ORIGINAL ARTICLE
ENDOSCOPY
http://dx.doi.org/10.1590/S1808-185120262502305048

AWAKE OUTPATIENT ANTERIOR ENDOSCOPIC CERVICAL FORAMINOTOMY FOR SPONDYLOTIC RADICULOPATHY

FORAMINOTOMIA CERVICAL ANTERIOR ENDOSCÓPICA AMBULATORIAL COM PACIENTE ACORDADO PARA RADICULOPATIA ESPONDILÓTICA

FORAMINOTOMÍA CERVICAL ANTERIOR ENDOSCÓPICA AMBULATORIA CON PACIENTE DESPIERTO PARA RADICULOPATÍA ESPONDILÓTICA

Jorge Felipe Ramírez León[1,2,3,4], Neal Angel Saji Rondan[5], José Gabriel Rugeles Ortíz[1,2,3], Carolina Ramírez Martínez[1,2,3], Nicolás Prada Ramírez[1,6], Viviana Marcela Plazas Bedoya[2], João Paulo Machado Bergamaschi[7,8], Gabriel Oswaldo Alonso Cuéllar[1,4]

1. Latin American Endoscopic Spine Surgeons LESS Invasiva Academy, Bogotá, D.C., Colombia.
2. Clínica Reina Sofía, Endoscopic Spine Surgery Department, Bogotá, D.C., Colombia.
3. Fundación Universitaria Sanitas, Orthopedic and Traumatology Department, Bogotá, D.C., Colombia.
4. Clínica Colsanitas S.A., Orthopedic and Traumatology Department, Orthopedics and Traumatology Research Group, Bogotá, Colombia.
5. LESS Invasiva Academy, Fellowship Visiting - Latin American Endoscopic Spine Surgeons, Bogotá, D.C., Colombia.
6. Clínica Foscal Internacional, Endoscopic Spine Surgery Department, Bucaramanga, Colombia.
7. Universidade de São Paulo (USP-RP), School of Medicine, Specialization Course in Endoscopic Spine Surgery, Ribeirão Preto, SP, Brazil.
8. Atualli Spine Care Clinic, São Paulo, SP, Brazil.

ABSTRACT

Objective: To report the clinical outcomes obtained using AECF for cervical spondylarthrosis treatment. Methods: A retrospective study evaluated the patient-reported outcome measures (PROM) and complications of patients with radiating cervical pain and imaging findings of spondylarthrosis and foraminal stenosis treated with awake outpatient AECF. Results: AECF was performed in 18 patients. A satisfaction rate between excellent and good was obtained in 82.4% of the patients. Neck Disability Index significantly decreased 37.4% ± 14.3 (95% CI 29.8 – 45.0) to 11.5% ± 9.7 (95% CI 5.54 - 17.4) (P<0.001). VAS scores showed a statistically significant variation from a preoperative pain of 7.83 ±1.38 (95% CI 7.15 – 8.52) and then, at the 24-month follow-up, a score of 2.20 ± 1.79 (95% CI 1.31 – 3.09). There were two complications and two reoperations. Conclusion: This case series demonstrated favorable clinical outcomes using the anterior endoscopic technique for radiculopathy due to cervical spondylosis, supporting AECF as a feasible surgical alternative. Although current evidence suggests endoscopic treatment as an alternative for lateral stenosis, further high-quality studies are needed to strengthen the level of evidence. ***Level of Evidence IV; Case Series***.

Keywords: Cervical Spondylosis; Foraminotomy; Spinal Stenosis; Ambulatory Surgical Procedures; Endoscopy.

RESUMO

Objetivo: Relatar os desfechos clínicos obtidos com o uso da foraminotomia cervical endoscópica anterior (AECF) em pacientes com radiculopatia cervical secundária à espondiloartrose. Métodos: Realizou-se análise retrospectiva para avaliar medidas de desfecho relatadas pelos pacientes (PROMs) e complicações relacionadas ao procedimento. Indivíduos com dor cervical irradiada e estenose foraminal confirmada por imagem foram submetidos à AECF sob anestesia local, em regime ambulatorial. Resultados: Dezoito pacientes foram incluídos. De acordo com os critérios modificados de MacNab, satisfação boa a excelente foi observada em 82,4% dos casos. O Índice de Incapacidade Cervical reduziu significativamente de 37,4% ± 14,3 (IC 95%: 29,8–45,0) no pré-operatório para 11,5% ± 9,7 (IC 95%: 5,54–17,4) no seguimento final (p < 0,001). A pontuação na Escala Visual Analógica diminuiu de 7,83 ± 1,38 (IC 95%: 7,15–8,52) para 2,20 ± 1,79 (IC 95%: 1,31–3,09) aos 24 meses. Foram registradas duas complicações e duas reoperações. Conclusão: Esta série de casos demonstrou desfechos favoráveis com a abordagem endoscópica anterior para radiculopatia cervical, sustentando a AECF como alternativa cirúrgica viável em pacientes selecionados. Contudo, estudos comparativos de maior qualidade metodológica ainda são necessários para fortalecer o nível de evidência disponível. ***Nível de Evidência: IV; Série de Casos.***

Descritores: *Espondilose Cervical; Foraminotomia; Estenose Espinal; Procedimentos Cirúrgicos Ambulatórios; Endoscopia.*

RESUMEN

Objetivo: Reportar los desenlaces clínicos de la AECF en pacientes con radiculopatía cervical secundaria a espondiloartrosis. Métodos: Se realizó un análisis retrospectivo para evaluar las medidas de desenlace reportadas por los pacientes (PROMs) y las complicaciones relacionadas con el procedimiento. Los individuos con dolor cervical irradiado y estenosis foraminal confirmada por imagen fueron sometidos

Study conducted by the Latinamerican Endoscopic Spine Surgeons - LESS Invasiva Academy, Carrera 45 N 104-76, Bogotá, Colombia.
Correspondence: Gabriel Oswaldo Alonso Cuéllar. Latinamerican Endoscopic Spine Surgeons - LESS Invasiva Academy, Carrera 45 N 104-76, Bogotá, Colombia. academy@lessinvasiva.com

Received on 01/29/2026 accepted on 02/10/2026
Reviewed by: Robert Meves

a AECF bajo anestesia local, en régimen ambulatorio. Resultados: Se incluyeron dieciocho pacientes. De acuerdo con los criterios modificados de MacNab, se observó satisfacción buena a excelente en el 82,4% de los casos. El Índice de Discapacidad Cervical se redujo significativamente de 37,4% ± 14,3 (IC 95%: 29,8–45,0) en el preoperatorio a 11,5% ± 9,7 (IC 95%: 5,54–17,4) en el seguimiento final (p < 0,001). La puntuación en la Escala Visual Analógica disminuyó de 7,83 ± 1,38 (IC 95%: 7,15–8,52) a 2,20 ± 1,79 (IC 95%: 1,31–3,09) a los 24 meses. Se registraron dos complicaciones y dos reintervenciones. Conclusión: Esta serie de casos demostró desenlaces favorables con el abordaje endoscópico anterior para la radiculopatía cervical, sustentando la AECF como alternativa quirúrgica viable en pacientes seleccionados. No obstante, aún se requieren estudios comparativos de mayor calidad metodológica para fortalecer el nivel de evidencia disponible. ***Nivel de Evidencia IV; Serie de Casos.***

Descriptores: *Espondilosis Cervical; Foraminotomía; Estenosis Espinal; Procedimientos Quirúrgicos Ambulatorios; Endoscopía.*

INTRODUCTION

Cervical spondylarthrosis (CS) is a chronic and degenerative process of the cervical spine usually found in patients over 50 years[1]. A recent systematic review study reports a CS prevalence between 23,6% to 89,7[2]. Clinical symptoms of CS include radicular and axial cervical pain, stiffness, and shoulder numbness caused by intervertebral foramina narrowing caused by herniated discs, bone spur formation, and compression of the spinal cord[3]. Several treatment options are available of treatment for CS[1]. The first-line treatment is medical management with analgesics, physical therapy, and injections[1,3]. When conservative management fails, a surgical option should be considered[4]. Developed in 1949, anterior cervical discectomy with fusion (ACDF) remains the gold standard in surgical management[5]. It is an effective alternative that allows adequate visualization of the structures[3-5]. However, it has been associated with complications such as dysphagia, postsurgical hematoma, unilateral paralysis of the recurrent laryngeal nerve, pseudoarthrosis, and adjacent segment syndrome, among others[6-10].

CS is an age-related disease, and the management of these patients is a clinical challenge because many of them have significant comorbidities, and general anesthesia and long hospitalization times could be risk factors[10]. To minimize the morbidity related to conventional procedures, mainly in elderly patients with underlying comorbidities and risks, minimally invasive techniques such as anterior endoscopic cervical foraminotomy (AECF) has been introduced for the treatment of foraminal stenosis due to spondylarthrosis[10-12]. Endoscopic procedures offer similar clinical outcomes with advantages such as preservation of segmental mobility, less exposure to adjacent tissues, less postoperative pain, and shorter recovery time[5-13]. As in ACDF, the surgical principle of AECF is to resect degenerative tissue compressing neural structures, enlarge the foraminal window, remove hypertrophic tissues, and free nervous structures and disc decompression, and neurolysis may reduce the effects of the inflammatory cytokines from degenerated intervertebral disk[10,13,14]. AECF is performed using local anesthesia with awake patients and without the need for hospitalization[14]. Another reported advantage of endoscopic approach is that the foraminotomy can be done on one or several levels with a lower risk of instability and without a fusion, being a motion-preserving surgery[5,11-16]. This study aims to report the clinical outcomes obtained using an awake and outpatient AECF with a blunt approach for treating radiculopathy caused by cervical spondylarthrosis.

MATERIALS AND METHODS

Clinical data

This study was approved by the institutional review board (CEIFUS #2714-25) of the Fundación Universitaria Sanitas (Sanitas University Foundation). Informed consent was obtained from each participant.

A 15-year institutional observational retrospective review was conducted evaluating clinical outcomes of patients who presented with symptoms of cervical pain radiating to the arms, with imaging findings consistent with spondylarthrosis and who underwent an AECF at one or two intervertebral disc segments. Two experienced specialists in spinal pathology made the diagnosis of spinal pathology: a neuroradiologist and an expert spine surgeon (orthopedist/neurosurgeon), based on clinical and imaging findings.

Inclusion and exclusion criteria

Medical records of patients with a history of radiating cervical pain of more than six months and magnetic resonance imaging (MRI) showed the presence of spondylarthrosis and foraminal stenosis, with no response to medical treatment, including foraminal injections, were included. The study excluded medical charts of patients under 18 years showing axial pain symptoms, a height loss greater than 50%, intervertebral space collapse, segmental instability, infection, coagulation disorders, bleeding, anatomical alterations, severe neurological deficit, progressive myelopathy, ossification of posterior longitudinal ligament, previous surgery at the same segment, impossibility to reach affected segment (patients with short neck or excessive obesity), and those medical charts without fully completed assessment criteria.

Surgical technique

Awake patient with conscious sedation was placed in a supine position with cervical extension. To obtain easier and more secure access to the affected area of the intervertebral space, a pad was placed under the shoulders, and the patient's head was slightly turned towards the contralateral side of the approach. Traction devices were not necessary. The anatomical landmark is the medial border of the sternocleidomastoid muscle and the intersection with the corresponding affected level previously identified using biplanar fluoroscopy (Figure 1). The esophagus and trachea were displaced medially, and the vascular-nervous bundle laterally firm pressure was applied with the finger in the space between the muscle and the trachea and directs it towards the vertebral surface. After local anesthesia infiltration, a 4mm skin incision was made, and a dilator and blunt cannula (without a sharp edge) were advanced to the anterior annulus by turning them gently together (Figure 2). Once the dilator tip was in front of the affected disc, a 0.65 mm spinal needle was advanced through the cannula until it was inside the intervertebral disc. Once the spinal needle was adequately positioned within the posterior third of the intervertebral cervical disc, chromo-discography and provocative discogenic using a combination of blue methylene and contrast were performed to confirm with the awake patient that the familiar pain generator was being treated. Before removing the needle, a guidewire was advanced intradiscally. Once the position of the guide was confirmed, the needle is removed, and the cervical endoscope's dilators and cannulas are advanced until they reach the foraminal area.

With the endoscope (Cervical Discoscope, Richard Wolf, Germany) in position and using a bipolar radiofrequency probe (Trigger Flex DTF 40, Elliquence LLC, NY, USA), small vessels were coagulated, and anterior cervical prevertebral fascia was removed to facilitate visibility (Figure 3). Osteophytes present in the foraminal window are removed endoscopically using a shaver, burr, or chisel. To obtain a complete decompression, an endoscopic discectomy using grasping forceps was performed. Complete neural decompression was verified endoscopically, visualizing the free cervical nerve root.

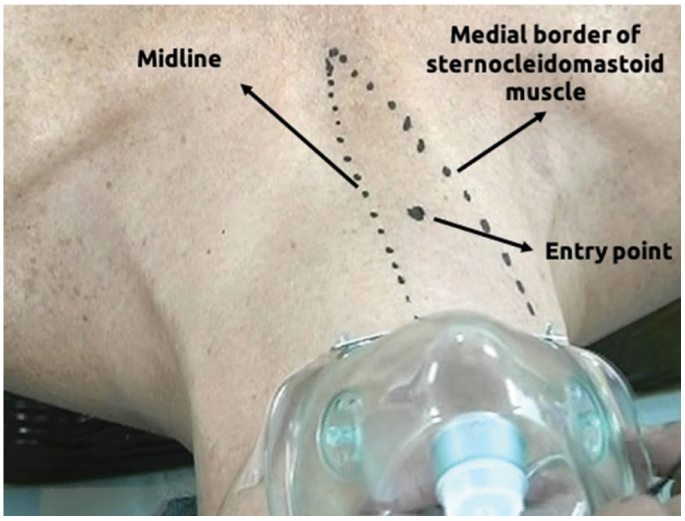

Figure 1. Anterior endoscopic cervical foraminotomy anatomical landmarks.

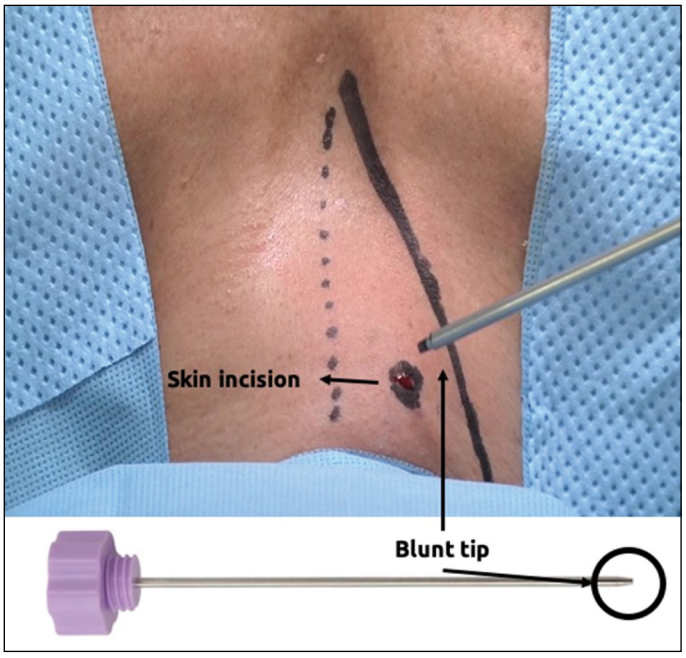

Figure 2. Secure approach using a blunt dilator.

PROMs evaluation

Three criteria were selected for perioperative evaluation: Visual Analog Pain Scale (VAS), Neck Disability Index (NDI), which determines the percentage of disability the pathology generates, and modified MacNab criterion. The first two criteria were evaluated at a 24-month follow-up in the preoperative and postoperative periods. The modified MacNab criterion, determining the degree of patient satisfaction with the procedure, was performed in the postoperative controls at 24-months of follow-up. Intra- and postsurgical complications and the need for reintervention were also collected.

Statistical analysis

Statistical analysis was performed using the statistical program Jamovi 2.6.44 for Windows. Descriptive statistics were performed with central tendency, dispersion, and frequency measures. The two groups' variables of interest were compared with the signed--rank test Wilcoxon, Mann Whitney, and Kruskal Wallis. Bivariate analyses were performed for the variables of interest to determine the association. Statistical significance was determined at a p-value of less than 0.05.

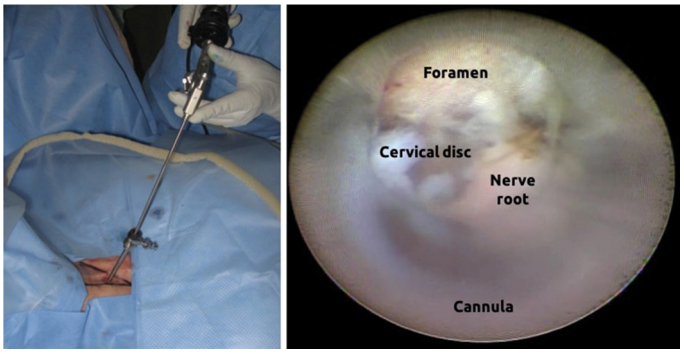

Figure 3. Anterior endoscopic cervical foraminotomy (endoscopic view).

RESULTS

Patients' characteristics

Eighteen patients were treated using the AECF technique for lateral stenosis secondary to cervical spondylarthrosis. 66.7% of the sample were women (n=12), and 33,3% (n=6) were men. The mean age of the sample was 44.2 ± 10.1 years (95% CI 39.1 – 49.2), ranging between 29 and 63 years.

Eight patients (44.4%) were "university professionals" or "office workers," and only one patient (5.6%) was a housewife. The laterality of arm pain was distributed as follows: 5 bilateral, 9 right, and 4 left. Sixty-six-point seven percent of patients reported no history of disease or medical treatment.

A total of 25 cervical levels were treated (Figure 4). Seven patients were treated at two levels, while 11 were treated at only one level. The level most frequently treated was C5-C6 in thirteen (52%) patients, followed by C6-C7 in six (24%) patients (Table 1).

Clinical outcome

Surgical mean time was 69.1 ± 26.75 minutes (95% CI 52.1 – 86.1) and mean blood loss was 14.3 ml. The longest duration and greatest bleeding occurred in the same patient (120 minutes and 100 ml), a 47-year-old man who underwent AECF at the C6-C7 level. However, this patient experienced complete resolution of symptoms.

Patients' self-reported VAS score demonstrated a statistically significant reduction from preoperative pain of 7.83 ±1.38 (95% CI 7.15 – 8.52) and then, at the 24-month follow-up, a score of 2.20 ± 1.79 (95% CI 1.31 – 3.09) (p<0,01). NDI test significantly decreased at the final 24-month follow-up (P<0.001). This functionality PROM score changed from an average of 37.4% ± 14.3 (95% CI

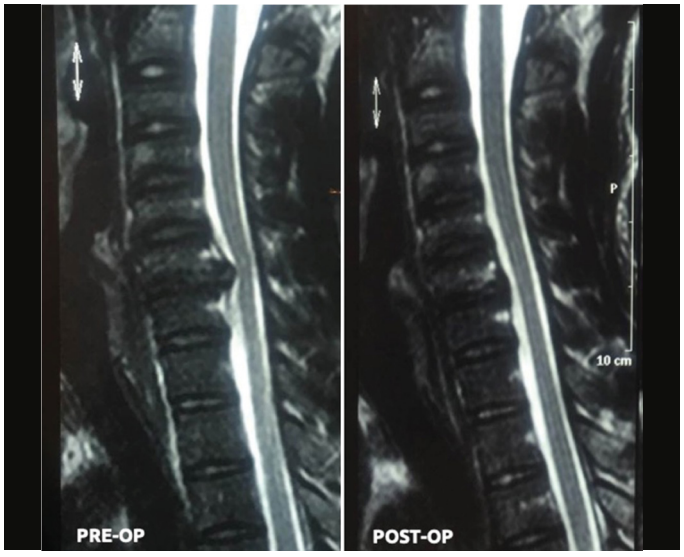

Figure 4. Pre and Postoperative MRI.

29.8 – 45.0) to 11.5% ± 9.7 (95% CI 5.54 – 17.4) at the last follow-up. The intensity of pain and the degree of disability stratified in each of the occupations reported by patients are shown in Table 2.

The MacNab index reported by patients showed that 82.4% of patients were satisfied with results ranging from "excellent to good," and only 17.6% were satisfied with results ranging from "fair to poor," with no results worse than before surgery.

Table 1. Distribution of the intervened segments with AECF.

Segments treated with AECF	n (%)
C3-C4	2 (8%)
C4-C5	4 (16%)
C5-C6	13 (52%)
C6-C7	6 (24%)

Table 2. Distribution and intensity of pain and degree of disability according to the patients' occupations.

Occupation	n (%)	VAS* pre^	VAS pop$	VAS dif ᶜ	NDI? pre	NDI pop	NDI dif
Professionals, scientists, and intellectuals.	5 (35.7)	7	2	5	40	17.7	22.2
Office employees.	3 (21.4)	8.67	2.67	6	45.3	86	36.6
Service and sales workers	3 (21.4)	8.3	3.3	5	34	5.5	28.5
Homemaker	1 (7.1)	8	5	3	42	21	21
Military forces	1 (7.1)	8	5	3	18	0	18
Members of the executive branch and legislative bodies	1 (7.1)	9	4	5	60	20	40
No data	4 (28.6)	7.5	3	4,5	26.6	10	16.6

* Visual Analogue Scale. ? Neck Disability Index. ^ preoperative period. $ postoperative period. ᶜ differences between preoperative and postoperative period.

Complication and reoperation

Total adverse events were noted in 4 patients (22%). There were two complications and two reoperation reports associated with the procedure. The two reoperations occurred between 6 and 12 months after the procedure. One of the patients developed axial pain and the presence of instability was confirmed, and the other presented symptoms consistent with myelopathy, so they underwent open surgery with fusion. Both complications were intraoperative: one patient developed radiculitis, and in one of the patients in the first stage of the curve, one of the discectomy clamps broke and was removed under endoscopic vision.

DISCUSSION

Cervical spondylosis (CS) is a highly prevalent spinal disorder and represents a significant global clinical challenge[2], with a reported prevalence of 3.5 per 1000 population[17]. This degenerative disease is highly age-related and implies the degeneration of the cervical spine structures, including the intervertebral disc, facet joint, and spinal ligaments, which may lead to cervical spondylotic radiculopathy and cervical spondylotic myelopathy[18]. The gold standard for treating lateral cervical stenosis for spondylosis continues to be AECF surgery - anteriorly or posteriorly- with or without fusion[5,11,17]. However, associated problems such as loss of height at the intervertebral level, pseudoarthrosis, need for reintervention, adjacent segment syndrome, and complications related to access to the surgical site have been reported[5,6,8,17]. In contrast, cervical endoscopic spine surgery is gaining popularity for several indications, including cervical degenerative disc disease, cervical radiculopathy, and myelopathy[17]. Monosegmental AECF was first described by Saringer et al. (2003)[14], who reported the use of anterior cervical endoscopy in lateral stenosis. In Latin America, the anterior endoscopic technique for cervical lesions was introduced in October 1997[15]. Currently, reports on endoscopic technique in this pathology are limited, and its application in Latin America is even more limited, because of its complex learning curve and region administrative difficulties[15,16]. AECF can achieve decompression through a minimally invasive approach with less damage to the adjacent tissue and allows magnification of the structures to be decompressed[15]. High-level evidence demonstrates cervical endoscopy clinical outcomes and pain relief like those with open techniques[6,10-15], but with several advantages such as less surgical time, minimal blood loss, low associated costs, and faster return to activities[6-8].

The clinical results obtained in this case-series are comparable to those reported in a randomized controlled trial using conventional ACDF[18], where authors reported 81% of patient satisfaction after two years of follow-up. Concerning complications, Fountas et al. (2007)[19] reported complication rates of up to 19%, including death in 0.1% of patients, higher than the 11% complication rate observed in our series. Another study reported a 19% rate of adjacent segment disease after ACDF. These factors indicate that although the clinical results may be similar, the advantages of using endoscopic techniques for complications and reinterventions are more significant. Regarding anterior endoscopic approach, the results in this study are comparable to those previously reported by Saringer et al. (2020)[12], who presented an improvement rate of over 96% in 16 patients, without complications or reinterventions, and 87.6% of patients were satisfied with the procedure. Likewise, Oezdemir et al. (2019)[11], presented 61 patients treated with cervical anterior endoscopy, an improvement in more than 80% of the patients and only 3% of reinterventions.

Anterior vs. Posterior Endoscopic Approach Rationale

Cervical spondylosis may be treated using an anterior or posterior uniportal approach[20]. Some factors can be determined by the surgeon's choice. Appropriate and sufficient training is fundamental for successfully implementing a novel surgical technique[13,21-23]. A recent systematic review shows the complication differences between the anterior and posterior approaches[24]. The authors report that the complications differ significantly: in the anterior approach, swallowing difficulty, recurrent disc, hematoma, endplate collapse, and dysphonia are the most common complications, and using the posterior approach, complications like transient dysesthesia, recurrence, dural tears, upper limb motor deficits, and persistent arm pain are reported. Another study suggests that the approach may be determined according to the zone of neural compression[23]. The anterior approach can be applied to patients at risk for general anesthesia because it may be performed under local anesthesia. Another anterior approach advantage was reported in a parametric study where authors showed that anterior endoscopic cervical procedures have a shorter surgical path, smaller surgical diameter, and less biomechanical influence on the cervical spine[25].

Limitations

This study has several limitations inherent to its design that must be highlighted. First, the results cannot be considered as inferences, as a descriptive study, with such a small sample. It had a relatively short follow-up; because it was retrospective and non-randomized, it had a high possibility of selection bias. This is a historical series of strictly selected cases, which explains the low volume, serving as proof of concept for the technique in the Latin American population. Finally, since this is not a comparative study, the superiority of the treatment over conventional techniques cannot be established.

CONCLUSION

This case series demonstrates favorable clinical outcomes of the anterior endoscopic technique for radiculopathy due to CS. According to the results obtained in this series, AECF can be considered a viable surgical option. Likewise, the existing evidence supports the endoscopic technique for treating lateral stenosis to be considered an alternative. However, it is crucial to increase the level of evidence in the different research studies that involve this technique.

CONFLICT OF INTEREST

The author(s) declared no potential direct (employment, stock ownership, grants, patents) conflicts of interest concerning this article's research, authorship, and/or publication. The coauthors JFR, JGR, CRM, and NPR have indirect conflicts of interest may exist due to honoraria, consultancies to other vendors, and companies including Elliquence, LLC. The authors NASR, JPB, VMPB. and GOAC have no direct or indirect conflicts of interest.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. JFRL, NASR: conceptualization, methodology, supervision, writing - original draft; JGRO: writing - proofreading and editing; CRM: validation; NPR: validation, research; VMPB: writing - proofreading and editing; JPB: writing - proofreading and editing; GOAC: conceptualization, methodology, formal analysis, writing- original draft.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

REFERENCES

1. Wang C, Tian F, Zhou Y, He W, Cai Z. The incidence of cervical spondylosis decreases with aging in the elderly, and increases with aging in the young and adult population: a hospital-based clinical analysis. Clin Interv Aging. 2016;11:47-53. doi: 10.2147/CIA.S93118.
2. Ju C, Kim S, Kim P, Lee S. Prevalence of cervical and thoracic spinal disease: a systematic review. J Minim Invasive Spine Surg Tech. 2023;8(1):9-20. doi: 10.21182/jmisst.2023.00731.
3. McAnany SJ, Kim JS, Overley SC, Baird EO, Anderson PA, Qureshi SA. A meta--analysis of cervical foraminotomy: open versus minimally-invasive techniques. Spine J. 2015;15(5):849-56. doi: 10.1016/j.spinee.2015.01.021.
4. Shibata R, Nagoshi N, Yamane J, Kono H, Nishimura S, Takeda K, et al. Comparative analysis of anterior cervical decompression and fusion versus posterior decompression for cervical spondylosis presenting with unilateral proximal upper limb muscle weakness. J Orthop Sci. 2025;S0949-2658(25)00280-5. doi: 10.1016/j.jos.2025.09.009.
5. Yin R, Jiang W, Ma W, Chen Y. Contralateral neurological symptoms after ACDF for radiculopathic cervical spondylosis: A case report. Int J Surg Case Rep. 2025;133:111634. doi: 10.1016/j.ijscr.2025.111634.
6. Wu PF, Liu BH, Wang B, Li YW, Dai YL, Qing YL, et al. Complications of full-endoscopic versus microendoscopic foraminotomy for cervical radiculopathy: a systematic review and meta-analysis. World Neurosurg. 2018;114:217-27. doi: 10.1016/j.wneu.2018.03.099.
7. Peng CW, Yeo W, Tan SB. Percutaneous endoscopic discectomy: clinical results and how it affects the quality of life. J Spinal Disord Tech. 2010;23(6):425-30. doi: 10.1097/BSD.0b013e3181b3f862.
8. Li XC, Zhong CF, Deng GB, Liang RW, Huang CM. Full-endoscopic procedures versus traditional discectomy surgery for discectomy: a systematic review and meta-analysis of current global clinical trials. Pain Physician. 2016;19(3):103-18.
9. Quillo-Olvera J, Lin GX, Kim JS. Percutaneous endoscopic cervical discectomy: a technical review. Ann Transl Med. 2018;6(6):100. doi: 10.21037/atm.2018.02.09.
10. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic anterior decompression versus conventional anterior decompression and fusion in cervical disc herniations. Int Orthop. 2009;33(6):1677-82. doi: 10.1007/s00264-008-0684-y.
11. Oezdemir S, Komp M, Hahn P, Ruetten S. [Decompression for cervical disc herniation using the full-endoscopic anterior technique - German version]. Oper Orthop Traumatol. 2019;31(1):25-35. doi: 10.1007/s00064-018-0531-2.
12. Zhang Y, Ouyang Z, Wang W. Percutaneous endoscopic cervical foraminotomy as a new treatment for cervical radiculopathy: A systematic review and meta-analysis. Medicine (Baltimore). 2020;99(45):e22744. doi: 10.1097/MD.0000000000022744.
13. Ramírez JF, Rugeles JG, Ramírez C, Alonso GO, Lewandrowski KU. Surgical treatment of cervical radiculopathy using an anterior cervical endoscopic decompression. J Spine Surg. 2020;6(Suppl 1):S179-S285. doi: 10.21037/jss.2019.09.24.
14. Saringer WF, Reddy B, Nöbauer-Huhmann I, Regatschnig R, Reddy M, Tschabitscher M, et al. Endoscopic anterior cervical foraminotomy for unilateral radiculopathy: anatomical morphometric analysis and preliminary clinical experience. J Neurosurg. 2003;98(2 Suppl):171-80. doi: 10.3171/spi.2003.98.2.0171.
15. Ramírez JF, Osorio E, Rugeles JG, Ramirez C, Alonso GO. Cervical endoscopic versus open foraminotomy for lateral uncovertebral stenosis. In: Lewandrowski KU, Schubert M, Ramirez JF, Fessler R (eds). Minimally invasive spinal surgery: principles and evidence-based practice. 1st Edition. London: Jaypee Brothers Medical, 2018. p. 21-6.
16. Baumann AN, Callaghan ME, Walley KC, Anastasio AT, Muralidharan A, Talaski G, et al. Outcomes and complications associated with the learning curve for endoscopic cervical foraminotomy: a systematic review and meta-analysis. Spine (Phila Pa 1976). 2024;49(7):470-7. doi: 10.1097/BRS.0000000000004859.
17. Salemi G, Savettieri G, Meneghini F, di Benedetto ME, Ragonese P, Morgante L, et al. Prevalence of cervical spondylotic radiculopathy: a door-to-door survey in a Sicilian municipality. Acta Neurol Scand. 1996;93(2-3):184-8. doi: 10.1111/j.1600-0404.1996.tb00196.x.
18. Engquist M, Löfgren H, Öberg B, Holtz A, Peolsson A, Söderlund A, et al. Surgery versus nonsurgical treatment of cervical radiculopathy: a prospective, randomized study comparing surgery plus physiotherapy with physiotherapy alone with a 2-year follow-up. Spine (Phila Pa 1976). 2013;38(20):1715-22. doi: 10.1097/BRS.0b013e31829ff095.
19. Fountas KN, Kapsalaki EZ, Nikolakakos LG, Smisson HF, Johnston KW, Grigorian AA, et al. Anterior cervical discectomy and fusion associated complications. Spine (Phila Pa 1976). 2007;32(21):2310-7. doi: 10.1097/BRS.0b013e318154c57e.
20. Chang CJ, Liu YF, Hsiao YM, Chang WL, Hsu CC, Liu KC, et al. Full endoscopic spine surgery for cervical spondylotic myelopathy: a systematic review. World Neurosurg. 2023;175:142-50. doi: 10.1016/j.wneu.2023.05.012.
21. Huang CC, Fitts J, Huie D, Bhowmick DA, Abd-El-Barr MM. Evolution of cervical endoscopic spine surgery: current progress and future directions - a narrative review. J Clin Med. 2024;13(7):2122. doi: 10.3390/jcm13072122.
22. Alomar SA, Maghrabi Y, Baeesa SS, Alves ÓL. Outcome of anterior and posterior endoscopic procedures for cervical radiculopathy due to degenerative disk disease: a systematic review and meta-analysis. Global Spine J. 2022;12(7):1546-60. doi: 10.1177/21925682211037270.
23. Ahn Y. Anterior endoscopic cervical discectomy: surgical technique and literature review. Neurospine. 2023;20(1):11-8. doi: 10.14245/ns.2346118.059.
24. Ju CI, Kim P, Seo JH, Kim SW, Lee SM. Complications of cervical endoscopic spinal surgery: a systematic review and narrative analysis. World Neurosurg. 2023;178:330-9. doi: 10.1016/j.wneu.2023.07.058.
25. Sun MS, Yuchi CX, Cai XY, Du CF, Mo ZJ. Parametric study of anterior percutaneous endoscopic cervical discectomy (APECD). Comput Methods Biomech Biomed Engin. 2021;24(6):687-99. doi: 10.1080/10255842.2020.1846186.