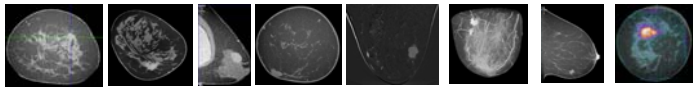
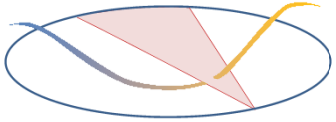


Advanced Imaging for Breast Cancer: Screening, Diagnosis, and Assessing Response to Therapy

Breast CT



John M. Boone, Ph.D., FAAPM, FSBI, FACR
Departments of Radiology and Biomedical Engineering
University of California Davis Medical Center

Disclosures (required by UC Davis):

- Varian Imaging Systems, Consultant
- CT Imaging, Consultant
- Stanford Research Institute, Consultant
- DxRay, Inc, Consultant

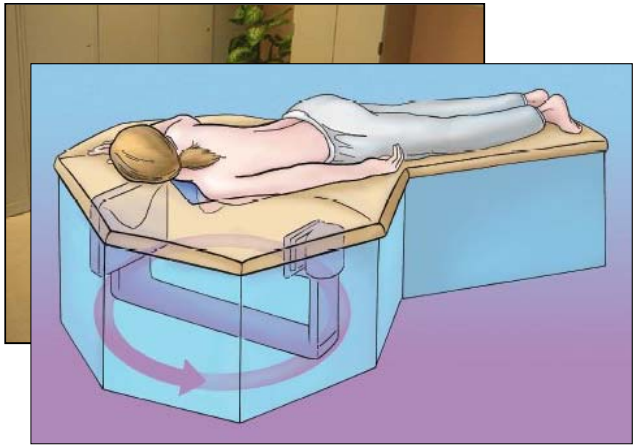
- Cedars Sinai Medical Center, Expert Witness
- Alston & Bird LLC, Expert Witness

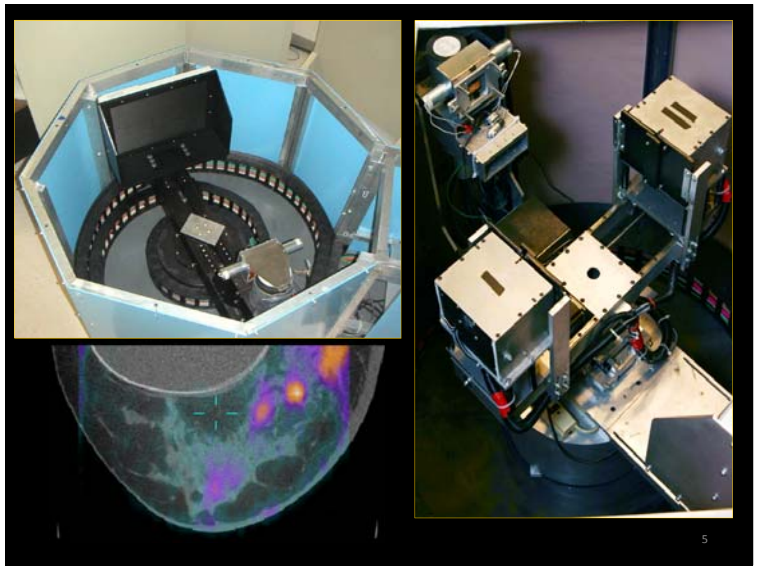
- Varian Imaging Systems, Research Funding
- Hologic Corporation, Research Funding
- Fuji Medical Systems, Research Funding
- Stanford Research Institute, Research Funding (R21 subcontract)
- Siemens Medical Systems, Research Funding

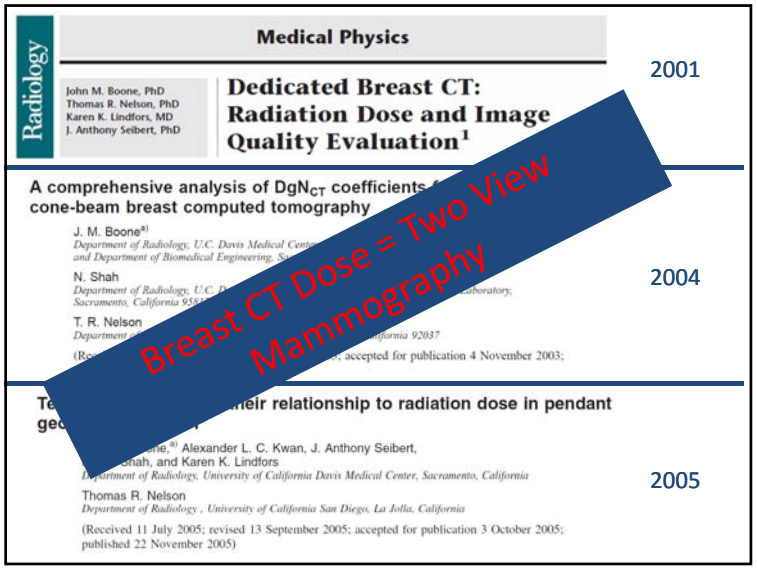
Breast CT

- Breast CT Technology
  - Preliminary Clinical Assessments
  - Mathematical Observer Metrics
    - Lesion Insertion / t3D versus 2D
    - Anatomical noise / M↔T↔bCT
  - CE-bCT versus Mammo and Tomo
  - Summary

Dedicated Breast CT







Radiology

Medical Physics

John M. Boone, PhD
Thomas R. Nelson, PhD
Karen K. Lindfors, MD
J. Anthony Seibert, PhD

Dedicated Breast CT: Radiation Dose and Image Quality Evaluation[1]

2001

A comprehensive analysis of DgN_{CT} coefficients
cone-beam breast computed tomography

J. M. Boone[a)]
Department of Radiology, U.C. Davis Medical Cente
and Department of Biomedical Engineering, S

N. Shah
Department of Radiology, U.C. D
Sacramento, California 958

T. R. Nelson
Department
alifornia 92037

(Re accepted for publication 4 November 2003;

2004

Te eir relationship to radiation dose in pendant
ge

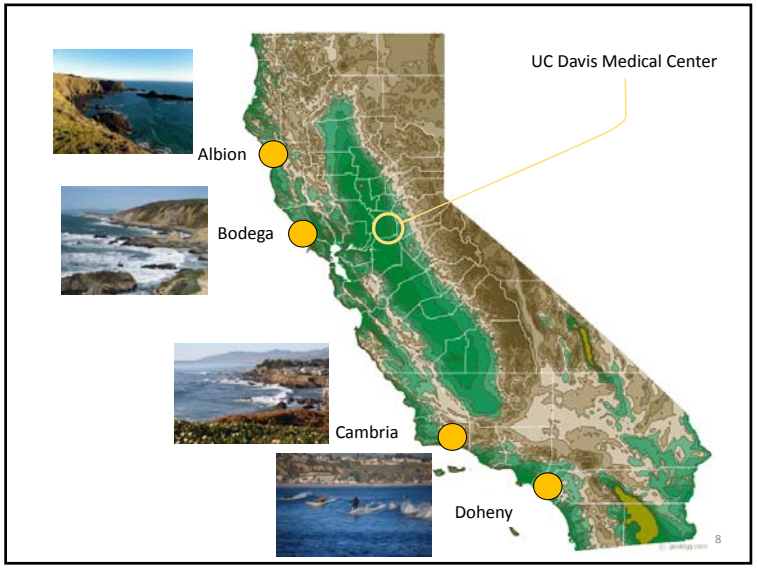
ne,[a)] Alexander L. C. Kwan, J. Anthony Seibert,
Shah, and Karen K. Lindfors
Department of Radiology, University of California Davis Medical Center, Sacramento, California

Thomas R. Nelson
Department of Radiology , University of California San Diego, La Jolla, California

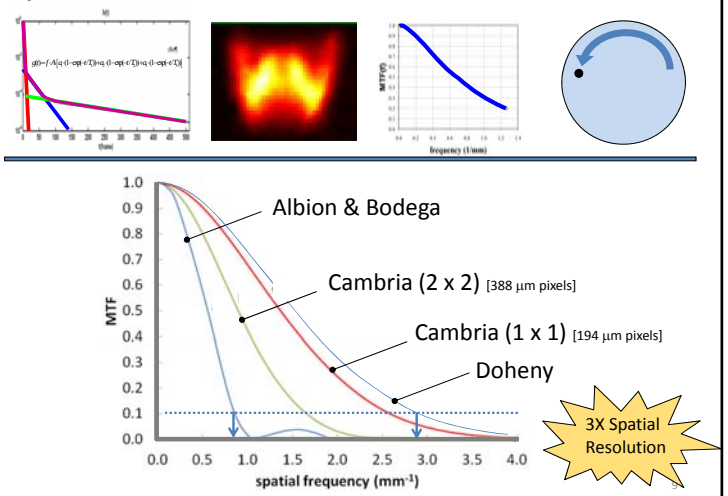
(Received 11 July 2005; revised 13 September 2005; accepted for publication 3 October 2005; published 22 November 2005)

2005

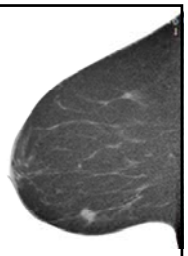
Breast CT Dose = Two View Mammography



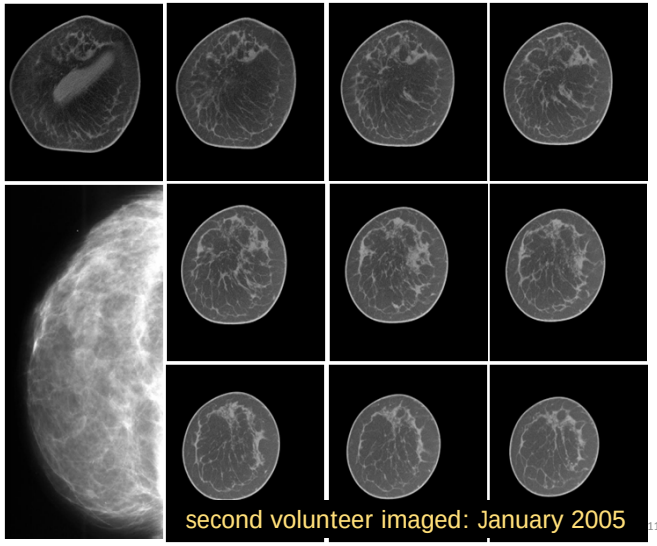
Spatial Resolution: Modeled & Measured MTF's

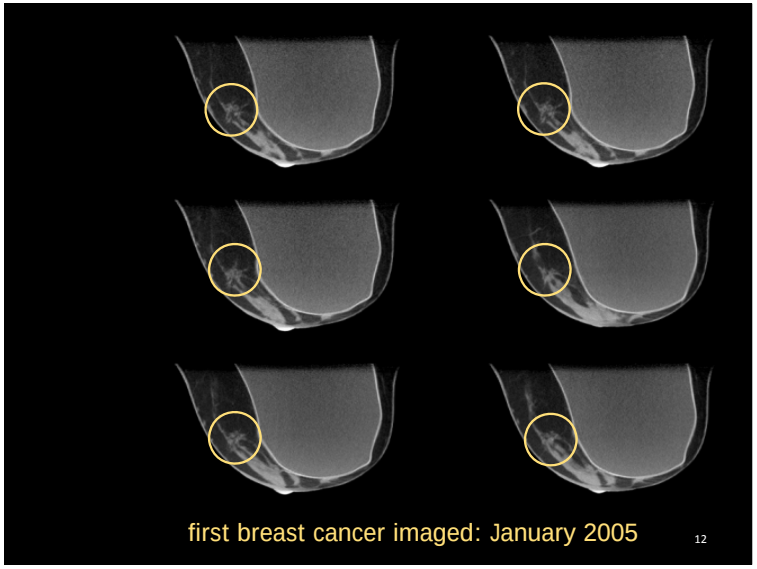


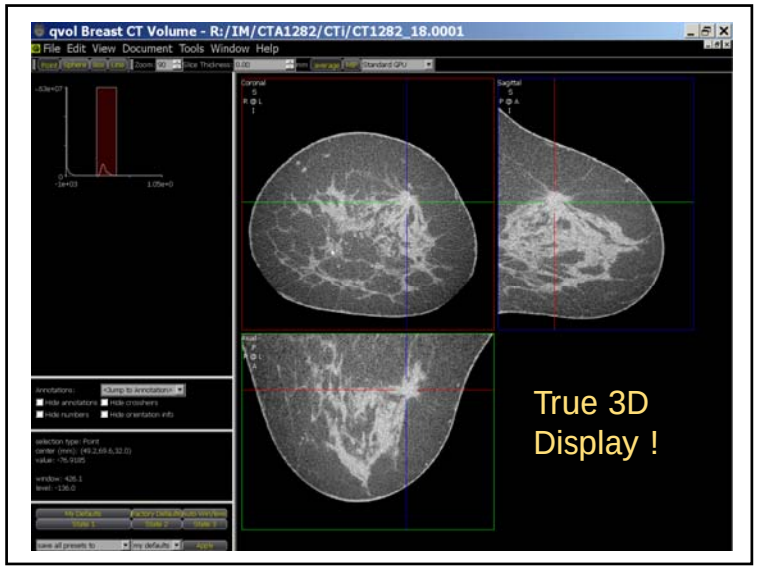
Breast CT

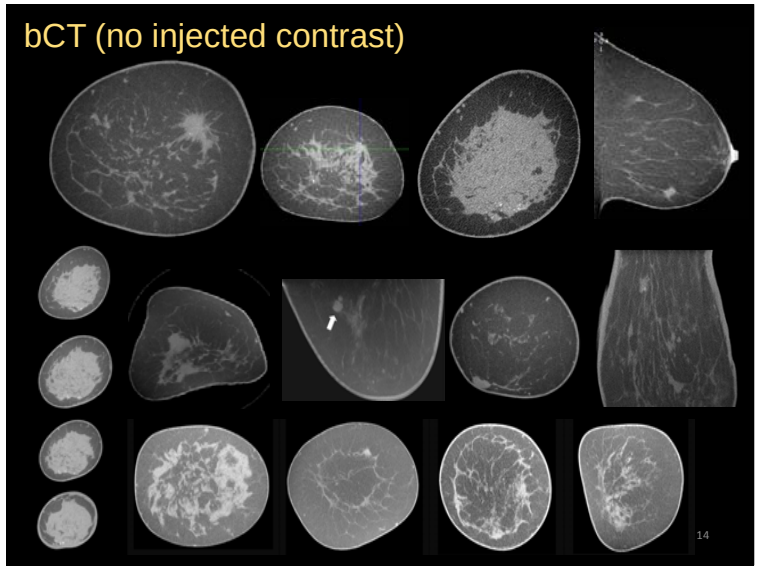


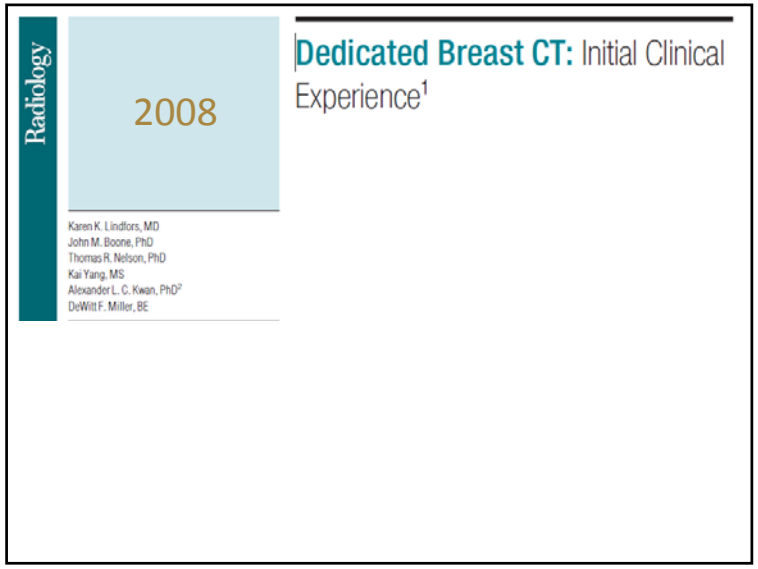
- Breast CT Technology
- Preliminary Clinical Assessments
- Mathematical Observer Metrics
  - Lesion Insertion / t3D versus 2D
  - Anatomical noise / M↔T↔bCT
- CE-bCT versus Mammo and Tomo
- Summary

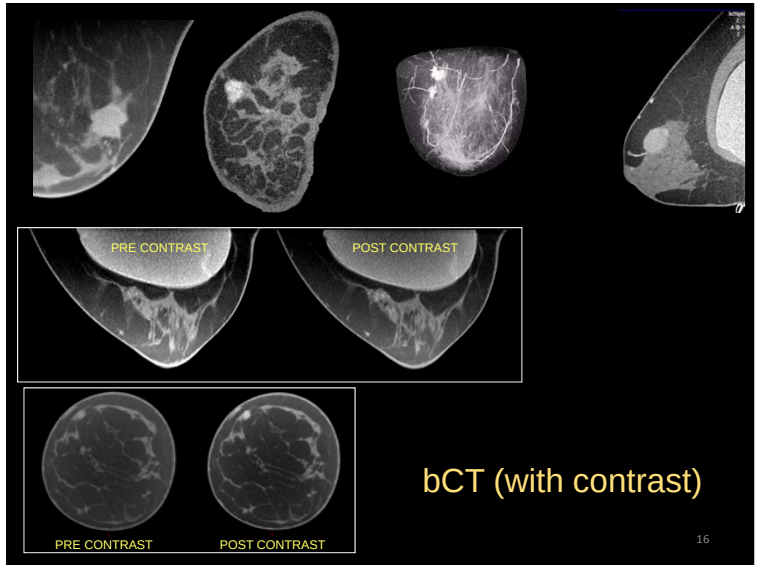


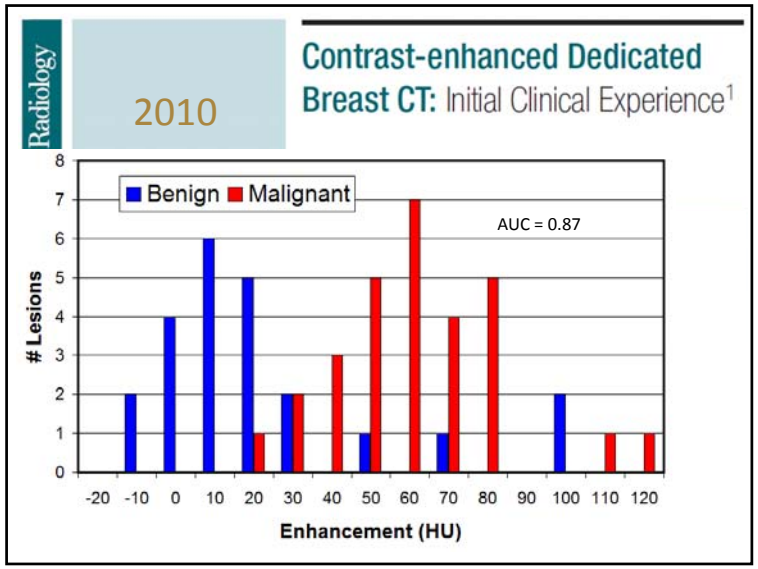



qvol Breast CT Volume - R:/IM/CTA1282/CTi/CT1282_18.0001
File Edit View Document Tools Window Help
True 3D Display !

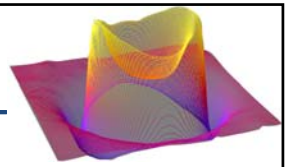

bCT (no injected contrast)
14


Radiology
2008
Dedicated Breast CT: Initial Clinical Experience[1]
Karen K. Lindfors, MD
John M. Boone, PhD
Thomas R. Nelson, PhD
Kai Yang, MS
Alexander L. C. Kwan, PhD[2]
DeWitt F. Miller, BE

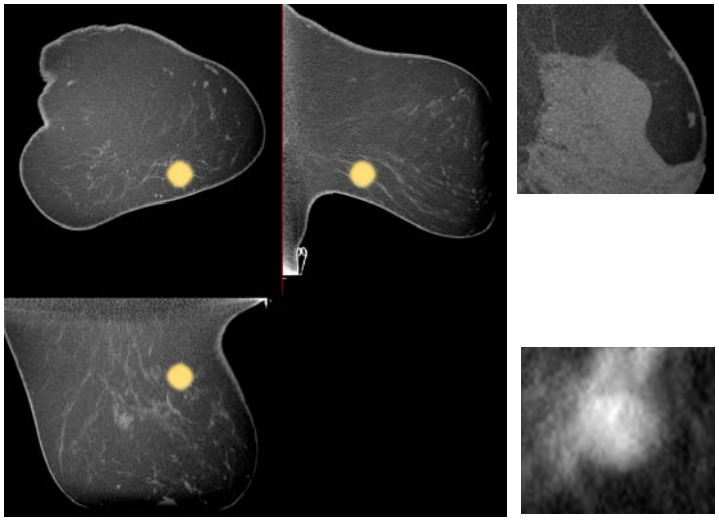

PRE CONTRAST
POST CONTRAST
PRE CONTRAST
POST CONTRAST
bCT (with contrast)
16

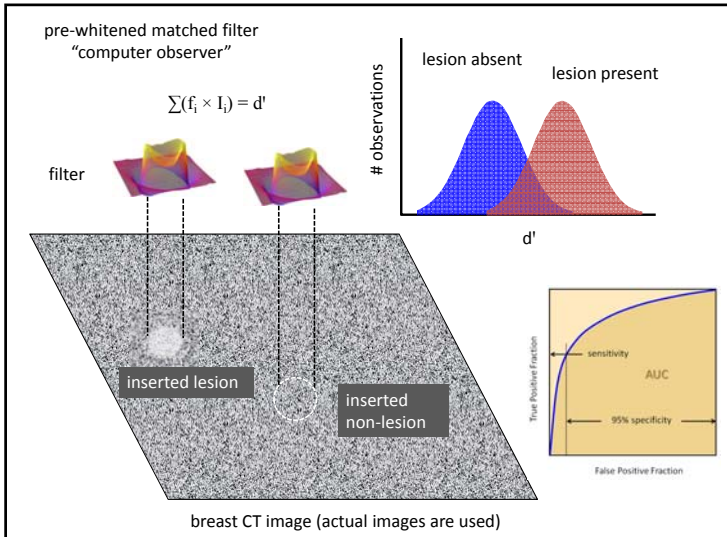


Breast CT



- Breast CT Technology
- Preliminary Clinical Assessments
- Mathematical Observer Metrics
  - ➡ Lesion Insertion / t3D versus 2D
  - Anatomical noise / M↔T↔bCT
- CE-bCT versus Mammo and Tomo
- Summary

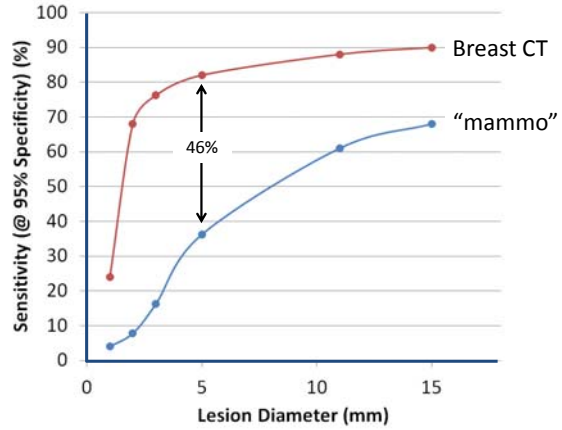




Effect of slice thickness on detectability in breast CT using a prewhitened matched filter and simulated mass lesions

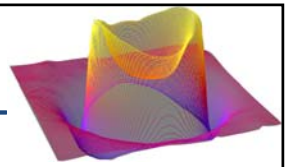
Nathan J. Packard
Carestream Health Inc., Rochester, New York 14615
Craig K. Abbey
Department of Psychology, University of California, Santa Barbara, California 93106
Kai Yang
Department of Radiology, University of California Davis Medical Center, Sacramento, California 95817
John M. Boone[a)]
Department of Radiology, University of California Davis Medical Center, Sacramento, California 95817 and Department of Biomedical Engineering, University of California, Davis, California 95616

(Received 11 April 2011; revised 22 December 2011; accepted for publication 25 January 2012; published 14 March 2012)



mass lesions only / results do not reflect microcalcifications

Breast CT



Breast CT Technology

Preliminary Clinical Assessments

- Mathematical Observer Metrics

  Lesion Insertion / t3D versus 2D

  ➡ Anatomical noise / M↔T↔bCT

CE-bCT versus Mammo and Tomo

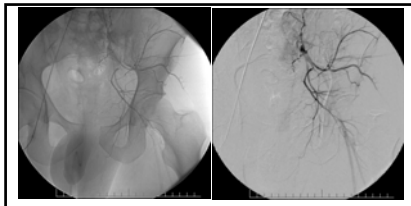
Summary

low

Background Noise

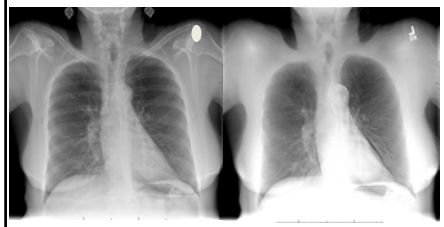
Anatomical Noise

high



Digital Subtraction Angiography
(Temporal Subtraction)

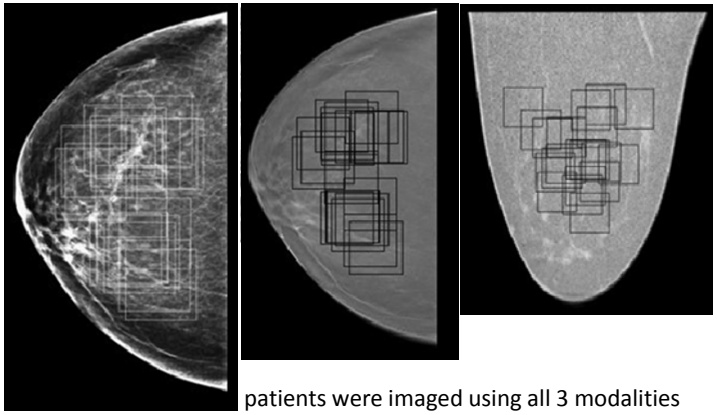
Reduces Anatomical Noise



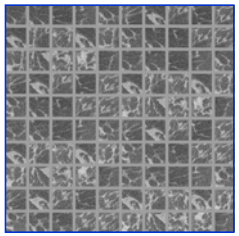
Dual Energy Chest Radiography
(Energy Subtraction)

Reduces Anatomical Noise

Mammo Tomo Breast CT

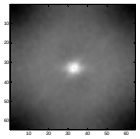


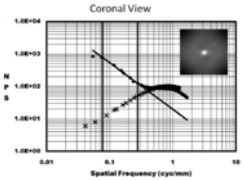
patients were imaged using all 3 modalities



$$NPS(f_x, f_y) = \frac{1}{N}\sum_{i=1}^{N}\left|DFT_{2D}[I_i(x,y)-\bar{I}_i]\right|^2 \frac{\Delta_x}{N_x}\frac{\Delta_y}{N_y}$$

2D Fourier analysis





$$f_r = \sqrt{f_x^2 + f_y^2}$$

radial averaging

$$\mathbf{y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}, \quad \mathbf{X} = \begin{pmatrix} \mathbf{x}_1^T \\ \mathbf{x}_2^T \\ \vdots \\ \mathbf{x}_n^T \end{pmatrix} = \begin{pmatrix} x_{11} & \cdots & x_{1p} \\ x_{21} & \cdots & x_{2p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix},$$

linear regression

β

β

27

Anatomical complexity in breast parenchyma and its implications for optimal breast imaging strategies

Lin Chen
Biomedical Engineering Graduate Group, University of California Davis, Sacramento, California 95817
Craig K. Abbey
Department of Psychology, University of California Santa Barbara, Santa Barbara, California 93106
Anita Nosratieh
Biomedical Engineering Graduate Group, University of California Davis, Sacramento, California 95817
Karen K. Lindfors
Department of Radiology, University of California Davis, Sacramento, California 95817
John M. Boone[40]
Department of Radiology, University of California Davis and Department of Biomedical Engineering, University of California Davis, Sacramento, California 95817

(Received 17 August 2011; revised 27 January 2012; accepted for publication 28 January 2012; published 23 February 2012)

IOP Publishing — Physics in Medicine and Biology
Phys. Med. Biol. **58** (2013) 1–19

Sylvia Sorkin Greenfield Award 2012

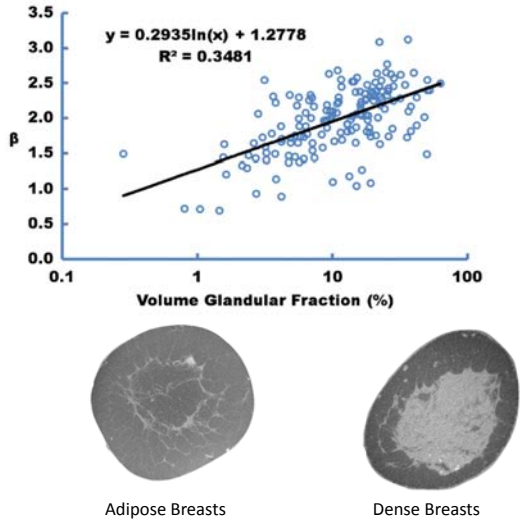
Association between power law coefficients of the anatomical noise power spectrum and lesion detectability in breast imaging modalities

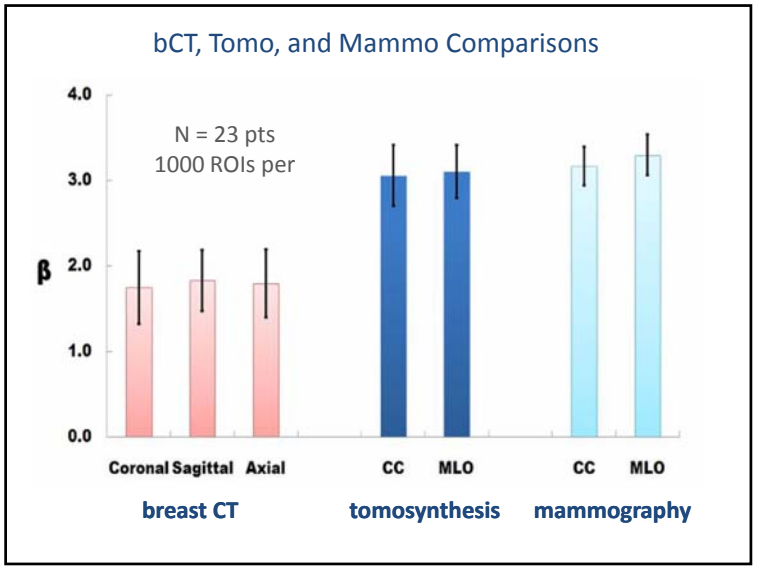
Lin Chen[1], Craig K Abbey[2] and John M Boone[1,3,4]

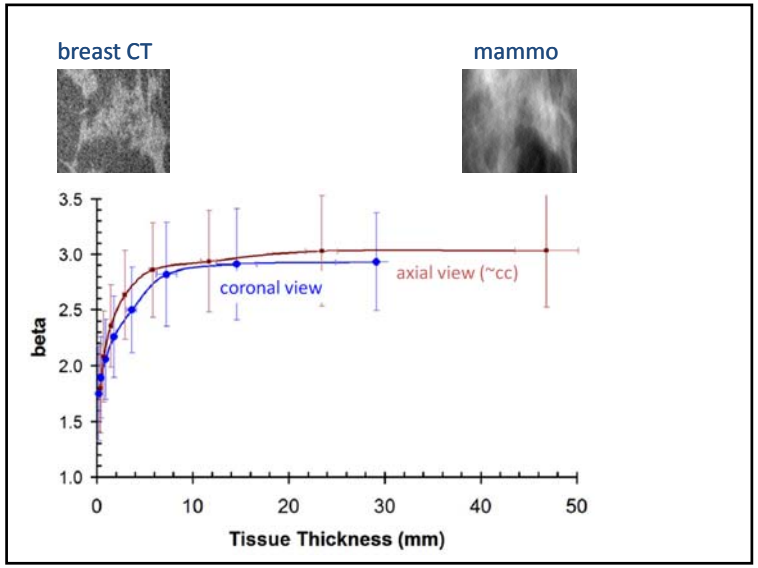
[1] Department of Biomedical Engineering, University of California Davis, Davis, CA, USA
[2] Department of Psychology, University of California Santa Barbara, Santa Barbara, CA, USA
[3] Department of Radiology, University of California Davis, Davis, CA, USA

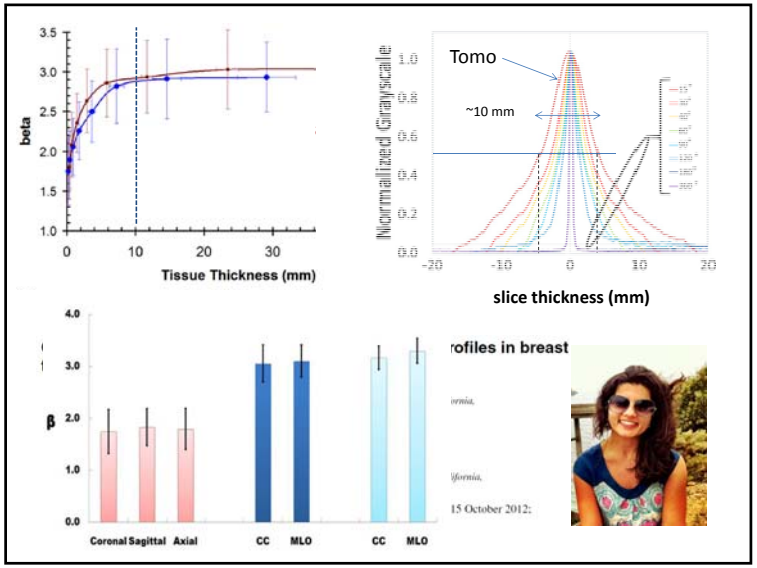
E-mail: john.boone@ucdmc.ucdavis.edu

Received 19 November 2012, in final form 21 January 2013

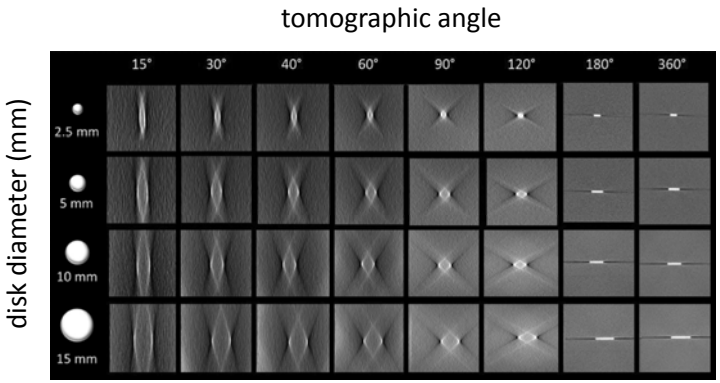

y = 0.2935ln(x) + 1.2778
R² = 0.3481
β
Volume Glandular Fraction (%)
Adipose Breasts
Dense Breasts

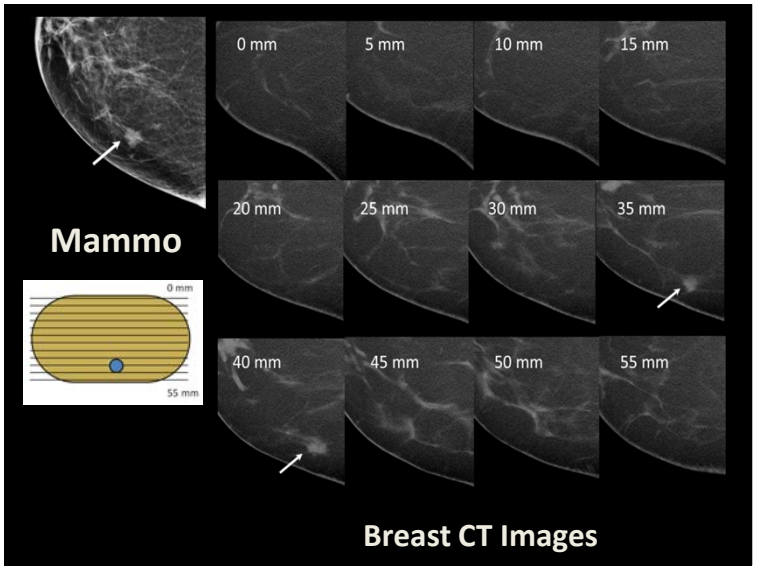

bCT, Tomo, and Mammo Comparisons
N = 23 pts
1000 ROIs per
β
Coronal Sagittal Axial
CC MLO
CC MLO
breast CT
tomosynthesis
mammography

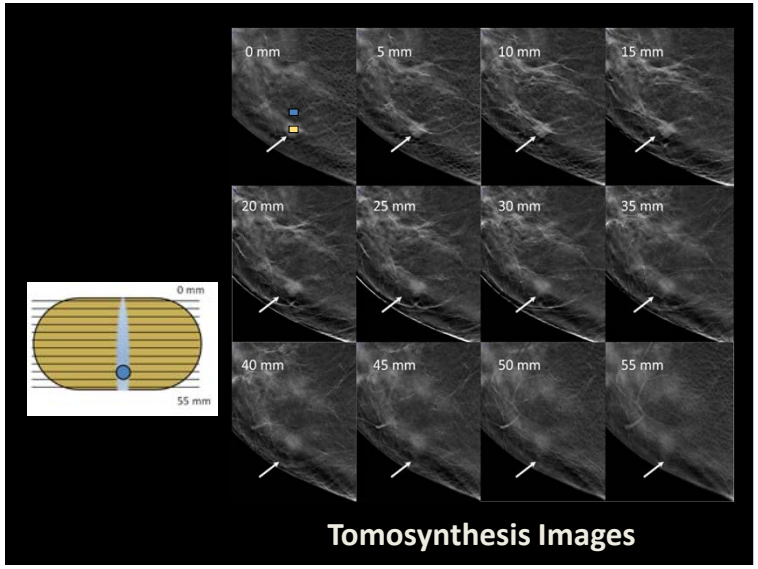

breast CT
mammo
beta
coronal view
axial view (~cc)
Tissue Thickness (mm)


beta
Tissue Thickness (mm)
Tomo
~10 mm
Normalized Grayscale
slice thickness (mm)
β
Coronal Sagittal Axial
CC MLO
CC MLO
rofiles in breast
15 October 2012:

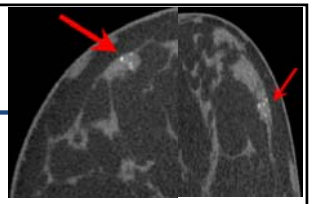
measured data on the breast CT system







Breast CT



Breast CT Technology

Preliminary Clinical Assessments

Mathematical Observer Metrics

- Lesion Insertion / t3D versus 2D
- Anatomical noise / M↔T↔bCT

- CE-bCT versus Mammo and Tomo

Summary

Prospective Clinical Trial

105 patients /103 lesions (BIRADS 4 or 5)
- imaged on VCO mammo / tomo / CE-bCT
- all biopsied

	microcalcifications	masses
malignant	31	27
benign	27	18
total	58	45

Shadi Shakeri, M.D.

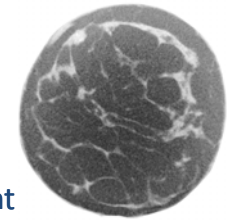
2 Radiologists Rated Lesions using a 0 to 10 Conspicuity Score

0 = not seen 10 = excellent

one-way ANOVA with correction for multiple comparisons

Embargoed Data until Published
(so not in printed notes)

Breast CT



Breast CT Technology

Preliminary Clinical Assessment

Mathematical Observer Metrics

Lesion Insertion / t3D versus 2D

Anatomical noise / M↔T↔bCT

CE-bCT versus Mammo and Tomo

- Summary

Breast CT (Summary)

Patients find bCT more comfortable

Radiation dose is the same as 2V mammography

Early trials and computer sims show better mass lesion detection performance than mammography

Computer simulations show bCT reduces anatomical noise / Mammo or Tomo / reasons understood

CE-bCT has better sensitivity and specificity than mammo or tomo

Breast Tomography Project

University of California Davis

Acknowledgements:

California BCRP 7EB-0075
California BCRP 11I-0114
R01 CA•89260
R01 EB•002138-10 (BRP)
R01 CA•129561 (RDB)
P30 CA•093373 (CCSG)
Susan G. Komen Foundation
University of Pittsburgh