induce muscle atrophy, spinal instability, and failed back surgery syndrome. To reduce surgical invasiveness, various less invasive techniques have been developed [1,3,12-14], and comparative studies have shown that less invasive surgeries have benefits compared to conventional surgeries in relation to operative time, estimated blood loss, lumbar muscle destruction, and complications. Among patients with spondylolisthesis who underwent less invasive decompression surgery, Mori et al. [15] revealed that there was a significant increase in the percentage of slip at postoperative year 2, and some previous studies pointed out risk factors for postoperative slippage [16,17]. There must be causal relationships between surgical invasiveness, preexisting risk factors and postoperative changes, accurate predictions for postoperative slippage, worsening in spinal alignment, and persistent low back pain is still impossible.

The present study was performed under the assumption that invasiveness would be greater in group A (conventional open surgery) than in groups B or C (less invasive surgery) for at least 2 years, and that some comparative results would be expected to show statistical differences that would suggest advantages of less invasive surgery such as length of incision, intraoperative blood loss per level decompressed, multifidus and contralateral facet joint preservation among three groups. Moreover, statistical differences were also showed in ipsilateral facet joint preservation and change of slippage between groups A and C. Considering these statistical differences in this study, less invasive surgery would be superior to conventional open surgery. However, preoperative factors could not be excluded because sagittalization of ipsilateral and contralateral facet joints was more severe in group A than in groups B or C.

On the other hand, some data resulted in complicated statistical differences between groups B and C such as JOA score recovery rate, change in lateral alignment in the lumbar spine, and a difference in ROM at each level decompressed.

When micro-endoscopic decompression was introduced at our institution, decompression within 2 levels was indicated given the learning curve of this method. This was thought to be the reason why a statistical difference in the number of levels decompressed was seen between groups A and C. Additionally, patients in group C were at the beginning of a case series examining micro-endoscopic decompression. This was thought to be the reason why operative time

was longer in group C than in groups A or B. In fact, the average operative time per single level of micro-endoscopic decompression in the 30 consecutive cases, which were performed followed by 200 completed cases, was 58.3 min ± 8.0 min. Using this data, there is no statistical difference in operative time per level decompressed among the 3 groups. Once the definite learning curve is over and experience has been acquired, the operative time should be shorter than at the beginning of a case series [18-21].

Even though Pearson's correlation coefficient between preoperative facet joint sagittalization and preservation was relatively low in all groups, all values indicated positive correlation. This may indicate that the more severe the facet joint sagittalization, the more difficult the facet preservation because spine surgeons must angle the chisel or tubular retractor to reset the medial facet according to the severity of facet joint sagittalization. Considering that the positive correlation between preoperative bilateral facet joint sagittalization and preservation was highest in group A, there is another possibility that the more extensive the exposure of the surgical field, the more facet joint preservation would be influenced by the severity of facet joint sagittalization.

## Conclusion

In conclusion, this study revealed that bilateral decompression via a unilateral approach using mini open or micro-endoscopic procedures could be better surgical interventions compared to a conventional unilateral open approach for paravertebral muscle and facet joint preservation for at least 2 years. However, there are limitations of this study. Because this study was performed without a control group with conservative treatments which would indicate the influences of degenerative aging process without decompression surgery, this study could not suggest how low the influences of mini open or micro-endoscopic procedures upon degenerative changes in lumbar spine.

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