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Microstructural MRI Quantifies Tract-Specific Injury And Correlates With Global Disability and Focal Neurological Deficits in Degenerative Cervical Myelopathy

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Introduction

Diffusion tensor imaging (DTI), magnetization transfer (MT), and T2*-weighted imaging measure aspects of spinal cord microstructure. This study investigates if these techniques can quantify injury to individual white matter (WM) tracts and correlate with focal neurological impairments in degenerative cervical myelopathy (DCM).

Methods

Fifty-seven DCM patients (age 56.7; 61% male; 32 mild, 16 moderate, 9 severe) underwent comprehensive clinical assessments and multimodal MRI (3T GE). Analysis with Spinal Cord Toolbox extracted fractional anisotropy (FA), MT ratio (MTR), and T2* WM/grey matter (GM) ratio (representing grey-white contrast) from regions of interest including: total WM, lateral corticospinal tracts (LCSTs), dorsal columns (DCs), and spinothalamic tracts (STTs) at C1-C2. Spearman correlations were calculated between total WM and global disability (mJOA), and between metrics in unilateral/bilateral WM tracts and measures of focal neurological impairment: mJOA upper/lower extremity (UE/LE) motor scores, UE strength, JAMAR grip force, and UE sensation.

Results

DCM subjects showed reduced FA ($p<0.00001$), decreased MTR ($p<0.001$), and increased T2*-WM/GM ratio ($p<0.00001$) vs. 32 healthy subjects (MANOVA $p<0.00001$). FA of the WM correlated well with mJOA ($r=0.69$, $p<0.01$), whereas the other metrics showed weaker relationships (T2*-WM/GM: $r=0.46$, $p=0.01$; MTR: $r=0.39$, $p=0.02$). FA provided the strongest correlations with focal neurological deficits (all $p<0.05$): FA of bilateral LCSTs correlated with mJOA motor scores ($r=0.65$); FA of ipsilateral LCST predicted arm power (left: $r=0.64$, right: $r=0.62$) and grip strength (left: $r=0.55$, right: $r=0.54$); FA of the DCs correlated well with ipsilateral hand sensation (left: $r=0.61$, right: $r=0.66$), while contralateral STTs showed a weaker association (left: $r=0.38$, right: $r=0.36$).

Conclusions

Microstructural MRI successfully measures WM injury rostral to cord compression in DCM, reflecting global and focal impairment. The DTI metric FA is a strong biomarker of tract-specific injury, and together these measures could potentially provide improved diagnostics, monitoring of disease progression, and prediction of outcomes.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) understand microstructural MRI methods, 2) appreciate their potential clinical applications for improved diagnostics, monitoring of disease progression, and prediction of outcomes, and 3) understand the positive results of this study showing that microstructural MRI detects global and focal tissue injury in the cord rostral to compression in DCM.

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