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# Anterior Neurodecompression of Kyphotic Spondylogenic Myelopathy Ranawat Grade III and Posterior Decompression of Lordotic Spine Improve Walking Ability

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**A B S T R A C T**

*Cervical spondylosis is common condition rarely associated with radiculomyelopathy which surgical treatment, according to meta-analysis, is not better than nonsurgical. Our hypothesis was that neurodecompression which type is chosen according to spinal alignment should result in better functional improvement comparing with nonsurgical treatment. Between January 1, 1998 and December 31, 2007 a total of 77 patients with spondylogenic myelopathy were selected for the study. The inclusion criteria were symptoms and signs of myelopathy Ranawat grade III. Exclusion criteria were amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS). The curvature of the cervical spine was determined by Ishihara index. Anterior corpectomies and fusion was performed in the kyphotic spines, laminectomy with fusion in patients with neutral position, and open door laminoplasty in lordotic spines. Clinical improvement was assessed as differences between preoperative and 1-year follow up Nurick, modified Japanese Orthopedic Association (mJOA) myelopathy scales and walking test. Preoperative and postoperative transverse cord area and subarachnoid space were measured. Forty-four male and 31 female patients were surgically treated. Two patients with electrophysiological signs of ALS were excluded. Preoperative and postoperative mean ± SD mJOA index was 9.15 ± 1 and 13.01 ± 1.4 (p<0.001), Nurick grading scale 3.05 ± 0.7 and 1.8 ± 0.6 (p<0.001), walking time (sec) 64.4 ± 3.2 and 46.2 ± 3.3 (p<0.001), and number of steps 69.7 ± 4.4 and 57.6 ± 2.8 (p<0.001) respectively. Preoperative and postoperative transverse cord area (mean ± SD, mm$^2$) was 46.7 ± 5.4 and 60.2 ± 2.6 (p<0.001), and subarachnoid space 48.0 ± 4.9 and 68.8 ± 8.5 (p<0.001) respectively. Our results showed that surgical treatment is beneficial for patients with spondylogenic myelopathy.*

***Key words:** cervical spondylosis, gait disorders, myelopathy, surgical decompression, spinal curvatures*

## Introduction

Cervical spondylotic myelopathy is a common cause of serious morbidity in middle age and elderly population[1]. Half of the middle-age population has radiologic or pathologic evidence of cervical spondylosis[2,3]. This condition is often asymptomatic, but in 10% to 15% of the population, it is associated with root or cord compression[4]. Therapeutic effects of surgery for myelopathy are not always satisfactory[5]. According to a meta-analysis, the outcome of the patients who underwent surgery is similar to the result obtained by non-surgical management[6]. In addition, surgical procedure for cervical myelopathy can be associated with severe complications, including death[7–11]. In the view of these uncertainties, it is not surprising that there are substantial variations in the proportion of patients with cervical spondylotic myelopathy who are referred for surgery[12]. Our hypothesis was that decompression which type is selected according to spinal alignment should result in functional improvement in well-se-

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lected myelopathic patients. The aim of our study is to present results obtained in the patients suffering from spondylogenic myelopathy who were surgically treated.

## Patients and Methods

### *Patients*

From January 1, 1998 to December 31, 2007, a total of 77 patients, 44 male and 31 female patients, with spondylogenic myelopathy eligible for the study were surgically treated by senior author in Department of neurosurgery County Hospital Pula or in the University Hospital of Traumatology, Zagreb, Croatia. The indication for surgical treatment and inclusion criteria were symptoms and signs of compressive myelopathy graded as Ranawat III[13]. Their symptoms had not improved despite the application of nonsurgical treatment. The existence of cord compression confirmed by MRI or CT-myelography was required for the inclusion into the study. Patient's consent to participate in the clinical trial and radiographic follow-up was also required. Patients with clinical and electrophysiological finding of anterolateral sclerosis and multiple sclerosis were excluded. Ethics committee approved the clinical trial.

### *Clinical evaluation*

Clinical findings were scored according to the Ranawat myelopathy grading score (Table 1)[13]. Patients classified as Ranawat grade III were included into the study. In addition, the Nurick grading scale (Table 2)[14], the modified Japanese Orthopaedic Association myelopathy grading scale (Table 3)[15] and walking test were used for clinical evaluation. Improvement was assessed as the difference between preoperative and one-year follow-up examination results.

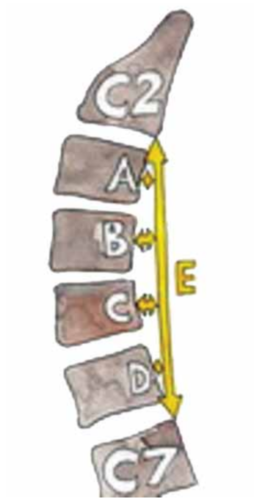


*Fig. 1. Ishihara index is calculated as: a+b+c+d/E x 100 where a,b,c and d represent distance between posterior corporal margin of vertebrae C3, C4,C5 and C6 and line E. Line E represents distance from caudal end of the C2 vertebra to cranial end of C7 vertebrae.*

**TABLE 1**
RANAWAT SCALE FOR QUANTIFICATION OF THE PATIENTS IMPAIREMENT WITH SPINAL CORD COMPRESSION

| Class | Clinical findings |
|---|---|
| **1** | No neural deficit |
| **2** | Subjective weakness with hyperreflexia and dysesthesia |
| **3** | Objective findings of weakness and long-tract signs |
| **3A** | Could walk |
| **3B** | Not ambulatory |

**TABLE 2**
NURICK CLASSIFICATION FOR ASSESMENT OF THE PATIENTS WITH SPONDYLOGENIC MYELOPATHY

| Grade | Clinical findings |
|---|---|
| 0 | Radiculopathy with no myelopathy |
| 1 | Positi Positive physical signs for upper motor neuron compression, but walking without impairement |
| 2 | Walk Walk with slight difficulty, able to work full working time |
| 3 | Walk with difficulty, unable to work full time |
| 4 | Walk with aid |
| 5 | Bad Bad or wheel chair ridden |

**TABLE 3**
MODIFIED JAPANESE ORTHOPAEDIC ASSOCIATION MYELOPATHY GRADING SCALE

| Grade | Clinical findings |
|---|---|
| I | Motor dysfunction of the upper extremity |
| 0 | Unable to feed oneself |
| 1 | Unable to use a knife and fork; able to eat with a spoon |
| 2 | Able to use a knife and fork with much difficulty |
| 3 | Able to use a knife and fork with slight difficulty |
| 4 | None |
| II | Motor dysfunction of the lower extremity |
| 0 | Unable to walk |
| 1 | Can walk on flat floor with walking aid |
| 2 | Can walk up and/or down stairs with handrail |
| 3 | Lack of stability and smooth gait |
| 4 | None |
| III | Sensory deficit |
| 0 | Upper extremity, severe sensory loss or pain |
| 1 | Upper extremity, mild sensory loss |
| 2 | Upper extremity, no sensory loss |
| | 0–2: lower extremity, 0–2: trunk |
| IV | Sphincter dysfunction |
| 0 | Unable to void |
| 1 | Marked difficulty in micturation (retention) |
| 2 | Difficulty in micturation |
| 3 | None |


*Fig. 2. Sagittal spinal stenosis was graded at the levels C4-5 and C5-6 as grade IV and at the level C6-7 as grade III; grade 0 = normal width of the spinal canal, no signs of anterior or posterior subarachnoid space narrowing; grade I = partial obliteration of the anterior or posterior subarachnoid space or both; grade II = complete obliteration of the anterior or posterior subaracnoid space or both; grade III = anterior or posterior cord impingement or both.*


*Fig. 3a. Stenosis at the axial plan images – axial plan stenosis shown at T2 sequence of MRI of the same patient at the most severely affected level C5-6.*

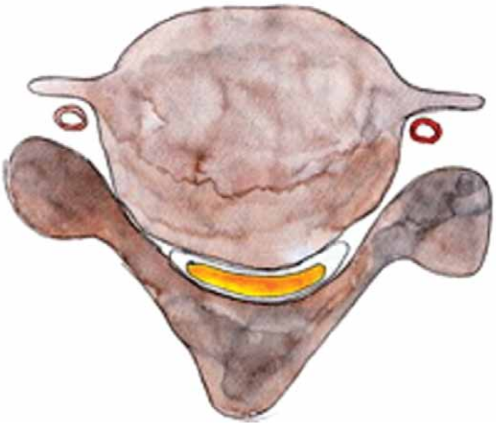

*Fig. 3b. Stenosis at the axial plan images – line drawing shows transverse cord area with yellow colour and subaracnoid area with light blue colour. Areas are calculated using computer softwers.*

### *Radiological evaluation*

Preoperative plain radiographs of cervical spine were obtained in all patients. The curvature of the cervical spine was measured using the Ishihara index (Figure 1)[16]. MRI was performed preoperatively and at one-year follow-up examination using the standard method. All levels of sagittal spinal stenosis were noted and graded at the most severely affected level according to Muhle, et al (Figure 2)[17]. The size of stenosis was measured on axial plain images (Figure 3) at the most compressed level: a) the transverse area of cervical spinal cord on T1-weighted spine echo image, b) the area of subarachnoidal space, and c) the remaining area of the subarachnoidal space on T2-weighted sequence. The severity of myelopathy was classified according to Wada et al.[18]: diffused hyperintensity, localized hyperintensity and without spinal cord intensity change on T2 sequence.

### *Surgical techniques*

Anterior cervical corpectomy with fusion is performed in the patients with a positive Ishihara index. The patient in general anesthesia is carefully placed in the supine position with a slightly extended neck and head to minimize potentials for new neurological deficit. The standard anterolateral approach to the cervical spine is used. Adequate decompression of the spinal canal is obtained by meticulous removal of bone, annular, and ligamentous structures with operating microscope assistance. Augmented fusion with autologous fibula strut graft is performed to restore the anterior column stability. The middle third of the fibula is harvested in the length that is needed to fill the defect produced by corpectomy (Figure 4). Fibular graft is positioned and locked with dynamic plate with screws.

Laminectomy with lateral mass fusion is performed in the patients with neutral Ischihara index. The patient in general anesthesia is placed in the prone position with the head on a Mayfield head-rest in a slightly extended position of the head and neck. Using the posterior mid-

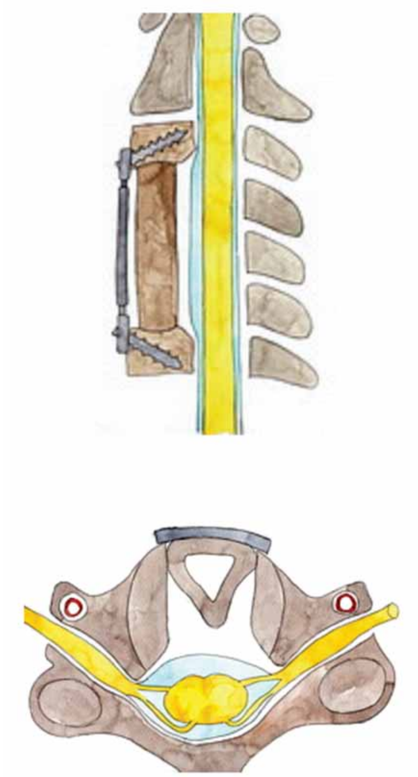

*Fig. 4. Augmented fusion with autologus fibula strut graft following corpectomies in: a) sagittal view b) axial view*

line approach, a bilateral subperiosteal dissection of posterior elements to the facets is carried out. A fine high-speed burr is used to thin the lamina at the facet-lamina junction (Figure 5a) and laminas are removed, while all preoperatively planned foraminotomies are performed. Lateral mass screws are placed according to the Magerl technique and connected with rods (Figure 5b).

Open door laminoplasty is performed in the patients with positive Ischihara index. The patient in general anesthesia is placed in the prone position with a slightly extended head and neck. Via the posterior midline approach, a bilateral subperiostal dissection of posterior elements to the facets is carried out. Spinal processes of C7 and T1 vertebrae are harvested. A gutter in the facet lamina junction is performed on the left side using a high speed drill. The ligamenta flava of both upper and lower ends of the laminar door are removed. The outer lamina at the right sided facet lamina junction is drilled. All planned foraminotomies are performed. Now, the laminar door is opened, and its closure is prevented by insertion of the spinal process between the lamina and facet joint at the upper and the lower end of the decompressed area (Figure 5c).

### *Statistics*

Descriptive statistics and the Smirnov-Kolmogorov test were performed to analyze data distribution. A pair-

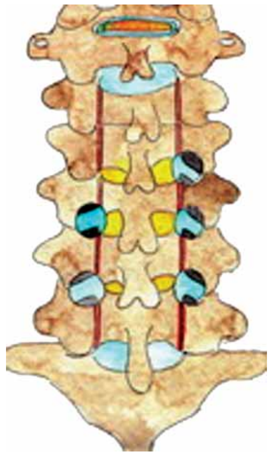

*Fig. 5a. Via posterior midline approach all needed foraminotomies and the furrows at the facet lamina junctions on the both sides are performed*

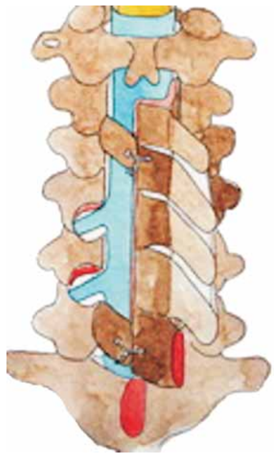

*Fig. 5b. Lateral mass screws are placed according to Mager technique after laminectomy.*

*Fig. 5c. Furrow on the left side is deepened to the dura, ligamenta flava above and below are removed, and laminas are hinged on the right-sided furrow; closure of the door is prevented by insertion of C7 and T1 spinal process between lamina and facet joint at the upper and the lower end of decompressed area.*

ed-samples t-test was conducted to evaluate the difference between pre-op and post-op data. All statistical procedures were performed with SPSS for Windows statistical package, version 15.0. All P values under 0.05 were considered significant.

## Results

In a ten-year period (January 1, 1998 – December 31, 2007), 77 patients with symptoms and signs of spondylogenic cervical myelopathy graded as Ranawat III were recruited for the study. During the first two years, clinical myelopathy was confirmed by CT myelography. In the next eight years, MRI was used for radiological confirmation of myelopathy. Two patients with electrophysiological signs of anterolateral sclerosis were excluded from the study. There were 44 male and 31 female patients aged 61 (range 48–69) years (Table 4).

The preoperative Ishihara index was positive in 23 patients, in whom open door laminoplasty was indicated. In 4 patients cervical spine had a straight alignment and laminectomy with lateral mass fusion was indicated. The Ishihara index was negative in 48 patients and multiple corpectomy with autologus fibula grafting was indicated. After one-year follow-up clinical improvement was noticed according to the Nurick grade (mean ± SD) changing from $3.05 \pm 0.7$ preoperatively to $1.8 \pm 0.6$ postoperatively ($p<0.001$). Modified Japanese Orthopedic Association score (mean ± SD) improved from $9.15 \pm 1$ preoperatively to $13.1 \pm 1.4$ ($p<0.001$) postoperatively. Walking time (mean ± SD) shortened from $64.4 \pm 3.214$ preoperatively to $46.2 \pm 3.3$ ($p<0.001$) postoperatively, and number of steps (mean ± SD) decreased from $69.73 \pm 4.363$ preoperatively to $57.6 \pm 2.8$ postoperatively ($p<0.001$).

At six-week follow- up MRI spinal cord was significantly more voluminous as seen from the transversal cord area (mean±SD, $mm^2$) that increased from $46.7 \pm 5.4$ preoperatively to postoperatively $60.2 \pm 2.6$ ($p<0.001$). The arachnoidal space (mean ± SD, $mm^2$) widened from $48 \pm 4.9$ preoperatively to $68.8 \pm 8.5$ postoperatively ($p<0.001$).

**TABLE 4**
CLINICAL DATA OF PATIENTS

| | | | |
|---|---|---|---|
| Gender (M/F) | | | 44/31 |
| Age (yr) | | | 61 (50–70) |
| Symptoms duration (months) | | | 11 (4–20) |
| MRI myelopathy according to Wade et al. | | | |
| Diffuse hyperintensity (T2) | | | 63 |
| Localized hyperintensity | | | 12 |
| Sagittal stenosis | | | |
| No of involved levels | Gr. II | Gr. III | Total |
| Two level | 5 | 14 | 19 |
| Three level | 10 | 30 | 40 |
| Four level | 5 | 11 | 16 |
| Total | 20 | 55 | 75 |

Transitional donor site pain was noticed in 9 patients from the anterior approach group. There were no patients with donor site pain at one-year follow-up examination. Two patients in the laminoplasty group had transitional left sided C5 and both C5 and C6 palsy. At one-year follow-up examination, there was no motor deficit in the above-mentioned two patients. In the laminoplasty group, delayed wound healing was noticed in three patients.

## Discussion

Our results showed that patients with spondylogenic cervical myelopathy improved significantly their ability to walk and quality of life after thorough surgical decompression. Type of decompression was chosen according to cervical spine alignment. Batzdorff and Batzdorff stressed that spinal geometry should be considered in the selection of the best surgical procedure for the patients with spondylogenic myelopathy[19]. In their study, they concluded that significant abnormalities of spinal curvature might account for some instances of poor outcome after laminectomy.

Our findings that patient's ability to walk and quality of life improved postoperatively are in disagreement with single class I study dealing with the outcome of surgically treated patients with spondylogenic cervical myelopathy. Bednarik and colleagues did not find any lasting beneficial effect of surgery in their randomized controlled trial[20]. Earlier studies conclude that progressive disability will not necessarily develop in the untreated individuals[21–24], but improvements with conservative treatment were anecdotally reported[25]. Persson and colleagues conclude that surgery, physiotherapy and a cervical collar are equally effective in the treatment of long lasting cervical radiculopathy[26].

Both static and dynamic spinal canal stenosis are important in the pathophysiology of SCM. A narrowed spinal canal causes compression of the enclosed cord, leading to local tissue ischemia, injury, and neurological impairment[27]. A growing body of evidence indicates that excessive motion of the compressed spinal cord results in injury within the spinal cord[28]. Sorar and colleagues showed in their study that patients with cervical spondylogenic myelopathy benefited from anterior decompression and fusion despite insufficient decompression of the spinal canal[29]. Their results suggested that the fusion was the main prognostic indicator. Yamaura and colleagues found both in experimental animals and humans spinal cord apoptosis under chronic compression with resulting irreversible neurologic deficit[30]. Surgical decompression resulted in improvements in neurological function and reorganization of the brain cortical representation of the affected extremity[31]. Mentioned pathophysiological characteristics suggest that thorough decompression in relatively short lasting myelopathy should be optimal treatment for these patients, and therefore we followed the rules.

For the kyphotic spines ventral decompression was chosen, for lordotic spines laminoplasty, while laminectomy plus lateral mass fixation was used for straightened spine[32–35]. Multiple corpectomies were used for decompression in patients with kyphotic deformity. Following initial description of anterior cervical spine decompression and fusion by Cloward and Smith and Robinson and multiple corpectomies and autologous fibula strut grafting by Whitecloud and LaRocca, these techniques are commonly in use[36–40]. A complete decompression often involves resection of the great part of vertebral body, leaving only lateral sides. Although this procedure can lead to a complete neurologic decompression and excellent clinical results, graft complications were reported. Progressive anterior cervical decompression significantly increases the instability of the spine[41]. Wang et al.[42], reported that 16 patients out of 249 who underwent multiple corporectomy and fusion without instrumentation experienced graft migration or displacement. The use of autologous iliac crest graft following 1 or 2 corpectomies and fibular graft after more than 2 corpectomies and graft locking with dynamic implants resulted with fusion in all our patients.

Open-door laminoplasty was used in lordotic patients. Kohno and colleagues found in their study that in patients with multisegmental stenosis expansive laminoplasty can provide a favorable outcome when canal is enlarged to the normal range (over 12 mm residual anteroposterior diameter and 200 $mm^2$ residual canal area)[43], but recovery rate is poor in patients with kyphotic deformity[44,45]. Significant neurological improvement is associated with posterior cord migration after laminoplasty (Figure 6)[46]

Houten et al.[47] concluded that multilevel laminectomy and instrumentation is associated with minimal morbidity, provides excellent decompression of the spine, produces immediate stability, prevents kyphotic deformity, and precludes further development of spondylosis at the fused levels. Neurological outcome is equal or superior to multilevel anterior procedure and prevents spinal deformity associate with laminoplasty or noninstrumented laminectomy[48].

*Fig. 6. Open door laminoplasty allows posterior migration of the spinal cord following thorought spinal cord decompression as shown in drawings: a – compressed spinal cord preoperatively, and b – thorought decompression postoperatively.*

Our results showed that surgical treatment is beneficial for well selected patients with spondylogenic myelopathy if surgical approach is planed according to spinal alignment.

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## PREDNJA DEKOMPRESIJA MIJELOPATIJE RANAWAT III KADA JE VRATNA KRALJEŽNICA KIFOTIČKI DEFORMIRANA I STRAŽNJA DEKOMPRESIJA LORDOTIČNE KRALJEŽNICE POBOLJŠAVA FUNKCIJU HODA

### S A Ž E T A K

Vratna spondiloza je česta pojava rijetko poveziva sa radikulomijeolpatijom čije kirurško liječenje prema meta-analizi nije ništa bolje od nekirurškog liječenja. Naša hipoteza je bila da neurodekompresija čiji tip je izabran prema zakivljenosti kralježnice, mora rezultirati boljim ishodom od nekirurškog liječenja. Od 1. siječnja 1998. do 31. prosinca 2007. godine ukupno 77 bolesnika sa spondilogenom vratnom mijelopatijom uključeno je u studiju. Kriteriji uključivanja bili su mijelopatija III stupnja Ranawat klasifikacije. Kriteriji isključivanja bili su amiotrofična lateralna skleroza (ALS) i multipla skleroza (MS). Zakrivljenost kralježnice određivana je prema Ishihara indeksu. Prednje korpektomije sa fuzijom učinjene su u kifotičnih kralježnica, lainektomije sa fuzijom u bolesnika sa neutralnim položajem a laminoplastika u lordotičnih kalježnica. Klinički oporavak ocijenjivan je prema razlici između preoperativnih vrijednosti i vrijednosti nakon 1 godine praćenja prema Nurick ljestvici, modificiranoj ljestvici Japanskog ortopedskog društva (mJOA) i prema testu hodanja. 44 muškarca i 41 žena su kirurški liječeni, 2 bolesnika sa znacima ALS-a su isključena iz studije. Postoperativni mJOA indeks bio je 9.15 ± 1 a postoperativni 13.01 ± 1.4 ($p<0.001$),vrijednosti Nurick ljestvice 3.05 ± 0.7 prije operacije te 1.8 ± 0.6 ($p<0.001$) postoperativno, zatim test hodanja (sec) 64.4 ± 3.2 i postoperativno 46.2 ± 3.3 ($p<0.001$), te broj koraka prijeoperativno 69.7 ± 4.4 a postoperativno 57.6 ± 2.8 ($p<0.001$). Preoperativna vrijednost površine moždine ($mm^2$) iznosila je 46.7 ± 5.4 a postoperativna 60.2 ± 2.6 ($p<0.001$), dok je površina subarahnoidalnog prostora ($mm^2$) prije operacije iznosila 48.0 ± 4.9 a nakon zahvata 68.8 ± 8.5 ($p<0.001$). Naši rezultati su pokazali da kirurško liječenje spondilogene mijelopatije, kada je planirano prema zakrivljenosti kralježnice, rezultira poboljšanjem hoda i kvalitete života.