

Breast Biopsy from the Physicists Perspective

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Conflict of Interest Statement

- ▶ Member of ACR Mammography Physics Subcommittee
- ▶ Member of ACR Committee on Practice Parameters and Technical Standards – Physics

Introduction Methods of Breast Biopsy

- ▶ The Old
 - ▶ Stereotactic Breast Biopsy
 - ▶ Ultrasound Breast Biopsy and FNA
 - ▶ MRI Guided Biopsy
- ▶ The New
 - ▶ Tomosynthesis Guided Breast Biopsy
- ▶ The Future
 - ▶ Molecular Breast Imaging Guided Biopsy
 - ▶ Contrast Enhanced Mammography Guided Biopsy

Introduction


- ▶ ACR Accreditation Program Requirements
 - ▶ Stereotactic Breast Biopsy
 - ▶ Breast Ultrasound
 - ▶ Breast MRI
 - ▶ Nuclear Medicine
- ▶ Breast Imaging Center of Excellence

Accreditation Programs Required for BICOE

- ▶ Mammography
 - ▶ State or ACR
 - ▶ Required by MOCA
 - ▶ FFDM Accreditation (ACR August 2016)
 - ▶ Physics annual testing required
- ▶ Stereotactic Breast Biopsy
 - ▶ Standard accreditation of prone or upright add on systems
 - ▶ No requirement for tomosynthesis guided systems yet!
 - ▶ Physics annual testing required

ACR Accreditation References

- ▶ BICOE: (<https://www.acraccreditation.org/Breast-Imaging-Center-of-Excellence>)
- ▶ Mammography: (<https://www.acraccreditation.org/Modalities/Mammography>)
 - ▶ <https://www.acraccreditation.org/media/ACRAccreditation/Documents/Mammography/Requirements.pdf?1a=en>
- ▶ Breast Ultrasound: (<https://www.acraccreditation.org/Modalities/Breast-Ultrasound>)
 - ▶ <https://www.acraccreditation.org/media/ACRAccreditation/Documents/Breast-Ultrasound/Requirements.pdf?1a=en>
- ▶ Stereotactic Breast Biopsy: (<https://www.acraccreditation.org/Modalities/Stereotactic-Breast-Biopsy>)
 - ▶ <https://www.acraccreditation.org/media/ACRAccreditation/Documents/Stereotactic/Requirements.pdf?1a=en>



ACR Accreditation References

- ▶ Breast MRI (<https://www.acraccreditation.org/Modalities/Breast-MRI>)
 - ▶ <https://www.acraccreditation.org/media/ACRAccreditation/Documents/Breast-MRI/Requirements.pdf?la=en>
- ▶ Nuclear Medicine (<https://www.acraccreditation.org/Modalities/Nuclear-Medicine-and-PET>)
 - ▶ <https://www.acraccreditation.org/media/ACRAccreditation/Documents/NucMed-PET/Nuclear-Medicine-Requirements.pdf?la=en>

Stereotactic Breast Biopsy Program Requirements Physicist

Medical Physicist
 A medical physicist performing surveys of stereotactic breast biopsy units in any setting must be currently qualified under MQSA and meet the following minimum criteria:

Qualifications	Medical Physicist
Initial	Qualified to perform mammography surveys under MQSA AND Performed 1 hands-on stereotactic breast biopsy physics survey under a qualified medical physicist or at least 3 independent surveys prior to 6/1/07
Continuing Experience	Upon renewal, 2 stereotactic breast biopsy unit surveys in the prior 24 months
Continuing Education	Upon renewal, 3 CEUs in stereotactic breast biopsy in the prior 36 months

Stereotactic Breast Biopsy Annual Tests

- ▶ Unit Assembly Evaluation
- ▶ Collimation Assessment
- ▶ Focal Spot Performance and System Limiting Spatial Resolution
- ▶ kVp Accuracy and Reproducibility
- ▶ Beam Quality Assessment (Half Value Layer)
- ▶ Automatic Exposure Control System or Manual Exposure Performance Assessment

Stereotactic Breast Biopsy Annual Tests (continued)

- ▶ Breast Entrance Exposure, Average Glandular Dose and Exposure Reproducibility
- ▶ Image Quality Evaluation
- ▶ Artifact Evaluation
- ▶ Localization Accuracy

Stereotactic Breast Biopsy Critical Tests

- ▶ Half Value Layer
- ▶ Automatic Exposure Control
- ▶ Average Glandular Dose
 - ▶ < 300 mrad (3 mGy)
- ▶ Localization Accuracy
 - ▶ Technologist competency



Breast Ultrasound Accreditation Program Requirements

- ▶ The QC tests listed in the table below are required (unless they are designated as optional) and must be performed at least annually on all machines and transducers in routine clinical use.

Breast Ultrasound Accreditation Physics Tests

Annual Survey (System Performance Evaluation)	
QC Test	Description
1. Physical and Mechanical Inspection	Assesses the mechanical integrity of the equipment, and the safety of patient and operator.
2. Image Uniformity and Artifact Survey	Identifies the presence of artifacts, often axial or lateral streaks in scans of uniform sections of a phantom. The use of "in-air" images (i.e., images acquired without the use of gel or phantoms) may also be useful in detecting superficial artifacts.
3. Geometric Accuracy (Optional)	Commonly involves use of the scanner calipers to measure known distances between phantom test targets in the axial and lateral directions and also in the elevational direction for 2D probes. Other tests of geometric accuracy are available, e.g., testing accuracy of the pixel size calibration in the image header.
4. System Sensitivity	Methods relying on visual determination of the maximum depth of visualization of speckle patterns or phantom targets, and quantitative measurements of signal-to-noise ratio (SNR), have been reported.
5. Ultrasound Scanner Electronic Image Display Performance	Maintaining the performance of the image display is critical for providing the greatest diagnostic benefit of the system. Display characteristics that are evaluated may include gray scale response and luminance calibration, presence of pixel defects, and overall image quality. These evaluations are typically performed using specialized test pattern images, and may also require photometric equipment. See AEC Technical Standard for Electronic Physics of Medical Imaging .
6. Primary Interpretation Display Performance (Optional)	Primary diagnostic displays may be electronic soft-copy displays on a PACS workstation or hard-copy prints. They should also include visible numbers (not used for primary interpretation (other than color analysis)). Display characteristics that are evaluated may include gray scale response and luminance calibration, presence of pixel defects, and overall image quality. These evaluations are typically performed using specialized test pattern images, and may also require photometric equipment. See AEC Technical Standard for Electronic Physics of Medical Imaging for additional information on tests and testing methods. (** Only required if located at the facility where ultrasound is performed.)
7. Contrast Resolution (Optional)	The use of both anechoic and low contrast echogenic targets has been suggested, as has the use of 2D cylindrical targets and 3D spherical targets.
8. Spatial Resolution (Optional)	Should be measured in the axial, lateral, and elevational directions. Various approaches have been described for these measurements (i.e. visual interpretation of groups of phantom (scatter) targets and using computer-based algorithms to measure pixel dimensions (**
9. Evaluation of QC Program (if applicable)	Provides an independent assessment of the QC program, checks that appropriate actions are taken to correct problems, identifies areas where quality and QC testing may be improved, and enables a comparison of QC practices with those of other ultrasound sites.

Breast MRI Accreditation Program Requirements Physicist

Qualifications Initial	Medical Physicist	MR Scientist
	<p>Board Certified</p> <ul style="list-style-type: none"> Certified in Diagnostic Radiological Physics, Diagnostic Medical Physics, or Radiological Physics by the American Board of Radiology, in Diagnostic Imaging Physics or Magnetic Resonance Imaging Physics by the American Board of Medical Physics, or in Diagnostic Radiology Physics or Magnetic Resonance Imaging Physics by the Canadian College of Physicians in Medicine <p>OR</p> <p>Not Board Certified in Required Subspecialty</p> <ul style="list-style-type: none"> Graduate degree in medical physics, radiologic physics, physics, or other relevant physical science or engineering discipline from an accredited institution, and Formal coursework in the biological sciences with at least <ul style="list-style-type: none"> - 1 course in biology or radiation biology, and - 1 course in anatomy, physiology, or similar topics related to the practice of medical physics 3 years of documented experience in a clinical MRI environment <p>OR</p> <p>Grandfathered</p> <p>Conducted surveys of at least 3 MRI units between January 1, 2007 and January 1, 2010.</p>	<ul style="list-style-type: none"> Graduate degree in a physical science involving nuclear MR (NMR) or MRI 3 years of documented experience in a clinical MRI environment
Continuing Experience	Upon renewal, 2 MRI unit surveys in prior 24 months	
Continuing Education	Upon renewal, 15 CEU/CME (1/2 Cat 1) in prior 36 months (must include credits pertinent to the accredited modality).	

Breast MRI ACR Accreditation Equipment Requirements

- ▶ There is no requirement for minimum field strength. However, the MR equipment must:
 - ▶ Have a dedicated, bilateral breast coil
 - ▶ Be capable of simultaneous, bilateral, imaging
 - ▶ Meet all state and federal performance requirements, including those for:
 - ▶ - Maximum static magnetic field strength
 - ▶ - Maximum rate of change of magnetic field strength (dB/dt)
 - ▶ - Maximum radiofrequency power deposition (specific absorption rate)
 - ▶ - Maximum auditory noise levels

Breast MRI Accreditation Requirements

- ▶ The medical physicist/MR scientist **must** perform the QC tests listed in the table below when the equipment is installed and **at least annually thereafter**.

Breast MRI Accreditation Physics Tests

Annual Medical Physicist/MR Scientist's MR System Performance Evaluation	
QC Test	Description
1. Magnetic Field Homogeneity	Checks the uniformity of the main magnetic field strength (B ₀) over a designated volume. Inhomogeneities can contribute to geometrical distortion of images, adversely influence image quality, and compromise the signal-to-noise ratio (SNR) in some fast imaging sequences.
2. Slice Position Accuracy	Checks the accuracy with which axial slices are positioned at specific locations utilizing a sagittal localizing image. The test determines whether the actual locations of acquired slices differ from their prescribed locations by substantially more than is normal for a well-functioning scanner.
3. Slice Thickness Accuracy	Checks the prescribed slice thickness against that of the measured slice thickness. Poor slice thickness accuracy may not only suggest that slices are too thick or thin, but can extend to factors such as incorrect image contrast or SNR.
4. Radiofrequency Coil Checks	Checks the trade-off between maximizing image uniformity and enhancing SNR that is inherent to various types of radiofrequency coils. Tests should be performed on all coils used clinically (including breast coils) and include 1) frequency and gain/attenuator verification (prescan values), 2) image signal-to-noise ratio (SNR), 3) intensity uniformity for volume coils, and 4) phase stability and image artifact assessment.
5. Soft-Copy Displays (Monitors)	Checks that display devices meet manufacturer's published specifications for 1) maximum and minimum luminance, 2) luminance uniformity, 3) resolution, and 4) spatial accuracy.
6. Evaluation of QC Program	Provides an external assessment of QC checks that appropriate actions are taken to correct problems, identifies areas where quality and QC testing may be improved, and enables a comparison of QC practices with those of other MRI sites.

Nuclear Medicine Accreditation Program Requirements

- ▶ Nuclear Medicine Accreditation
 - ▶ As of 1/18/18: Every unit used to produce diagnostic clinical images for patients must successfully pass ACR accreditation testing for the facility to be accredited.
 - ▶ Not necessary for BICOE

Nuclear Medicine Program Requirements - Physicist

Qualifications	
Initial	<p align="center">Medical Physicists</p> <p align="center">Board Certified</p> <p>Certified in Medical Nuclear Physics or Radiological Physics by the American Board of Radiology, in Nuclear Medicine Physics by the American Board of Medical Physics, in Nuclear Medicine Physics by the Canadian College of Physicists in Medicine, or in Nuclear Medicine Physics and Instrumentation by the American Board of Science in Nuclear Medicine</p> <p align="center">OR</p> <p align="center">Not Board Certified in Required Subspecialty</p> <ul style="list-style-type: none"> Graduate degree in medical physics, radiologic physics, physics, or other relevant physical science or engineering discipline from an accredited institution, and Formal coursework in the biological sciences with at least <ul style="list-style-type: none"> 1 course in biology or radiation biology, and 1 course in anatomy, physiology, or similar topics related to the practice of medical physics 3 years of documented experience in a clinical nuclear medicine environment <p align="center">OR</p> <p align="center">Grandfathered</p> <p>Conducted surveys of at least 3 NM units between January 1, 2007 and January 1, 2010</p>
Continuing Experience	Upon renewal, 2 NM camera surveys in prior 24 months
Continuing Education	<p>Upon renewal, must meet one of the following:</p> <ol style="list-style-type: none"> Currently meet the Maintenance of Certification (MOC) requirements for ABR (see ABR MOC for Medical Physics) <p align="center">OR</p> <p>Completes 15 CEUCME (1/2 Cat 1) in the prior 36 months (must include credits pertinent to the accredited modality)</p>

Nuclear Medicine Required Tests

- ▶ Intrinsic Uniformity
- ▶ System Uniformity
- ▶ Intrinsic or System Spatial Resolution
- ▶ Relative Sensitivity
- ▶ Intrinsic or System Spatial Resolution
- ▶ Relative Sensitivity
- ▶ Energy Resolution
- ▶ Count Rate Parameters
- ▶ Monitor Evaluation
- ▶ System Interlocks
- ▶ Dose Calibrators

Clinical Cases

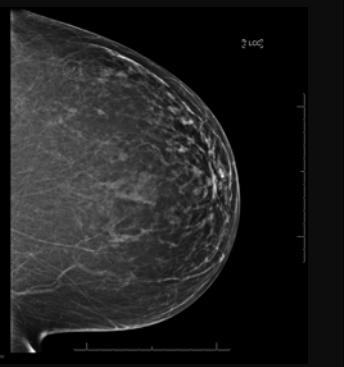
- ▶ Stereotactic Breast Biopsy
- ▶ Tomosynthesis Guided Biopsy
- ▶ Ultrasound Guided Biopsy
- ▶ MRI Guided Biopsy

Stereotactic Breast Biopsy

- ▶ 61 y.o. female indeterminate calcifications in the left breast on screening – BIRADS 0 additional imaging needed
- ▶ Diagnostic mammogram – magnification views show suspicious calcifications recommend stereotactic biopsy
- ▶ Performed biopsy

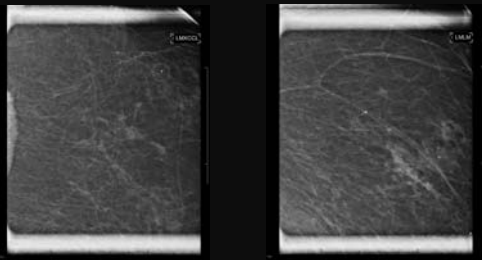
CC View

Suspicious Calcifications
BIRADS 0 additional imaging



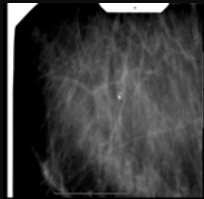
Magnification views

Suspicious Calcifications BIRADS 4

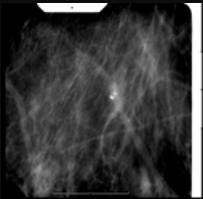


Stereo Pair

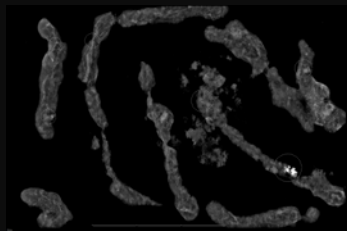
-15 degrees



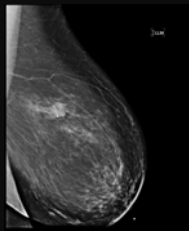
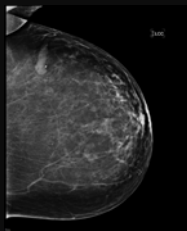
+ 15 degrees

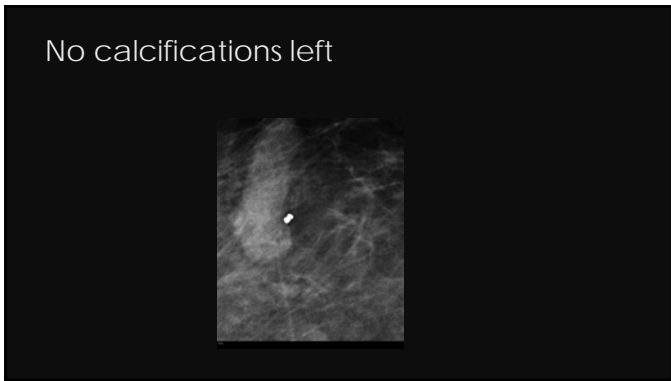


Specimen Radiograph



Clip Placement



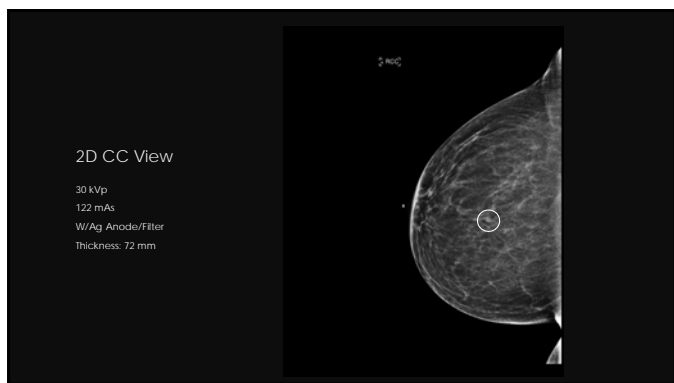


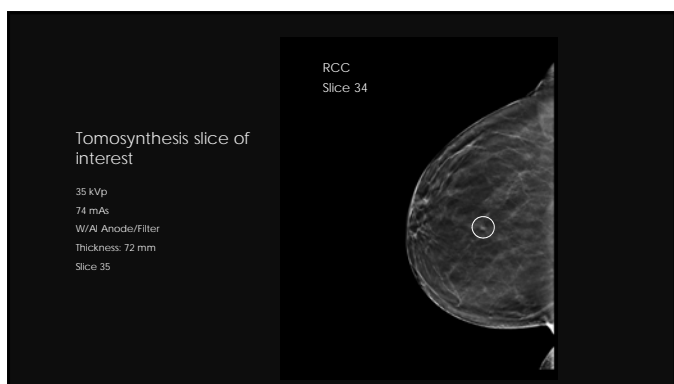
Pathology Results

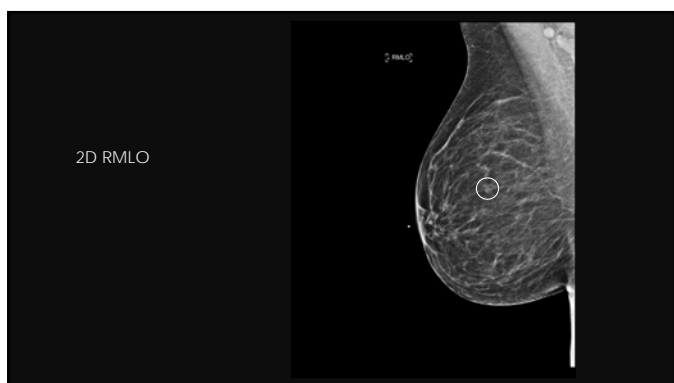
- ▶ Fibroadenoma, fibroadneomatous change and benign breast tissue with associated calcifications

Tomosynthesis Guided Biopsy – Clinical Case

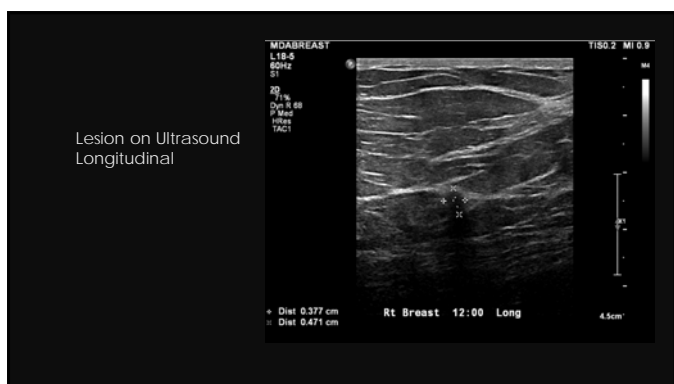
- ▶ 64 YO female with prior left mastectomy with new 4 mm oval mass in right breast not seen on previous mammogram
- ▶ Possible Cyst: Send to ultrasound
- ▶ Ultrasound
 - ▶ Irregular mass corresponding to mass on mammography
 - ▶ Recommend stereotactic core biopsy
- ▶ Biopsy: converted from stereotactic guided to tomosynthesis guided
- ▶ Pathology results:
 - ▶ Infiltrating ductal carcinoma and DCIS

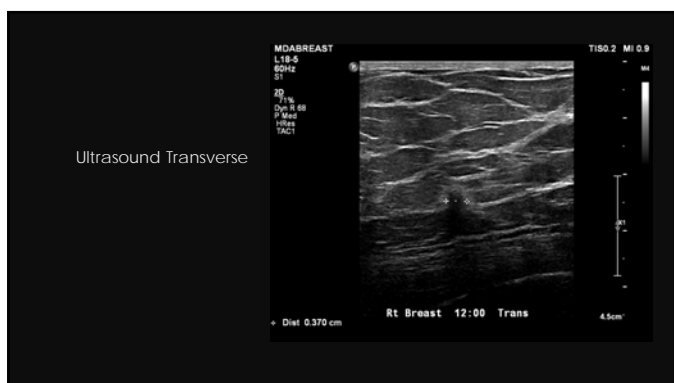


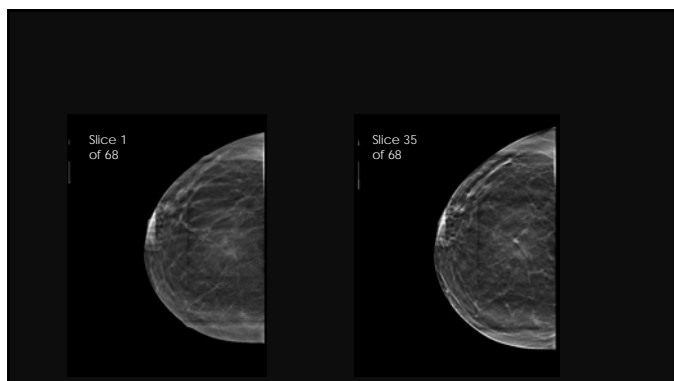


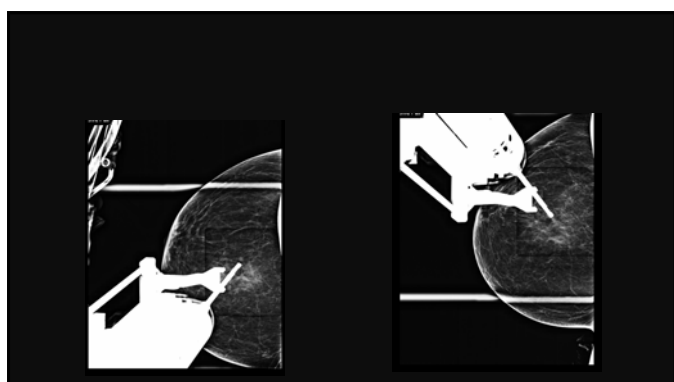


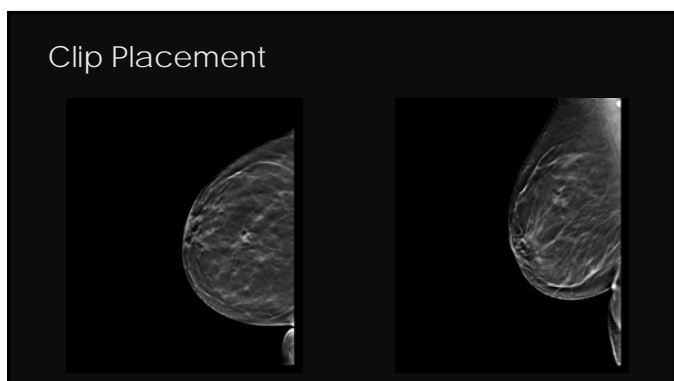




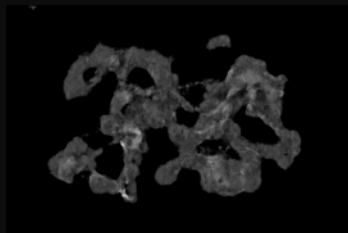








Specimen X-ray

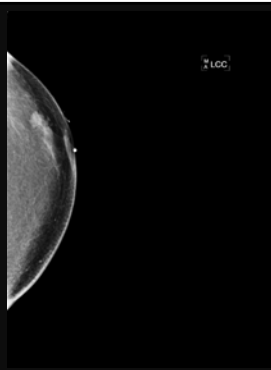


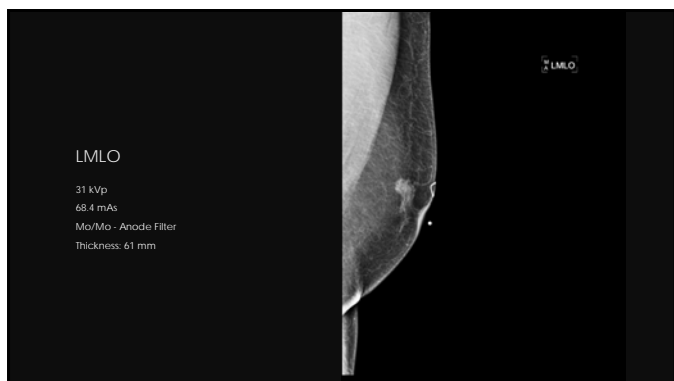
Ultrasound Guided Biopsy

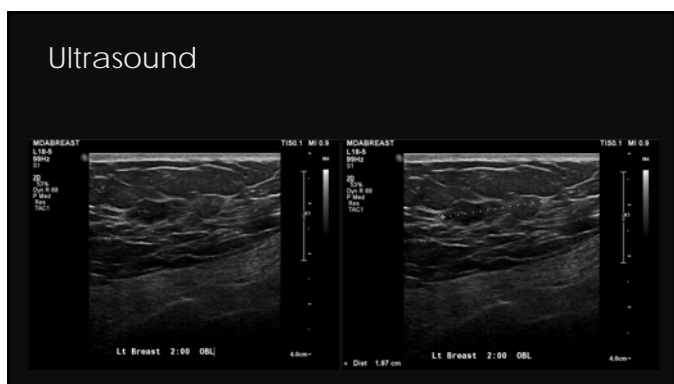
- ▶ 81 year old male patient presented with palpable finding in left breast
- ▶ Digital Unilateral Mammogram performed
 - ▶ 1 cm irregular mass noted
 - ▶ Left breast ultrasound with possible biopsy recommended
- ▶ Ultrasound performed and biopsy recommended
- ▶ Biopsy performed
- ▶ Invasive and in situ papillary carcinoma no calcifications, no necrosis

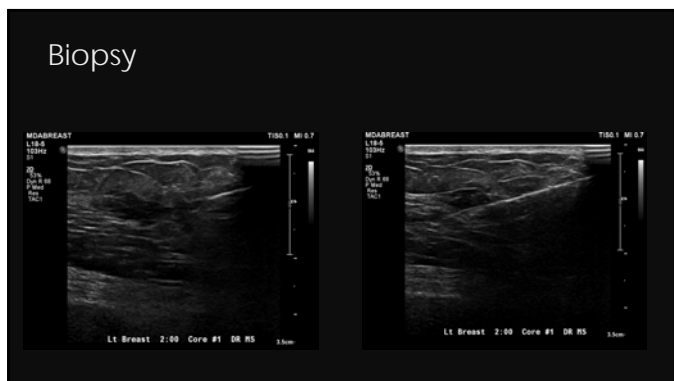
LCC

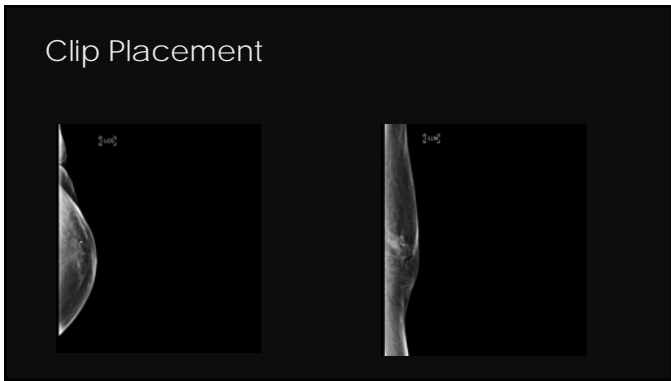
31 kVp
55 mAs
Mo/Mo - Anode/Filter
Thickness: 61 mm





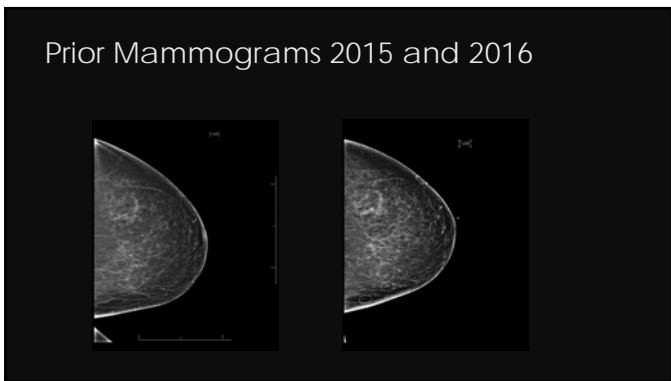


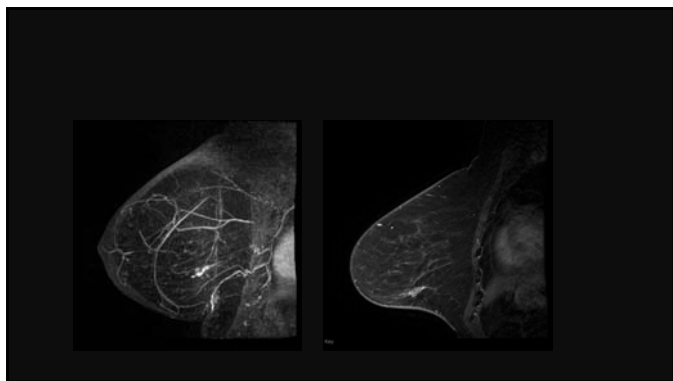


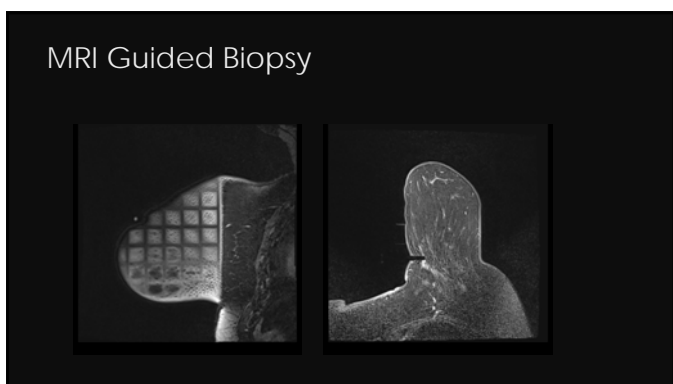


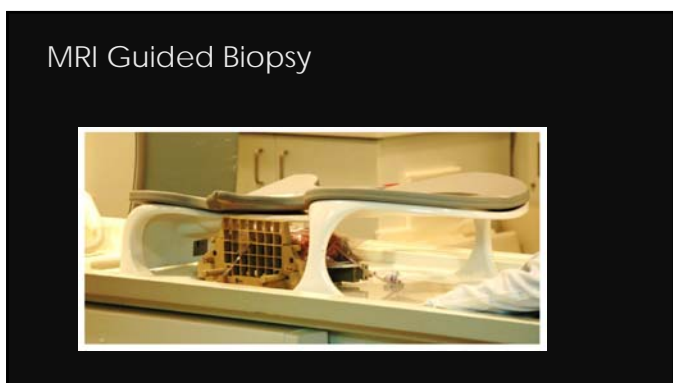
MRI Guided Biopsy

- ▶ 65 Y.O. patient BRCA 2 positive under high risk surveillance
- ▶ Screening mammogram with tomosynthesis – no changes from previous year
- ▶ Screening MRI – New area of enhancement
 - ▶ MRI guided biopsy of areas of enhancement requested
- ▶ Biopsy performed with following results
 - ▶ Predominantly Ductal Carcinoma In Situ (DCIS), high grade with comedonecrosis and microinvasive ductal carcinoma

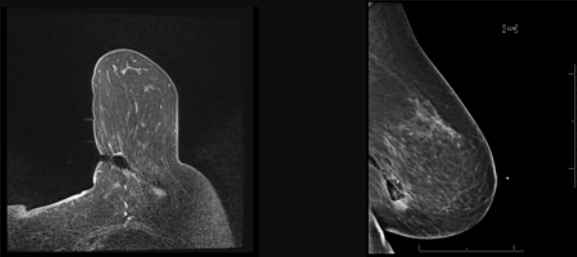






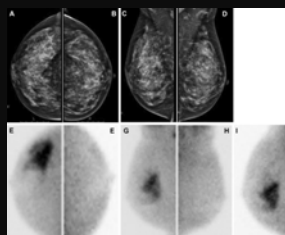


MRI Guided Biopsy – clip placement



MBI (Molecular Breast Imaging)

- ▶ The procedure
 - ▶ Inject 8 mCi Technetium 99m Sestimibi IV
 - ▶ Wait a few minutes
 - ▶ Position patient on imaging device
 - ▶ Approximately 10 minutes per image (CC and MLO)

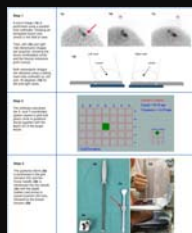


Dilon Biopsy Device



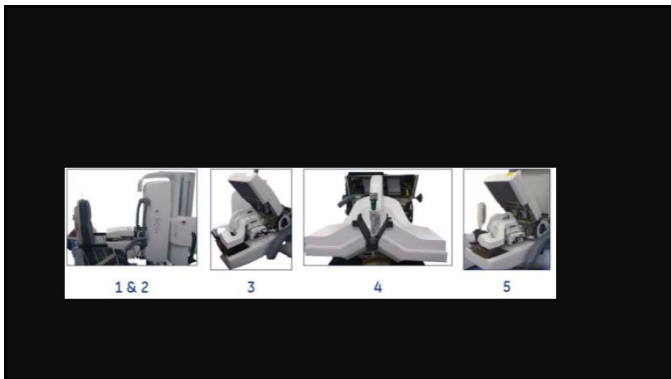
Gamma Imaging – Guided Minimally Invasive Breast Biopsy Initial Clinical Experience, Rachel Brem et. al. AJR, March 2018

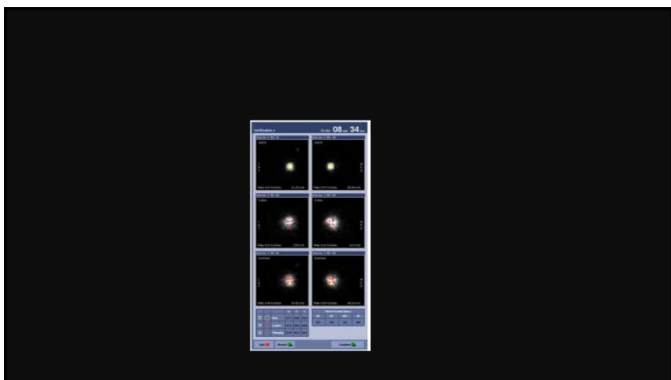
Clin Transl Imaging 2016 4-5: 367 - 376



► GE add on approved by FDA in November 2016







Contrast Enhanced Biopsy

- ▶ No word yet from the vendors!
- ▶ Most likely some form of stereotactic breast biopsy using contrast enhanced digital mammography.
