ENDOSCOPIC AND MICROSURGICAL DECOMPRESSION FOR CENTRAL LUMBAR SPINAL STENOSIS

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Objective. To perform comparative analysis of the results of endoscopic and microsurgical decompression for lumbar spinal stenosis.
Material and Methods. Design: Retrospective monocentric intra-cohort comparison of two groups of patients. The study included 99 patients aged 51–88 years with clinically significant lumbar spinal stenosis manifested by neurogenic intermittent claudication syndrome. Endoscopic decompression was performed in 51 patients, and microsurgical decompression – in 48 patients. To objectify and standardize clinical symptoms, walking distance in meters, pain syndrome and quality of life were assessed before and after surgery using standard scales and questionnaires (VAS, ODI). On the first day after surgery, back and lower limb pain were assessed, and during the observation period back and lower limb pain, quality of life and walking distance were assessed. Functional lumbar radiography was performed to exclude instability of the spinal motion segment. Using MRI, the cross-sectional area of the dural sac at the level of stenosis was measured before and after surgery. Clinical efficacy was assessed using the MCID (Minimal Clinical Important Difference) criterion. The results of the operation were followed-up for 12 months after the operation.
Results. Blood loss in the endoscopic intervention group was less than in the microsurgical group. Pain in the lumbar spine and in the lower extremities decreased, and the cross-sectional area of the dural sac increased. In the first days after surgery, patients after endoscopic decompression had less severe back and lower extremity pain than patients after microsurgical decompression due to less soft tissue trauma. Pain syndrome in back 10–12 months after surgery was without statistically significant difference between the groups. Patients after endoscopic decompression had statistically significantly better quality of life according to ODI, lesser pain in the lower extremities according to VAS and longer walking distance than those in the microsurgical decompression group. Surgical treatment in both groups turned out to be effective, which is confirmed by MCID. The time of endoscopic intervention is significantly longer than that of microsurgical intervention. The length of the incision during endoscopic decompression is shorter than that of microsurgical decompression.
Conclusion. A comparative analysis of the results of endoscopic and microsurgical decompression for degenerative central lumbar stenosis showed comparable effectiveness of both methods, including an increase in the spinal canal dimension and ensuring regression of clinical symptoms. The results of the comparison do not allow making a sufficiently substantiated judgment on the advantages of one of the methods, which dictates the need for further research.
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According to MRI and CT data, lumbar spinal stenosis is detected in more than 80 % of patients over 70 [1] and is the most frequent reason for spinal surgery in elderly and senile patients [2].

A decreased cross-sectional area of the dural sac of less than 130 mm^2 (relative stenosis) and less than 100 mm^2 (absolute stenosis) is defined as the criteria for central stenosis [3–5]. A typical clinical manifestation of spinal stenosis is neurogenic intermittent claudication syndrome that significantly worsens quality of life of the patients.

If conservative treatment options are ineffective, then surgical decompression of the nerve roots is performed [5, 6]. Currently, laminectomy is not widely used for this purpose since it is traumatic and may result in instability of the spinal motion segment. Microsurgical bilateral over-the-top decompression is a modern minimally invasive surgical option in patientas with lumbar spinal stenosis [7–9]. Endoscopic bilateral over-the-top decompression is a relatively new technique used in spinal stenosis [10–14]. The number of papers on endoscopic decompression for lumbar spinal stenosis has been growing since 2018, and its outcomes and efficacy are being actively discussed.

The objective is to perform a comparative analysis of the results of endoscopic and microsurgical treatment for degenerative lumbar spinal stenosis.

Material and Methods

Design: retrospective monocentric intra-cohort comparison of two groups of patients.

The surgical outcomes of patients with degenerative lumbar spinal stenosis operated in the Department of Spine and Neurosurgery of the Novosibirsk Federal Center of Neurosurgery from 2013 to 2023 were analyzed. Among 860 patients with clinical manifestations of lumbar spinal stenosis, 99 patients (57 women and 42 men) with MRI-confirmed stenosis who matched the following criteria were included in the study:

– *inclusion criteria:* central spinal stenosis (Grade B, C, D according to Schizas) with clinical manifestations as neurogenic intermittent claudication [15];

– *exclusion criteria:* segmental instability, spondylolisthesis, scoliosis (Cobb angle greater than 10°), sagittal balance disorders requiring correction, history of spinal injury or infection.

Open surgery using microsurgical decompression was performed in 48 patients (Group 1) and endoscopic decompression in 51 patients (Group 2). A unilateral approach for bilateral over-the-top nerve root decompression was chosen in both groups. The mean age of the patients operated on using open microsurgical technique was 68 years (60–80 years); those operated on endoscopically were 65 years old (51–88 years).

Indications for the surgical treatment: nerve root compression syndrome and neurogenic intermittent claudication associated with degenerative central spinal stenosis and failure of nonsurgical treatment options for 2 months.

The intensity of back and lower extremities pain (VAS-10), Oswestry index (ODI), and walking distance in meters before the onset of symptoms of neurogenic intermittent claudication were evaluated in the pre- and postoperative periods.

MRI, plain and flexion-extention spondylography of the lumbar spine were performed. The cross-sectional area of the dural sac and the central spinal stenosis grade according to Schizas [15] were determined using MRI and T2-weighted images. The neurogenic claudication was usually found in grade C and D stenosis and less frequently in grade B stenosis. Schizas grade B stenosis is defined as moderate; nerve roots occupy the entire lumen of the dural sac, but they are viewed in the background of a small amount of cerebrospinal fluid. Grade C: nerve roots and cerebrospinal fluid are not differentiated, but the epidural fat is identified dorsally. Grade D: neither the roots, nor the cerebrospinal fluid, nor the epidural fat are differentiated. MRI data were also used to evaluate the degenerative changes in the intervertebral discs and facet joints. In most patients, degenerative changes in the intervertebral disc at the level of stenosis corresponded to Pfirrmann grade IV, and those changes of the facet joints corresponded to Fujiwara grade IV.

Moreover, the clinical efficacy of treatment was evaluated using the Minimal Clinical Important Difference (MCID) criterion with the following reference values for lumbar stenosis: ODI – 12.8; VAS (lower extremities) – 1.6; VAS (back) – 1.2 [16–19].

Treatment outcomes were studied in the early postoperative period (3–4 days) and 10-12 months after surgery. In the early postoperative period, only the pain severity was evaluated, since the assessment of walking distance and ODI was impossible.

Surgical technique. All surgical procedures were performed on the Wilson spinal frame with the patient in prone position to avoid abdominal compression. Microsurgical decompression was performed using a surgical microscope with a magnification of 2 to 3. The adjacent edges of the laminae, the base of the spinous process, and the partially medial parts of the homolateral facet joint were resected using a high-speed drill. The hypertrophied ligamentum flavum was then removed from both the homolateral and contralateral sides. Visualization of the dural sac and spinal nerve root cuffs with the pulsation was considered as criteria of appropriate decompression.

Endoscopic decompression was performed from a 1.5–2.0 cm linear incision along the edge of the spinous process. A working cannula was inserted through cone retractors into the interlaminar space with an endoscope with a diameter of 10 mm and a visual angle of 15°.

Preserving resection of the adjacent edges of the laminae homolaterally and of medial parts of the facet joint was performed through the endoscope working channel using a high-speed drill. The base of the spinous process and, if required, the medial parts of the contralateral facet joint were also resected. The hypertrophied ligamentum flavum was resected using an endoscopic dissector and bone cutters homo- and contralaterally until decompression criteria were achieved. The surgery was performed with continuous irrigation with NaCl saline.

The majority of patients in both groups were operated on at the L4–L5 level (Table 1). No patients with central stenosis at the L5–S1 level were included.

Statistical analysis. Statistical data processing was performed using R software (basic functionality) [R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. 2022, https://www.r-project.org/].

The normal distribution hypothesis of the numerical data was verified using the Shapiro-Wilk test. Since the hypothesis of normal distribution was rejected for most of the data, non-parametric tests were used. The following standard was used to describe the data: mean/median (1; 3 quartiles). The groups were compared using the Mann-Whitney U Test and asymptotic realization of Fisher's exact test (for comparison of groups by the severity of central stenosis in Schizas patient groups). The Wilcoxon signed-rank test was used to compare the results before surgery and in the long-term period. The statistical significance value was accepted as $p < 0.05$.

Results

All patients showed clinical manifestations of nerve root compression and neurogenic intermittent claudication on admission to the hospital, along with central spinal canal stenosis. The intensity of low back pain and ODI were similar in both groups of patients;

however, leg pain was less pronounced and walking distance was greater in the endoscopic surgery group compared to the microsurgical decompression group (Table 2).

The spinal canal dimensions in both groups met the criteria for central stenosis of grades B, C, and D [3, 4, 20]. Most often, spinal stenosis corresponded to grade C and only in a few cases to grade B (Table 3). There were no statistically significant differences in the cross-sectional area of the dural sac between the groups (p = 0.245). The cross-sectional area was 0.53/0.52 (0.41/0.64) cm^2 in the group of endoscopic surgeries and 0.43/0.42 (0.27/0.58) cm^2 in the group of microsurgical procedures.

The mean incision length in the microsurgical decompression group was 4.0 cm; and it was 1.8 cm in the endoscopic decompression group. Meanwhile, the blood loss volume at endoscopic surgeries was lower compared to microsurgical surgeries: 44/40 (35; 58) mL and 149/135 (105; 160) mL, respectively; $p < 0.001$.

The cross-sectional area of the dural sac enlarged after microsurgical and endoscopic surgical procedures (Table 4).

Endoscopic decompression was prolonged compared with microsurgical decompression.

In the first year of endoscopic surgery, the mean duration was 137 minutes. However, it decreased to 110 minutes over time due to accumulated experience. Nonetheless, the endoscopic surgery duration was longer compared to microsurgery, 130/120 (108; 150) and 90/88 (75; 105) min, respectively ($p < 0.001$). The mean time to perform microsurgical decompression remained unchanged over time (Fig. 1).

A statistically significant reduction of pain in the legs and back was registered in the patients of both groups in the immediate postoperative period (3–5 days). The severity of back pain in the early postoperative period was lower in patients of the endoscopic surgery group (Table 5). Walking distance and ODI were not evaluated in the early postoperative period because of limitations of physical activity in the hospital.

Table 1

Distribution of patients by surgical levels, n (%)

Surgical level	Endoscopic decompression (n = 51)	Microsurgical decompression (n = 48)
L2–L3	6 (11.8)	3 (6.3)
L3–L4	21 (41.2)	18 (37.5)
L4–L5	24 (47.0)	27 (56.2)

A statistically significant reduction of low back and leg pain, as well as a distinct positive trend of ODI, was registered in both groups of patients after 10–12 months. Nevertheless, leg pain scores on VAS, ODI values, and walking distance before the manifestation of leg pain were better after endoscopic surgery (Tables 5, 6).

The surgical treatment was effective in both groups that is confirmed by the MCID (VAS for back and leg pain, ODI) criterion. Changes in the scores of scales and questionnaires before and after surgery according to the MCID criterion are illustrated in Table 7. MCID score thresholds: leg pain on VAS: 1.6; back pain on VAS: 1.2; ODI: 12.8 [16–18].

The preserving resection of bone structures prevented instability of the operated spinal motion segments during the follow-up period; pain in the lumbar spine was less pronounced than before surgery, and no instability was revealed on lumbar flexion-extention spondylographs.

Case Study. Patient H., female, 68 years old, complained of pain, numbness, and weakness in the lower extremities when walking 30 meters, disappearing at rest. The duration of the disease before admission to the hospital was 12 months. The courses of conservative treatment were ineffective. At the admission to the hospital, the neurological status revealed a decreased patellar reflex on the right side and paresis of extensors of the right tibia (4 points). There are no objectively detectable sensory disorders. MRI revealed central spinal stenosis at the L3–L4 level, Grade C according to Schizas. Intervertebral disc degeneration degree according to Pfirrmann was 4, and of facet joints according to Fujiwara was 4. An endoscopic bilateral over-the-top decompression of the nerve roots at L3–L4 level from a unilateral approach was performed. The symptoms of neurogenic claudication resolved after the surgery; there was no progression of neurological deficit; back pain decreased from 5 to 2 points according to VAS; leg pain decreased from 6 to 1 point of VAS; walking distance increased from 30 to 1,000 m; quality of life improved from 48 to 23 according to ODI (Table 7). According to MRI data, the dural sac is inflated, and the nerve roots and cerebrospinal fluid are differentiated. The cross-sectional area of the dural sac increased from 0.44 to 1.34 cm2 (Fig. 2).

Surgical complications are given in Table 8. The number of complications in the group of endoscopic surgery was higher than in the group of microsurgical surgery. The primary surgical complication during endoscopic decompression was perforation of the dural sac, with nerve root prolapse in one case that required conversion and suturing of the dura mater. Injuries of the dural sac during endoscopic decompression were reported during the period of the technique's development until 2021, and they are not currently found. The increase of neurological deficit in both groups as mild hypoesthesia and weakness in the foot was noted immediately after surgery and regressed during the follow-up period.

Discussion

The application of minimally invasive technologies in spine surgery allows to reduce surgical injury, and consequently, postoperative pain syndrome, to reduce the patient's hospital stay

Table 2

Preoperative VAS, ODI and walking distance scores in groups of operated patients

Procedures	Values of M/Me (Q1; Q3)			
	VAS (leg pain)*	VAS (back pain)**	ODI***	Walking distance, m****
Endoscopic (n = 51)	4.6/5.0 (3; 6)	5.4/6.0 (4; 6)	46.8/46.7 (40.0; 52.2)	130/120 (108; 150)
Microsurgical (n = 48)	5.9/6.0 (4; 8)	5.0/5.0 (4; 6)	50.4/51.7 (41.2; 60.5)	90/88 (75; 105)

* p = 0.016; ** p = 0.536; *** p = 0.191; **** p = 0.018.

Table 3

Distribution of patients by severity of central stenosis according to Schizas et al. [15], n (%)

Stenosis severity	Endoscopic decompression (n = 51)	Microsurgical decompression (n = 48)
Grade B	1 (2.7)	3 (6.3)
Grade C	32 (62.2)	23 (47.9)
Grade D	18 (35.1)	22 (45.8)

Table 4

Changes in the cross-sectional area of the dural sac after decompression

Procedure	Cross-sectional area of the dural sac, cm^2 (M/Me, Q1; Q3)		
	Before surgery	After surgery	p
Endoscopic (n = 51)	0.53/0.52 (0.41; 0.64)	1.03/1.01 (0.87; 1.19)	<0.001
Microsurgical (n = 48)	0.43/0.42 (0.27; 0.58)	1.1/1.04 (0.87; 1.22)	<0.001

and to accelerate the rehabilitation. Moreover, minimal resection of the facet joints can prevent the development of spinal motion segment instability, and the outcomes of such surgery are comparable to those of open surgery [21].

The most common minimally invasive technique of surgical treatment of central spinal stenosis is microsurgical bilateral over-the-top decompression of nerve roots through a unilateral approach. Since the 1970s of the XX century, microsurgical decompression through an interlaminar approach has been developed [7]. The first reports on endoscopically assisted decompression appeared in the late 1990s, and fully endoscopic decompression techniques as well as the first articles comparing microsurgical and endoscopic decompression were published in the 2000s [22]. In 2019–2020, the number of papers on endoscopic decompression techniques has increased significantly; review articles and meta-analyses have been published [11, 14, 23].

There have appeared articles comparing microsurgical decompression techniques with biportal endoscopic surgeries [14], micro-endoscopic techniques using endoscopic insertion tube to lead instruments [12], endoscopic decompression with decompression and stabilization [10], or endoscopic decompression for lateral stenosis with microsurgical decompression [22]. These studies are not relevant for comparison with our study since they involve decompression techniques that are different from the ones we used.

Similar in terms of the compared decompression techniques are the papers by McGrath et al. [24] and Komp et al. [25] that compared the outcomes of bilateral microsurgical and endoscopic decompression for lumbar central spinal stenosis (95 and 135 patients, respectively).

At the Department of Spine and Neurosurgery of the Novosibirsk Federal Center of Neurosurgery, microsurgical nerve root decompression for lumbar central spinal stenosis has been performed since 2013, and endoscopic decompression has been performed since 2018.

The surgery using endoscopic and microsurgical techniques were done at the levels of L2–L3, L3–L4, L4–L5, but not due to the 'rejection' of patients with stenosis at the level of L5–S1 since there were no patients with such pathologies. This is explained by anatomical features: the cross-sectional area of the dural sac and the spinal canal is larger at the L5–S1 level than at the L2–L3, L3–L4, and L4–L5 levels; accordingly, clinically significant central stenosis with neurogenic intermittent claudication is less frequent. Yet, clinically significant lateral and foraminal stenosis at the L5–S1 level is not rare at all [26, 27].

Patients in the studied groups did not differ statistically significantly in back pain and quality of life according to ODI prior to surgery. However, there was significantly less leg pain and greater walking distance in the group of endoscopic surgery that is due to the slightly larger cross-sectional area of the dural sac compared to patients in the group of micro-

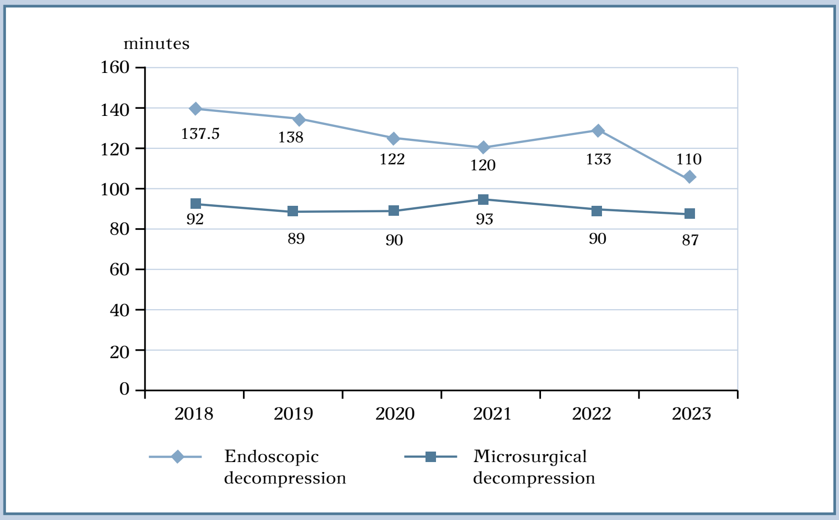

Fig. 1
Mean duration of endoscopic and microsurgical decompression in different years

surgical decompression. Table 3 shows that the number of patients with Grade C stenosis according to Schizas is higher in the endoscopic group compared to the microsurgery one. Such discrepancies in the groups are associated with the assumption that at the initial stages of endoscopic decompression, patients with less severe spinal canal stenosis (Grade C according to Schizas) underwent surgery. Nevertheless, the initial cross-sectional area did not significantly differ between the patient groups.

According to the papers by McGrath et al. [24] and Komp et al. [25], patient age, preoperative ODI and VAS scores did not differ significantly. In other studies, preoperative quality of life according to ODI, and pain syndrome according to VAS were not assessed [10, 12, 22].

We observed that the duration of endoscopic decompression is longer than that of microsurgical technique because of the technical peculiarities of the procedure and its mastering at the initial stage. According to McGrath et al. [24], the time of endoscopic decompression is also longer than that of microsurgical decompression.

According to the study by Komp et al. [25], the microsurgical decompression duration was 64 min that was statistically significantly longer ($p < 0.05$) than endoscopic decompression duration (42 min). Nevertheless, there is no data on the initial cross-sectional area of the dural sac,

Table 5
Changes over time in pain syndrome according to VAS before and after endoscopic and microsurgical decompressions

Procedure	Pain syndrome					
	Back			Legs		
	Before surgery	3–5 days after	11–12 months after	Before surgery	3–5 days after	11–12 months after
Endoscopic (n = 51)	5.4/6.0 (4; 6)	3.5/3.0 (3; 4)	3.4/3.0 (3; 4)	4.6/5.0 (3; 6)	2.2/2.0 (1; 3)	1.9/2.0 (1; 3)
Microsurgical (n = 48)	5.0/5.0 (4; 6)	4.8/5.0 (4; 5)	3.4/4.0 (2; 5)	5.9/6.0 (4; 8)	4.0/4.0 (2; 5)	2.9/3.0 (1; 4)
p	0.536	<0.001	0.889	0.016	<0.001	0.025

Table 6
Changes over time in ODI and walking distance before surgery and in the long-term period after endoscopic and microsurgical decompressions

Procedure	ODI, points (M/Me; Q1, Q3)		Walking distance, m (M/Me; Q1, Q3)	
	Before surgery	11–12 months after	Before surgery	11–12 months after
Endoscopic (n = 51)	46.8/46.7 (40.0; 52.2)	28.9/28.9 (27.0; 31.0)	130/120 (108; 150)	1335/1500 (1000; 1750)
Microsurgical (n = 48)	50.4/51.7 (41.2; 60.5)	34.3/34.7 (30.0; 42.0)	90/88 (75; 105)	974/750 (500; 1500)
p	0.191	0.001	<0.001	0.006

Table 7

Mean postoperative changes in VAS and ODI in relation to the minimal clinical important difference (MCID) of these parameters

Procedure	Δ VAS*		Δ ODI*
	Back	Legs	
Endoscopic	2.0	2.7	17.9
Microsurgical	1.5	2.6	15.2
MCID**	1.2	1.6	12.8

* Difference between long-term (9–12 months) and preoperative parameters;

** MCID reference values for VAS and ODI.

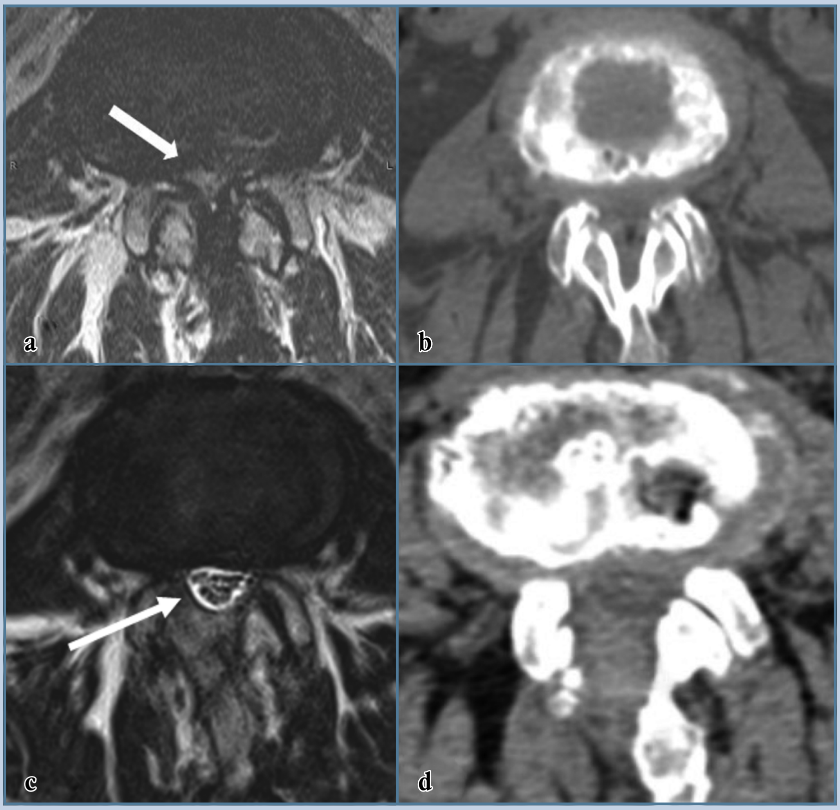

Fig. 2

MRI and CT of patient H., female, 68 years old: **a, b** – before surgery, central stenosis of the spinal canal at the level of L3–L4, Grade C according to Schizas, the stenosis is indicated by the white arrow; **c, d** – after surgery, the inflated dural sac is indicated by the white arrow, the roots and cerebrospinal fluid are differentiated

the degree of central stenosis, or the criteria for decompression in this study. The outcomes similar to ours are reported in the study of McGrath et al. [24]: significantly longer duration of endoscopic decompression (161 min) and shorter duration of microsurgical decompression (99 min).

Enlargement of the cross-sectional area of the dural sac and clinically significant reduction of back and leg pain were achieved in both groups of patients. During the early postoperative period, leg pain and back pain was less pronounced in the endoscopic group that was associated with less surgical injury to the soft tissues. A comparable reduction in back pain, increased walking distance, and improved ODI scores were recorded in patients 10–12 months after surgery. Yet there was statistically significantly less pain in the lower extremities, better ODI scores, and greater walking distance in the group of endoscopic surgeries; however, the cross-sectional area of the dural sac as a result of decompression was comparable.

Similar outcomes were reported in the study by McGrath et al. [24]: 12 months after surgery, the endoscopic decompression group had statistically significantly less leg pain and better quality of life according to ODI. The better outcomes of endoscopic decompression are associated with shorter incision length, minimal soft tissue injury compared to microsurgical decompression, and a less pronounced epidural scar-adhesive process, as described in Panjeton et al. [28], Hang et al. [22]. Nevertheless, the postoperative leg pain, back pain, and ODI scores were not significantly different between the microsurgical and endoscopic decompression groups in the study by Komp et al. [25].

The leg pain, longer walking distance, and better ODI quality of life scores in the endoscopic decompression group in our study are presumably related to the initial leg pain, longer walking distance preoperatively due to a larger cross-sectional area of the dural sac, and, consequently, a smaller degree of stenosis (Grade D according to Schizas). Furthermore, endoscopic decompression is performed with less injury to soft tissues [28, 29].

The proportion of surgical complications with endoscopic decompression was 9.8 %, whereas with microsurgery it was 4.2 %. Dural sac perforation during endoscopic decompression that required suturing of the defect with conversion of the surgery into an open one, was a case when the technique was being mastered, and it has not occurred since 2021. The frequency of complications in the micro-

Table 8

Complications of surgeries using microsurgical and endoscopic techniques, n

Complications	Endoscopic decompression (n = 51)	Microsurgical decompression (n = 48)
Increase of neurological deficit	1	1
Surgical site infection	–	1
Dural sac perforation	4	–
Total	5 (9.8 %)	2 (4.2 %)

surgical and endoscopic decompression groups has been reported to be similar in the literature [11, 14, 23].

Conclusion

A comparative analysis of the outcomes of endoscopic and microsurgical decompression for degenerative lumbar central stenosis revealed as follows: both techniques, different in their approach but similar in the technique of the main stage of surgery, have effectively increased the size of the spinal canal and provided regression of clinical symptoms. In the early postoperative period, the better VAS scores in the group of endoscopic surgeries may be explained by both less injury rate and less intense preoperative pain. Less pronounced leg pain, better ODI, and longer walking distance in patients after endoscopic surgeries 11–12 months following the procedure are associated with better initial indexes and a larger cross-sectional area of the dural sac. The absence of statistically significant differences between the groups in the back pain intensity after 10–12 months was associated with the regression of local postoperative inflammatory changes in soft tissues. The duration of endoscopic surgeries and the surgical complication rate at their initial stages are related naturally to the learning curve of a technically complicated procedure.

The results of this evaluation do not provide a reasonable judgment of the benefits of either of the techniques, thus necessitating further study.

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The study was approved by the local ethics committees of the institutions. All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.

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