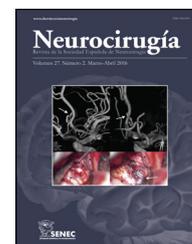




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Special article

Cervical laminoplasty with unilateral C4-5 foraminotomy: Technical note and case series[☆]

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ABSTRACT

Objective: The open-door laminoplasty technique is widely used in the treatment of multi-level cervical myelopathy. Despite the satisfactory functional and radiological results of this technique, postoperative C5 palsy is still a severe and disabling complication with a variable incidence in the literature. The objective of this article is to describe and demonstrate the surgical technique step by step with the addition of unilateral C4-5 foraminotomy and to evaluate the results obtained to date, with special emphasis on C5 palsy.

Material and methods: Retrospective study of 20 patients operated on for cervical myelopathy using the “extended” laminoplasty technique, which is described step by step.

Results: Between January 2013 and April 2019, 20 patients were operated on using the extended laminoplasty technique. Only one patient (5%) presented postoperative C5 palsy. The postoperative recovery rate of the modified JOA (Japanese Orthopaedic Association) score was 54.5%, similar to that observed in other series.

Conclusion: The extended cervical laminoplasty technique with unilateral C4-5 foraminotomy was developed and demonstrated for the prevention of C5 palsy. The results were analysed and an incidence of C5 palsy coinciding with the lowest percentage reported in the literature was obtained. A prospective randomised study would be useful to assess the role of preventive unilateral C4-5 foraminotomy.

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Laminoplastia cervical con foraminotomía unilateral C4-C5: nota técnica y serie de casos

R E S U M E N

Palabras clave:

Laminoplastia
Parálisis de C5
Laminectomía
Mielopatía cervical
Complicaciones postoperatorias

Objetivo: La laminoplastia “open door” es una técnica ampliamente utilizada para el tratamiento de la mielopatía cervical multinivel. A pesar de presentar resultados funcionales y radiológicos satisfactorios a largo plazo, la parálisis de C5 posoperatoria continúa siendo una complicación severa e invalidante con una incidencia variable en la literatura. El objetivo del presente trabajo es describir e ilustrar la técnica quirúrgica paso a paso con el agregado de la foraminotomía unilateral C4-5 y evaluar los resultados obtenidos hasta el momento, haciendo especial énfasis en la parálisis de C5.

Material y métodos: Estudio retrospectivo de 20 pacientes intervenidos por mielopatía cervical mediante la técnica de laminoplastia cervical “extendida” con foraminotomía unilateral, para la cual se detallan los pasos.

Resultados: Entre enero de 2013 y abril de 2019 se trataron 20 pacientes con “laminoplastia cervical extendida”. Un solo paciente agregó déficit de C5 postoperatorio (5%). El porcentaje de recuperación del JOA modificado (Japanese orthopaedic association score) postoperatorio fue de 54,5%, siendo similar a lo observado en otras series.

Conclusión: Se desarrolló e ilustró la técnica de laminoplastia cervical “extendida” con foraminotomía unilateral de C4-5 para la prevención de la parálisis de C5. Se analizaron los resultados y se obtuvo una incidencia de parálisis de C5 coincidente con el menor porcentaje reportado en la literatura. Sería de utilidad un estudio prospectivo y aleatorizado para valorar el rol de la foraminotomía preventiva C4-5 unilateral.

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Introduction

Cervical laminoplasty with the open-door technique is widely used to treat multilevel cervical myelopathy in patients with preserved cervical lordosis. Preservation of posterior vertebral elements decreases the risk of complications such as postoperative kyphosis and iatrogenic instability.^{1,2} Other surgical options such as decompression with arthrodesis through an anterior approach and laminectomy through a posterior approach have shown similar clinical outcomes, but have been associated with a higher risk of complications.³⁻⁵

Despite satisfactory long-term functional and radiological outcomes with laminoplasty, postoperative C5 palsy remains a severe complication, with an incidence reported in the literature ranging from 5% to 17%.⁶⁻¹²

The pathophysiology of C5 palsy primarily derives from mechanical damage to the root secondary to decompression of the spinal cord, though it could also derive from nerve thermal injury, ischaemia or spinal damage.^{13,14}

From 1978 to the present, multiple modifications in the open-door technique described by Hirabayashi et al. have been proposed, with unilateral or bilateral C4-C5 foraminotomy being an alternative for the prevention of C5 palsy.¹

The objective of this study was to describe and illustrate the surgical technique with unilateral C4-C5 foraminotomy step by step, to evaluate the outcomes achieved in our series and to compare them to those reported in the literature.

Materials and methods

This retrospective study enrolled 20 patients diagnosed with multilevel cervical myelopathy and treated with laminoplasty plus unilateral C4-C5 foraminotomy using the technique described below. Between January 2013 and May 2019, 74 cervical laminoplasty procedures were performed in our department; among those procedures, the technique in question was employed in 20 patients (Fig. 1).

Clinical, radiological and operative findings were examined. The clinical evaluation included demographic data and duration of symptoms. Preoperative and postoperative functional status were evaluated using the modified Japanese Orthopaedic Association (JOA) scale, and the calculated postoperative JOA recovery rate ($JRR = \frac{JOA \text{ at the end of follow-up} - \text{preoperative JOA}}{\text{preoperative JOA}} \times 100$).^{15,16} The patients were examined by means of cervical magnetic resonance imaging (MRI), computed tomography (CT) and X-ray both preoperatively and postoperatively. Operative time, measured in minutes, and number of days of admission were evaluated. The surgical complications seen in the postoperative period were documented.

C5 palsy was defined as a decrease in deltoid motor function by at least one level on the Medical Research Council (MRC) Scale for Muscle Strength within six weeks following the operation.¹⁷ Patients were followed up for at least six months.

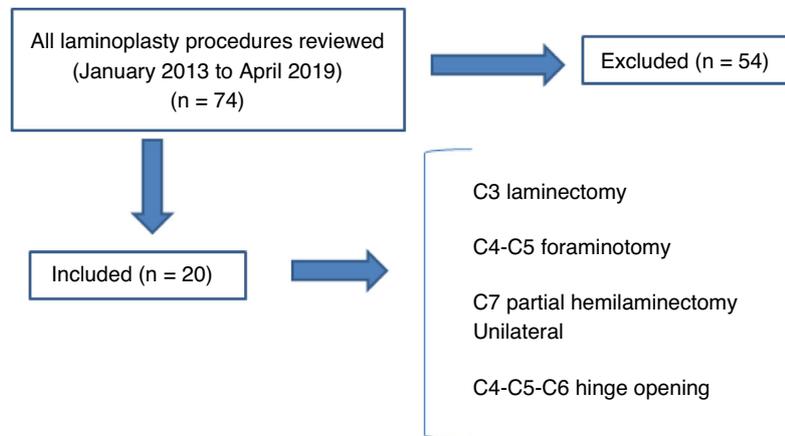


Fig. 1 – All study patients.

Surgical technique

To describe in detail and illustrate the surgical technique, the operative reports and the digital file for our surgical procedures were analysed. A literature review was conducted in order to compare our technique to those of other teams.

Preoperative planning

All patients were examined with cervical MRI without contrast in which the numbers and levels of the segments affected were evaluated. Frontal and profile X-rays were taken to calculate cervical lordosis. X-rays were taken in flexion and extension to rule out prior cervical instability.

The “posterior vertebral line” was determined in order to evaluate spinal alignment and establish the benefit of the technique in question as a treatment for cervical spinal stenosis.¹⁸

Patient preparation and positioning

Baseline motor and sensory potentials were recorded before the patient was positioned, and electrophysiological monitoring was continued throughout the surgical procedure.

The patient was placed in ventral decubitus with the head fixed in a three-point head holder in slight flexion.

Using radioscopy, the skin incision was marked from C2 to C7 and double-checked during the surgical approach (Fig. 1).

Surgical approach

A posterior cervical approach is taken following the avascular plane of the midline and preserving muscle integrity. Laminar subperiosteal curettage is performed from C3 to C6 and the superior half of the C7 lamina is exposed. The supraspinous and interspinous ligaments of all segments approached are preserved. The muscles that attach to C2 must be protected.

Surgical procedure

We use the open-door technique, with complete osteotomy on one side and partial osteotomy on the other. The more symptomatic side is opened completely, as this achieves greater spinal decompression.

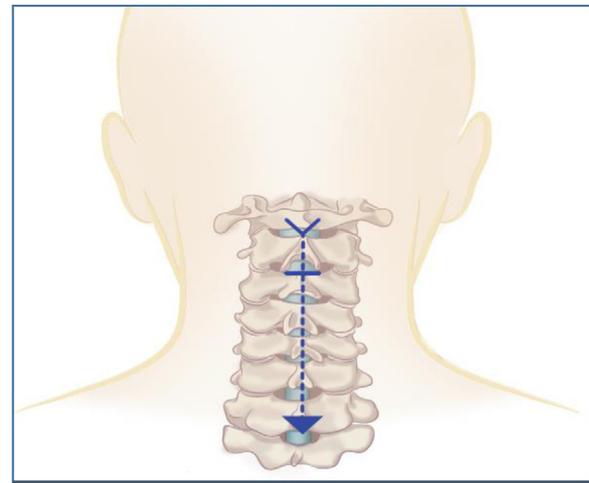


Fig. 2 – Marking of skin incision from C2 to C7 using radioscopy. The C2 spinous process (upper arrow) and the C7 spinous process (lower arrow) are identified as bone reference points. The blue crossbar, in the C2-C3 space, marks the starting point for laminar subperiosteal curettage (the importance of preserving the muscles that attach to C2 must be stressed).

Under microscopic vision, a C3 laminectomy (Fig. 2) and a superior C7 hemilaminectomy are performed with a high-speed drill (on the side with complete osteotomy).

Next, the C4-C5 foraminotomy is performed on the side with the opening. The surgeon begins to drill at the junction of the cranial lamina, caudal lamina and articular facet. Part of the superior facet is resected since this usually causes nerve compression; the surgeon must not resect more than one-third of the facet to prevent added postoperative instability.

After that, the canal is drilled at the lamino-articular junction and osteotomy is completed with a 1-mm or 2-mm Kerrison rongeur. The lamina is partially drilled (preserving the anterior cortical bone) on the side where the greenstick fracture is made.

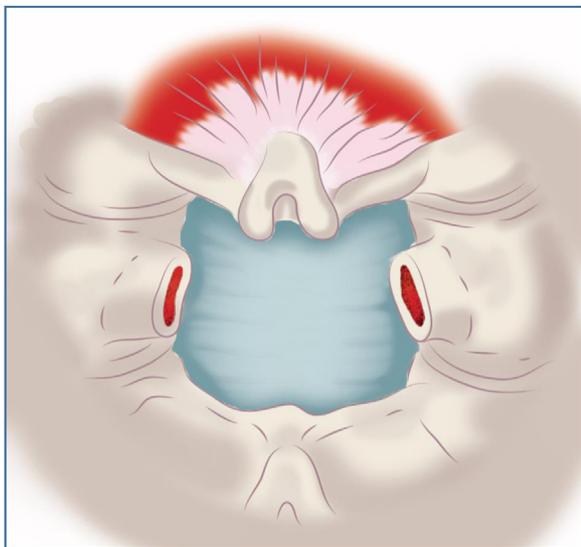


Fig. 3 – Detail of C3 bilateral laminectomy with preservation of C2 spinous process muscle attachments.

The C4-C6 bone block is luxated and the extradural adhesions are dissected (Fig. 3). Miniplates are placed with screws in the laminae and lateral masses from C4 to C6 (Fig. 4). Finally, an epidural drain is placed (Fig. 5).

Results

Of the 20 patients enrolled, 12 were men (60%) with an average age of 58 years (range: 44–81). The form of clinical presentation was myelopathy in 13 cases and myeloradiculopathy in seven cases.

The duration of preoperative symptoms was six months on average. In 17 cases (85%) an improvement in mean JOA was seen, with an average JOA recovery rate of 54.5%. Of the three patients who did not show postoperative improvement, one patient showed a decrease by one point on the JOA and the other two remained stable at the end of follow-up. One patient experienced added unilateral C5 palsy (5%) on the “decompressed side”; this completely recovered after nine months of follow-up. Four patients required physiotherapy for postoperative spinal pain. There were no cases of restenosis or infection of the surgical site. The average operative time was 160 min, and the average duration of admission was 3.5 days. The average follow-up was 18.7 months (6–62 months).

Discussion

Laminoplasty is usually indicated in patients who present cervical myelopathy secondary to multisegmental disc disease, congenital spinal stenosis, ossification of the posterior longitudinal ligament or post-traumatic central cord syndrome.^{3,19,20}

In cervical myelopathy due to congenital stenosis or ligamentum flavum hypertrophy, direct decompression of the canal is achieved through its expansion. In multiple

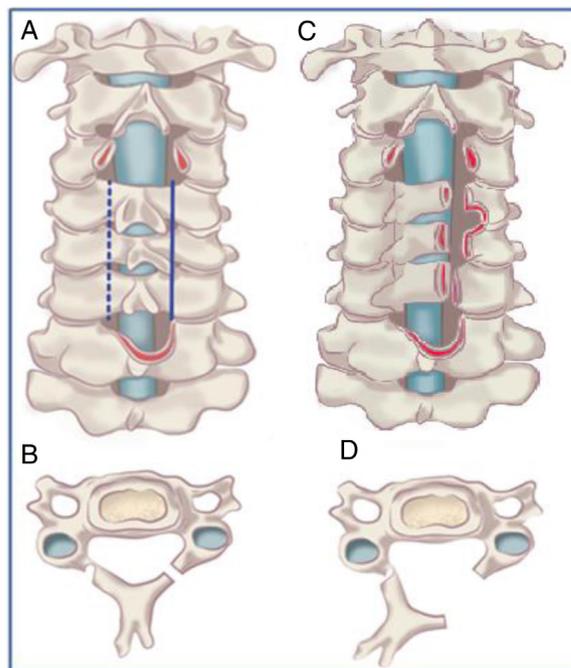


Fig. 4 – A) C3 bilateral laminectomy and C7 superior hemilaminectomy. The blue lines show the lamino-articular junction, where both channels will be carved (greenstick fracture on the dotted line). B) Axial cross-sectional view after drilling showing preservation of the anterior cortical bone on one side and complete osteotomy on the other. C) Luxation of the C4-C6 bone block, with careful dissection of extradural adhesions. D) The diameter of the spinal canal is seen to increase after the C4-C6 bone block is luxated.

hernias or ossification of the posterior ligament, indirect decompression is achieved when the spinal cord migrates dorsally.²¹

Better positioning of the spinal cord within the spinal canal is achieved in patients with suitable preoperative cervical lordosis, but clinical and radiological improvement has also been seen in patients with a neutral or kyphotic spine. The literature recommends the use of this technique in patients with no more than 15 degrees of kyphosis.^{13,22,23}

Since 1973, when laminoplasty began to be used to treat cervical spinal stenosis, multiple surgical techniques have been developed. One of the most commonly used techniques is the open-door technique, developed by Hirabayashi et al. in 1978, which consists of osteotomy on one side and a hinge opening of the posterior elements. The other commonly used technique is the French-door or double-door technique, in which two channels are formed at the lamina-facet junction, the spinous process is drilled and each half of the lamina is opened laterally to achieve a symmetric opening in the spinal canal, unlike the open-door technique, which results in asymmetric decompression. A meta-analysis demonstrated that there is no difference in clinical improvement between the two techniques,²⁴ but a better opening of the canal is achieved with the open-door technique; for this reason, we decided to use this technique at our institution.²¹

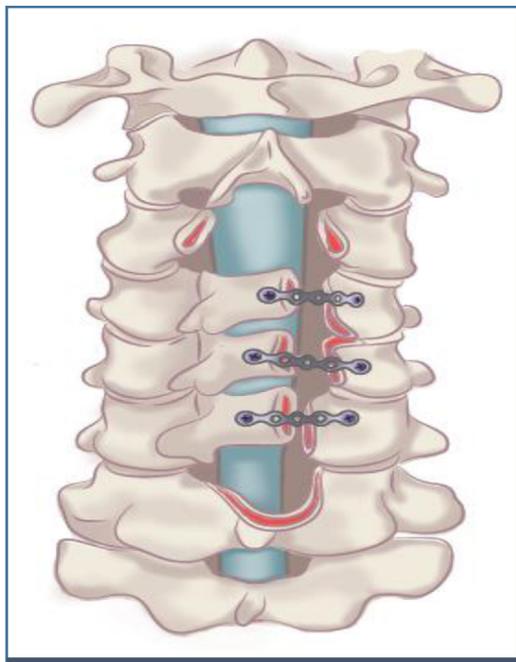


Fig. 5 – End result following placement of miniplates and screws on and in the laminae and lateral masses from C4 to C6.

Due to the high rate of restenosis in patients having undergone surgery in which the original open-door technique was used, new methods were developed to keep the spinal canal opening stable. Some of these are autologous bone and miniplates with screws which decrease the risk of narrowing of the spinal canal in the postoperative period.^{25,26} In our cases, we used miniplates as recommended by Wang et al., who demonstrated a lower incidence of spinal pain in the postoperative period and fewer complications with the use of miniplates over sutures.²⁷

Detachment of the muscles that attach to the C2 spinous process (the rectus capitis posterior major muscle and the obliquus capitis inferior muscle) has been seen to predispose the patient to kyphosis and to postoperative cervical spinal pain. Preservation of these muscle attachments to C2 during the C3 laminectomy surgical approach and procedure prevents postoperative complications.^{28,29} A similar situation arises in the musculature that attaches to the C7 spinous process. Preservation thereof is an important factor in prevention of postoperative cervical pain; hence, a decision was made to drill only the superior edge of the side where the opening in the bone is to be made.³⁰

Laminoplasty using the open-door technique has been reported to be a safe and effective procedure in the short and long term. In the initial reports by Hirabayashi et al., a 66% improvement in JRR was achieved after three years of follow-up, which reflected an increase in these patients' quality of life.¹ In our case, we achieved a 60% improvement in JRR; this rate was similar to that published by Yoshii et al.³¹

Postoperative C5 palsy presents as weakness of the deltoid and/or biceps muscle with a decrease in or loss of the biceps reflex (seen to be bilateral in only 5% of cases).^{12,20,32} The concept of C5 palsy varies in the literature; in our case,

we considered it to be a drop by one or more points on the MRC Scale for Muscle Strength as defined by Fiore et al.¹⁸ This palsy is associated with all cervical spine surgical procedures, both through an anterior approach and through a posterior approach. The pathophysiology of this entity is not clearly understood, but it is thought to be due to traction on the root following decompression. The C5 root is particularly affected as it is a short root and as it is located in the centre of cervical lordosis. Other possible causes are thermal injury during drilling, ischaemia and spinal cord reperfusion injury.³³

Should C5 palsy develop in the postoperative period, it is important to rule out instrumentation failure with associated nerve root compression by means of imaging. Treatment with corticosteroids lacks reliable evidence and scientific support.¹⁸

The incidence of C5 palsy subsequent to laminoplasty varies widely in the literature reviewed, from 5% to 17%.¹² In more than half of cases, complete recovery is achieved after a year, and just 17% of cases do not show improvement in follow-up.

Wang et al. identified some risk factors for the development of C5 palsy, including male sex, posterior approaches and ossification of the posterior ligament.²⁷ In our study, just one patient presented postoperative palsy; it should be noted that this patient was a 58-year-old man who showed complete motor improvement nine months after surgery.

Kurakawa et al. reported a higher incidence of C5 palsy in laminoplasty procedures using the open-door technique compared to the double-door technique, probably due to asymmetric spinal decompression resulting in greater traction on the root on the open side.^{34,35}

Multiple studies have proposed prophylactic bilateral foraminotomy to prevent C5 palsy.³⁶⁻³⁹ However, as there is insufficient evidence to be certain that bilateral foraminotomy does not increase the risk of instability, and as in 75% of cases palsy develops on the contralateral side to the hinge opening, we propose in this study the use of the unilateral foraminotomy technique on the "open" side in order to decrease the risk of C5 palsy and, at the same time, prevent possible complications secondary to bilateral foraminotomy.

Conclusion

The "extended" cervical laminoplasty technique with unilateral C4-C5 foraminotomy for the prevention of C5 palsy was developed and illustrated. The outcomes were analysed, and an incidence of C5 palsy consistent with the lowest percentage reported in the literature was achieved. For this reason, we believe that a randomised prospective study to assess the role of preventive unilateral C4-C5 foraminotomy would be useful.

Limitations

Our series was evaluated retrospectively with all the imperfections inherent to that methodology.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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