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Unilateral Laminectomy by Endoscopy in Central Lumbar Canal Spinal Stenosis

Technical Note and Early Outcomes

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Study Design. Retrospective study.

Objective. To evaluate the outcomes and safety of endoscopic laminectomy for central lumbar canal spinal stenosis.

Summary of Background Data. Spinal endoscopy is mostly used in the treatment of lumbar disc herniation, while endoscopic laminectomy for lumbar spinal stenosis is rarely reported.

Methods. From January 2016 to June 2017, 38 patients with central lumbar canal spinal stenosis were treated with endoscopic laminectomy. Clinical symptoms were evaluated at 1, 3, 6, and 12 months and the last follow-up after surgery. Functional outcomes were assessed by using the Japanese Orthopedic Association Scores (JOA) and Oswestry Disability Index (ODI). The decompression effect was assessed by using the dural sac cross-sectional area (DSCA). Lumbar stability was evaluated using lumbar range of motion (ROM), ventral intervertebral space height (VH), and dorsal intervertebral space height (DH).

Results. The mean age of the cases was 60.8 years, the mean operation time was 66.3 minutes, the blood loss was 38.8 mL, and the length of incision was 19.6 mm. The mean time in bed was 22.3 hours, and the mean hospital stay was 8.8 days. JOA scores were improved from 10.9 to 24.1 ($P<0.05$), ODI scores were improved from 79.0 to 27.9 ($P<0.05$), DSCA was improved from 55.7 to 109.5 mm^2 ($P<0.05$), ROM scores were improved from 5.6° to 5.7° ($P<0.05$), and DH scores were reduced from 6.6 to 6.5 mm ($P<0.05$). There was no significant difference in VH before and after operation ($P>0.05$). There were no serious complications during the follow-ups.

Conclusion. Endoscopic laminectomy had the advantage of a wider view, which was effective, safe, and less invasive for lumbar spinal stenosis.

Key words: endoscopes, laminectomy, lumbar vertebrae, minimally invasive, spinal stenosis, surgical procedures.

Level of Evidence: 5

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Degenerative lumbar spinal stenosis (DLSS) is a common degenerative disease of the lumbar spine in clinic. According to the guidelines formulated by the North American Spine Society (NASS) in 2011,[1] degenerative lumbar spinal stenosis is caused by degeneration of the spinal canal, resulting in reduced space for nerve and vascular components in the spinal canal. The different degrees of compression contribute to various clinical symptoms. The incidence of DLSS ranges from 1.7% to 10%[2,3] and is especially common among the middle-aged and elderly.[4]

The symptomatic improvement rate of lumbar spinal stenosis after conservative treatment is 15% to 43%.[5,6] Most patients prefer surgical treatment, which is more effective than conservative treatment in relieving symptoms.[7] Resection of partial lamina and facet joint is a traditional surgical procedure, which can achieve adequate decompression of the spinal cord and nerve roots. Because of the long history of traditional open decompression surgery, it has been regarded as a standard surgical and training method for clinical residents. However, extensive dissection of soft tissues is required for open surgery, which may cause severe trauma, excessive muscle injury, and changes in the mechanical structure of the lumbar spine, leading to complications such as chronic lumbar pain after surgery.

Endoscopic spinal surgery effectively reduces local injuries. Endoscopic hemilaminectomy and decompression achieve precise decompression and individualized decompression accordingly.

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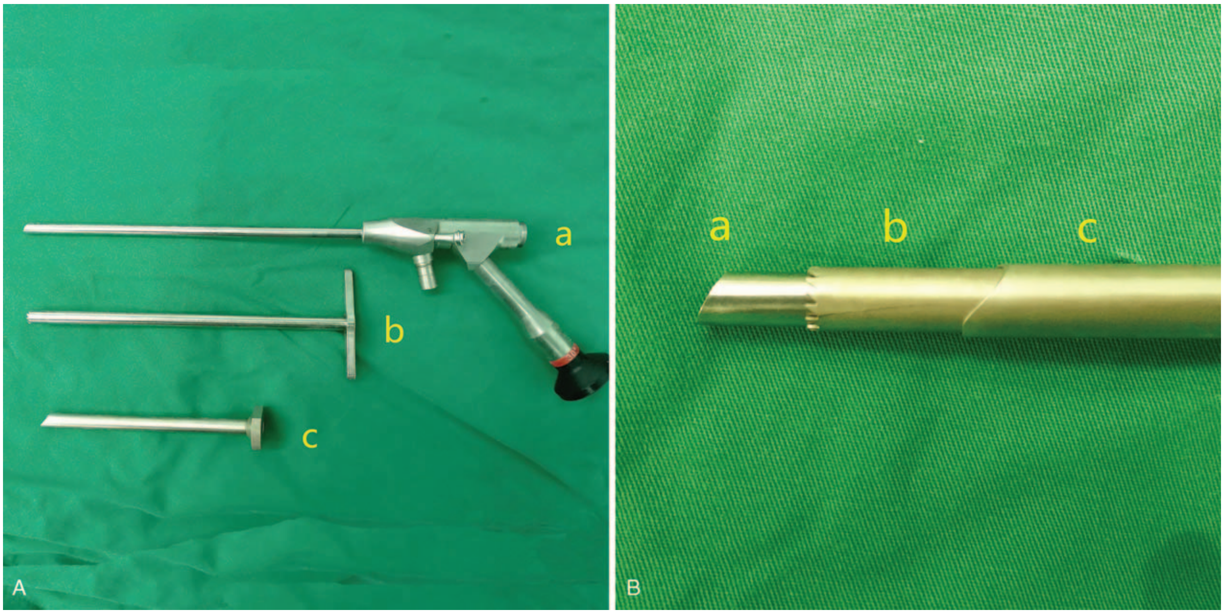

Figure 1. Endoscopic spine system (**A**, **B**). Endoscope (**a**), duck-mouth protective cannula (**b**), and trephines (**c**).

In this study, endoscopic treatment of single-level degenerative central lumbar canal spinal stenosis (CLCSS) was selected, and follow-up was conducted according to the unified requirements to evaluate the clinical efficacy.

MATERIALS AND METHODS

Participants

From January, 2016 to June, 2017, 38 patients with central lumbar canal spinal stenosis who met the inclusion criteria were treated with endoscopic laminectomy. All the procedures were approved by Beijing Rehabilitation Hospital Ethics Committee.

Inclusion criteria: (1) single-level degenerative CLCSS; (2) obvious symptoms of limp, lower back pain, or leg pain that was non-surgically treated for more than 6 months; (3) patients who knew the plan and details of the treatment, including the mechanism of surgery, predictive outcomes, potential risks, and side effects; (4) patients who signed informed consent and were willing to return for follow-up; (5) patients who were assessed with functional assessment, x-ray, CT, and MRI during the follow-up; (6) patients who received endoscopic laminectomy that was followed up on for more than 1 year.

Exclusion criteria: (1) patients with segmental instability, severe central stenosis, and cauda equina syndrome; (2) patients who had a history of lumbar surgery or medical diseases unsuitable for surgery; (3) patients with incomplete information or uncooperative patients.

Surgical Procedures

All procedures were carried out via the endoscopic spine system. Special instruments for the laminectomy were designed and constructed (Figure 1A, B). The lumbar decompression was performed using trephines under the endoscopic system, and the schematic diagram of the laminectomy is shown in painting (Supplement Figure 1AB, http://links.lww.com/BRS/B536).

All patients assumed the prone position, and the entry point was determined by C-arm fluoroscopy. The entry point was usually 4 to 5 cm lateral from the midline and about 15° to 20° to the head side. The spinal needle was inserted into 1/3 of the superior articular process under a C-arm fluoroscope. The incision was about 1 to 2 cm along the spinal needle. Thereafter, the working channel and spinal endoscope were introduced (Figure 2A, B). Under an endoscope, the first trephine was positioned at 1/3 of the superior articular process, which was resected by the trepan (Supplement Figure 2A, http://links.lww.com/BRS/B537). When the bone was rotated with the trepan (just like opening a bottle cap), it indicated that the bone had been successfully resected. The 2nd, 3rd, and 4th trephines decompress along the lamina in turn, and the range of decompression may be changed according to the hypertrophic ligamentum flavum (Supplement Figure 2B, C, http://links.lww.com/BRS/B537). Certainly, a Kerrison punch can also be used to resect smaller parts of the peripheral bone. The operation starts from the lateral pars and superior articular process and resects bone mesial. Part of the superior articular process and part of the upper lamina were resected (Supplement Figure 2D, http://links.lww.com/BRS/B537). The decompression could reach the root of the spinous process. The range of decompression can be adjusted accordingly. The proliferative ligamentum flavum were removed to expose the dura and nerve roots. For the combined lateral recess stenosis, the ventral and lateral bone of the caudal portion of the inferior facet can be removed. If necessary, radiofrequency ablation can be used to stop bleeding and forceps can be used to remove herniated disc tissue. At the end of the operation, endoscopic examination showed no

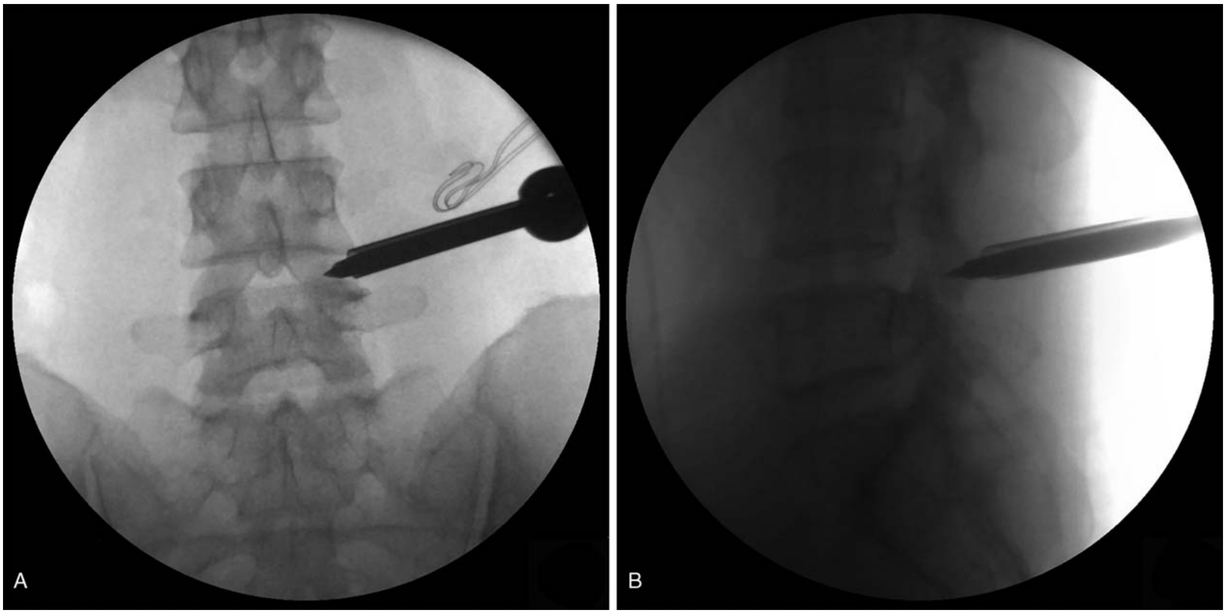

Figure 2. Localization and puncture in a female (left). The entry point was determined by C-arm fluoroscopy, a spinal needle was inserted into 1/3 of the superior articular process, the working channel was introduced (**A, B**).

bleeding and good nerve root pulsation (Supplement Figure 3A–H, http://links.lww.com/BRS/B538). The incision at the puncture site was sutured.

Outcome Assessment

The patients were evaluated at 1 month, 3 months, 6 months, and 12 months and at the last follow-up after surgery. Functional outcomes were measured by Japanese Orthopedic Association Scores (JOA)[8] and Oswestry Disability Index (ODI).[9] Decompression effects were assessed using dural sac cross-sectional area (DSCA) (mm^2).[10] DSCA was used to measure the most narrow area of the dural sac cross-section in the lumbar spine MRI (Figure 3A, B). Lumbar stability was evaluated by ventral intervertebral space height (VH) (mm), dorsal intervertebral space height (DH) (mm), and lumbar range of motion (ROM) (°). VH and DH were measured on normal lateral x-ray of the lumbar spine (Figure 3C). The lumbar activity was detected by x-ray at the flexion–extension position. Two straight lines were selected from the upper and lower edges of the adjacent vertebrae. The Cobb angle referred to the angle between the two vertical lines (Figure 3D). Lumbar ROM meant difference of the two Cobb angles.

Statistical Analysis

All statistical analyses were performed using SPSS 17.0 (SPSS Inc., Chicago, IL). The data were presented as means ± standard deviation and analyzed using the paired t test, and $P < 0.05$ was considered significant.

RESULTS

Demographic Characteristics and Outcomes of the Patients

According to the inclusion and exclusion criteria, 38 patients were enrolled in this study. There were 12 men and 26 women, and the mean age was 60.8 years (48–76 yrs), with a body mass index (BMI) of 24.0 (14.5–33.4). The position of decompression was at the left side in 17 cases and at the right side in 21 cases. There was one case with stenosis at L2–3, 14 cases at L3–4, 21 at L4–5, and 2 at L5–S1. The mean operation time was 66.3 minutes (48–115 min), the mean blood loss was 38.8 mL (25–60 mL), and the mean length of incision was 19.6 mm (14–25 mm). The mean time in bed was 22.3 hours (15–31 h), and the mean hospital stay was 8.8 days (4–17 d). The average follow-up was 19.7 months (15–26 mo). The details are shown in Table 1.

Clinical Results

JOA scores improved significantly. There was significant difference between preoperative scores and postoperative scores of JOA at different time points (1 month, 3 months, 6 months, 1 year, and the last follow-up) ($P < 0.05$). ODI also improved significantly, also having significant difference between preoperative scores and postoperative scores of ODI at different time points. The details are shown in Table 2.

DSCA improved significantly, with significant difference between preoperative scores and postoperative scores of DSCA at different time points ($P < 0.05$). There was a significant difference between preoperative ROM scores and ROM scores at 1 month, 6 months, 12 months, and the last follow-up after operation ($P < 0.05$) and between preoperative DH scores and DH scores at 3 months, 6 months, 12 months, and the last follow-up after operation ($P < 0.05$). There was no significant difference in VH before and after operation ($P > 0.05$). The details are shown in Table 3.

Representative Cases

Representative cases are illustrated in Supplement Figure 4A–H, http://links.lww.com/BRS/B539.

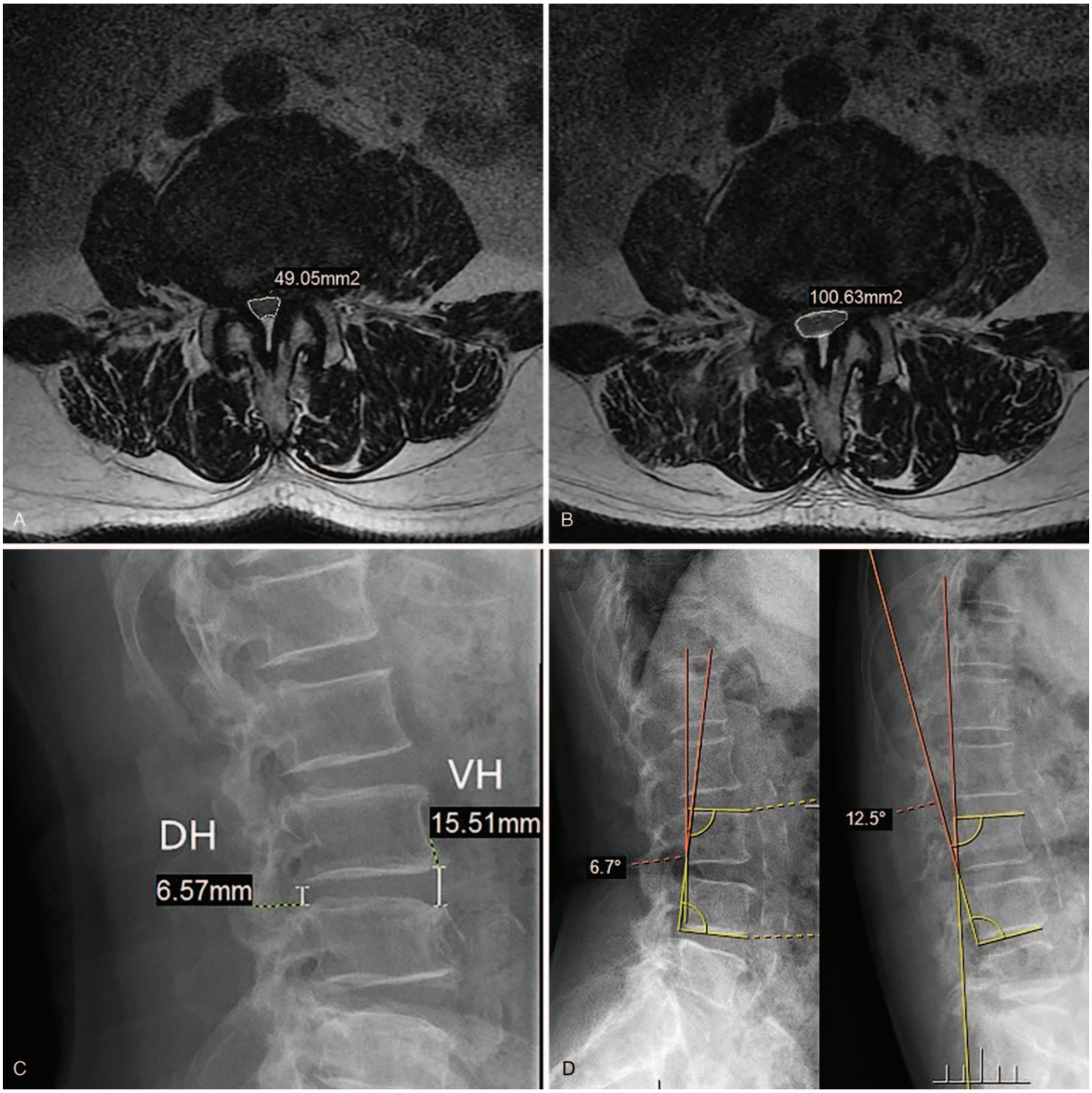

Figure 3. Diagram of decompression effects and lumbar stability. Preoperative measurement of DSCA (**A**); Postoperative measurement of DSCA (**B**); measurement of intervertebral space height, including VH and DH (**C**); measurement of Cobb Angle by X-ray at the flexion-extension position (**D**). DH indicates dorsal intervertebral space height; DSCA, dural sac cross-sectional area; VH, ventral intervertebral space height.

DISCUSSION

At present, the efficacy of surgical treatment for lumbar spinal stenosis has been widely recognized.[11,12] Laminectomy is the most basic procedure for the treatment of lumbar spinal stenosis. Open decompression of the vertebral lamina may cause peripheral muscle denervation and local atrophy, resulting in persistent lower back pain and even lumbar instability.

Endoscopic spinal surgery has been widely used in the treatment of various lumbar diseases, especially lumbar disc herniation, because of its advantages of less trauma, less bleeding, and faster recovery. Yeung endoscopic spine system (YESS) and transforaminal endoscopic spine system (TESSYS) are commonly used as percutaneous endoscopic lumbar discectomy (PELD) to treat lumbar disc herniation. Kambin triangle in intervertebral foramen is selected as the entry point of YESS technology, and the inferior intervertebral foramen is chosen as the entry point of TESSYS technology. The two techniques are transforaminal approaches, and the spinal canal is entered for decompression.[13] With the development of PELD, which can also be used to treat LSS, Kim *et al*[14,15] have gained good clinical outcomes in patients with LSS. PELD under the transforaminal endoscopic spine system was designed to remove herniated disk tissues by expanding intervertebral foramen. Because of the limited anatomical structure of the intervertebral foramen, decompression of lamina and ligaments is not effective.

TABLE 1. Demographics of Patients in this Study

	Mean ± SD (Range) or n (%)
Age, yrs	60.8 ± 7.2 (48–76)
BMI, kg/m^2	24.0 ± 4.2 (14.5–33.4)
Sex	
Male	12
Female	26
Position	
Left	17
Right	21
Levels involved	
L2–L3	1
L3–L4	14
L4–L5	21
L5–S1	2
Duration of surgery, min	66.3 ± 14.1 (48–115)
Blood loss, mL	38.8 ± 10.6 (25–60)
Length of incision, mm	19.6 ± 3.0 (14–25)
Time in bed, h	22.3 ± 4.1 (15–31)
Hospital stay, d	8.9 ± 2.9 (4–17)
Follow-up, mo	19.7 ± 3.3 (15–26)

BMI indicates body mass index.

Endoscopic laminectomy can simulate the decompression by open surgery, which is different from transforaminal decompression in the treatment of lumbar spinal stenosis. The starting point was inserted into the superior articular process, which was higher than YESS and TESSYS. Because of its unique anatomical marks, localization and operation become relatively safe and easy. YESS technique inserted directly into the intervertebral space and the intervertebral disc, meanwhile the first field of vision of TESSYS was the intervertebral foramen.

The trephine only resected 1/3 of the superior articular process, while the lower 2/3 of the joint was retained. The range of decompression may be changed according to the hypertrophic ligamentum flavum. The square-like window opening achieved by four times of trephines is the most ideal decompression operation. Most endoscopic techniques to date have been trans-articular or extraforaminal for herniated discs, and ours is expanding this technique to decompress the lateral recess. In practice, the number of trephines may be increased accordingly. The range of decompression is various: the head side may reach the lower edge of the upper pedicle, the lateral side may reach the outer orifice of the intervertebral foramen, the caudal side may reach the upper edge of the lower pedicle, and the contralateral side may reach the midline of the spinous process or even beyond the midline of the spinous process. Decompression was performed on the dorsal and ventral sides of the spinal canal and lateral recess.

There is evidence that unilateral facetectomy of greater than 75% alter the translational displacement and flexibilities of the motion segment.[16] Our resection range is about 1/3 much lower than 75%. Other research has reported that facet joint destruction will not produce acute instability, but it will transfer the loads to the adjacent disc and conceivably accelerate its degeneration.[17] In the current cohort, DH was reduced from 6.6 to 6.5 mm after 3 months ($P < 0.05$). It was believed that the reduction of DH may be attributed to manipulation of the posterior column of the lumbar spine. However, the reduction of DH was only 0.1 mm, and the loss of DH was only about 2%. Thus, the difference was almost negligible for the lumbar vertebral morphology. Of course, removal of a small part of the facet joint may accelerate the degeneration of the disc, but this change is a chronic process, which needs further long-term follow-up study.

Endoscopic laminectomy is based on open decompression, which is different from traditional endoscopic surgery. The endoscopic lens is equivalent to the operator's eyes, while endoscopic instruments replace traditional open

TABLE 2. JOA and ODI Improvement

Follow-Up	Mean ± SD (Range)	*P* Value
JOA (0–29)		
Preoperation	10.9 ± 1.8 (6–14)	
1 month after operation	19.5 ± 2.7 (14–25)	0.000
3 months after operation	24.3 ± 2.1 (19–28)	0.000
6 months after operation	25.1 ± 1.5 (21–28)	0.000
1 year after operation	24.4 ± 1.5 (20–27)	0.000
The last follow-up	24.1 ± 1.5 (21–26)	0.000
ODI (0–100)		
Preoperation	79.0 ± 8.7 (57.6–94)	
1 month after operation	32.4 ± 7.8 (18–48)	0.000
3 months after operation	25.7 ± 6.1 (14–36)	0.000
6 months after operation	24.2 ± 4.5 (12–34)	0.000
1 year after operation	26.2 ± 4.5 (14–36)	0.000
The last follow-up	27.9 ± 5.0 (14–40)	0.000

JOA indicates Japanese Orthopedic Association Scores; ODI, Oswestry Disability Index.

TABLE 3. DSCA, ROM, VH, and DH Improvement

Follow-Up	Mean ± SD (Range)	*P* Value
DSCA, mm^2		
Preoperation	55.7 ± 10.5 (39.6–75.3)	
1 month after operation	117.0 ± 11.8 (98.0–143.3)	0.000
3 months after operation	115.1 ± 10.4 (98.6–139.9)	0.000
6 months after operation	112.8 ± 9.4 (97.2–127.0)	0.000
1 year after operation	111.5 ± 9.6 (98.6–126.6)	0.000
The last follow-up	109.5 ± 9.9 (95.5–126.3)	0.000
ROM, °		
Pre-operation	5.6 ± 1.2 (3.1–8.3)	
1 month after operation	5.1 ± 1.0 (2.8–7.8)	0.000
3 months after operation	5.6 ± 1.2 (3.0–8.5)	0.651
6 months after operation	5.7 ± 1.1 (3.1–8.7)	0.003
1 year after operation	5.8 ± 1.1 (3.1–8.4)	0.003
The last follow-up	5.7 ± 1.0 (2.9–7.9)	0.046
VH, mm		
Preoperation	14.8 ± 3.0 (8.3–19.0)	
1 month after operation	14.7 ± 2.9 (8.3–19.3)	0.143
3 months after operation	14.7 ± 2.8 (8.4–19.1)	0.343
6 months after operation	14.6 ± 2.8 (8.5–19.1)	0.107
1 year after operation	14.6 ± 2.8 (8.5–18.8)	0.052
The last follow-up	14.6 ± 2.8 (8.4–19.0)	0.055
DH, mm		
Preoperation	6.6 ± 1.2 (4.6–8.8)	
1 month after operation	6.5 ± 1.1 (4.5–8.8)	0.058
3 months after operation	6.5 ± 1.1 (4.6–8.8)	0.002
6 months after operation	6.5 ± 1.1 (4.5–8.7)	0.000
1 year after operation	6.5 ± 1.1 (4.6–8.7)	0.002
The last follow-up	6.5 ± 1.1 (4.6–8.7)	0.001

DH indicates dorsal intervertebral space height; DSCH, dural sac cross-sectional area; ROM, range of motion; VH, ventral intervertebral space height.

surgical instruments and perform laminectomy under spinal endoscopy. Endoscopic laminectomy enlarges the field of vision tenfold, makes the field of vision clearer, reduces the risk of nerve injury, and can precisely decompress the target dural sac and nerve root. By adjusting the lens, the visual blind area that is not reached by open surgery can be observed, and decompression of about 270° in the dorsal and ventral dural sacs can be achieved. In the whole process, 0.9% Saline Solution is connected with the water inlet of the endoscope system by the infusion set, and the endoscope instrument channel is also the water outlet. The operation is carried out under the water medium, the interface being clearer. The water pressure has a certain hemostatic effect, and the flowing water medium ensures that the operation area is cleaner and reduces the probability of infection. No special retractor is needed, the body tissue is perforated by the step by step casing structure, with good sealing and less invasive. In addition, because of the use of local anesthesia, the lower limb reactions of patients are observed, which ensures the safety and effectiveness of treatment compared with open surgery using general anesthesia.

Endoscopic spine surgery and unilateral laminectomy are two well-established procedures. Studies and reports focused on endoscopic laminectomy are rare. In the current study, we retrospectively reviewed 38 cases with CLCSS and analyzed the clinical effect. The JOA scores and ODI scores improved significantly at 1 month after operation. After 3 months, the lumbar spine function tended to be stable. DSCA less than 70 mm^2 has been previously suggested to represent critical stenosis on MRI images.[18] The average area of DSCA before operation was 55.7 mm^2 (<70 mm^2) and reached 117 mm^2 1 month after operation. The DSCA was over 100 mm^2 at different time points after operation. The DSCA was nearly 100% larger than that before operation, and the decompression effect was obvious. ROM activity decreased at 1 month after surgery compared with that before operation ($P < 0.05$). It was considered that the lumbar motion decreased as a result of wearing the abdominal belt for 1 month. In addition, ROM improved from 6 months to the last follow-up ($P < 0.05$), which may be attributed to relief of lower back pain symptoms. Generally speaking, the lumbar function and symptom relief after surgery were significant, so endoscopic laminectomy is indicated to be feasible and safe.

For lumbar spinal stenosis combined with lumbar disc herniation, the operation also achieved positive effects, but because of the relatively small number of cases, it has not been included in the systematic study. In addition, endoscopic treatment of lumbar spinal stenosis combined with lumbar instability is still controversial.[19] In the process of designing the experiment, considering the consistency and comparability of the experiment, we selected patients with single-segment central lumbar spinal stenosis to conduct a comparative study, and satisfactory therapeutic outcomes were obtained. With the increase in surgical cases and types, we will gradually include other types of lumbar spinal stenosis into the study.

CONCLUSION

In conclusion, endoscopic laminectomy is effective, less invasive, and safe for central lumbar canal spinal stenosis.

➢ Key Points

- ❑ Endoscopic spinal surgery has been widely used in the treatment of various lumbar diseases, but less used in the treatment of lumbar spinal stenosis.
- ❑ Endoscopic laminectomy can simulate the decompression by open surgery for patients with central lumbar canal spinal stenosis.
- ❑ Endoscopic laminectomy is less invasive, effective, and safe for central lumbar canal spinal stenosis.

Supplemental digital content is available for this article. Direct URL citations appearing in the printed text are provided in the HTML and PDF version of this article on the journal's Web site (www.spinejournal.com).

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