



# Analysis of Myelomalacia and Posterior Longitudinal Ligament Ossification as Prognostic Factors in Patients with Cervical Spondylotic Myelopathy Submitted to Laminoplasty

## *Análise de mielomalácia e ossificação do ligamento longitudinal posterior como fatores prognósticos em pacientes com mielopatia espondilótica cervical submetidos a laminoplastia*

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Arq Bras Neurocir 2022;41(2):e102–e107.

### Abstract

**Background** Cervical spondylotic myelopathy is a degenerative disease of the intervertebral disc and the vertebral body of the spine that causes cervical spinal cord injury due to central vertebral canal stenosis. Its prevalence is higher in the elderly. Treatment is usually surgical when the spinal cord is affected either clinically with pyramidal release or radiologically with the altered spinal cord.

**Objective** The goal of the present study is to analyze the myelomalacia and the ossification of the posterior longitudinal ligament as prognostic factors in the postoperative evolution of patients with cervical canal compression who underwent laminoplasty with the open- or French-door techniques.

**Methods** We performed a retrospective analysis of 18 surgical cases of spondylotic cervical myelopathy of the same senior neurosurgeon, using the chi-squared test to analyze prognostic factors for patients' postoperative evolution in the Nurick scale, after open-door or French-door laminoplasty.

**Findings** The comparison between the pre and postoperative showed an improvement of 71.43% in cases that did not have ligament ossification compared with 45.45% of cases that presented posterior longitudinal ligament ossification. Also, there was a

### Keywords

- ▶ cervical spondylotic myelopathy
- ▶ myelomalacia
- ▶ ossification of posterior longitudinal ligament
- ▶ laminoplasty
- ▶ prognostic factors

received

April 25, 2021

accepted

October 13, 2021

published online

April 4, 2022

DOI <https://doi.org/10.1055/s-0042-1742298>.

ISSN 0103-5355.

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## Resumo

better prognosis in patients without myelomalacia, as 71.43% of them improved their condition against only 45.45% of improvement in those with myelomalacia.

**Conclusion** There is a need for further studies with larger samples to expressively prove that the presence of longitudinal ligament ossification and the previous presence of myelomalacia are factors that can lead to worse prognosis in the postoperative evolution of patients with cervical spondylotic myelopathy submitted to laminoplasty.

**Introdução** A mielopatia espondilótica cervical é uma doença degenerativa do disco intervertebral e do corpo da coluna vertebral que causa lesão da medula espinhal cervical devido à estenose do canal vertebral central. Sua prevalência é maior em idosos. O tratamento geralmente é cirúrgico quando a medula espinhal é afetada clinicamente com a liberação piramidal ou radiologicamente com a medula espinhal alterada.

**Objetivo** Este estudo tem como objetivo analisar a mielomalácia e a ossificação do ligamento longitudinal posterior como fatores prognósticos na evolução pós-operatória de pacientes com compressão do canal cervical submetidos à laminoplastia pelas técnicas de porta aberta ou porta francesa.

**Métodos** Foi realizada uma análise retrospectiva de 18 casos cirúrgicos de mielopatia espondilótica cervical do mesmo neurocirurgião sênior, utilizando o teste do qui-quadrado para analisar os fatores prognósticos da evolução pós-operatória dos pacientes na escala de Nurick, após laminoplastia aberta ou francesa.

**Resultados** A comparação entre o pré e pós-operatório mostrou uma melhora de 71,43% nos casos que não apresentavam ossificação ligamentar em comparação com 45,45% nos casos que apresentavam ossificação do ligamento longitudinal posterior. Além disso, houve um melhor prognóstico em pacientes sem mielomalácia, pois 71,43% deles melhoraram sua condição contra apenas 45,45% de melhora naqueles com mielomalácia.

**Conclusão** Há necessidade de mais estudos com amostras maiores para comprovar expressivamente que a presença de ossificação ligamentar longitudinal e a presença prévia de mielomalácia são fatores de pior prognóstico na evolução pós-operatória de pacientes com mielopatia espondilótica cervical submetidos à laminoplastia.

### Palavras-chave

- ▶ mielopatia espondilótica cervical
- ▶ mielomalácia
- ▶ ossificação do ligamento longitudinal posterior
- ▶ laminoplastia
- ▶ fatores prognósticos

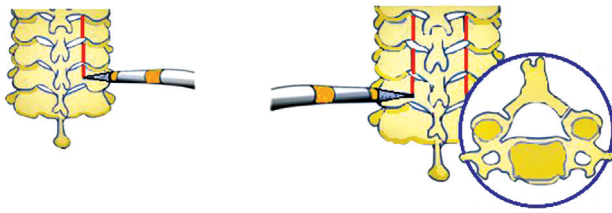
## Introduction

Cervical spondylotic myelopathy is a degenerative disease of the intervertebral disc and the vertebral body of the spine that causes cervical spinal cord injury due to central vertebral canal stenosis, being the most common cause of cervical spinal involvement in adults.<sup>1</sup> Its clinical picture can be presented with a change in gait, difficulty in performing fine movements and in controlling the sphincter; besides, the neurological examination reveals hyperreflexia in the limbs and changes in proprioceptive sensitivity. Genetic, environmental, and biochemical factors have been implicated in the development of this disease, which is of high prevalence in the Asian population.<sup>2-4</sup> The prognosis is related to factors such as time of disease progression—the longer, the greater the impairment—and the age of the patients—with worse prognosis in the elderly.<sup>1</sup>

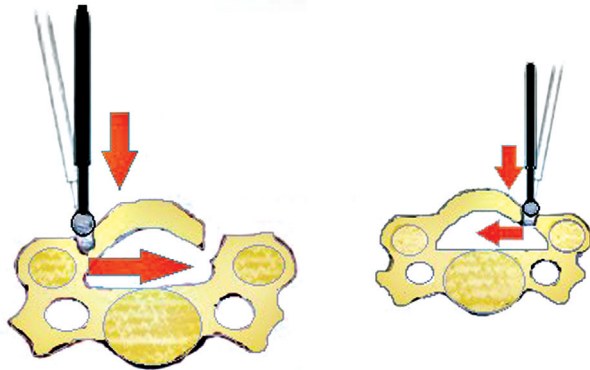
The evolution of cervical myelopathy may be unpredictable; 75% of patients discontinuously get worse after several years of stability, 20% progressively develop the disease over a short amount of time, and 5% have a catastrophic evolution

with severe acute decompensation after minor trauma or even without any apparent cause. Thus, different surgical techniques have been suggested to address cervical spondylotic myelopathy: anteriorly, anterolaterally, and posteriorly.<sup>1</sup> It should be noted that some factors impact the patients' evolution after surgery, among them, myelomalacia and ossification of the posterior longitudinal ligament (OPLL), the factors under analysis in this study.

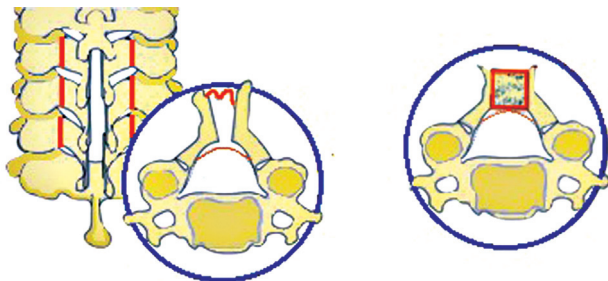
In cases of multilevel cervical stenosis with preservation of the lordotic curvature, laminoplasty is indicated, as well as in situations of posterior longitudinal ligament thickening or ossification, posterior comprehension of the spine cord by the flavum ligament, limiting factors of the anterior route such as the short neck and multiple levels (above 3). When laminectomy is contraindicated due to the risk of lordosis accentuation or risk of C5 paralysis syndrome, laminoplasty is considered a better option. This intervention aims to provide spine cord decompression, prevent instability, beneficially decrease movement rate by up to 50%, prevent kyphosis, a complication of laminectomy, and



**Fig. 1** Drawing showing the groove and the bone cut, to be able to rotate in a block and to place ceramic bone or bone graft between the blade and lateral mass



**Fig. 2** Channel opening and green branch fracture



**Fig. 3** The median opening of the spiny apophysis showing the opening in French-door

prevent perimedullary fibrosis and the risks of the lateral mass screw.

The vast majority of neurosurgeons use the posterior approach of laminoplasty if the patient has the involvement of several levels—3 or more.<sup>5</sup> For this approach, there is the open-door laminoplasty technique (images 1 and 2), described by Hirabayashi in 1981<sup>6</sup> and modified over the years, and there is the French-door laminoplasty technique (image 3), published by Hukuda et al. (1985)<sup>7</sup> and Hase et al. (1991)<sup>8</sup> and modified over decades by other authors.

The objective of this study is to analyze the myelomalacia and the OPLL as prognostic factors in the postoperative evolution of patients with cervical canal compression who underwent laminoplasty by open-door or French-door techniques (►Figs. 1 to 3).

**Table 1** Nurick myelopathy scale

Nurick scale	Patient's situation
0	Patient has signs and symptoms of root involvement but no spinal cord disease
1	Patient has signs of spinal cord disease with difficulty
2	Patient has slight difficulty walking that does not prevent full-time employment
3	Patient has difficulty walking that prevents full-time employment or completion of daily tasks, but does not require assistance with walking
4	Patient is able to walk only with a walker or human assistance
5	Patient is chairbound or bedridden

\*Based on Nurick, 1972.

## Methods

Cases of 18 patients operated by the same senior neurosurgeon between 1998 and 2019 were reviewed. The study is composed of 14 male and 4 female participants, with a minimum age of 45 and a maximum age of 82 years (average age 66.5); 2 patients were characterized as brown, 11 as Caucasian, and 5 as Asian. They were analyzed according to the presence or absence of posterior longitudinal ligament calcification from pre and postmagnetic resonance image scans used to identify myelomalacia. The individuals were classified and divided according to the Nurick myelopathy scale (►Table 1).

To compare the individuals before and after surgery, their clinical aspects were listed (►Table 2), taking into consideration their basic information, as well as the pre and postoperative status that was listed according to the MRI evaluation. The baseline characteristics of our subjects were also organized (►Table 3). Then, we used the chi-squared test to examine the association of myelomalacia's or posterior longitudinal ligament ossification's presence in the patients' postoperative evolution in the Nurick classification.

## Results

First, examining the interaction between the presence or absence of myelomalacia and the subjects' postoperative evolution in the Nurick scale, after laminoplasty (►Table 4), it was possible to note that, regarding patients who previously had myelomalacia, 45.45% of them improved their condition, while 27.27% had no change, and another 27.27% got worse.

Regarding the participants who did not have myelomalacia, 71.43% evolved to better Nurick classification and 28.57% remained unchanged, but no patient got worse.

When analyzing the evolution of patients with previous OPLL, after laminoplasty (►Table 5), it was possible to note an improvement in 45.45%, worsening in 18.18% of cases, and

**Table 2** Clinical features

Patient	Ethnicity	Sex	Age	Ligament Calcification	Preoperative Nurick	Technique	Postoperative Nurick	Preoperative MRI	Postoperative MRI	Additional surgery	Follow up
EO	Asian	M	45	Existent	I	Open-door	III	With myelomalacia	Unchanged	Laminectomy	48 months
OER	Caucasian	M	73	Absent	III	Open-door	I	With myelomalacia	Unchanged	-	26 months
CMK	Asian	M	63	Existent	III	Open-door	I	Without myelomalacia	Unchanged	Anterior way	84 months
CAS	Caucasian	M	74	Existent	II	Open-door	I	Without myelomalacia	Unchanged	Anterior way	168 months
VM	Caucasian	M	61	Existent	III	Open-door	II	With myelomalacia	Unchanged	Anterior way + lateral mass	24 months
CBM	Caucasian	W	74	Absent	II	Open-door	III	With myelomalacia	Unchanged	Arcochristectomy	180 months
HER	Brown	M	55	Absent	III	Open-door	II	With myelomalacia	Unchanged	-	84 months
VK	Asian	W	55	Existent	I	Open-door	I	With myelomalacia	Unchanged	-	216 months
CAC	Caucasian	M	53	Existent	III	French-door	I	Without myelomalacia	Unchanged	-	72 months
ATS	Asian	M	56	Existent	II	French-door	I	With myelomalacia	Unchanged	Anterior way	132 months
LAP	Caucasian	M	56	Existent	I	French-door	I	Without myelomalacia	Unchanged	-	Lost follow up
ET	Caucasian	M	60	Absent	I	French-door	I	Without myelomalacia	Unchanged	Anterior way	120 months
FS	Caucasian	M	50	Existent	III	French-door	III	With myelomalacia	Unchanged	Anterior way	120 months
HH	Asiatic	W	55	Existent	III	French-door	III	With myelomalacia	Unchanged	-	Death 2019
CFG	Brown	M	76	Existent	IV	French-door	V	With myelomalacia	Unchanged	Anterior way	Death 2005
AT	Caucasian	W	75	Absent	II	French-door	I	Without myelomalacia	Unchanged	Later Tie	Alzheimer 10 years ago
CB	Caucasian	M	82	Absent	III	French-door	I	With myelomalacia	Unchanged	-	36 months
MKG	Caucasian	M	67	Absent	II	French-door	I	With myelomalacia	Unchanged	Anterior way	60 months

**Table 3** Baseline characteristics

VARIABLES	n	%
<b>GENDER</b>		
Male	14	77.78
Female	4	22.22
<b>ETHNICITY</b>		
Asiatic	5	27.78
Caucasian	11	61.11
Brown	2	11.11
<b>LIGAMENT CALCIFICATION</b>		
Existent	11	61.11
Absent	7	38.89
<b>MYELOMALACIA (MRI)</b>		
Existent	11	61.11
Absent	7	38.89
<b>TECHNIQUE</b>		
Open-door	8	44.44
French-door	10	55.56
<b>PREOPERATIVE NURICK</b>		
I	4	22.22
II	5	27.78
III	8	44.44
IV	1	5.56
<b>POSTOPERATIVE NURICK</b>		
I	11	61.11
II	2	11.11
III	4	22.22
IV	0	0.00
V	1	5.56
<b>AGE</b>	<b>MEAN (sd)</b>	<b>min-max</b>
	62.78 (10.64)	45-82

Abbreviations: MRI, magnetic resonance imaging; sd, standard deviation.

**Table 4** Patient's evolution/presence of myelomalacia

MYELOMALACIA	PATIENT'S EVOLUTION			p
	Better n (%)	No change n (%)	Worse n (%)	
Existent	5 (45.45)	3 (27.27)	3 (27.27)	0.297
Absent	5 (71.43)	2 (28.57)	0 (0.00)	

36.36% did not show any change in the Nurick scale. Moreover, for those who did not previously present OPLL, the evolution in the postoperative period was 71.43% for a better prognosis, 14.14% showed worsening after surgery, and 14.29% did not show a significant change in evolution.

Regarding the techniques used (– **Table 6**), 62.50% of individuals who underwent laminoplasty with the open-door technique had an evolution in their condition, reducing

**Table 5** Patient's evolution/presence of posterior longitudinal ligament ossification

LIGAMENT OSSIFICATION	PATIENT'S EVOLUTION			p
	Better n (%)	No change n (%)	Worse n (%)	
Existent	5 (45.45)	4 (36.36)	2 (18.18)	0.520
Absent	5 (71.43)	1 (14.23)	1 (14.29)	

**Table 6** Patient's evolution/surgical techniques

TECHNIQUE	PATIENT'S EVOLUTION			p
	Better n (%)	No change n (%)	Worse n (%)	
Open-door	5 (62.50)	1 (12.50)	2 (25.00)	0.380
French-door	5 (50.00)	4 (40.00)	1 (10.00)	

their Nurick classification; on the other hand, 25% worsened the condition, and 12.5% had no changes. For those who underwent laminoplasty with the French-door technique, there was an evolution in 50% of cases, no change in 40%, and worsening in 10%.

## Discussion

Success in the surgical treatment of the patient with spondylotic cervical myelopathy is highly dependent on the previous factors presented by the patient. Some studies analyzed and demonstrated the postoperative evolution taking into account the patient's age, smoking history, compromised levels, and cervical spine instability.<sup>9</sup>

Our study, on the other hand, sought to analyze the operative evolution of patients with myelopathy, taking into account the previous condition of OPLL or its absence, as well as the existence of myelomalacia, classifying them through the Nurick scale (1972) in the pre and postoperative periods.

Ossification of the posterior longitudinal ligament is a hyperostotic condition of the spine, in which the posterior longitudinal ligament becomes progressively calcified, usually leading to symptomatic stenosis of the spinal canal.<sup>2,10,11</sup>

Our study tried to identify the presence of calcification in the ligament as a factor of worse prognosis. This can be explained by the greater spinal cord injury caused during surgery, since the presence of the calcified content may promote more spinal cord injury when removed as it is commonly densely adherent to the underlying dura. Miyakoshi et al.,<sup>12</sup> for example, described dural adhesions as a deleterious factor for preoperative and short-term postoperative neurological evolution.

Myelomalacia, on the other hand, is characterized by the condition of softening of the spinal cord, which occurs due to ischemia in the spinal cord caused by an episode of hemorrhage or poor local circulation.



It was possible to identify, in our results, that there was a significant evolution according to the Nurick scale in patients who previously had myelomalacia, as they were classified between classes II and III in the preoperative, and then reclassified as class I after surgery. However, there was a worse prognosis of evolution for cases whose initial Nurick classification was already high, presenting worsening in the classification after laminoplasty (evolving from IV to V postoperatively).

This can be explained by the different presentation of the spinal cord resulting from advanced myelomalacia, which leads to greater difficulty in the surgical procedure. Besides, myelomalacia is responsible for neurological injuries, which in addition to altering the structure of the spinal cord may result in a worse prognosis for patients undergoing laminoplasty.

Regarding the laminoplasty techniques, anterior decompression is a procedure of greater technical difficulty and with potential risk of complications.<sup>13</sup> There is a possibility of damage to the dura mater and possible postoperative cerebrospinal fluid fistula in the anterior access. Epstein NE (1994)<sup>14</sup> reviewed 112 patients with OPLL who underwent surgical treatment and found better results in those undergoing posterior decompression; for this reason, the posterior access was the route used in the patients in the present study. However, it was possible to note in our results that the use of open- or French-door technique did not interfere in the subjects' postoperative evolution.

Laminoplasty is still the technique of choice when the patient has OPLL and/or myelomalacia. And although it is possible to observe a certain evolution in patients submitted to laminoplasty based on the Nurick classification, as presented in the analysis of the cases, the patient's previous condition needs to be carefully evaluated, concerning the mentioned factors, for better surgical preparation.

It is worth highlighting that our study was limited by the difficulty in gathering a large sample of patients with the conditions that we sought to analyze, which is something that can also be noticed as a limiting factor in other studies described in the literature.

## Conclusion

Concluding, it was possible to identify, statistically, that there was no significant discrepancy in the postoperative prognosis for those patients who previously had longitudinal ligament ossification or/and myelomalacia. However, if the study had a larger number of cases, the tendency could be to reveal a worse prognosis for individuals who preoperatively had both characteristics analyzed.

Therefore, besides the necessity of further studies, with larger sample sizes, to confirm this issue, the presence of OPLL as well as the previous presence of myelomalacia may be considered worse prognostic factors, individually or when both are present, in patients with spondylotic

cervical myelopathy submitted to laminoplasty, especially when the patient's preoperative Nurick classification is already high.

## Conflict of Interests

The authors have no conflict of interests to declare.

## References

- 1 Siqueira MG. Neurosurgery Treaty. Surgical treatment of cervical spondylotic myelopathy. Manole; 2016:p874–883
- 2 Inamasu J, Guiot BH, Sachs DC. Ossification of the posterior longitudinal ligament: an update on its biology, epidemiology, and natural history. *Neurosurgery* 2006;58(06):1027–1039. doi: 10.1227/01.NEU.0000215867.87770.73
- 3 Matsunaga S, Yamaguchi M, Hayashi K, Sakou T. Genetic analysis of ossification of the posterior longitudinal ligament. *Spine* 1999; 24(10):937–938, discussion 939
- 4 Sugrue PA, McClendon J Jr, Halpin RJ, Liu JC, Koski TR, Ganju A. Surgical management of cervical ossification of the posterior longitudinal ligament: natural history and the role of surgical decompression and stabilization. *Neurosurg Focus* 2011;30(03): E3. doi: 10.3171/2010.12.FOCUS10283
- 5 Serra M, Aguiar P, Penzo L, Nakasone F. Cervical laminoplasty in compressive myelopathy. *Technical Principles of Neurosurgery-Atlas and Text 1ed São Paulo. Di Livros* 2016 v., p. 477–481
- 6 Hirabayashi K, Miyakawa J, Satomi K, Maruyama T, Wakano K. Operative results and postoperative progression of ossification among patients with ossification of cervical posterior longitudinal ligament. *Spine* 1981;6(04):354–364
- 7 Hukuda S, Mochizuki T, Ogata M, Shichikawa K, Shimomura Y. Operations for cervical spondylotic myelopathy. A comparison of the results of anterior and posterior procedures. *J Bone Joint Surg Br* 1985;67(04):609–615
- 8 Hase H, Watanabe T, Hirasawa Y, et al. Bilateral open laminoplasty using ceramic laminas for cervical myelopathy. *Spine* 1991;16 (11):1269–1276
- 9 Meluzzi A, Taricco MA, Brock R, et al. Fatores prognósticos associados ao tratamento cirúrgico da mielorradiculopatia espondilótica cervical. *Coluna/Columna* 2012;11(01):52–62. doi: 10.1590/S1808-18512012000100010
- 10 Fargen KM, Cox JB, Hoh DJ. Does ossification of the posterior longitudinal ligament progress after laminoplasty? Radiographic and clinical evidence of ossification of the posterior longitudinal ligament lesion growth and the risk factors for late neurologic deterioration. *J Neurosurg Spine* 2012;17(06):512–524. doi: 10.3171/2012.9.SPINE12548
- 11 Iwasaki M, Okuda S, Miyauchi A, et al. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament: Part 2: Advantages of anterior decompression and fusion over laminoplasty. *Spine* 2007;32(06):654–660. doi: 10.1097/01.brs.0000257566.91177.cb
- 12 Miyakoshi N, Shimada Y, Suzuki T, et al. Factors related to long-term outcome after decompressive surgery for ossification of the ligamentum flavum of the thoracic spine. *J Neurosurg* 2003;99(3, Suppl):251–256
- 13 Trojan DA, Pouchot J, Pokrupa R, et al. Diagnosis and treatment of ossification of the posterior longitudinal ligament of the spine: report of eight cases and literature review. *Am J Med* 1992;92(03):296–306
- 14 Epstein NE. The surgical management of ossification of the posterior longitudinal ligament in 43 north americans. *Spine* 1994;19(06):664–672