Elastografia por ultrassom

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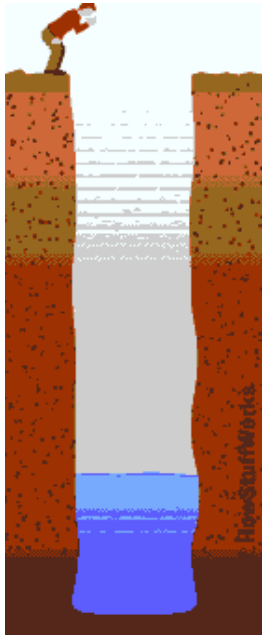
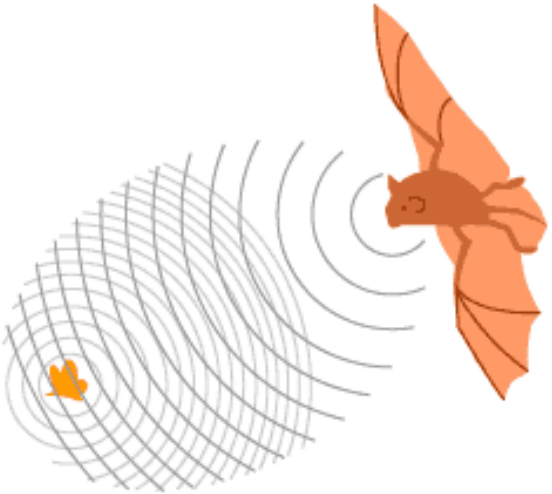
Universidade de São Paulo, FFCLRP, Departamento de Física

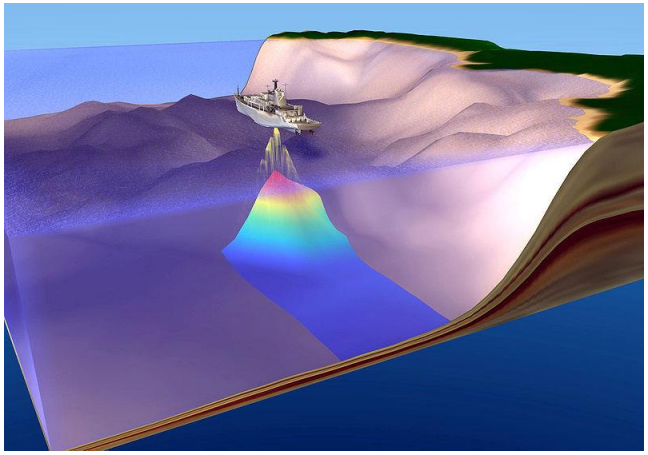
Ultrassom

Som audível





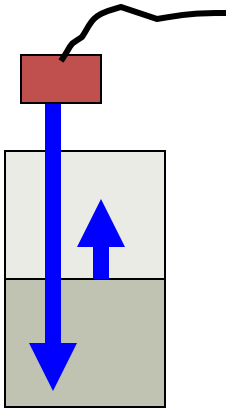
Ultrassom ~ kHz



Ultrassonografia diagnóstica 1 a 15 MHz.

Impedância acústica (Z)

O eco só surge quando o feixe de ultrassom passa por dois meios com diferentes impedâncias.



$$Z = \rho.v$$

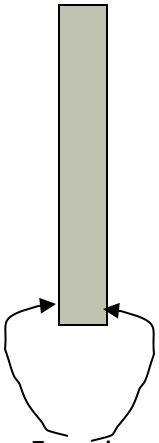
- **Z - impedância acústica**
- **ρ - densidade do meio**
- **V - velocidade do som nesse meio**

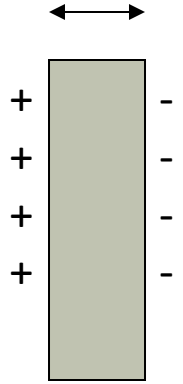
Ultrassonografia

Pavan TZ, et al, Ciência Hoje, 2008

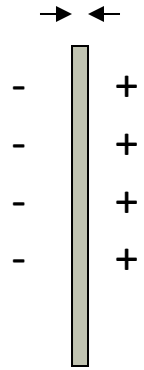
Transdutores

Elementos piezelétricos



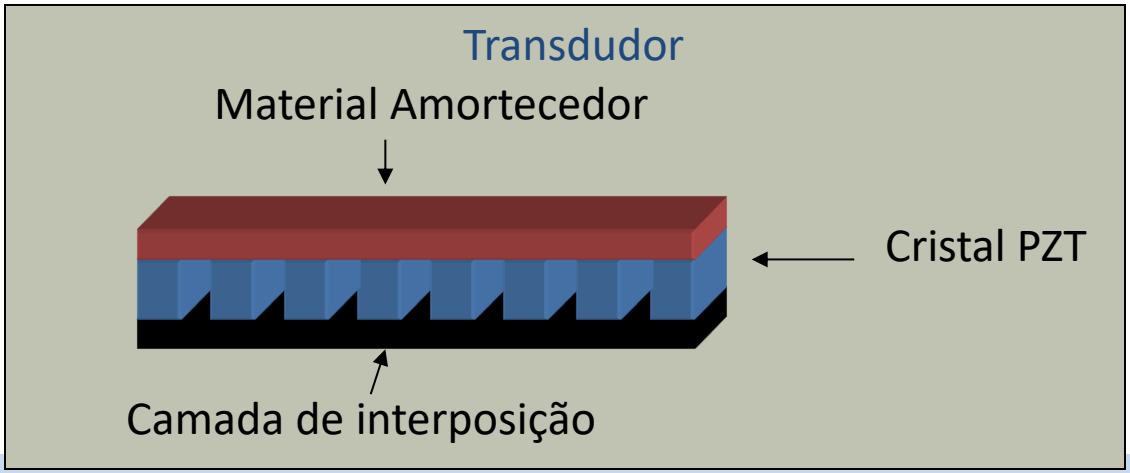


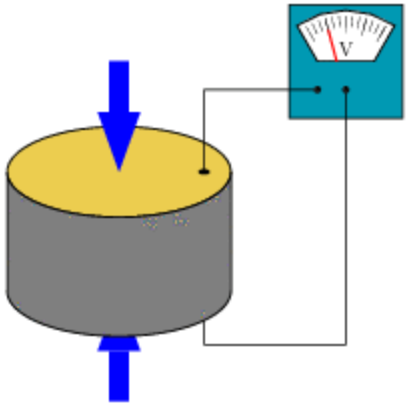
dilatação



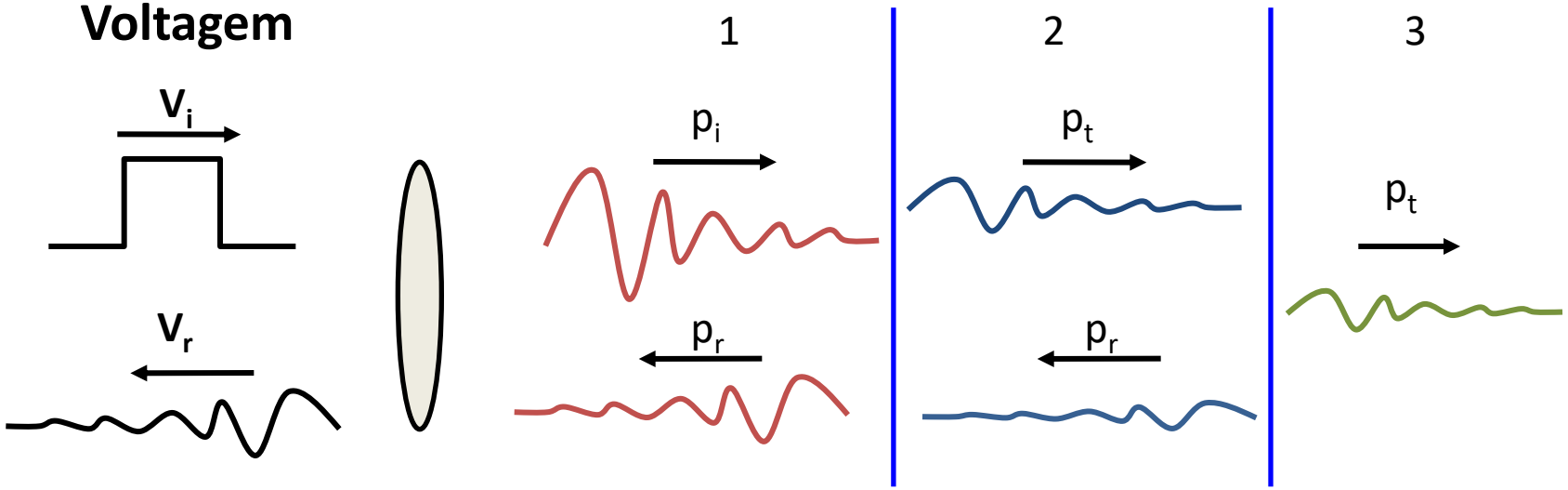
compressão

Descoberto pelos irmãos Pierre e Jacques Curie , na França, em 1880





O que é um sinal de RF?



Modo B - Transformada de Hilbert

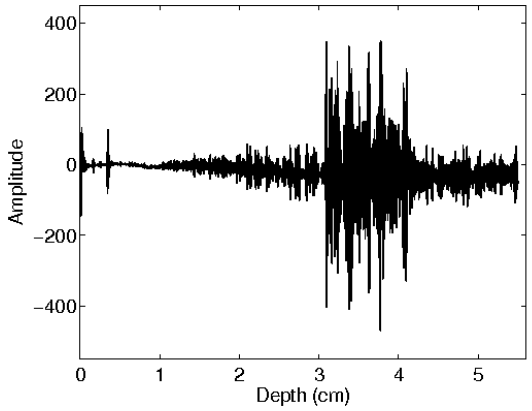
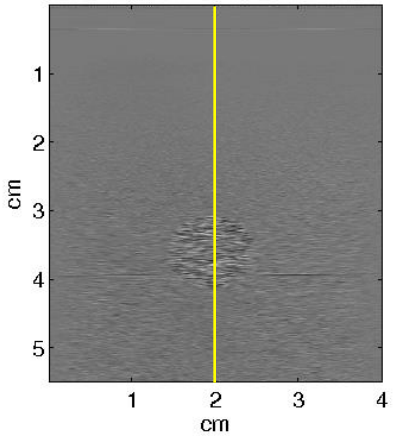


Imagem RF



Histogram

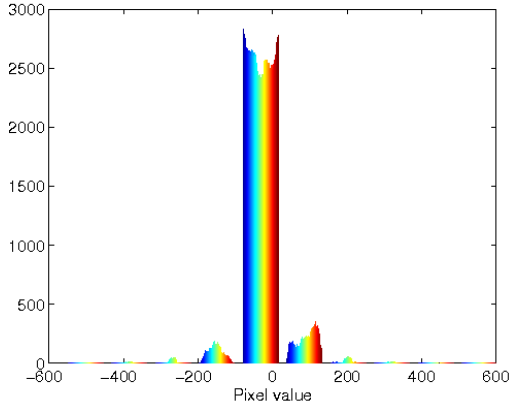
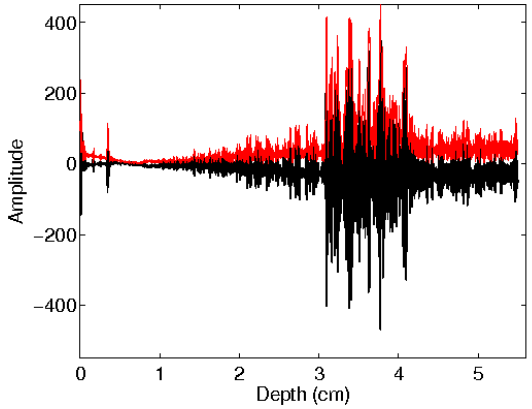
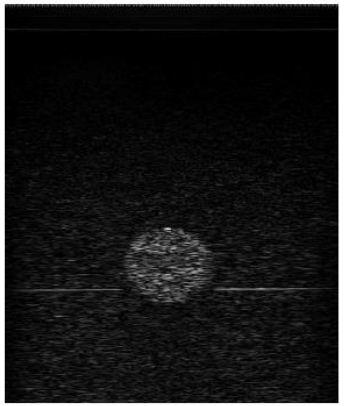
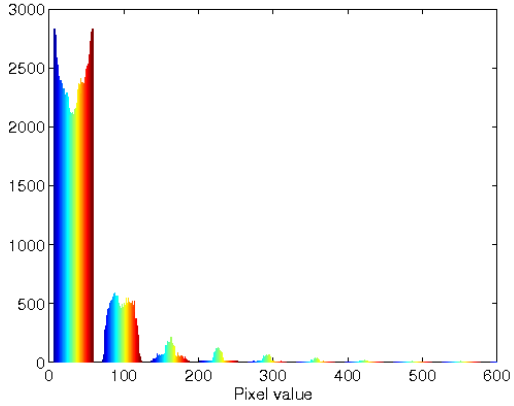


Imagem Modo B







Introdução - Elastografia

MUDANÇAS DAS CARACTERÍSTICAS MECÂNICAS DE UM TECIDO → **PATOLOGIA**

- Tumores mamários
  - Benignos (fibroadenoma) → Rígidos
  - Malignos (carcinoma) → Rígidos

Introdução - Elastografia

- Elastografia por ultrassom;
  - Perturbar o tecido mecanicamente;
  - Investigar a resposta do tecido usando ultrassom.
- Dinâmica;
  - Exemplo: Sonoelastografia, Elastografia por força de radiação acústica.
- Quasi-estática;
  - Mão Livre.

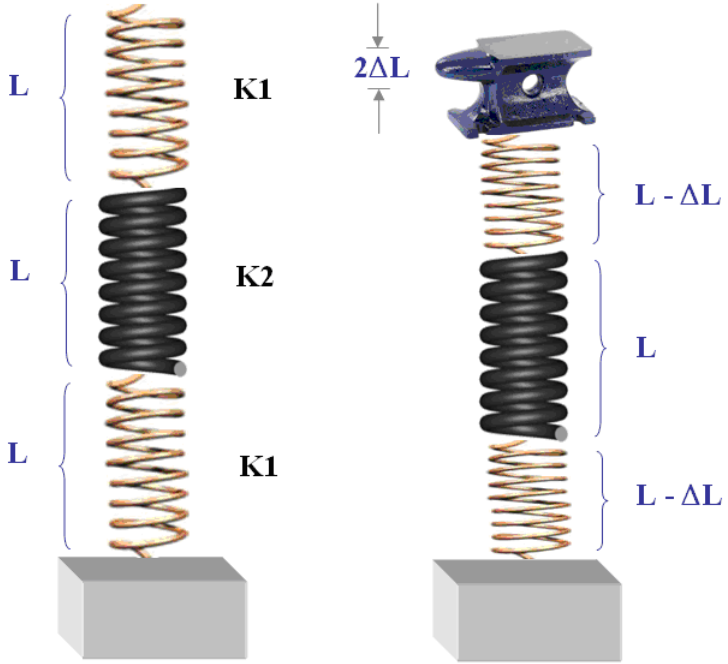
Motivações

J.Ophir,E.I.Cespedes,H.Ponnekanti,Y.Yazdi,andX.Li,

“Elastography: A method for imaging the elasticity in biological tissues,” *Ultrasond Imaging*, vol. 13, pp. 111–134, 1991.

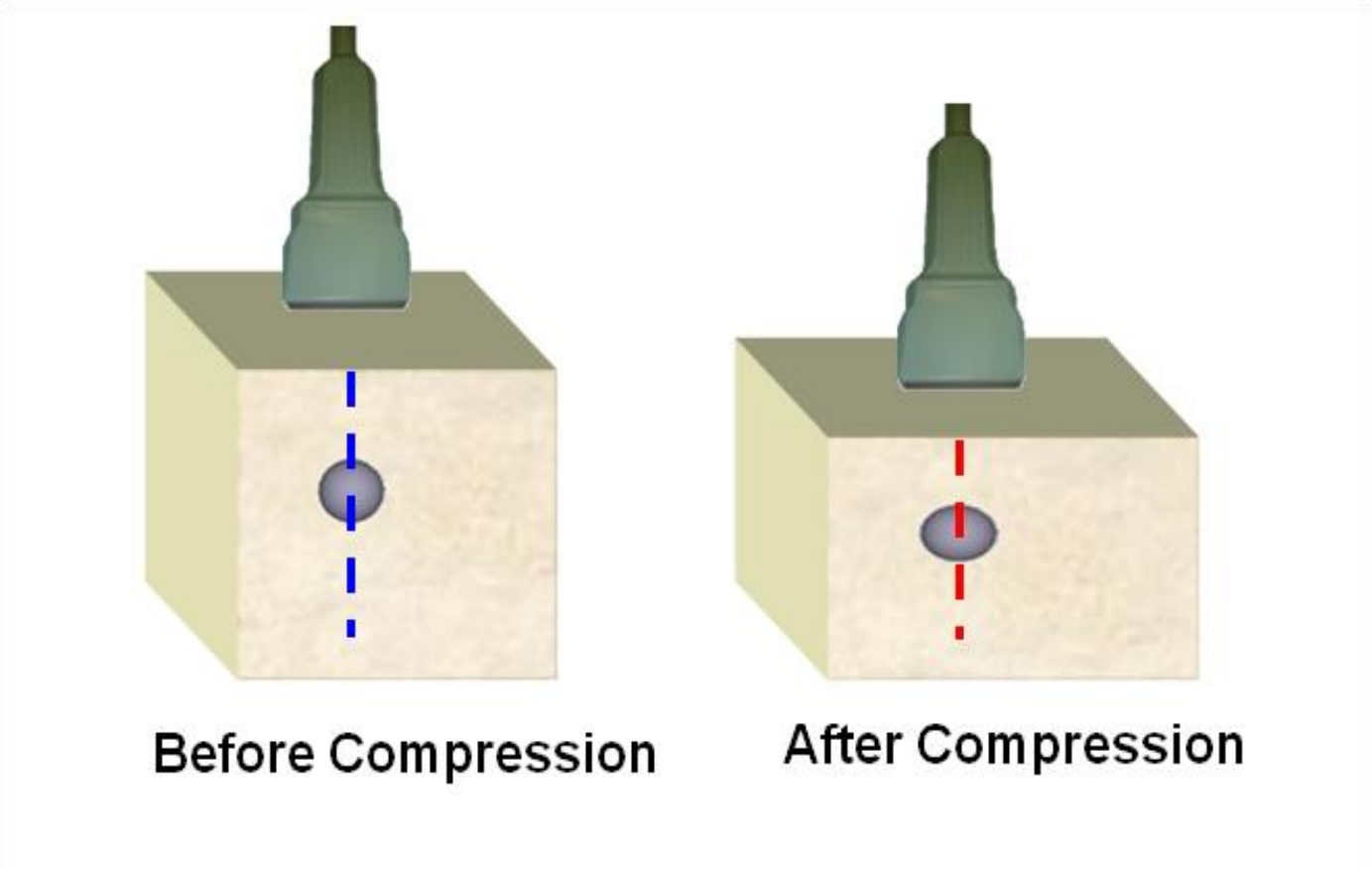
“O principal objetivo dessa modalidade de imagem é encontrar a diferença das propriedades mecânicas entre os tumores de mama benignos e malignos e minimizar a realização de biópsias desnecessárias.’’ (Jonathan Ophir)

(Quasi) Static - Elastography

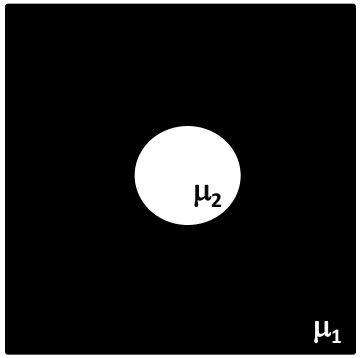


Pavan TZ, Neves, LP, Carneiro AAO; Elastografia por ultra-som: uma nova modalidade de imagem; *Ciência Hoje;* 2008.

Elastography



Displacement - Strain



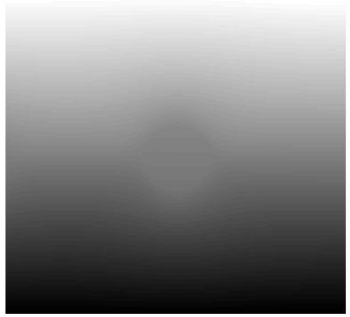
$$\varepsilon_x = \frac{\partial U_x}{\partial x}$$

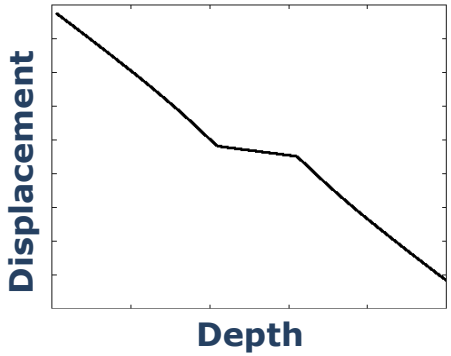
ε ⟶ **Strain**

U ⟶ **Displacement**

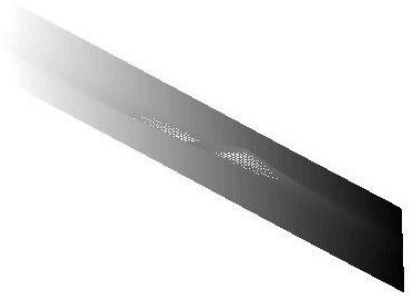
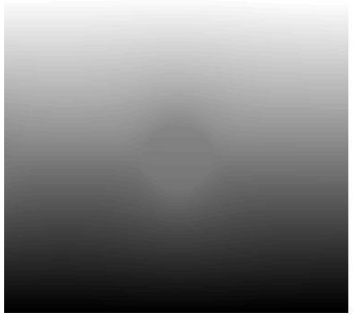
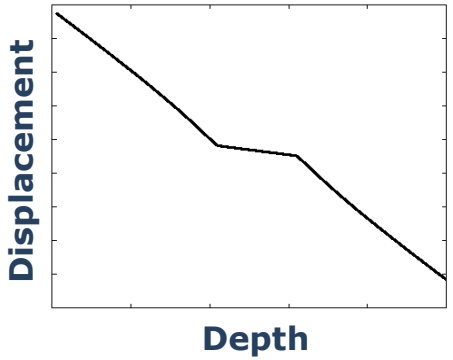
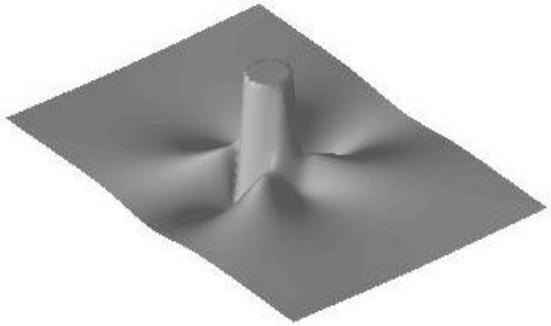
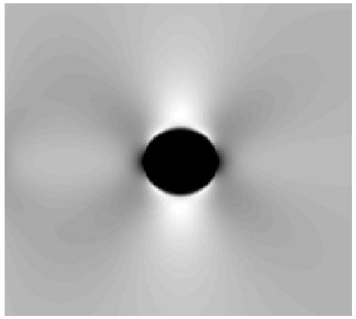
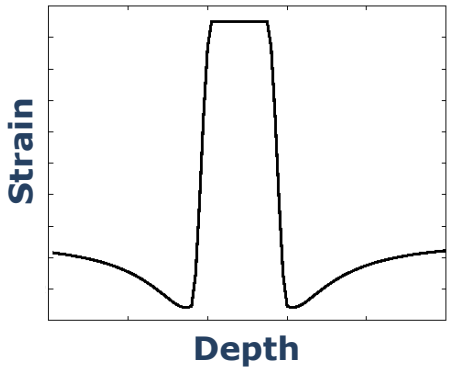
Strain

Displacement

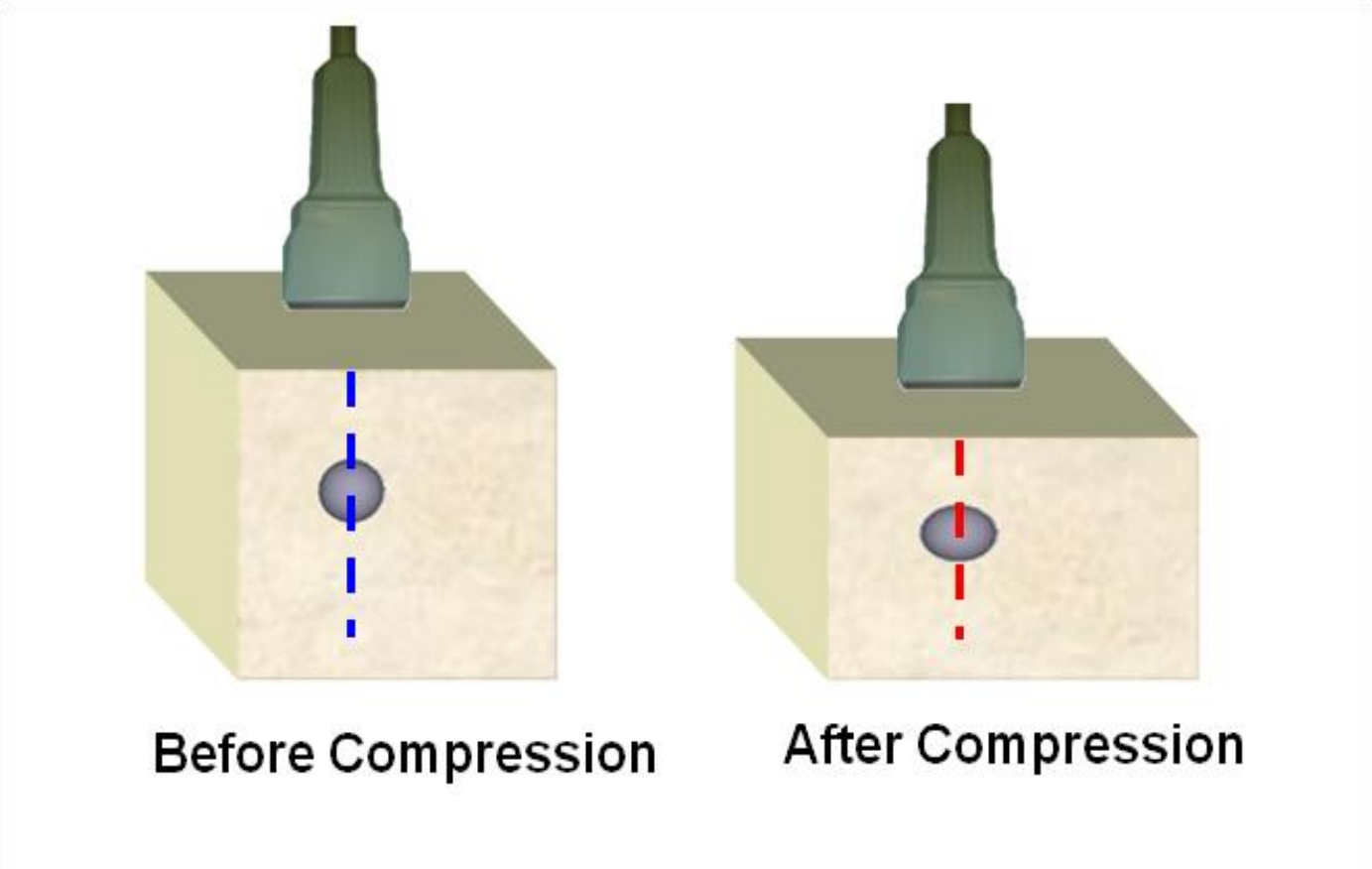


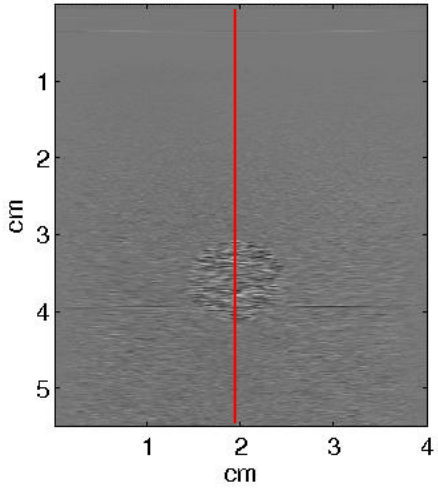


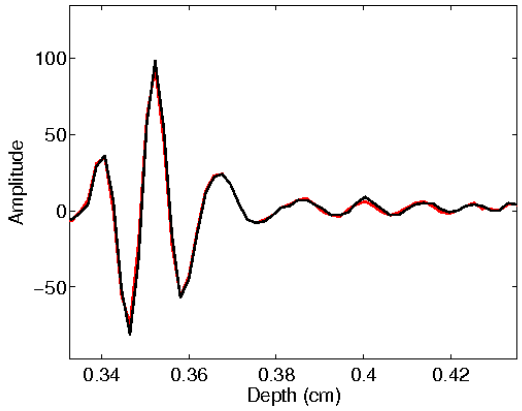
Displacement – Elastogram

	Surface	2D - Image	1D - Plot
Displacement			
Strain			

Elastography

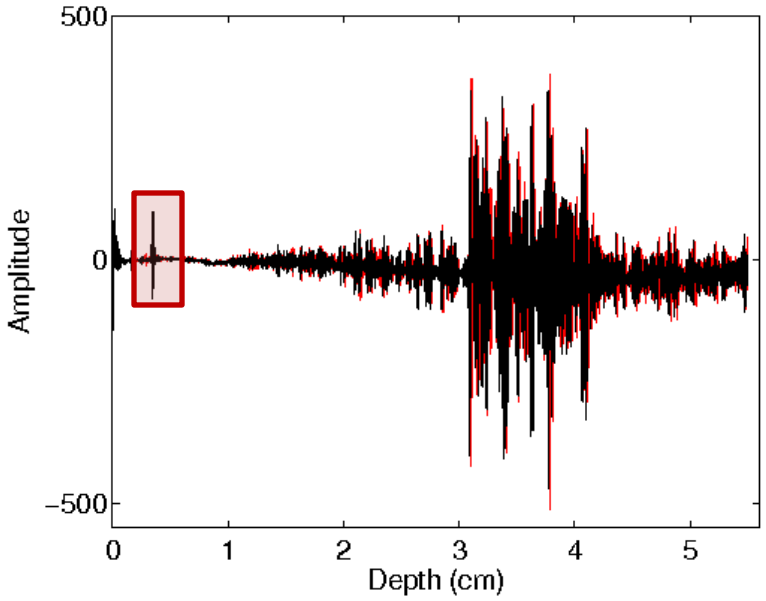


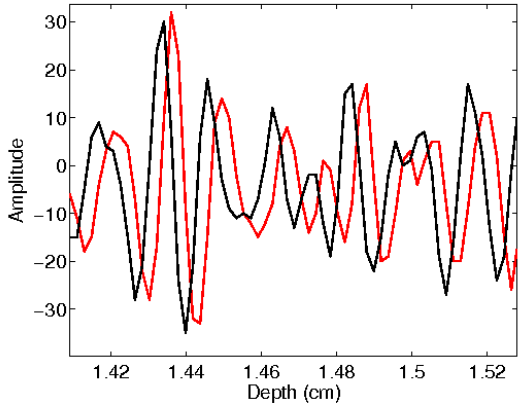


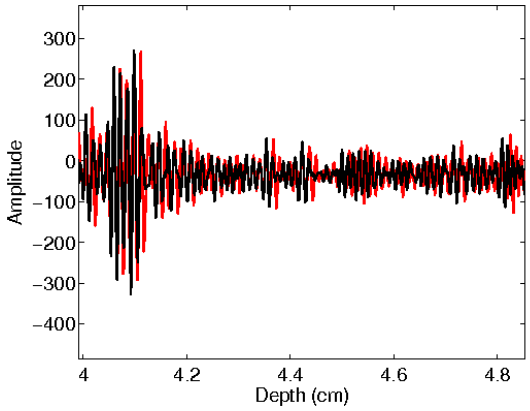


Black → Before deformation

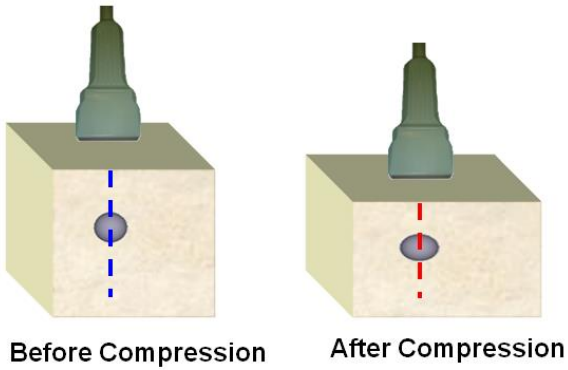
Red → After deformation

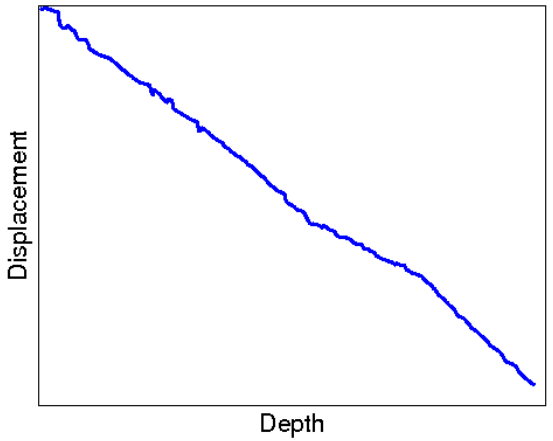




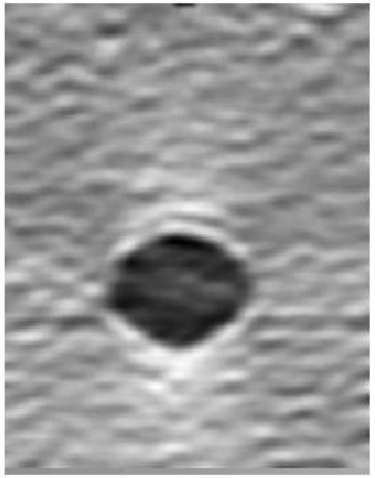


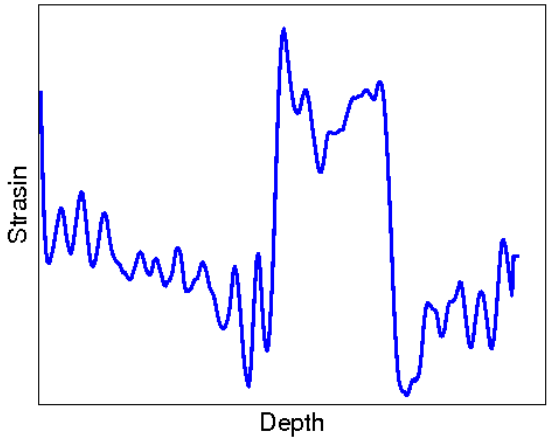
Generating the image





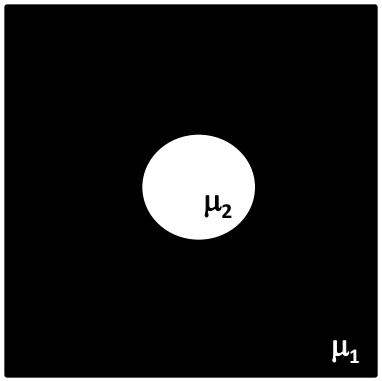
Inclusion 2.5 times stiffer than the background





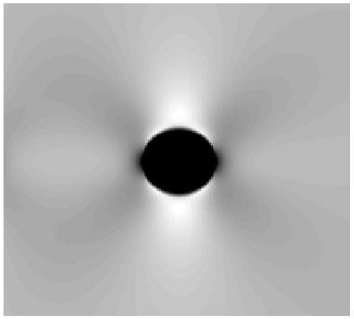
Strain Images

Elastic Modulus Distribution

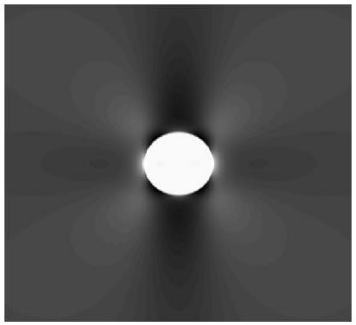


Elastogram or Strain Imaging

If $\mu_2 > \mu_1$

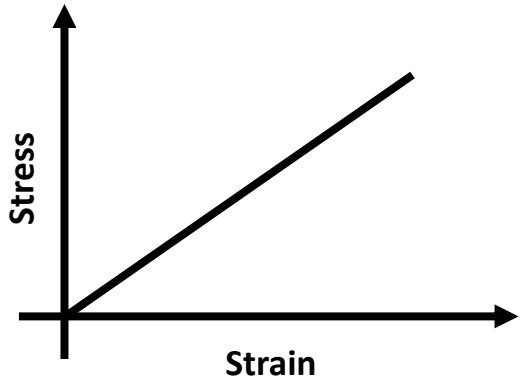


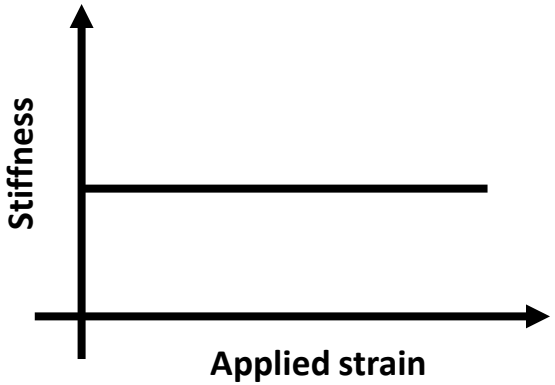
If $\mu_2 < \mu_1$



What do we evaluate in elastography?

Stiffness → Young's modulus → Slope of the stress strain curve



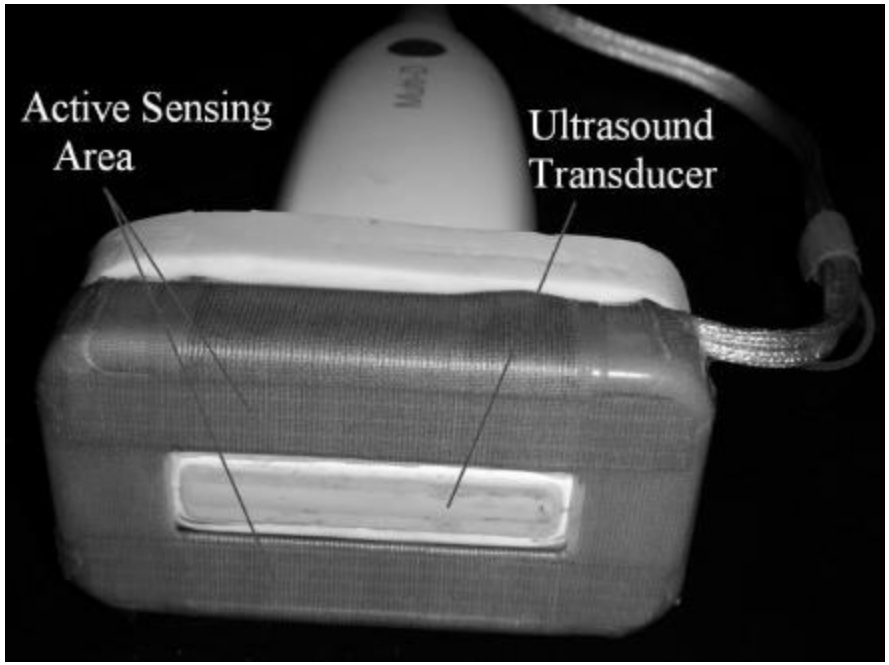


$$E = \frac{stress}{strain} = \frac{\sigma}{\varepsilon} = \frac{F / A_0}{\Delta L / L_0} = \frac{F L_0}{A_0 \Delta L}$$

- ***E*** **is the Young's modulus (modulus of elasticity)**
- ***F*** **is the force applied to the object;**
- A_0 **is the original cross-sectional area through which the force is applied;**
- ΔL **is the amount by which the length of the object changes;**
- L_0 **is the original length of the object.**

Transdutor com sensor de carga

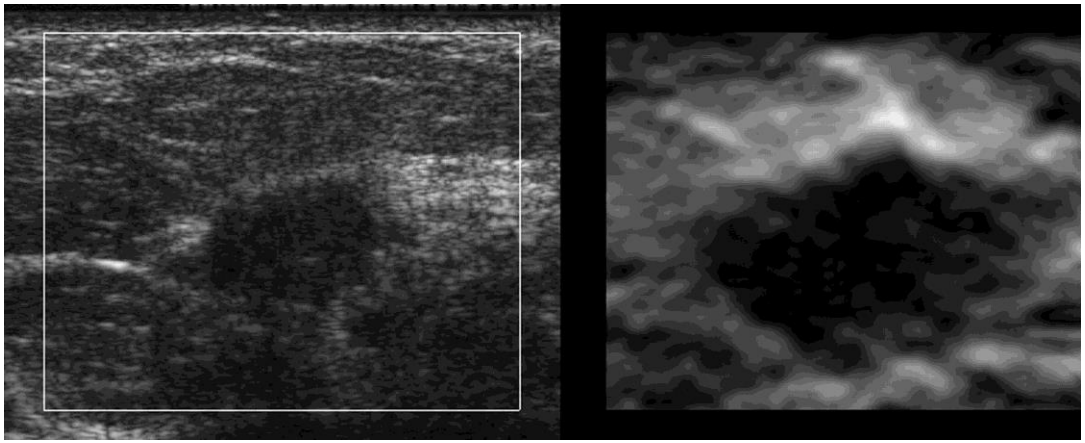
$$E = \frac{stress}{strain} = \frac{\sigma}{\varepsilon} = \frac{F / A_0}{\Delta L / L_0} = \frac{F L_0}{A_0 \Delta L}$$



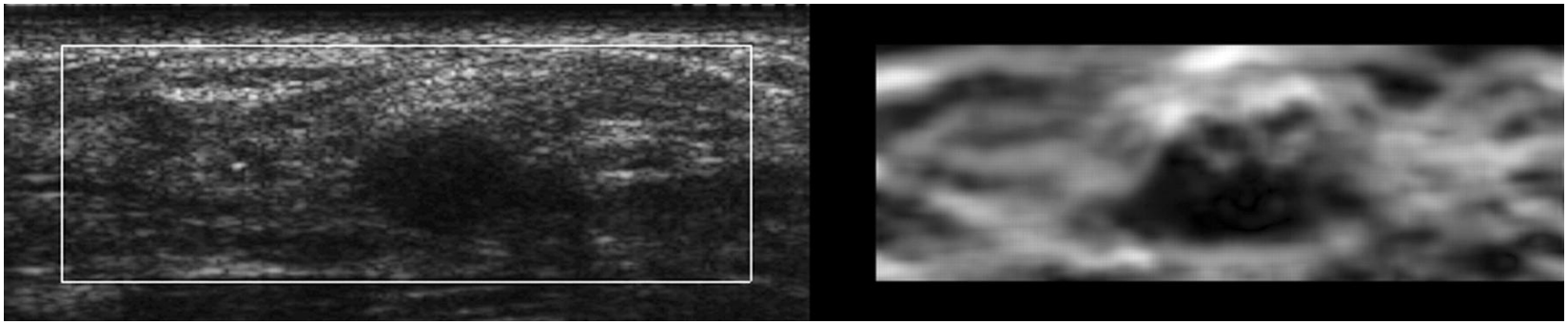
Kiessel LM et al. IEEE International Ultrasonic Symposium, 2007

Breast Elastography

Transverse B-mode (left) and strain (right) images of invasive ductal carcinoma displayed side by side. The lesion on the strain image is much larger than that on the B-mode image.



Transverse B-mode (left) and strain (right) images of fibroadenoma displayed side by side.



Burnside E S et al. Radiology 2007; 245:401-410

Radiology

Breast Elastography

1 2 3 4 5

Figure 1: Images present general appearance of lesions for elasticity scores of **(a)** 1, **(b)** 2, **(c)** 3, **(d)** 4, and **(e)** 5. Black circle indicates outline of hypoechoic lesion (ie, border between lesion and surrounding breast tissue) on B-mode images.

Itoh A et al. Radiology 2006; 239:341-350

Radiology

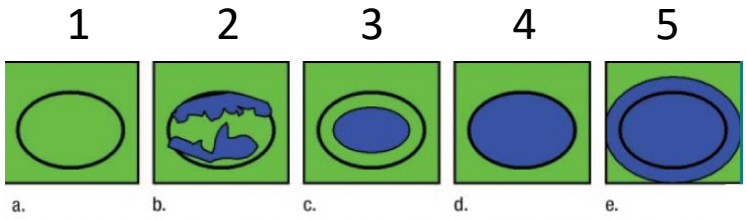
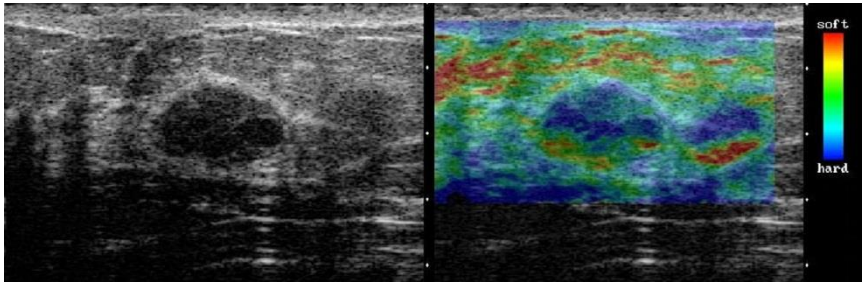
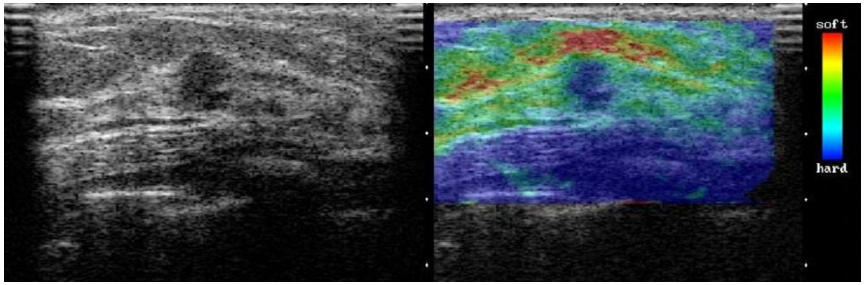


Figure 1: Images present general appearance of lesions for elasticity scores of **(a)** 1, **(b)** 2, **(c)** 3, **(d)** 4, and **(e)** 5. Black circle indicates outline of hypoechoic lesion (ie, border between lesion and surrounding breast tissue) on B-mode images.

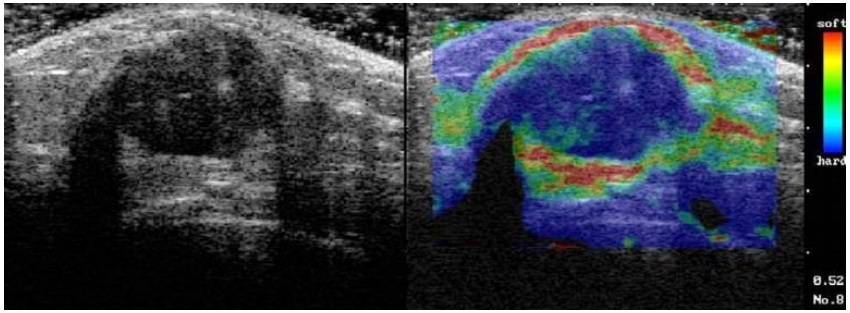
Fibroadenoma with elasticity score of **2** in 39-year-old woman.



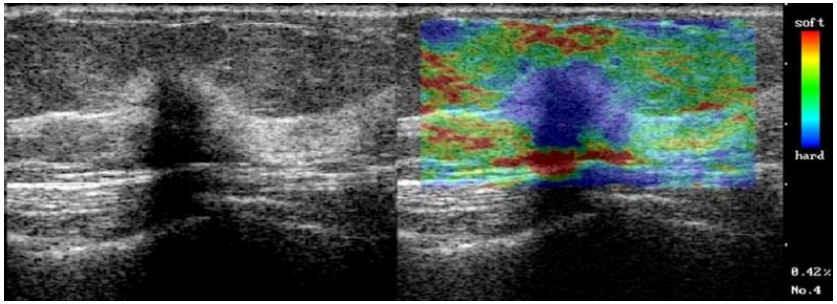
Lobular carcinoma in situ with elasticity score of **3** in 46-year-old woman.



Nonscirrhous type invasive ductal carcinoma with elasticity score of **4** in 29-year-old woman.



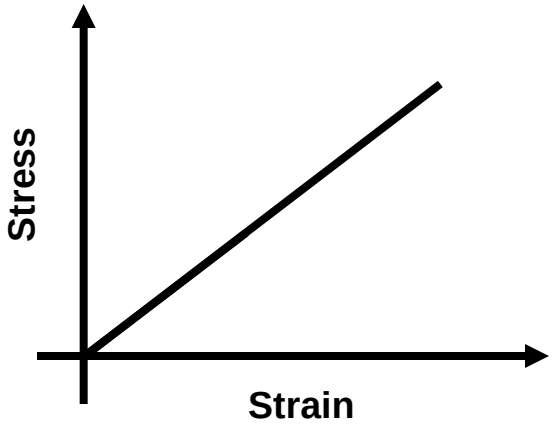
Scirrhous type invasive ductal carcinoma with elasticity score of **5** in 55-year-old woman.

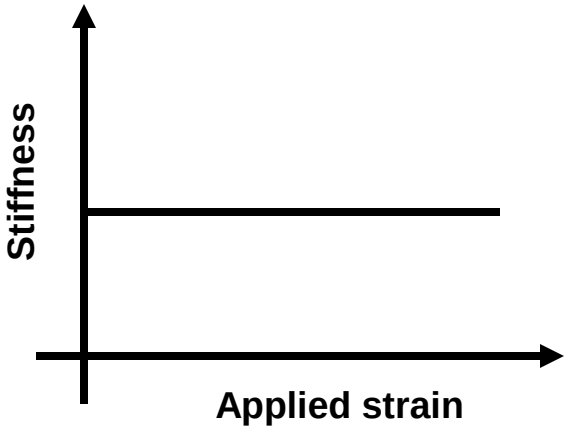


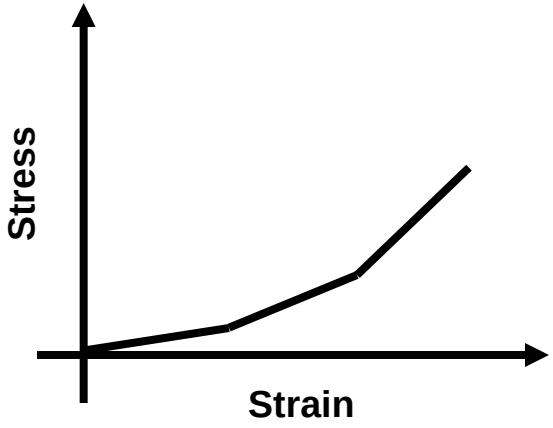
Itoh A et al. Radiology 2006; 239:341-350

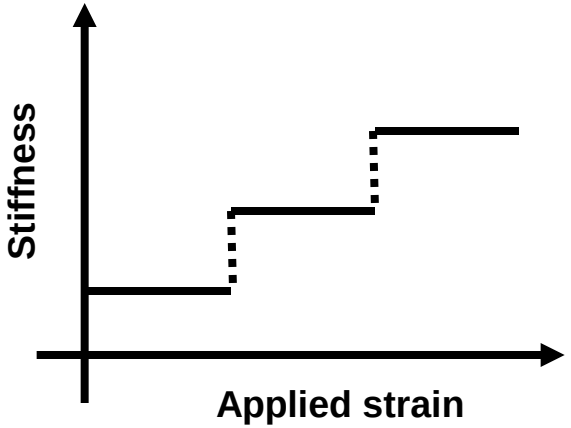
Radiology

Linear vs. Não-linear



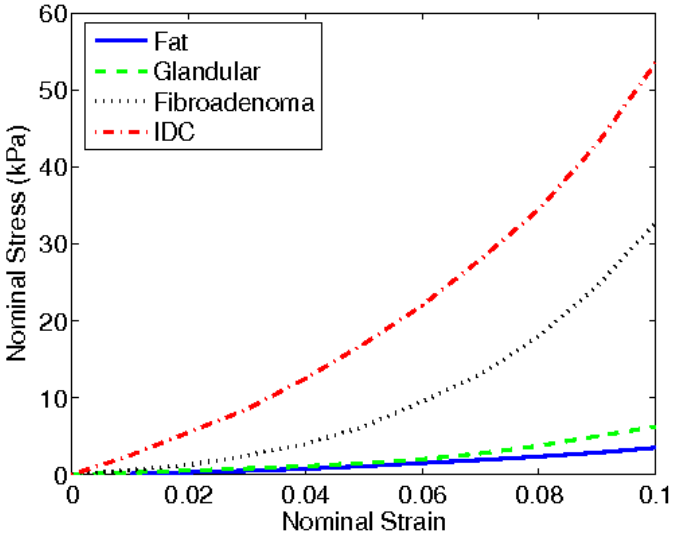






Tissues

- Biological tissues usually present nonlinear stress strain behavior
- Conventional elastography does not take into account this fact



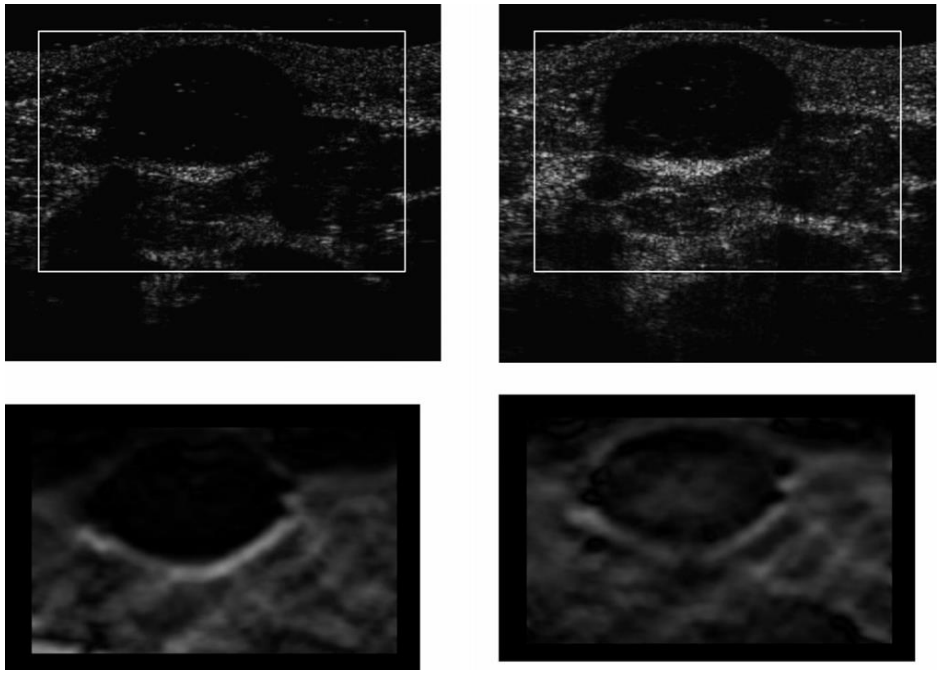
- This approximation is fine for compressions up to 5%

Wellman SA *et al ; Arch Surg*; 2001

Elastograms

- Linear
  - Contrast would not change
- Nonlinear
  - Contrast changes with applied strain

Fibroadenoma

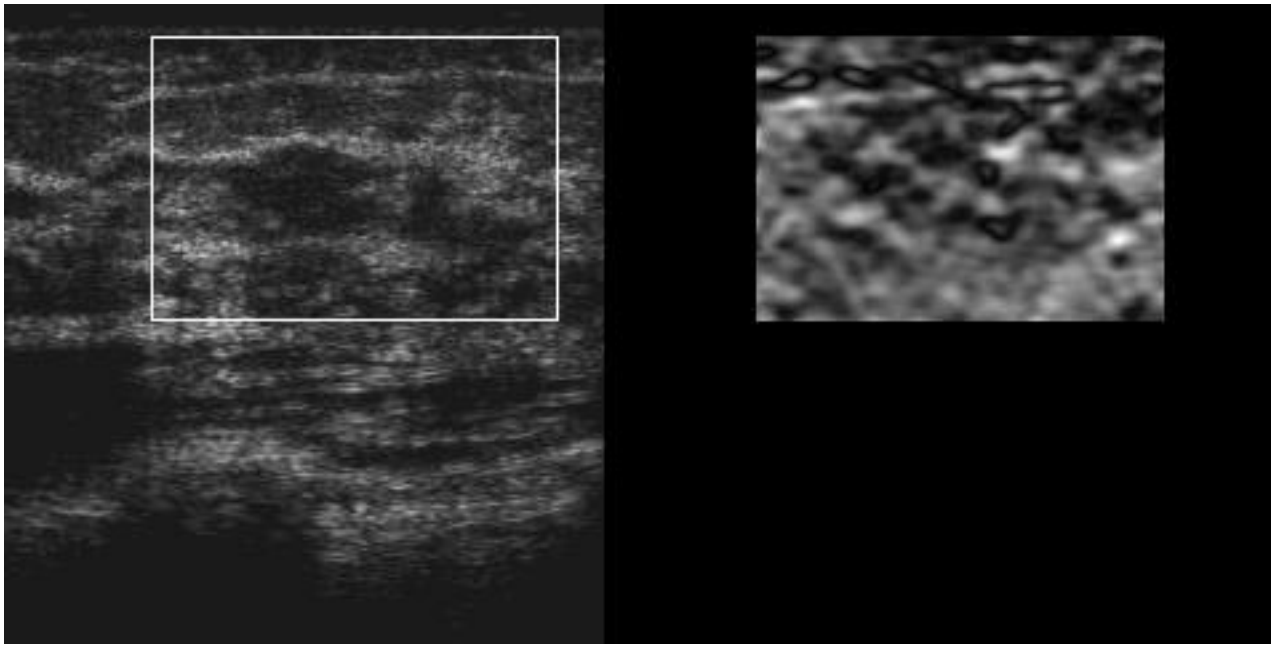


Overall applied strain → **~2%** **~12%**

Hall TJ *et al* ; *Ultrasonics Symposium;* 2007 & Oberai AA *et al* ; *Physics in Medicine and Biology;* 2009

Breast elastography

Fibroadenoma

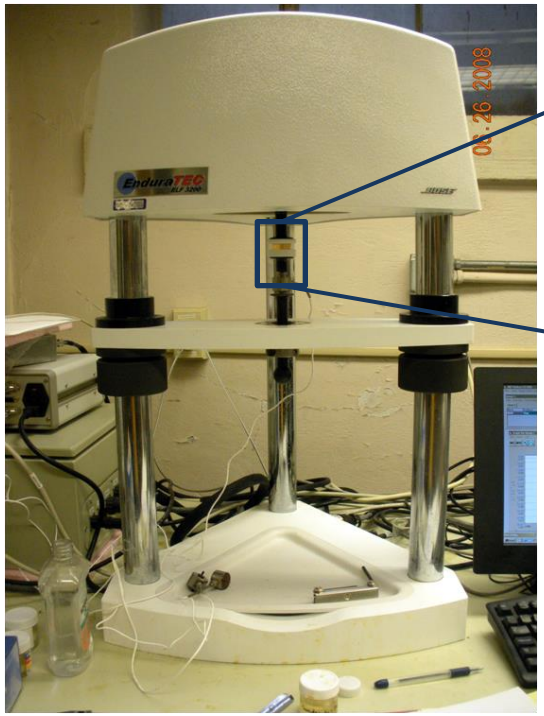


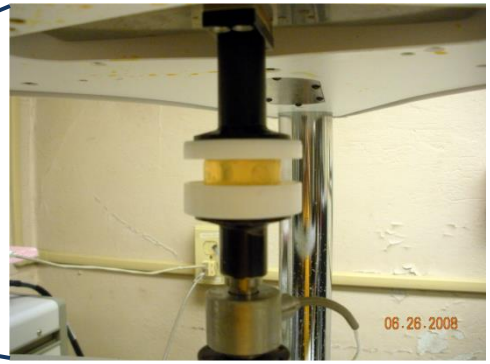
Burnside E S et al. Radiology 2007; 245:401-410

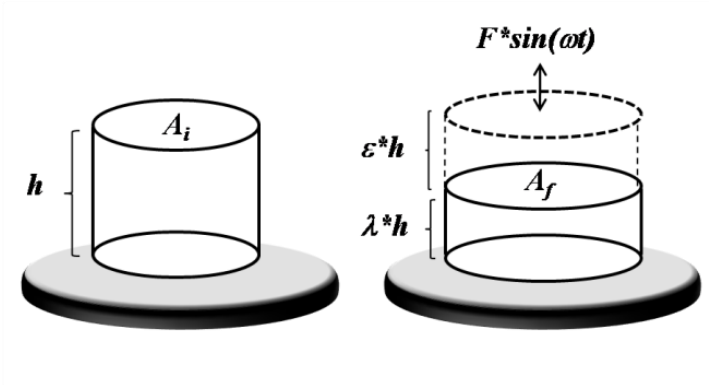
Uso de phantoms

- O uso de phantoms com inclusões e com boa estabilidade elástica é de fundamental importância para teste de algoritmos, treinamento entre outros.

Mechanical Test - ELF

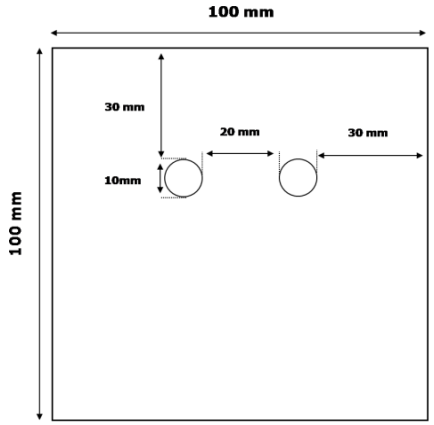


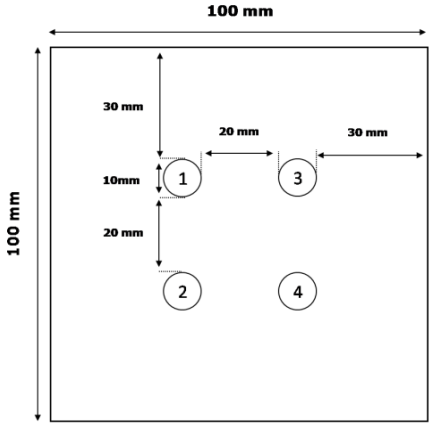


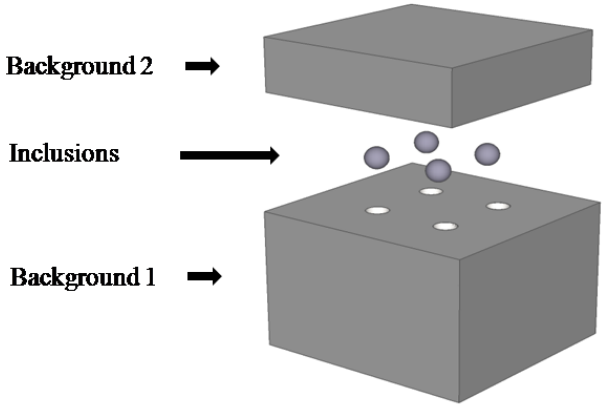


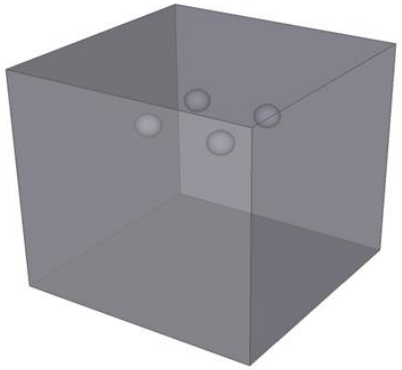
Pavan TZ, Madsen EL, Frank GR, Carneiro AAO, Hall TJ; Nonlinear elastic behavior of phantom materials for elastography; *Physics in Medicine and Biology*; **55**(9); 2679; 2010.

Phantom study

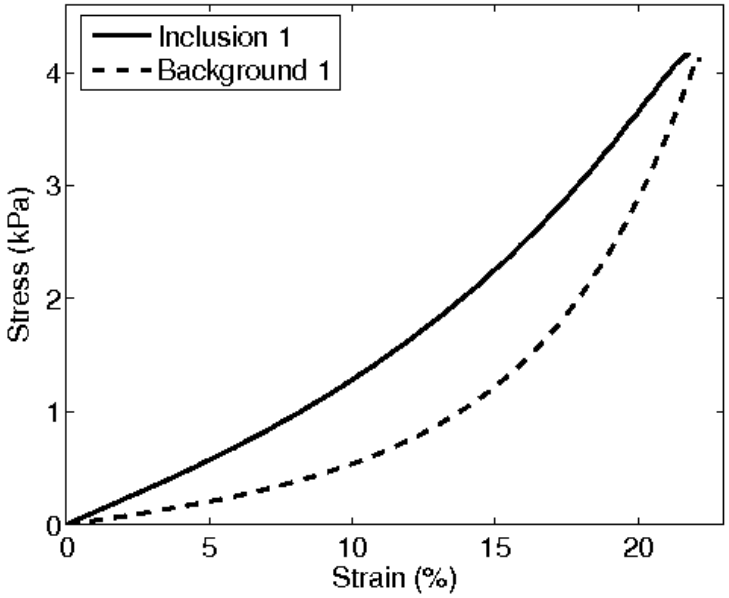


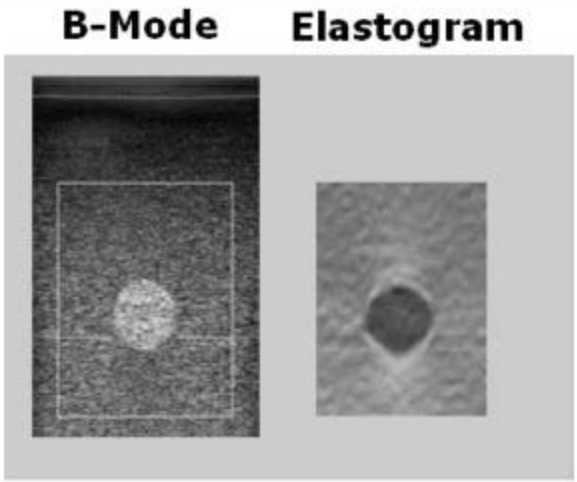


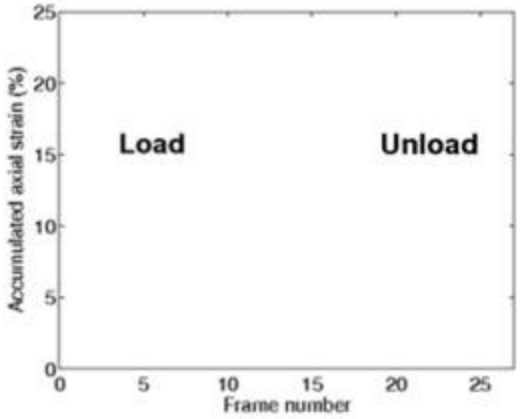




Inclusion 1







Pavan TZ, Madsen EL, Frank GR, Carneiro AAO, Jiang JF, Hall TJ; A Nonlinear elastography phantom containing spherical inclusions; *Physics in Medicine and Biology*, 2012.

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- Home
- About Us
- People
- Facilities
- Research
- Research Grants
- Publications
- Software
  - Hip Image Data
  - WinFiber3D
  - MPM For Cell Biomechanics
  - GAGSim3D
  - WarpLab
  - Support
- Opportunities
- News
- Login
- Contact us

Home ▸ Software

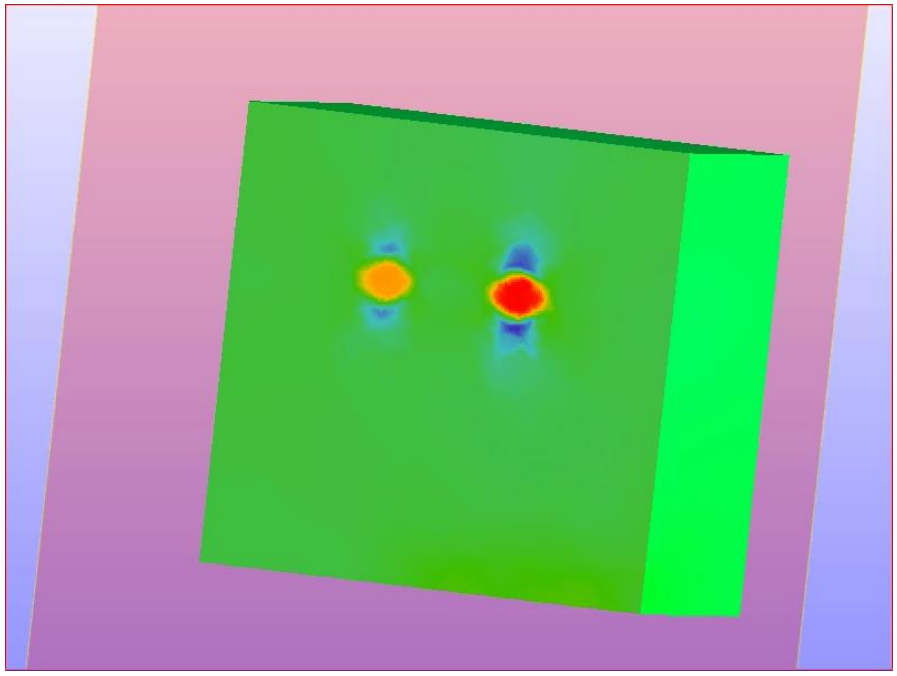
This is a repository for software packages that we have developed during the course of our research and are providing to the community free of charge. If you need software support, please visit the software forums or contact the software developer indicated for each package.

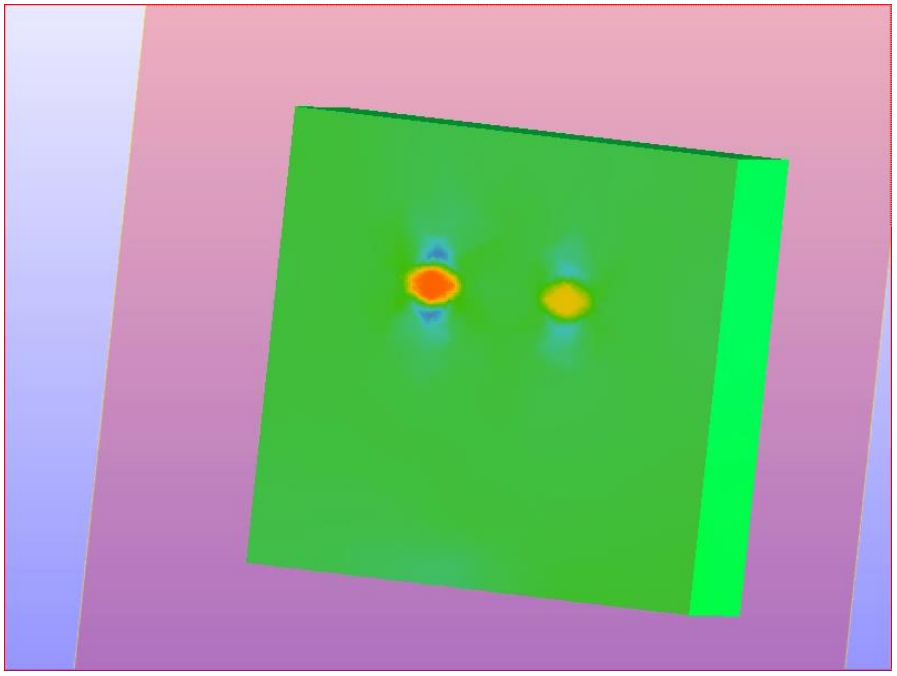
FEBio is a software tool that uses the finite element method for solving nonlinear large deformation problems in solid biomechanics. It is specifically aimed at solving problems in the field of biomechanics, by providing appropriate modeling scenarios, constitutive models and boundary conditions.

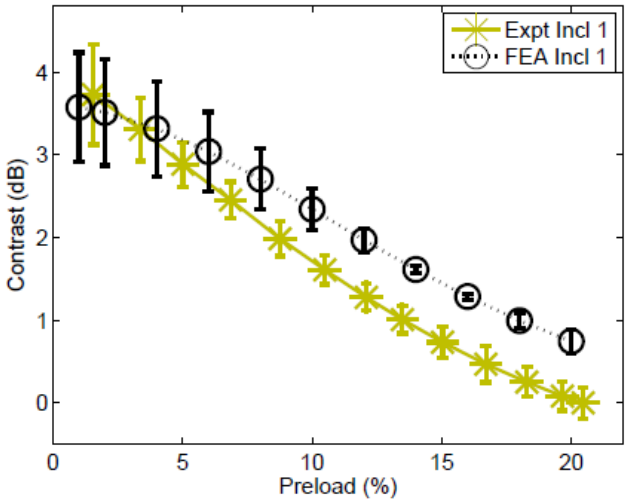
PreView is a mesh editing tool that has been specifically designed to set up FE problems for FEBio. It allows the user to specify the boundary conditions and material properties in a user-friendly GUI. The FE mesh can be either created by PreView or imported from another mesh generator.

▸ READ MORE...

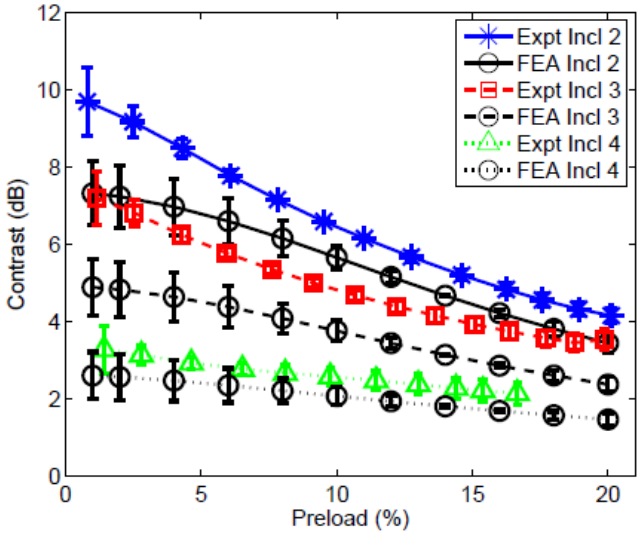
Postview is a finite element post-processor that is designed to post-process the results from FEBio. It offers the user a graphical user interface to visualize and analyze the FE model. Several tools are available to assist the user in this process, such as surface plots, isosurface plots, vector plots, plane cuts and many other.







(a) Inclusion 1



(b) Inclusions 2,3, and 4

ULTRASOUND ELASTOGRAPHY ASSESSMENT OF THE MEDIAN NERVE IN LEPROSY PATIENTS

MARCELLO H. NOGUEIRA-BARBOSA, MD, PhD,[1] HELENA B. LUGÃO, MD, PhD,[2] EVERALDO GREGIO-JÚNIOR, MD, PhD,[1] MICHEL D. CREMA, MD,[3] MARIANA T.T. KOBAYASHI, MD,[1] MARCO A.C. FRADE, MD, PhD,[2] THEO Z. PAVAN, PhD,[4] and ANTONIO A.O. CARNEIRO, PhD[4] Muscle and Nerve, 2017

Compare median nerve elasticity between leprosy patients (LPs) and healthy volunteers (HVs) using ultrasound elastography (UE). Two radiologists independently measured the strain ratio of the median nerve/flexor digitorum superficialis muscle (MN/FDSM) of 18 LP and 18 HV using real-time freehand UE.

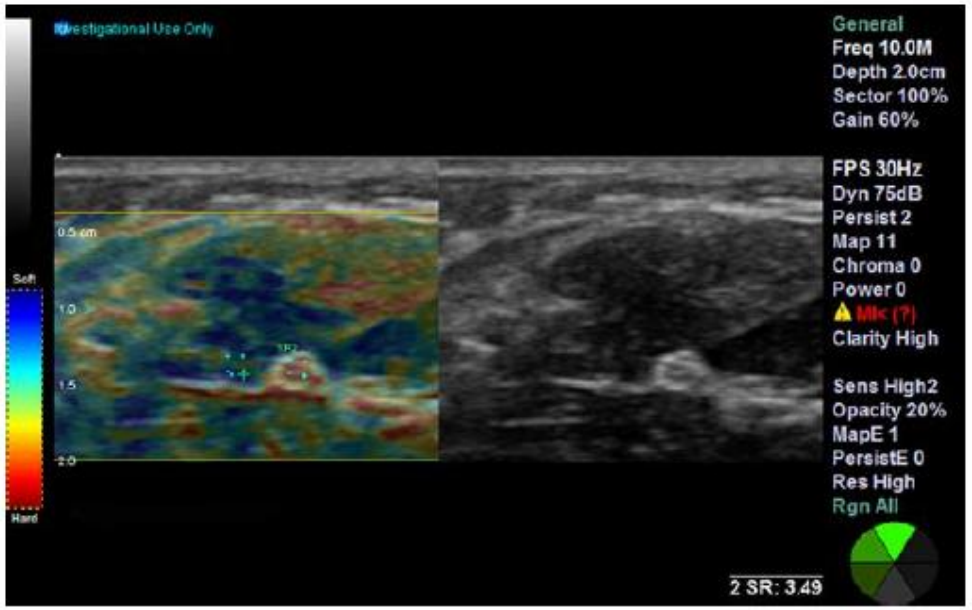


FIGURE 1. Left image: elastographic strain image of the distal forearm region showing the positioning of the ROIs used to measure the MN/FDSM strain ratio. Right image: corresponding B mode image.

Linfedema

- AVALIAÇÃO DAS CARACTERÍSTICAS BIOMECÂNICAS DE VISCOSIDADE E ELASTICIDADE NO TECIDO AFETADO POR LINFEDEMA DECORRENTE DO TRATAMENTO DO CÂNCER DE MAMA

- Dra. Carla Silva Perez
- Orientadora: Profa. Dra. Elaine Caldeira de Oliveira Guirro
- Coorientador: Prof. Dr. Antonio Adilton Oliveira Carneiro

Linfedema

O *Strain Ratio* foi calculado fazendo a razão entre os valores alcançados para a deformação média no gel em relação ao tecido de interesse. O módulo de Young do gel foi previamente caracterizado com ensaios mecânicos.

Figura 9. Imagem ilustrativa da colocação do *pad* e avaliação para obtenção das imagens de ultrassom.
Fonte: Arquivo Pessoal


SIF
SIF
L14-5/38-GEN-[Carla Perez]
L14-5/38-GEN-[Carla Perez]
Will
Will
11/20/17
9:51:28 AM
Investigational Use Only
General
Freq 10.0M
Depth 5.0cm
Sector 100%
Gain 70%
FPS 30Hz
Dyn 79dB
Persist 0
Map 4
Chroma 0
Power 0
MI< (?)
Clarity High
Sens High2
Opacity 20%
MapE 1
PersistE 0
Res High
Rgn All
Soft
Hard
74
1
x 1
B

Obrigado