DEVICE FOR MINIMALLY INVASIVE NON-DESTRUCTIVE ANALYSIS OF LOCAL TISSUE BIOMECHANICS

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INTRODUCTION

- *In vivo* biomechanics differ largely from *in vitro*
- Local quantification of mechanics useful for diagnosis of tissue health and for tumor removal
- Non-optical method of measurement needed for minimally invasive, clinically practical device

METHODS

Device and Setup

- 1st gen negative aspiration pipette built using Pyrex tubing with two copper electrodes (15x7mm) fastened at tip
- 2nd gen probe utilizes fabricated microarray of gold plated electrodes (200x200um) inside bore of 2.4mm probe; 6 pairs, stacked vertically at 200um

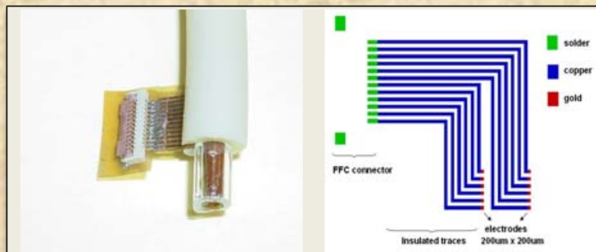

Figure 1: Microarray secured in glass tip and fitted inside of silicon bore. External connection to electrodes protruding from the left.

Phantoms and Tissue

- Initial testing performed on uniform gel phantoms of agarose of 1.5, 2.3, and 3.0% strength
- Further testing used freshly excised porcine tissue
- First round of testing performed on single heart, liver, and lung (n=6) in centralized spot; depicted repeatability of system
- Second round of testing consisted of 6 hearts, livers, and lungs, with one trial on each; highlighted ability to differentiate tissue based on organ type

Experimental Setup

- Tissue samples were mounted on a Petri dish underneath Zeiss microscope; aspiration probe tip firmly pressed against sample
- WPI syringe pump used to secure and elongate tissue at a uniform pump rate
- Validyne USB2250 acquisition system used to collect data from electrodes and pressure transducer
- Validyne and ImagePro software recorded measurements and captured images, in sync, every 4 seconds

RESULTS

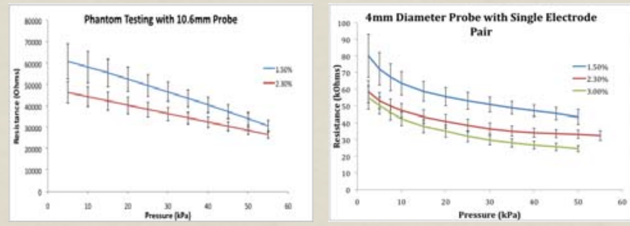

Figure 2: Agarose phantom testing with 1st generation prototype

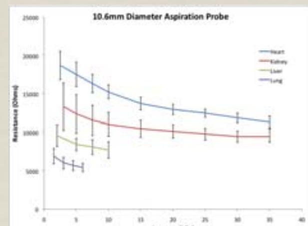

Figure 3: Pressure v. Resistance of porcine organs (n=6)

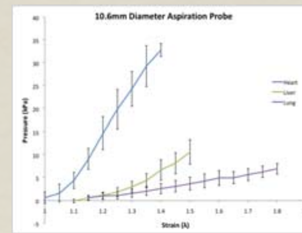

Figure 4: Pressure v. stretch ratio of porcine organs (n=6)

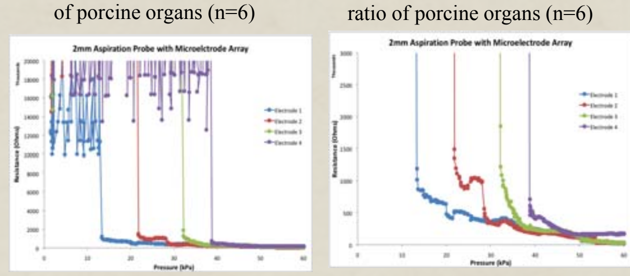

Figure 5: Agarose phantom (1%) under test with 2nd gen prototype

DISCUSSION

- Nonlinear response of resistance as tissue distended over electrodes (Fig 3) expected from R = (ρ*L)/A; hard to model elongation across single electrode pair
- Manual measurement of elongation allowed for construction of stress-strain curves (Fig 4) for tested organs; similar mechanics to previous *in vitro* reports observed
- Order of magnitude drop in 2nd generation tests (Fig 5) indicates shift from infinite to finite resistance value; shows exact pressure when tissue crosses electrode pair
- Utilization of electrode pair geometry (height in stack) allows for a known length to be mapped to the precise pressure when tissue becomes incident on electrode pair; stress-strain data point can be assigned
- Impedance measurement of tissue response to signal waves will be implemented as an additional parameter for tissue characterization