Quality Control for Stereotactic Breast Biopsy

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Guided Breast Biopsy

- Ultrasound guided, hand-held needle
- Stereotactically guided core biopsy
  Not visible on ultrasound
Core Biopsy
The CCD Image Receptor

- Charge-Coupled Device
- An integrated circuit (chip) silicon wafer
- About the size of a postage stamp
- Converts light into electronic detectors and amplifiers
CCD Image Receptors

- 5cm x 5cm FOV CCD, typical
- LoRad DSM (below) 5 cm x 5 cm
- GE Senovision (right) 8 cm x 8 cm
Conventional x-ray exposure creates an aerial image

- Intensifying screen converts latent x-ray image to visible light image

- Minify light image to CCD size

- Readout CCD to computer

- Display, manipulate, archive digital image
Light sensitive region
Optical coupling/mirror system

Light reflection from phosphor
Side View

Focal Spot

X-ray Tube

Small area Collimator

Compressed Breast

Phosphor

Fiber Optic

CCD

Front View

2:1 fiberoptic taper demagnification

Light transmission through phosphor
Digital Image Quality

- Contrast
- Blur
- Noise
- Artifacts
- Dose
Contrast
Completely adjustable by the user

Optical Density

Log E2/E1
Image Matrix
- 50 mm field of view
- 1,024 x 1,024 pixels
- ~0.05 mm per pixel
- Objects may not be centered on pixel

CRT Display
- 20 cm x 30 cm screen
- 480 x 640 pixels (VGA)
- 0.04 cm per pixel
- Mag view
Noise

- Noise decreases (improves) with increasing mAs
- Images may be produced using any mAs technique (from 10 - 500 mAs)
- Window and level controls can be used to make the image “appear” properly exposed
- System noise will change
Factors Affecting Breast Dose

- kVp, mAs
- breast thickness
- breast composition (dense or fatty)
- multiple exposures

- digital image processing does NOT affect dose
- optical density of film (if hardcopy is used) does NOT affect dose
To Minimize Breast Dose

- Develop and maintain a good technique chart
- Obtain manufacturer’s suggested techniques
- Evaluate image quality at different mAs values (Technologist and Medical Physicist)
- Moderately higher mAs will reduce image noise, but increase dose
- Insufficient mAs will produce a noisy (grainy) image, but can be made to appear “well exposed” with window/level control
- Excessive mAs images may also appear “OK” with window/level adjustment
- Minimize retakes
### Mammography Phototimer Technique Chart

<table>
<thead>
<tr>
<th>Compressed Breast Thickness</th>
<th>Fatty Breast</th>
<th>50% Fatty-50% Dense</th>
<th>Dense Breast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Filter</td>
<td>kVp</td>
</tr>
<tr>
<td>&lt;3 cm</td>
<td>moly</td>
<td>moly</td>
<td>27</td>
</tr>
<tr>
<td>3 to 5 cm</td>
<td>moly</td>
<td>moly</td>
<td>27</td>
</tr>
<tr>
<td>5 to 7 cm</td>
<td>moly</td>
<td>moly</td>
<td>27</td>
</tr>
<tr>
<td>&gt;7 cm</td>
<td>moly</td>
<td>moly</td>
<td>27</td>
</tr>
</tbody>
</table>

Techniques based upon proper photocell placement under the most dense portion of breast, screen-film combinations, and processing. Taut compression should be used for all patients except where noted.

**Focal spot size for:**
- Nonmagnification Technique: 3 mm
- Magnification Technique: 1 mm

### Special Techniques

- Implant Displaced Views—
  - Photofliming same as above chart

### Manual Techniques for Implant Views

<table>
<thead>
<tr>
<th>Breast size</th>
<th>Target</th>
<th>Filter</th>
<th>kVp</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small &lt; 3</td>
<td>moly</td>
<td>moly</td>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>Medium 5/6</td>
<td>moly</td>
<td>moly</td>
<td>28</td>
<td>80</td>
</tr>
<tr>
<td>Large 7/5</td>
<td>moly</td>
<td>moly</td>
<td>29</td>
<td>80</td>
</tr>
</tbody>
</table>

Apply minimal compression—enough to prevent motion.

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**Figure 2. Mammography Phototimer Technique Chart**

**Specimens**

<table>
<thead>
<tr>
<th>22</th>
<th>18</th>
</tr>
</thead>
</table>

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**Specimens must be compressed**
ACR-SBBAP

History

- Committee convened Fall, 1995
  Develop professional standards
  Develop SBBAP materials for facilities
- Pilot program 1st quarter, 1996
- Announced at ACR Breast Cancer Meeting (April, 1996)
- Reviewers trained
ACR-SBBAP

- Modeled after ACR-MAP
- 1996 vs. 1987
- Personnel qualifications
- Equipment performance
- QC
- Procedure verification (through clinical image evaluation)
- Image quality (phantom images)
- Dose
Personnel Qualifications

Medical Physicist

- Board Certification or alternate requirements
- 15 hours CE in Mammo Physics every 3 years
- >6/1/97
  
  1 hands-on SBB MP Survey under guidance
- At least 1 SBB MP Survey per year
- 3 hrs CE in SBB Physics every 3 years
Physician Qualifications

Collaborative vs. Independent Practice Model

In a collaborative practice, the patient derives the benefit of consultation and collaboration from the radiologist and surgeon (or other physician) working together.

Where a radiologist or surgeon (or other physician) are practicing independently, the expertise in the diagnosis and management of breast disease of an individual physician may provide the patient with an equivalent benefit.
Physician Credentials

- All participating physicians
- Training, Experience
  - Mammography
  - SBB
- Category I SBB courses
- QA
- Radiation Physics Training
- Supervision of RT and MP
- Post biopsy recommendations
- Lesion identification at time of biopsy
Approximate Status

May 31, 2001

- 551 facilities applied (active)
- 488 facilities accredited
- 83% accredited on first attempt

- Historically, deficiencies (on 1st attempt)
  40% clinical images only
  20% phantom images only
  10% dose failure

- Nearly 75% passed upon re-submission
The latest word...

- No longer accepting optical disk or diskette. Hard copy images only.
- FDA will implement regulations mandating accreditation of facilities if they do not comply voluntarily
- Check TLD technique (9% failure rate for dose)
- QC Manual printed and available
## QC Tests Unique to SBB
### Minimum Testing Frequencies

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Alignment Test</td>
<td>Before each patient</td>
</tr>
<tr>
<td>(only on some units)</td>
<td></td>
</tr>
<tr>
<td>Localization Accuracy Test (in Air)</td>
<td>Daily</td>
</tr>
<tr>
<td>Phantom Image Quality Test</td>
<td>Weekly</td>
</tr>
<tr>
<td>Hardcopy Output Quality</td>
<td>Monthly</td>
</tr>
<tr>
<td>(if hard copy is produced from digital data)</td>
<td></td>
</tr>
<tr>
<td>Visual Equipment Check</td>
<td>Monthly</td>
</tr>
<tr>
<td>Repeat Analysis</td>
<td>Semi-annually</td>
</tr>
<tr>
<td>Compression Force Test</td>
<td>Semi-annually</td>
</tr>
</tbody>
</table>
Zero Alignment Test

- Perform before each patient
- Verify that zero coordinate is accurate
- Assures that stereotactic unit is not improperly installed
Localization Accuracy

- Closed loop system test
- Position needle to a known coordinate
- Digitize position of needle tip
- Targeting software calculates position of needle tip
- Coordinates should be identical
- ±1.0 mm sphere
Phantom Image
Quality Evaluation

Nuclear Associates Digital Mini Phantom

Mammography Accreditation Phantom
<table>
<thead>
<tr>
<th></th>
<th>ACR Accreditation</th>
<th>NA Digital</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fibers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.56</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>1.12</td>
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<td>x</td>
</tr>
<tr>
<td>0.8</td>
<td>0.93</td>
<td></td>
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<tr>
<td>0.75</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>0.54</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td><strong>Specks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.54</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>0.32</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>0.24</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>0.16</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td><strong>Masses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>
# Minimum Passing Phantom Image Scores

<table>
<thead>
<tr>
<th></th>
<th>ACR-MAP Screen/film</th>
<th>Accreditation Phantom Digital</th>
<th>Mini-Phantom Digital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibers</td>
<td>4.0</td>
<td>5.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Specks</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Masses</td>
<td>3.0</td>
<td>3.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Be sure to use only an approved phantom.
Phantom Imaging:

a common avoidable failure

- NAD Digital Mini Phantom
  1st image (image quality)
  2nd image (TLD)
- Mammo Accreditation Phantom
  4 images for image quality
  5th image for TLD
- OK to window/level digital images
- Use grid (or not) per clinical technique
Hardcopy Output Quality

- Laser or multiformat camera
- Evaluate SMPTE Test Pattern, if available
- Record window width, level
- Produce hardcopy
- Measure OD at 4 consistent locations
- Record and monitor for consistency
Visual Checklist

- Use ACR checklist or equivalent
- Lights, switches, motion, accessories
- Customize for your machine/room
- Documentation (date, initials)
Repeat Analysis

- Count repeated and rejected film by category and tabulate
- Use a log of images repeated
- Document *analysis* and *corrective action* - even if your repeat rate is low
- Repeat rate probably will not be low
STEREOTATIC BREAST BIOPSY
DIGITAL SBB
REPEAT ANALYSIS WORKSHEET

(For each case performed, document any repeated exposures that required the patient to have additional dose beyond that of a “perfect” exam)

Six month period
From _____ to _______
Repeat Rate (%) = \[
\frac{100 \times \text{Total # Repeats}}{\text{Total # Exposures}}
\]
Compression Force

- Bathroom scale or compression gauge
- Measure maximum compression in manual and power modes
- The scale should read 25-40 pounds in automatic mode
- Documentation
# Additional Technologist’s QC Tests (Screen-Film only)

<table>
<thead>
<tr>
<th>TEST</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkroom Cleanliness</td>
<td>Daily</td>
</tr>
<tr>
<td>processor QC</td>
<td>Daily</td>
</tr>
<tr>
<td>Screen Cleanliness</td>
<td>Weekly</td>
</tr>
<tr>
<td>Viewboxes &amp; Viewing Conditions</td>
<td>Weekly</td>
</tr>
<tr>
<td>Fixer Retention Analysis</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Screen-Film Contact</td>
<td>Semi-Annually</td>
</tr>
<tr>
<td>Darkroom Fog</td>
<td>Semi-Annually</td>
</tr>
</tbody>
</table>
SBB Annual Medical Physics Survey

- SBB Unit Assembly Evaluation
- Collimation Assessment
- Focal Spot Performance and System Limiting Resolution
- kVp Accuracy and Reproducibility
- Beam Quality Assessment (HVL)
- Automatic Exposure Control System Performance
- Uniformity of Screen Speed or Digital Field
- Breast ESE, AGD, AEC Reproducibility
- Image Quality Evaluation (phantom)
- Artifact Evaluation
- Localization Accuracy
Assembly Evaluation

- Free-standing unit is mechanically stable
- All moving parts move smoothly, without obstructions to motion
- All locks and detents work properly
- Image receptor holder is free from vibrations
- Image receptor is held securely by assembly in any orientation
Assembly Evaluation

- Image receptor slides smoothly into holder assembly
- Compressed breast thickness scale is accurate to ±0.5 cm, reproducible to ±2 mm
- Patient or operator is not exposed to sharp or rough edges or other hazards
- Operator technique charts are posted
- Operator protected by adequate radiation shielding
Collimation

- Does the x-ray beam exceed the image receptor?

**Note:** X-rays beyond the digital image receptor will not be seen on the monitor.

- Does the biopsy window align with the image field of view?
Focal Spot Size Performance - System Limiting Resolution

- Line Pair Test Pattern
- Use film (x-ray machine)
- Use CRT image ("system")
- Technique, clinical kVp
- Scoring the image
  - Film - Lines distinct over 1/2 length
  - CRT - Lines distinct, correct # over any part of pattern
kVp Accuracy - Reproducibility

- Verify that actual kVp’s are the same as the indicated kVp’s
- Range of clinical kVp values
- Accuracy within 5%
- Reproducible CV <0.02
Beam Quality (HVL)

- Thickness of aluminum to reduce radiation exposure by one-half
- Affects contrast and dose
- Used in dose calculation
- Minimum = kVp/100
- No compression paddle lucite in the beam
AEC System Performance

- AEC available on some digital SBB units
- Performance Capability
  
  *Record signal level as function of thickness and technique*
- Monitor exposure time
- Performance Capability (4,6,8 cm)
- Provide suggested technique chart
Varying thicknesses of breast equivalent material
Develop a Technique Chart

<table>
<thead>
<tr>
<th>Thickness</th>
<th>kVp</th>
<th>mAs</th>
<th>Signal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3 cm</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3 - 5 cm</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>5 - 7 cm</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>&gt; 7 cm</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Uniformity of Screen Speed or Digital Field

- Image a uniform phantom
- Screen Film systems
  
  *Each cassette produces the same optical density under the same conditions*

- Digital Systems
  
  *Digital detector produces uniform signal values across the field of view*
Phantom Image Quality

- Same procedure as for technologists
- Medical Physicist reviews scoring procedure and checks for consistency
- Uses technique factors for dose determination
Breast Entrance Exposure

AGD

- Data per technique chart
- Measure ESE
- HVL determines DgN
- AGD = ESE * DgN
- AGD < 300 mrad
- Dose and Optical Density
Artifact Evaluation

Unwanted irregularity not caused by structures of interest

Causes (Digital)
- Digital Image Receptor

Common Causes
- Unwanted objects in x-ray beam
Targeting Accuracy

- Performed annually by technologist under supervision of medical physicist
- Position gel-type phantom
- Image, target and sample
- Result: was the lesion collected?
QC Program Review

For all Technologist QC Tests

- Review procedures (ACR SBB-QC Manual)
- Review documentation
- Answer questions
- Written recommendations
Role of the Surgeon in Quality Control

- Understand the importance of QC in SBB
- Assures that personnel remain qualified
- Support QC activities
  - Allow enough time for QC
  - Provide for QC training
  - Periodically check that QC is done as required
- Confer with medical physicist annually
- Assure that follow-up is done if the QC program indicates corrective action is required
Summary

- ACR SBBAP
- Technologist’s QC Tests
- Medical Physicists QC Tests