# Finding brain tumours using ultrasound

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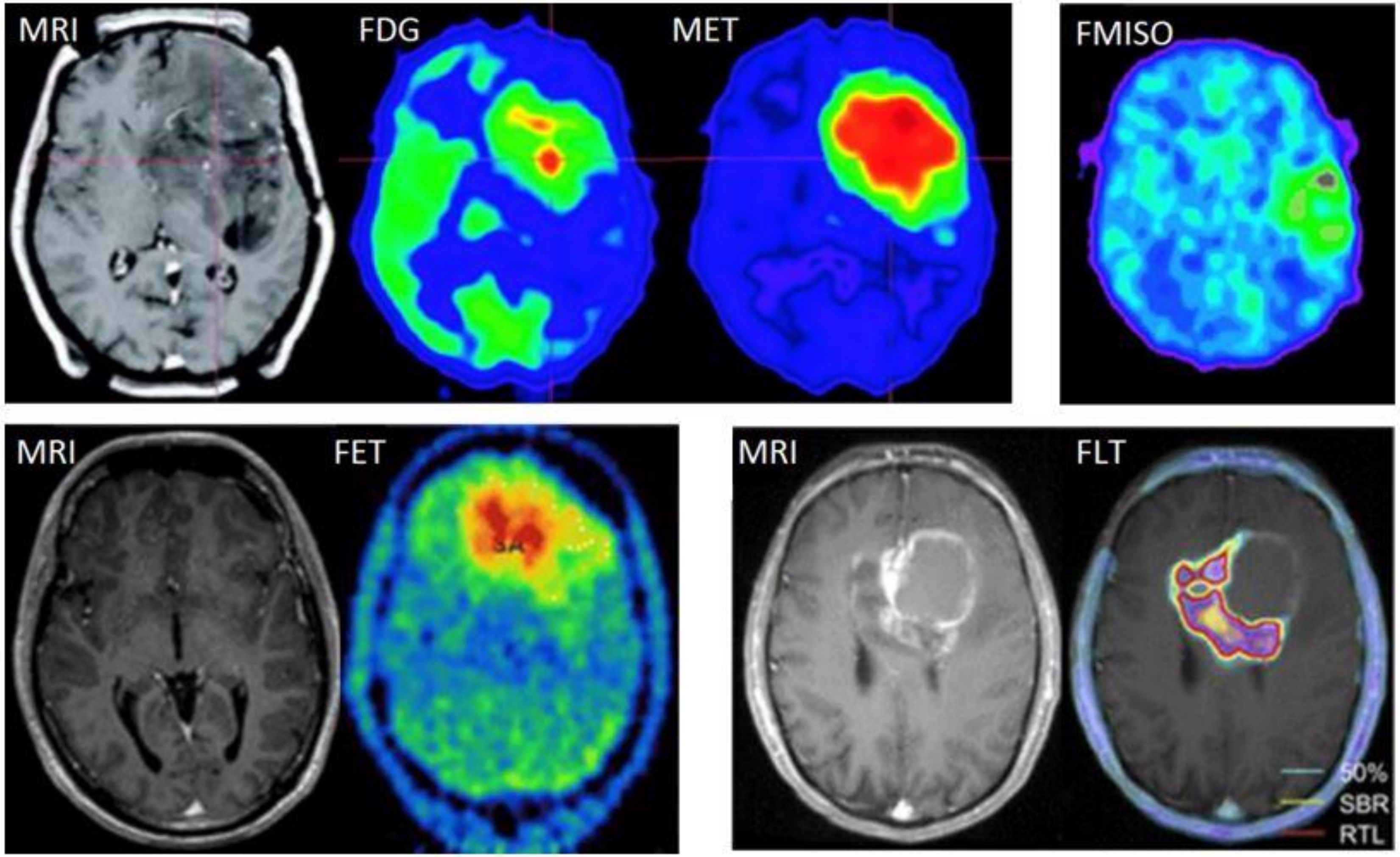
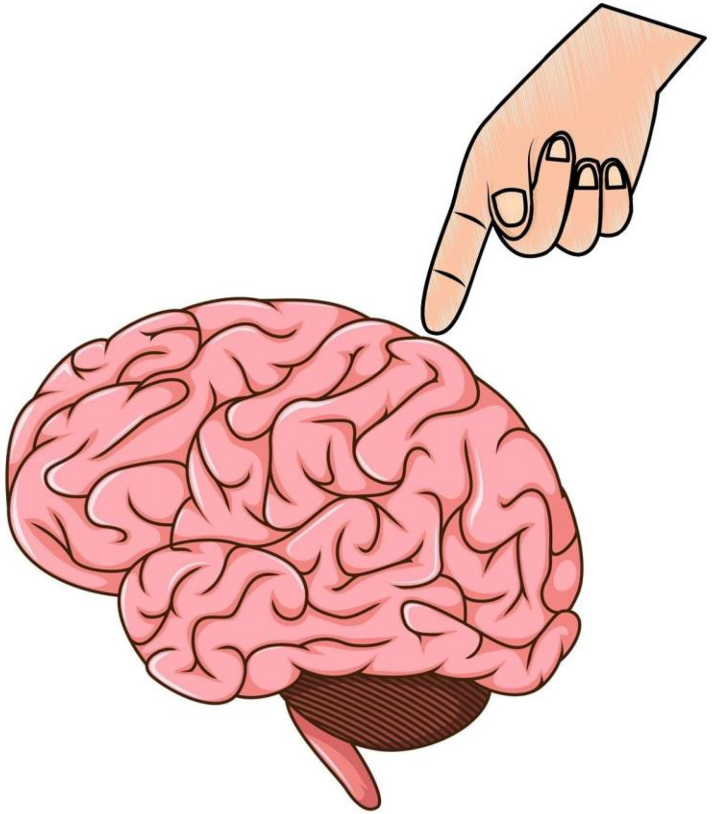



**Before** surgery:

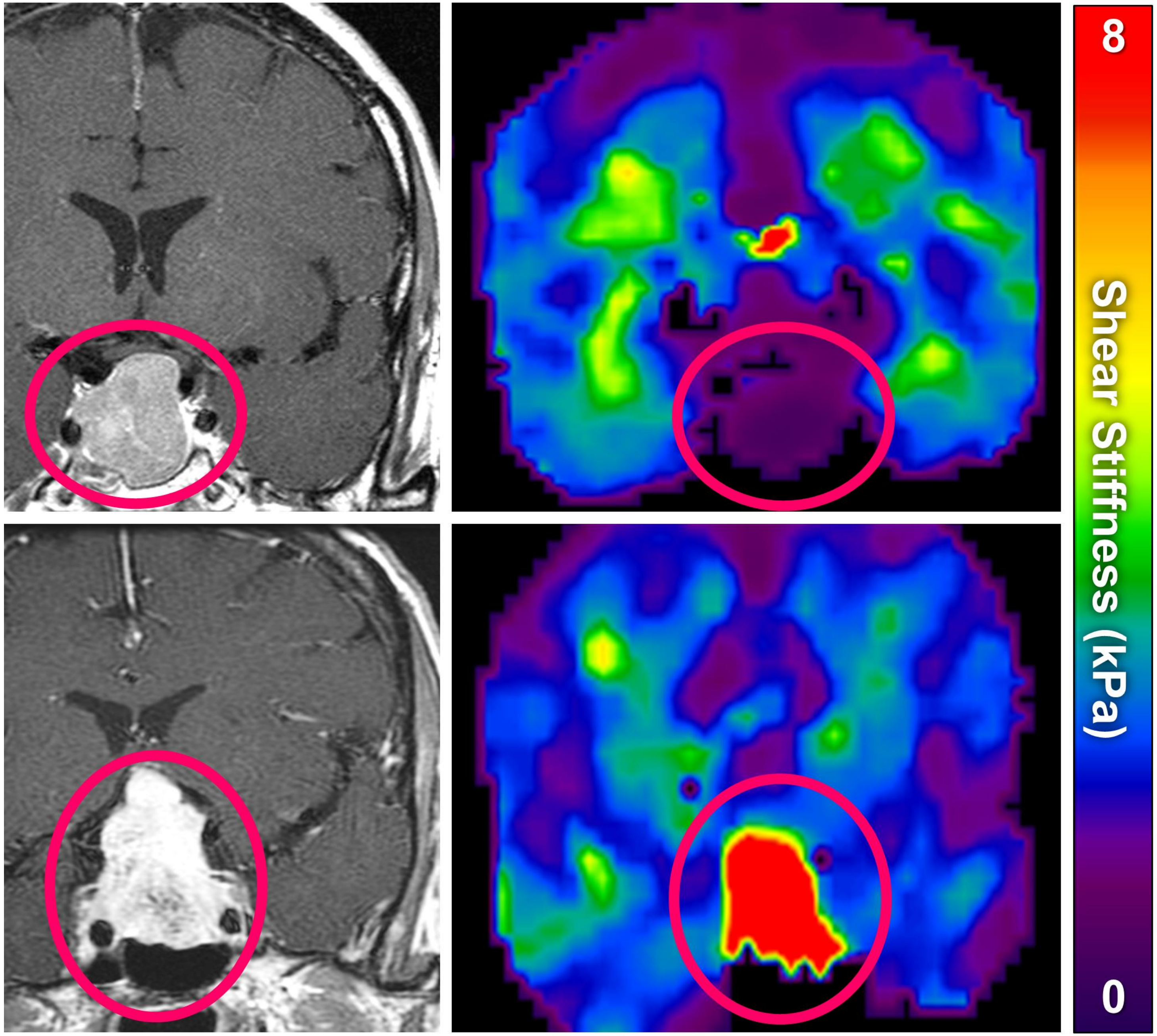
Tumours easily seen with MRI

**During** surgery:



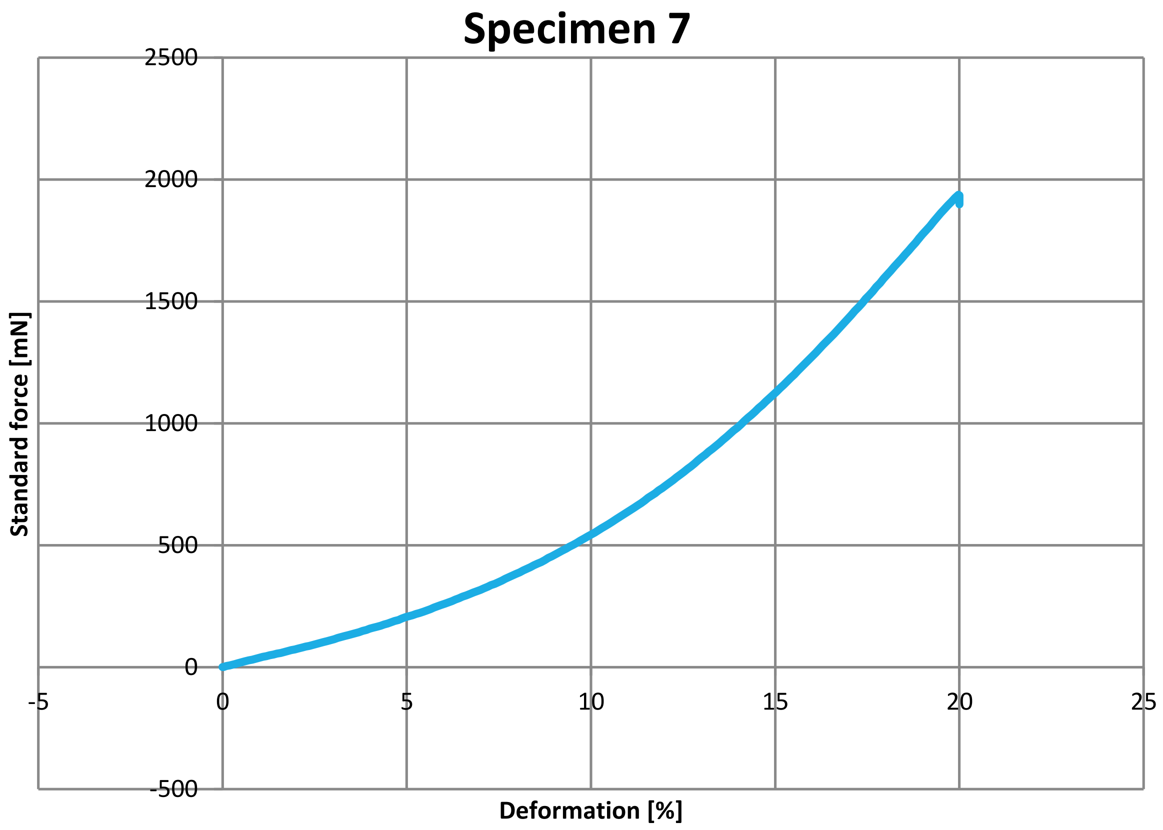
# Goals:

- Make brain stiffness maps during surgery
- Locate stiffer brain tumours/diseased tissue
- Not relying on palpation only!



# Making and characterising fake brain tissue

- Using agar to make a really soft gel
- Compression testing to get Youngs modulus
- Assume material is hyperelastic, incompressible and isotropic
- Try to fit to different models




Data from compression test

# Mooney Rivlin Model

Mooney-Rivlin Model

$W = C_1(I_1 - 3) + C_2(I_2 - 3)$ - Strain energy function

$\sigma = C_1(\lambda^2 - \lambda^{-1}) + \mathrm{C}_2(\lambda - \lambda^{-2})$ - Cauchy stress tensor

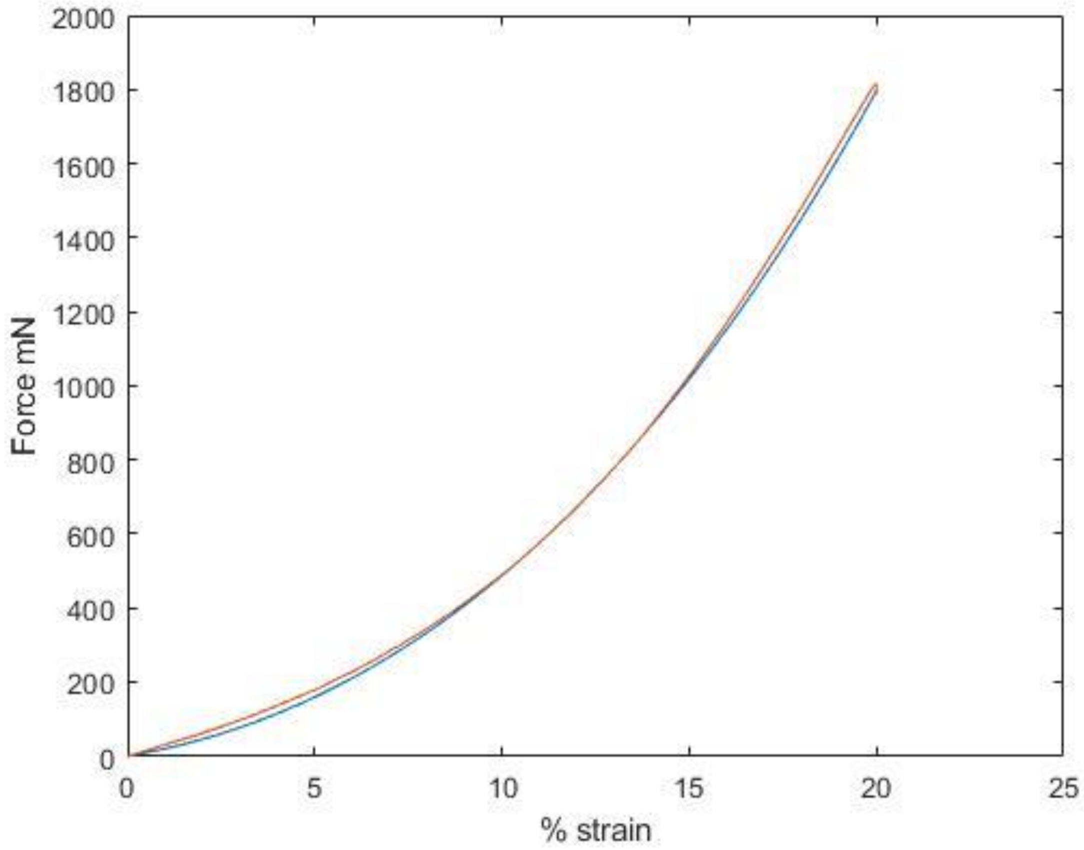
Where $\lambda$ is the stretch, $I_1$ and $I_2$ are the invariants, C are constants

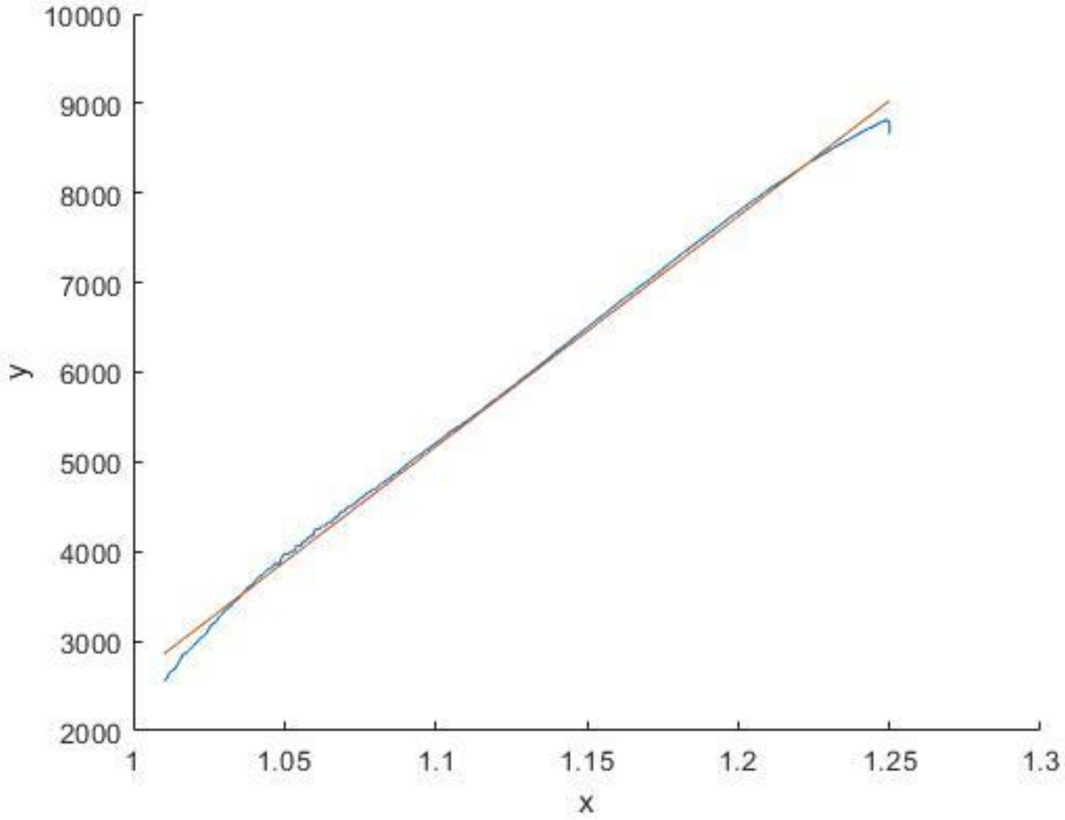
Re-scale the data and plot y = $\sigma/\ (\lambda^2 - \lambda^{-1})$ x = $\lambda^{-1}$

If all goes well, should get a straight line to find the constants!

$y = C_1 + C_2 x$

# Preliminary results (Mooney Rivlin)

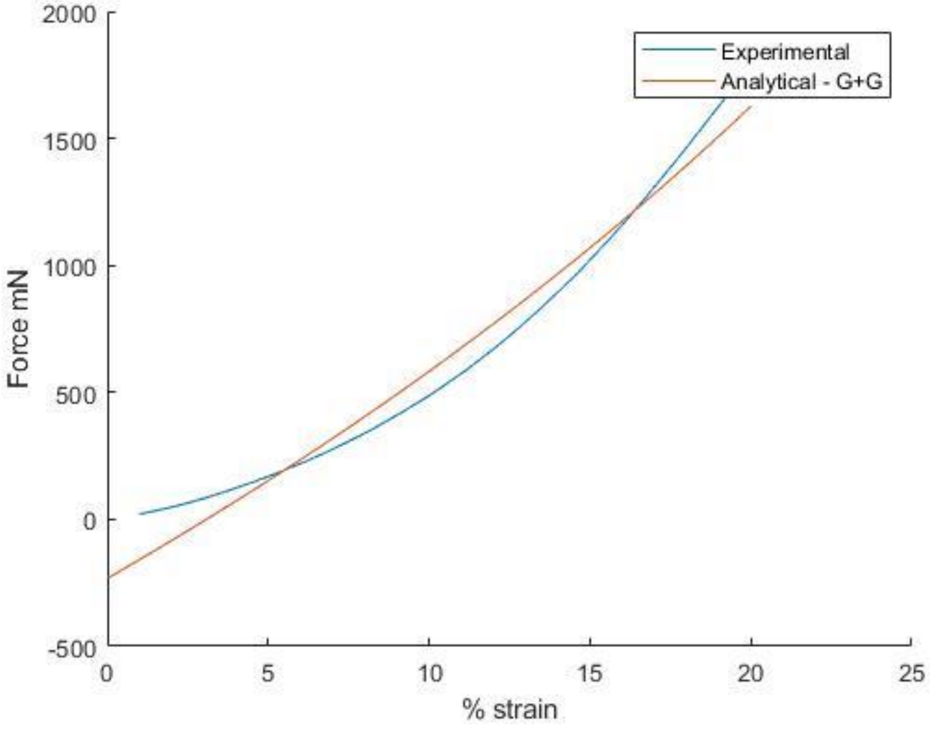


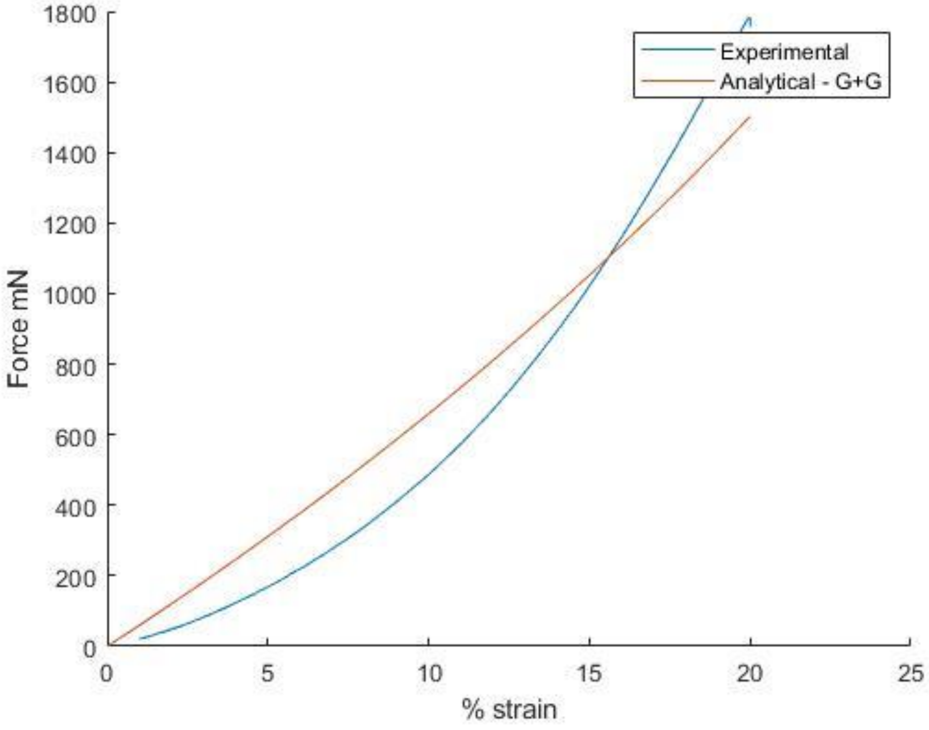

Blue = Experimental, Orange = Analytical solution

Fit well but have a negative $C_1$!

# Preliminary results (Gent + Gent)



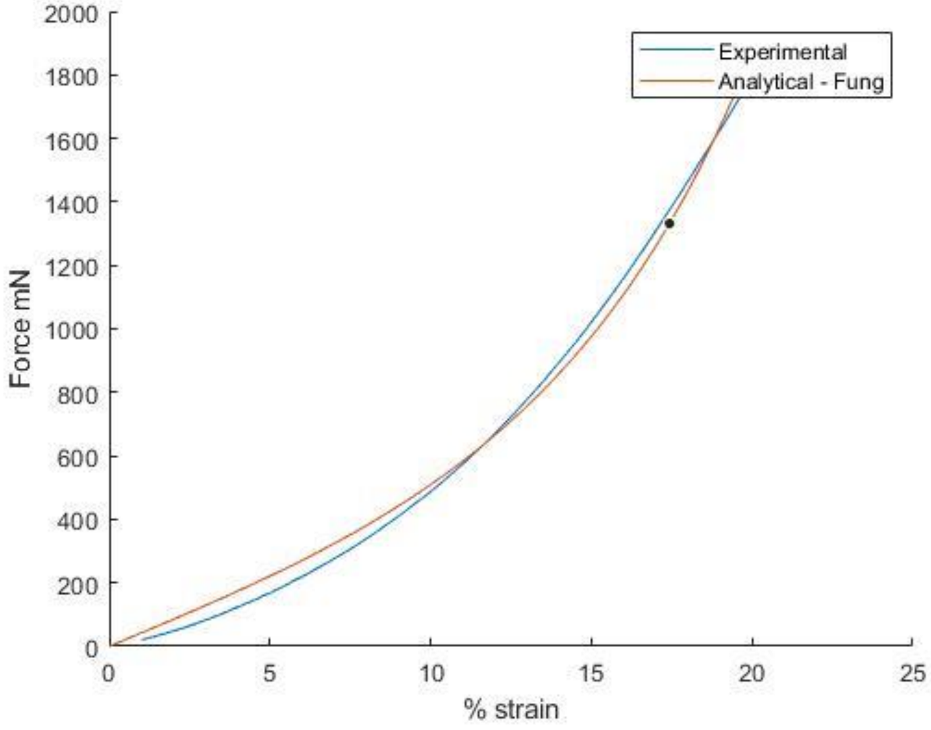

Unconstrained Fit




Constrained Fit

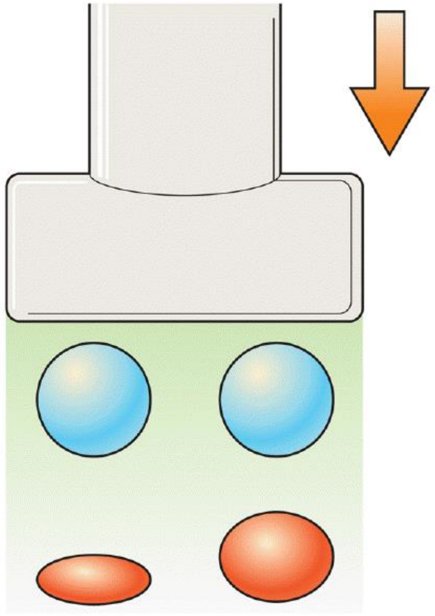
# Preliminary results (Fung)

- Fung showing the best fit so far, but not sure about constants
- Shear modulus = 10.6 and b = 1.543
- May need to do more testing

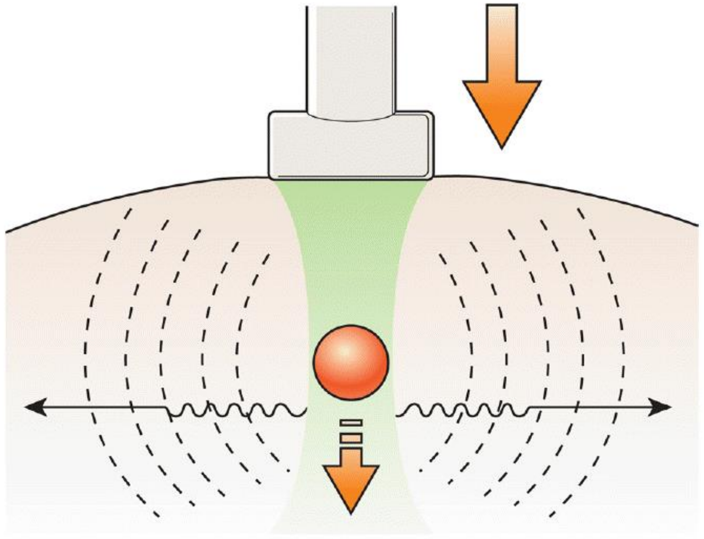


# Making stiffness maps

- Can either create a deformation using the probe itself, or use shear waves.
- Shear waves user independent
- More accurate, also a lot harder to do!



A



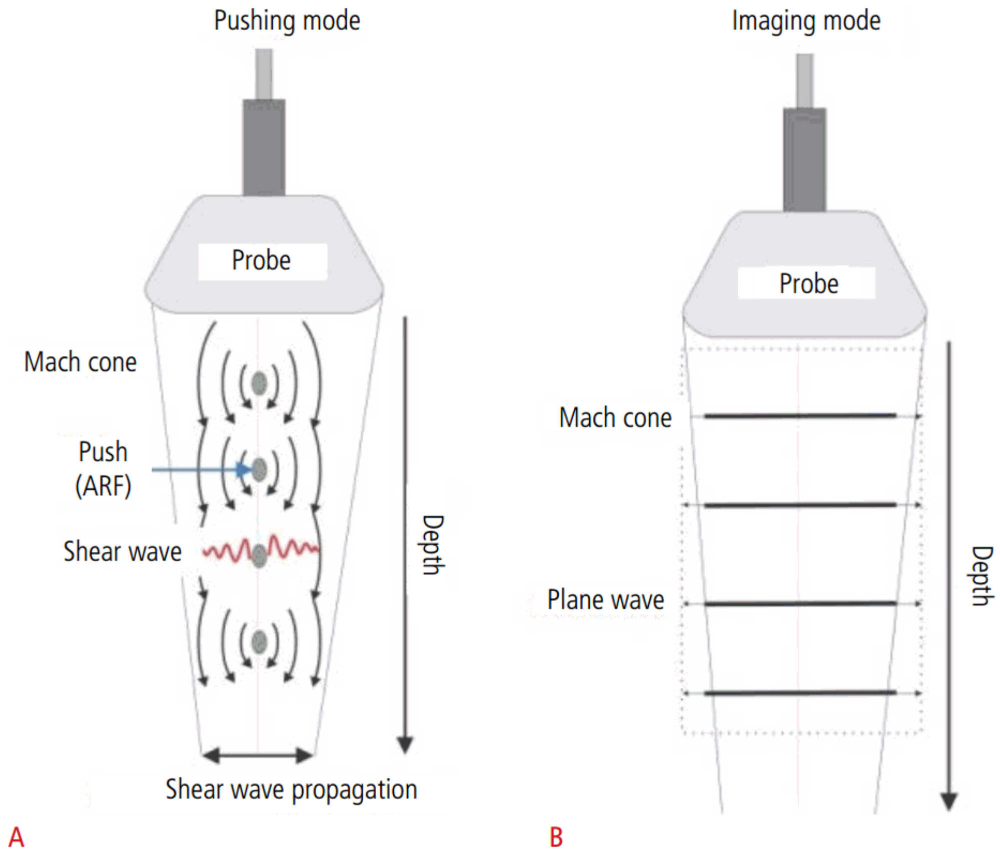
B

A. Quasi-static elastography

B. Shear wave elastography

# Shear wave generation

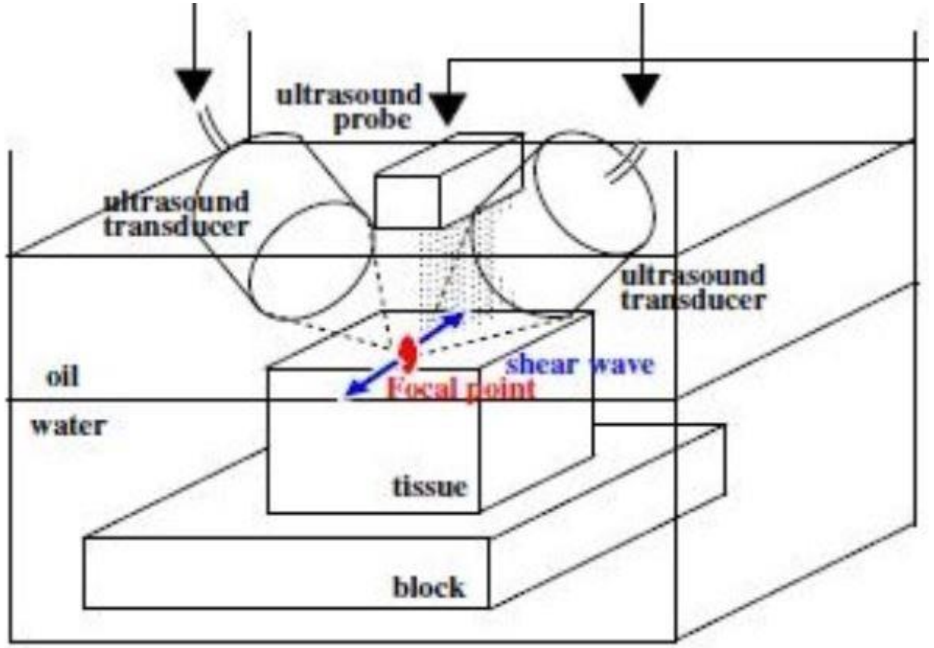
- State of the art systems focus at different depths and track the shear waves from the same probe
- Difficult to compute
- Expensive! ~200k




Example of supersonic shear wave imaging

# Our idea

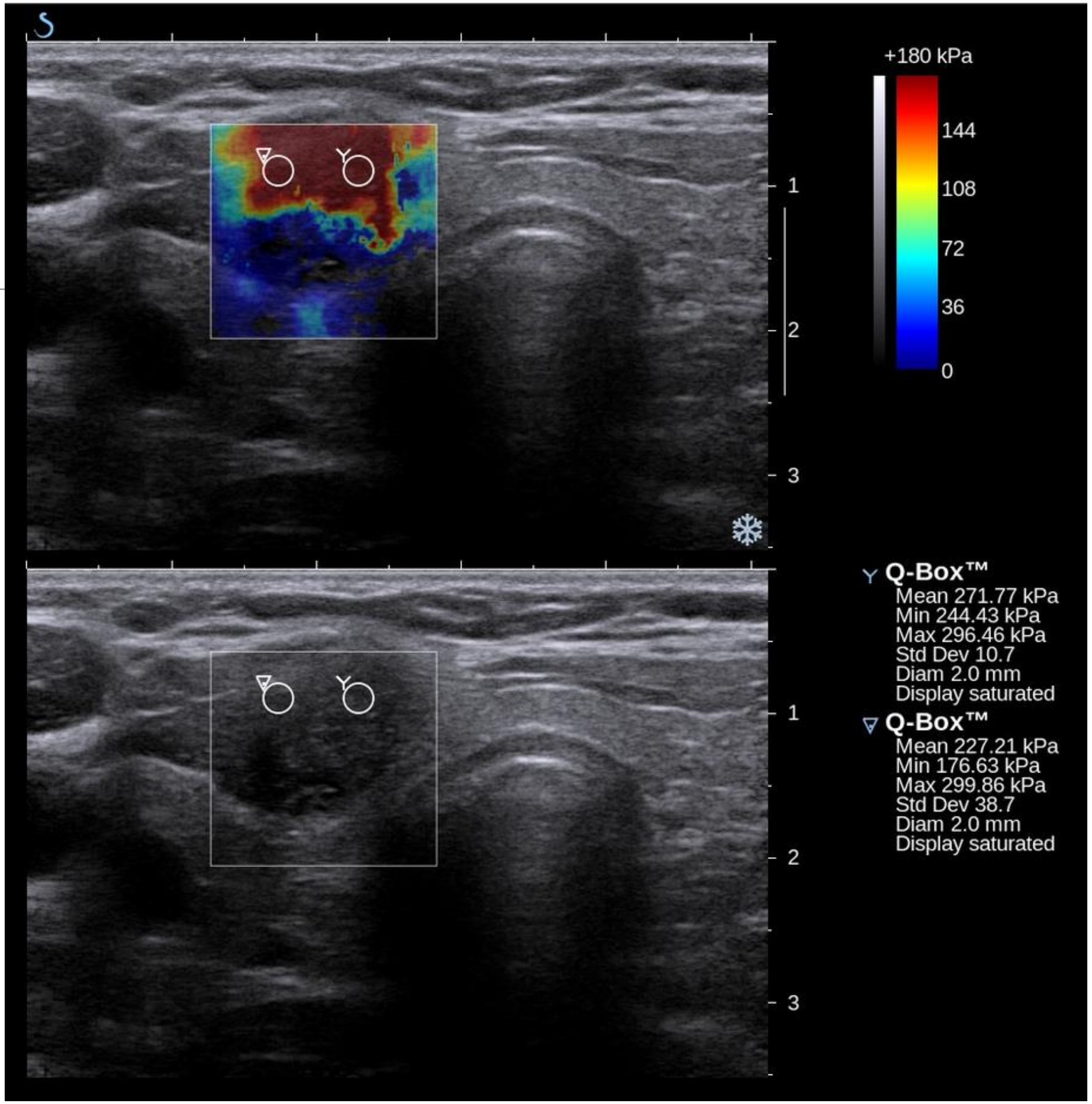
- Focus two ultrasound beams, same frequency at the same point.
- Create a push and watch the shear waves with the ultrasound probe.
- $c_s = \sqrt{\frac{\mu}{\rho}}$
- $c_s$ is the shear wave speed, $\mu$ is the shear modulus and $\rho$ is the density
- $E \approx 3\rho c_s^2$
- Can track velocity to make a stiffness map




Example of setup

# End goal

- Try to create a low cost proof of concept system that can create and image shear waves.
- Make stiffness maps of soft tissue to identify diseases such as tumours.
- Get a PhD!




Example of thyroid imaging