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PERCUTANEOUS ENDOSCOPIC DECOMPRESSION OF THE CENTRAL DEGENERATIVE STENOSES OF THE LUMBOSACRAL SPINE

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Background. Degenerative stenosis of the spinal canal is a condition observed mostly in the elderly. It significantly decreases their quality of life and physical activity. Surgical treatment of the patients is frequently associated with significant surgical and anesthesiologic risks especially during conventional open decompression. The problem of decreasing invasiveness of surgical interventions is important for these patients because in their case lighter postoperative injury and decreased recovery duration after surgery are crucial.

Aim. To evaluate clinical outcomes in patients with central degenerative lumbosacral stenoses after percutaneous endoscopic decompression.

Materials and methods. Comparison of clinical and radiological characteristics before surgery, on day 1 and month 6 after surgery was performed. Among clinical characteristics, pain syndrome in the leg/legs per the Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) were evaluated. The evaluated radiological characteristic was the spinal canal cross-sectional area (CSA) in cm^2 per the magnetic resonance imaging. Statistical analysis was performed using the SPSS Statistics v. 26.0 (IBM, USA) software.

Results. Pain syndrome in the leg/legs (decreased VAS score) after surgery decreased significantly (p = 0.006). No significant difference between the VAS scores on day 1 and 6 months after the surgery was found (adjusted significance level p_{adj} = 1.000). Similarly, disability index changes were statistically significant after surgery (p = 0.005): ODI score decreased. Additionally, no statistically significant differences between ODI score on day 1 and 6 months after surgery were observed (p_{adj} = 1.000). Increase in CSA of the spinal canal was statistically significant (p = 0.001), no differences in this parameter on day 1 and 6 months after surgery were found. Conversion to microsurgical access was necessary in 4 (23.5 %) of 17 patients. No statistically significant differences in VAS, ODI scores and CSA changes at different time points were observed in patients who required conversion.

Conclusion. Results of the study show significant improvement of the patients' clinical status (per the VAS and ODI) and achievement of adequate radiological decompression (increased spinal canal CSA) which persisted for 6 months after percutaneous endoscopic interventions.

Keywords: degenerative stenosis of the spinal canal, pain syndrome, endoscopic intervention, minimally invasive spinal surgery, percutaneous endoscopic decompression, elderly patients

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BACKGROUND

The problems of treatment selection and decreasing invasiveness of surgical interventions are extremely important for patients with degenerative spinal stenoses. These conditions primarily occur in the elderly, and surgical treatment is associated with significant surgical and anesthesiologic risks, especially during open decompression [1, 2].

In degenerative stenosis with significant posterior compression by the ligamentum flavum and intervertebral joints, endoscopic decompression is possible. Potential benefits of this approach are maximal preservation of the posterior supportive complex (vertebral arches, spinous processes), minimal intraoperative injury of the muscles and soft tissues, quick restoration of activity and easier rehabilitation.

Endoscopic interventions on the spine are a type of minimally invasive spine surgery. They entered the spinal neurosurgery practice relatively recently (in the 1990s). Portal and transcutaneous endoscopy have already demonstrated effectiveness in resection of intervertebral disk herniations [3–9]. This promotes the study of the

possibility of more extensive endoscopic decompressive interventions (with interlaminar, transformative, posterolateral accesses) and decompressive-stabilizing surgeries (open decompression, interbody stabilization, transpedicular fixation) [10].

The technique of endoscopic decompression for central degenerative stenoses is being actively developed in other countries and has demonstrated its effectiveness in comparison with traditional open decompression [11–13]. This technique is especially useful for elderly women with osteoporosis complicating stabilizing intervention and concomitant disorders complicating anesthesia during long traumatic stabilizing surgery. However, in our country the technique of percutaneous decompression has not yet entered routine neurosurgical practice. Its place in treatment of patients with central degenerative spinal stenoses has also not been established.

Aim of the study – to evaluate clinical outcomes in patients with central degenerative lumbosacral stenoses after percutaneous endoscopic decompression.

MATERIALS AND METHODS

Study design, patients, evaluated parameters. The study is a prospective non-randomized single-cohort study.

The participants were selected from patients hospitalized at the Research Center of Neurology and patients receiving outpatient treatment at the Scientific and Consulting Division of the Research Center of Neurology.

Study inclusion criteria:

- age >18 years;
- presence of central degenerative lumbosacral stenosis per radiological data (types B, C, D per Schizas);
- presence of clinical signs of spinal stenosis (axial pain in the back and/or neurogenic intermittent claudication);
- ineffectiveness of conservative therapy >3 months.

Non-inclusion criteria:

- refusal to participate in the study;
- presence of spondylolisthesis grade ≥II;
- presence of sequestered disk herniation;
- presence of hemodynamically significant atherosclerosis of the lower limbs;
- presence of decompensated somatic pathology.

Exclusion criteria:

- refusal to continue the study;
- decompensation of somatic pathology.

Prior to surgery, on day 1, and 6 months after surgery all study participants underwent general neurologic examination, evaluation of pain syndrome in the leg/legs per the Visual Analogue Scale (VAS), evaluation of the Oswestry Disability Index (ODI), magnetic resonance imaging (MRI) of the lumbosacral spine. Pain syndrome per VAS prior to surgery was evaluated as the maximal intensity of radicular pain in the leg/legs during physical activity (standing or walking). Stenosis severity per MRI data prior to surgery was evaluated using the Schizas classification; patients with symptomatic type B, C and D stenoses were included in the study.

Additionally, information was gathered on outcomes of surgical treatment per the MacNab scale and on postoperative complications, both early (at the time of discharge) and late (at time of examination 6 months post-surgery).

Percutaneous endoscopic decompression technique. The patients underwent monoportal endoscopic decompression using the over-the-top Joimax ILESSYS Delta endoscopic system. The port has diameter 10 mm, is installed per the typical technique of interlaminar access. Radiological control of port installation is presented in Fig. 1.

After port installation, skeletonization of the arch, ipsilateral intervertebral joint, spinous process base (for future over-the-top access) followed by the necessary resection of the bone structures using a bur and Kerrison rongeurs are performed. Flavectomy on the ipsilateral side is performed, root is visualized at the access side and decompressed (Fig. 2). Then the ligamentum flavum is removed centrally and on the contralateral side until contralateral root is decompressed. The surgery can be completed when there is conviction that the nervous structures on both sides are decompressed.

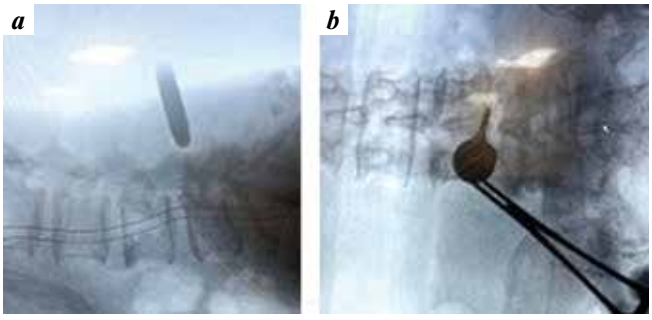

Fig. 1. *Radiological control of endoscopic port installation at the L_4–L_5 level: lateral (a) and frontal (b) projections*

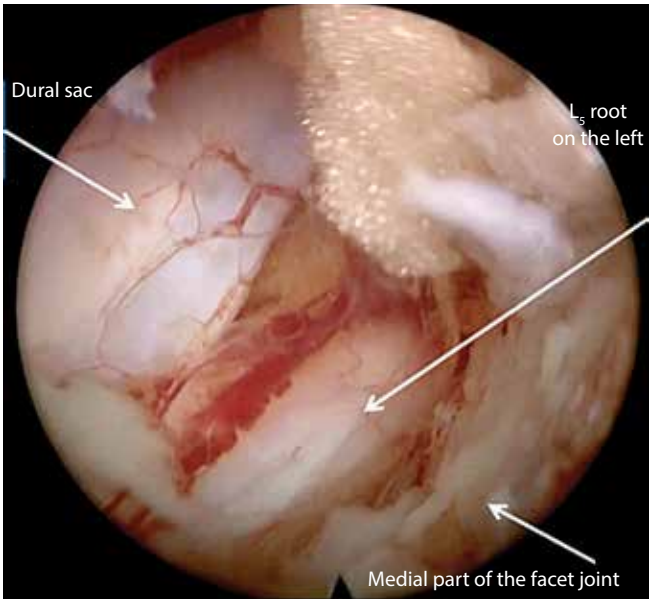

Fig. 2. *Decompression of the ipsilateral root*

Statistical analysis was performed using the SPSS Statistics version 26.0 (IBM, USA) software. In all cases, two-sided variants of statistical tests were used. The null hypothesis was rejected at significance level p <0.05 (for post-hoc pairwise comparisons at corrected significance level p_{adj} <0.05). For comparison of temporal dynamics of VAS, ODI and spinal canal cross-sectional area (CSA) in the 3 related groups, Friedman test with post-hoc pairwise comparisons was used. In post-hoc pairwise comparisons the Bonferroni method was used for correction for multiple comparisons. For comparison of 2 unrelated groups (with conversion and without conversion to microsurgical access) the Mann–Whitney test was used.

RESULTS

Description of the groups. Endoscopic intervention was performed in 17 patients: 13 (76.5 %) women and 4 (23.5 %) men. Mean patient age was 66.5 ± 6.2 years.

Thirteen (76.5 %) of 17 patients underwent surgical intervention on 1 level, 4 (23.5 %) patients – on 2 levels, therefore the total number of cases (levels) of surgical interventions was 21. Frequency of surgical intervention levels is presented in Fig. 3. Surgical access was performed at the symptomatic side (more pronounced pain syndrome in the leg): in 16 (76.2 %) of 21 cases, access was on the left side, in 5 (23.8 %) cases – on the right.

Median operative time was 180.0 [145.0; 180.0] min. In two-level decompressions, in 1 of 4 patients, the intervention lasted 120 min; in 3 of 4 patients, 180 min. Mean duration of single level interventions was 147.0 ± 7.0 min. Blood loss volume was 10.0 [10.0; 20.0] mL, median time spent in hospital was 4.5 [4.0; 6.5] days.

Per the MacNab surgical outcome scale, the following results were achieved: fair in 3 (17.6 %) of 17 patients, good also in 3 (17.6 %) patients, excellent in 11 (64.7 %) patients.

Temporal dynamics of pain syndrome (VAS score). Time changes of pain syndrome per VAS scores (leg/legs) were statistically significant (p = 0.006) (Fig. 4).

Post-hoc analysis showed that on day 1 after surgery VAS scores (leg/legs) were significantly lower than prior to surgery (1.5 [1.0; 3.0] *versus* 8.0 [7.0; 8.0], p_{adj} = 0.018). Six months after surgery, VAS scores remained significantly lower than prior to surgery (1.0 [1.0; 2.0] versus 8.0 [7.0; 8.0], p_{adj} = 0.042). At the same time, differences between VAS scores on day 1 and 6 months after surgery did not reach statistical significance (p_{adj} = 1.000).

Temporal dynamics of functional status (ODI). Time changes of the ODI scores were statistically significant (p = 0.005) (Fig. 5).

Post-hoc analysis showed that on day 1 after surgery ODI score was significantly lower than prior to surgery (14.4 [8.9; 18.0] % versus 42.2 [32.0; 52.0] %, p_{adj} = 0.010). Six months after the intervention, ODI remained significantly lower than prior to surgery (8.0 [6.0; 26.7] % *versus* 42.2 [32.0; 52.0] %, p_{adj} = 0.023). At the same time, differences between ODI values on day 1 and 6 months after surgery did not reach statistical significance (p_{adj} = 1.000).

Temporal dynamics of spinal canal CSA. Time changes in spinal canal CSA (cm²) were statistically significant (p = 0.001) (Fig. 6).

Post-hoc analysis showed that on day 1 after surgery spinal canal CSA was significantly higher than prior to surgery (1.59 [1.04; 1.88] cm² versus 0.65 [0.48; 0.93] cm², p_{adj} = 0.001). Six months after surgery this value remained significantly higher than prior to the intervention (1.15 [0.98; 1.49] cm² versus 0.65 [0.48; 0.93] cm², p_{adj} = 0.042). At the same time, differences in spinal canal CSA on day 1 and 6 months after surgery did not reach statistical significance (p_{adj} = 0.791).

Dynamics of spinal canal CSA increase per MRI data is presented in Fig. 7.

Complications. Intraoperative complication developed in 1 (5.9 %) of 17 patients. It consisted of an injury of the

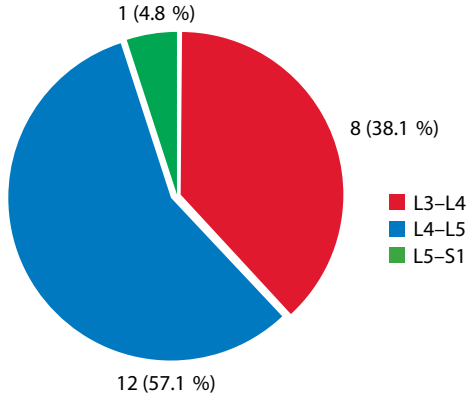

Fig. 3. *Incidence of the levels of surgical intervention*

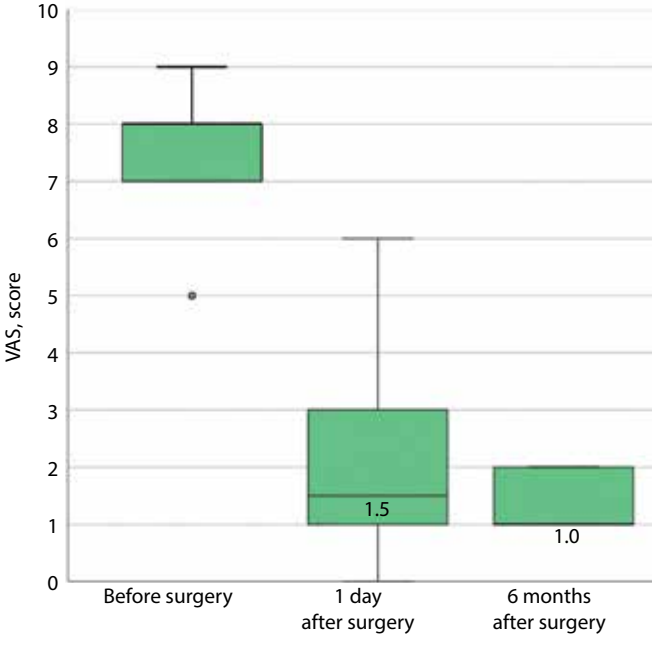

Fig. 4. *Temporal dynamics of pain syndrome in leg/legs evaluated using the Visual Analogue Scale (VAS)*

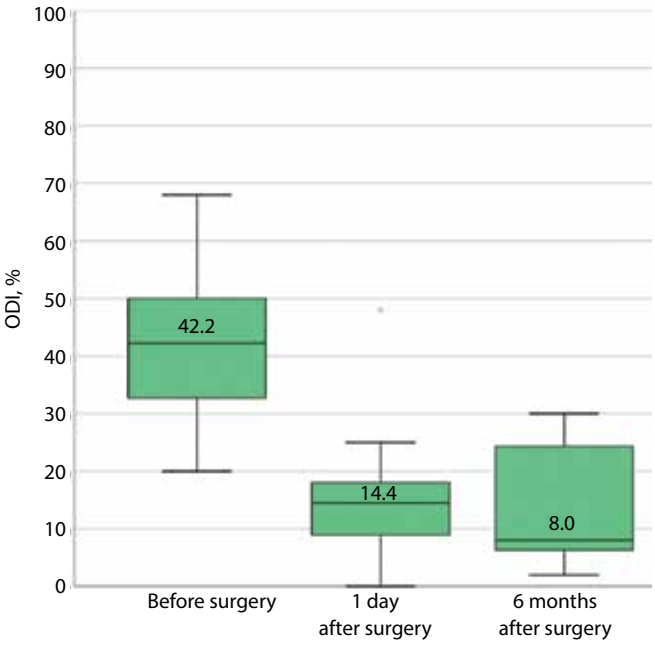

Fig. 5. *Temporal dynamics of the Oswestry Disability Index (ODI)*

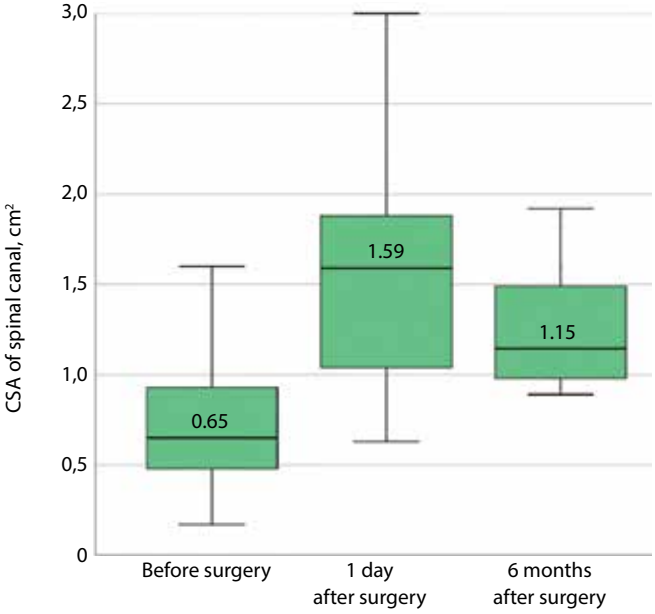

Fig. 6. *Temporal dynamics of the cross-sectional area (CSA) of the spinal canal in cm² per magnetic resonance imaging*

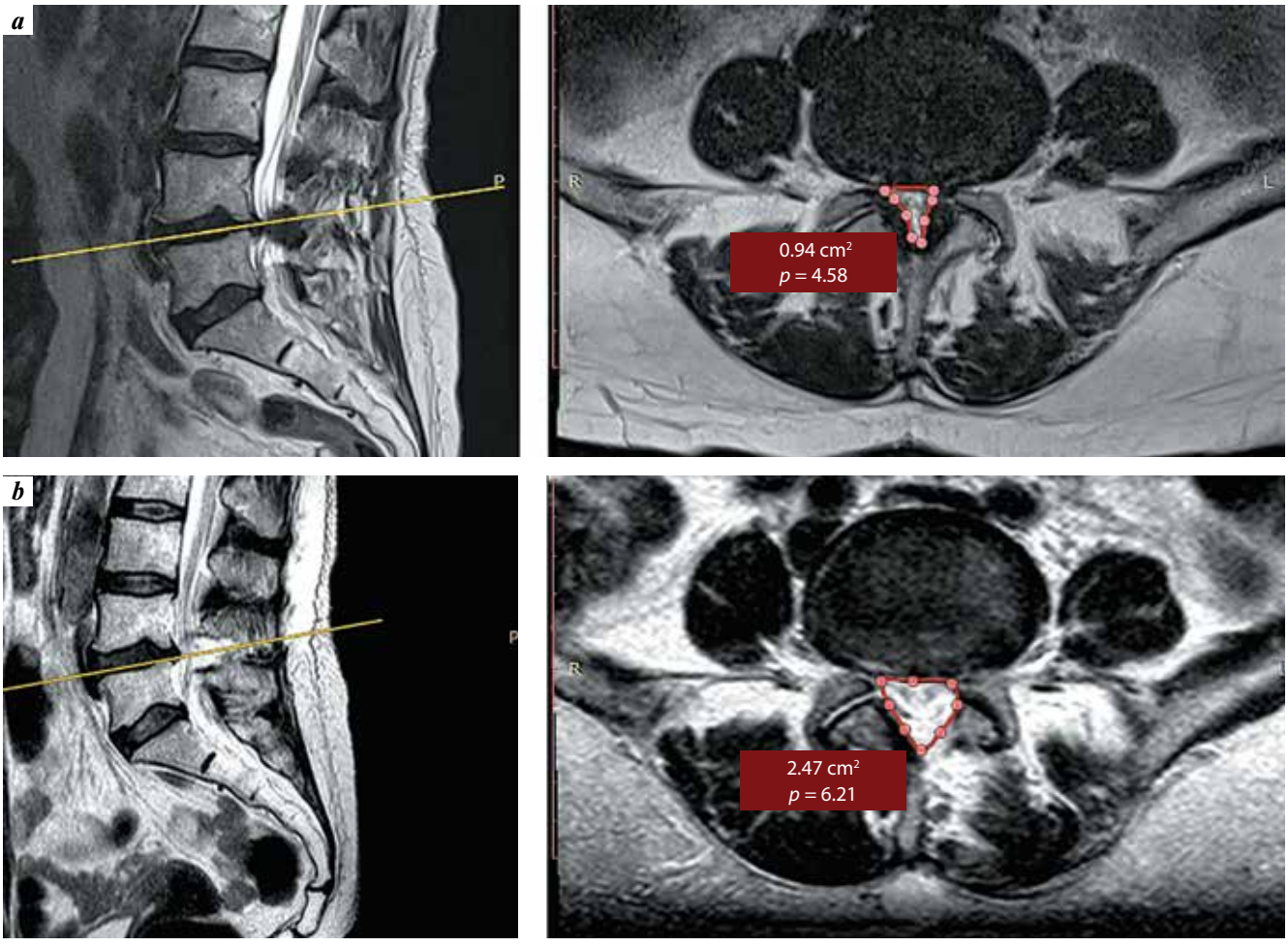

Fig. 7. *Dynamics of the cross-sectional area (CSA) of the spinal canal in cm² per magnetic resonance imaging: a – prior to surgery: CSA = 0.94 cm²; b – on day 1 after endoscopic decompression: CSA = 2.47 cm²*

dura mater and arachnoid meninges of the dural sac. Conversion to microsurgical access was not performed due to small size of the defect, the patient was prescribed bed rest for 1 day after surgery, no further complications developed (no neurologic deficit, no clinical manifestations of cerebrospinal fluid (CSF) dynamics, no CSF leak/arachnoid cyst formation).

Conversion of endoscopic access into microsurgical was required in 4 (23.5 %) of 17 patients: in 1 case in a female patient with two-level intervention; in 3 cases during single level decompression. All cases of conversion occurred at the access stage due to marked bleeding from the soft tissues due to much too lateral location of the port. This caused inconvenience despite working in water medium, and significantly increased operative time, therefore a decision to convert to microsurgical access was made. In none of the time points (on day 1 and 6 months after surgery), statistically significant differences in the evaluated VAS, ODI and MacNab values, spinal canal CSA changes were observed. However, the absence of differences can be caused by insufficient statistical power of comparisons (due to small group sizes).

DISCUSSION

During our study a hypothesis was formulated that in patients after endoscopic decompression of central degenerative stenoses clinical outcomes improve, namely pain syndrome decreases, functional status improves. This is supported by multiple studies of effectiveness and safety of minimally invasive interventions on the spine.

In the papers by H.S. Kim et al., the results of endoscopic decompression of degenerative stenoses were analyzed [8, 14, 15]. The authors state high effectiveness of this technique in central stenoses, lateral recess stenoses, actively use decompression of the contralateral side. R. Wagner from Germany, one of the leading specialists in endoscopy for spinal neurosurgery, in multiple studies performed in collaboration with other specialists demonstrates high applicability of endoscopic technique [9, 11, 16], its advantages compared to other methods, including advantages of tubular microendoscopy [17]. Russian teams of specialists actively performing endoscopic surgeries also describe quick patient rehabilitation after endoscopic interventions and extended indications for percutaneous surgery [4–7].

In surgery of degenerative stenoses, microsurgical technique is considered the "gold standard". However, currently percutaneous endoscopic techniques have been coming to the fore despite traditionality and widespread use of microsurgical accesses. Provided the surgeon's professionalism, high manual skills in operating the endoscope and endoscopic instruments, the use of endoscopic accesses leads to highly effective results comparable with the results of microsurgical decompressions or even surpassing them. However, this requires certain technical and time resources in the form of long skill training, procurement of the necessary costly equipment and, in general, passing the learning curve for endoscopic techniques. C.J. Siepe et al. mention the problem of the learning curve for endoscopic techniques which is one of the main and significant disadvantages of minimally invasive surgery – endoscopic interventions. And if previously endoscopic surgeries were performed for a limited spectrum of indications (for example, for acute herniated disks), primarily in young athletic patients, currently due to improvement of the equipment and techniques, surgical treatment of central degenerative stenoses in elderly patients with comorbid pathology has become possible [18, 19].

In studies dedicated to comparison of conservative and surgical methods of treatment of degenerative spinal disorders [20–22], heterogeneousness of the compared characteristics is observed which makes their analysis not completely accurate. The development of an algorithm of management of patients with degenerative stenoses including conservative, surgical and rehabilitative treatment stages remains an important problem.

The selection of preferable surgical tactics for treatment of patients with degenerative stenoses of the lumbosacral spine is dependent on the clinical and neurologic characteristics of the disease, as well as radiological data (primarily, MRI; in cases of suspected segment instability, X-ray of the lumbosacral spine with functional tests) [3, 10]. Despite the spread of minimally invasive approaches, the signs of instability of the affected by degenerative process spinal motor segment serve as an indication for stabilizing surgery [10, 23–25].

CONCLUSION

Our study has shown that both clinical (pain syndrome regression in the leg/legs per VAS, improved functional status per ODI, prevalence of good and excellent results per the MacNab scale) and radiological (adequate decompression volume determined through spinal canal CSA increase) results achieved using percutaneous endoscopic decompression of spinal central degenerative stenoses persist for at least 6 months after intervention which makes these surgeries effective both in the short and long terms.

However, this study is limited by insufficient sample power and limited accumulated material. Patient enlistment in the study continues, and further data analysis is planned.

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Authors' contributions
A.R. Yusupova performing endoscopic operations, collecting data for analysis, analysis of the data obtained, patients monitoring, article writing;
A.O. Gushcha: research design development, endoscopic surgery, patient monitoring, analysis of the data obtained, editing and approval of the article;
S.O. Arestov, D.V. Petrosyan: performing endoscopic operations, patient monitoring, editing of the article.

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Compliance with patient rights and principles of bioethics. The study protocol was approved by the local ethics committee of the Research Center of Neurology (protocol No. 1-4/22 dated 19.01.2022.). All patients gave written informed consent to participate in the study.

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