Neuroimaging of Spinal Canal Stenosis

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KEYWORDS

• Spinal stenosis • Central canal stenosis • Lateral stenosis • Foraminal stenosis
• Neurogenic intermittent claudication • Cauda equina compression
• Cervical spondylotic myelopathy

KEY POINTS

- Spinal stenosis is a broad term encompassing central, lateral, and foraminal narrowing and implies compromise of the neural structures passing through that space.
- Imaging of spinal stenosis is primarily with MR imaging; however, CT and CT myelography (CTM) are acceptable alternatives.
- There is often a mismatch between imaging and clinical findings; accurate and rigorous interpretation of the imaging is necessary for correct management decisions.
- Cross-sectional imaging is usually acquired in a supine neutral position that under-recognizes the dynamic and load-bearing functions of the spinal column.

INTRODUCTION

The deceptively simple term, *spinal stenosis*, is actually a complex and multifaceted concept that means different things to different people. The purely anatomic observation of central canal stenosis implies a pathophysiology that is poorly understood and a set of clinical syndromes that correlate only loosely with the degree of stenosis. The ideal imaging modality that perfectly reflects the clinical presentation and predicts the future course of the pathophysiology is far from achieved, and as such it is essential for health care professionals to understand the limitations, the scope, and the potential of neuroimaging in the context of spinal stenosis.

Anatomically, spinal stenosis can be divided into cervical, thoracic, and lumbar forms because of variations in incidence, presentation, and management. The most common form is lumber canal stenosis, where neurogenic intermittent claudication (NIC) and radiculopathy dominate the clinical picture. Next is cervical canal stenosis with associated myelopathy plus/minus radiculopathy. Thoracic canal stenosis is much rarer (at least as a result of degenerative/spondylotic pathoetiology) and also presents with myelopathy plus/minus radicular symptoms.

This article reviews

1. The congenital and degenerative circumstances underlying the physical narrowing of the spinal canal (including the central canal, the lateral recesses, and the neural foramina)
2. The pathophysiology of the clinical syndromes associated with spinal stenosis (ie, myelopathy, NIC, and radiculopathy)
3. Assessment of the strengths and weaknesses of the different imaging strategies, with an emphasis on MR imaging
4. Critical review of the different observational signs and objective criteria that have been proposed in the neuroimaging literature so far
5. Review of the application of upright scanning and axial loading in the diagnostic lexicon

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6. Assessment of the potential impact of advanced imaging strategies, such as diffusion tensor imaging

The primary substrate of spinal stenosis considered in this review is spondylosis; other acquired processes, such as neoplastic, traumatic, infective, and inflammatory pathologies leading to a secondary compressive effect on the spinal cord or cauda equine, are not specifically discussed in this review; however, there is an obvious crossover of understanding and imaging technique.

LUMBAR SPINAL STENOSIS

The North American Spine Society 2011 revised guidelines[1] provide the following definition:

Degenerative lumbar spinal stenosis describes a condition in which there is diminished space available for the neural and vascular elements in the lumbar spine secondary to degenerative changes in the spinal canal. When symptomatic, this causes a variable clinical syndrome of gluteal and/or lower extremity pain and/or fatigue, which may occur with or without back pain. Symptomatic lumbar spinal stenosis has certain characteristic provocative and palliative features. Provocative features include upright exercise, such as walking or positionally induced neurogenic claudication. Palliative features commonly include symptomatic relief with forward flexion, sitting, and/or recumbency.

Epidemiology/Prevalence

The initial description of mechanical compression of the cauda equine is attributed to Verbiest[6] from 1954; 60 years later, the incidence and natural history of the condition remain poorly documented. The Framingham Study data have been used by Kalichman and colleagues[2] to establish the prevalence of lumbar central canal stenosis in a community population. They used anterior-posterior dimensions less than 12 mm for relative stenosis and less than 10 mm for absolute stenosis on CT imaging (**Table 1**).

The frequency of acquired absolute stenosis of less than 10 mm increased from 4% in patients under age 40 to 14.3% in those over 60 years of age.

In this study the presence of absolute stenosis was significantly associated with low back pain but not leg pain. There review of the literature found a prevalence ranging from 1.7% to 13.1%.

The Japanese Wakayama Spine Study,[3] a population-based study of more than 1000 people, found a prevalence of symptomatic lumbar spinal stenosis of approximately 10%.

Table 1
The Framingham Study

Framingham Study	Relative: Anterior-Posterior <12 mm	Absolute: Anterior-Posterior <10 mm
Congenital	4.7%	2.6%
Acquired	22.5%	7.3%

Data from Kalichman L, Cole R, Kim DH, et al. Spinal stenosis prevalence and association with symptoms: the Framingham study. Spine J 2009;9(7):545–50.

Given the wide variation in accepted criteria for defining lumbar spinal stenosis, it is unsurprising that there is considerable variation in the reported incidence and prevalence of the condition.

NATURAL HISTORY

There is a conspicuous absence of good-quality longitudinal studies documenting the natural history of patients with symptomatic lumbar canal stenosis. The North American Spine Society issued a statement that in the absence of reliable evidence, it is likely that the natural history of patients with mild to moderate symptomatic degenerative stenosis is favorable in one-third to one-half of patients. In patients with mild to moderate symptomatic stenosis, rapid or catastrophic neurologic decline is a rare phenomenon. There is no reliable evidence to define the natural history of clinically or radiologically severe stenosis.[1]

Congenital/Developmental Stenosis

Primary stenosis is uncommon, occurring in only 9% of cases. Congenital malformations include the following:

- Incomplete vertebral arch closure (spinal dysraphism)
- Segmentation failure
- Achondroplasia
- Osteopetrosis

Developmental flaws include the following:

- Early vertebral arch ossification
- Shortened pedicles
- Thoracolumbar kyphosis
- Apical vertebral wedging
- Anterior vertebral beaking (Morquio syndrome)
- Osseous exostosis

Acquired Stenosis

The most important structures underlying degenerative lumbar stenosis are the intervertebral