

SEVERE CERVICAL MYELOPATHY: APPROACHES AND POSTOPERATIVE EVALUATION

MIELOPATIA CERVICAL GRAVE: VIAS DE ACESSO E AVALIAÇÃO PÓS-OPERATÓRIA

MIELOPATÍA CERVICAL GRAVE: VÍAS DE ACCESO Y EVALUACIÓN POSTOPERATORIA

GABRIEL FARIA CERQUEIRA¹, ÁLYNSON LAROCCA KULCHESKI², ANDRÉ LUÍS SEBEN², PEDRO GREIN DEL SANTORO², MARCEL LUIZ BENATO², XAVIER SOLER I GRAELLS^{1,2}

1. Hospital de Clínicas da Universidade Federal do Paraná. Curitiba, PR, Brazil.

2. Hospital do Trabalhador. Curitiba, PR, Brazil.

ABSTRACT

Objectives: To evaluate and compare the clinical evolution of surgical approaches used in patients with severe cervical myelopathy. **Methods:** Retrospective observational study in which 19 patients with myelopathy who underwent surgery were evaluated. Neurological assessments using the Frankel scale were conducted both preoperatively and one year following surgery, and the modified Japanese Orthopedic Association (JOA), Nurick, and Visual Analog Scale for pain (VAS) questionnaires were applied 1 year after the surgical procedure. **Results:** 89% of the participants were male and the average age was 63.9 years. No patient had postoperative neurological worsening, 12 patients (63.16%) had mild pain, and seven (36.84%) had moderate pain. The group with degenerative disease showed neurological improvement after surgery and the exclusively anterior approach was used in 84% of the cases, the exclusively posterior approach in 10% of the cases, and the dual approach in 6% of the cases. **Conclusion:** Surgical treatment has good results for inhibiting the unfavorable natural evolution of myelopathy within 1 year following surgery and promotes neurological improvement in degenerative cases, making it possible to use the anterior access route in most cases. **Level of evidence III; Retrospective Study.**

Keywords: Myelopathy; Compressive Myelopathy; Traumatic Myelopathy.

RESUMO

Objetivos: Avaliar a evolução clínica em comparação com as vias de acesso cirúrgico em pacientes com mielopatia cervical grave. **Métodos:** Estudo observacional retrospectivo no qual foram avaliados 19 pacientes com mielopatia submetidos à cirurgia. Foram aplicados o questionário da Japanese Orthopedic Association (JOA) modificado, a Escala de Nurick e a Escala Visual Analógica (EVA) da dor um ano depois do procedimento cirúrgico e realizada avaliação neurológica pré-operatória e após um ano da cirurgia com a Escala de Frankel. **Resultados:** Os participantes eram 89% do sexo masculino e a média de idade foi de 63,9 anos. Nenhum paciente apresentou piora neurológica pós-operatória, 12 pacientes (63,16%) apresentaram dor leve e sete (36,84%) dor moderada. O grupo com doença degenerativa apresentou melhora neurológica depois da cirurgia e a via de acesso anterior exclusiva foi utilizada em 84% dos casos, 10% tiveram acesso exclusivamente por via posterior e 6% tiveram acesso com dupla via. **Conclusões:** O tratamento cirúrgico apresenta bons resultados para inibir a evolução natural desfavorável da mielopatia no período de um ano depois da cirurgia e promove melhora neurológica nos casos degenerativos, sendo possível a utilização da via de acesso anterior na maior parte dos casos. **Nível de evidência III; Estudo Retrospectivo.**

Descritores: Mielopatia; Mielopatia Compressiva; Mielopatia Traumática.

RESUMEN

Objetivos: Evaluar la evolución clínica en comparación con las vías de acceso quirúrgico en pacientes con mielopatía cervical severa. **Métodos:** Estudio observacional retrospectivo en el que se evaluaron 19 pacientes con mielopatía intervenidos quirúrgicamente. Se aplicó el cuestionario modificado de la Japanese Orthopedic Association (JOA), la escala de Nurick y la Escala Visual Analógica (EVA) del dolor 1 año después de la intervención quirúrgica y se realizó la evaluación neurológica preoperatoria y un año después de la cirugía utilizando la Escala de Frankel. **Resultados:** El 89% de los participantes eran hombres y la edad promedio era de 63,9 años. Ningún paciente presentó empeoramiento neurológico postoperatorio, 12 pacientes (63,16%) presentaron dolor leve y siete (36,84%) dolor moderado. El grupo con enfermedad degenerativa presentó mejoría neurológica tras la cirugía y en el 84% de los casos se utilizó la vía de acceso anterior exclusiva, el 10% la vía posterior exclusiva y el 6% la vía doble. **Conclusión:** El tratamiento quirúrgico presenta buenos resultados al inhibir la evolución natural desfavorable de la mielopatía en el período de un año después de la cirugía y promueve la mejoría neurológica en los casos degenerativos, posibilitando el uso de la vía de acceso anterior en la mayoría de los casos. **Nivel de evidencia III; Estudio Retrospectivo.**

Descriptorios: Mielopatía; Mielopatía Compresiva; Mielopatía Traumática.

Study conducted at the Orthopedics Service of the Hospital do Trabalhador, Universidade Federal do Paraná, Curitiba, PR, Brazil.

Correspondence: Gabriel Faria Cerqueira. Rua Francisca Azolin 246, casa 2. Santa Felicidade, Curitiba, PR, Brasil. 82015-060. gabrielcerqueira08@hotmail.com



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INTRODUCTION

Compressive cervical myelopathy is a progressive spine disease and the leading cause of spinal cord dysfunction worldwide. Medullary compression can be secondary to degeneration of the cervical spine or be associated with a traumatic event. It frequently affects male patients between 40 and 60 years of age. Among the clinical manifestations of this disease are gait and balance disturbances, changes in reflexes, such as hyperreflexia, clonus, and the presence of Hoffman and Babinski signs, as well as motor coordination dysfunctions. These signs and symptoms result from changes in the upper motor neuron.¹⁻⁴

Asymptomatic cases that present spinal cord compression in imaging examinations are classified as mild. Cases with cervical pain symptoms, with or without radiating pain, are characterized as moderate, while severe cases present classic signs and symptoms such as changes in gait, balance, and loss of fine motor skills. Conservative treatment is recommended for patients with the mild form. Surgical intervention is indicated in moderate and severe cases aimed at changing the natural history and preventing progressive neurological deterioration. The degree of recovery depends largely on the severity of the myelopathy at the time of intervention.⁵

Surgical approaches include anterior, posterior, and combined access procedures. The approach consists of cervical discectomy or corpectomy with fusion, while the posterior approach consists of laminoplasty and laminectomy with or without fusion. (Figure 1)^{6,7}

There are several methods for analyzing the clinical impairment caused by myelopathy. The JOA and Nurick scales are the most widely used.^{5,8}

There is no consensus in the literature about the most effective approach for surgical treatment and the choice is based on the preference and experience of the surgeon and on the location of the spinal compression.⁵

Severe cervical myelopathy presents significant morbidity if the diagnosis is delayed. Adequate early treatment may result in a more effective recovery.

The objective of this study was to evaluate the clinical evolution and the surgical approaches to severe cervical myelopathy in a tertiary hospital that is a reference in spine surgery.

METHODS

This is a longitudinal, observational, retrospective study. It was approved by the Institutional Review Board of the university hospital as CAEE number 18879019.6.0000.5225. All the participants signed the Informed Consent Form.

Individuals of both sexes ranging from 10 to 90 years of age, who had been diagnosed with severe degenerative or traumatic compressive cervical myelopathy and underwent surgical treatment during the period from January 2017 to July 2019, were included in the study. Clinical changes to the upper motor neuron related to the strength and sensitivity of the upper or lower limbs, hyperreflexia, gait and balance changes, and the presence of pathological reflexes, such as the Hoffman, Babinski, and Oppenheim signs, were

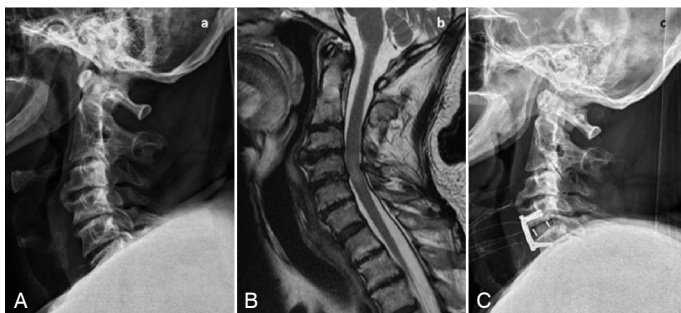


Figure 1. Case of myelopathy operated at one level by anterior approach with preoperative radiography (A), sagittal magnetic resonance in T2 (B), and postoperative radiography of the cervical spine (C).

evaluated. Image analysis included radiography, computed tomography, and magnetic resonance of the cervical spine to confirm the myelopathy diagnosis and identify the number of levels affected. The presence of a symptom and a change in an imaging examination, with spinal cord compression and a medullary hypersignal, were considered criteria for inclusion in the study.

Patients submitted to surgical treatment who did not wish to participate in the research project, who were lost to patient follow-up, who had incomplete medical records data, who were victims of a high-impact traumatic event resulting in the fracture or dislocation of a cervical vertebra, as well as mild and moderate cases of myelopathy were excluded.

The patients were separated into two groups (traumatic and degenerative), with traumatic causes defined as those patients who underwent any traumatic event immediately before the onset or worsening of symptoms.

The JOA and Nurick functional scales were applied to the patients. Pain was verified using the visual analog scale (VAS) for pain and neurological status was evaluated using the Frankel scale. The clinical evaluation took place at least one year following surgery.^{9,10} The preoperative neurological evaluation and approach used for treatment were obtained through analysis of the medical records. A comparative analysis of the mean postoperative JOA scores between the one and multiple level spinal involvement groups was conducted.

For the assessment of age as an independent predictive factor, the cases were separated into eight age groups, as shown in Table 1.

For the statistical test, the JOA scale was divided into two groups of results: poor, with a score from 0 to 11, and good, with a score from 12 to 17. The VAS was divided into mild pain (0, 1 and 2), moderate pain (3, 4, 5, 6 and 7), and severe pain (8, 9 and 10) and, for the Nurick scale, results from 1 to 4 were considered.^{7,10}

The exact probability of symmetry test was used to compare the pre- and postoperative neurological status and the non-parametric Mann-Whitney test was used to compare the number of myelopathy levels. Fisher's exact test was performed for all the other clinical outcomes with a significance level of 5%.¹¹

RESULTS

Initially, 30 patients with myelopathy were selected. Eleven were excluded for not meeting the criteria, five of whom for polytraumatization with cervical dislocation, four for incomplete preoperative neurological assessment data in their medical records, and two who died less than a year following surgery, leaving 19 patients who met all the inclusion criteria. Two patients were female (11%) and 17 were male (89%). The women ranged from 55 and 74 years of age with a mean age of 64.5 years and the men ranged from 37 to 75 years of age with a mean of 58.9 years of age. Nine (47%) cases were of traumatic origin and ten (53%) of degenerative origin.

Surgical approach

The most frequently used surgical approach was anterior access (16) followed by posterior access (2), and one case needed to be complemented by a posterior approach procedure due to worsening symptoms and spinal cord compression following anterior access. It was not possible to perform a statistical comparison due to the disproportionate numbers of cases between the two approaches. (Figure 2)

Neurological Evaluation

The pre- and postoperative evaluations are shown in Figure 3. Among the degenerative cause patients 80% presented neurological improvement one year after surgery as compared to the

Table 1. Age groups.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
(10,20)	(20,30)	(30,40)	(40,50)	(50,60)	(60,70)	(70,80)	(80,90)

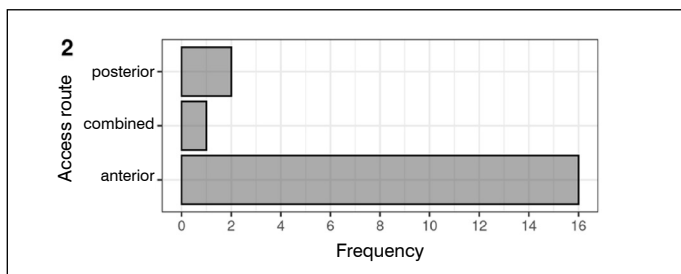


Figure 2. Frequency of patients for each access route.

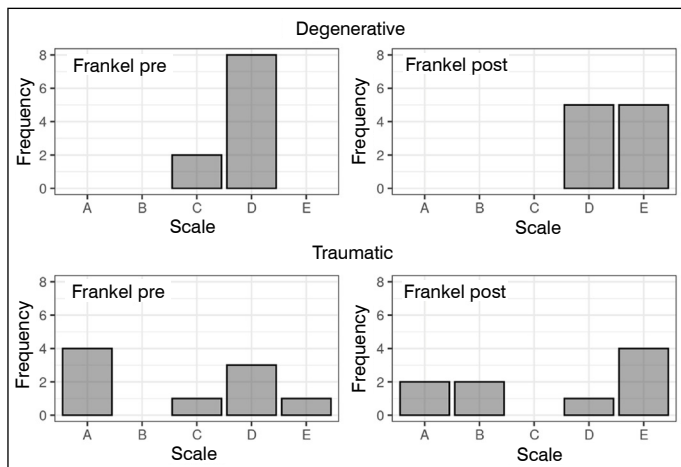


Figure 3. Pre- and postoperative frequency of patients on the Frankel scale by disease type.

preoperative period ($p=0.03$). The most severe neurological changes were observed in the traumatic patient group. Following surgery, two of the four patients characterized as Frankel A in the preoperative evaluation progressed to Frankel B while two remained as Frankel A.

Myelopathy Levels

There were six cases of single-level myelopathy with a mean postoperative JOA score of 14.3 ± 1.4 and 13 multiple-level cases with a mean JOA score of 10.6 ± 3.8 . The group with multiple-level involvement had a significantly lower mean JOA score ($p=0.017$). (Table 2)

JOA

When the JOA questionnaire was applied, we observed six good results (> 12) and four poor results (< 12) for the degenerative cause cases. For the traumatic cause cases there were six good and three poor scores, with no statistical difference between them for either cause ($p=1.0$). (Table 3)

The most severe cases according to the JOA questionnaire occurred in patients above 50 years of age. There was no statistical difference when good and poor cases were compared in each age group ($p=0.875$). (Table 4)

Nurick

There was no statistical difference between traumatic and degenerative cause cases in the Nurick questionnaire evaluation ($p=0.5$). The traumatic cases had a higher frequency of scores of 4, while the predominant degenerative case scores were 1 and 3. (Table 3)

The Nurick scores by age group are shown in Table 4.

Age groups 5 and 6 had the highest frequencies of a score of 4 and in group 3 the predominant score was 1. There was no statistical difference between the age groups ($p=0.51$).

VAS

There were six cases of mild pain from both traumatic and degenerative causes and the remaining cases had moderate pain. No cases of severe pain were observed ($p=1.0$). (Table 2)

Table 2. Myelopathy levels and mean and median JOA values.

	Levels with lesions		p value
	1 level (n = 6)	2 or 3 levels (n = 13)	
JOA score, Mean \pm SD	14.3 \pm 1.4	10.6 \pm 3.8	0.017*
Median(min-max)	14.5 (12-16)	11 (4-16)	

*Significance of the non-parametric Mann-Whitney test.

Table 3. Frequency of patients by type of disease for each clinical outcome.

Type of disease	JOA			
	Good	Poor		
Degenerative	6	4		
Traumatic	6	3		
Type of disease	VAS			
	Mild	Moderate		
Degenerative	6	4		
Traumatic	6	3		
Type of disease	Nurick			
	1	2	3	4
Degenerative	3	2	3	2
Traumatic	1	3	1	4

Table 4. Frequency of patients in each clinical outcome by age.

Age	JOA			
	Good	Poor		
30-40	2	1		
40-50	2	0		
50-60	1	2		
60-70	3	2		
70-80	4	2		
Age	VAS			
	Mild	Moderate		
30-40	2	1		
40-50	1	1		
50-60	2	1		
60-70	2	3		
70-80	5	1		
Age	Nurick			
	1	2	3	4
30-40	2	0	1	0
40-50	0	0	1	1
50-60	1	0	0	2
60-70	0	2	1	2
70-80	1	3	1	1

The distribution of the pain scale results by age group is shown in Table 4. Group 6 had the highest number of cases with moderate pain ($p=0.69$).

DISCUSSION

Cervical myelopathy is a disease that predominantly affects males above 50 years of age. In their study, Northover et al. showed that women account for 26.9% of cases with a mean age less than that of men (57 vs. 66.5 years of age).¹² The present study confirmed the predominance of male cases (89%), with an overall mean age of 59 years. Contrary to the literature, the mean age of the men was lower than that of the women (58.9 vs. 64.5 years of age). The small number of female cases in the study may have influenced these divergent data. Additionally, the younger traumatic cases could have reduced the final mean male age.

In the natural history of cervical myelopathy, around 75% of cases present worsening symptoms, 20% evolve slowly and progressively, and 5% start and progress rapidly. Most patients experience progressive symptoms and neurological worsening. The greater the

severity of the lesion and the neurological changes, the smaller the chance of recovery. The goal of surgery is to stop the unfavorable natural evolution of the disease. Several studies have reported favorable results following surgery, with improved function and quality of life.¹³ Sampath et al. demonstrated better results in the surgical group.¹⁴ In their systematic review, Fehlings et al. stated that 20 to 60% of the patients with myelopathy had worsening neurological conditions in their natural evolution without surgical intervention.¹⁵ Chagas et al., in their prospective analysis, observed that 64% of the patients improved neurologically and functionally after undergoing discectomy and intervertebral fusion surgery and only 2.6% worsened after a minimum period of 18 months following surgery.¹⁶ The present work only evaluated patients with severe myelopathy. Our results showed that 12 months following surgery no patient had a worse postoperative neurological status and 69% showed improvement over preoperative conditions. We obtained satisfactory neurological improvement outcomes like those reported in the literature, confirming the importance of surgical treatment for symptomatic cases. The main triggering event for the disease is spinal cord compression, be it caused by anterior or posterior elements, and surgery permits removal of these compressive elements.

There continues to be controversy around the best surgical approach for myelopathy and opinions are divided. The choice between anterior and posterior depends on the experience of the surgeon and the location and size of the lesion. The number of levels affected, sagittal alignment, the presence of instability and the clinical symptoms must also be considered.^{2,5}

Patients with medullary compression from hypertrophy of the yellow ligament are candidates for posterior approach decompression.¹⁷ A laminectomy can result in instability and cervical kyphotization and is therefore avoided in cases with previous kyphosis.⁵ The anterior approach is a direct decompression method and with arthrodesis allows correction of both the deformity and instability.⁵ Connor and Darden reported good and excellent results in 70% of the patients and a high satisfaction rate with anterior access.¹⁸ Some studies have shown better recovery of neurological function and better scores on the JOA scale in patients who underwent corpectomy as compared to laminoplasty when there was more than 60% compression of the spinal canal.² Cervical medullary compression is caused mainly by the anterior elements.⁵ The present study shows a preference for the anterior route and suggests that most cases of severe myelopathy can be treated via this approach safely and effectively. The anterior approach was performed in 16 (84%) of the 19 study cases, all with good clinical results. Around 69% of the cases presented neurological improvement after one year and no case experienced worsening. We observed that the main cause of spinal cord compression was secondary to the disc osteophyte complex and that the anterior approach allowed satisfactory direct decompression, associated with the release of the posterior longitudinal ligament with an increase in the intervertebral disc space and indirect posterior decompression resulting from the retensioning of the yellow ligament. Compression from the yellow ligament worsened in one case and supplementation with posterior approach decompression was necessary. A comparison of the final clinical outcomes of the two access routes was not possible due to the discrepancy in the number of cases.

Several studies have shown that younger patients have better neurological recovery. Meluzzi et al. observed a strong association between chronological age and postoperative performance, with improved JOA scale scores in individuals below 70 years of age and the best performance in the group in their thirties. The condition of patients above 70 years of age had tended to worsen at the 24-month evaluation.¹⁹ Myelopathy occurs due to three physiopathological factors: static, dynamic, and ischemic mechanics. Accentuated

hypertrophy of the yellow ligament, instability, cervical vertebral subluxation, and low medullary vascularization (ischemia) are factors frequently encountered in the elderly.⁶ In the present study, age correlated with the postoperative clinical results and better outcomes were observed in the younger age ranges, while worse JOA and Nurick scale scores were observed in patients over 50 years of age.

The postoperative outcome may be related to the cause of the myelopathy. Fengbin et al. evaluated patients with myelopathy and cervical instability and associated mild trauma with higher incidences of neurological changes and worse postoperative results when compared to patients without associated trauma. The traumatic event causes concussion or spinal cord contusion and can aggravate a pre-existing cervical lesion.^{20,21} The present work observed that the cases with more serious neurological lesions were in the traumatic group, as reported in the literature. In the initial evaluation, all patients classified as Frankel A had traumatic causes, while those in the degenerative group were classified as Frankel C or D. The degenerative group had better neurological recovery and 80% of these patients improved after surgery ($p=0.03$).

The extent of the myelopathy is related to the final postoperative outcome. Meluzzi et al. observed better improvement in the JOA score after surgery in the group with spinal cord compression at one level compared to the multiple-level group.¹⁹ In the present study, the group with myelopathy at one level had a significantly higher mean postoperative JOA score (mean JOA=14.3) than the multiple-level group (mean JOA=10.6) ($p=0.017$). Functional and neurological recovery tended to be more favorable and have a better prognosis in the cases with single-level myelopathy.

The JOA and Nurick questionnaires are those most often used for functional assessment of patients with myelopathy.^{8,9} Both questionnaires are easy to apply, and the clinical results are easy to reproduce using objective criteria. Coutinho et al. uses the JOA and Nurick scores as a prognostic factor following surgery and states that the higher the preoperative score, the better the postoperative score, and they demonstrated a strong correlation between the two evaluation methods. The mean JOA and Nurick values for their sample three months after surgery were 10.7 and 2.8, respectively. No difference was found in the JOA and Nurick values either between the traumatic and degenerative groups or the age groups.

The number of cases evaluated and the one-year follow-up period were identified as limitations of the present study. Even though other studies with monitoring periods of 18 and 24 months reported similar results following surgery, some late complications, such as worsening neurological conditions and adjacent-level degeneration, were not able to be identified during this period.^{16,19}

The surgical approach to be used remains dependent on the experience and preference of the surgeon. Multicenter, prospective studies focused on the access route could assist in decision-making around the most effective approach.

CONCLUSION

Surgical treatment was effective in preventing the unfavorable natural progression of severe myelopathy, with 69% neurological improvement and 100% stabilization of the progression of the disease during the first postoperative year.

Neurological improvement was most evident in the degenerative cases.

The anterior approach was shown to be effective and was the predominant access route used in the treatment of severe myelopathy.

All authors declare no potential conflict of interest related to this article.

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REFERENCES

1. Fehlings MG, Tetreault LA, Riew KD, Middleton JW, Aarabi B, Arnold PM, et al. A Clinical Practice Guideline for the Management of Patients With Degenerative Cervical Myelopathy: Recommendations for Patients With Mild, Moderate, and Severe Disease and Nonmyelopathic Patients With Evidence of Cord Compression. *Glob Spine J*. 2017;7(3 Suppl):70S–83S. <https://doi.org/10.1177/2192568217701914>
2. Qin R, Chen X, Zhou P, Li M, Hao J, Zhang F. Anterior cervical corpectomy and fusion versus posterior laminoplasty for the treatment of oppressive myelopathy owing to cervical ossification of posterior longitudinal ligament: a meta-analysis. *Eur Spine J*. 2018;27(6):1375–87. doi:10.1007/s00586-017-5451-6
3. Braly BA, Lunardini D, Cornett C, Donaldson WF. Operative treatment of cervical myelopathy: cervical laminoplasty. *Adv Orthop*. 2012;2012:508534. doi:10.1155/2012/508534
4. Kalsi-Ryan S, Karadimas SK, Fehlings MG. Cervical spondylotic myelopathy: the clinical phenomenon and the current pathobiology of an increasingly prevalent and devastating disorder. *Neuroscientist*. 2013;19(4):409–21. doi:10.1177/1073858412467377
5. Emery SE. Cervical Spondylotic Myelopathy: Diagnosis and Treatment. *J Am Acad Orthop Surg*. 2001;9(6):376–88.
6. Baron EM, Young WF. Cervical spondylotic myelopathy: a brief review of its pathophysiology, clinical course, and diagnosis. *Neurosurgery*. 2007;60(1 Suppl 1):S35–41. doi:10.1227/01.NEU.0000215383.64386.82
7. Lozorio AR, Borges M, Batista Junior JL, Chacab Junior C, Machado IC, Rezende R. Correlation between the clinic and the index of cervical myelopathy Torg. *Acta Ortop Bras*. 2012;20(3):180–3.
8. Kato S, Oshima Y, Oka H, Chikuda H, Takeshita Y, Miyoshi K, et al. Comparison of the Japanese Orthopaedic Association (JOA) score and modified JOA (mJOA) score for the assessment of cervical myelopathy: a multicenter observational study. *PLoS One*. 2015;10(4):e0123022. <https://doi.org/10.1371/journal.pone.0123022>
9. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I. Paraplegia. 1969;7(3):179–192. <https://doi.org/10.1038/sc.1969.30>
10. Martinez JE, Grassi DC, Marques LG. Análise da aplicabilidade de três instrumentos de avaliação de dor em distintas unidades de atendimento: ambulatório, enfermagem e urgência. *Rev Bras Reumatol*. 2011;51(4):304–8. <https://doi.org/10.1590/S0482-50042011000400002>
11. Giolo SR. *Introdução à análise de dados categóricos com aplicações*. São Paulo: Editora Blucher. 2017.
12. Northover JR, Wild JB, Braybrooke J, Blanco J. The epidemiology of cervical spondylotic myelopathy. *Skeletal Radiol*. 2012;41(12):1543–6. doi:10.1007/s00256-012-1388-3
13. Fehlings MG, Wilson JR, Kopjar B, Yoon ST, Arnold PM, Massicott EM, et al. Efficacy and Safety of Surgical Decompression in Patients with Cervical Spondylotic Myelopathy: results of the AOSpine North America prospective multi-center study. *J Bone Joint Surg Am*. 2013;95(18):1651–8. doi:10.2106/JBJS.L00589
14. Sampath P, Bendebba M, Davis JD, Ducker TB. Outcome of patients treated for cervical myelopathy: Aprospective, multicenter study with independent clinical review. *Spine*. 2000;25(6):670–6.
15. Fehlings MG, Tetreault LA, Wilson JR, Skelly AC. Cervical Spondylotic Myelopathy: Current State of the Art and Future Directions. *Spine*. 2013;38(22 Suppl 1):S1–8. doi:10.1097/BRS.0b013e3182a7e9e0
16. Chagas H, Domingues F, Aversa A, Fonseca ALV, Souza JM. Cervical spondylotic myelopathy: 10 years of prospective outcome analysis of anterior decompression and fusion. *Surg Neurol*. 2005;64(Suppl 1):30–5. doi:10.1016/j.surneu.2005.02.016
17. Pimenta Junior WE, Daher S, Souza Junior ZA, Cardoso ALP, Moraes FB. Mielopatia cervical espondilótica - tratamento com laminoplastia e artrodese com sistema de fixação de massa lateral. *Coluna/Columna*. 2008;7(1):17–22.
18. Connor PM, Darden BV 2nd. Cervical discography complications and clinical efficacy. *Spine (Phila Pa 1976)*. 1993;18(14):2035–8.
19. Meluzzi A, Taricco MA, Brock RS, Dias MRP, Nakaguawa G, Guirado VMP, et al. Fatores prognósticos associados ao tratamento cirúrgico da mielorradiculopatia espondilótica cervical. *Coluna/Columna*. 2012;11(1):52–62. <https://doi.org/10.1590/S1808-18512012000100010>
20. Fengbin Y, Deyu C, Xinwei W, Yu C, Jinhao M, Xinyuan L, et al. Trauma-induced spinal cord injury in cervical spondylotic myelopathy with or without lower cervical instability. *J. Clin. Neurosci*. 2013;20(3):419–22.
21. Correia MC, Leal JS, Resende RLC, Ghedini DF. Tratamento cirúrgico das fraturas luxações da coluna cervical baixa por redução aberta e sem uso de tração craniana. *Coluna/Columna*. 2013;12(3):235–7. <https://doi.org/10.1590/S1808-18512013000300013>
22. Coutinho TP, Lutaka AD, Cristante AF, Rocha ID, Marcon RM, Oliveira RP, et al. Functional assessment of patients with cervical myelopathy who underwent surgical treatment. *Coluna/Columna*. 2014;13(1):23–26. <https://doi.org/10.1590/S1808-18512014130100217>