ORIGINAL ARTICLE
DEGENERATIVE
http://dx.doi.org/10.1590/S1808-185120262501295516

DEGENERATIVE CERVICAL MYELOPATHY: COMPARATIVE ANALYSIS OF POSTERIOR DECOMPRESSION TECHNIQUES

MIELOPATIA CERVICAL DEGENERATIVA: ANÁLISE COMPARATIVA DE TÉCNICAS DE DESCOMPRESSÃO POSTERIOR

MIELOPATÍA CERVICAL DEGENERATIVA: ANÁLISIS COMPARATIVO DE TÉCNICAS DE DESCOMPRESIÓN POSTERIOR

Carlos Betancourt-Quiroz[1], Julio César López-Valdés[2,3,4], Daniel Alejandro Vega-Moreno[5], José Gilberto Valadez-Cabrero[1], Erik Rodrigo Velázquez-Coria[2,3], Laura Mestre-Orozco[6], Gonzalo Cancino-González[7], Ulises García-González[1,2]

1. The American British Cowdray Medical Center, Department of Spine Surgery, Cuajimalpa, Mexico City, Mexico.
2. Hospital Central Sur de Alta Especialidad (PEMEX), Department of Neurosurgery, Tlalpan, Mexico City, Mexico.
3. Universidad Nacional Autónoma de México, Ciudad Universitaria, Postgraduate Department, Mexico City, Mexico.
4. Universidad Autónoma de Tamaulipas, Medicine Faculty of Tampico "Dr. Alberto Romo Caballero", Research Department, Tampico, Tamaulipas, Mexico.
5. Department of Oncological Neurosurgery, Mexico City, Mexico.
6. The American British Cowdray Medical Center, Department of Surgical Pathology, Cuajimalpa, Mexico City, Mexico.
7. Centro Médico Nacional, Hospital 20 de Noviembre (I.S.S.S.T.E), Department of Spine Surgery. Coyoacán, Mexico City, Mexico.

ABSTRACT

Objective: To compare posterior decompression techniques in degenerative cervical myelopathy (DCM) and evaluate their clinical outcomes. Methods: A retrospective observational study was conducted on patients with DCM who underwent posterior cervical decompression surgery between 2012 and 2022. Variables analyzed included surgical time, intraoperative blood loss, and hospital stay. Results: A total of 32 patients were included. Open surgery had a surgical time of 176.6 ± 45.3 minutes, blood loss of 300.5 ± 236.3 ml, and a hospital stay of 4.5 ± 4.4 days. Minimally invasive surgery had a surgical time of 161.5 ± 72 minutes, blood loss of 93.8 ± 69.5 ml, and a hospital stay of 1.8 ± 1 day. Conclusions: Minimally invasive decompression resulted in shorter surgical time, reduced blood loss, and shorter hospital stay compared to open surgery. Further research is needed to determine its impact on functional outcomes. ***Level of Evidence II; Retrospective[f] Study.***

Keywords: Spinal Cord Compression; Myelopathy; Surgical Decompression; Minimally Invasive Surgical Procedures.

RESUMO

Objetivo: Comparar as técnicas de descompressão posterior na mielopatia cervical degenerativa (MCD) e avaliar seus resultados clínicos. Métodos: Foi realizado um estudo observacional retrospectivo em pacientes com MCD submetidos à cirurgia de descompressão cervical posterior entre 2012 e 2022. As variáveis analisadas incluíram tempo cirúrgico, perda de sangue intraoperatória e tempo de internamento hospitalar. Resultados: Um total de 32 pacientes foi incluído. A cirurgia aberta teve um tempo cirúrgico de 176,6 ± 45,3 minutos, perda de sangue de 300,5 ± 236,3 ml e um tempo de internamento de 4,5 ± 4,4 dias. A cirurgia minimamente invasiva teve um tempo cirúrgico de 161,5 ± 72 minutos, perda de sangue de 93,8 ± 69,5 ml e um tempo de internamento de 1,8 ± 1 dia. Conclusões: A descompressão minimamente invasiva resultou em menor tempo cirúrgico, redução da perda de sangue e menor tempo de internamento hospitalar em comparação com a cirurgia aberta. Pesquisas adicionais são necessárias para determinar seu impacto nos resultados funcionais. ***Nível de Evidência: II; Estudo Retrospectivo[f].***

Descritores: Compressão da Medula Espinhal, Mielopatia; Descompressão Cirúrgica; Procedimentos Cirúrgicos Minimamente Invasivos.

RESUMEN

Objetivo: Comparar las técnicas de descompresión posterior en la mielopatía cervical degenerativa (MCD) y evaluar sus resultados clínicos. Métodos: Se realizó un estudio observacional retrospectivo en pacientes con MCD que se sometieron a cirugía de descompresión cervical posterior entre 2012 y 2022. Las variables analizadas incluyeron el tiempo quirúrgico, la pérdida de sangre intraoperatoria y la estancia hospitalaria. Resultados: Se incluyó un total de 32 pacientes. La cirugía abierta tuvo un tiempo quirúrgico de 176,6 ± 45,3 minutos, una pérdida de sangre de 300,5 ± 236,3 ml y una estancia hospitalaria de 4,5 ± 4,4 días. La cirugía mínimamente invasiva tuvo un tiempo quirúrgico de 161,5 ± 72 minutos, una pérdida de sangre de 93,8 ± 69,5 ml y una estancia hospitalaria de 1,8 ± 1 día. Conclusiones: La descompresión mínimamente invasiva resultó en un menor tiempo quirúrgico, una reducción de la pérdida de sangre y una menor estancia hospitalaria en comparación con la cirugía abierta. Se necesita más investigación para determinar su impacto en los resultados funcionales. ***Nivel de Evidencia: II; Estudio Retrospectivo[f].***

Descriptores: *Compresión de la Médula Espinal; Mielopatía; Compresión de la Médula Espinal; Procedimientos Quirúrgicos Mínimamente Invasivos.*

Study conducted by the Central South High Specialty Hospital, Anillo Perif. 4091, Fuentes del Pedregal, Tlalpan, 14140 Ciudad de México, CDMX, México.
Correspondence: Julio Cesar López Valdés. 811, Pedro J. Méndez, Colonia Cascaj, Tampico, Tamaulipas, Mexico. 89280. jc.lopz@live.com

Received on 03/29/2025 accepted on 10/20/2025
Reviewed by: Erasmo Abreu Zardo

INTRODUCTION

Degenerative cervical myelopathy (DCM) is a condition caused by progressive spinal cord compression due to degenerative changes in the cervical spine.[1,2] These changes include disc herniation, ligament hypertrophy, and osteophyte formation, leading to symptoms such as pain, weakness, sensory disturbances, and gait disorders.[1-3] DCM is the most common cause of spinal cord disability in older adults and requires surgical intervention when conservative treatment fails.[1-4]

Surgical treatment consists of anterior or posterior decompression techniques, depending on the compression pattern and spinal alignment.[5,6] Posterior decompression options include laminectomy, which removes posterior bony elements, and laminoplasty, which expands the spinal canal without removing bone structures.[5-7] Minimally invasive techniques have gained relevance as they preserve musculature and reduce surgical trauma. However, the superiority of one technique over another in terms of clinical outcomes and functional recovery remains undetermined.[6-11]

This study aims to compare different posterior decompression techniques used to manage DCM and to evaluate their impact on surgical and hospital outcomes.

PATIENTS AND METHODS

Study Design

A descriptive, retrospective study was conducted from January 2012 to March 2022 in patients over 18 years old diagnosed with degenerative cervical myelopathy (ICD-10: M500: Cervical disc disorder with myelopathy, unspecified cervical region).[12] Following STROBE[13] recommendations, electronic clinical records were analyzed using convenience sampling.

This research adhered to the Declaration of Helsinki and the Health Research Regulations of the General Health Law.[14] Patient privacy and data confidentiality were ensured by storing information in a restricted-access system.

The study was approved by the institutional review board with waiver of informed consent (Approval No. 36-2022).

Criteria Selection

• Inclusion criteria: Patients aged 18-85 years diagnosed with DCM who underwent posterior cervical decompression via laminectomy, hemilaminectomy, laminoplasty, or laminoforaminotomy, using either open or minimally invasive techniques. Only patients with complete clinical records were included.

• Exclusion criteria: Patients with rheumatic disease, peripheral neuropathy due to other causes, or non-degenerative cervical myelopathy were excluded. Patients with incomplete records or those who could not be analyzed (e.g., death from unrelated causes, poor follow-up compliance) were also eliminated.

Outcome

Patients were assessed daily during hospitalization and in outpatient follow-ups every 15 days. Outcomes were evaluated based on hospitalization duration and the Modified Japanese Orthopaedic Association (mJOA) score[15] preoperatively, at six weeks, and at six months postoperatively.

Data Collection

Sociodemographic and clinical variables (affected cervical levels, number of levels involved) and surgical variables (operative time, intraoperative bleeding, hospital stay, mJOA score,[16] and Nurick scale)[3] were collected. Open approaches (laminectomy and laminoplasty) were compared with minimally invasive approaches (hemilaminectomy and laminoforaminotomy). Data were extracted from hospital administration records, hospitalization notes, outpatient consultations, and surgical reports.

Database structuring was performed using Microsoft Excel™ by the first and second investigators (CBQ & DAVM), while statistical analysis was conducted using IBM SPSS V21™ by a third investigator (JCLV). Missing data were reviewed via electronic radiological records (JGVC & LMO).

Statistical Analysis

Descriptive statistics were used to obtain frequencies, central tendency measures (median or mean), and dispersion measures (proportions or standard deviation) for clinical and surgical characteristics.

Kolmogorov-Smirnov tests were used to assess the distribution of the data. Central tendency and dispersion measures were applied for quantitative variables. The Kruskal-Wallis test was used for comparative analysis between treatments, while ANOVA assessed mJOA improvement at six weeks and six months. Analyses were performed using SPSS v21 and visualized in Excel. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 32 patients with DCM underwent cervical decompression surgery. The majority were male (n=26, 81%), with a mean age of 70.5 ± 8.9 years (range: 52-87 years). (Figure 1)

The most affected levels were C4 (n=26, 81.2%) and C5 (n=26, 81.2%), either as single- or multi-level involvement. The most common number of affected levels was four (n=12) and two (n=9). Additional data are presented in Table 1.

According to the mJOA classification for myelopathy severity: Mild myelopathy: 14 patients (43.7%), moderate myelopathy: 7 patients (21.7%), Severe myelopathy: 12 patients (37.5%). (Table 2)

The most common imaging findings included ligamentum flavum hypertrophy, disc protrusion or herniation, facet hypertrophy, and cervical canal stenosis. Spinal cord myelomalacia (MRI, T2 hyperintensity) was observed in 18 patients (40.6%).

Electrophysiological studies were available for only 18 patients, with the most common finding being large-fiber conduction block in the posterior columns (n=7, 38.9%).

Surgical Outcomes

A total of 19 open surgeries (59.4%) and 13 minimally invasive surgeries (40.6%) were performed (Figure 2). Outcomes assessed included surgical time, intraoperative blood loss, and postoperative hospital stay. (Tables 3 and 4)

Significant differences were observed between decompression techniques: Minimally invasive techniques significantly reduced surgical time, blood loss, and hospital stay compared to open approaches.

However, Fisher's exact test for pre- and postoperative mJOA scores showed that although patients undergoing minimally

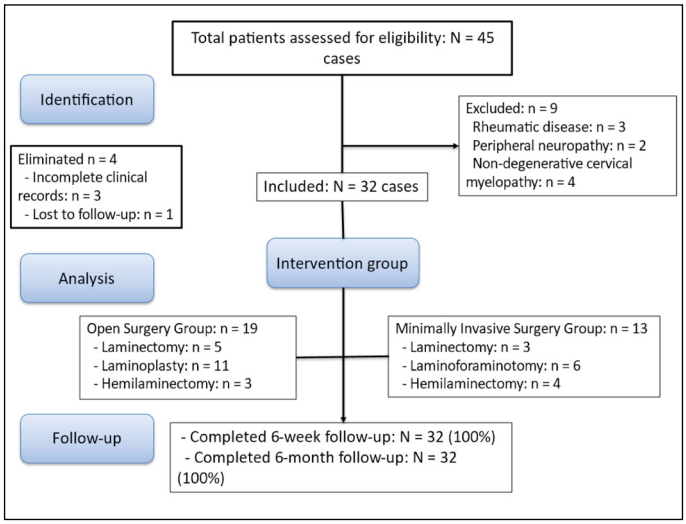

Figure 1. Flowchart for patient selection.

Table 1. Demographic Characteristics of the Study Population.

Variable	Total (N = 32)
Age (years)	70.5 ± 8.9
Gender (M vs F)	26 vs 6
Diagnosis	
- Myelopathy	12 (37.5%)
- Myeloradiculopathy	20 (62.5%)
Previous anterior cervical decompression	7 (21.7%)
Disease duration (months ± SD)	21 ± 26
Preoperative mJOA score (points ± SD)	12.8 ± 2.1
Affected Levels	**Cases (n)**
C2	1 (3.1%)
C3	14 (43.7%)
C4	26 (81.2%)
C5	26 (81.2%)
C6	23 (71.8%)
C7	15 (46.8%)
Nurick Scale[16]	**Cases (n)**
Grade 1	7 (21.9%)
Grade 2	7 (21.9%)
Grade 3	5 (15.6%)
Grade 4	9 (28.1%)
Grade 5	4 (15.6%)

Table 2. Population Characteristics According to Myelopathy Severity Based on the mJOA Scale.

Variable	Cases (n)	Age ± SD (years)	Disease Duration ± SD (months)
Mild Myelopathy	13 (40.6%)	66.9 ± 9.4	26.5 ± 32.4
Moderate Myelopathy	7 (21.9%)	68.9 ± 6.7	24.9 ± 25
Severe Myelopathy	12 (37.5%)	75.4 ± 7.9	14.5 ± 19.6
Total	N=32	70.5 ± 8.9	21 ± 26

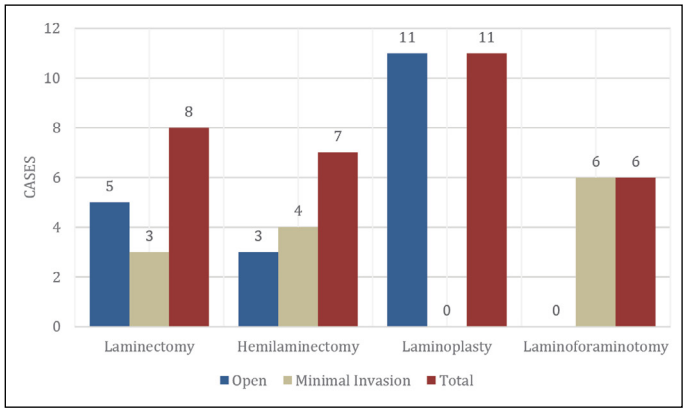

Figure 2. Approaches used for posterior cervical decompression.

invasive techniques exhibited better clinical improvement, the difference was not statistically significant (p=0.166). A trend toward better postoperative function was observed in the minimally invasive group. (Table 5)

When specifically analyzing the domains assessed in the mJOA questionnaire for evaluating preoperative spinal cord impairment, the average scores obtained were upper limb motor function, μ= 3.75 ± 0.84 (SD) points and for lower limb motor function μ= 4.46 ± 1.9 (SD) points; sensory function μ=2.09 ± 0.39 (SD) points and sphincter control μ= 2.5 ± 0.91 (SD) points Among these, sensory function showed the greatest impairment.

According to the type of intervention, the following results were obtained, comparing preoperative mJOA scores with changes observed at six weeks and six months postoperatively. (Table 4, Figure 3)

Additionally, a comparative analysis of follow-up assessments

Table 4. Comparison of Surgical Techniques.

Intervention Type	Surgical Time (hours ± SD)	Blood Loss (ml ± SD)	Hospital Stay (days ± SD)
Open Surgery			
Laminectomy (n=5)	190 ± 76.8	322 ± 359.9	2.8 ± 2.4
Hemilaminectomy (n=3)	151 ± 35.5	133 ± 57.7	3 ± 1
Laminoplasty (n=11)	177 ± 28.3	336.4 ± 195.1	5.7 ± 5.3
Minimally Invasive			
Laminectomy (n=3)	210 ± 108.2	110 ± 36.1	2.6 ± 1.5
Hemilaminectomy (n=4)	112.5 ± 45	82.5 ± 78.9	1.3 ± 0.5
Laminoforaminotomy (n=6)	170 ± 55.9	93.3 ± 84.1	1.8 ± 0.8

Table 5. Difference between mJOA scores at six weeks and six months.

Type of procedure	Approach	Six weeks Δ mJOA	Six months Δ mJOA
Open	Laminectomy	1.2	2.8
	Hemilaminectomy	2.67	5.67
	Laminoplasty	1.27	3.73
Minimal invasion	Laminectomy	3.67	6.33
	Hemilaminectomy	1.75	4.5
	Laminoforaminotomy	0.5	3.5

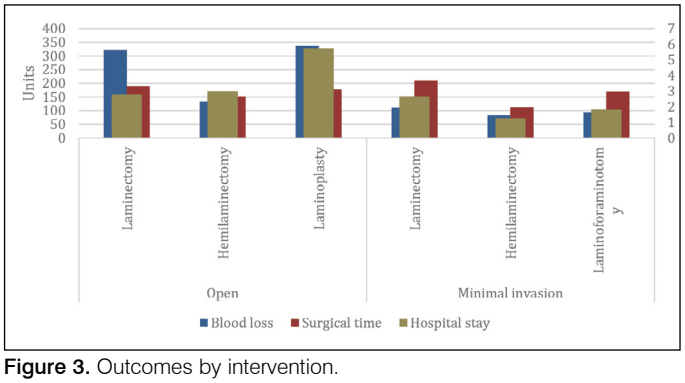

Figure 3. Outcomes by intervention.

Table 3. Comparative Analysis Between Open Surgery and Minimally Invasive Surgery.

Variable	Total (N = 32)	Open Surgery (n = 19)	Minimally Invasive Surgery (n = 13)	Test	p-value
Age (years, mean ± SD)	70.5 ± 8.9	72.3 ± 7.5	68.1 ± 9.8	t = 1.37	0.179
Male gender (%)	81%	79%	85%	---	---
Affected levels (mean ± SD)	2.4 ± 0.9	2.7 ± 1.1	2.1 ± 0.8	t = 1.78	0.083
Preoperative mJOA (mean ± SD)	12.8 ± 2.1	12.5 ± 2.3	13.2 ± 1.9	t = 0.90	0.372
Surgical time (min ± SD)	176.6 ± 45.3	190 ± 76.8	161.5 ± 72	t = 1.05	0.299
Blood loss (ml ± SD)	300.5 ± 236.3	322 ± 359.9	93.8 ± 69.5	t = 2.24	0.032*
Hospital stay (days ± SD)	4.5 ± 4.4	4.8 ± 4.9	1.8 ± 1	t = 2.16	0.038*

using the mJOA scale demonstrated that all patients, regardless of surgical approach, showed functional improvement that remained consistent throughout the 6-month follow-up period. (Figure 4)

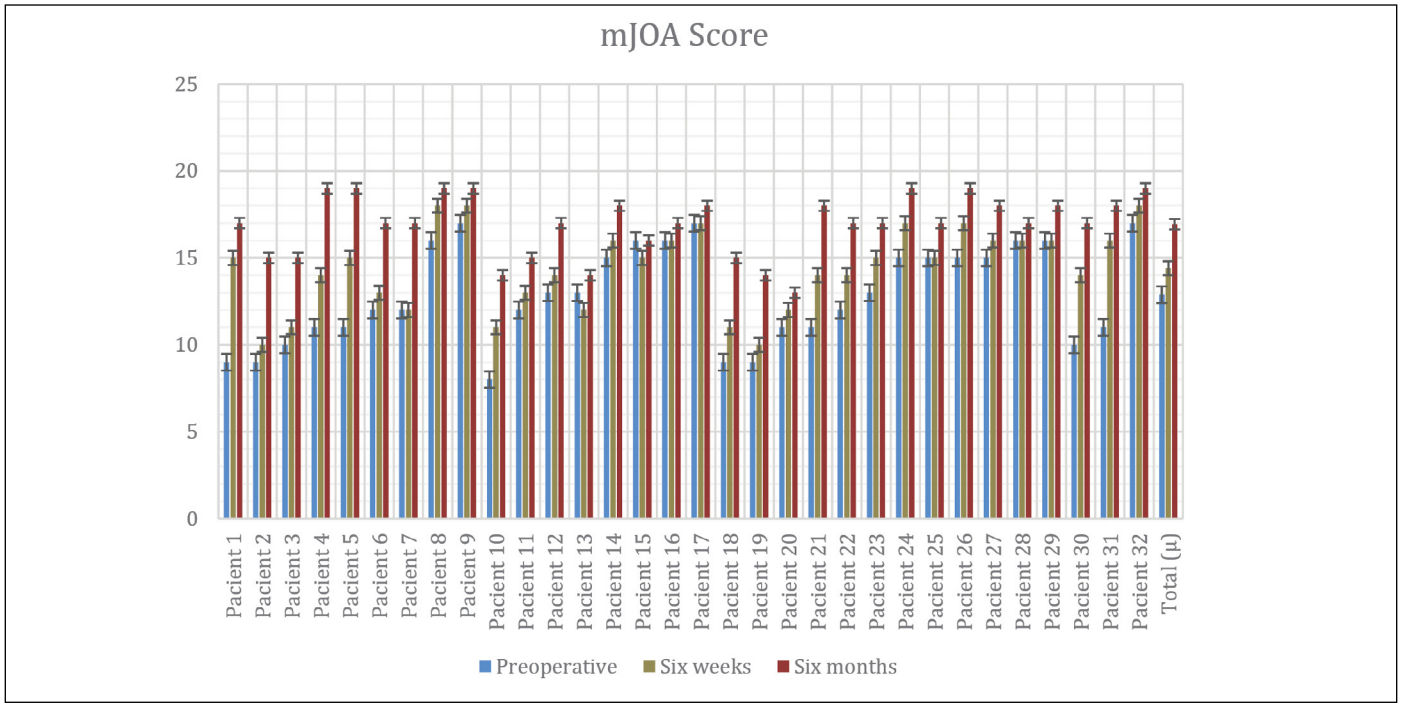

Figure 4. Difference between preoperative mJOA and mJOA scores at six weeks and six months.

DISCUSSION

The primary objective of this study was to compare open surgery and minimally invasive posterior approaches for the management of degenerative cervical myelopathy (DCM). Our findings suggest that minimally invasive surgery yields better outcomes, regardless of patient age, procedure type, number of affected levels, or diagnosis.

These results align with recent literature on posterior cervical decompression for DCM.[8-10,16] Previous studies have shown that minimally invasive techniques are associated with shorter surgical time and reduced blood loss compared to open procedures.[17,18] Specifically, studies such as Ito et al. have reported significant reductions in hospital stay duration and postoperative pain in patients undergoing minimally invasive procedures.[8-10,17-19]

The reduced surgical time and intraoperative blood loss observed in this study are consistent with the findings of Soares, et al.[20] who demonstrated that minimally invasive approaches better preserve paraspinal musculature and reduce postoperative inflammation, leading to faster recovery. However, despite these advantages, the functional improvement measured by the mJOA scale was not statistically significant, suggesting that effective spinal cord decompression remains the key factor in recovery, regardless of the technique used.

A critical factor to consider is patient selection for each surgical approach.[21] According to Fehlings et al.,[22] minimally invasive techniques are most beneficial for patients with preserved cervical lordosis and no significant spinal instability. In contrast, laminectomy with fusion remains the preferred approach in cases of kyphotic deformity or severe multilevel involvement.

Despite the observed advantages, minimally invasive techniques require a significant learning curve, which may contribute to variability in reported outcomes.[18,19] Additionally, recent studies suggest that preserving the range of motion with laminoplasty may reduce the incidence of adjacent segment disease. This factor should be considered in long-term surgical planning.[23-25]

The results suggest that minimally invasive posterior decompression for cervical myelopathy offers significant advantages in reducing surgical time, blood loss, and hospital stay compared to open surgery.[18,19,21,23-25] However, functional recovery showed no statistically significant differences between techniques, indicating that effective spinal cord decompression remains the primary determinant of patient outcomes.[21,23-25]

Further studies with larger cohorts and long-term follow-up are needed to determine the definitive functional impact of these techniques and establish optimal surgical recommendations for DCM patients.

These findings reinforce the clinical utility of minimally invasive techniques for posterior cervical decompression, reducing postoperative complications and promoting faster recovery. However, the lack of statistically significant differences in functional improvement highlights the need for careful patient selection and individualized surgical planning.

Limitations & Strengths

The study included only 32 patients, limiting the generalizability of the results. Also, the follow-up period was limited to 6 months, preventing assessment of long-term functional outcomes. Not all patients underwent electrophysiological studies, which may have affected the objective evaluation of spinal cord impairment.

Multiple surgical and clinical parameters were assessed, providing a comprehensive analysis of each technique's impact.

Functional evaluation was conducted using the mJOA scale, allowing comparisons with other studies. Both open and minimally invasive techniques were analyzed, enabling the identification of variations within each surgical approach.

CONCLUSION

Minimally invasive posterior decompression techniques for DCM offer significant advantages, including shorter surgical time, reduced blood loss, and shorter hospital stays compared to open surgery. However, postoperative functional improvement did not significantly differ between techniques, indicating that effective spinal cord decompression remains the primary determinant of recovery.

Further studies with larger sample sizes and long-term follow-ups are required to determine the definitive functional impact of these techniques and establish precise surgical selection guidelines for DCM patients.

CONFLICT OF INTEREST

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

CONTRIBUTIONS OF THE AUTHORS

Each author made significant individual contributions to the development of this manuscript. CBQ, DAVM, JCLV and JGVC: Conceptualization; DAVM, and JCLV: Formal Analysis; CBQ, DAVM, JCLV, LMO and ERVC: Investigation; CBQ, DAVM, JCLV, and UGG; Methodology: CBQ, and UGG: Project Administration; CBQ, DAVM, and JCLV: Writing – Original Draft; CBQ, DAVM, JCLV, and UGG: Writing – Review & Editing.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available from the corresponding author upon request.

REFERENCES

1. Davies BM, Mowforth OD, Smith EK, Kotter MR. Degenerative cervical myelopathy. BMJ. 2018;360:k186. doi: 10.1136/bmj.k186.
2. Nouri A, Tetreault L, Singh A, Karadimas SK, Fehlings MG. Degenerative Cervical Myelopathy: Epidemiology, Genetics, and Pathogenesis. Spine (Phila Pa 1976). 2015;40(12):E675-93. doi: 10.1097/BRS.0000000000000913.
3. Nurick S. The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain. 1972;95(1):87-100. doi: 10.1093/brain/95.1.87.
4. Abolfotouh, S. Degenerative Cervical Myelopathy (DCM), Guidelines, Treatment, and Future Directions: A Narrative Review. Advanced Spine Journal. 2022;41(4). doi: 10.57055/2314-8969.1280.
5. Hirayama Y, Mowforth OD, Davies BM, Kotter MRN. Determinants of quality of life in degenerative cervical myelopathy: a systematic review. Br J Neurosurg. 2023;37(1):71-81. doi: 10.1080/02688697.2021.1999390.
6. Sánchez-Calderón MD, Córdoba-Mosqueda ME, Aguilar-Calderón JR, Domínguez-Herz CR, Ochoa-Cacique D, Vega-Moreno DA, et al. Anterior and Posterior Approach Results for Treatment of Cervical Myelopathy in the Elderly: A 10-Year Experience in a Mexican Institution. Open Journal of Orthopedics. 2021;11(7):207-219. doi: 10.4236/ojo.2021.117020.
7. Sangondimath G, Mallepally AR, Marathe N, Mak KC, Suman Salimath. Degenerative cervical myelopathy: Recent updates and future directions. J Clin Orthop Trauma. 2020;11(5):822-829. doi: 10.1016/j.jcot.2020.07.012. Epub 2020 Jul 21.
8. Badhiwala JH, Ahuja CS, Akbar MA, Witiw CD, Nassiri F, Furlan JC, et al. Degenerative cervical myelopathy - update and future directions. Nat Rev Neurol. 2020;16(2):108-124. doi: 10.1038/s41582-019-0303-0.
9. Feng S, Zheng B, Zhang L, Wang W. A systematic review and meta-analysis compare surgical treatment and conservative treatment in patients with cervical spondylotic myelopathy. Ann Palliat Med. 2021;10(7):7671-7680. doi: 10.21037/apm-21-1365.
10. Satomi K, Ogawa J, Ishii Y, Hirabayashi K. Short-term complications and long-term results of expansive open-door laminoplasty for cervical stenotic myelopathy. Spine J. 2001;1(1):26-30. doi: 10.1016/s1529-9430(01)00008-0.
11. Steinmetz MP, Resnick DK. Cervical laminoplasty. Spine J. 2006;6(6 Suppl):274S-281S. doi: 10.1016/j.spinee.2006.04.023.
12. World Health Organization (WHO). [Internet]. 1992 International Statistical Classification of Diseases and Related Health Problems (ICD). Available at: https://www.who.int/standards/classifications/classification-of-diseases
13. STROBE. Strengthening the reporting of observational studies in epidemiology. [Internet]. 2025. What is STROBE?. Available at: https://www.strobe-statement.org/.
14. de la Salud, P. Reglamento de la ley general de salud en materia de investigación para la salud. [Internet]. 1987. Diario Oficial de la Federación. Available at: https://www.diputados.gob.mx/LeyesBiblio/regley/Reg_LGS_MIS.pdf
15. 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. doi: 10.1371/journal.pone.0123022.
16. Benzel EC, Lancon J, Kesterson L, Hadden T. Cervical laminectomy and dentate ligament section for cervical spondylotic myelopathy. J Spinal Disord. 1991;4(3):286-95. doi: 10.1097/00002517-199109000-00005.
17. Tetreault L, Goldstein CL, Arnold P, Harrop J, Hilibrand A, Nouri A, et al. Degenerative Cervical Myelopathy: A Spectrum of Related Disorders Affecting the Aging Spine. Neurosurgery. 2015;77 Suppl 4:S51-67. doi: 10.1227/NEU.0000000000000951.
18. Ito Z, Shibayama M, Nakamura S, Yamada M, Kawai M, Takeuchi M, et al. Clinical Comparison of Unilateral Biportal Endoscopic Laminectomy versus Microendoscopic Laminectomy for Single-Level Laminectomy: A Single-Center, Retrospective Analysis. World Neurosurg. 2021;148:e581-e588. doi: 10.1016/j.wneu.2021.01.031.
19. Hur JW, Kim JS, Shin MH, Ryu KS. Minimally invasive posterior cervical decompression using tubular retractor: The technical note and early clinical outcome. Surg Neurol Int. 2014;5:34. doi: 10.4103/2152-7806.128915.
20. Soares RO, Astur N, Rabello de Oliveira L, Kanas M, Wajchenberg M, Martins DE. Qualitative Evaluation of Paraspinal Musculature After Minimally Invasive Lumbar Decompression: A Prospective Study. Int J Spine Surg. 2024;18(4):448-454. doi: 10.14444/8631.
21. Komotar RJ, Mocco J, Kaiser MG. Surgical management of cervical myelopathy: indications and techniques for laminectomy and fusion. Spine J. 2006;6(6 Suppl):252S-267S. doi: 10.1016/j.spinee.2006.04.029.
22. Fehlings MG, Ibrahim A, Tetreault L, Albanese V, Alvarado M, Arnold P, et al. A global perspective on the outcomes of surgical decompression in patients with cervical spondylotic myelopathy: results from the prospective multicenter AOSpine international study on 479 patients. Spine (Phila Pa 1976). 2015;40(17):1322-8. doi: 10.1097/BRS.0000000000000988.
23. Wewel JT, Brahimaj BC, Kasliwal MK, Traynelis VC. Perioperative complications with multilevel anterior and posterior cervical decompression and fusion. J Neurosurg Spine. 2019;32(1):9-14. doi: 10.3171/2019.6.SPINE198.
24. Vergara P. Minimally Invasive Microscopic Posterior Cervical Decompression: Simple, Safe, and Effective. J Neurol Surg A Cent Eur Neurosurg. 2017;78(5):440-445. doi: 10.1055/s-0037-1598051.
25. Wang J, Wo J, Wen J, Zhang L, Xu W, Wang X. Laminoplasty versus laminectomy with fusion for treatment of multilevel cervical compressive myelopathy: an updated meta-analysis. Postgrad Med J. 2022;98(1163):680-688. doi: 10.1136/postgradmedj-2020-139667.