

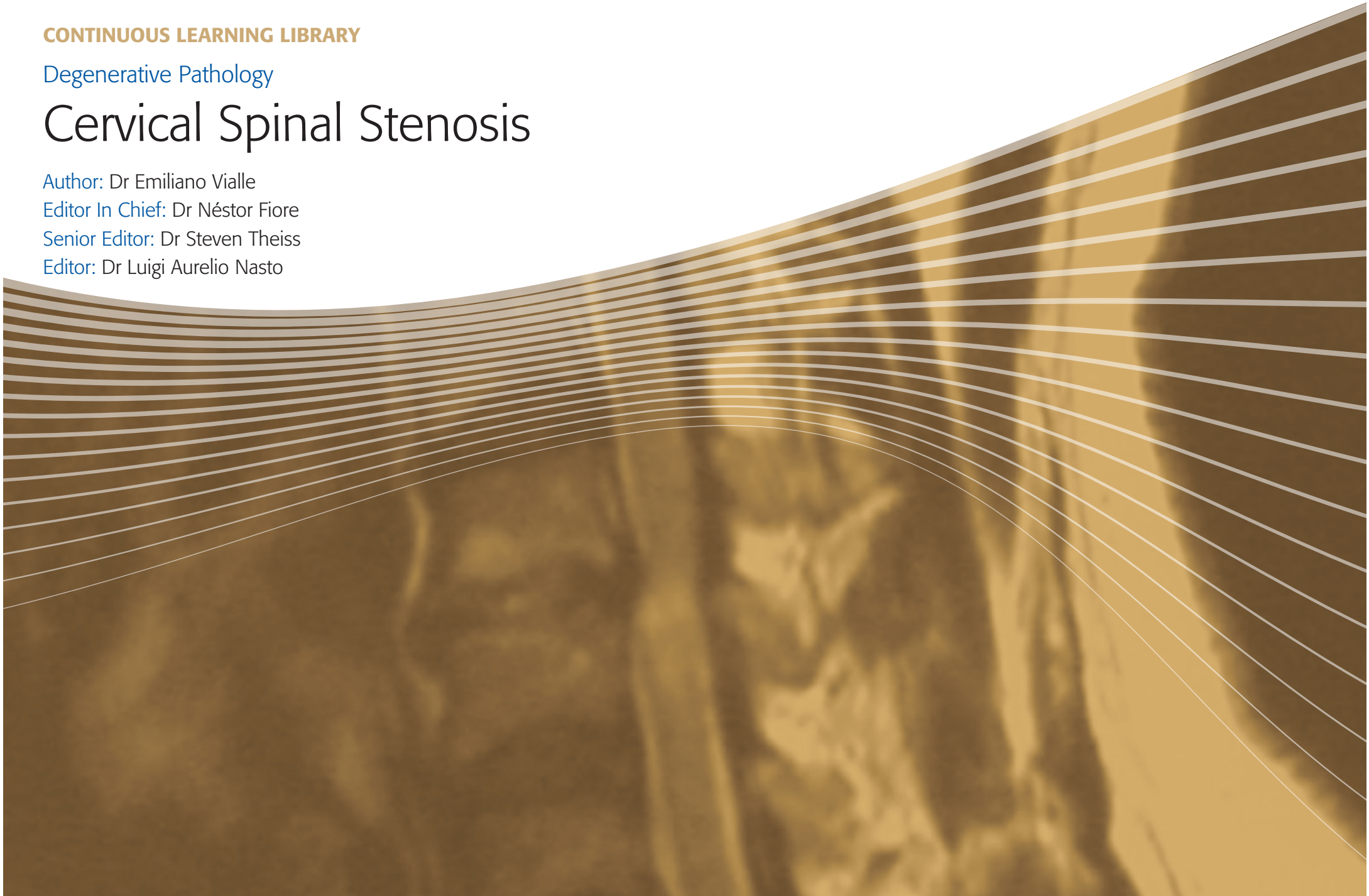
Cervical Spinal Stenosis

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OBJECTIVES

CONTINUOUS LEARNING LIBRARY

Degenerative Pathology

Cervical Spinal Stenosis

- To describe the pathophysiology and clinical presentation of cervical spondylotic myelopathy.
- To discuss features of clinical and imaging diagnosis.
- To analyze differential diagnosis regarding other entities.
- To describe indications, possible treatments, and expected outcomes.

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In severe cases, upper motor neuron signs may be present in lower extremities, and lower motor neuron signs are observed in upper extremities.

1. INTRODUCTION

Overview

The clinical syndrome of spinal cord compression due to cervical spondylosis was first described by Bailey and Casamajor in 1911. In 1928, another study by Stookey described the relation between secondary quadriplegia and cervical spinal cord spondylotic compression (Stookey, 1928). The term spondylotic cervical myelopathy (SCM) became widely used when, in 1952, Brian, Northfield and Wilkinson described the role of vascular compromise in producing the associated neurological signs and symptoms of the cervical spinal cord myelopathy (Brain, Northfield and Wilkinson, 1952).

Narrowing of the vertebral canal due to the presence of osteophytes, ossification of the posterior longitudinal ligament or central disc herniation can cause a compression of spinal cord and nerve roots, leading to cervical pain and varying degrees of neurological symptoms and disability (Bertalanffy and Eggert, 1989; Rao, 2002).

The initial clinical presentation of cervical myelopathy can be misleading. Patients may note a progressive difficulty in walking and maintaining balance, generally attributed to old age or distal joint osteoarthritis (of the lower limbs).

Other possible manifestations include a loss of coordination and altered sensory function in the hands, leading to a deterioration of handwriting and difficulty with fine motor activities (i.e. loss of dexterity). This is often the first recognized symptom of spinal cord dysfunction (Rao, 2002).

Spondylotic cervical myelopathy is the primary cause of spinal cord dysfunction in the adult population (Bertalanffy and Eggert, 1989; Rao, 2002).

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2. PHYSICAL EXAMINATION AND CLINICAL ASSESSMENT

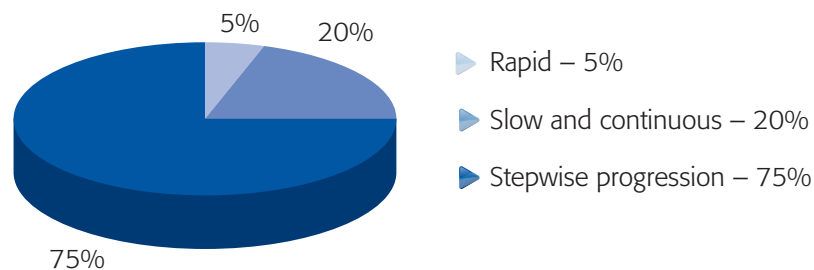
Introduction

A physical examination reveals a combination of the following signs:

- exaggerated deep tendon reflexes (i.e. hyperreflexia);
- clonus, spasticity, gait disturbances, and ataxia;
- reduced superficial reflexes (e.g. abdominal reflex);
- presence of pathological reflexes (e.g. Babinski sign)
- atrophy of the interosseous muscles;
- sensory or vibratory deficits.

Spasticity, decreased muscle strength, and reduced proprioception contribute to the progressive incapacity of these patients to perform simple tasks.

Clarke and Robinson, in their classic article, described the natural history of cervical myelopathy in a group of 120 patients. They observed that 5% presented rapid progression of symptoms, 20% presented slow and continuous progression, and 75% presented with long periods of stable symptoms with intervening episodes of severe deterioration and appearance of new signs/symptoms.



Progression of cervical myelopathy (Clarke and Robinson, 1956).

Functional assessment scales

Nurick scale

The Nurick (1972) scale is a system focused on assessment of gait abnormalities. The score ranges from 0 to 5, where 5 represents the most severely compromised state (i.e. a patient who is bedridden or confined to a wheelchair).

| Grade | Clinical findings |
|-------|---|
| 0 | Signs or symptoms of radicular involvement, with no evidence of myelopathy |
| 1 | Signs of myelopathy without difficulty in walking. |
| 2 | Slight difficulty in walking, which does not prevent full-time employment. |
| 3 | Difficulty in walking, which prevents full-time employment and requires assistance. |
| 4 | Able to walk only with assistance of a walker. |
| 5 | Bedridden or wheelchair bound. |

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Modified Japanese Orthopedic Association (mJOA) scale

The mJOA is a functional assessment scale which includes four subdomains::

- • upper limbs motor dysfunction;
- • lower limbs motor dysfunction;
- • sensory deficits;
- • sphincter dysfunction.

The mJOA allows assessment of the severity of cervical myelopathy by assigning a disability score to each subdomain. Intra- and inter-observer reliability of the mJOA scale is high, with correlation coefficients of 0.81 and 0.84, respectively (Yonenobu, Abumi, Nagata, Taketomi and Ueyama, 2001).

In addition to assessing the severity of myelopathy, the scale can also be used to measure postoperative recovery rate (RR) by applying the following formula:

$$RR = \frac{(\text{postoperative score} - \text{preoperative score}) \times 100}{(\text{normal score} - \text{preoperative score})}$$

Recovery rate in cases of cervical myelopathy (Kadanka et al., 2000).

| Score | Description |
|--------------------------------------|--|
| I. Upper limbs motor function | |
| 0 | Unable to feed oneself |
| 1 | Able to eat with a spoon, but unable to use knife and fork |
| 2 | Able to use knife and fork with much difficulty |
| 3 | Able to use knife and fork with slight difficulty |
| 4 | Normal |
| II. Lower extremity function | |
| 0 | Unable to walk |
| 1 | Can walk on flat floor with walking aid |
| 2 | Can walk up and/or down stairs with handrail |
| 3 | Lack of stability and smooth gait |
| 4 | Normal |
| III. Sensory | |
| Upper limbs | |
| 0 | Severe sensory loss or pain |
| 1 | Mild sensory loss |
| 2 | Normal |
| Lower limbs | |
| 0 | Severe sensory loss or pain |
| 1 | Mild sensory loss |
| 2 | Normal |
| Trunk | |
| 0 | Severe sensory loss or pain |
| 1 | Mild sensory loss |
| 2 | Normal |
| IV. Urinary function | |
| 0 | Complete retention/unable to void |
| 1 | Marked difficulty in micturition (retention) |
| 2 | Difficulty in micturition (frequency, hesitation) |
| 3 | Normal |
| 17 | Normal maximum total |

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Neck disability index (NDI)

The NDI is a quality of life assessment tool, used specifically for cervical spine diseases.

It evaluates 10 parameters affecting daily activities (Vernon and Mior, 1991):

- personal care;
- ability to lift weight;
- reading;
- work;
- driving;
- sleep;
- recreation;
- intensity of pain;
- concentration;
- headache.

There are six possible responses for each parameter, describing a progressively greater degree of disability (where 0 equals no disability and 5 equals severe disability). An overall score out of 100 points is calculated by summing the single scores and multiplying the total by 2. The higher the score, the greater the degree of disability. This index has proved to be a valid, reliable, and sensitive tool to assess disability in a wide population of patients suffering from cervical pain (Hains, Waalen and Mior, 1998; Vernon and Mior, 1991).

Thirty-meter walk test

Patients start the test sitting on a chair and when they receive the order, “walk as quickly as you can, without running”, they stand up and walk on a flat and even surface over a previously measured distance (15 m, returning to the starting point after one ‘lap’), then sit down again. The time taken to do this is recorded, and the number of steps is counted. Patients should walk at a comfortable speed (with whatever assistance they have for walking). This method proved reliable and valid in a population of cervical myelopathy patients (Singh and Crockard, 1999).

Summary:

PHYSICAL EXAMINATION AND CLINICAL ASSESSMENT

Clinical symptoms of cervical myelopathy develop slowly and a high level of suspicion is needed to reach an early diagnosis. Often the only symptom recognized by the patient is numbness in their hands. The earliest physical exam finding is an altered gait but these patients are often referred to a neurology for central nervous system assessments before the presence of cervical myelopathy is suspected. Thorough physical examination is essential to achieve the right diagnosis.

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3. DIAGNOSTIC WORK-UP

Introduction

Imaging studies should be used to confirm clinical suspicion and provide a diagnosis of cervical cord compression and myelopathy. Imaging studies are also very helpful in planning for treatment, should surgery be required.

Radiography

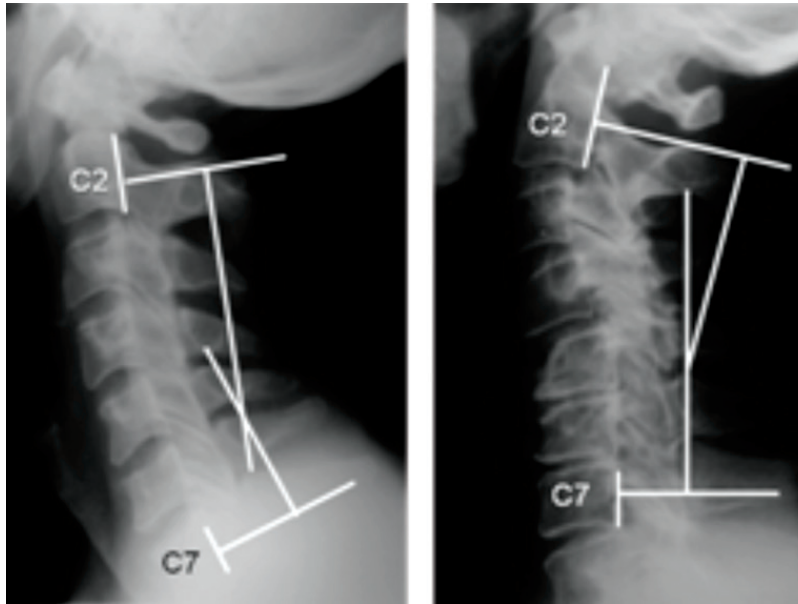
Degenerative changes commonly encountered in the cervical spine are of little or no diagnostic or prognostic value. However, some indirect signs and measurements can raise suspicion for the diagnosis and affect therapeutic decision for patients with clinically identified myelopathy.

The Torg-Pavlov ratio is used to identify a congenitally narrow spinal canal. It is based on the ratio between the anteroposterior diameter of the vertebral body and the width of the vertebral canal (measured from the posterior vertebral body wall to the spino-laminar line). This ratio is normally higher than 1, and a ratio lower than 0.8 is considered to be indicative of spinal canal stenosis.

Sagittal alignment is best assessed using Harrison's posterior tangent method (Harrison et al., 2000). In this method, the degree of cervical lordosis or kyphosis is measured by the absolute rotation angle (ARA), which is formed by the intersecting tangents of the posterior margins of the C2 and C7 vertebral bodies. This method has been shown to be reliable and more accurate than the Cobb method (Harrison et al., 2000). Cervical alignment is not only important for the diagnosis of deviations from the normal postural alignment, but it is also important in determining the correct surgical approach.



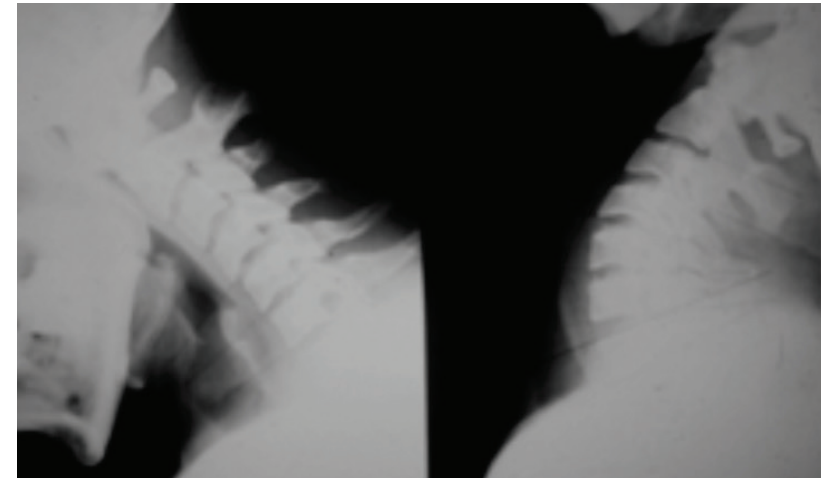
Torg-Pavlov ratio: indicative of a constitutionally narrow canal.



Measurement of sagittal alignment using the small angle absolute rotation method.

Mobility in the sagittal plane is assessed using cervical flexion and extension x rays. These are best obtained by having the patient voluntarily extend and flexion the neck as much as comfortably possible and obtaining a lateral radiograph in each position. It is important the patient control the limits of motion to avoid a neurologic injury.

To establish the segmental mobility of a vertebral level, the flexion and extension images are compared. The displacement (in millimeters) between the images of the upper vertebra represents its mobility relative to the static position of the lower vertebra (level segmental mobility). With this method segmental hypermobility potentially causing dynamic spinal cord compression can be identified. Instability, as defined by White and Panjabi, is greater than 3.5 mm of translation of the vertebral segments of interest compared to the adjacent segments.



Lateral X-rays during flexion and extension of the cervical spine to assess segmental instability.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is currently the test of choice for detecting spondylotic cervical myelopathy. Changes in the medullary spinal cord signal on MRI have also been shown to have a prognostic value.

Medullary signal changes can indicate some of the following pathological processes:

- demyelination;
- edema;
- gliosis;
- ischemia;
- myelomalacia

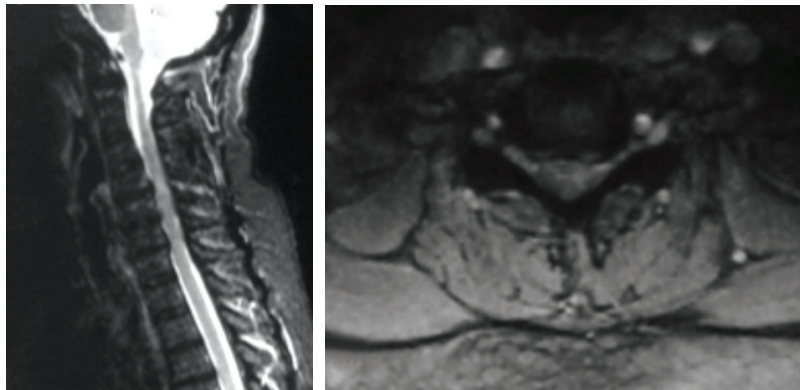
T1 and T2 sagittal and axial images should be obtained to assess the intensity of the medullary signal. The disc level causing medullary signal changes and maximum spinal cord compression is generally considered the level responsible for cervical myelopathy.

Three signal alteration patterns can be detected in both T1 and T2 (Morio et al., 2001):

- normal T1/normal T2 (N/N);
- normal T1/hyperintensity T2 (N/Hi);
- hypointensity T1/hyperintensity T2 (Low/Hi).

Two measurements of spinal cord compression can be assessed:

- area (mm²) of maximum compression on MRI (Morio et al., 2001);
- mean spinal cord diameter (mm) on the T2-weighted MRI at the level of vertebral bodies and intervertebral discs.



Stenosis with spinal cord compromise can be observed.

MRI, T2-weighted sequence, sagittal and axial sections.

The mean diameter of the vertebral canal is 17–18 mm from C3 to C7. A diameter of less than 13 mm is considered a congenital or developmental stenosis. The degree of spinal cord decompression achieved with surgery can also be estimated from two different methods:

- difference between the baseline and post-treatment areas (mm²) measured by MRI (Morio et al., 2001);
- difference between the baseline and post-treatment diameters (mm) of the spinal cord on T2-weighted MRI.

According to Suri, with the aid of these measurements, decompression can be graded into three grades (Suri, Chabbra, Mehta, Gaikwad and Pandey, 2003):

| Grade | |
|-------|-----------------------------------|
| 1 | Complete decompression. |
| 2 | Reduced subarachnoid space. |
| 3 | Residual spinal cord compression. |

Myelography (myelo-CT) should be used in patients with a clinical contraindication to MRI. Myelo-CT allows evaluation of spinal cord compression and post-operative decompression in terms of the area of maximum compression (mm²) and the medullary diameter (mm). Suri's qualitative assessment should also be estimated.

Neurophysiological studies

In general, peripheral nerve conduction studies are not helpful in assessing patients with cervical myelopathy as concomitant arthrosis and peripheral neuropathy may exist.

The use of somatosensory evoked potentials can help to identify spinal cord compression. In cervical myelopathy, both amplitude and latency period may be affected.

Summary:

DIAGNOSTIC WORK-UP

MRI is the test of choice: it helps define the differential diagnosis and determine the extent of spinal cord compression. X-rays are useful in assessing cervical alignment, potential instability and planning for surgical treatment.

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4. DIFFERENTIAL DIAGNOSIS

Given the large number of pathologies that can simulate signs and symptoms of cervical radiculopathy or myelopathy, obtaining a thorough differential diagnosis is essential.

The most important diagnoses are presented below:

- upper extremity nerve compression syndrome / radiculopathy;
- shoulder disorders (rotator cuff injuries, impingement syndrome, tendinitis);
- acute plexopathies (Parsonage-Turner syndrome, neuralgic amyotrophy);
- thoracic outlet syndrome;
- brachial neuritis/plexitis (herpes zoster);
- tumors (Pancoast tumor), spinal cord tumors, arteriovenous malformations;
- amyotrophic lateral sclerosis, multiple sclerosis, myelitis;
- coronary heart disease;
- B12 hypovitaminosis.

A thorough physical exam and neurophysiologic examination are the two most useful tests to rule out other diagnoses.

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Medical treatment should be considered before surgical intervention in old patients or patients with clinical contraindication to surgery.

The aim of surgery is to increase the diameter of the spinal canal and relieve pressure on the spinal cord.

5. TREATMENT

Nonoperative treatment

Nonoperative treatment consists of restriction of hazardous activities, physiotherapy, and pain control.

Short-term results are variable; however, no treatment can affect the natural progression of the myelopathy.

Surgical treatment

Surgical treatment is the treatment method of choice for clinically evident myelopathy. While the natural history of myelopathy describes a variable course of progression of symptoms and disability, recent evidence has demonstrated that early surgical intervention is best for patients with clinical symptoms of myelopathy (Fehlings et al 2013).

Various surgical procedures have been described for the treatment of cervical myelopathy. However, the best option for each case is still a matter of debate.

The common goal of all methods is to decompress the spinal cord to achieve the best possible neurological outcome. Nevertheless, there is a constant percentage of patients whose neurological symptoms are not improved by the procedure, regardless of the method employed (Clarke and Robinson, 1953).

Potential complications vary according to the surgical method applied.

Surgical treatment options include an anterior or posterior approach. In fact a recent study by Fehlings et al showed no differences in the results of an anterior or posterior approach when some basic indications are followed (Fehlings, 2013). The two most common posterior approach are laminoplasty and laminectomy with arthrodesis.

Laminectomy alone was the first method used to treat myelopathy, but several publications have reported poor results, with a high rate of postoperative instability and development of late cervical deformity.

Alternatives to laminectomy include laminoplasty, which is a posterior approach that preserves the stabilizing ligaments and bone structures, avoiding the need for fusion. Laminoplasty was developed by Hirabayashi et al. (1983). Different modifications have been described since then, all with the purpose of simplifying the procedure (Hirabayashi et al., 1983). These posterior approaches should only be considered when the cervical spine is either in a lordotic posture on upright radiographs, or a lordotic posture can be achieved and maintained with a fusion following decompression. When lordosis cannot be achieved, an anterior approach is required.

Surgical techniques

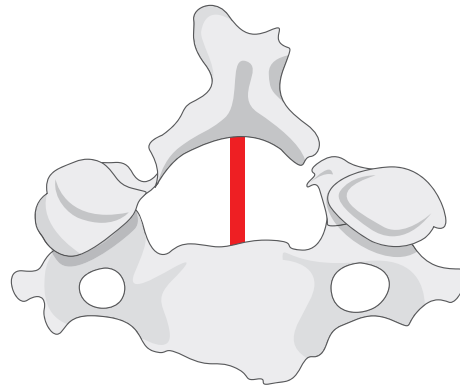
Laminoplasty

Cervical laminoplasty was developed after complications were identified following multilevel laminectomy. Kirita, Miyazaki and Hayashi (1976) developed a laminectomy technique that triggered an era of laminoplasty development. Oyama, Hattori and Moriwaki (1973) then described a Z-laminoplasty for widening the vertebral canal. In 1977, expansive open-door laminoplasty was developed.

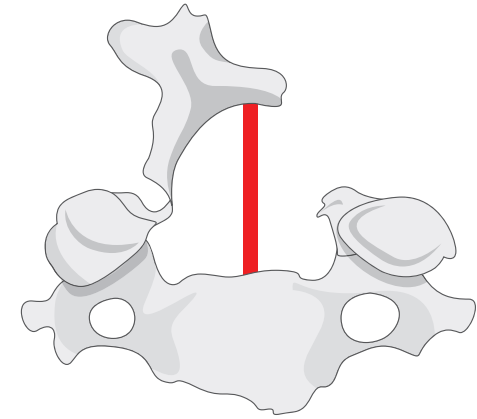
The purpose of a laminoplasty is to increase the size of the spinal canal, while preserving posterior elements, joints, and segmental movement

In open-door laminoplasty, the canal is opened by performing a complete osteotomy on one side (both cortical layers) and an incomplete osteotomy on the other side (only the superficial cortical layer) of the lamina at the lamina facet joint junction. The posterior arch is then opened like a door hinging at the side of the incomplete osteotomy. This is usually performed at multiple levels.

An example of canal expansion by a laminoplasty is illustrated below.



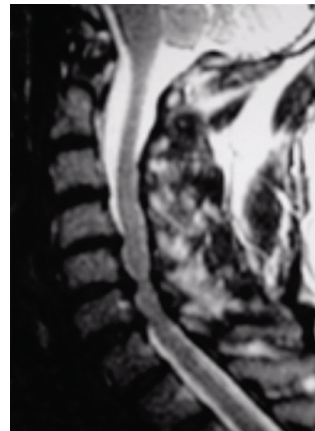
Complete unilateral osteotomy (right side of the diagram) and partial contralateral osteotomy (left side of the diagram).



Depiction of canal opening (red line). A greenstick fracture is created at the hinge side.

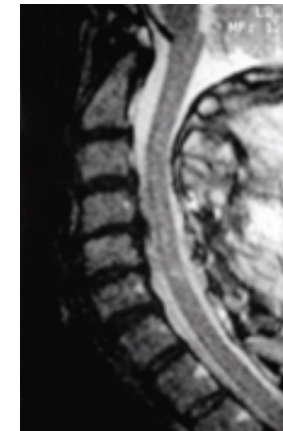
Lateral opening (open-door) of a cervical laminoplasty.

A case of myelopathy treated by laminoplasty is presented next, as an example.



Spinal cord compression is evident.

Pre-laminoplasty MRI, T2 sequence, sagittal section.



Appearance of the liberated spinal cord centered in the spinal canal.

Post-laminoplasty MRI, T2 sequence, sagittal section.

Several studies have documented the results of laminoplasty for cervical myelopathy. Most generally describe good clinical and X-ray outcomes with few complications. This includes:

- Postoperative improvement in terms of strength, pain, paresthesia and gait was above 80%.
- Postoperative improvement of one or more Nurick grades was achieved in 62% of patients.
- Laminoplasty appears to effectively enlarge the spinal canal diameter.

Two complications occur frequently following laminoplasty: axial cervical pain and C5 root palsy (Wang, Shah and Green, 2004).

- The incidence of postoperative axial pain is high. Where evaluated, 40–60% of patients reported axial pain. This can be minimized by several methods, including preserving the C2 and C7 muscle attachments as well as early range of motion postoperatively (Riew et al, Evid Based Spine J 2013).
- With regard to C5 nerve root palsy, the average incidence amounts to 5%. The presentation can be delayed, but the symptoms inevitably resolve over time (Shou et al, Eur Spine J, 2015).

Laminectomy

Laminectomy was described in 1901 for cases of trauma and, subsequently, was used for decompression of stenosis secondary to cervical spondylosis.

Laminectomy outcomes, like laminoplasty, have been quite good and predictable.

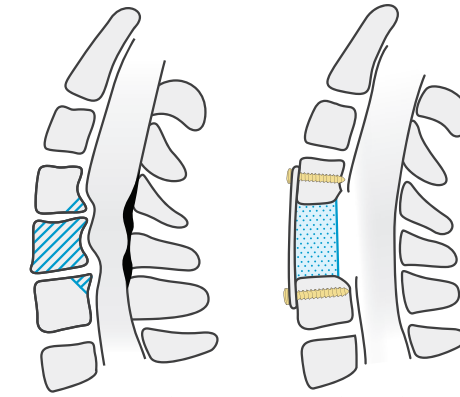
Houten et al in 2003 showed 97% of patients improved their JOA scale scores, without cervical alignment alteration, at 3 years postop (Houten et al, Neurosurgery 2003. Numerous other studies have indicated reliable results.

Multiple other studies have compared and 29% got worse (Kaptain, Simmons, Replogle and Pobereskin, 2000).

In two laminectomy vs. laminoplasty comparative studies, improvement relative to gait, strength, sensory function and pain was similar in both groups. Patients who underwent a laminectomy presented more late complications, including instability, C4-C5 subluxation and increased kyphosis (Kumar et al., 1999)..

Anterior decompression

Anterior decompression is a logical approach, considering that compression is predominantly anterior.



Depiction of decompression through C4 corpectomy and C3 to C5 arthrodesis.

Diagram of anterior release and arthrodesis (Rao, Gourab and David, 2006).

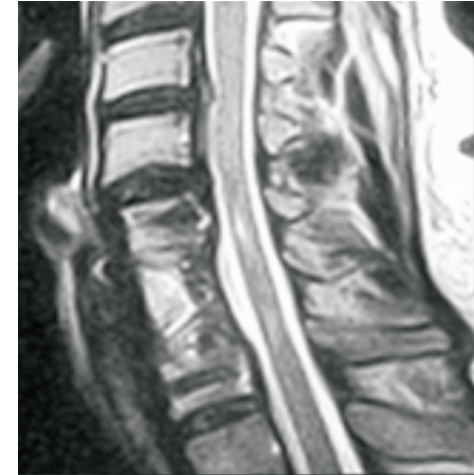
The aim of this procedure is to achieve maximum decompression, with sagittal realignment of the cervical spine without compromising stability.

The case of a patient with a myelopathy treated via the anterior approach is presented next:



Clear compression at C6/C7 level and signs of myelomalacia are evident

Prerelease and arthrodesis pre-operative MRI, T2-weighted sequence, sagittal section



The good release achieved is shown.

Prerelease and arthrodesis postoperative MRI, T2-weighted sequence, sagittal section

Clinical outcomes are similar to patients who underwent laminoplasty. The group of patients receiving corpectomy and arthrodesis (anterior approach) experienced more complications.

Results from anterior decompression are primarily obtained from case series. Different studies present patient improvements that vary between 50% and 87% (Swank, Sutterlin, Bossons and Dials, 1997), with an average morbidity rate of 30%.

With the anterior approach, the fusion rate varies with the number of segments operated. In monosegmental procedures, pseudoarthrosis is reported in 4–6% of cases. This percentage increases with the number of levels operated, as does the incidence of complications, which varies from 3% to 60% (Swank et al., 1997).

Summary of indications

Surgical treatment of cervical spondylotic myelopathy can be categorized as follows:

- Surgery via an anterior approach is recommended for patients suffering from spinal cord compression at one or two levels. If compression occurs at intervertebral disc level, the first option is discectomy with interbody fusion (ACDF); on the other hand, if compression occurs in the vertebral body region, corpectomy with bone graft and an anterior plate is recommended.
- Posterior approach surgery is performed in patients with spinal cord compression over three or more levels, laminoplasty being the most widely used method. In cases with a history of significant cervical pain or loss of cervical lordosis, posterior decompression with a laminectomy and arthrodesis using instrumentation is recommended.

Summary: TREATMENT

Surgical treatment of cervical myelopathy can be performed with an anterior or a posterior approach, according to the surgeon's preference. Both approaches present advantages and disadvantages, limitations and complications that are well defined in medical literature.

Pathologies of one or two levels can be treated anteriorly. For more extensive lesions, a posterior approach may be a better alternative.

Combined approaches may be required for complex cases with severe cervical kyphosis.

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