Repeatability of healthy subjects using intrinsically-activated MR elastography

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Introduction: MR elastography of *in vivo* brain tissue has recently been a popular avenue for elasticity imaging due to the wide array of disease processes that affect tissue mechanics. However, estimates of the brain tissue mechanical properties vary, in part due to lack of tissue actuation in deeper structures. One possible way to negate the need for external tissue actuation is known as 'intrinsic activation', where the natural pulsatility of the brain serves as the source of motion and an altered phase-contrast MRI technique is used to measure the deformation of the tissue during the cardiac cycle. Initial results for this technique on brain tissue look feasible[1] and also show a significant difference between controls and patients stricken with hydrocephalus[2]. Beyond disease, healthy subjects can have varied brain tissue mechanics due to differences in heart rate, blood pressure, medications, or everyday activities. Therefore, we hypothesize that 1) the variation in estimated tissue stiffness will be smaller when a patient is scanned three times in a row versus three times on separate days and 2) the intrasubject variation will be smaller than the intersubject variation.

Methods: A series of healthy subjects were scanned using the same technique described in previous applications[1,2]. In brief, a phase-contrast MR angiography sequence was used in addition to a fractional-encoding technique with a very small velocity encoding gradient (1 cm/s) to extract tissue velocities, where the divergence theorem for the Fourier transform was applied to retrieve a 3D displacement field. The displacements were processed with the same techniques used in externally-actuated MRE. A poroelastic mechanical model provided estimates of a shear modulus and a pore-pressure[3]. Six healthy subjects have been scanned anywhere from 1 to 15 times each. Multiple subjects have been scanned in what are termed 'repeat studies' – where the subject stays in the scanner for three consecutive scans with the same field of view. Repeatability was measured using the coefficient of variation (σ/μ).

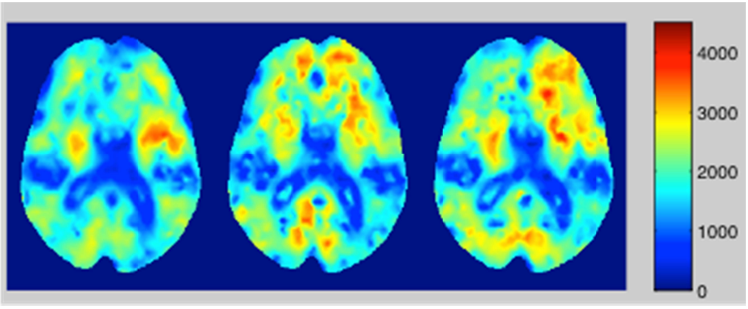

Figure 1 - Shear modulus map (in Pascals) of the same coronal slice for three separate sessions of a repeat study for a healthy subject.

Table 1 - Coefficients of variation for the four subjects with multiple sessions. Subject B and D did not have repeated sessions.

Subject	Coeff. of Var. (%) (non-repeat)	Coeff. of Var. (%) (repeat)
A	7.53	6.41
B	12.3	N/A
C	4.41	3.84
D	12.1	N/A

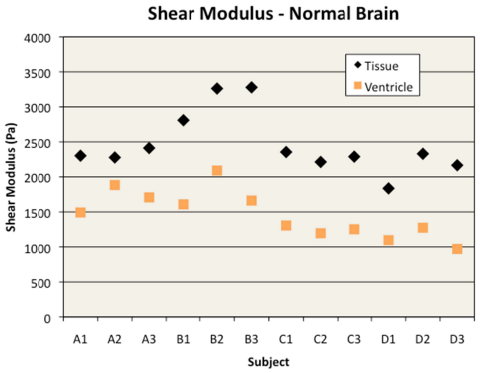

Figure 2 - Shear modulus estimates of normal subjects for the non-repeated studies.

Results: To test the first hypothesis, the repeatability of the repeat studies was compared with studies performed on different days. As seen in Table 1, Subject A went from 6.4% with 3 consecutive scans to 7.9% over 3 separate days. For subject C, the value went from 3.8% to 4.5% (see Figure 1). The second hypothesis was tested comparing the repeatability of the sessions for a certain subject (intrasubject) with the repeatability of the shear modulus means among the different subjects (intersubject). The average intrasubject variation for the four patients that were scanned on three separate days (see Figure 2) was 8.6% whereas the intersubject variation among this group was 16.5%.

Conclusions: The results show that intrinsic activation is repeatable and may be sensitive to 1) changes in a single subject over a range of time and 2) changes among patients. The coefficients of variation show a slight increase in the variability of the data when taken over separate days versus when taken consecutively. While the change is small, it elucidates that the natural changes in brain tissue properties change over time. Also, the small coefficients of variation show that the reconstructions are giving consistent results. The intrasubject variation is found to be much smaller than the intersubject variation, which shows that this technique can detect different mechanical property signatures for different subjects consistently.

References:

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