

High resolution assessment of viscoelastic properties of intracranial tumors by multifrequency magnetic resonance elastography

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TARGET AUDIENCE

Neuroradiologists and neurosurgeons interested in the non-invasive mechanical characterisation of intracerebral tumors using Magnetic Resonance Elastography (MRE).

PURPOSE

In recent years Magnetic Resonance Elastography (MRE) emerged into a clinically applicable imaging technique, especially focusing on the noninvasive diagnosis of diffuse diseases such as hepatic fibrosis (1). In the brain, it has been shown that MRE is capable of measuring global changes of the viscoelastic properties of cerebral tissue related to Alzheimer's disease (2) or Parkinson (3). The purpose of our study was to evaluate a spatially resolved three-dimensional multi-frequent MRE (3DMMRE) for assessment of the viscoelastic properties of intracranial tumors.

METHODS

We included 26 patients (63±13 yrs., 18 female) in our study. All examinations were performed on a clinical 3.0 Tesla scanner, using a standard 12-channel head coil and a modified phase-contrast single-shot spin-echo EPI sequence (15 slices, TR/TE 3000/71 ms; FoV 250x187 mm, iPAT=2, spatial resolution 2x2x2 mm, scan time 75 sec). The harmonic vibrations were induced by a subwoofer and transduced via a telescopic carbon fiber rod onto a custom-designed cradle, located inside the head coil. We used 7 vibration frequencies in the low acoustic range (30, 35, 40, 45, 50, 55, 60 Hz) with a temporal resolution of 8 dynamics per wave cycle, obtained by shifting the trigger pulse in consecutive scans by increments of 1/8* vibration frequency f. Data post-processing included the proposed multifrequency dual elasto-visco (MDEV) inversion (4) to generate high-resolution maps of the magnitude $|G^*|$ and the phase angle Φ of the complex valued shear modulus in the human brain.

RESULTS

All examinations were performed properly and evaluated successfully. The tumor entities included in this study were: glioblastoma multiforme WHO °IV (n=11), anaplastic astrocytoma WHO °III (n=3), meningioma (n=7), cerebral metastasis (n=4), and intracerebral abscess formation (n=1). All tumors were located supratentorial. Fig.1 shows two example image slices of standard clinical MRI and $|G^*|$ in two different types of tumors. Compared to the normal appearing contralateral white matter (NAWM) as well as to all other entities, meningiomas appeared to be more viscous giving rise to a higher ratio of $\Phi_{\text{tumor}}/\Phi_{\text{NAWM}}$ as can be seen in Fig.2. Primary brain tumors and cerebral metastases were not distinguishable in terms of $|G^*|$ and Φ . In our group, a trend was delineable that WHO grade II and III tumors are stiffer compared to grade IV glioblastoma. The latter one displayed the largest range of $|G^*|$ values.

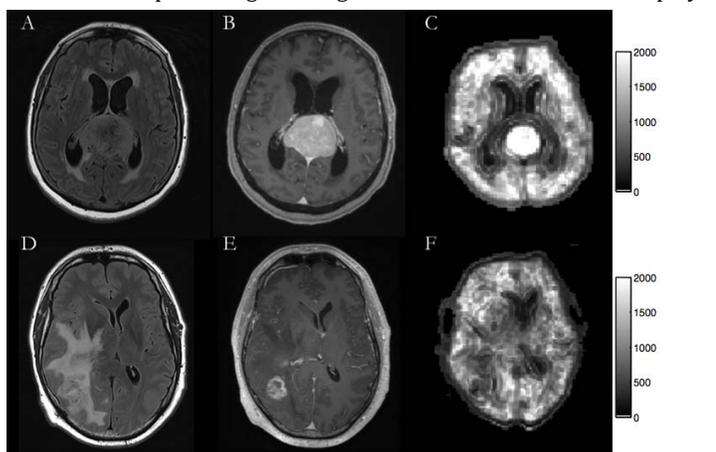


Fig.1: The upper row displays a central meningioma (A - FLAIR, B - CA-enhanced T1-w, C - elasticity map $|G^*|$), showing the increased stiffness of the tumor, compared to the surrounding tissue.

The bottom row displays a glioblastoma multiforme WHO °IV with a central enhancing portion. There is an inhomogeneous elasticity of the tumor, which is mainly softer than the NAWM.

DISCUSSION / CONCLUSION

Conventional MRI provides only limited information about tissue structure and parenchymal connectivity. This is a pilot study analyzing the viscoelastic constants of various intracranial tumor entities. Using 3DMMRE and MDEV inversion, it is possible to characterize intracranial tumors by their mechanical properties with improved spatial resolution compared to previous work in MRE on tumors (5, 6). We were able to clearly delineate meningiomas from intraaxial tumors, while for the latter group an overlap remains in viscoelastic terms.

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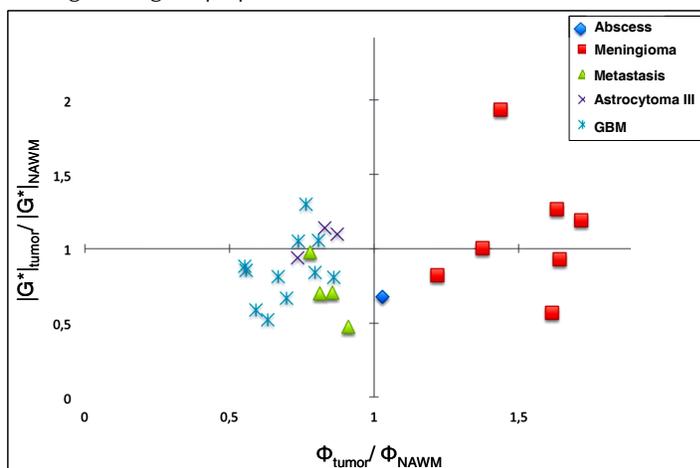


Fig.2: Relative viscoelasticity of intracranial tumors to normal appearing white matter (NAWM).