Comparison of viscoelasticity measurements by shear wave elastography, by passive elastography and by surface fluctuations spectroscopy

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Background, Motivation and Objective

Recently, viscoelasticity of a 100 um diameter mouse oocyte has been measured with a 15 kHz propagating shear wave, using passive elastography technique. However, very few measurements are available at these scales and frequencies, so we lack of gold standard to compare the results.
The objective of this work is to compare different viscoelastic measurement techniques at high frequencies.
We choose to measure a well-defined medium with passive elastography, shear wave elastography and free surface thermal fluctuations technique.
Passive elastography uses shear waves propagating randomly in a medium.
Shear wave elastography tracks shear wave speed with different methods such as time-of-flight.
Surface fluctuations spectroscopy observes the deviation of a laser by a free surface moving randomly under thermal fluctuations.

Statement of Contribution/Methods

A sample made of a carbopol polymer microgel was used.
Passive and shear wave elastography used a 50 um diameter pipette to induce shear waves at frequencies between 100 Hz to 10 kHz. A high speed camera tracked the shear wave. Displacement was computed with an optical flow technique and elasticity reconstructed with time of flight and passive elastography algorithms.
Free surface thermal fluctuation setup was built using a 632 nm laser focused on the sample surface. Reflected laser deviations were measured with a four quadrants photodiode. Surface fluctuations among a band of frequency of 10 Hz to 100 kHz has been measured, giving the real and imaginary part of the viscoelastic modulus.

Results/Discussion

Viscoelastic measurements were comparable in all techniques, showing a linear increase of viscoelasticity G* with frequency over the range 100 Hz to 10 kHz. Viscoelasticity was however slightly lower for shear wave elastography and passive elastography than surface spectroscopy. This difference was supposed to be due to elasticity variation between surface and bulk of the medium. Note also that techniques requirements are different, limiting the number of comparison cases: elastography need to track shear waves, limiting the frequency range (at low frequency, shear waves are hard to track, while at high frequency, shear wave attenuation is too strong). Conversely, surface fluctuations techniques need a specular surface to reflect the laser beam, and hardly provide measurements in the bulk.