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ORIGINAL ARTICLE

High Resolution Imaging of Viscoelastic Properties of Intracranial Tumours by Multi-Frequency Magnetic Resonance Elastography

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Abstract
Purpose In recent years Magnetic Resonance Elastography (MRE) emerged into a clinically applicable imaging technique. It has been shown that MRE is capable of measuring global changes of the viscoelastic properties of cerebral tissue. 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 tumours.
Methods A total of 27 patients (63±13 years) were included. All examinations were performed on a 3.0 T scanner, using a modified phase-contrast echo planar imaging sequence. We used 7 vibration frequencies in the low acoustic range with a temporal resolution of 8 dynamics per wave cycle. Post-processing included multi-frequency dual elasto-visco (MDEV) inversion to generate high-resolution maps of the magnitude $|G^*|$ and the phase angle φ of the complex valued shear modulus.
Results The tumour entities included in this study were: glioblastoma ($n=11$), anaplastic astrocytoma ($n=3$), meningioma ($n=7$), cerebral metastasis ($n=5$) and intracerebral abscess formation ($n=1$). Primary brain tumours and cerebral metastases were not distinguishable in terms of $|G^*|$ and φ. Glioblastoma presented the largest range of $|G^*|$ values and a trend was delineable that glioblastoma were slightly softer than WHO grade III tumours. In terms of φ, meningiomas were clearly distinguishable from all other entities.
Conclusions In this pilot study, while analysing the viscoelastic constants of various intracranial tumour entities with an improved spatial resolution, it was possible to characterize intracranial tumours by their mechanical properties. We were able to clearly delineate meningiomas from intraaxial tumours, while for the latter group an overlap remains in viscoelastic terms.

Keywords MR elastography · Multi-frequency · Brain tumours · Meningioma · Viscoelastic properties

Introduction

Manual palpation and interpretation of haptic sensations is one of the most basic medical examinations of human organs, but is limited to the accessibility of organs. The in vivo evaluation of viscoelastic properties of the brain or intracranial tumours is confined to neurosurgeons performing craniotomy since it is surrounded and protected by the skull.

Undoubtedly being the method of choice for evaluation of the central nervous system, magnetic resonance imaging (MRI) emerged from sole anatomic characterization of the brain to assessment of metabolic changes by MR spectroscopy, of microstructural and functional parameters by diffusion and perfusion imaging as well as blood oxygenation

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