Beth Schueler, Ph.D. Mayo Clinic Rochester

THE ART OF THE IMAGE IN MAMMOGRAPHY Artifacts In 2D And 3D Breast Imaging: Their Origin, Presentation, And Remediation

AAPM Spring Clinical Meeting 2018

# What will be covered:

2D FFDM
 Tomosynthesis
 Contrast-enhanced

Contrast-enhance spectral mammography



# Artifact Presentation

In clinical images
In flat field artifact QC test
In ACR phantom images



# FFDM-2D Artifacts



## Cause:

Detector readout malfunction, failure of switching gate lines

- Resolution:
  - Replace detector



## Cause:

 Dead pixel cluster resulting in charge build-up affecting signal in neighboring pixels

- Resolution:
  - Replace detector



## • Cause:

### Dead pixel

• Troubleshoot by re-imaging phantom in a different location on the detector or perform an artifact test

Dead pixels may be either minus or plus signal

## Resolution:

Map out dead pixel (service function)

# **Dead Pixel Removal**

 Map is created that replaces the specified pixel value with the average of surrounding pixels

- Manufacturer test method
  - Uniform phantom
  - Acquire image with typical clinical technique
  - View image with specified W/L
  - Repeat for different anode/filters and mag mode



Zoom and pan image looking for artifacts
 Use ROI utility if available

14	Cine					
	Tools	Notices	Comm	ents	Service	ROI
	ROI					
		Mean		= 3	311.02	
		Mean	*	= 2	261.02	
		Std		= 5	57.25	
		SNR*		= 4	4.56	
		Min		= 4	19	
		Max		= 3	360	
		DC Of	ffset	= 5	50	
	Loc	cation(	X,Y)	= (	186,25	8)
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- 2016 ACR Digital Mammography QC Manual
  - Artifact evaluation part of phantom IQ test



- W/L to optimize visualization of test objects
- View as entire phantom
- View as full resolution (1 display pixel = 1 image pixel)
- Repeat for other anodes/filters, mag mode





## Cause:

• Dead pixel cluster with averaging correction applied

## Resolution:

- Adjust pixels included in the averaging correction in the dead pixel map (service function)
- If cluster is large, replace detector



## Cause:

- Debris embedded in MammoPad breast cushion attached to phantom
  - Troubleshooting: If an artifact moves with the phantom, debris on phantom or wax insert is likely
- Resolution:
  - Replace MammoPad





## Cause:

 Debris on phantom during gain calibration resulting in a plus density artifact

## Resolution:

- Recalibrate detector
  - Ensure phantom and detector cover are clean
  - Carefully review flat field images acquired during gain calibration



## • Cause:

Dead line in detector

## Resolution:

Map out dead line (service function) or replace detector

# **Dead Line Artifact Detection**

- Image mesh at 45 deg angle (screen-film contact test tool)
- Corrected dead lines are visible as discontinuities in mesh





# Dead Pixel/Line Specification

## DirectRay Detector

- < 80 defective clusters (contiguous dead pixels)</li>
- < 20 defective lines (gate line or source half-line)
  - No adjacent defective gate lines
  - No more than 2 adjacent defective source half-lines
- < 3397 defective pixels</p>





## • Cause:

- Intermittent electromagnetic interference
- Resolution:
  - Eliminate cause of interference
    - Replacement of the high voltage supply resolved this particular case
    - Other references attribute artifact to
      - cooling fans (Ayyala et al, Radiographics 2008)
      - external magnetic fields from an adjacent transformer (Jiang et al, AAPM 2017)





## • Cause:

• Degradation of detector array coating

## • Resolution:

Replace detector

![](_page_30_Picture_0.jpeg)

## • Cause:

## Ghosting

- Residual image of the previous exposure is visible
- Direct conversion detector has reduced x-ray sensitivity in areas of high exposure
- Occurs especially with high technique factors

## Resolution:

- Increase time interval between images
- Modify detector refresh rate

# **Ghost Image Evaluation Test**

![](_page_32_Picture_1.jpeg)

Wait 1 min between exposures

# Ghost Image Evaluation Test Ghosting index = (S<sub>3</sub>-S<sub>1</sub>)/(S<sub>1</sub>-S<sub>2</sub>) Should be < 0.3</li>

![](_page_33_Figure_1.jpeg)

![](_page_34_Picture_0.jpeg)

## Cause:

- Visible grid
  - High transmission cellular (HTC) grid was stationary for a portion of the exposure
  - Intermittently seen in clinical images
- Resolution:
  - Service to the bucky mechanism resulted in consistent grid movement

![](_page_36_Picture_1.jpeg)

## • Cause:

- Visible HTC grid during gain calibration
- Grid stationary during a portion of the exposure

## Resolution:

 Service adjustment of exposure timing to eliminate exposure when grid is stationary at end of travel

![](_page_38_Picture_1.jpeg)

## • Cause:

 Debris on filter, included in gain calibration, then shifted slightly

## Resolution:

Clean debris off filter, repeat gain calibration

![](_page_40_Picture_0.jpeg)

## Cause:

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

![](_page_42_Picture_0.jpeg)

![](_page_43_Picture_0.jpeg)

![](_page_43_Picture_1.jpeg)

Original

100 mm thickness, 44 kV

## • Cause:

 Error in compressed breast thickness readout resulted in high kVp selection and detector burnout

## Resolution:

 Recalibrate compressed breast thickness readout

# **CR** Artifacts

![](_page_46_Picture_0.jpeg)

## • Cause:

• Debris or defect on CR imaging plate

## Resolution:

- Clean imaging plate using method recommended by manufacturer
- If artifact cannot be removed, replace imaging plate

# Tomosynthesis (DBT) Artifacts

![](_page_49_Picture_0.jpeg)

## Cause:

- Artificial low density surrounding high density objects along the scan direction ("halo" artifact)
- Due to limited angular range in acquisition sweep

## Resolution:

- Various reconstruction algorithm modifications have been proposed to reduce appearance
  - Based on removing high contrast object from the projection images prior to reconstruction, then adding back into slice images

![](_page_51_Picture_1.jpeg)

Ref: Wu et al, Med Phys 2006

## • Cause:

- Out-of-plane high contrast object is visible as "zipper" artifact along the scan direction
- Caused by limited angular range in acquisition sweep
- Resolution:
  - Same solutions as halo artifact reduction

![](_page_53_Picture_0.jpeg)

Ref: Zhang et al, Med Phys 2007 DBT

## • Cause:

 Limited angular range in acquisition sweep results in "staircase" artifact at the edge of reconstruction field

## Resolution:

Same solutions as halo artifact reduction

![](_page_55_Picture_0.jpeg)

False calcifications on a 2D image synthesized from tomosynthesis slices

- Cause:
  - Overlapping dense ligaments in slice images combine to appear as calcifications
- Resolution:
  - Modification of 2D image synthesis algorithm

# Contrast-enhanced Spectral Mammography (CESM) Artifacts

# **CESM Method**

![](_page_58_Figure_1.jpeg)

![](_page_59_Picture_0.jpeg)

![](_page_59_Picture_1.jpeg)

Low Energy 28-32 kVp Rh or Ag filter High Energy 45-49 kVp Cu filter

Subtraction image

#### CESM

#### Low energy image

![](_page_60_Picture_2.jpeg)

#### Subtraction image

![](_page_60_Picture_4.jpeg)

#### Reference: Bhimani et al, Acad Rad 2017

## Cause:

- Patient motion between the low and high energy exposures
- Resolution:
  - Motion more likely due to dual exposure method. Adequate compression and patient instruction needed.

![](_page_62_Picture_0.jpeg)

Reference: Bhimani et al, Acad Rad 2017

## Cause:

- Iodine contrast splattered on breast tray
  - Iodine visible on high E image only, appears white on subtracted image
  - Note that calcifications appear dark on subtracted image

## Resolution:

 Disconnect power injector from patient away from the mammography unit. Wipe breast tray and paddle before imaging.

# Conclusions

- Artifacts may mimic or mask image detail in mammograms
- Becoming familiar with potential artifacts

   their appearance, cause and
   resolution is helpful for image quality
   optimization

## References:

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