Higher-Resolution MR Elastography Reveals Early Mechanical Signatures of Neuroinflammation in Patients with Clinically Isolated Syndrome

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Purpose: To assess if higher-resolution magnetic resonance elastography (MRE) is a technique that can measure the in vivo mechanical properties of brain tissue and is sensitive to early signatures of brain tissue degradation in patients with clinically isolated syndrome (CIS).

Materials and Methods: Seventeen patients with CIS and 33 controls were investigated by MRE with a 3T MRI scanner. Full-wave field data were acquired at seven drive frequencies from 30 to 60 Hz. The spatially resolved higher-resolution maps of magnitude $|G^*|$ and phase angle φ of the complex-valued shear modulus were obtained in addition to springpot model parameters. These parameters were spatially averaged in white matter (WM) and whole-brain regions and correlated with clinical and radiological parameters.

Results: Spatially resolved MRE revealed that CIS reduced WM viscoelasticity, independent of imaging markers of multiple sclerosis and clinical scores. $|G^*|$ was reduced by 14% in CIS (1.4 ± 0.2 kPa vs. 1.7 ± 0.2 kPa, $P < 0.001$, 95% confidence interval [CI] [–0.4, –0.1] kPa), while φ (0.66 ± 0.04 vs. 0.67 ± 0.04, $P = 0.65$, 95% CI [–0.04, 0.02]) remained unaltered. Springpot-based shear elasticity showed only a trend of CIS-related reduction (3.4 ± 0.5 kPa vs. 3.7 ± 0.5 kPa, $P = 0.06$, 95% CI [–0.6, 0.02] kPa) in the whole brain.

Conclusion: We demonstrate that CIS leads to significantly reduced elasticity of brain parenchyma, raising the prospect of using MRE as an imaging marker for subtle and diffuse tissue damage in neuroinflammatory diseases.

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Clinically isolated syndrome (CIS) is considered the first clinical manifestation of an inflammatory demyelinating disorder of the central nervous system (CNS), which may later become multiple sclerosis (MS).[1] CIS is defined as a first episode of neurological symptoms with features suggestive of MS that lasts at least 24 hours in the absence of fever, infection, or encephalopathy.[1,2] Commonly affected brain regions include the optic nerve, spinal cord, brainstem, cerebellum, and the cerebral hemispheres.[1] Conversion to MS is seen in ~60% of all cases.[3] The prediction of MS based on clinical and paraclinical markers in CIS is an active area of research.[3–6] Thus, the evaluation of patients at the very onset of MS may provide new insights into the mechanisms leading to axonal loss and neuronal dysfunction, which occur early in the disease course.[7,8]

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