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

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

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
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. 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 hyporeflexia 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. 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.

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 decompression 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. 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 oflordosis 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 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.

Introduction 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.
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. For this approach, there is the open-door laminoplasty technique (images 1 and 2), described by Hirabayashi in 1981 and modified over the years, and there is the French-door laminoplasty technique (image 3), published by Hukuda et al. (1985) and Hase et al. (1991) 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).

### 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

<table>
<thead>
<tr>
<th>Patient</th>
<th>Ethnicity</th>
<th>Sex</th>
<th>Age</th>
<th>Ligament Calcification</th>
<th>Preoperative Nurick</th>
<th>Technique</th>
<th>Postoperative Nurick</th>
<th>Preoperative MRI</th>
<th>Postoperative MRI</th>
<th>Additional surgery</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO</td>
<td>Asian</td>
<td>M</td>
<td>45</td>
<td>Existent</td>
<td>I</td>
<td>Open-door</td>
<td>III</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Laminectomy</td>
<td>48 months</td>
</tr>
<tr>
<td>OER</td>
<td>Caucasian</td>
<td>M</td>
<td>73</td>
<td>Absent</td>
<td>III</td>
<td>Open-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>26 months</td>
</tr>
<tr>
<td>CMK</td>
<td>Asian</td>
<td>M</td>
<td>63</td>
<td>Existent</td>
<td>III</td>
<td>Open-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>84 months</td>
</tr>
<tr>
<td>CAS</td>
<td>Caucasian</td>
<td>M</td>
<td>74</td>
<td>Existent</td>
<td>II</td>
<td>Open-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>168 months</td>
</tr>
<tr>
<td>VM</td>
<td>Caucasian</td>
<td>M</td>
<td>61</td>
<td>Existent</td>
<td>III</td>
<td>Open-door</td>
<td>II</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way + lateral mass</td>
<td>24 months</td>
</tr>
<tr>
<td>CBM</td>
<td>Caucasian</td>
<td>W</td>
<td>74</td>
<td>Absent</td>
<td>II</td>
<td>Open-door</td>
<td>III</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Arcocristectomy</td>
<td>180 months</td>
</tr>
<tr>
<td>HER</td>
<td>Brown</td>
<td>M</td>
<td>55</td>
<td>Absent</td>
<td>III</td>
<td>Open-door</td>
<td>II</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>84 months</td>
</tr>
<tr>
<td>VK</td>
<td>Asian</td>
<td>W</td>
<td>55</td>
<td>Existent</td>
<td>I</td>
<td>Open-door</td>
<td>I</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>216 months</td>
</tr>
<tr>
<td>CAC</td>
<td>Caucasian</td>
<td>M</td>
<td>53</td>
<td>Existent</td>
<td>III</td>
<td>French-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>72 months</td>
</tr>
<tr>
<td>ATS</td>
<td>Asian</td>
<td>M</td>
<td>56</td>
<td>Existent</td>
<td>II</td>
<td>French-door</td>
<td>I</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>132 months</td>
</tr>
<tr>
<td>LAP</td>
<td>Caucasian</td>
<td>M</td>
<td>56</td>
<td>Existent</td>
<td>I</td>
<td>French-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>Lost follow up</td>
</tr>
<tr>
<td>ET</td>
<td>Caucasian</td>
<td>M</td>
<td>60</td>
<td>Absent</td>
<td>I</td>
<td>French-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>120 months</td>
</tr>
<tr>
<td>FS</td>
<td>Caucasian</td>
<td>M</td>
<td>50</td>
<td>Existent</td>
<td>III</td>
<td>French-door</td>
<td>III</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>120 months</td>
</tr>
<tr>
<td>HH</td>
<td>Asiatic</td>
<td>W</td>
<td>55</td>
<td>Existent</td>
<td>III</td>
<td>French-door</td>
<td>III</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>Death 2019</td>
</tr>
<tr>
<td>CFG</td>
<td>Brown</td>
<td>M</td>
<td>76</td>
<td>Existent</td>
<td>IV</td>
<td>French-door</td>
<td>V</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>Death 2005</td>
</tr>
<tr>
<td>AT</td>
<td>Caucasian</td>
<td>W</td>
<td>75</td>
<td>Absent</td>
<td>II</td>
<td>French-door</td>
<td>I</td>
<td>Without myelomalacia</td>
<td>Unchanged</td>
<td>Later Tie</td>
<td>Alzheimer 10 years ago</td>
</tr>
<tr>
<td>CB</td>
<td>Caucasian</td>
<td>M</td>
<td>82</td>
<td>Absent</td>
<td>III</td>
<td>French-door</td>
<td>I</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>–</td>
<td>36 months</td>
</tr>
<tr>
<td>MRG</td>
<td>Caucasian</td>
<td>M</td>
<td>67</td>
<td>Absent</td>
<td>II</td>
<td>French-door</td>
<td>I</td>
<td>With myelomalacia</td>
<td>Unchanged</td>
<td>Anterior way</td>
<td>60 months</td>
</tr>
</tbody>
</table>
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 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. 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.²,¹⁰,¹¹

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.,¹² 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.\textsuperscript{13} There is a possibility of damage to the dura mater and possible postoperative cerebrospinal fluid fistula in the anterior access. Epstein NE (1994)\textsuperscript{14} 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**