Advanced Imaging Markers of Spinal Cord Demyelination Enhance the Prediction of Neurological Outcomes in Mild Degenerative Cervical Myelopathy

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Objectives

Degenerative cervical myelopathy (DCM) is the most prevalent cause of non-traumatic spinal cord injury globally. Clinical decisions regarding surgery in patients with mild DCM who experience subtle neurological deficits remain filled with uncertainty due to the unpredictable natural history of disease progression. This study aims to define predictive imaging and clinical biomarkers of neurological decline in mild DCM through the use of quantitative MRI (qMRI) and machine learning models, aiding clinical practice and assisting surgeons in stratifying patients for surgical intervention.

Method

This prospective cohort study included 49 patients with non-operative, mild DCM who underwent advanced MRI scanning protocols, including T2-weighted imaging, diffusion tensor imaging (DTI), and magnetization transfer (MT) imaging. Clinical evaluations were conducted at baseline and six-month intervals for up to two years. qMRI metrics were derived above and below the maximally compressed cervical level (MCCL). Machine learning models integrating both clinical and qMRI metrics were developed to predict six-month neurological deterioration, with feature importance examined to identify the most predictive metrics.

Results

Across 110 six-month interval scans, neurological deterioration was observed in 38% of patients. Models combining clinical and qMRI data achieved superior predictive performance, with a balanced accuracy of 83% and an AUC-ROC of 0.87. The MT ratio, specifically myelin loss in the dorsal and ventral funiculi above MCCL, emerged as a top predictive feature, along with symptoms of moderate tingling in the upper extremities (quickDASH item 10). The qMRI-enhanced models significantly outperformed clinical-only (b.acc: 68.1%) and imaging-only (b.acc: 57.4%) models, underscoring the value of advanced imaging in clinical decision-making.

Conclusions

This study presents qMRI-derived metrics as valuable, actionable markers for neurological deterioration in mild DCM. Identifying early myelin degeneration in dorsal and ventral tracts, combined with upper extremity sensory symptoms, may inform surgical decisions in patients with minimal yet progressive deficits. These findings promote a proactive approach in DCM management, reducing uncertainty in surgical decision-making. Multi-center studies are needed to validate these findings, with the goal of supporting timely, targeted intervention.