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Surgical Treatment of Severe Spondylogenic Cervical Myelopathy by Laminoplasty

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Objective. The objective of this study is to analyze the results of surgical treatment of patients with cervical myelopathy by laminoplasty. **Material and methods.** The surgical treatment of 30 patients (mean age 59.4 years) with cervical stenosis complicated with myelopathy was analyzed. Hirabayashi laminoplasty was performed in 26 patients and Kurokawa laminoplasty was performed in 4 patients. All patients were diagnosed with extended cervical spinal stenosis. Diagnosis was based on the results of examination, including the dynamic clinical and neurological examination, X-ray study, CT, MRI, SSEP, and TMS. Nurick scale, the scale of the Japanese Orthopaedic Association (JOA), and the recovery rate scale were used to assess the severity of myelopathy. **Results.** The long-term outcome in terms of clinical status and radiographic and neuroimaging parameters was evaluated in patients with cervical myelopathy who underwent laminoplasty. **Conclusion.** Laminoplasty is the method of choice in the treatment of extended spondylogenic cervical stenosis. Proper selection of patients based on clinical symptoms, assessment of the extent of stenosis, neurological examination and neuroimaging data leads to excellent results.

Keywords: *cervical myelopathy, laminoplasty, stenosis of the cervical spine.*

Abbreviations

CEMR — cortical evoked motor response
CT — computed tomography
MRI — Magnetic Resonance Imaging
SSEP — somatosensory evoked potentials
TMS — transcranial magnetic stimulation
JOA — Japanese Orthopedic Association

Classic spondylogenic cervical myelopathy (lower spastic paraparesis, flaccid paresis of the upper extremities, sensory conduction disorders) has rather low incidence. As a rule, patients seeking medical help have one or more of the following symptoms:

— movement disorders (decrease in strength, increased tone and spasticity in the legs, ataxia, etc.);

— sensory disorders (decrease/disruption of pain, joint and muscle sensitivity, etc.);

— reflex disorders (increase/reduction in tendon reflexes of arms and legs, abnormal plantar and carpal signs: Babinski, Rossolimo, Hoffmann).

Progressing degenerative changes in the spine and subsequent narrowing of the spinal canal are the most common causes of development of myelopathic presentation of the disease. Chronic compression of the spinal cord and roots causes ischemic changes in the nervous tissue.

Nowadays advances in the medicine allow nearly all patients with degenerative disorders of the cervical spine to undergo complex conservative treatment. Myelopathic presentation of the disease is typical for patients with long-lasting illness. The average time from the onset of clinical symptoms to seeking surgical help is 4 years. It should be noted that the number of patients seeking help form neurologists and neurosurgeons is growing every year.

Historically, the standard of care in spondylogenic myelopathy was cervical laminectomy. Over the time, however, this method has been replaced by more modern ones, and nowadays most surgeons prefer to perform decompression from the anterior approach (discectomy/corporectomy) [1]. Laminoplasty is one of the treatment options for spondylogenic myelopathy. The Z-shaped cervical laminoplasty was first described by M. Oyama et al. in 1973 [4] as a treatment for spondylogenic myelopathy due to spinal cord compression by the ossificated longitudinal ligament. Later the primary intervention has undergone numerous modifications and currently the most frequently used methods are those by K. Hirabayashi [2] and T. Kurokawa [12].

The aim of our research is to define indications for laminoplasty in patients with myelopathy and to analyze early and long-term outcomes of the interventions.

Material and Methods

The treatment efficiency was analyzed in patients with cervical stenosis complicated by myelopathy. All patients were operated on using laminoplasty. Out of 30 patients, Hirabayashi laminoplasty was performed in 26 patients and Kurokawa laminoplasty was performed in 4 patients. The average age of patients was 58.4 years; the ratio of women to men was 9:21. According to neuroimaging, 26 (76%) patients had compression at three levels, 3 (18%) patients had stenosis at four levels, and 1 (6%) patient had compression along 5 levels. The diagnosis was based on the results of dynamic clinical and neurological examination, X-ray study, CT, MRI, SSEP, and TMS. Indications for surgical treatment included compression at three levels or more, myelopathic syndrome due to compression of the spinal cord, motor and sensory

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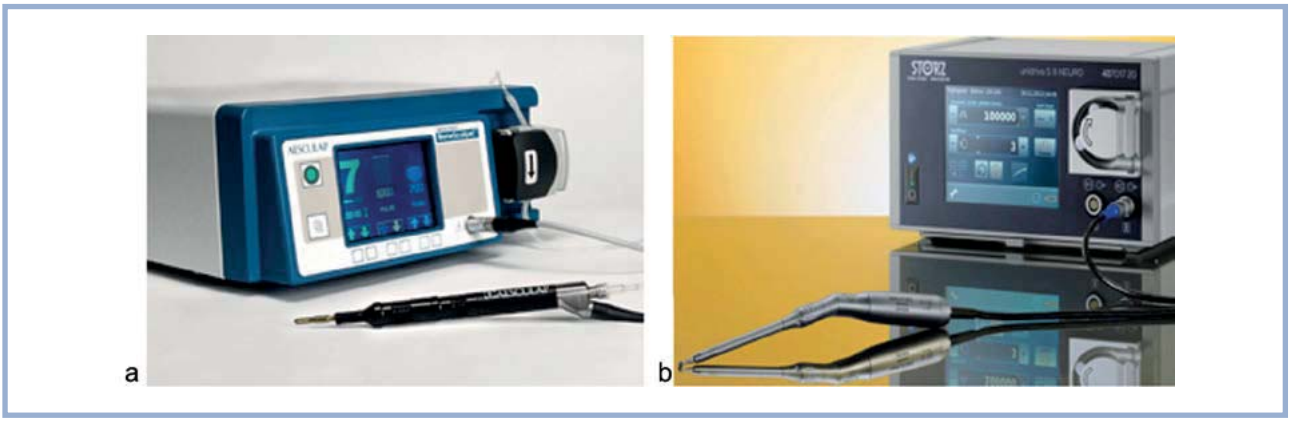


Fig. 1. **Power equipment required to perform laminoplasty with simultaneous foraminotomy.**
a — bone scalpel; b — high-speed burr.

disorders, dysfunction of the pelvic organs, changes observed in SSEP and TMS. A prerequisite for laminoplasty was preservation of slight lordosis or straightening thereof. Absolute contraindications for surgical treatment included acute inflammatory diseases and obvious signs of segmental instability.

Instruments used

In addition to a standard set of surgical instruments for operations on the spine, we used high speed burr with diamond tips and ultrasonic bone scalpel (MisonixBoneScalpel) **(Fig. 1)**.

Surgical technique: laminoplasty

A total of 26 patients were operated using Hirabayashi method under general endotracheal anesthesia. The position on the operating table: on the abdomen, upper limbs are placed along the body; the head is fixed in the «MAYFIELD» skull clamp. An EOC was used in all cases to map the surgical field and for intraoperative monitoring. Midline incision (8—10 cm in size) was performed above the spinous processes, and an electric scalpel was used to skeletonize the pedicle and facet joints of the adjacent vertebrae. Bleeding from soft tissue was stopped with gauze soaked in hydrogen peroxide solution and by bipolar coagulation. Yard retractor was inserted into the wound. Prior to the main phase of the surgery, we performed C4—C5 foraminotomy **(Fig. 2, 3)** as prophylaxis for C5 root palsy (incidence of 8% without foraminotomy).

After partial resection of the spinous processes (1/2 of the height), high-speed burr or bone scalpel was used to drill through the vertebral arches; a course of 2–3 mm (with the preservation of the internal cortical layer of the arches) was cut out on the opposite side. After cutting through, microsurgical instruments were used to remove the yellow ligament within the visible area to mobilize "arch — spinous process" complex. This complex was then lifted up as a whole and fixed with microplates and screws (6 mm). It should be noted that in our case the "arch — spinous process" complex was lifted up and fixed at least 30 degrees. It is necessary to achieve visualization of the dural sac in all cases **(Fig. 2)**. All patients were monitored in the intensive care ward for 24 hours after the surgery and the cervical spine was immobilized with Schantz collar for a period of 4 to 6 weeks [4, 9].

A total of 4 patients underwent laminoplasty according to Kurokawa: bilateral cut through the arches that was followed by central cut through the spinous process and its abduction. It expanded a section of the spinal canal, which was fixed in the predetermined position by metal-osteosynthesis.

Postoperative results were evaluated by both the diagnostic methods listed above (clinical and neurological examination, X-ray, CT, MRI) and by using the JOA scale, Nurick scale and Recovery rate scale [13, 14].

Results and Discussion

Unfortunately, modern surgical methods are not 100% effective in treatment of cervical spondylogenic myelopathy. Along with the increase in the number of patients with cervical myelopathy, there is an increase in the number of surgeries performed all over the world to treat cervical stenosis of various localization, and the increasing number of surgeries result in the increase in the number of patients for whom the surgery failed to provide expected outcomes.

Despite advance in and continuous refinement of spine surgery techniques, the issue of selecting the optimal surgical approach to treat spondylogenic cervical stenosis remains relevant. All currently used surgical methods have both advantages and disadvantages.

Laminoplasty, which is the subject of this paper, is a relatively new method of treatment of cervical stenoses. Since the method was first described in 1973, it has not received proper attention in the Russian surgical practice.

The main criteria for postoperative evaluation were: dynamics of clinical symptoms, increase in the anteroposterior section of the spinal canal and preservation of supporting ability.

The average time from the onset of the disease to the surgery was 45 months.

Prior to the surgery, all patients (100%) had symptoms of myeloplastic syndrome with varying degrees of severity (**Table 1**).

The JOA cervical myelopathy scale was used for objective assessment of neurological symptoms [13, 14] with subsequent calculation of the recovery rate. The average severity of myelopathy based on JOA scale was 8.27 points in the preoperative period and 11.18 points in the postoperative period **(Fig. 4)**. Recovery rate in our group of patients was quite high: 43.2% [14].

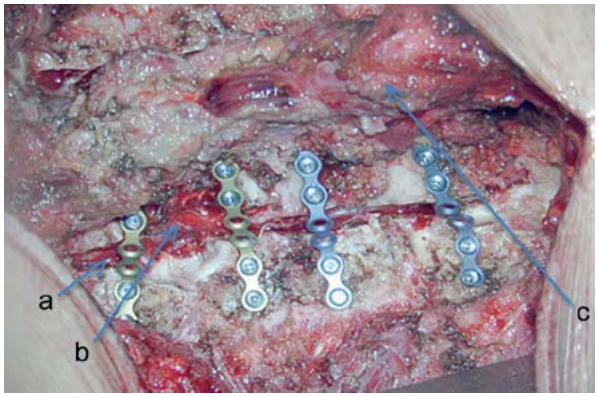


Fig. 2. **The final view of the post-operative wound.**

a — visualization of the dural sac pulsation; b — foraminotomy; c — spinous process, supraspinal ligament.

One of the clinical indicators of the treatment efficiency was assessment of gait disorders (Nurick scale) [14]. The majority of patients (88%) had average values of motor disorders of I-III degree, while the clinical presentation of the disease in 2 (12%) patients corresponded to VI degree. The median value of disorders severity amounted to 2 points prior to the surgery and 2.7 points after it **(Fig. 4)**. Therefore laminoplasty had a good clinical effect.

In addition to the clinical picture, we have calculated the diameter of the anteroposterior section of the spinal canal in the pre- and postoperative periods. The anterior

Table 1. **Severity of neurological symptoms in patients operated on for cervical stenosis**

Neurological symptom	*n* (*N*=30)
Upper paraparesis	11 (33%)
Tetrapareses	17 (51%)
Sensory disorders	15 (45%)
Pelvic disorders	2 (6%)
Increase/decrease in reflexes	29 (97%)
Change of gait	17 (51%)
Muscle atrophy	20 (60%)

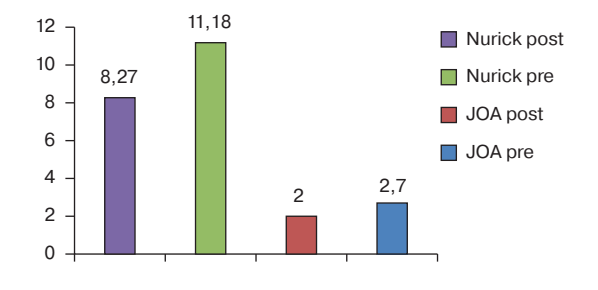


Fig. 4. **Evaluation of the neurological status of the patients on JOA and Nurick scales in the pre- and postoperative period (see text for the explanations).**

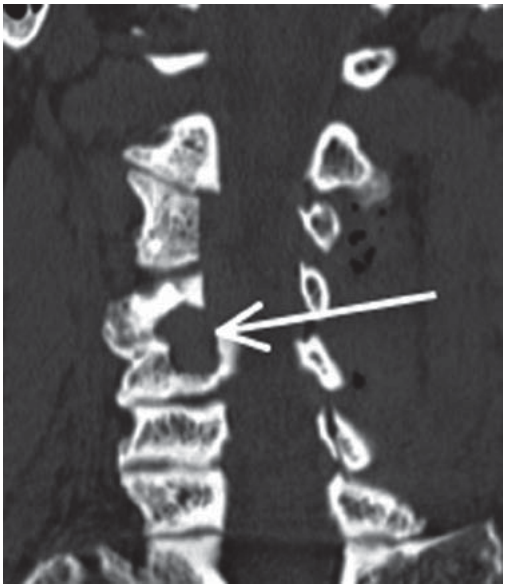


Fig. 3. **Postoperative CT examination.**

C4—C5 foraminotomy is indicated by an arrow.

starting point was the dorsal surface of the compression factor (ossified longitudinal ligament, herniated disc, marginal osteophytes), and the posterior point was the base of the spinous process. Average diameters of the spinal canal in patients without [3] and with cervical stenosis in our groups (before and after the surgery) are shown in **Table 2**.

Sagittal cross-section of the spinal canal after the surgery was measured by localizing software ClearCanvas Workstation 2.0. The anteroposterior size of the spinal canal has been increased by an average of 0.77±0.23 cm (**Fig. 5** and 6). In one third of the cases, we have expanded the spinal canal more than 2-fold (**Fig. 7, 8).**

In addition to neuroimaging techniques, TMS and the resulting SSEP are widely used for diagnosis of spondylogenic myelopathy. TMS allows evaluating the function of corticospinal tract **(Fig. 9)**.

The SSEP was used to assess the state of afferent pathways. Changes in the amplitude-time parameters of N13 and N20 components reflect the degree of dysfunction of afferent spinal cord pathways. The N13 component is the dorsal horns response and represents dysfunction of the central gray matter. Reduced amplitude of the N13 component during recording SSEP of the median, ulnar and radial nerves is pathognomonic for myelopathy. However, SSEP method does not allow assessment of the functional state of the motor tracts. Another drawback of SSEP is its inability to accurately pinpoint the level of spinal cord lesions **(Fig. 10)**.

In patients with no clinical symptoms of the disease the decision to perform the surgery was based on the data of the neurophysiological monitoring (TMS, SSEP). The

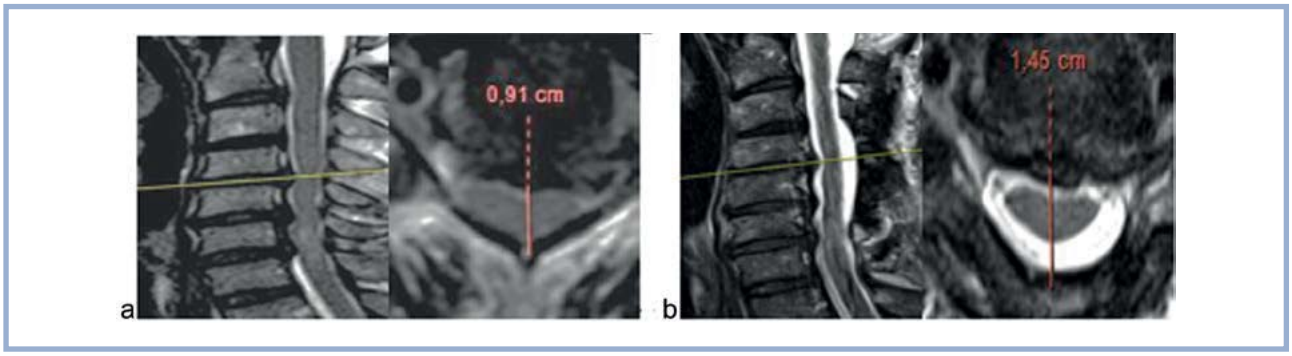


Fig. 5. **Calculation of the cross section before (a=0.91 cm) and after the surgery (b=1.45 cm). The sagittal and axial section at the C4—C5 level.**

a — rough compression of the spinal cord; b — the spinal cord is decompressed, the front and rear subarachnoid spaces can be visualized completely.

Table 2. **Spinal canal diameter at different levels in patients without cervical stenosis [3] and in our group in patients in pre- and postoperative periods**

Indicator	C3	C4	C5	C6	C7
Average values in patients without stenosis, mm	14.3±1.6	13.9±1.6	14.0±1.6	14.0±1.6	14.1±1.4
Averages values in our group before laminoplasty, mm	11.1±1.3	10.6±1.5	10.8±1.7	11.0±1.3	10.6±1.3
Averages values in our group after laminoplasty, mm	18.4±1.9	19.3±1.7	19.7±4.9	19.9±4.3	19.5±3.3

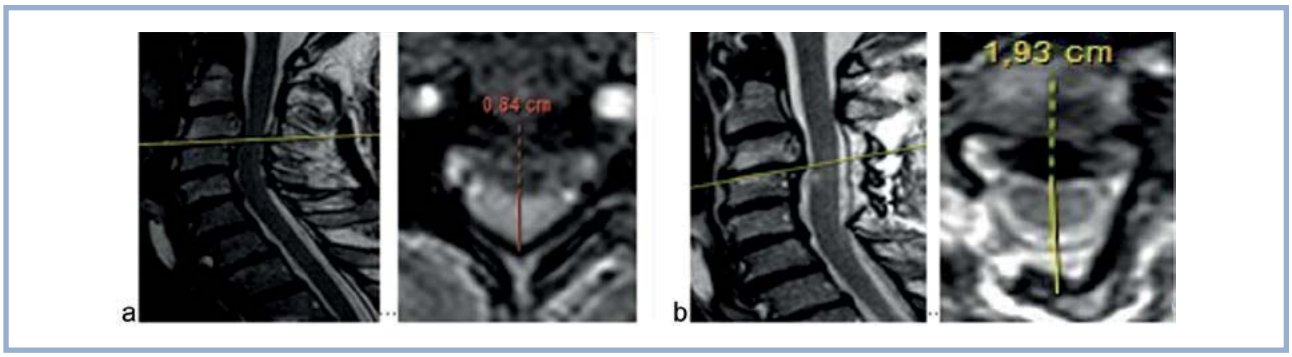


Fig. 6. **Calculation of the cross section before (a=0.84 cm) and after the surgery (b=1.93 cm). The sagittal and axial section at the C3—C4 level.**

a —rough compression of the spinal cord; b — the spinal cord is decompressed, the front and rear subarachnoid spaces can be visualized completely.

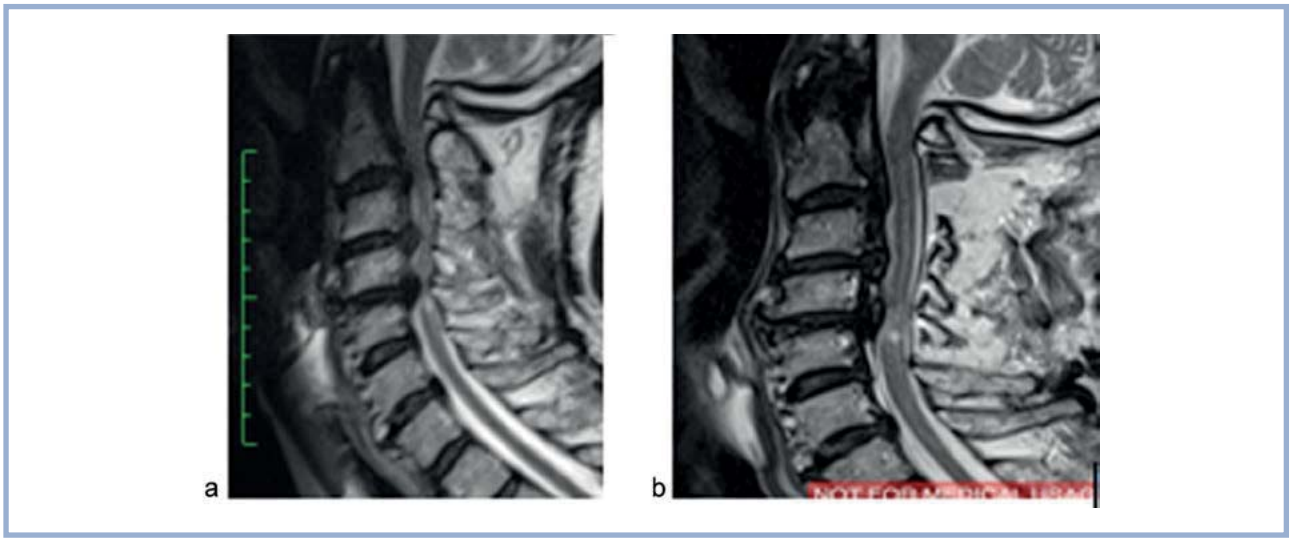


Fig. 7. **MRI of the patient *B*.**

a — prior to the surgery. Rough compression of the spinal cord at the C2—C4 levels with the formation of myelodysplastic focus. Absolutely no visualization of the anterior and posterior subarachnoid spaces; b — after surgery. Decompression allowed visualization of the part of the anterior and the complete posterior subarachnoid space.

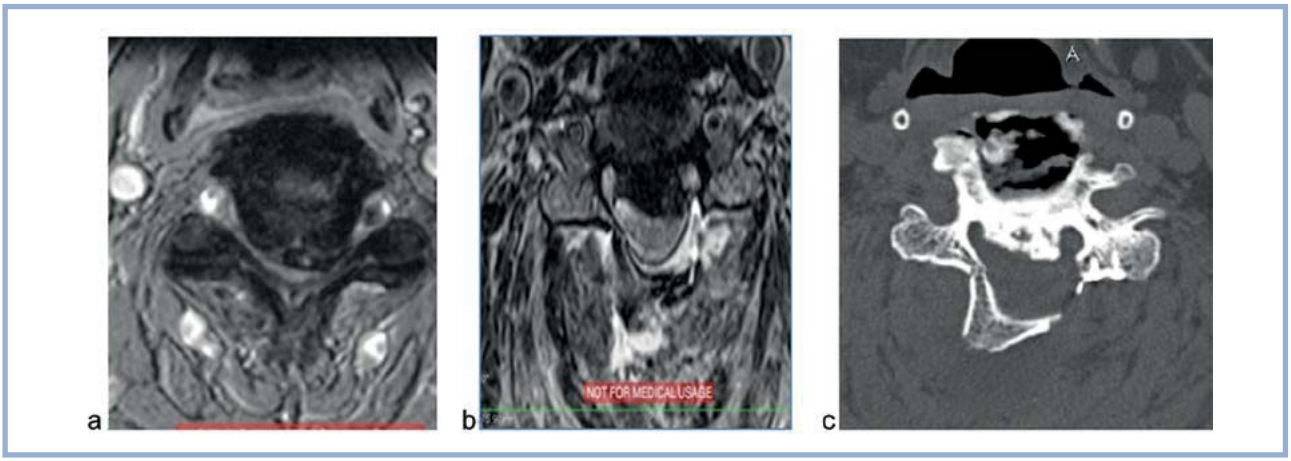


Fig. 8. **MRI and MSCT of the patient *Sh.***

a — rough spinal cord compression by osteophytes at C5—C6 level; b, c — MRI and MSCT after the laminoplasty; despite the presence of the osteophyte, lifting of the posterior of the complex had created a complete decompression of the spinal cord.

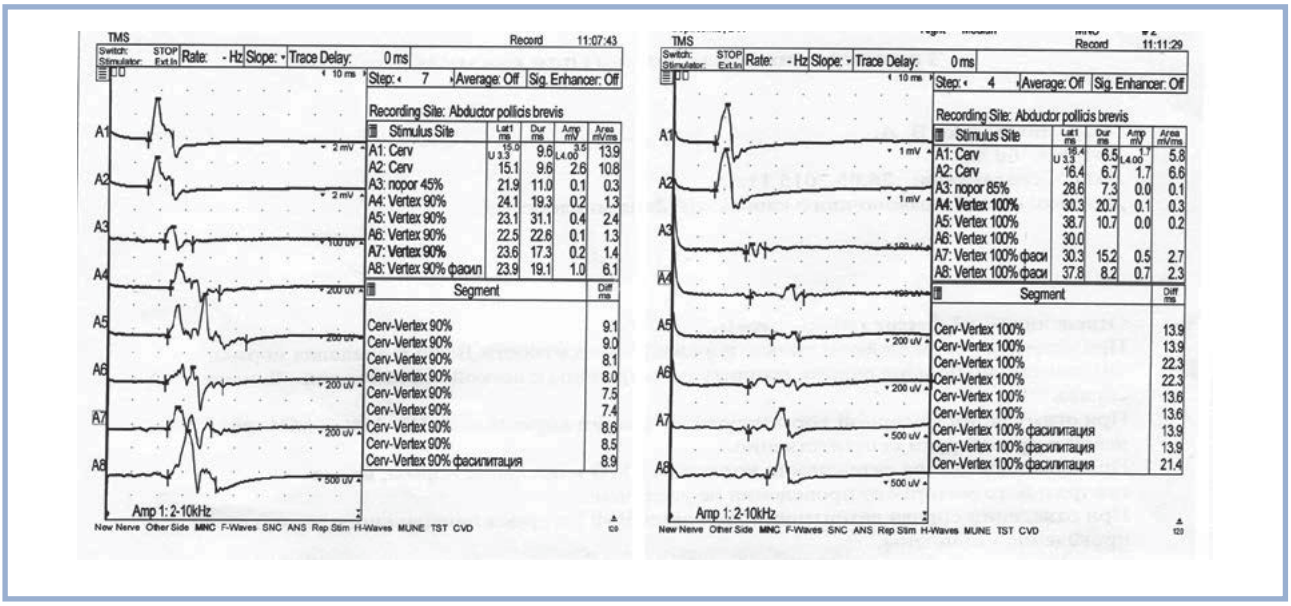


Fig. 9. **Transcranial magnetic stimulation, bilateral abduction of m. abductor pollicis brevis, m. abductor digiti minimi on the right revealed signs of bilateral disruption of conductivity along corticocervical tract: moderate at the left abduction, expressed in the study of the right hand.**

presence of changes in the amplitude-time parameters, reflecting the degree of spinal cord dysfunction, as well as changes in time for central motor conduction along corticospinal tract were indicative of high risk of development of neurological symptoms, and laminoplasty was suggested to this group of patients to prevent myelodysplastic syndrome. In the absence of the above, the surgery was not suggested.

To eliminate segmental instability, functional X-rays were performed in all patients prior to the surgery. In the postoperative period, the follow-up examination 3—6 months after the surgery did not reveal any signs of instability in our group of patients **(Fig. 11)**.

Complications

A total of 3 (10.2%) patients have developed C5 paresis, which regressed on its own by the time of discharge. Analysis of foreign literature demonstrated that this complication have an incidence of 8% [6, 8]. For example, Sasai K. and T. Saito [10] had no deficit in the C5 root in a group with simultaneous foraminotomy, but 4 cases of C5 palsy in the group without foraminotomy at this level.

Taking into account the preoperative MRI data, 1 (3.3%) patient underwent laminoplasty at C3—C4, C6. A short-term post-operative outcome was good, but control MRI revealed increase in compression at C5 and

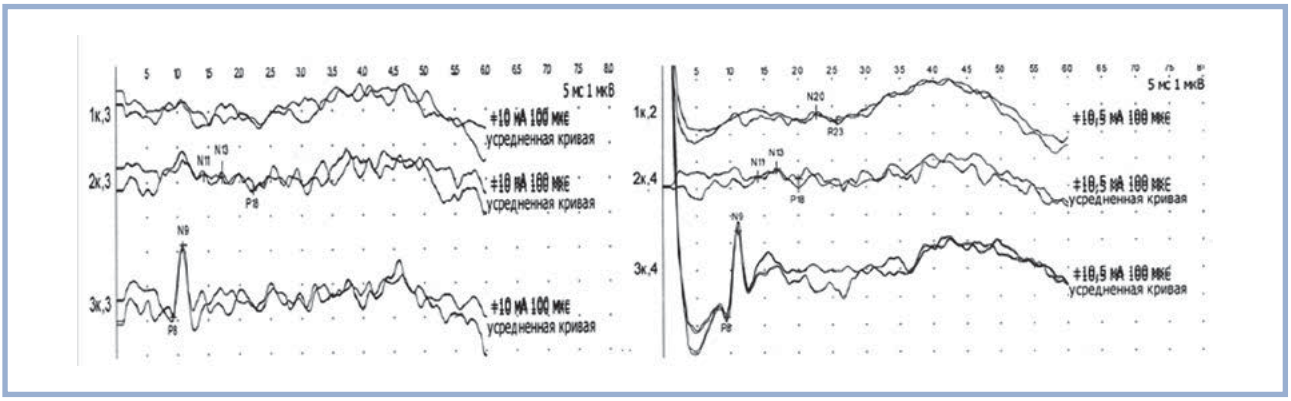


Fig. 10. **SSEP examination demonstrated that stimulation of the median nerves result in preserved peripheral level responses. The components of brainstem-spinal and cortical levels are reduced and are recorded unreliably, with a significant increase in latency and reduction in amplitude, and are better expressed with stimulation on the right (with the increase in the central conduction time and N9-N11 interval). There is marked disruption of afferentation at spinal-brainstem level: expressed with stimulation of the right, rough with stimulation on the left.**

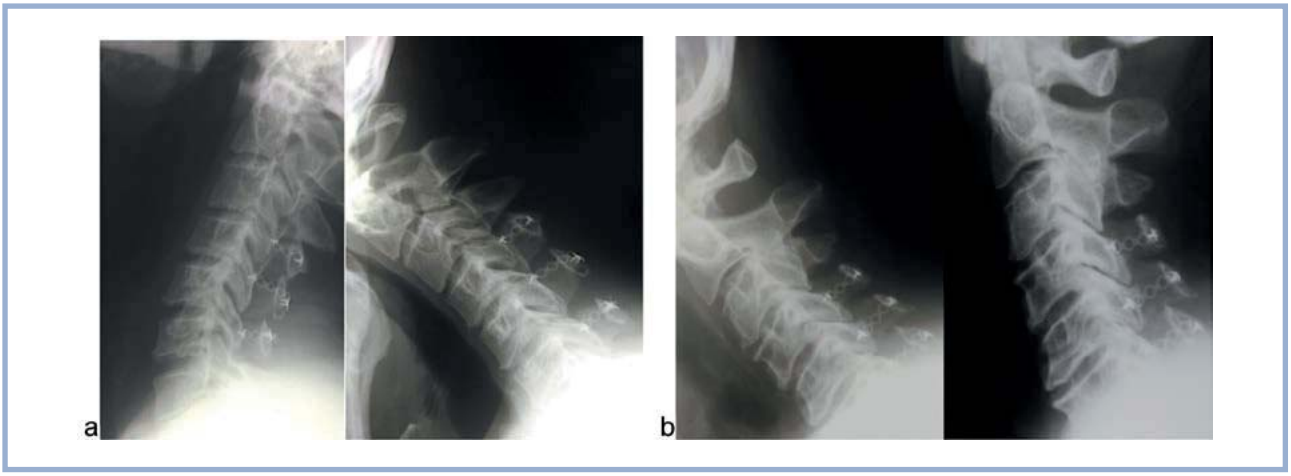


Fig. 11. **An example of the functional postoperative radiographs after 16 months.**

Signs of segmental instability are absent.

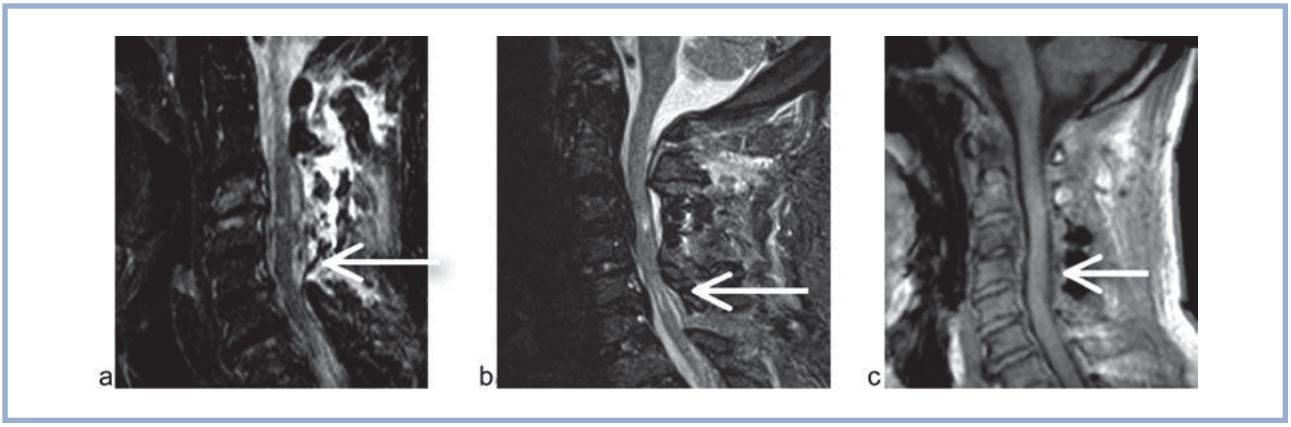


Fig. 12. **The MRI of the patient *P.***

a — MRI before the operation: the arrow indicates compression; b — MRI of the same patient 3 months after the decompression: the arrow indicates the preservation of compression at the level of C5; c — MRI after re-intervention: compression is eliminated

the appearance of clinical symptoms **(Fig. 12)**. Therefore, the primary surgery was later supplemented by C5 laminoplasty.

The control MRI of 1 (3.3%) patient revealed a tense hematoma with spinal cord compression, and the patient underwent revision surgery with good clinical outcome.

In one case, a patient developed severe ataxia in the early postoperative period. The MRI examination revealed no surgical complications. The patient was referred to rehabilitation and achieved good clinical outcome.

Visual analogue scale was used to assess pain in the postoperative period; the average value amounted to 2—3 points, i.e. good outcomes.

Conclusion

Our results demonstrate the need for accurate and comprehensive analysis of the neurologic status, neuroimaging findings and data of neurophysiological studies in patients with cervical myelopathy. Laminoplasty, as an adequate method of treatment, is an alternative to anterior decompression. It is not inferior to it, and in some cases (expanded stenosis) have undeniable advantages. Correctly chosen treatment tactics can significantly improve the clinical status of patients in this group. Laminoplasty is fairly easy to perform and does not require any special technical skills from a neurosurgeon. Small financial costs associated with the surgery allow its implementation in local and regional neurosurgical hospitals. The method is the "golden mean" between major anterior decompressions (multilevel corporectomy with fixation) and standard laminectomy.

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Commentary

This article describes the initial experience of the authors in the use of expansive laminoplasty for treating cervical spinal stenosis.

The authors provide detailed description of both the procedure and the issues and complications associated with this type of surgeries. This is useful for Russian neurosurgery, where the use of foreign sources for daily improvement of their education is not a characteristic mode of behavior for practicing neurosurgeons.

Evaluation of advantages and disadvantages of the method presented by the authors in comparison with the anterior approach and elucidation of the indications for the intervention are not the main objective of this paper. The author of works ensures that with further accumulation of scientific advances in neurosurgical practice and follow-up data the team of Professor A.O. Guscha will present new papers on effectiveness and differential use of all methods for treatment of cervical myelopathy caused by spinal canal stenosis.

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