

# ROLE OF MODIFIED OPEN-DOOR LAMINOPLASTY IN THE TREATMENT OF MULTILEVEL CERVICAL SPINAL STENOSIS: A RETROSPECTIVE ANALYSIS OF 43 CASES

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## A MÓDOSÍTOTT „OPEN DOOR” LAMINOPLASZTIKA SZEREPE A MULTISZEGMENTÁLIS NYAKI GERINC-CSATORNA-SZŰKÜLET SEBÉSZI KEZELÉSÉBEN: 43 ESET RETROSPEKTÍV ELEMZÉSE

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**Background and purpose** – Symptomatic degenerative multilevel cervical spinal stenosis - beside other methods - is often treated using the open-door laminoplasty. This procedure aims to decompress the spinal cord and preserve the stability of the cervical spine. The efficiency and safety of the method was proved by numerous Japanese and American studies, also the technique related complications are well known.

We treated 43 patients with symptomatic multilevel cervical spine stenosis using the open-door laminoplasty as a surgical procedure of choice in the National Institute of Clinical Neurosciences between 2009 and 2012. In this article we analyse our results and the related literature is discussed.

**Methods** – Symptomatic patients with a minimum of three-segment cervical spine stenosis and radiologically proved myelopathy or with electrophysiologically verified subclinical myelopathy were selected for laminoplasty. Patients in whom cervical kyphosis was present were operated on using laminectomy and posterior fusion. Postoperative control CT, MRI and/or X-ray images were made after the surgery and at six weeks, three, six and 12 months after the operation and in the same time neurological evaluation was performed. The modified Japanese Orthopaedic Association (mJOA) scale value was assigned to patients preoperatively, six weeks, three, six and 12 months after the operation. The statistical difference between the groups of data was tested by chi square test.

**Results** – The average follow-up time was 27 months (minimum seven, maximum 42). According to the mJOA scale, 26 patient's condition (61%) improved, in 13 cases (30%) remained unchanged, and in one case (2%) we detected neurological deterioration. We lost three patients during the follow up period. The median of mJOA preoperatively was 12 (minimum eight, maximum 18), while six week postoper-

**Bevezetés** – A multiszegmentális degeneratív nyaki gerinc-csatorna-szűkület sebészeti kezelésében – más eljárások mellett – gyakran használt módszer a módosított „open-door” laminoplasztika. A műtét célja a gerincvelő dekompressziója a gerinc stabilitásának párhuzamos megőrzésével. A módszer hatékonyságát és biztonságát számos japán és észak-amerikai vizsgálat eredménye bizonyította, emellett a technika szövődményei is jól ismertek.

**Célkitűzés** – Célunk az Országos Klinikai Idegtudományi Intézetben 2009 és 2012 között nyaki gerinc-csatorna-szűkület miatt módosított open-door laminoplasztikán átesett 43 beteg posztoperatív eredményeinek retrospektív elemzése a nemzetközi irodalom tükrében.

**Módszer** – Ha a tünetekkel rendelkező betegeinknél radiológiailag igazolt, minimum három szegmensre kiterjedő nyaki gerinc-csatorna-szűkület állt fenn, myelopathiával vagy elektrofiziológiailag igazolt szubklinikus myelopathia volt igazolható, laminoplasztikára került sor. Nyaki kyphosis esetén laminectomia és hátsó fixáció volt a választott eljárás. Posztoperatív kontroll-CT-, -MRI- és/vagy röntgenfelvételek készültek a műtétet követően, valamint hat hét, három, hat és 12 hónap elteltével. Ugyanezekben az időpontokban neurológiai vizsgálatokra is sor került. A betegek állapotát a preoperatív, majd a posztoperatív hat hét, három, hat és 12 hónap elteltével a módosított Japanese Orthopaedic Association (mJOA) -skála alapján értékeltük. A csoportok közötti eltéréseket  $\chi^2$ -próbbával teszteltük.

**Eredmények** – Az átlagos követési idő 27 hónap volt (7–42). Az mJOA-skála alapján 26 beteg (61%) állapota javult, míg 13-é (30%) nem változott és egy esetben (2%) tapasztaltunk romlást. A követési idő alatt három beteg esett ki. A preoperatív mJOA-értékek mediánja 12 (8–18), míg a posztoperatív 6. héten 14 (10–17) volt. Három, hat és 12 hónap elteltével a medián nem változott, amely jelzi, hogy a

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ative mJOA was 14 (minimum 10, maximum 17). Three, six and 12 months mean value of mJOA was 14 which shows that the improvement in patients' condition remained stable at one year after surgery. The difference was statistically significant ( $p < 0.05$ ). The canal's average anteroposterior diameter on CT was  $8.29 \pm 0.92$  mm at the level of C III, while after the operation we measured  $15.16 \pm 1.02$  mm;  $7.54 \pm 0.62$  mm at the level of C IV before, and  $15.29 \pm 0.2$  mm after;  $9.05 \pm 0.48$  mm at the level of C V before and  $17.23 \pm 0.4$  mm after the surgery. The differences proved to be significant ( $p = 0.0001$ ).

**Conclusion** – According to our experiences the modified open-door laminoplasty is an efficient and safe method for the treatment of symptomatic multilevel cervical spinal stenosis.

**Keywords:** cervical myelopathy, multilevel cervical stenosis, open-door laminoplasty

With increasing age, a significant part of the population shows radiological signs of spondylosis or discopathy, leading to stenosis of the spinal canal, usually in the region of the cervical spine (multilevel cervical stenosis). Although congenital stenosis is also possible, this is mostly result of progressive disc degeneration, accompanied by disc protrusion or herniation, formation of ventral spondylophyte, thickening of the ligamentum flavum, hypertrophy of the dorsal facets and ossification of posterior longitudinal ligament (OPLL). These changes cause local damage to the spinal cord, and also affect the vessels feeding it. There is a close association between the presence of spinal stenosis and the occurrence of cervical myelopathy which peaks between the ages of 50 and 60<sup>1</sup>.

Clinical course of the disease is highly variable. Symptoms usually develop slowly. Enhanced reflexes, spasticity, pyramidal tract symptoms are characteristics of this disease, sensory disturbances are usually not related to dermatomes. According to the literature most symptoms worsen over the years. There is evidence that about 5% of all patients with asymptomatic spinal cord compression become symptomatic each year<sup>2</sup>. There are also patients with an acute clinical course. In patients with asymptomatic, but severe stenosis acute spinal cord compression after a minor trauma may lead to tetraparesis or even tetraplegia.

The suitable strategy for the treatment of symptomatic multilevel cervical spinal stenosis, has to be chosen carefully. It can consist of conservative treatment options as well as surgical solutions. In cases with myelopathy surgical treatment is pre-

ferred, because the myelopathy can rapidly lead to persistent deterioration. It is important to mention that no conclusive evidence exists which proves superiority of surgery over the conservative treatment when myelopathy is not present<sup>3</sup>.

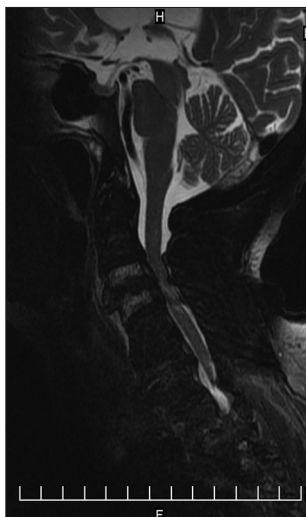
The goal of the surgery is to decompress the cervical spinal cord. To achieve this, space occupying elements must be removed. This can be done ventrally, by resection of the intervertebral disc, removal of the spondylophytes, in some of the cases the body of the vertebra, or dorsally by removing the ligamentum flavum, hypertrophic facets, laminae. The decision on dorsal or ventral decompression depends on many factors: the number of affected segments, how is the alignment and instability of the cervical spine, is OPLL present or not, how severe is the accompanying neck pain, how old is the patient, etc. and the surgeon's experience in using the different techniques.

**Következtetés** – Eredményeink alapján a módosított open-door laminoplasztika hatékony és biztonságos eljárás a multiszegmentális nyaki gerincsatorna-szűkület sebészi kezelésében.

**Kulcsszavak:** nyaki myelopathia, multiszegmentális nyaki gerincsatorna-szűkület, open-door laminoplasztika

The long-term results of ventral approaches and dorsal decompression are equivalent.

With the aim of preserving and reconstructing the posterior structures and preventing the frequently reported postoperative complications, various types of laminoplasty techniques have been described<sup>4-9</sup>. The laminoplasties are divided two main group: unilateral (open door procedure) and bilateral (double door or French door) laminoplasty<sup>10</sup>. Several publications deal with different techniques of reconstruction of the laminar roof, which is proved to be a valuable alternative to laminectomy. In addition laminoplasty can be use in cases where the anterior approach is not recommended. In the past many clinical study demonstrated the



**Figure 1.** T2 weighted MRI image shows spinal canal stenosis at the level of C III-V



**Figure 2.** T2 weighted cervical MRI image shows no signs of stenosis six months after the operation: in addition the vertical alignment has changed

efficiency and safety of cervical laminoplasty from East Asia and USA while there are only a few information about the European experiences<sup>11-16</sup>.

Significant differences between the different laminoplasty techniques have not been found. The operating time, blood loss, outcome and morbidities are all supposed to be similar between the two main group of laminoplasty techniques. One less bone gutter to be made in the middle in unilateral laminoplasty seems to be time-sparing for surgeons who prefer the open door procedure<sup>10</sup>.

We analyzed and summarized our experiences with modified open-door cervical laminoplasty.

## Method

Fourty-three patients were operated on with symptomatic multilevel cervical spine stenosis using open-door laminoplasty, from 2009 to 2012 in the National Institute of Clinical Neuroscience. The group of patients contained 32 males and 11 females. Patients with minimum three or more level stenosis with myelopathy were selected for surgery. The myelopathy was verified with MRI (**Figure 1.**), subclinical myelopathy was diagnosed electrophysiologically. We made X-ray and CT imaging preoperatively in all patients to determine the bony elements causing compression and to verify the possibility of OPLL.

Patients who had kyphotic cervical alignment or instability was suspected were treated with laminectomy and dorsal fusion with transpedicular or massa lateral screws and rods, or using ventral approach with corpectomy and ventral fixation. Control MRI was made in all patients at six weeks, six and 12

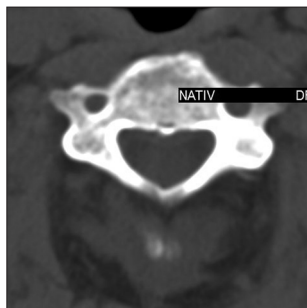
months to verify the decompression and visualize the structure of the myelon and the extension of the signs of myelopathy (**Figure 2.**). Control CT and X-ray were made, in all patients after the surgery and at six weeks, three, six and 12 months to check the bony elements, visualize the bony healings, the position of the implants and the presence of kyphotic tendency and neurological evaluation was done at the same time (**Figures 3A-D**). In all cases we made functional lateral X-ray image in order to check the stability of the cervical spine.

In order to quantify the data, we assigned a score from the modified Japanese Orthopaedic Association scale (mJOA scale) to all patients preoperatively and six weeks three, six and 12 months after the operation. This score is consists of four parts. The first is scoring the motor function of upper limb from 0 to five, the second the motor and sensory function of lower limb from 0 to seven, the third the sensory function of upper limb from 0 to three while the fourth one the vegetative functions from 0 to three. In all parts 0 is the worst score. The maximum score a healthy person can gain is 18, while the minimum score is 0. The difference between the groups of data was tested with chi square test using Medcalc® for Windows software (MedCalc Software).

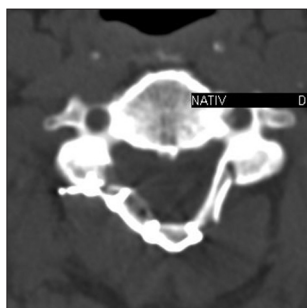
Measures were performed to check the enlargement of the antero-posterior (axial) diameter of the spinal canal at the operated levels.

## SURGICAL TECHNIQUE

We used modified open-door laminoplasty with autograft spacer in all of the cases. The patient lay in prone position (**Figure 4.**) while the head and neck were held in mild flexion fixed in Mayfield device. Midline incision was taken. On the clinically more symptomatic side just medial to the facet the lamina was transected, then on the other side –



**Figure 3A.** Axial CT image shows the spinal canal before the operation the miniplate at the level of C III



**Figure 3B.** Axial CT image shows the fixed bone graft with titanium miniplates at the level of C III: the cervical spinal canal diameter is enlarged



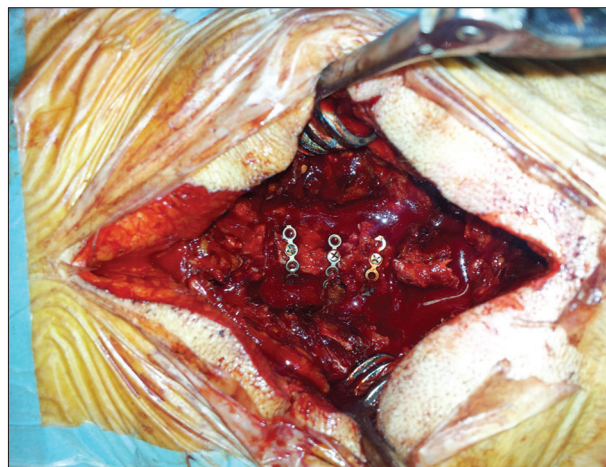
**Figure 3C.** Sagittal CT reconstruction image shows no spinal canal stenosis after the surgical intervention



**Figure 3D.** 3D reconstructed CT image shows the cervical spine after laminoplasty with bone graft and fixed by miniplates and screws: the diameter of CIII-VI levels are enlarged



**Figure 4.** The intraoperative positioning of the patient (prone position, the head fixed with tree-point fixation device - Mayfield)



**Figure 5.** Intraoperative image shows bonegrafts fixed with titanium miniplates and screws

the hinge side – the laminae were only thinned with cutter. After that, the cutted laminae were lifted up carefully together, so we expanded the spinal canal in antero-posterior diameter. A part of the operated vertebra's spinous process were used as a spacer and fixed with titanium mini plates and screws to the two sides of transected lamina (**Figure 5.**).

In case of accompanied radiculopathy, the nerve root decompression was done in addition to laminoplasty on the open side.

## Results

The patient's mean age was 62 years with the range from 42 to 79 years. In most cases (35 patients =

82%) the origin of cervical spinal canal stenosis was degenerative. The ossification of posterior longitudinal ligament (OPLL) was the cause of stenosis in four cases (9%), three patients (7%) had congenital stenosis, while in one case (2%) trauma was presented. The most common preoperative symptom was paraesthesia (29 cases, 67%). 26 patients (60%) had paresis: tetraparesis in 16 cases (37%) monoparesis in seven (16%) cases and hemiparesis in two cases (5%). Furthermore we observed difficulty of walking (23, 53%), muscle weakness (19, 44%), irradiating pain in arms (17, 40%) and vegetative disorders (19%).

Twenty patients underwent cervical laminoplasty at three levels, 17 patient at four, five patient at five and one patient at six levels. The average num-

ber of operated laminas was 3.55. The nerve root decompression was done in addition to laminoplasty in three cases. After the surgery the irradiating pain improved.

The average follow-up time was 27 months (minimum seven, maximum 42).

The preoperative median mJOA was 12 (ranged from eight to 18), while in the sixth postoperative week was 14 (range from 10 to 17). The difference was significant ( $p < 0.05$ ) with chi square test. Three, six, and 12 months median value of mJOA was 14 which shows that the improvement in the patient's condition remained stable at one year after procedure.

We lost three patients during follow up, two of them did not appear to a regular examination time, while one patient died due to co-morbidity.

Out of the other 40 patients 26 improved (~61%), 13 (~30%) remained unchanged and one (~2%) patient's condition deteriorated. Postoperative instability of cervical spine was not seen on flexion-extension fluoroscopy.

The most common complication was the axial-neck pain which was present in 6 cases (14%). Nerve root palsy occurred at two patients (5%), both of them involved C5 root. Wound healing problem did not occur. In three cases blood transfusion was needed due to intraoperative blood loss. After the surgery we suggested to all of the patients to wear cervical collar for six weeks.

Postoperative CT or MR images in all of the cases showed that the anteroposterior diameter of spinal canal enlarged. The canal's average anteroposterior diameter on CT was  $8.29 \pm 0.92$  mm at the level of C III, while after the operation we measured  $15.16 \pm 1.02$  mm;  $7.54 \pm 0.62$  mm at the level of C IV before, and  $15.29 \pm 0.2$  mm after;  $9.05 \pm 0.48$  mm at the level of C V before and  $17.23 \pm 0.4$  mm after the surgery. The differences proved to be significant ( $p = 0.0001$ ).

## Discussion

There is no exact information about the prevalence of cervical spondylotic myelopathy (CSM). According to the literature it peaks between 50–60 years<sup>17</sup> so it occurs mainly in the older population. Our data support this, in our patient group age ranged from 42 to 79, the mean age of the patients was 62. The sex ratio was 2.9:1 (male:female) in our study which comparable with data in the literature, (2.7:1)<sup>17</sup>.

Prevalence of OPLL is significantly higher in Asia, where the 1.9-4.3% of population suffers from

it. In Europe and in the USA the prevalence is 0.01-1.7%. OPLL patient's average age is about 50 years and the gender distribution is male:female 2:1<sup>18</sup>. Four percent of our patients were operated on because of cervical spinal stenosis caused by OPLL.

In both of CSM and OPLL pathophysiology is multifactorial. Evolution of OPLL is attached to some genes - such as BMP2 or TGF $\beta$  - which have key functions in osteogenesis and in bone mineralization<sup>18</sup>. Development of CSM can be described as a cascade: static and mechanical factors together cause degenerative changes in spine, which can lead to ischaemia in spinal cord and the result is myelopathy<sup>19</sup>.

Because of the diversity of causes, the most reliable treatment of multilevel cervical stenosis is surgical intervention, however in cases where myelopathy has not yet developed the disease can be treated conservatively. Surgical techniques can be divided into two groups depending on the direction of approach: anterior and posterior methods<sup>20</sup>.

The anterior surgical procedures are used if the cause of stenosis is localised in front of spinal cord, so that can be removed directly. They have the advantage of maintaining and restituting the cervical lordosis. Performing a laminectomy with posterior fusion is also an effective procedure when kyphosis or instability is present. These techniques can be used for both single and multilevel stenosis, nevertheless there are some cases when the anterior approach cannot be done. If the cause of the spinal canal stenosis is OPLL, the discectomy is not sufficient because the back surface of the vertebra cannot be seen from this approach. Corpectomy could solve this problem, but it is important to note in case the ossified ligamentum is attached to dura, performing corpectomy can cause dural injury, liquor leakage and moreover injury of spinal cord. Further problem is that in cases of two or more level corpectomy HALO or posterior fixation is necessary and the surgical stress for patients is high, so it is not recommended for the treatment of older patients, or in patients with significant co-morbidity.

The disadvantages of anterior techniques can be avoided by posterior methods. The oldest technique is to decompress the spinal cord posteriorly was the laminectomy. This procedure may destroy the stability of the cervical spine and surgical stabilization may become necessary later. Laminectomy with posterior fixation can preserve the stability, but implants increase the costs.

Laminoplasty is a posterior surgical technique its goal is to decompress the spinal cord with the enlargement of the spinal canal while the dorsal

bony elements are partially kept and therefore the biomechanics of the spine is maintained. Multilevel stenosis with myelopathy verified by MR imaging or subclinically by electrophysiological tests are the main indication for laminoplasty, but if stenosis affects only one level, laminoplasty is not recommended. Further contraindications are the preoperative kyphosis of cervical spine, severe axial-neck pain - because these are the complications of the procedure too -, any pathological change of the posterior structures - such as ossification of ligamentum flavum or epidural fibrosis<sup>21</sup>.

When radiculopathy accompanies, the nerve roots decompression is possible by foraminotomy in addition to laminoplasty. In case of open door laminoplasty, nerve root decompression by foraminotomy feasible on the open side, but the side to be opened may variable the laterality of symptoms<sup>10</sup>.

According to the literature the average improvement of patients is 55-65%<sup>3</sup>. Sixty one percent of our patients improved and remained stable after 12 months. Some previous data suggest that this improvement is not stable and patient's state deteriorates later<sup>3</sup>. We plan to perform a long-term follow up regarding our patients for investigating this statement.

There are some risk factors associated with the recovery. Poorly controlled diabetes discourages the return of sensory functions, mainly in the legs<sup>22</sup>. The severity of stenosis and the duration of symptoms are risk factors too, it is recommended to perform the surgery as soon as possible<sup>23</sup>.

Two main complications of the laminoplasty are the axial neck-pain and nerve root palsy. There are minor complications such as kyphosis, loss of motion

range and local hematoma. Axial-neck pain is common, it occurs in 0-60% of patients, in our series 14% of patients mentioned it. It develops due to the neck muscle disruption and it's incidence is significantly correlated with the preservation of C7 vertebra<sup>24</sup>.

Occurrence of nerve root palsy is 0-30%<sup>25</sup>. Similarly to the literature we observed it in our series in 5% (two patients). Currently the exact pathomechanism is not known, but there are some theories trying to interpret that. Mainly it is attributed to the intraoperative injury of nerve root. This is acceptable if the palsy occurs immediately after the operation, but not in cases appearing days after the operation. According to the "tethering phenomenon" the success of the decompression is highest in the C5 segment therefore postoperatively here could develop a stretch on the root due to the backward move of spinal cord and this tension able to cause the palsy.

Another hypothesis is that injury is caused by evolving re-perfusion due to decompression.

Although the clinical and radiologic results are very promising, the limited follow-up time does not allow us to draw conclusions with respect to long-term results of the procedure.

## Conclusion

Our experiences verify the statement that modified open-door laminoplasty is an effective and safe procedure for decompression of the cervical spinal cord. Data we gained from our series are in accordance with the international data. Further investigations are needed to determine the long-term follow up results of the procedure.

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