Using Magnetic Resonance Elastography to determine brain viscoelasticity in chronically shunted hydrocephalus

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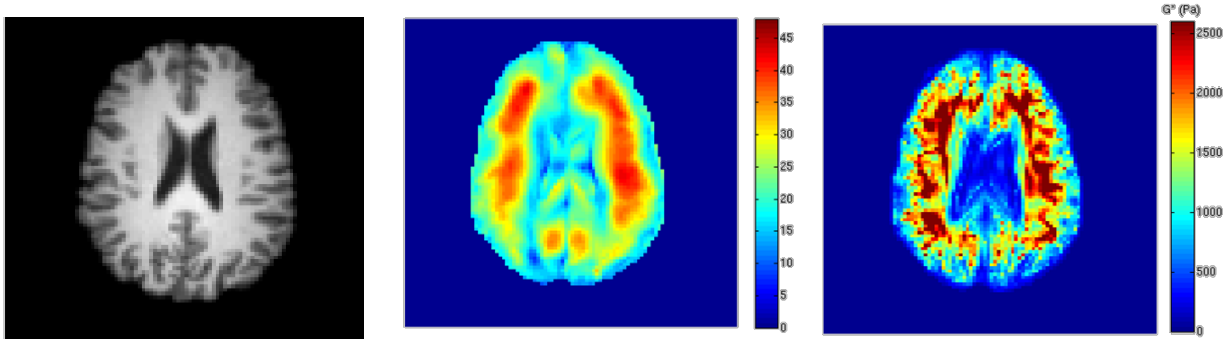
Chronic headaches are a well-documented complaint of shunted hydrocephalic patients. However, it is also one of the signs of shunt malfunction. Cranial compliance deficiency may be a cause of chronic headaches in some chronically shunted patients with functioning shunts (often with slit or smaller than normal ventricles). This study aims to use a novel, non-invasive imaging technique, Magnetic Resonance Elastography (MRE) to investigate the role of brain viscoelasticity in pediatric hydrocephalic patients.

Shunt-dependent patients who developed hydrocephalus as infants were selected. Preliminary results from 16 patients (age 15-37, median age 23) who suffer from chronic headaches (excluding patients with abnormally large ventricles, defined as ventricular volume < 25 cm^3) are shown. MRE was performed by inducing a mechanical wave at 30Hz, transmitted through the zygomatic arches. Wave propagation speed was used to estimate viscoelasticity (shear modulus, G*). Images were motion and distortion corrected using MRE magnitude and field maps respectively. Image segmentation was performed on registered high-resolution images to produce CSF, white and gray matter masks using FSL.

Good wave penetration was observed in MRE results allowing high quality data to be reconstructed.



(a) (b) (c)

Figure 1: Typical dataset: (a) high-res anatomical (b) total motion displacement (c) viscoelasticity map

Preliminary results show that brain viscoelasticity decreased in patients compared to controls ($p<0.05$) in whole white matter and whole gray matter. Further analysis is conducted in segmenting results to smaller white matter regions such as the internal capsule and the corpus callosum as well as correlating these results to headache survey measures.

This pilot study demonstrates that MRE could be a powerful diagnostic tool to be used in pediatric hydrocephalic patients. Preliminary results show the brain to be less viscoelastic in patients compared to controls indicating that compliance could be key in understanding the cause of headaches in chronically shunted patients. This study is ongoing with the aim of comparing control and patient data and correlating viscoelasticity to headache severity.