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Effective Biportal Endoscopic Spine Surgery Technique With Better Facet Joint Preserving for Lumbar Lateral Recess Stenosis

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ABSTRACT

Background: Biportal endoscopic spinal surgery (BESS) for the treatment of spinal stenosis provided favorable clinical outcomes in many studies. They reported that interlaminar BESS decompression achieved favorable effects in patients with central spinal stenosis. However, many patients still experienced radiating pain even after conventional interlaminar BESS decompression. Therefore, a more reliable BESS decompression method for traversing root and lateral recess areas is necessary. Hence, we investigated a method to better decompress both lateral recess areas while preserving both facet joints as much as possible with bilateral radiculopathy.

Methods: We retrospectively analyzed the data of 48 patients undergoing interlaminar BESS decompression; 24 patients underwent decompression using the conventional BESS technique (group A), and the other 24 patients underwent a both facet joint preserving BESS technique (group B). The following steps are the characteristics of a better decompression technique: using a 30° endoscope at ipsilateral side decompression, enough decompression through traversing root pathway, and enough removal of fibrotic tissue. Clinical outcomes (visual analog scale scores for pain, pregabalin usage, and modified MacNab criteria) and radiological changes (using magnetic resonance imaging) in the spinal canal expansion, lateral recess angle, and facet joint preservation were evaluated.

Results: In radiological outcomes, there were significant differences in ipsilateral facet joint preservation ratio and contralateral lateral recess increasing ratio (ipsilateral facet joint preservation ratio 92.15% ± 2.62% vs 90.96% ± 2.88%, P value 0.041 and contralateral lateral recess increasing ratio 155.22% ± 15.99% vs 165.39% ± 22.07%, $P = 0.0136$). In clinical outcomes, there were significant differences between the 2 groups over time in leg visual analog scale score and pregabalin medication use.

Conclusion: The BESS technique for preserving both facet joints was an effective treatment option in long-term follow-up; it achieved favorable clinical outcomes while preserving both facet joints and making as much decompression space as possible.

Level of Evidence: 3.

Endoscopic Minimally Invasive Surgery

Keywords: biportal endoscopic spine surgery, 30-degree endoscope, lateral recess stenosis, posterior decompression, minimal invasive surgery

INTRODUCTION

Lumbar spinal stenosis is a degenerative disease that increases with age and is the most common indication for lumbar spinal surgery.[1] There are several points of nerve root compression in lumbar spinal stenosis because of degenerative changes that include loss of intervertebral disc height, ligamentum flavum (LF) hypertrophy, disc herniation, facet joint hypertrophy, and syndesmophytes.[2,3] Several studies have demonstrated that surgical treatment provides better clinical outcomes than conservative treatment. Recently, the use of the biportal endoscopic spinal surgery (BESS) for the treatment of spinal stenosis achieved favorable clinical outcomes.[4–7]

However, many patients still experienced radiating pain even after conventional interlaminar BESS decompression. Therefore, we believed a more reliable BESS decompression method for traversing root and lateral recess areas is necessary. In this study, we investigated a method to better decompress both lateral recess areas while preserving both facet joints as much as possible with bilateral radiculopathy. In addition, we evaluated whether this method yielded better clinical and radiological outcomes than the conventional method.

MATERIALS AND METHODS

Study Population

From August 2021 to January 2022, 72 patients who were treated with BESS decompression were retrospectively reviewed. A single spine surgeon performed all procedures. Surgery was performed in patients with neurological abnormalities and persistent bilateral radiculopathy despite conservative treatment for a minimum of 6 weeks due to single-level central canal and lateral recess stenosis on magnetic resonance imaging (MRI). Exclusion criteria were as follows: (1) radiculopathy with only disc herniation; (2) moderate-to-severe foraminal stenosis; (3) neurological challenges caused by vascular stenosis; (4) unilateral lower leg radiculopathy or multilevel stenosis; (5) pre-existing degenerative scoliosis with Cobb's angle >20°, more than grade II degenerative spondylolisthesis or segmental instability on dynamic radiographs; (6) loss to follow-up before 6 months following surgery; and (7) previous history of lumbar surgery. A total of 48 patients were included in this study; 24 patients underwent decompression using the conventional BESS technique (group A), and the other 24 patients underwent surgery using a both facet joint–preserving BESS technique (group B).

Surgical Techniques

Compared with the conventional BESS decompression technique, which was performed in group A, the BESS technique in group B differed as follows:

1. Complete removal of the LF on the articular process area and sufficient drilling of the sublaminar space to create more free space around the dural sac area.
2. Removal of hypertrophic osteophyte in the superior articular process (SAP) base and removal of a little more bony structure (such as the osteophytic ridge of the disc and the hypertrophic osteophyte under the surface of the lower lamina) around the pedicle to create more free space for the traversing root pathway.
3. Use of a 30° endoscope and spinal curette at ipsilateral decompression can preserve the facet joint as much as possible with enough decompression.
4. If adhesive tissue or fibrotic tissue is present around the neural structure, release them using a tiny radiofrequency system coagulator, root hook, and micropituitary to make redundancy of neural structure.

Whole surgical methods (shown in online supplemental video 1) were performed at our hospital as follows:

Step 1. Ipsilateral decompression

1. Using a 4 mm high-speed diamond burr, ipsilateral laminotomy was performed cranially until the origin of the LF that we called the "LF notch."
2. We checked the ipsilateral side lateral margin of the LF with a dura dissector or blunt root hook while drilling the hypertrophic facet joint medial margin to prevent an ipsilateral facet joint.
3. Using a blunt hook, the LF was cut in half from the LF notch to the caudal portion in the epidural fat layer, and the ipsilateral side LF was removed with curette, Kerrison punch, or pituitary.

Step 2. Contralateral sublaminar decompression

4. The LF was separated from the undersurface of the contralateral lamina using a dura dissector or tiny radiofrequency.
5. When the LF was detached, there was sufficient space to insert the burr between the lamina and the LF. The undersurface of the contralateral lamina was drilled until the lateral recess was reached.
6. After the removal of the contralateral side LF, the lateral margin of the dural sac and traversing root pathway were checked. If the space in that area was inadequate, more removal of LF attached to the SAP, the bony ingrowth portion in the SAP base, or the bony structure around the pedicle was performed to make space using a straight or curved upward Kerrison punch. A curved upward Kerrison punch or a rotatory Kerrison punch could remove a little more hypertrophic osteophyte under the surface of the lower lamina.
7. Even with a 0° endoscope, it is possible to check the exit root that goes out to the foramen and SAP tip.
8. The hypertrophied SAP tip was removed with Kerrison punch or a hockey chisel osteotome, and after the removal of the foraminal ligament, we could identify the entry point of the exiting root.

Step 3. Ipsilateral decompression

9. By changing the 0° endoscope to the 30° endoscope, we could better view the ipsilateral facet joint medial area.
10. Using the 30° endoscope, we could expose more lateral margin space of the ipsilateral dural sac and traversing root and adequately check the ipsilateral SAP tip and exiting root pathway with the same procedure as on the contralateral side to create sufficient space for the traversing root pathway, dural sac lateral area, and exiting root pathway area. Also, using a spinal curette, we could remove lateral recess LF without more resection of facet joint area.

Outcome Evaluation

Clinical outcome was evaluated using the visual analog scale (VAS) score for both back and leg pain and medication use. Although there are various types of medications used for spinal stenosis, we investigated the amount of pregabalin, which is used in relation to radiculopathy symptoms to evaluate the improvement of radiculopathy after surgery. These values were assessed pre- and postoperatively at 1, 3, and 6 months. Additionally, the modified MacNab criteria for overall treatment outcomes were performed preoperatively and at final follow-up.

The radiological outcome was evaluated as the percentage of dura expansion volume, percentage preservation of both facets, and both lateral recess angles using pre- and postoperative MRI to evaluate the results of decompression within 3 days following surgery. MRI images were analyzed using the ZETTA PACS viewer system. Dura expansion volume was measured using an imaginary line encircling the area between the facet joint and lamina in the axial image at the most stenotic level to evaluate the decompression result. The lateral recess angle was defined as the angle between the floor of the lateral recess and the LF on the ventral side of the inferior articular process. The percentage of facet preservation volume was defined as cross sectional area of facet joint (Figure 1). To calculate the cross-sectional area of the facet joint, a hypothetical line was drawn around the facet joint at the site of the impacted compression.

Statistical Analysis

All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Differences in continuous and noncontinuous variables between groups were analyzed using independent 2-sample t test and χ^2 tests. The linear mixed model through repeated measures 2-way analysis of variance was performed to determine whether the measured clinical outcomes differed based on the evaluation periods between or within groups. P value < 0.05 was considered statistically significant.

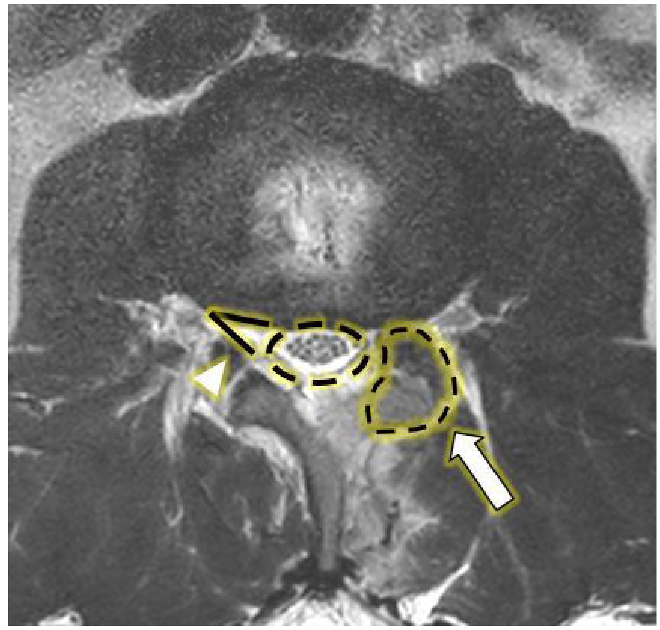

Figure 1. Measurement of dural sac expansion areas, lateral recess angle (white arrowhead), and facet joint preservation volume (white arrow).

RESULTS

Demographic Data

A total of 48 patients underwent single-level decompression using the BESS technique. In group A, the average operation time was 61 minutes, the intraoperative bleeding was 65 cc, and the average hospital stay was 3.8 days. In group B, the average operation time was 65 minutes, the intraoperative bleeding was 63 cc, and the average hospital stay was 3.5 days; there were no statistically significant differences between the 2 groups. In group A, 2 patients experienced a dura tear with 2–3 mm length, but there were no complications observed. Moreover, in group B, 1 patient reported mild headache up to 2 days after surgery, and postoperative MRI revealed epidural hematoma in 1 patient, but no complications were observed (Table 1).

Radiological Outcomes

Pre- and postoperative MRI results were compared as percentages. In group A, the average dural sac diameter increased by 192.62%, the ipsilateral

Table 1. Demographic data.

Variable	Mean ± SD or *n* (%)			*P*
	Total (*N* = 48)	Group A (*N* = 24)	Group B (*N* = 24)	
Age, y	65.88 ± 13.49	69.04 ± 13.47	62.71 ± 13.02	0.104
Gender				0.082
Female	22 (45.83)	14 (58.33)	8 (33.33)	
Male	26 (54.17)	10 (41.67)	16 (66.67)	
LOS, d	3.42 ± 0.92	3.83 ± 0.92	3.500 ± 0.72	0.065
Operative time, min	63.79 ± 25.57	61.75 ± 24.13	65.83 ± 24.64	0.067
Intraoperative bleeding, cc	69.33 ± 22.20	65.00 ± 25.51	63.67 ± 28.36	0.483

Abbreviations: BESS, biportal endoscopic spine surgery; LOS, Length of stay.
Note: Group A underwent conventional BESS technique. Group B underwent both-facet joint–preserving BESS technique. $P < 0.05$ was considered a statistically significant difference.

side of the facet joint was 90.96%, and the contralateral side of the facet joint was preserved by 93.64%. The ipsilateral side lateral recess angle increased by 150.38%, and the contralateral side increased by 155.22%. In group B, the average dural sac diameter increased by 197.74%, the ipsilateral side of the facet joint was 92.15%, and the contralateral side was preserved by 93.61%. The ipsilateral side lateral recess angle increased by 156.11%, and the contralateral side increased by 165.39%. Among these, there was a statistically significant difference between the 2 groups in the ipsilateral side facet joint preservation ratio and the increase in the contralateral side lateral recess angle (Table 2).

Clinical Outcomes

Back VAS score in groups A and B decreased from 4.417 to 1.792 and 4.417 to 1.375, respectively, at 6 months after surgery. There was no statistically significant differences between the 2 groups over time. Leg VAS scores in groups A and B decreased from 7.750 to 2.375 and 7.375 to 1.458, respectively, at 6 months after surgery. There was a statistically significant difference in leg pain improvement between the 2 groups over time ($P = 0.004$). Average pregabalin drug use decreased from 137.50 to 52.08 and 143.75 to 30.20 mg in groups A and B, respectively, at 6 months after surgery. The amount of drug used also showed a statistically significant difference between the 2 groups over time ($P = 0.0125$; Table 3). Clinical outcomes evaluated before and 6 months after surgery using the modified MacNab criteria revealed that 10 of 24 patients showed fair to excellent outcomes in group A and 13 of 24 patients in group B; however, there were no significant differences between the 2 groups (Table 4).

Table 2. Radiological outcomes.

Outcome Measure	Mean ± SD			*P*
	Total (*N* = 48)	Group A (*N* = 24)	Group B (*N* = 24)	
Diameter of dural sac, mm^2				
Preoperative	48.17 ± 20.05	41.79 ± 16.11	54.59 ± 25.97	
Postoperative	83.69 ± 21.80	73.93 ± 16.41	95.49 ± 29.20	
Expansion ratio of dural sac, %	195.21 ± 62.94	192.62 ± 49.39	197.74 ± 74.32	0.6994
Ipsilateral facet joint volume, mm^2				
Preoperative	10.09 ± 1.96	10.13 ± 1.98	10.06 ± 1.93	
Postoperative	9.26 ± 1.87	9.23 ± 1.88	9.29 ± 1.85	
Preservation ratio, %	91.01 ± 2.24	90.96 ± 2.88	92.15 ± 2.62	0.041
Contralateral facet joint volume, mm^2				
Preoperative	9.97 ± 2.08	10.07 ± 2.11	9.88 ± 2.05	
Postoperative	9.36 ± 2.06	9.47 ± 2.12	9.26 ± 2.00	
Preservation ratio (%)	93.63 ± 2.42	93.64 ± 2.61	93.61 ± 2.25	0.9443
Ipsilateral lateral recess angle (°)				
Preoperative	26.59 ± 5.04	27.52 ± 4.41	25.67 ± 5.90	
Postoperative	40.52 ± 5.24	40.89 ± 4.66	40.13 ± 5.78	
Increasing ratio, %	153.28 ± 20.27	150.38 ± 15.91	156.11 ± 23.62	0.1777
Contralateral lateral recess angle, (°)				
Preoperative	27.75 ± 4.66	28.57 ± 3.96	26.93 ± 5.38	
Postoperative	43.76 ± 4.82	43.87 ± 3.95	43.66 ± 5.84	
Increasing ratio, %	160.36 ± 19.87	155.22 ± 15.99	165.39 ± 22.07	0.0136

Abbreviation: BESS, biportal endoscopic spine surgery.
Note: Group A underwent conventional BESS technique. Group B underwent both-facet joint–preserving BESS technique. $P < 0.05$ was considered a statistically significant difference.

Table 3. Clinical outcomes—VAS score and medication use.

Outcome Measure	Estimated Mean (SE)		Overall *P*	
	Group A	Group B	Label	*P*
Back VAS Score				
Preoperative	4.417 (0.169)	4.417 (0.169)	Group	0.1574
1 mo	3.042 (0.127)	2.958 (0.127)	Time	<0.0001
3 mo	2.375 (0.130)	2.042 (0.130)	Group × time	0.2331
6 mo	1.792 (0.133)	1.375 (0.133)		
Leg VAS score				
Preoperative	7.750 (0.186)	7.375 (0.186)	Group	0.0114
1 mo	4.125 (0.186)	3.375 (0.186)	Time	<0.0001
3 mo	2.375 (0.174)	2.208 (0.174)	Group × time	0.004
6 mo	2.375 (0.203)	1.458 (0.203)		
Medication Use, mg				
Preoperative	137.500 (4.017)	143.750 (4.017)	Group	0.0492
1 mo	100.000 (5.948)	81.250 (5.948)	Time	<0.0001
3 mo	72.917 (7.554)	51.042 (7.554)	Group × time	0.0125
6 mo	52.083 (8.026)	30.208 (8.026)		

Abbreviations: BESS, biportal endoscopic spine surgery; VAS, visual analog scale.
Note: Group A underwent conventional BESS technique. Group B underwent both-facet joint–preserving BESS technique. $P < 0.05$ was considered a statistically significant difference.

DISCUSSION

Crock first mentioned lateral recess stenosis that indicates the isolated narrowing of the semitubular structure, which is the nerve root running from the thecal sac to the entrance of the intervertebral foramen.[8] The most common pathologies of lateral recess stenosis are hypertrophic facet joint osteoarthritis, bulging of the disc annulus, or posterior endplate osteophytes.[9,10] Lee et al divided the lateral recess into 3 zones, and a different surgical decompression was required due to differences in pathology and contents.[9] The most common cause of entrance zone stenosis is hypertrophic osteoarthritis of the SAP, medial facetectomy, or removal of an osteophytic ridge along the disc for decompression. Midzone stenosis can be caused by osteophytes under the pars interarticularis, and it causes entrapment of the dorsal root ganglion. Hypertrophic LF and osteophyte should be removed while preserving the facet joint or lamina. A common cause for exit zone stenosis is hypertrophic osteoarthritis changes of the facet joints with subluxation and osteophytic ridge formation along the superior margin of the disc. Adequate decompression can be achieved by trimming the medial, lateral, and superior margins of the SAP.

Table 4. Clinical outcomes—modified MacNab criteria.

Outcome Measure	*N* (%)			*P*
	Total	Group A	Group B	
Preoperative				0.079
Fair	20 (41.67)	7 (29.17)	13 (54.17)	
Poor	28 (58.33)	17 (70.83)	11 (45.83)	
6 mo				0.1575
Excellent	18 (37.50)	6 (25.00)	12 (50.00)	
Fair	5 (10.42)	4 (16.67)	1 (4.17)	
Good	25 (52.08)	14 (58.33)	11 (45.83)	

Abbreviation: BESS, biportal endoscopic spine surgery.
Note: Group A underwent conventional BESS technique. Group B underwent both-facet joint–preserving BESS technique. $P < 0.05$ was considered a statistically significant difference.

Diagnosis of symptomatic lateral recess stenosis is controversial. Bartynski et al reported that the sensitivity of MRI criteria to detect lateral recess stenosis has been suggested to be only approximately 60%, conventional myelography has been proposed to have a higher sensitivity to detect, and there was a variety of radiographic criteria such as lateral recess height, depth, and angle have been proposed.[11] Strojnik reported that a lateral recess angle <30° could be a high indication of stenosis.[12] Moreover, according to Birjandian et al, the lateral recess angle was 19.3° ± 1.5° on the symptomatic side compared with 35.7° ± 3.0° on the asymptomatic side.[13]

To address these pathophysiological characteristics, uniportal and biportal endoscopic decompression technology was gradually developed. Nowadays, endoscopic decompression methods can easily incline the endoscope to the contralateral side using the unilateral approach method, enabling a detailed view of the contralateral side of the intervertebral foramen and the lateral recess under the endoscope. Yeung et al performed biportal endoscopic ipsilateral decompression and contralateral decompression in predominant unilateral radiculopathy lumbar stenosis. There was a significant improvement in recess diameter with contralateral decompression than ipsilateral decompression

(217% vs 154%).[5] Also Park et al showed statistical significance in dura sac widening between microscopic unilateral ipsilateral laminotomy and contralateral laminotomy (187% vs 146%).[14]

In our study, there was no statistically significant difference in the increase in the diameter of the dural sac, but in particular, the ipsilateral side facet joint preservation increased significantly in group B. Additionally, by increasing both lateral recess angles ratio was further increased in group B, we were able to achieve our goal of using a 30° endoscope on the ipsilateral side and obtaining more decompression of the lateral recess area using a curette and upward curved punch. Kim et al first reported that 30° endoscopy had the advantage of obtaining a wider view while also allowing satisfactory clinical results and a reduction in surgical infection.[15] Although there was no statistically significant difference, the results show that group B achieved much better decompression. This indicates that, compared with the conventional method, it is possible to achieve more definitive decompression of the lateral recess while preserving both facet joints more effectively.

Epidural fibrosis and adhesion tissue are known as some of the most important factors of failed back surgery syndrome or spinal stenosis. Many patients showed the effectiveness of percutaneous epidural adhesiolysis as disruption of perineural fibrosis and inhibition of repeated scar formation on affected spinal levels.[16] So far, there have been no studies reporting the degree of epidural fibrosis or adhesive tissue depending on the degree of stenosis. Although further study will be needed, we found that the more severe the stenosis in our patients and the longer the period of disease, the greater the proportion of patients requiring adhesiolysis in the BESS procedure.

Especially significant improvement in leg VAS score and medication use between 2 groups over time, this result is thought to be affected by our improved decompression surgical technique. First, a 30° endoscope allows you to see the ipsilateral area more wide and clear, making decompression more precise. Second, we can release the pathway of the natural structure as much as possible based on the lateral recess stenosis pathology discussed earlier. Finally, you can accurately find fibrotic or adhesive tissues around the neural structure through the BESS procedure, and by removing that, you can clearly improve the patient's symptoms through enough adhesiolysis of the neural structure. Through our surgical method, ipsilateral and contralateral side decompression can be sufficiently performed and also make sufficient space for the exiting and traversing roots, which appear effective in further improving the patient's symptoms. Therefore, sufficient decompression is necessary for specific parts of the process as we suggested (Figures 2 and 3).

Our limitations are that the duration of follow-up was only 6 months, and our study was retrospectively performed at a single center. Radiological and clinical outcomes must be assessed by long-term follow-up. It is also necessary for other surgeons at various centers to perform the same surgical method to confirm the results.

CONCLUSION

We expect our both facet joint-preserving BESS technique to be an effective treatment option in long-term follow-up, as it achieves favorable

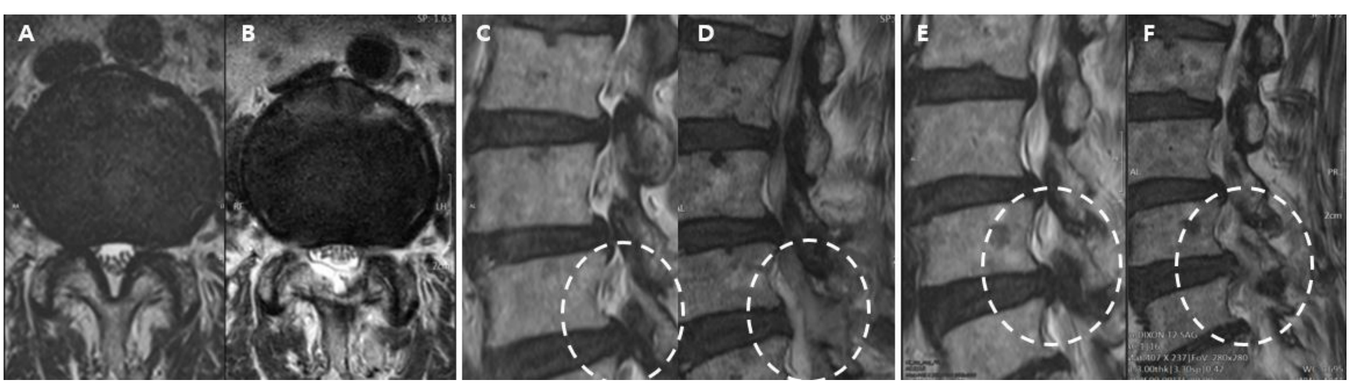

Figure 2. Preoperative (A, C, and E) and postoperative (B, D, and F) magnetic resonance imaging findings of group B patient. (A and B) Showing good decompression of lateral recess area with both facet joint preservation. (C and D) Showing good decompression of the contralateral side lateral recess area. (E and F) Showing good decompression of ipsilateral side lateral recess area.

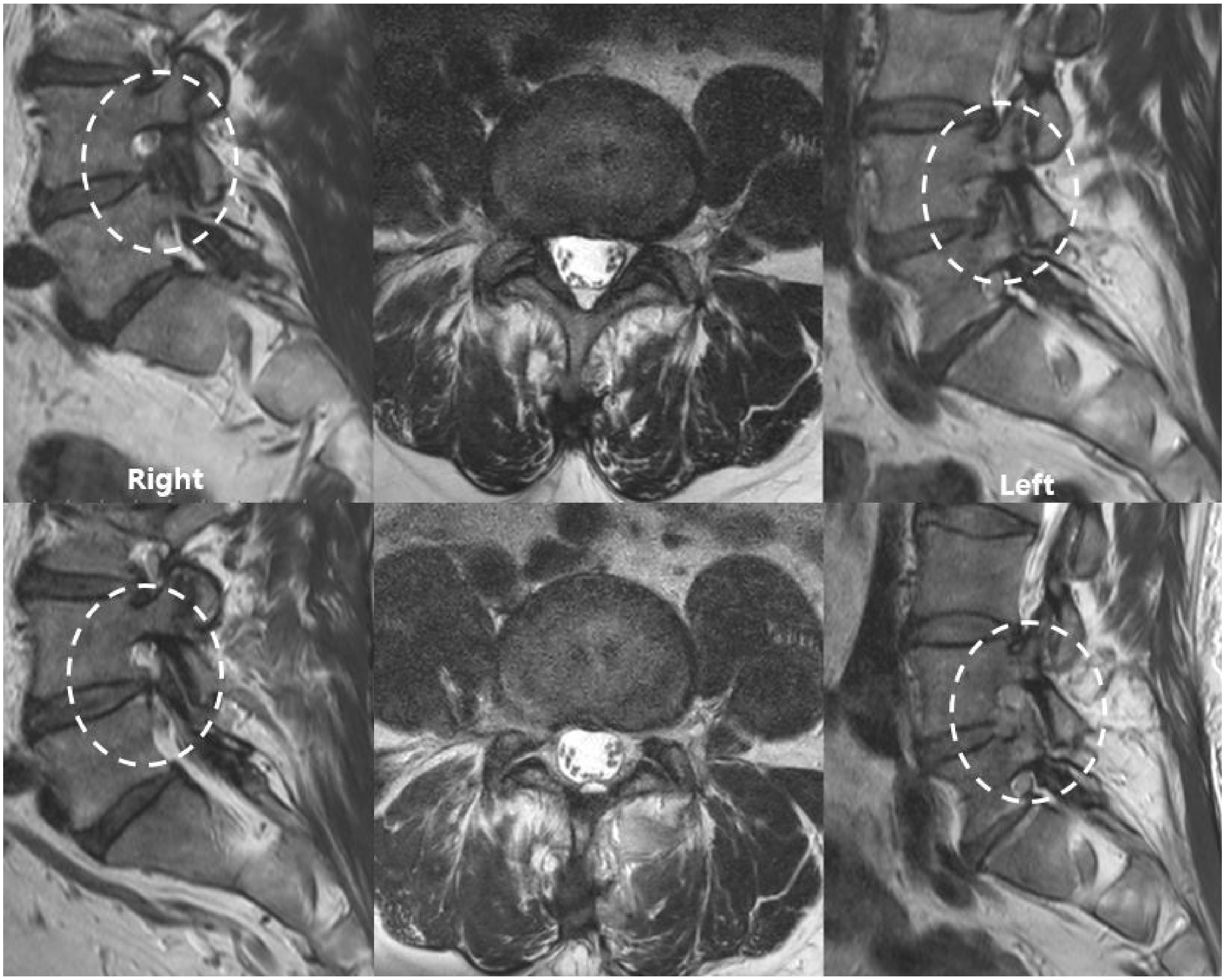

Figure 3. Pre- and postoperative magnetic resonance imaging findings of foraminal area decompression in a group B patient. The surgery was performed by the left ipsilateral sublaminar approach, and both sides of the foramen were more decompressed than before surgery.

clinical outcomes while maximizing preservation in both facet joints and making as much decompression space as possible.

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