Future Directions and New Technologies for the Management of Degenerative Cervical Myelopathy

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KEYWORDS

• Degenerative cervical myelopathy • Nanotechnology • Biomedical engineering • Biomaterials • Osteobiologics • Spinal implants • Neuroprotective drugs • Regenerative strategies

KEY POINTS

- Biomarkers are sought to both detect early structural changes of the spinal cord in degenerative cervical myelopathy (DCM) and to predict the outcome. Clinical studies are testing whether multiparameter analysis of high-Tesla MRI sequences and metabolic images could enhance diagnostic and prognostic information.
- Biomedical engineering is fostering the next generation of spinal implants to correct spinal alignment, increase fusion rate, and preserve range of motion at adjacent levels. To address these needs, engineers are designing hybrid systems, incorporating microelectromechanical and nanoelectromechanical systems, and using functionalized coatings with osteoinducing properties.
- Biomaterials proposed for innovative spinal implants include metals, alloys, and ceramics with nonperiodic nanostructure that enhance the interaction and activity of osteoblasts. Nanoscaffolds, nanoleaves, and nanoneedles are all good examples of this type of nanofabrication.
- Minimally invasive anterior and posterior approaches are already part of the surgical practice; nonetheless, given the refinement of biomaterials and the better understanding of the pathologic processes leading to DCM, their role could potentially become more important in the next years in the setting of a truly personalized medicine.
- Neuroprotective agents (eg, preoperative and postoperative administration of Riluzole, a sodium-channel blocker preserving mitochondrial function and reducing oxidative damage in neurons) and regenerative strategies (eg, application on the decompressed dural layer of Cethrin, a Rho inhibitor promoting axonal sprouting) may soon become common strategies for augmenting the effects of surgical treatment.

INTRODUCTION

Spinal surgery is witnessing a fast-paced evolution in management strategies for degenerative cervical myelopathy (DCM). This metamorphosis has been prompted by the need to address the issue of an expected increase in the prevalence of DCM (due to an aging population prone to

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developing the disease), and has been due to the fruitful collaboration with basic scientists.

Progressive compression of the cervical spinal cord due to degeneration and narrowing of the spinal canal is the main pathophysiology underlying DCM. The optimal timing of intervention in DCM is still an area of ongoing debate; however, experimental studies have shown that delays in decompression could increase the extent of ischemia-reperfusion injury and astrogliosis, resulting in poorer neurologic recovery.[1–3] Given the progressive and irreversible nature of DCM, which has an enormous effect on patients' quality of life, early diagnosis and appropriately chosen surgical treatment are the mainstays of current management. For an effective improvement in terms of both clinical outcome and health-economic parameters, it is extremely important to understand the pathologic process as early as possible to intervene in a timely manner and block progression. Furthermore, it is necessary to adopt more cost-effective materials for spinal implants and identify biologics able to extend the bony healing effects of autograft. Finally, it is desirable to introduce pharmacologic strategies able to slow down or reverse the neuronal degeneration related to DCM.

ENHANCED DIAGNOSTIC PROTOCOLS: TOWARD NEURORADIOLOGICAL AND METABOLIC BIOMARKERS

Baptiste and Fehlings[4] suggested that the demyelination and neurologic deterioration seen at later stages of DCM are due to factors such as ischemic injury caused by chronic compression of the spinal cord vasculature, glutamate-mediated excitotoxicity, and oligodendrocyte apoptosis. Therefore, many attempts have been made to develop diagnostic protocols focused on early identification of DCM, and the correlation of clinical and laboratory biomarkers.[5,6] The diagnostic protocols developed have since been adopted as predictors of disease outcome during the decision-making process for the management of patients with DCM.[5,6] For example, clinical outcome scales, such as the modified Japanese Orthopedic Association (mJOA) are sensitive to both moderate and severe DCM, but are relatively insensitive when predicting outcomes for patients with mild DCM. In an attempt to provide better clinical tools to objectively assess upper and lower extremity motor function in patients with DCM, new diagnostic tests were proposed, as shown in **Table 1**.[7–11] When examining laboratory biomarkers, as genomic and proteomic

Table 1
Recently proposed clinical tests for DCM

G&R test[a]	The test consists of counting the number of fingers' G&R cycles; it was proposed in 2 versions: 10-s and 15-s. The test identifies paradoxic wrist motion (trick motion) and lack of finger coordination in patients with DCM.	Hosono et al,[8] 2012; Hosono et al,[7] 2010
10-s step test[b]	The test consists of simply counting the number of steps patients take within 10 s. This test significantly correlates with the number of fingers G&R test in 10 s, walking grade of the mJOA score and the total mJOA score.	Yukawa et al,[11] 2009
Triangle step test[b]	The test consists of instructing patients to step on marks at each apex of a triangle. The number of steps in 10 s are counted for each foot; this test significantly correlates with the number of finger G&R test, the Nurick score, and the total JOA score.	Mihara et al,[9] 2010
Simple foot tapping test[b]	The test consists of measuring repetitive movements of the ankle joint. This test correlates with the number of finger G&R in 10 s and the total mJOA score. This test is particularly useful in assessing patients with severe CSM who are unable to walk.	Numasawa et al,[10] 2012

Abbreviations: CSM, cervical spondylotic myelopathy; DCM, degenerative cervical myelopathy; G&R test, grip and release test; JOA, Japanese Orthopedic Association; mJOA, modified JOA.

[a] This test can be used the assess the severity of motor function in upper extremities in patients with DCM preoperatively, and when performed in the early postoperative period (24 hours) can predict long-term outcome following decompressive surgery.

[b] These tests can be used to assess the severity of motor function in lower extremities in patients with DCM preoperatively, and the improvements following decompressive surgery.