High resolution MR-elastography mouse brain study: towards a mechanical atlas

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Introduction

Magnetic resonance elastography (MRE) is an innovative imaging technique developed to non-invasively map and quantify the viscoelastic properties of tissue *in vivo*. MRE has been used as a tool to image and assess human tissue properties in several areas of the body such as breast tissue, prostate and skeletal muscle and brain[(1,2)]. A change in elasticity can often represent a pathological change in the tissue. The investigation of the effect of different brain pathological processes such as neurodegeneration, protein aggregation or demyelination in viscoelastic properties of cerebral tissue using experimental rodent model appears to be essential to evaluate the interest of this non-invasive imaging technique to help diagnosis and/or the evaluation of the therapeutics. However, the first step is to test data reproducibility in order to allow longitudinal studies. Thus, we attempted to test reproducibility regarding mouse brain viscoelastic properties of the corpus callosum checking a group of 8 weeks-aged C57Bl/6 mice against repeated sessions of MRI protocol.

Methods

Longitudinal waves were transmitted into the mouse brain with a mechanical transducer consisting of a coil driven by a programmable pulse generator. An excitation of 1000Hz was used to optimise wave penetration within mouse brain. Wave propagation into the brain was analyzed with a phase-locked spin-echo sequence on a 7T animal MRI scanner (Bruker). A total of 20 brain sections of 300µm slice thickness and 300µm isotropic in-plane resolution were acquired. In addition, high-resolution T2-weighted images were acquired with identical slice positioning but increase in-plane resolution (150µm).

Results

High resolution mouse brain images were obtained using a T2-weight sequence (RARE) (Fig 1a). Fig 1b shows manually defined Roi of mouse corpus callosum. Storage moduli maps (Fig 1d, e and f) were reconstructed using isotropic reconstruction mode. Mean elasticity (Fig 1d), viscosity (Fig 1e) and |G*| were calculated on 6 adjacent brain sections where corpus callosum was clearly visible on high resolution MR images. Values from 5 mice each scanned 3 times over 3 weeks were as follows (kPa): <Gd> = 7.36±0.5 (7%); <Gl> = 3,33±0,8 (25%); <|G*|> = 8,21±0,6 (8%). It is to note that other "stiff" brain structures containing myelinated fibers can be clearly identified from reconstructed images like the optic tract (Fig1g) or the superior cerebellar peduncle (Fig1h).

Discussion

First results obtained within corpus callosum of C57Bl/6 mice seem to be very robust (only about 7% variance for elasticity and 25% for viscosity). These encouraging data may then allow the comparison between different experimental mouse groups. Currently we attempt to study the effect of demyelination/remyelination on mechanical properties of corpus callosum using the well-established cuprizone-challenged mice[(3)]. Data acquisition is ongoing. Correlations between different MRI scans, clinical global motor score and histopathological data will be conducted. A methodology based on mechanical measurements of brain structures such as MRE might open new possibilities for the early detection and the management of central demyelinating disorders such as multiple sclerosis or Alzheimer's disease.

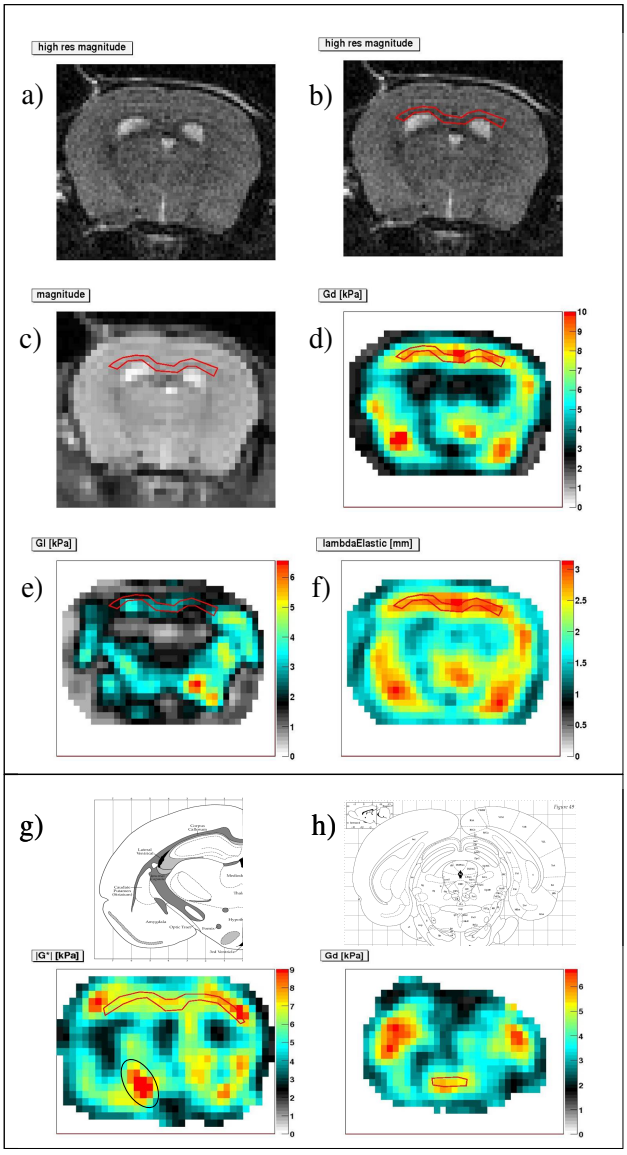

Fig.1: a) High resolution T2 image of the mouse brain in coronal plane. b) Example of defined Roi delimitating the corpus callosum. c) Magnitude image of MRE scan. d,e) Images of elasticity (d) and viscosity (e) measured in kPa. f) Image of wavelength of vibrations in units of mm. g,h) Detection of mouse brain regions containing myelinated-fibers such as the corpus callosum and the optic tract (g) and the superior cerebellar peduncle (h)

References

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2. Sinkus R et al., Magn Reson Imaging 2005, 23(2): p 159-165.
3. Matsushima and Morell, Brain Pathology 2001, 11: p 107-116.