

MEASURING the TOUGHNESS of SOLID CANCERS A FRACTURE MECHANICS APPROACH

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Tissue Stiffness Drives Tumor Formation



108.2461.1 : Posted 2 Nov 2008

PANEL 1: Cells of a normal breast duct

PANEL 2: Structure of the duct begins to degrade

PANEL 3: Uncontrolled cell growth of duct-lining cells invade the duct tube

CANCER CELL : SEPTEMBER 2005

Tensional homeostasis and the malignant phenotype

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Mature Precursors

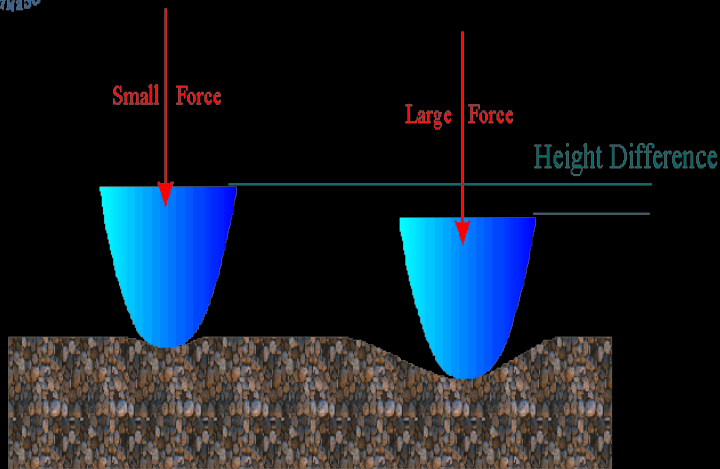
Elastography

- Manual Compression
- Transient Elastography
- Acoustic Radiation Force

Stiffness



Stiffness Measurement



- Height change at force change is determined by the stiffness
- Interaction function: elastic constants

Othmar Marti, Experimentelle Physik, Universität Ulm

4

Courtesy: O.Marti

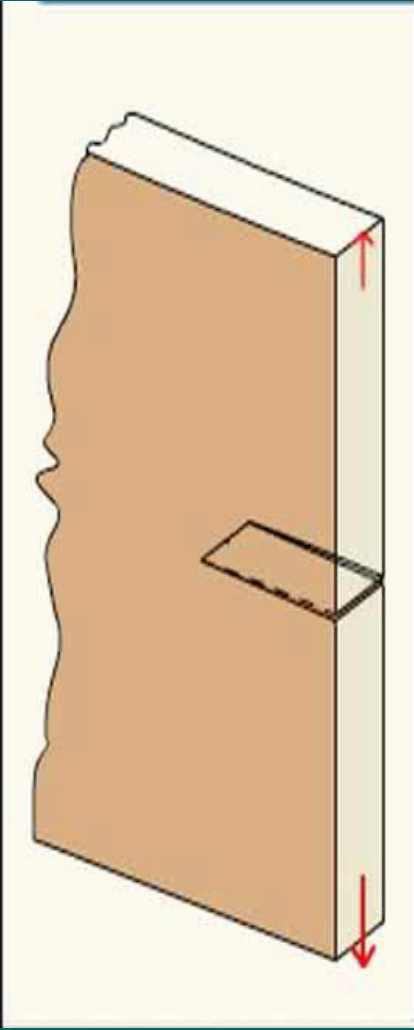
Fracture Mechanics Based Method

Elasticity + Fracture Creation



Fracture Toughness

Mode 1 Fracture



FRACTURE TOUGHNESS >>> **REPRESENTS**
 Energy needed to create a unit fracture surface

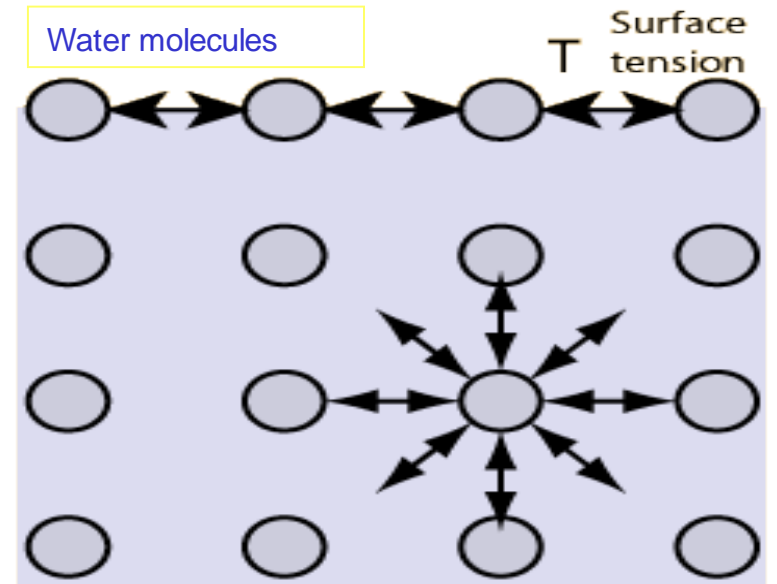
Courtesy: Prof. Ramesh [IIT Madras]

FRACTURE MECHANICS

Describes how cracks initiate & propagate in solids and semisolids

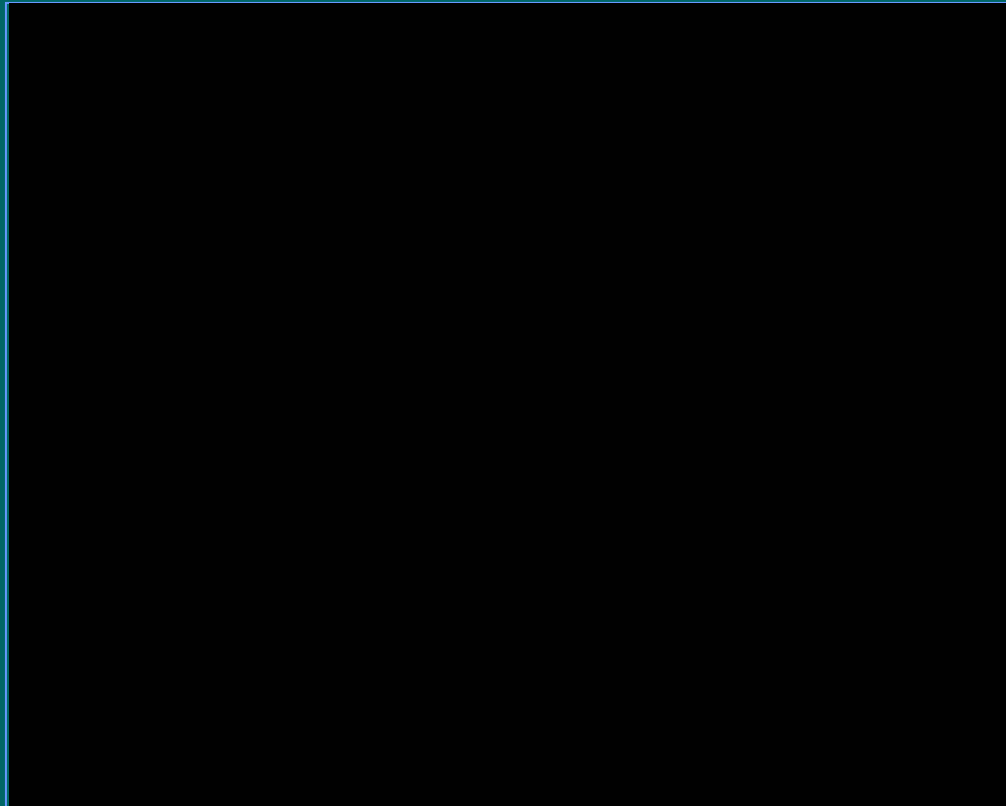
FRACTURE Leads:

- Two new surfaces
- Energy is consumed to overcome Surface Energy



MEASURING the TOUGHNESS of SOLID CANCERS

QUALITATIVE METHOD

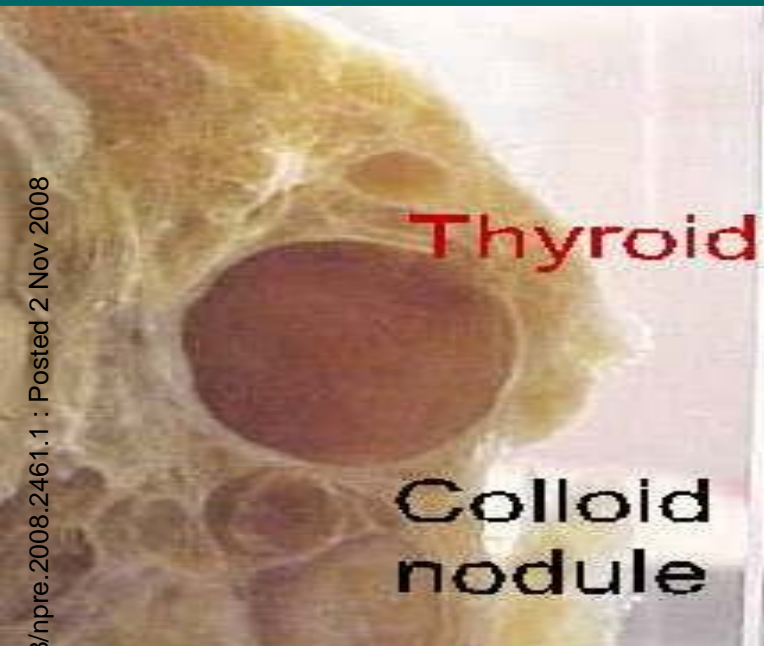


This movie clip demonstrates the technique of manual probing of the solid thyroid tumor with a fine needle. Note the apparent ease with which the needle travels through a non-cancerous tumor. In contrast, a cancerous tumor offers substantial resistance to needle insertion and penetration. Remarkable differences in haptic force cues were apparent between cancerous and benign tumors.

Click here for file

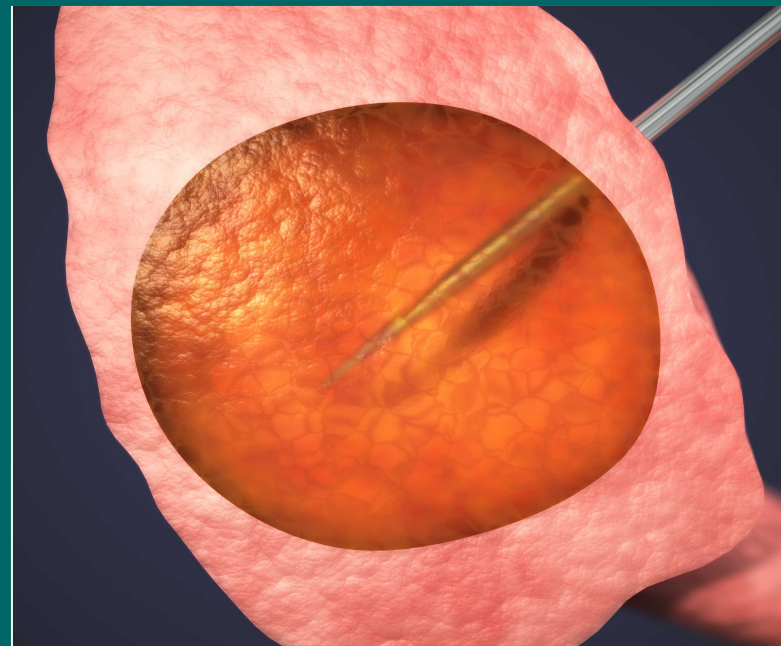
[<http://www.biomedcentral.com/content/supplementary/1754-1611-2-12-S1.mov>]

Simulations: Haptic Differences Between Benign and Malignant Tumors



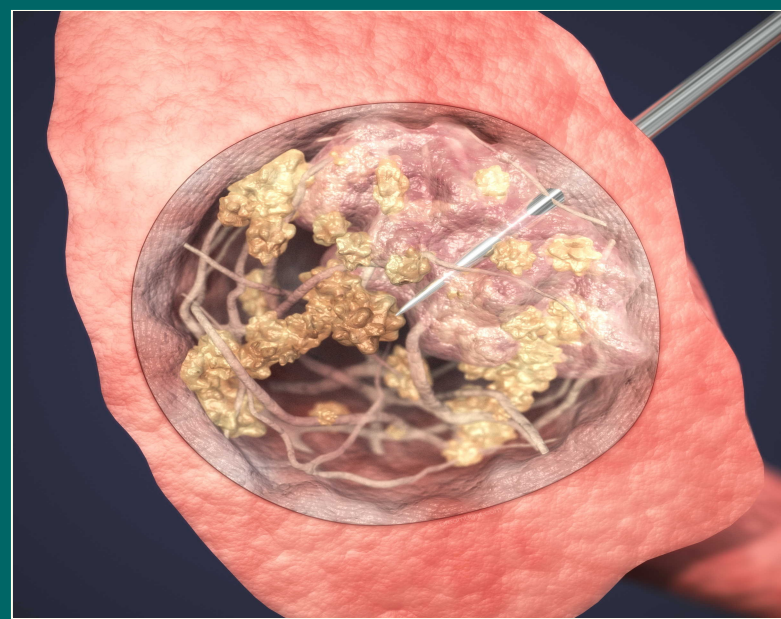
Benign Tumor:

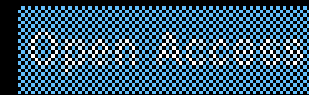
No Resistance to
Needle Penetration



Malignant Tumor:

Variable Resistance
to Needle Penetration





In vivo analysis of fracture toughness of thyroid gland tumors

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Journal of Biological Engineering 2008, 2:12

doi:10.1186/1754-1611-2-12

ure Precedings : doi:10.1038/npre.2008.24611

- Qualitative Method
- Operator Bias

● PROTOTYPE:

Mechanical Device to measure fracture toughness of solid tumors is under development.

Summary

Fracture Toughness

Mechanical Property of Solid Tumors

Potentially Quantifiable

Mechanical Tumor Marker

Goal – Next Phase

Measure fracture toughness of a solid tumor

Assess malignant potential

The End