Practical Approaches to Mammography Artifacts and Radiation Safety

Jeff Frimeth, M.Sc., MCCPM, CIIP, MRSO (MRSC™), MRSE (MRSC™), CDIP
President & Chief Medical Physicist
Qualified Medical Physicist (Diagnostic Radiological Physics)
Certified Mammography Physicist
Certified Imaging Informatics Professional
Certified MR Safety Officer and Expert
Certified DICOM Integration Professional

1

Disclosures/Disclaimers

- JF Medical Physics Inc. does provide mammography physics services.
- JF Medical Physics Inc. does not have any financial agreements with Ontario Health (Cancer Care Ontario), the Canadian Association of Radiologists, manufacturers/vendors, or other organizations referred to within this presentation.
- The content within this presentation serves to represent JF Medical Physics' advice on adherence to standards (including best practices) and unless specifically stated, content is not to be interpreted as requirements to follow.

2

Overall Objectives

- Brief overview of 2D and 3D mammography technology
- Defining what artifacts are and how they can possibly be a clinical issue
- Identifying and troubleshooting artifacts in 2D mammography
- Identifying and troubleshooting artifacts in 3D mammography
- Top three FAQ's related to radiation safety
- Key points

3

Artifacts Acknowledgement

Artifacts in 2D and 3D Breast Imaging: Their Origin, Presentation, and Remediation

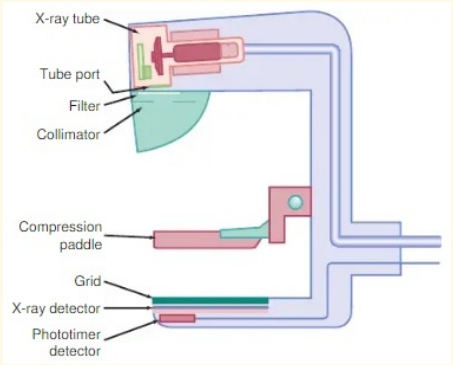
Beth Schueler, Mayo Clinic (schueler.beth@mayo.edu)

Clinical Troubleshooting for the Mammography Physicist

Mary Ellen Jafari, Kaiser Permanente (MaryEllen.Jafari@kp.org)

4

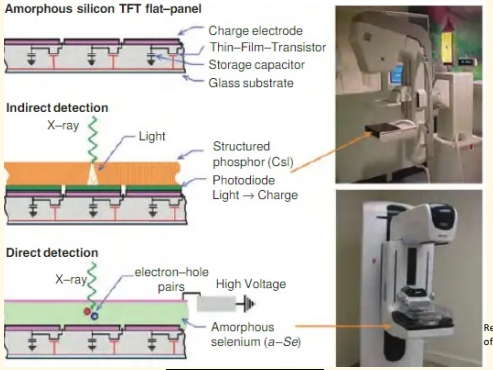
2D Technology



Ref: Bushberg, et. al., The Essential Physics of Medical Imaging: 3rd edition, 2012.

5

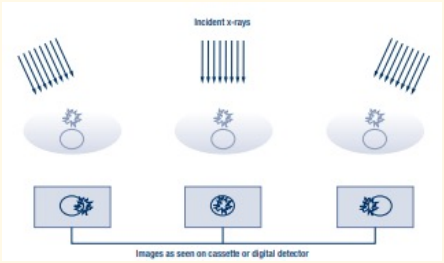
2D Technology

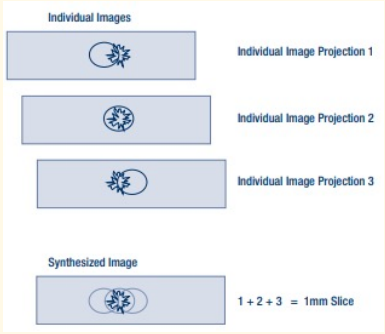


Ref: Bushberg, et. al., The Essential Physics of Medical Imaging: 3rd edition, 2012.

6

3D Technology (Digital Breast Tomosynthesis)





https://www.radiologyofindiana.com/wp-content/uploads/2017/04/fundamentals-of-breast-tomosynthesis.pdf

7

Artifacts - 101

- "Any feature in an image that mimics or masks clinical features"
  - Dr. Charles Willis (retired)
- You see an artifact, now what?
  - Is it too bad to pass along?
  - Will anyone notice?
  - Can it be improved by modification?
  - Should it be repeated?
  - **Why did this happen? What can be done to correct? What can be done to ensure/minimize this does not occur again?**

8

Essential Personnel

- Radiologists and MRTs
  - Artifacts can adversely affect image interpretation and diagnostic accuracy.
  - Repeats due to artifacts result in call backs and increased patient radiation dose.
- Medical Physicists
  - Interface between radiologist and mammography staff and service engineers.
  - Investigates artifacts to determine origin and recommends corrective action.
  - Verifies artifact resolution.

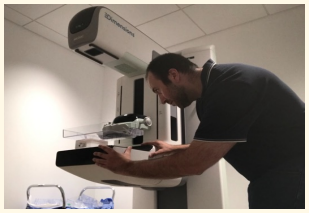


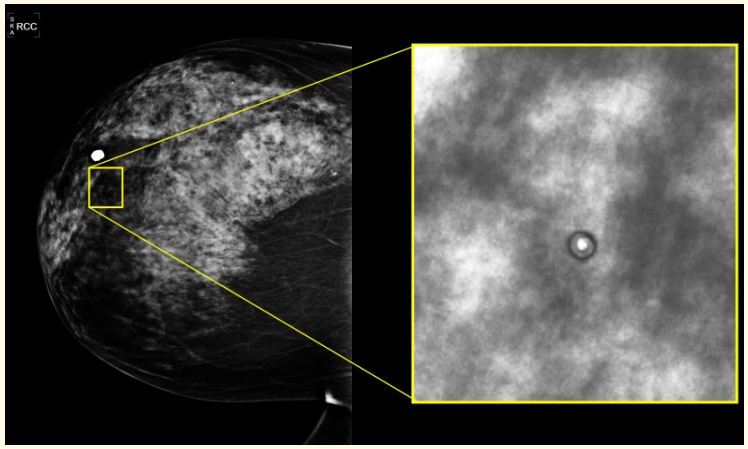
Table 1. List of required technologist QC tests for OBSP sites

Test	Frequency	CAR MAP requirement	OBSP requirement	Corrective action timeline
Visual check/daily checklist	Daily	√	√	N/A
Acquisition workstation (AWS) display cleaning	Daily	√	√	Before clinical use*
Radiologist review workstation (RWS) display cleaning and viewing conditions	Daily	√	√	Before clinical use
Artifact evaluation (flat field)	Weekly and Monthly	√	√	Before clinical use if artifacts are clinically significant; all other artifacts within 30 days**

Ontario Health (Cancer Care Ontario), Ontario Breast Screening Program (OBSP) Mammography Equipment Quality Assurance (QA) Guidance Document, March 2020

Detector Artifact

- Cause:
  - Malfunction causing readout error of detector
  - Failure of switching gate lines
- Solution:
  - Replace detector
  - Ensure appropriate medical physics evaluation

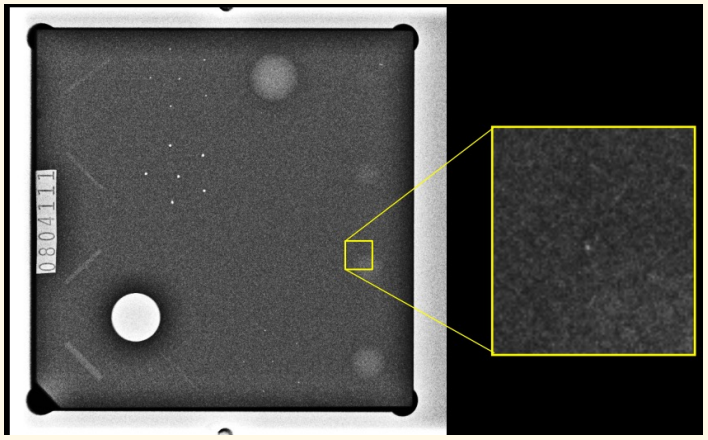


13

Detector Artifact

- Cause:
  - Dead pixel cluster resulting in charge build-up affecting signal in neighboring pixels
- Solution:
  - Replace detector
  - Ensure appropriate medical physics evaluation

14

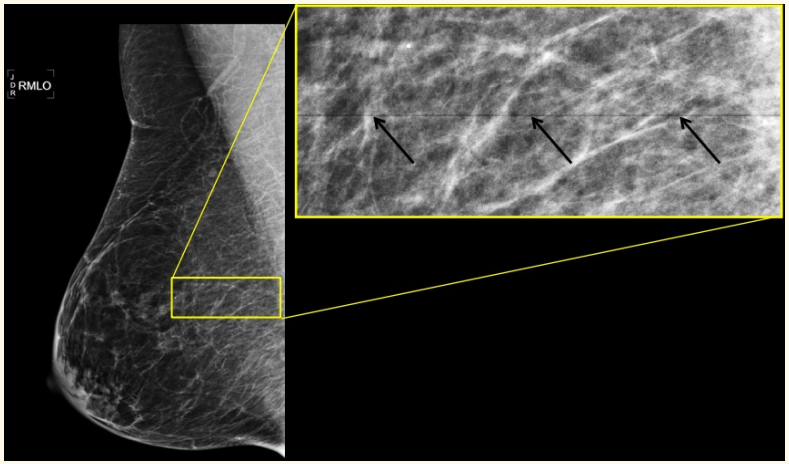


15

Dead Pixel Artifact

- Cause:
  - Troubleshoot by re-imaging phantom in a different location on the detector or perform an artifact test
  - May be either white or dark
- Solution:
  - Perform appropriate detector calibration
  - Ensure appropriate medical physics evaluation

16

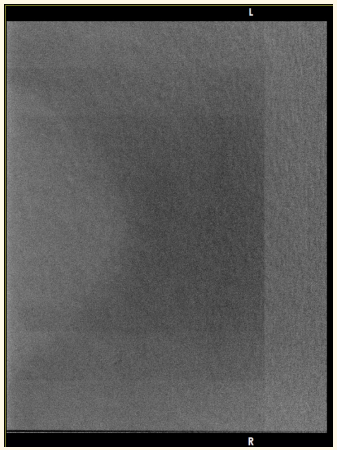


17

Dead Line Artifact

- Cause:
  - Dead line in detector
- Solution:
  - Map out dead line (service function) or replace detector

18

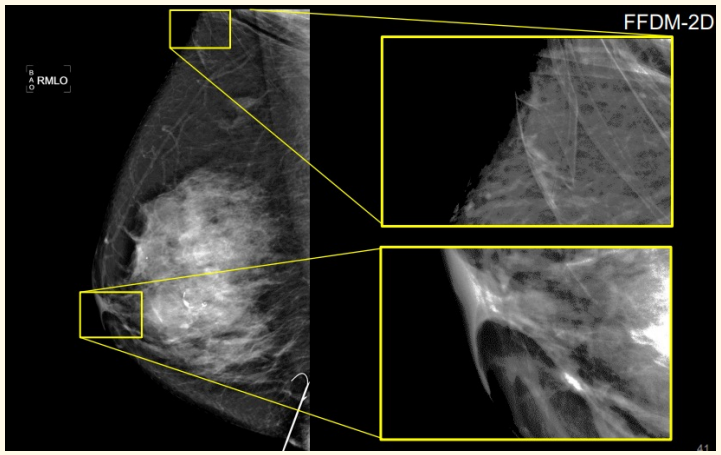


19

Ghosting Artifact

- Cause:
  - Previous image not fully erased from the detector.
  - May occur after repeated use.
  - Can occur after physics or service if detector not protected from radiation.
- Solution:
  - Detector calibration by service engineer.
  - Ensure appropriate medical physics evaluation

20

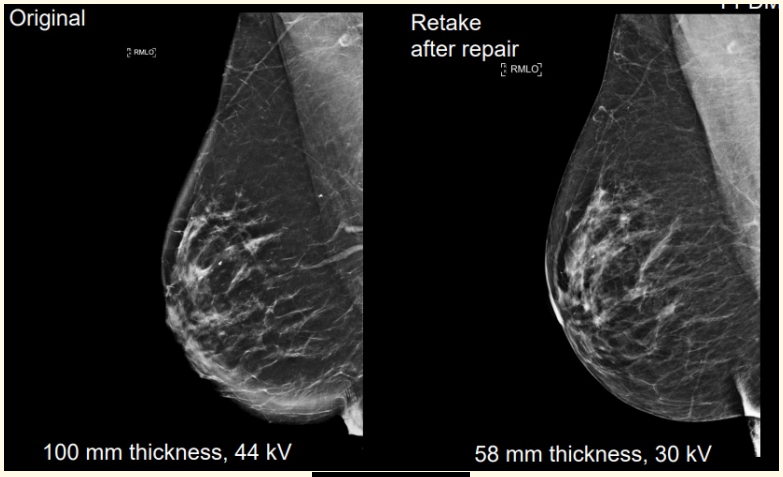


21

Image Processing Artifact

- Cause:
  - Error in skin line image processing clips tissue in the image
- Solution:
  - Adjust sensitivity of skin line detection algorithm

22

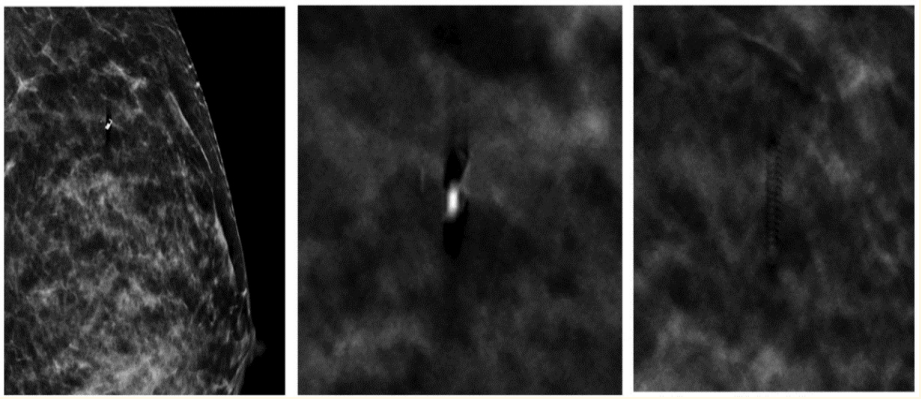


23

Image Burnout Artifact

- Cause:
  - Error in compressed breast thickness readout resulted in high kVp selection and detector burnout
- Solution:
  - Recalibrate compressed breast thickness readout

24



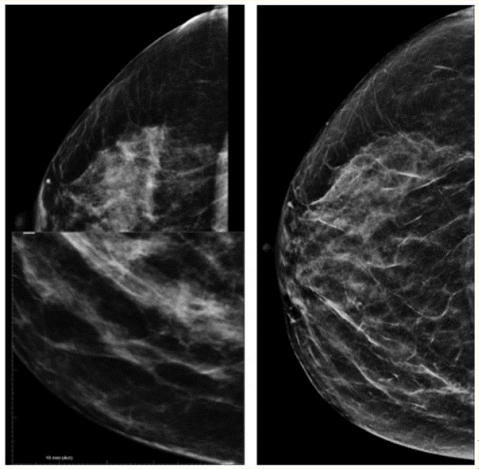
Tirada, et. al., Digital Breast Tomosynthesis: Physics, Artifacts, and Quality Control Considerations, Radiographics, Vol. 39 (2)

25

Blurring-ripple Artifact

- Cause:
  - Replications of high attenuation objects (e.g. metallic clips, course microcalcifications)
  - Blurring on out-of-plane images and, therefore, remain visible on out-of-plane slices in the direction of the x-ray tube sweep.
  - # ripples = # projections
- Solution:
  - Use of metal reduction post-processing (if applicable)

26



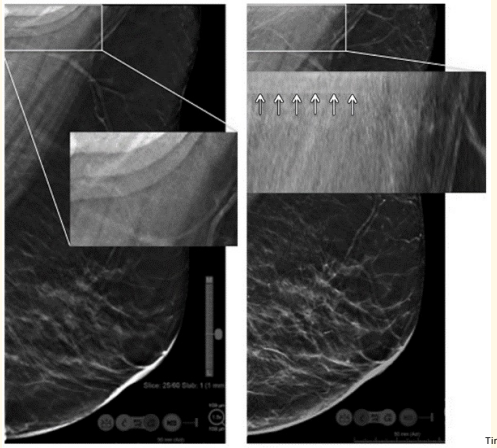
Tirada, et. al., Digital Breast Tomosynthesis: Physics, Artifacts, and Quality Control Considerations, Radiographics, Vol. 39 (2)

27

Motion Artifact

- Cause:
  - Patient movement, inadequate compression, overly long exposures, or poor positioning technique
- Solution:
  - Ensure adequate compression, proper positioning, exposure times adequate

28

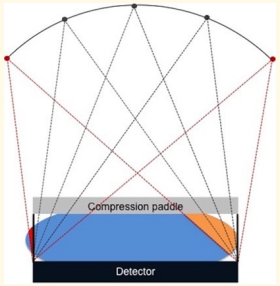


Tirada, et. al., Digital Breast Tomosynthesis: Physics, Artifacts, and Quality Control Considerations, Radiographics, Vol. 39 (2)

29

Truncation Artifact

- Cause:
  - Limited angular range and detector size results in breast tissue at the detector edges to not be within the reconstructed volume
  - Most evident in MLO views
- Solution:
  - Larger detector sizes can minimize this artifact
  - Improvements in reconstruction algorithms help



Tirada, et. al., Digital Breast Tomosynthesis: Physics, Artifacts, and Quality Control Considerations, Radiographics, Vol. 39 (2)

30

FAQ #1 – Radiation Safety

- Hey, I'm pregnant! Is it OK for me to still do mammos or should I take a "desk job"?
  - Very little scatter received by anyone within the control booth
  - Time, distance, shielding
    - Small exposure time, ~ 1-2 m away from breast, 0.5 mm Pb glass
  - Dose to fetus is negligible
    - Any radiation that penetrates the control booth window, falls incident on the skin, penetrates through the body to be absorbed by the fetus is ~ 0 (not distinguishable)
    - HARPA Reg. 543 – maximum exposure to member of the public → 0.1 mGy/week

31

FAQ #2 – Radiation Safety

- Should I ditch my thyroid shields to the land of Oz or listen to Dr. Oz?
  - ditch it!
  - ~ 0.04 mGy total (screening exam)
    - FYI: You receive 0.01 mGy of background radiation daily
  - Shields are cumbersome and interfere when positioning patients and may be seen in images
    - May also cause increase in repeats (overall higher dose to breast)

https://w3.aapm.org/media/releases/LeadApronsMammographyResponse.php

32

FAQ #3 – Radiation Safety

- Dr. Google tells me that getting a mammogram means getting radiation. Isn't radiation harmful?
  - Justification, optimization, and protection
  - Patient's exam is medically justified (referring physician)
  - The system is configured to deliver only the necessary radiation to the breast necessary for achieving a specific level of necessary image quality
  - Yes, the breast is receiving radiation, but the technologist implements many aspects to mitigate that potential risk
    - Compression, use of AEC, appropriate positioning
  - The risk is really theoretical.
  - The anticipated benefits to the patient from a necessary diagnostic imaging substantially outweigh any potential radiation effect.

https://www.aapm.org/org/policies/details.asp?type=PP&id=3615

Key Points

- Artifacts may result from either the technology itself, the patient, or the MRT
- Some artifacts may actually interfere with interpretation
  - QC mitigates this
  - Team approach with radiologists, MRTs, and medical physicists
- When an artifact is identified, YOU are the first line of defense to decide whether or not to proceed:
  - With the exam
  - Notifying the radiologist
  - Notifying the medical physicist
  - Deciding whether or not to call service
- Mammography uses much lower radiation for patients than do other DI modalities (e.g. general radiography, CT)
  - This, along with other factors (i.e. adequate compression, regular QC checks, etc.) significantly reduces the dose the patients and hence the scatter radiation to you as the MRT inside the room and behind the control booth
- We will eventually see different types of artifacts once more AI-based reconstruction types eventually come out in the field…stay tuned!

Contact Information

(416) 779-9674
jf@jfmedphys.com
www.jfmedphys.com

Questions?