UMP
UPSTATE MEDICAL PHYSICS

LANDAUER MEDICAL PHYSICS
POWERFUL PARTNERSHIPS ADVANCING IMAGING AND THERAPY

Stereotactic Breast Biopsy vs Mammography: Image Quality and Dose

Vikas Patel, PhD, DABR
Upstate Medical Physics

2014 Annual Meeting
The American Association of Physicists in Medicine
Austin, TX

Disclosures

- None

Learning Objectives

- Image quality and dose characteristics of
  - Stereotactic Breast Biopsy (SBB) systems
  - Screen-Film and Full-Field Digital Mammography systems

Outline

- Introduction
- Image quality characteristics of:
  - Stereotactic Breast Biopsy (SBB) systems
  - Screen-Film mammography (SFM) systems
  - Full-field digital mammography (FFDM) systems
- Patient dose: Average Glandular Dose (AGD)
- Summary

Introduction

- Mammograms show abnormalities such as a suspicious solid mass, microcalcification clusters etc.
- Biopsy done to determine the abnormalities are benign or malignant
  - Reduces number of benign open surgeries
- Types of breast biopsy:
  - Fine Needle Aspirations (FNA)
  - Vacuum Assisted (VA)
  - Core Needle (CN)
  - Open Surgical

Introduction

Normal mammogram

Benign cyst (not cancer)

Cancer

http://www.cancer.gov/cancertopics/screening/understanding-breast-changes/page6

Introduction

- Accuracy of localization of the lesion is critical in biopsy procedures
- It depends on:
  - Accuracy of the equipment used
  - Sample volume size
  - Skill of the clinician

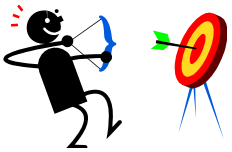


Image-guided Biopsy

- Grid coordinate system
  - Uses dedicated mammography equipment
  - Only 2D localization – lack of depth accuracy
- Ultrasound-guided biopsy systems
  - Lack of visualization and accuracy of localization
- Stereotactic breast biopsy systems (SBB)

Stereotactic Breast Biopsy (SBB) Systems

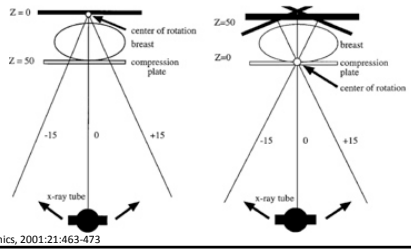
- Localization in 3D and accurate to within 1mm
- Less dependent on operator skills compared to other methods
- Limitations include localization of lesions:
  - Widely scattered throughout the breast
  - Near the chest wall or high in axilla
  - In very thin breasts

Stereotactic Breast Biopsy (SBB) Systems

Image courtesy Siemens, Hologic and IMS (Giotto)

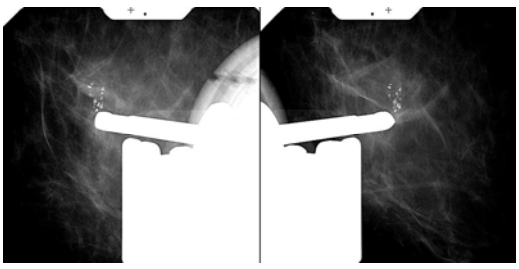
Stereotactic Breast Biopsy (SBB) Systems

- Based on a "zero-degree" scout and two radiographs 30 degrees apart (±15 deg)



Carr et. al., Radiographics, 2001:21:463-473

Stereotactic Breast Biopsy (SBB) Systems



www.Radiologictechnology.org

Requirements

Mammography	SBB
Detection and characterization of abnormalities	Localization, targeting and sampling the abnormalities

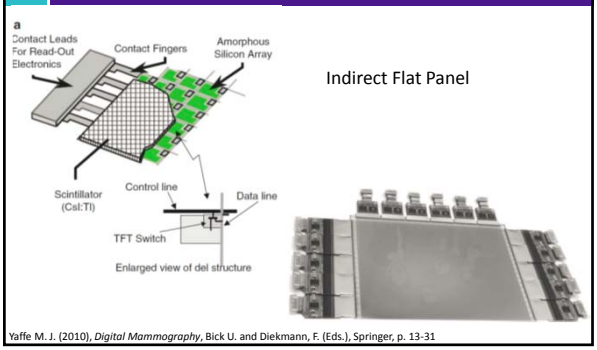
System Design

Mammography	SBB (prone systems)
• Mo/Mo, Mo/Rh, Rh/Rh, W/Rh, W/Ag • Large target angle • 0.1 and 0.3 mm focal spot • Grid for scatter removal (contact mode) • Strong compression • Not much geometric blur in contact mode • SID ~65cm	• Mo/Mo and Mo/Rh • Steep target angle • 0.25 mm focal spot • Air gap for scatter removal • Light Compression • Possible high geometric blur • SID ~88 cm

System Design

Mammography	SBB (prone systems)
• 18 cm x 24 cm and 24 cm x 30 cm FOV • Film screen, direct and indirect flat-panel receptors • 100 micron pixel size (digital systems)	• 5 cm x 5 cm FOV • CCD-based lens-coupled or fiber-optic coupled receptors • 50 micron effective pixel size

Digital Receptors

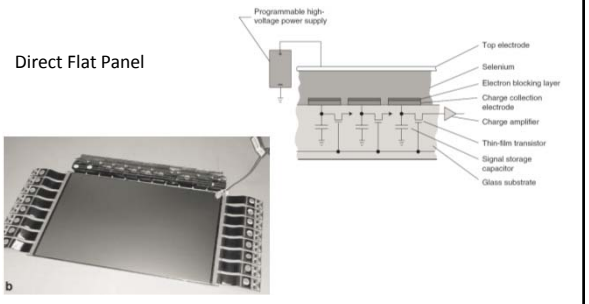


Indirect Flat Panel

Yaffe M. J. (2010), *Digital Mammography*, Bick U. and Diekmann, F. (Eds.), Springer, p. 13-31

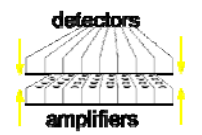
Digital Receptors

Direct Flat Panel

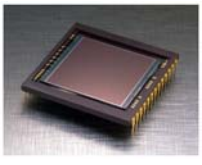


Yaffe M. J. (2010), *Digital Mammography*, Bick U. and Diekmann, F. (Eds.), Springer, p. 13-31

Digital Receptors

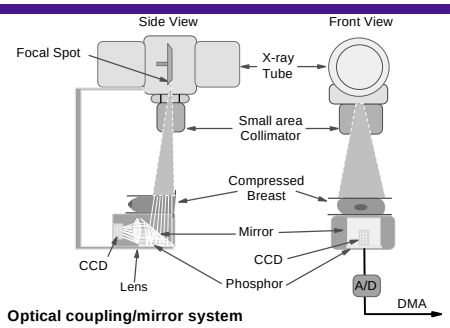


CCD Detectors



CCD image courtesy R. J. Pizzutiello

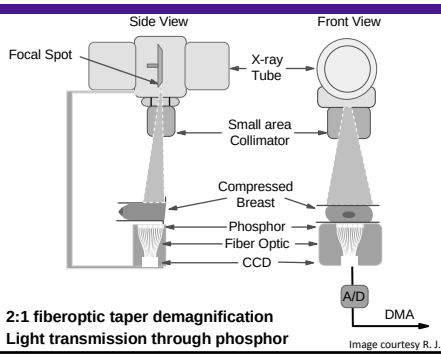
System Design



Optical coupling/mirror system
Light *reflection* from phosphor

Image courtesy R. J. Pizzutiello

System Design



2:1 fiberoptic taper demagnification
Light transmission through phosphor

Image courtesy R. J. Pizzutiello

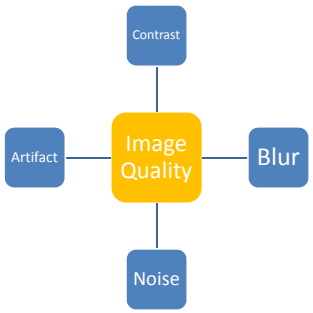
Type of SBB systems

	Prone Systems	Add-on Upright Systems
Cost and space		✓
Less Patient fatigue and motion	✓	
Less Patient fear	✓	
No patient weight issue		✓
Better for handicapped patients		✓
Access to the breast	✓	
Stroke margin safety	✓	
Overall imaging performance		✓

Outline

- ✓ Introduction
- Image quality characteristics of:
  - Stereotactic Breast Biopsy (SBB) systems
  - Screen-Film mammography (SFM) systems
  - Full-field digital mammography (FFDM) systems
- Patient dose: Average Glandular Dose (AGD)
- Summary

Image Quality Characteristics



Factors Affecting Image Quality

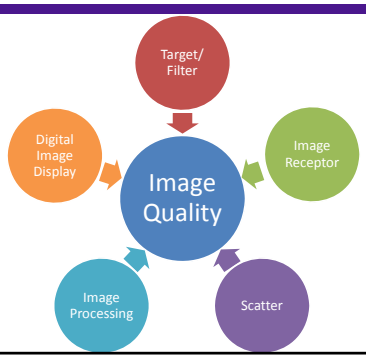


Image Quality Characteristics

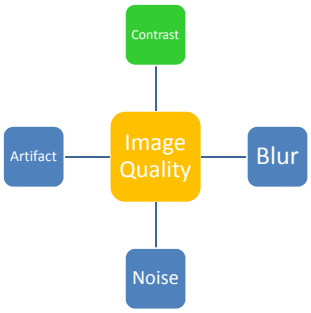
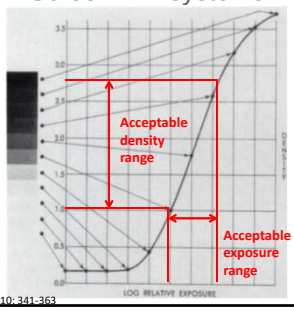


Image Quality Characteristics – Contrast

Screen-film systems



Yaffe, M. J., RadioGraphics 1990; 10: 341-363

Image Quality Characteristics – Contrast

Digital receptors

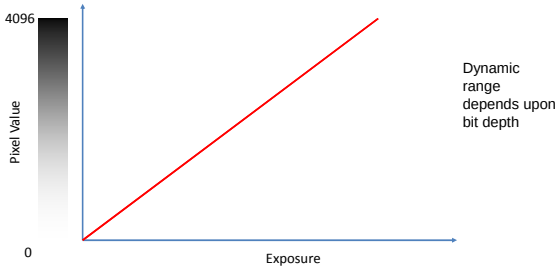


Image Quality Characteristics – Contrast

- Image processing
- Digital displays
- Window width and level functions

Image Quality Characteristics

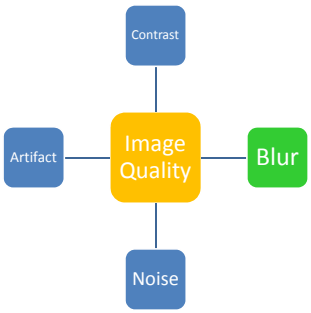


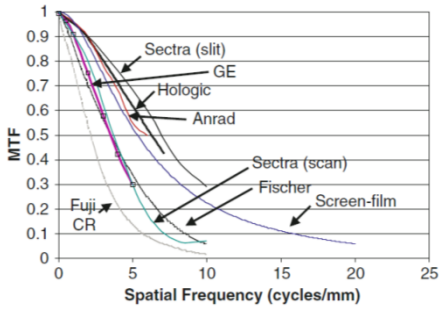
Image Quality Characteristics – Blur

- Geometric blur
  - Higher in SBB system compared to mammography systems
    - Increased mag due to air gap
    - No compression in the "open" part of the compression paddle
- Patient motion blur
  - SBB procedures take significantly more time compared to typical mammography procedures

Image Quality Characteristics – Blur

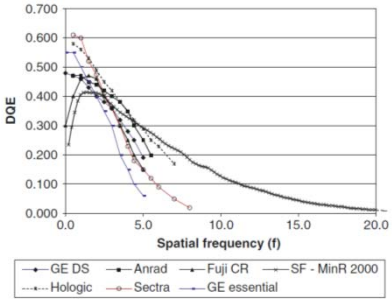
- Image receptor blur
  - SBB: 50 micron pixel (7-10 lp/mm in 1024x1024 mode)
  - Screen-film: grain size dependent (15-20 lp/mm)
  - Digital flat panel: approx. 100 micron pixel (8-10 lp/mm)
- Matrix size
  - 512 x 512 has less resolution than 1024 x 1024

Image Quality Characteristics – Blur



Yaffe M. J. (2010), *Digital Mammography*, Bick U. and Diekmann, F. (Eds.), Springer, p. 13-31

Image Quality Characteristics – Blur



Yaffe M. J. (2010), *Digital Mammography*, Bick U. and Diekmann, F. (Eds.), Springer, p. 13-31

Image Quality Characteristics

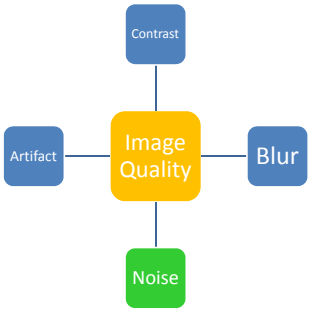


Image Quality Characteristics – Noise

- Electronic "dark" noise for digital systems
- Speed is an issue for screen-film systems
  - eg. Kodak's dual emulsion screen-film system
- Technique factors

Image Quality Characteristics – Noise

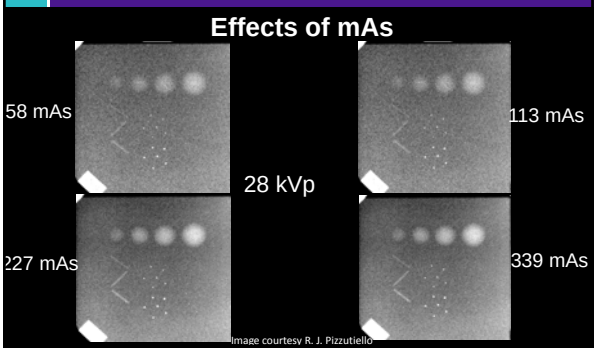


Image Quality Characteristics

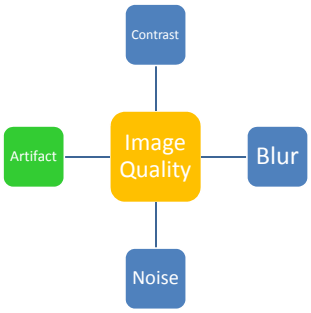
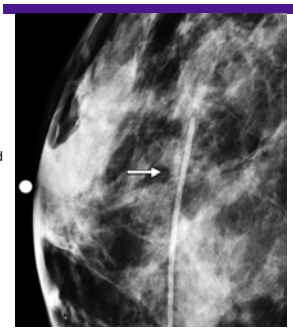
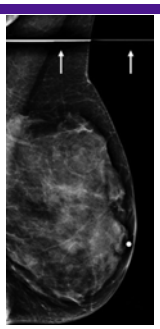


Image Quality Characteristics – Artifacts

Dead pixel



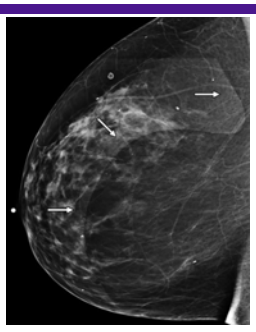


Read-out failure

Geiser et. al., American Journal of Roentgenology 2011 197:6

Image Quality Characteristics – Artifacts

Ghosting



Geiser et. al., American Journal of Roentgenology 2011 197:6

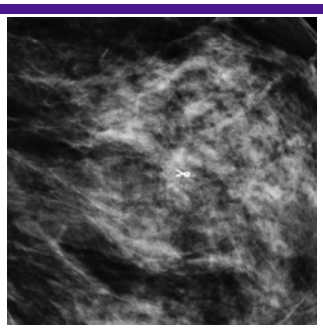
Image Quality Characteristics – Artifacts

Dust

Geiser et. al., American Journal of Roentgenology 2011 197:6

Image Quality Characteristics – Artifacts

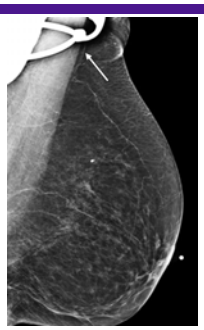
Gridlines



Geiser et. al., American Journal of Roentgenology 2011 197:6

Image Quality Characteristics – Artifacts

Patient accessories



Geiser et. al., American Journal of Roentgenology 2011 197:6

Outline

- ✓ Introduction
- ✓ Image quality characteristics of:
  - Stereotactic Breast Biopsy (SBB) systems
  - Screen-Film mammography (SFM) systems
  - Full-field digital mammography (FFDM) systems
- Patient dose: Average Glandular Dose (AGD)
- Summary

Patient Dose

Lamborghini Huracan LP 610-4

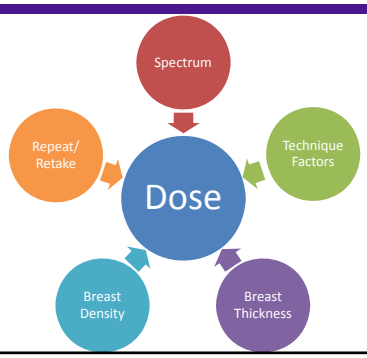
http://abcnews.go.com/Blotter/dear-abc-news-fixer-work-owes-money/story?id=10880537

Average Glandular Dose (AGD)

- Dose index to estimate *average* dose to the glandular tissue just like CTDI is in CT
- Displayed on the units and calculated periodically
- "Standard" breast (4.2 cm compressed thickness and 50% Fatty and 50% Glandular composition) equivalent phantom

www.gammex.com/n-portfolio/productpage.asp?id=299&category=Mammography&name=Mammographic+Accreditation+Phantom%2C+Gammex+156

Factors Affecting AGD



Average Glandular Dose (AGD)

- Typical doses for one cc view
  - SF systems – 180 – 250 mrad
  - Digital systems – 100 – 190 mrad
- Use of AEC and proper technique chart along with less repeats will minimize patient dose

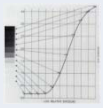
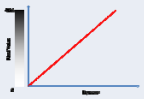
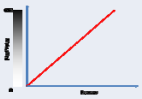
Outline

- ✓ Introduction
- ✓ Image quality characteristics of:
  - Stereotactic Breast Biopsy (SBB) systems
  - Screen-Film mammography (SFM) systems
  - Full-field digital mammography (FFDM) systems
- ✓ Patient dose: Average Glandular Dose (AGD)
- Summary

Summary

- SBB systems have different requirements compared to mammography systems which leads to unique system design
- Image quality characteristics were reviewed
- Factors affecting dose were reviewed

Future?

	Screen-Film	SBB (Prone systems)	FFDM
Blur	15-20 lp/mm	7-10 lp/mm (1024 mode)	8-10 lp/mm (contact mode)
Contrast			
Display	Viewbox	**CRT:** 480x640, 0.4 mm x 0.4 mm pixel pitch **Flatpanel/LCD:** 1280x1024 (1.3 MP), 0.285 mm x 0.285 mm pixel pitch, 550:1 contrast ratio	**Flatpanel/LCD:** 2560 x 2048 (5MP), 0.165 mm x 0.165 mm pixel pitch, 850:1 contrast ratio

Future?

FFDM	SBB (Prone systems)	SBB from Add-ons