〈Regular Article〉

Long-term outcomes of microendoscopic laminoplasty in patients with lumbar spinal stenosis: impact of the surgical approach and facet tropism

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ABSTRACT Microendoscopic laminoplasty (MEL) is the surgical procedure of choice at our institution for decompressing nerve roots in lumbar spinal stenosis (LSS). This minimally invasive procedure allows for bilateral decompression via unilateral endoscopic surgical access and maximum preservation of the lumbar zygapophyseal (facet) joints at the level (s) of interest. For this procedure, the surgical approach is generally made on the ipsilateral side of the stenosis. However, this rule of thumb is not always applicable because of lumbar facet joint degeneration and variations in the long-axis orientation of the spinous processes.

Few studies to date have proposed criteria about the surgical approach for MEL. Surgeons use their clinical judgment to decide on a case-by-case basis. Facet tropism is frequently encountered in patients with LSS undergoing MEL. Long-term postoperative changes in spinal alignment parameters could guide selection of the side for the surgical approach in MEL.

This retrospective study included 45 patients who underwent MEL for single-level LSS between April 1, 2010 and June 30, 2014. The mean age of the patients was 74.8 ± 8.2 years; 23 (51%) were male. FT was defined as a bilateral facet joint angle difference of ≥10 degrees. Study variables included lumbar lordosis angle, Cobb angle, and vertebral slippage based on standing radiographic images. The study population was divided into two groups based on the degree of facet joint sagittal orientation on the side of the incision. Specifically, patients in whom the surgical approach was made on the side of the more sagittally oriented facet joint were categorized into Group S. The other patients were categorized into Group N.

The percent change in mean Cobb angle between preoperative and postoperative assessments was 124 ± 164% for Group S and 45.6 ± 62.5% for Group N ($P < 0.05$), indicating postoperative progression of scoliosis in Group S.

Considering the postoperative risk of scoliosis and related complications, approaching from

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the side of the less sagittally oriented facet joint is preferable in MEL for the treatment of LSS in patients with FT.

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Key words：Lumbar spinal stenosis, Microendoscopic laminoplasty, Facet tropism, Approach

INTRODUCTION

Microendoscopic laminoplasty (MEL) via a unilateral approach is the surgical procedure of choice at our clinic for decompressing nerve roots in lumbar spinal stenosis (LSS). This minimally invasive procedure allows for bilateral decompression via unilateral endoscopic surgical access and maximum preservation of the lumbar zygapophyseal (facet) joints at the level or levels of interest[1]. For this procedure, the surgical approach is generally made from the side of the stenosis. However, this does not always occur because of lumbar facet joint degeneration and variations in the long-axis orientation of the spinous processes. Few studies to date have proposed criteria about the surgical approach for MEL[2]. Surgeons use their clinical judgment to decide on a case-by-case basis.

Morphological abnormalities of the lumbar facet joint often represent a major deciding factor for the laterality of the approach. A typical example of such abnormalities is facet tropism (FT), or asymmetry of the left and right facet joint angles with one joint having a greater sagittal orientation than the other. FT is a common cause of lumbar disk herniation and LSS[3, 4]. Patients with LSS frequently undergo MEL. Long-term postoperative changes in spinal alignment parameters could guide selection of the side for the surgical approach in MEL.

MATERIALS AND METHODS

Between April 1, 2010 and June 30, 2014, 141 patients underwent MEL for single-level LSS at our clinic. Patients who were not observed for more than 5 years after surgery were excluded. This retrospective study included 45 patients who underwent MEL for single-level LSS at least 5 years prior.

The mean age of the patients was 74.8 ± 8.2 years; 23 (51%) were male. FT was defined as a bilateral facet joint angle difference of ≥ 10 degrees (Fig. 1). Study variables included lumbar lordosis (LL) angle, Cobb angle, and vertebral slippage based on standing radiographic images (Fig. 2). Radiographical data were reviewed retrospectively.

The study population was divided into two groups based on the degree of facet joint sagittal orientation

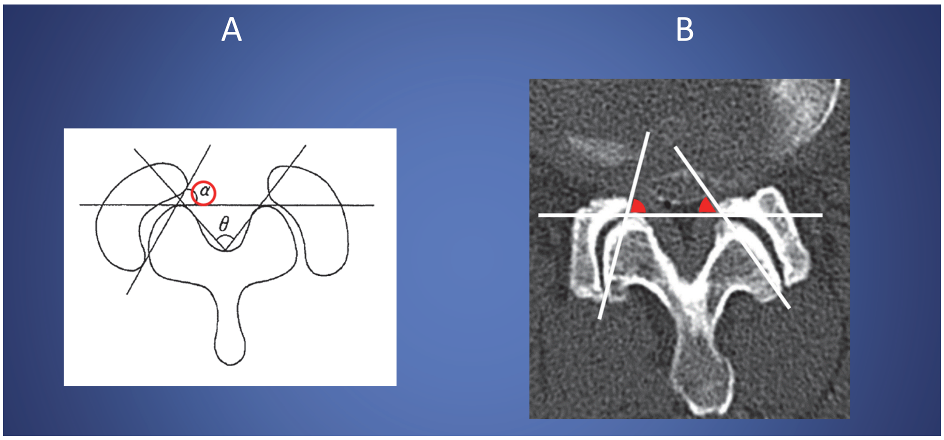

Fig. 1. A: Facet joint angle (α), B: Axial CT image showing facet tropism (right angle: 73°, left angle: 43°)

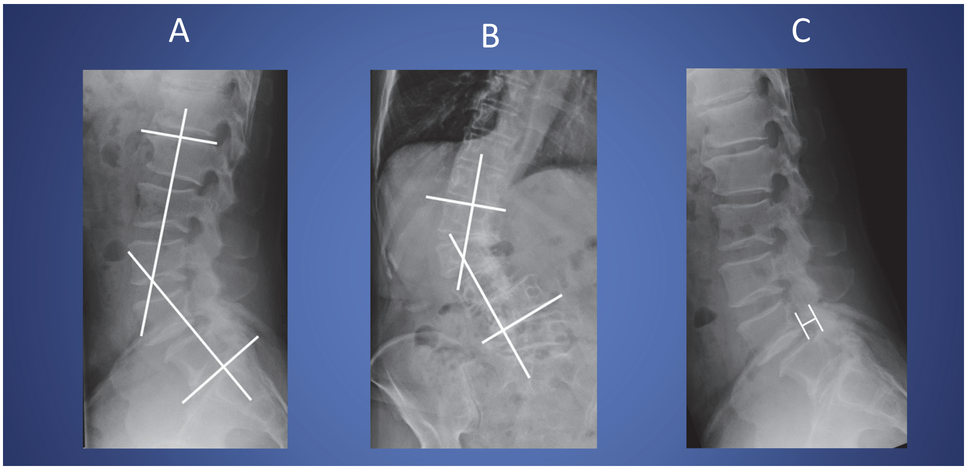

Fig. 2. Radiographic parameters, lumbar lordosis angle (A), Cobb angle (B), and vertebral slippage (C)

Table 1. Summary of preoperative data

Characteristic	Group S	Group N	p Value
No. of patients	25	20	
Male/Female ratio	13 : 12	10 : 10	0.89
Age(yrs)			
mean	76.7 ± 8.4	72.8 ± 7.5	0.14
Decompression level			0.56
L3/4	4	2	
L4/5	21	18	
Pre-op LL (°)			
mean	38.2 ± 10.4	36.5 ± 14.7	0.73
Pre-op Cobb angle (°)			
mean	4.2 ± 4.2	4.8 ± 3.7	0.61
Pre-op vertebral slippage (mm)			
mean	4.0 ± 4.7	4.1 ± 4.9	0.96

on the side of the approach. Specifically, patients in whom the surgical approach was made on the side with the larger facet angle were categorized into Group S. The other patients were categorized into Group N. There were 25 patients (56%) in Group S and 20 patients (44%) in Group N (Table 1).

LL angles were measured from the L1 to S1 segments. Vertebral slippage was measured in the midsagittal plane based on the difference in position between the posteroinferior border of the dislocated vertebra and the posterosuperior border of the vertebra beneath it (Fig. 2). Statistical analysis was conducted using a two-tailed Student's t-test or Welch's t-test. $P < 0.05$ was regarded as significant. Statistical analyses were performed using IBM SPSS Statistics software, version 26.

This study was conducted in compliance with the Declaration of Helsinki. All study participants received explanations of the purpose and methodology of the study. All participants provided written informed consent. The study protocol was approved by our institutional ethics committee prior to initiation (Kawasaki Medical School Ethics Committee, Approval No. 3561).

RESULTS

In the overall study population, mean LL angle showed a nonsignificant increase from 37.4 ± 13° before surgery to 38.3 ± 12.5° after surgery (*P* =

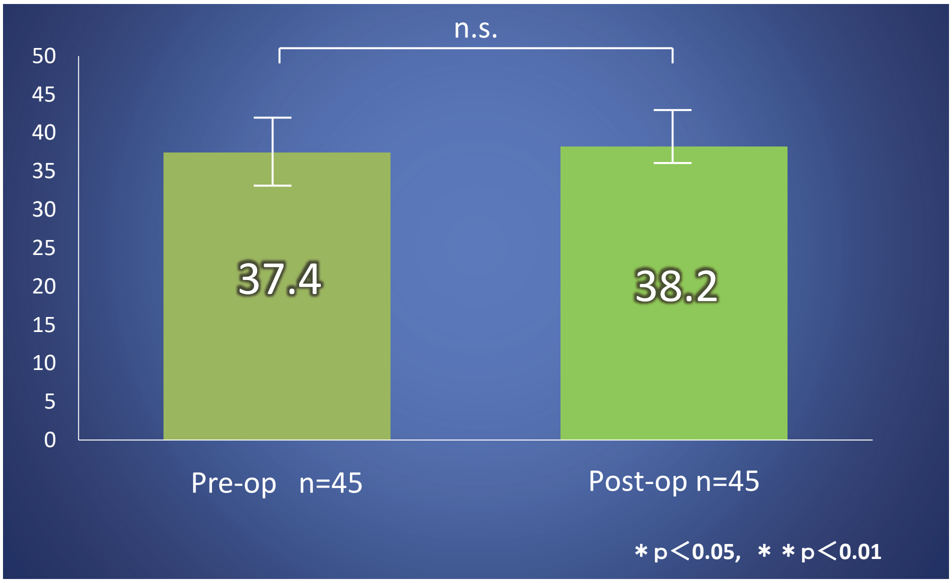

Fig. 3. Mean lumbar lordosis angle (°)

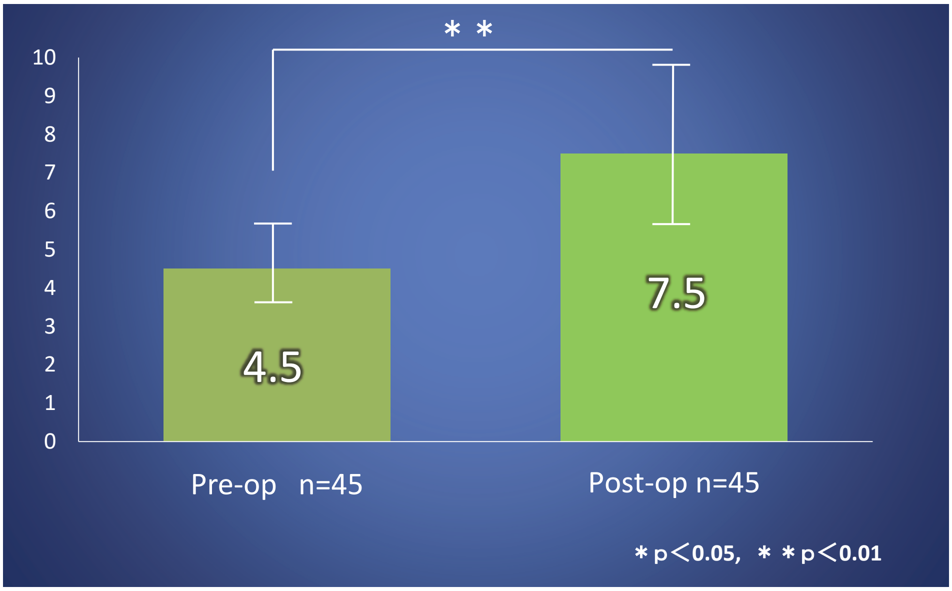

Fig. 4. Mean Cobb angle (°)

0.58) (Fig. 3). The mean Cobb angle increased significantly from 4.6 ± 4.0 ° before surgery to 7.5 ± 7.8 ° after surgery ($P < 0.01$) (Fig. 4). Moreover, mean vertebral slippage increased significantly from 4.1 ± 4.7 mm before surgery to 5.3 ± 5.4 mm after surgery ($P < 0.01$) (Fig. 5). These findings indicated that study patients had mild postoperative progression of scoliosis and spondylolisthesis, respectively.

The percent change in mean LL angle between preoperative and postoperative assessments was 6.5 ± 22.6% for Group S and 9.8 ± 22.7% for Group

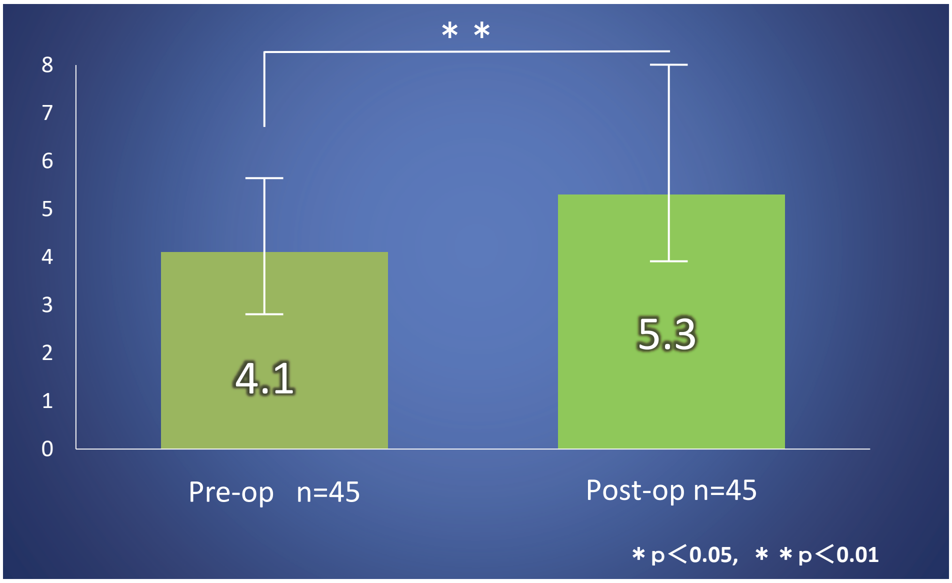

Fig. 5. Mean vertebral slippage (mm)

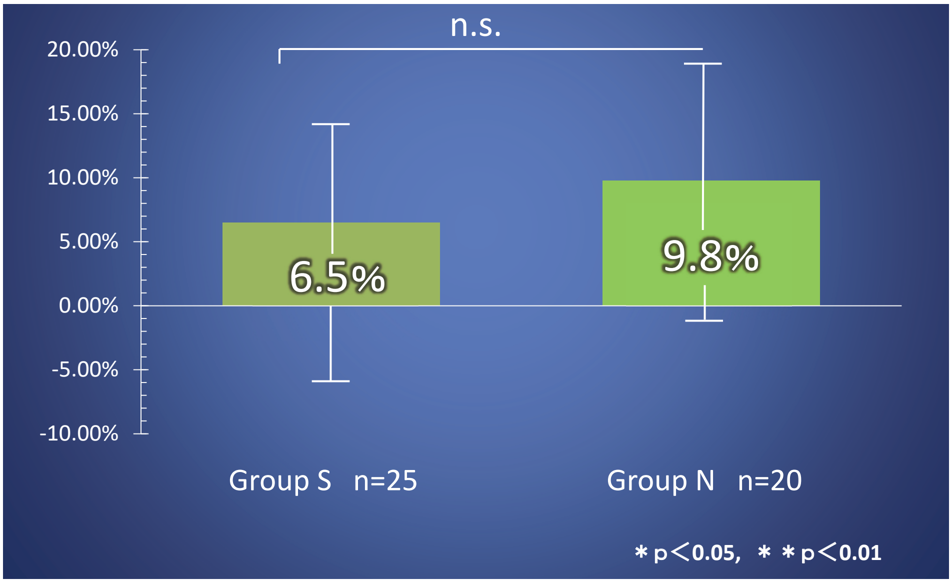

Fig. 6. Percent change in mean lumbar lordosis angle (Group S vs. Group N)

N. Group N had a greater, but this difference was not statistically significant ($P = 0.64$) (Fig. 6).

The percent change in mean Cobb angle between preoperative and postoperative assessments was 124 ± 164% for Group S and 45.6 ± 62.5% for Group N, indicating a statistically significant between-group difference ($P < 0.05$) (Fig. 7). These results indicate postoperative progression of scoliosis in Group S. The mean percent change in vertebral slippage between the preoperative and postoperative assessments was 11.4 ± 32.3% for Group S and 50.7 ± 117% for Group N. Group N had a greater,

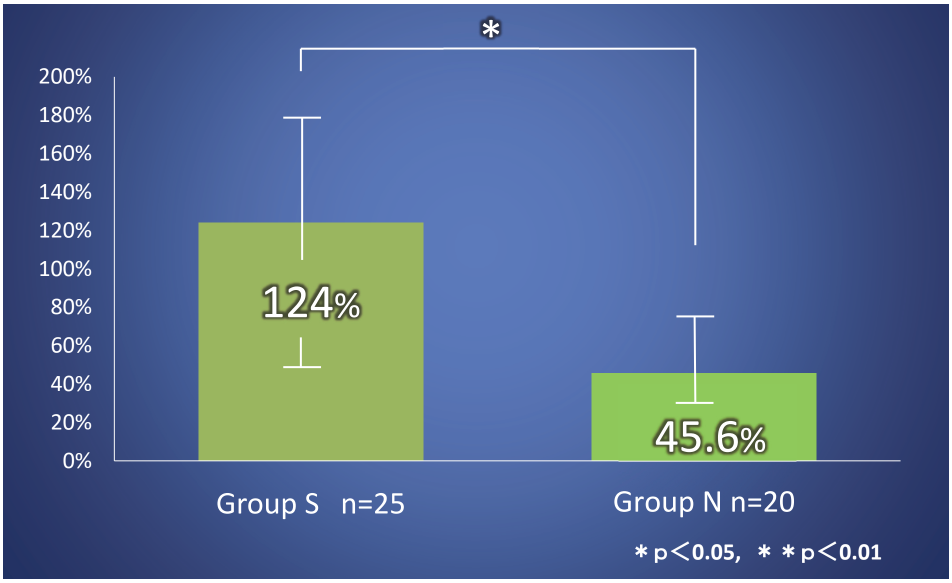

Fig. 7. Percent change in mean Cobb angle (Group S vs. Group N)

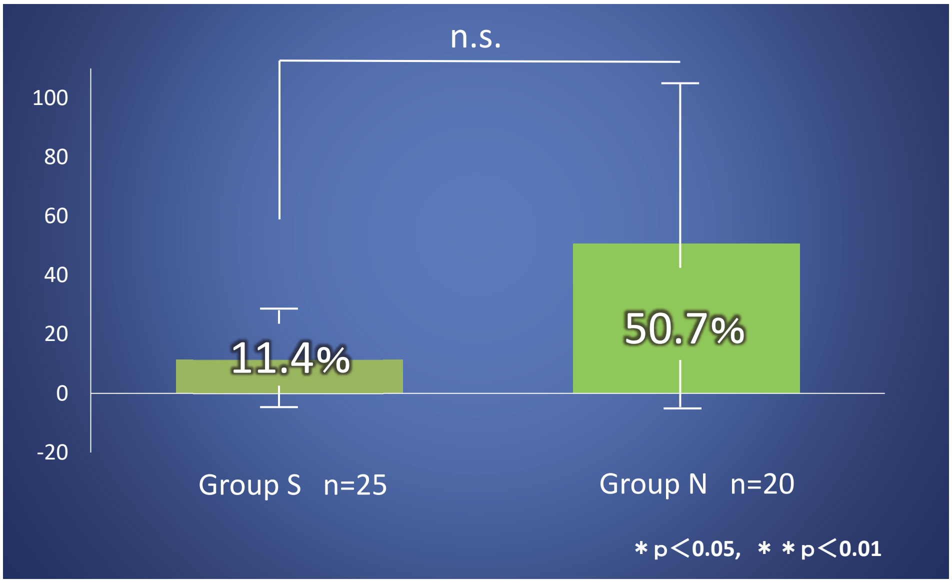

Fig. 8. Percent change in vertebral slippage (Group S vs. Group N)

but not statistically significant, change from preoperative baseline than Group S ($P = 0.17$) (Fig. 8).

DISCUSSION

Several studies of long-term outcomes in patients with LSS who underwent MEL have reported postoperative changes such as mild vertebral slippage and other degenerative changes that did not interfere with surgical outcomes[5, 6]. Significant postoperative increases in Cobb angle and vertebral slippage were observed in our study, demonstrating mild progression of spinal degeneration after surgery.

As indicated by postoperative Cobb angle changes in Group S, using a surgical approach from the side of the more sagittally oriented facet joint results in postoperative coronal imbalance of the spine, which is presumably attributable to surgical manipulation of the facet joint and underlying back muscle atrophy (Fig. 9)[7].

Approaching from the side of the less sagittally oriented facet joint could increase the postoperative risk of spondylolisthesis. A morphological study of the facet joints in spondylolisthesis identified a significant correlation between sagittal orientation and spondylolisthesis[8]. Surgical reconstruction of the lamina, which may compromise the integrity of the posterior supporting structures, could increase the risk of postoperative spondylolisthesis. However, given that the natural history of lumbar spondylolisthesis typically involves age-related disease progression[9], the impact of MEL on the risk of spondylolisthesis remains unclear.

In a retrospective study of degenerative lumbar scoliosis, Matsumura *et al*. showed that microscopic bilateral decompression via a unilateral approach achieved good postoperative outcomes and that the convex approach improved facet joint preservation[2]. Their findings informed our analysis of the benefits of MEL to treat LSS.

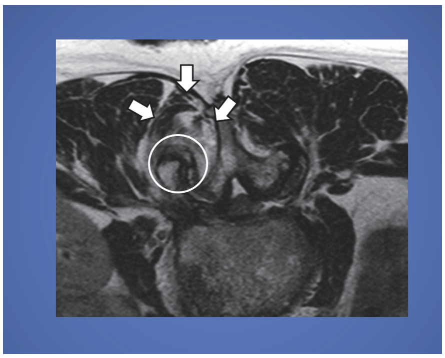

Fig. 9. Axial magnetic resonance imaging showing facet hypertrophy and arthropathy (white circle) and back muscle atrophy (white arrows)

In our study, 40 patients (89%) had mild scoliosis before surgery (Cobb angle, 3 ° to 16 °), including 20 patients (42%) with the less sagittally oriented facet joint on the convex side of the spine. Consequently, we did not observe a meaningful relationship between the onset of scoliosis and facet joint morphology.

FT is frequently observed in patients with LSS. In patients with FT, the asymmetric orientation of the facet joints destabilizes axial spinal rotation and thereby induces articular degeneration[3]. Facet hypertrophy and arthropathy are typical causes of LSS.

In MEL, degenerative changes of the facet joint on the side of the approach may hamper the surgeon's view and access to the stenotic lesion. In particular, greater sagittal orientation of the facet joint is often associated with a narrower arch, which may cause the surgeon to incorrectly identify the extent of laminar removal. Therefore, approaching from the side of the more sagittally oriented facet joint is likely to involve a greater risk of injury to the ipsilateral facet joint than approaching from the other side. Moreover, patients with FT are likely to be predisposed to back muscle atrophy. We argue that these factors contribute to a greater postoperative risk of coronal imbalance associated with approaching from the side of the more sagittally oriented facet joint.

The primary objective of this study was to investigate the side that should be chosen for the approach in MEL among patients with FT: the side with the more or less sagittally oriented facet joint. From the viewpoint of selective nerve decompression, restenosis resulting from spondylolisthesis is not a major concern because the impact of spondylolisthesis can be lessened with posterior decompression. However, scoliosis may cause pathologic conditions as a result of nerve root overstretching on the convex side of the spine

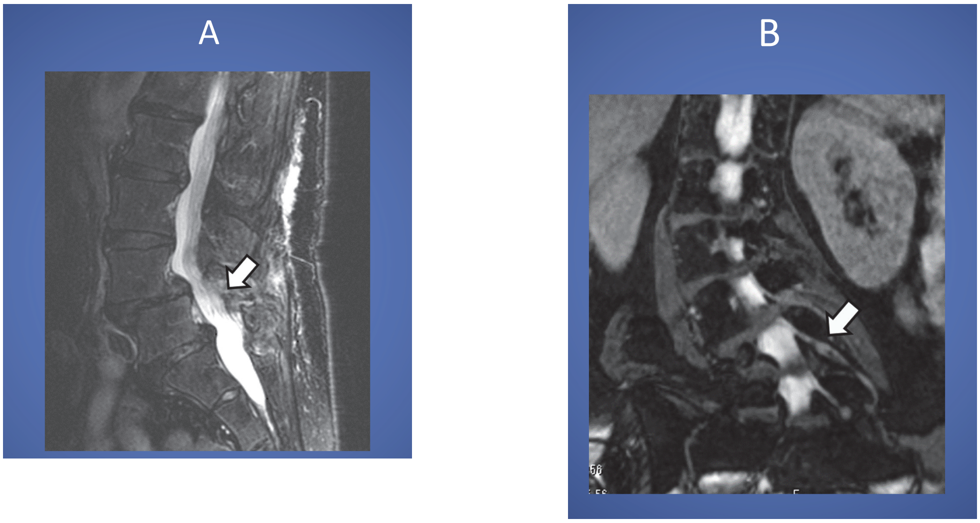

Fig. 10. Sagittal magnetic resonance imaging showing that the impact of spondylolisthesis can be lessened with posterior decompression (A).
Nerve root overstretching on the convex side of the spine (B).

(Fig. 10)[10]. Such malalignment-induced conditions cannot be properly addressed by decompression and may require corrective spinal fixation. Therefore, surgeons who perform minimally invasive surgery for LSS should prioritize minimizing the risk of postoperative Cobb angle increase. This leads us to prefer approaching from the side of the less sagittally oriented facet joint for MEL.

The microendoscopic paramedian approach, advocated by Nomura *et al*., achieves satisfactory decompression of the nerve root contralateral to the side of the approach[11]. This technique can liberate surgeons from the idea of approaching from the diseased side.

This study has several limitations. First, the number of patients was limited. It was a retrospective study and approximately two-thirds of patients were excluded because of loss to follow-up. Second, this study is based only on imaging findings. Whether patients with these findings require treatment or not, it is necessary to evaluate the presence of postoperative symptoms in the future.

Given the complex nature of LSS, surgeons should use their clinical judgment to determine the side for the approach in MEL. Lumbar disc herniation, bone spurs on the facet joints, and other comorbid conditions often prevent an approach from the side of the less sagittally oriented facet joint. Based on a realistic assessment of their surgical skills, surgeons should choose the side for the approach that maximizes patient safety. Surgeons who perform MEL should always strive to improve their technical skills to deal with a variety of degenerative changes underlying LSS.

CONCLUSIONS

This study investigated differences associated with the side for the approach in MEL among patients with LSS and FT. Approaching from the side of the more sagittally oriented facet joint significantly increases mean postoperative Cobb angle, whereas approaching from the side of the less sagittally oriented facet joint results in a greater, though not statistically significant, increase in postoperative vertebral slippage. Considering the postoperative risk of scoliosis and related complications, approaching from the side of the less sagittally oriented facet joint is preferable in MEL for the treatment of LSS in patients with FT.

DISCLOSURES

The authors report no conflicts of interest related to this work.

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