Imaging Evaluation of Degenerative Cervical Myelopathy

Current State of the Art and Future Directions

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KEYWORDS

• Magnetic resonance imaging • MRI • Spine • Degenerative cervical myelopathy

KEY POINTS

- Radiographs, CT, and MRI offer unique and complementary assessments, and all have important uses in current clinical practice.
- Several microstructural and functional MRI techniques can reveal detailed information about changes in the spinal cord and brain, including diffusion tensor imaging, myelin imaging, atrophy measures, and functional MRI.
- These emerging MRI techniques have the potential to transform clinical practice by offering earlier and more accurate diagnosis, monitoring of disease progression and treatment effects, and prediction of outcomes.

INTRODUCTION

Degenerative Cervical Myelopathy

Degenerative cervical myelopathy (DCM) is a spectrum of disorders that involve extrinsic spinal cord compression leading to neurologic dysfunction, including intervertebral disk herniation, cervical spondylotic myelopathy (CSM), and ossified posterior longitudinal ligament (OPLL).[1] These pathologies variably involve degeneration of the intervertebral disks, hypertrophy and/or ossification of the spinal ligaments, and remodeling (flattening and widening) of the vertebrae.[1] These changes lead to compression of the spinal cord and result in ischemia, dynamic (motion-related) injury, and inflammation that injure the gray and white matter of the cervical spinal cord. The

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most common level of compression is C5-6, but compression often occurs at multiple levels in the region between C3 and C7.[2] The prevalence of symptomatic DCM is poorly characterized due to a lack of large population-based studies and challenges with accurate diagnosis; however, estimates suggest that it is the most common cause of myelopathy in adults.[3,4]

Clinical Management of Degenerative Cervical Myelopathy

When DCM symptoms arise, they typically begin with subtle fine motor dysfunction of the hands, imbalance when walking, and numbness of the hands. As myelopathic impairment worsens, marked loss of hand dexterity, gait dysfunction, severe hand numbness, bladder incontinence, and focal weakness of the upper extremities commonly occur. Clinical practice guidelines recommend surgery for moderate to severe cases,[5] but the optimal treatment of mild CSM is unclear because some patients experience long-term stability whereas others deteriorate.[6] For individuals with minimal deficits, the decision to undergo surgery is difficult, because the risks and benefits are closely balanced. Due to this uncertainty, surgery is often delayed until the onset of more substantial neurologic deficits, but these are only partially reversible with surgery.[7] Thus, prediction or early detection of neurologic decline could substantially improve patient outcomes. Unfortunately, efforts to identify clinical and imaging predictors have shown weak performance.[8]

The Role of Imaging in Degenerative Cervical Myelopathy

The field of medical imaging has rapidly evolved over the past 50 years, and several of these advances have led to major changes in the clinical management of DCM. Imaging currently plays several critical roles in managing DCM patients, including diagnosis, planning surgical treatment, prognostication, and postoperative assessment. Although MRI can be considered the gold standard imaging investigation, providing the most important clinical information for each of these purposes, radiographs and CT continue to be useful, contributing unique and complementary information. This article reviews each of these imaging modalities and describe their strengths, limitations, and clinical utility for the aforementioned clinical uses (**Table 1**), followed by a discussion of emerging spinal cord imaging techniques and their implications for the future of clinical management of DCM.

A SUMMARY OF CURRENT IMAGING TECHNIQUES

Radiographs

Radiographs, also known as plain films or x-rays, are based on the differential tissue absorption of electromagnetic radiation in the x-ray spectrum (3×10^{16} to 3×10^{19}). Despite their simplicity and numerous limitations, radiographs provide versatile 2-D views of the spine that display several important features and can identify many sources of pathology. Due to the high calcium and mineral

Table 1
Strengths and limitations of current imaging techniques

	Radiographs	CT	MRI	Quantitative MRI
Strengths	• Alignment (physiologic) • Osteophytes • Spondylosis • OPLL, ossified ligamentum flavum • Bony lesions • Versatile projections/angles • Instability (flexion/extension)	• 3-D • Detailed bony anatomy/lesions • Spondylosis • OPLL, ossified ligamentum flavum • Screw planning • Bone quality	• 3D • Detailed soft tissue anatomy • Spinal cord compression • Disks • Ligaments • Microhemorrhage • Intramedullary signal change (T1-weighted, T2-weighted)	• Spinal cord tissue changes (microstructure) • May improve diagnosis, monitoring for progression, outcome prediction
Limitations	• 2-D • Minimal soft tissue view	• Supine • Limited soft tissue view	• Supine • Limited bony anatomy • Spinal cord tissue changes	• Complex techniques (acquisition and analysis) • Limited by noise, wide range of normal