THE ART OF THE IMAGE: IDENTIFICATION AND REMEDIATION OF IMAGE ARTIFACTS IN MAMMOGRAPHY

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INTRODUCTION

- Screen Film Mammography
  - Processor Related
  - Technologist Related
  - Equipment Related
  - Patient Related
- Digital Mammography
  - Detector Related
  - Processing Related
  - Equipment related
  - Patient Related

LEARNING OBJECTIVES

1. Have a renewed appreciation for the variety of causes and presentation of imaging artifacts in mammography.
2. Learn techniques to assist in the investigation of imaging artifacts.
3. Discover online educational resources to continue their education on image artifact presentation and remediation.

THE STORY

- Identification of the artifact
- Trouble shooting
- Resolution – if known

IMAGE QUALITY: WHO IS RESPONSIBLE?

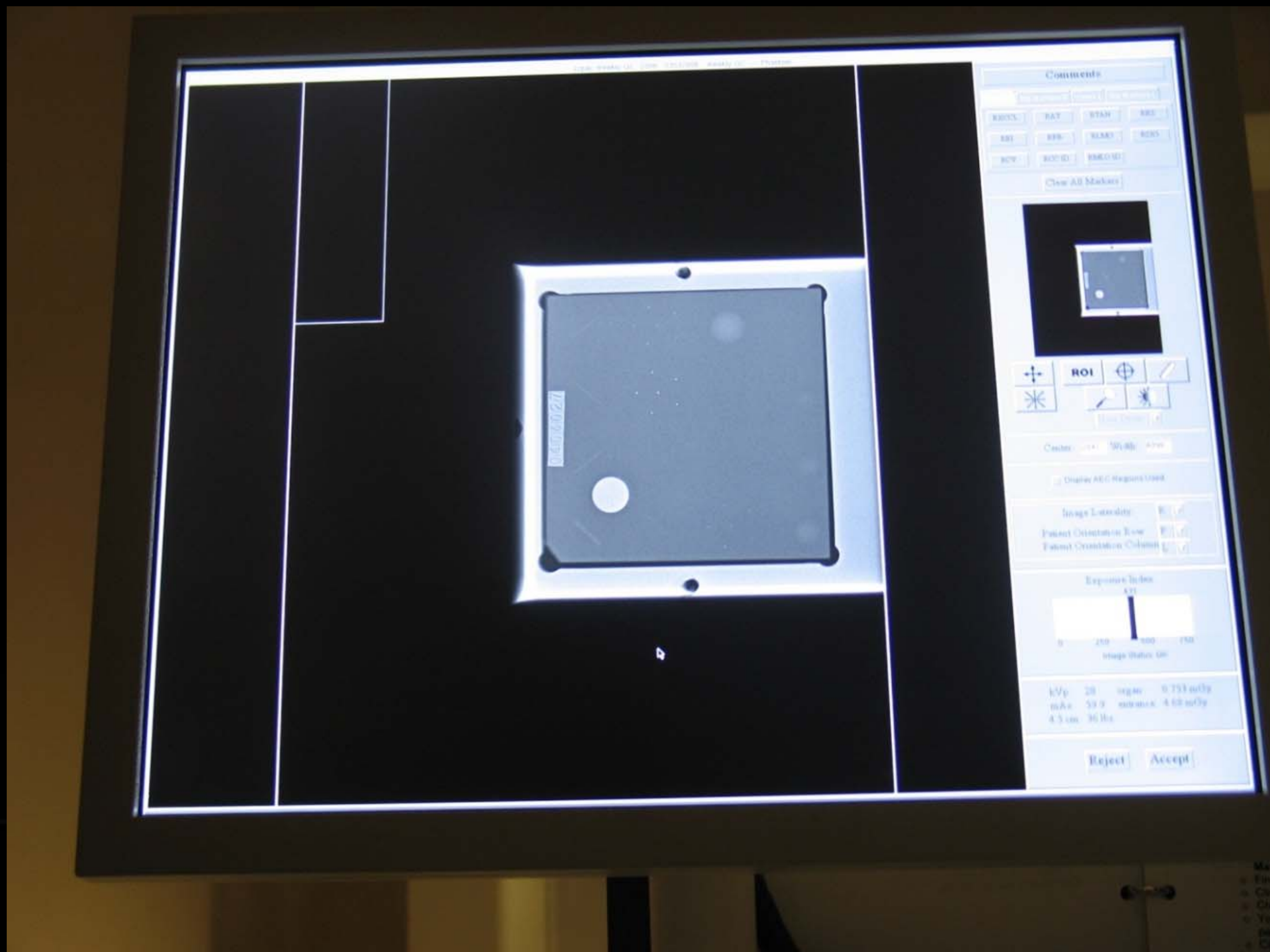
- Technologist
  - Film Screen
  - Digital (FFDM, CR)
- Radiologist
  - Film Screen
  - Digital
- Medical Physicist
  - Film Screen
  - Digital

TECHNOLOGIST

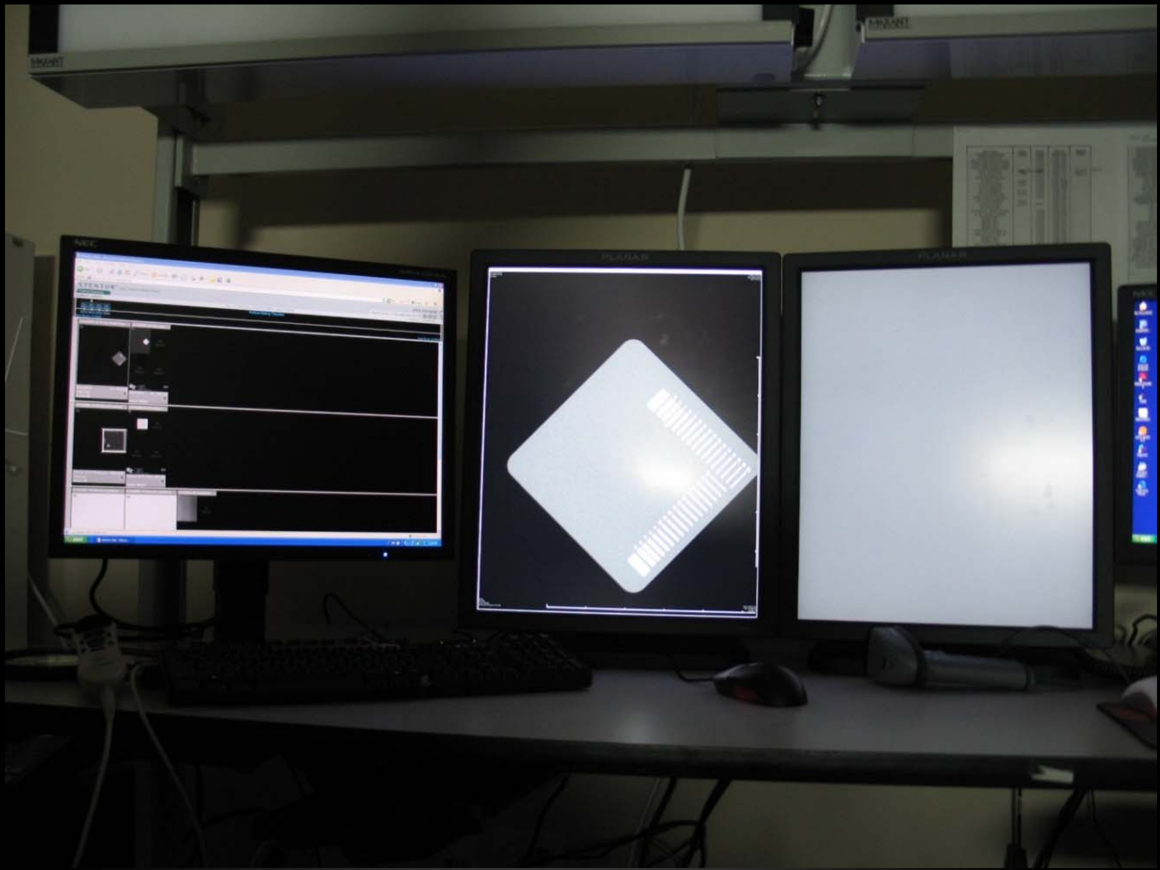
- Film Screen
  - Overall image quality check
    - Positioning
    - Blurring
    - Artifacts
  - Turn in mostly artifact free images to radiologist
- Digital
  - First look
    - Positioning
    - Large scale and easily visible artifacts

FILM ON VIEW BOX

TECHNOLOGIST DIGITAL IMAGE DISPLAY



RADIOLOGIST DIGITAL DISPLAY



MEDICAL PHYSICIST

- Film Screen
  - Annual testing
  - Help with processor problems
  - View boxes and viewing conditions
- Digital
  - Quantification of artifacts
    - Processing
    - Detector related

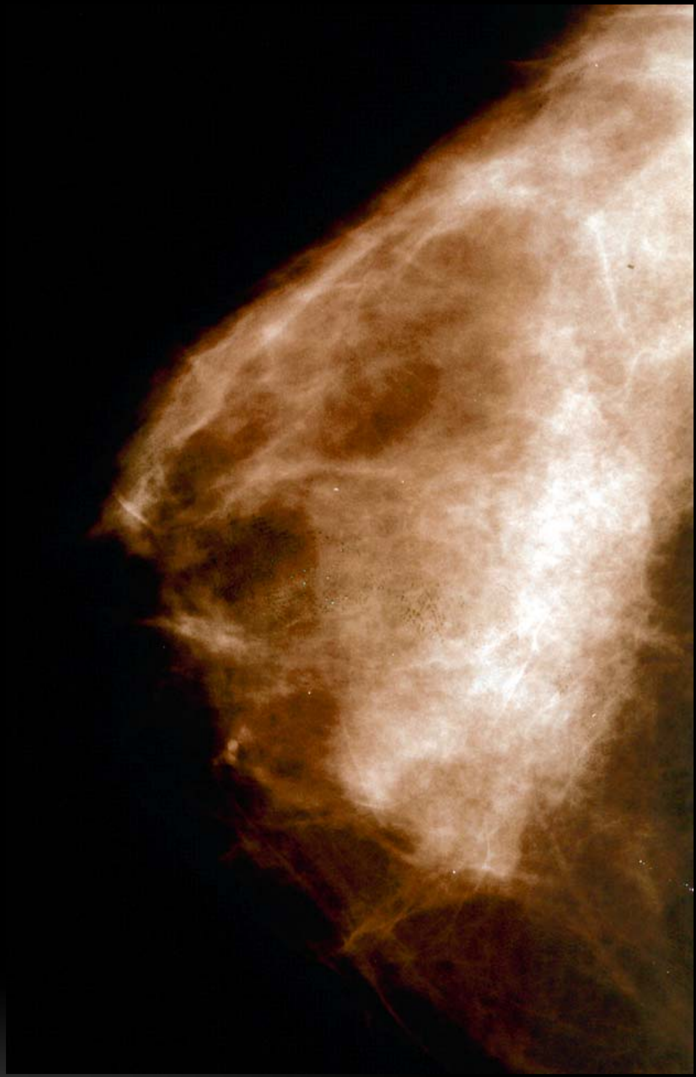
BASIC FILM SCREEN ARTIFACTS

- Processor
- Technologist
- Mammographic Unit
- Patient

PROCESSOR RELATED ARTIFACTS

- Fixer Retention
- Scratches
- Static

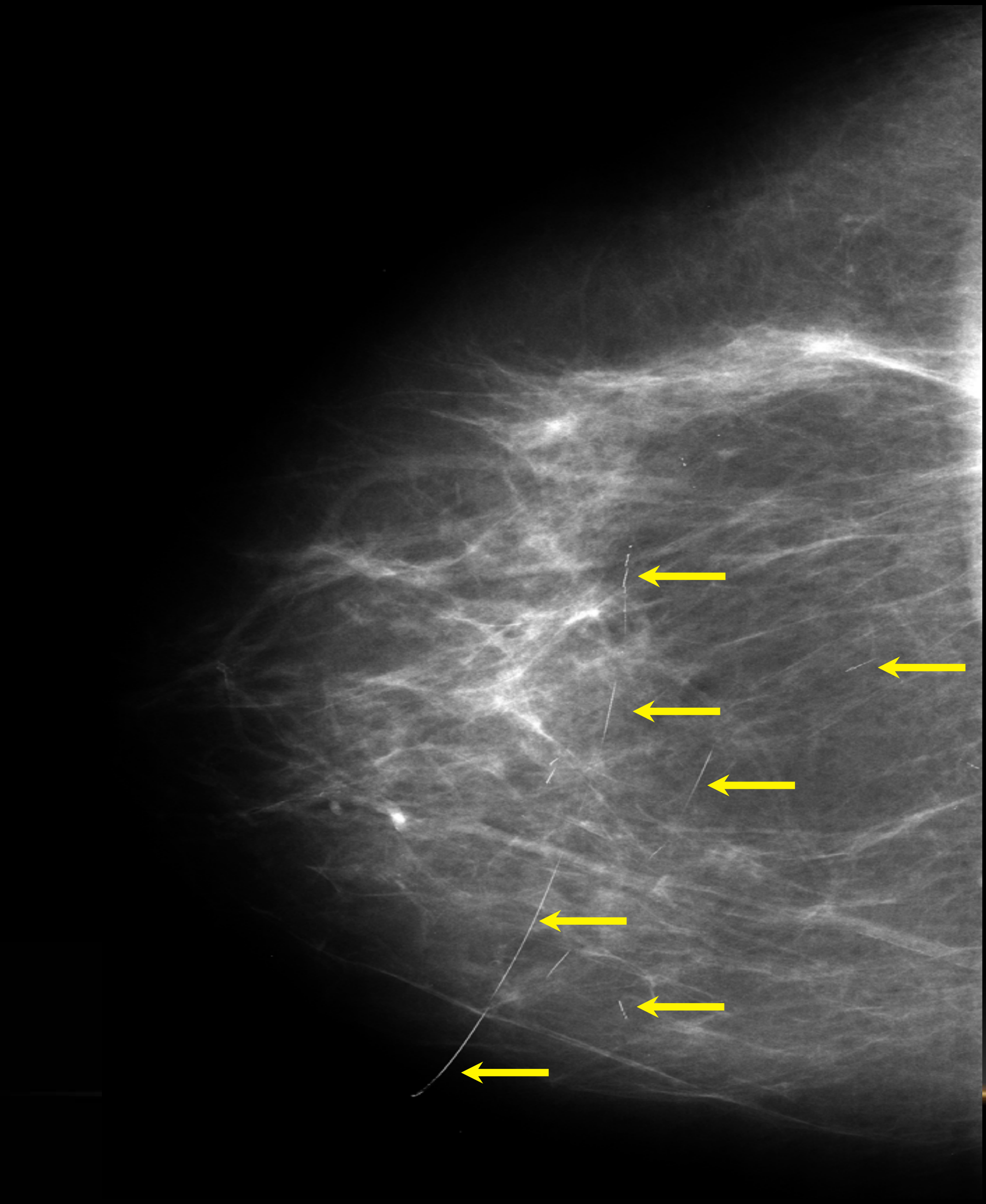
This incompletely fixed film is browned.



FILM DISCOLORATION

Film discoloration may result from incomplete or improper fixation.

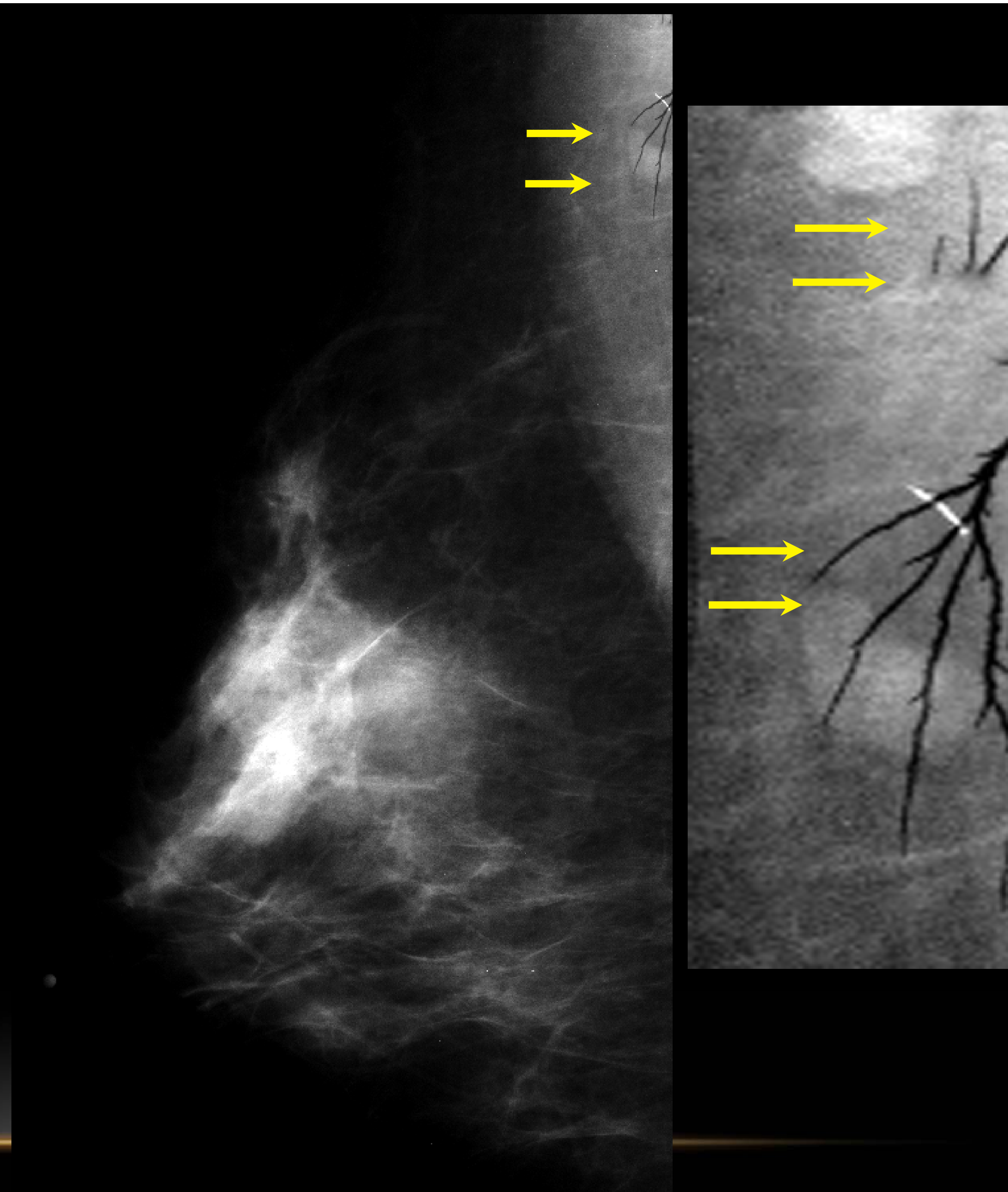
Loss of circulation in the fixer tank, improperly mixed fixer, a low amount of fixer, or low fixer temperature may cause incomplete or improper fixation.



Scratches

Scratches and scrapes may result from dirty or worn rollers, incorrect tension on the drive chains, improperly positioned crossover rollers, misaligned guide shoes, improper alignment of the film on the feed tray, improperly mixed processor chemicals, or a deficient replenishment rate. Wedding rings, long fingernails are also causes of film scratches.

Lightning-like static artifact .



- Static artifact may result from low humidity, under-replenishment of processor chemicals, improper film handling, or improper electrical grounding of the processor. Extremely dry air in the area may also be a cause.

TECHNOLOGIST – FILM HANDLING

- Improper loading
- Cassette cleaning
- Finger Prints
- Scratches

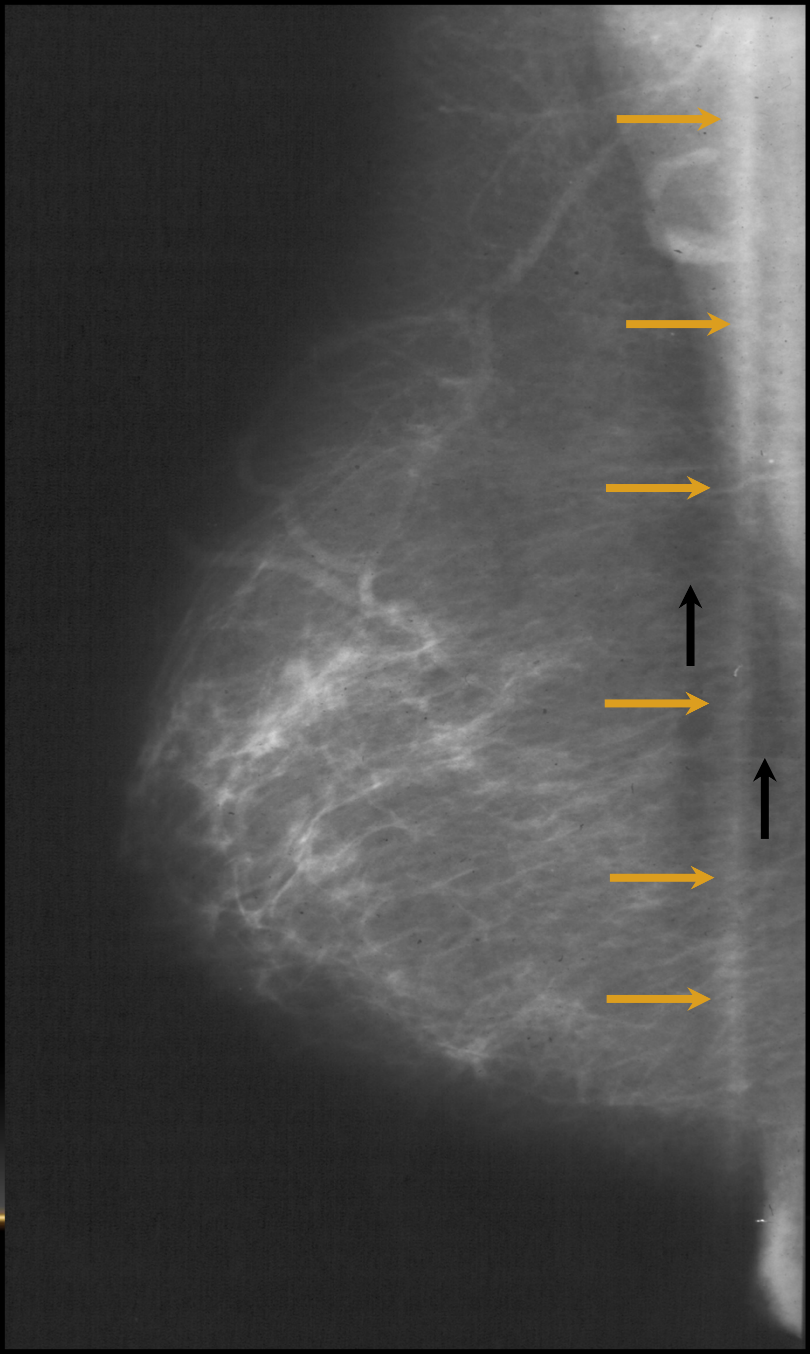
Improper loading of films or cassettes into the mammography unit is a common cause of mammographic artifacts.

Accidental loading of two films into the same cassette will result in an underexposed silhouette of the breast .

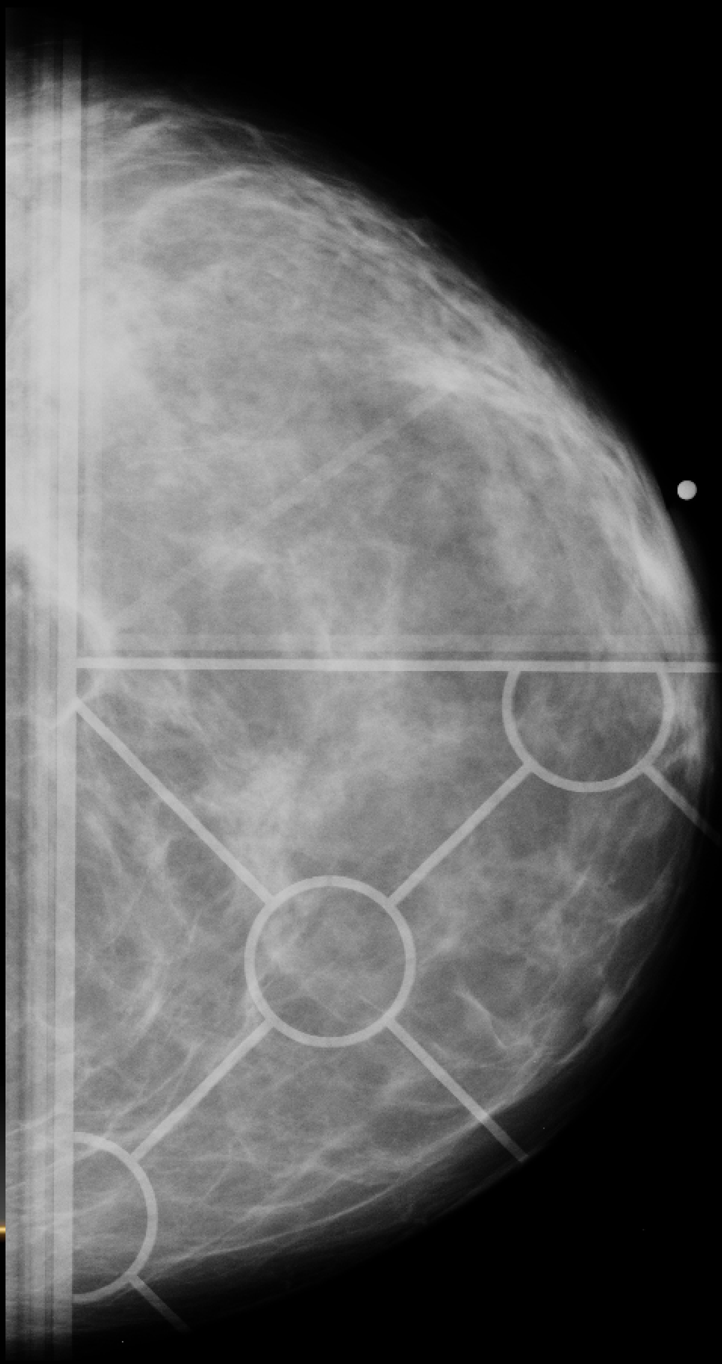
A film that is folded inside the cassette will have an underexposed area with a linear crease artifact and an adjacent area of poor screen-film contact .

This underexposed image is the result of having two films in the same cassette.

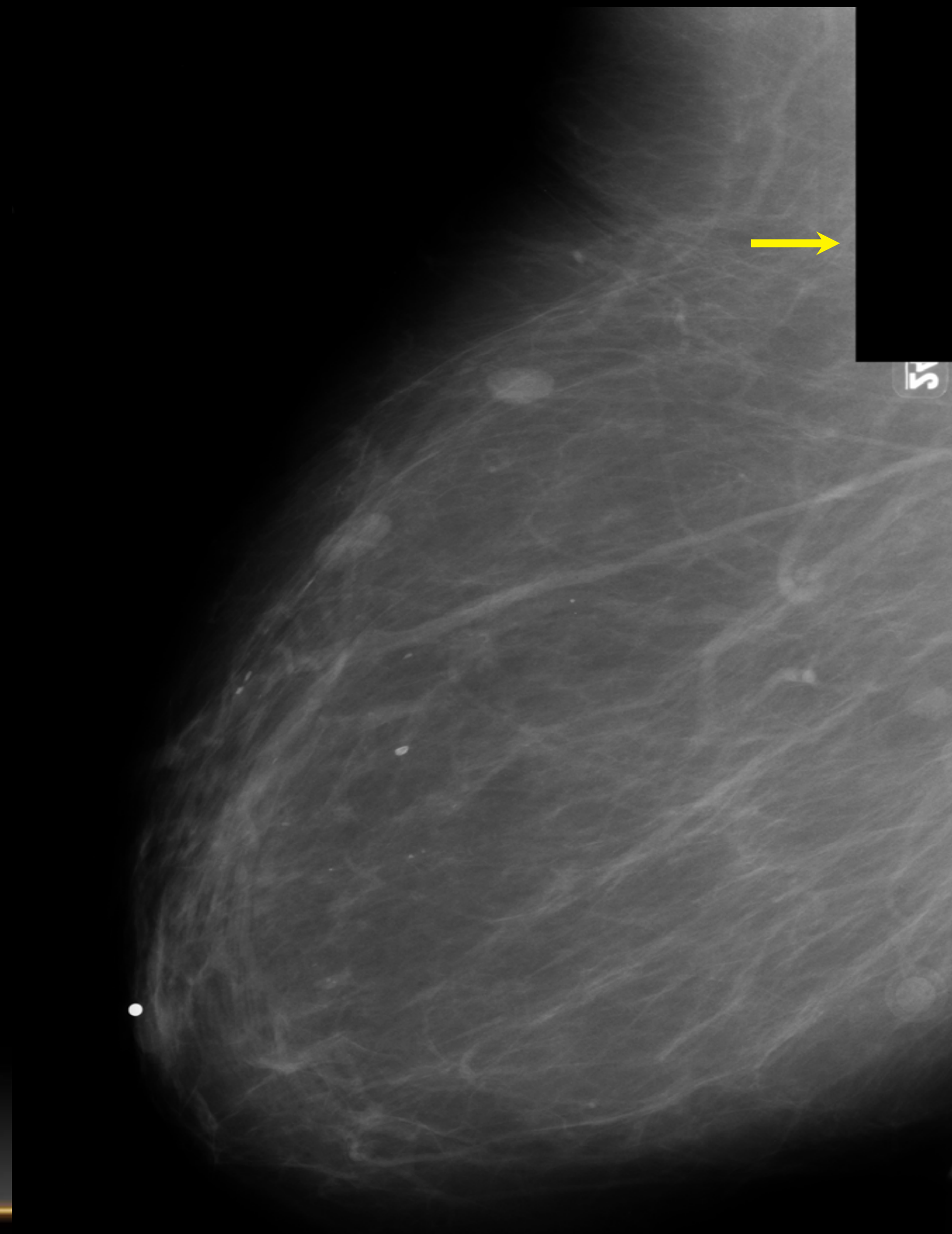
Linear crease artifact (black arrows) and adjacent poor screen-film contact (orange arrows) result from the film being folded in the cassette.

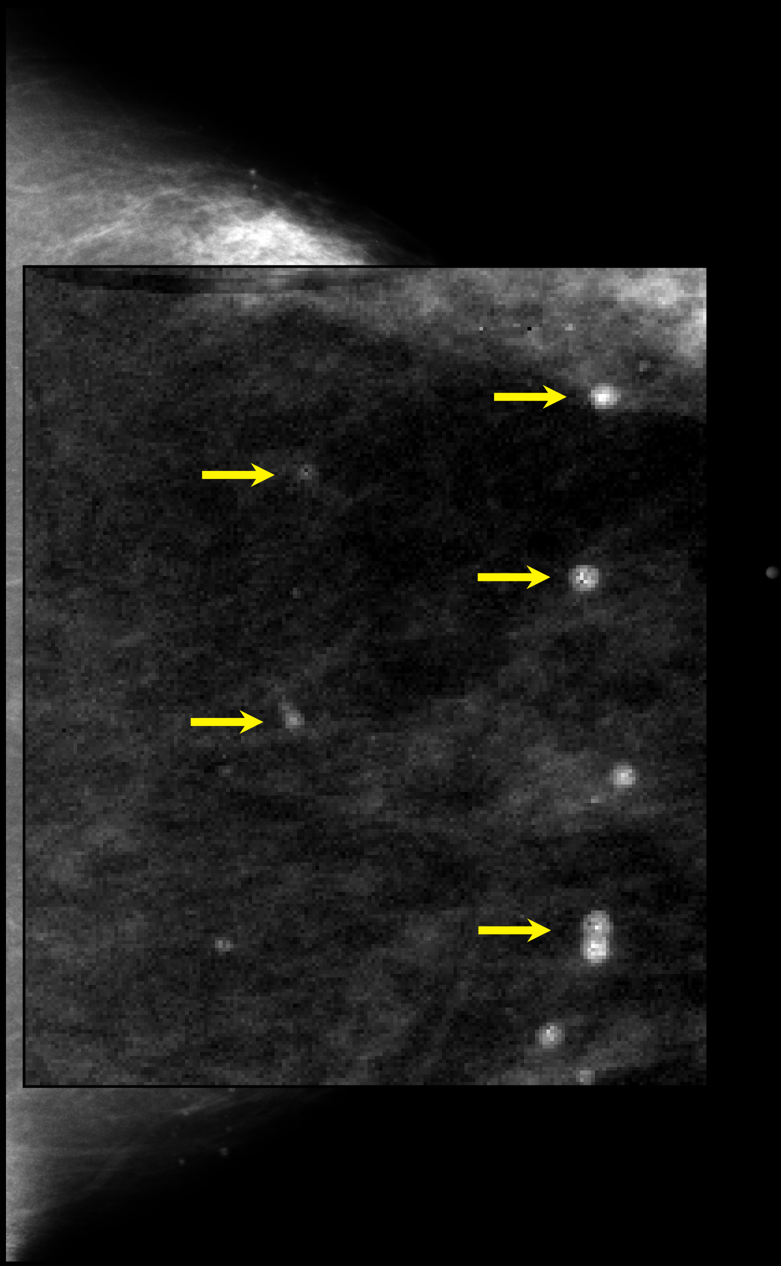


The internal structure of the cassette is superimposed on the image when the cassette is loaded upside-down into the Bucky tray.



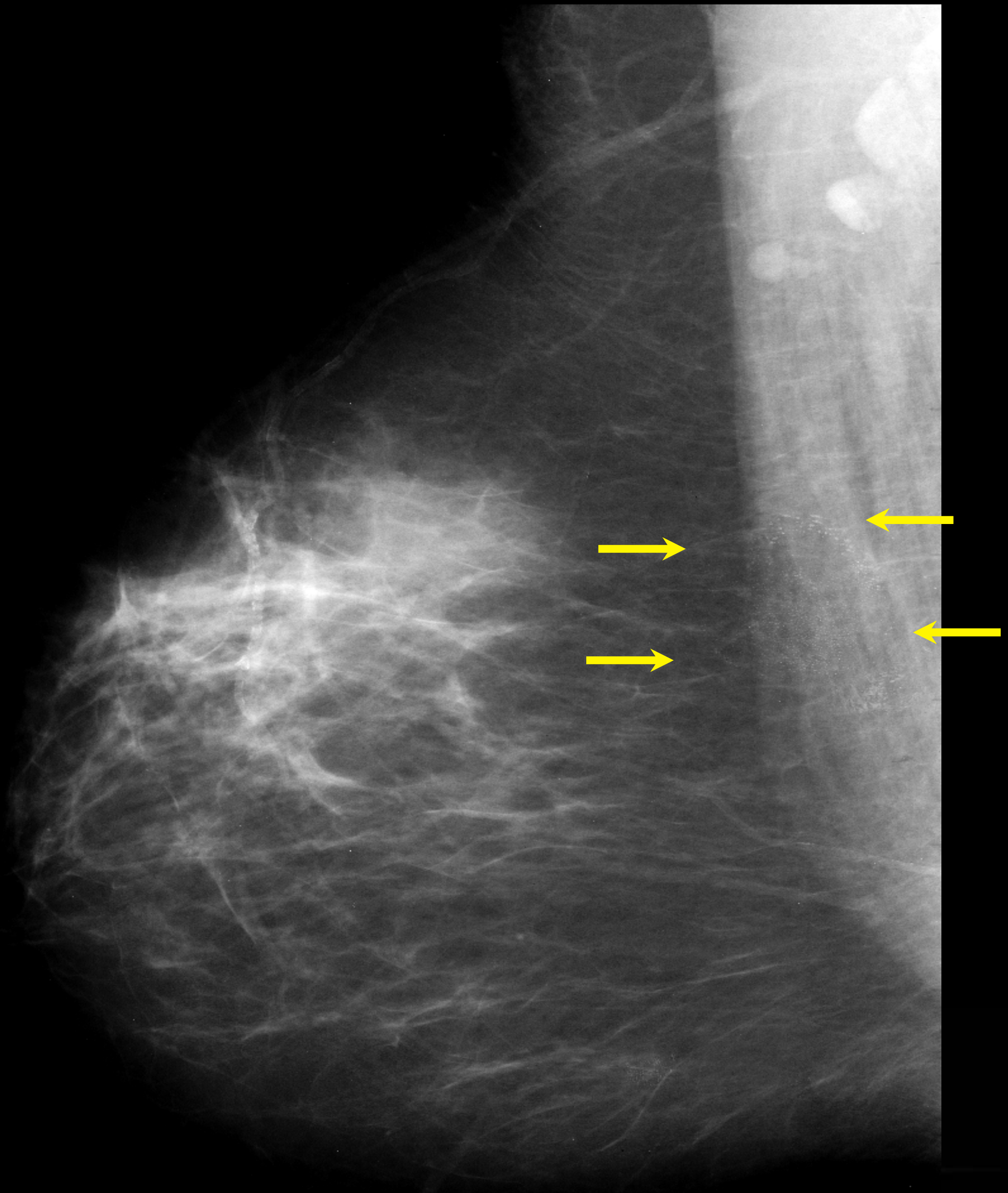
The identification flash (arrow) is super-imposed over the breast when the cassette is loaded in a front-back reversed fashion into the Bucky tray.

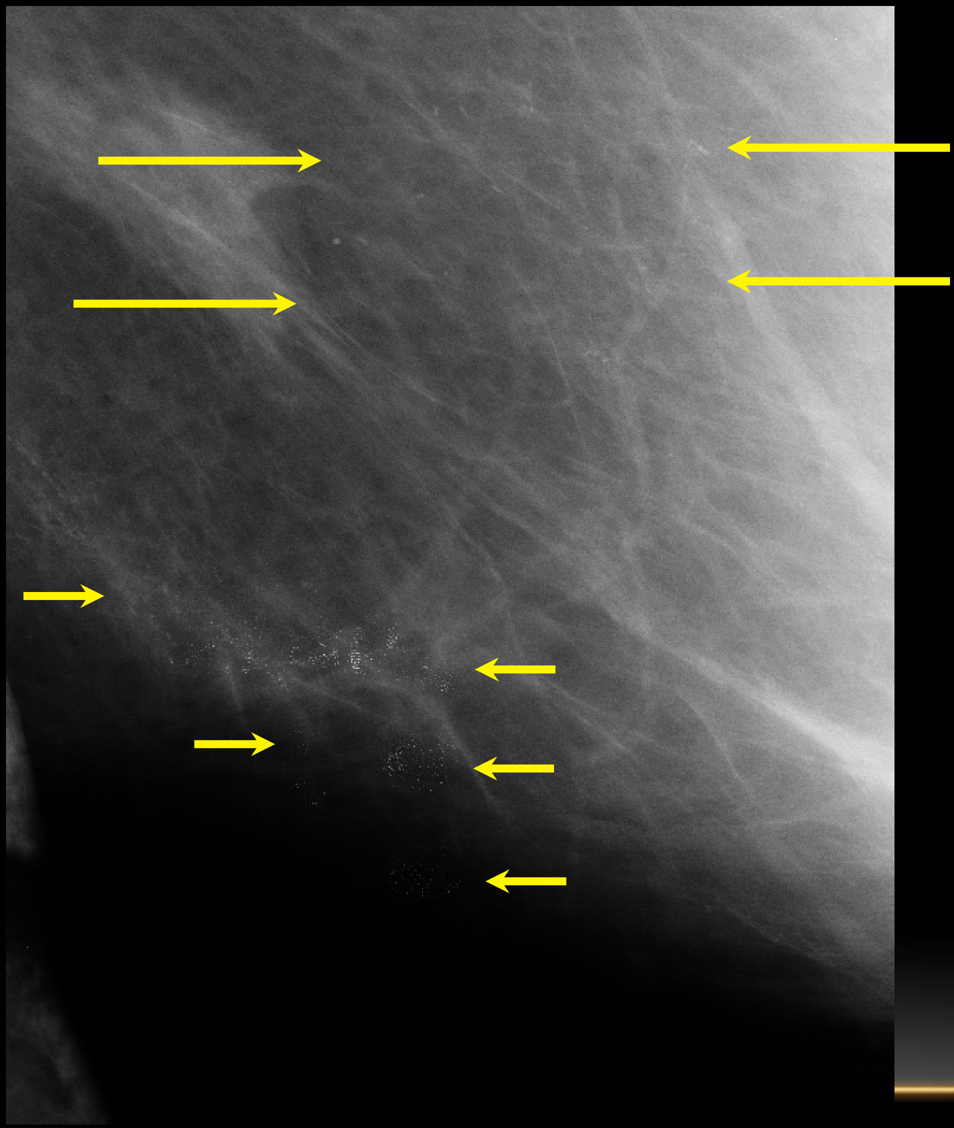




Cleaning solution artifacts (arrows).

Fingerprints (arrows).



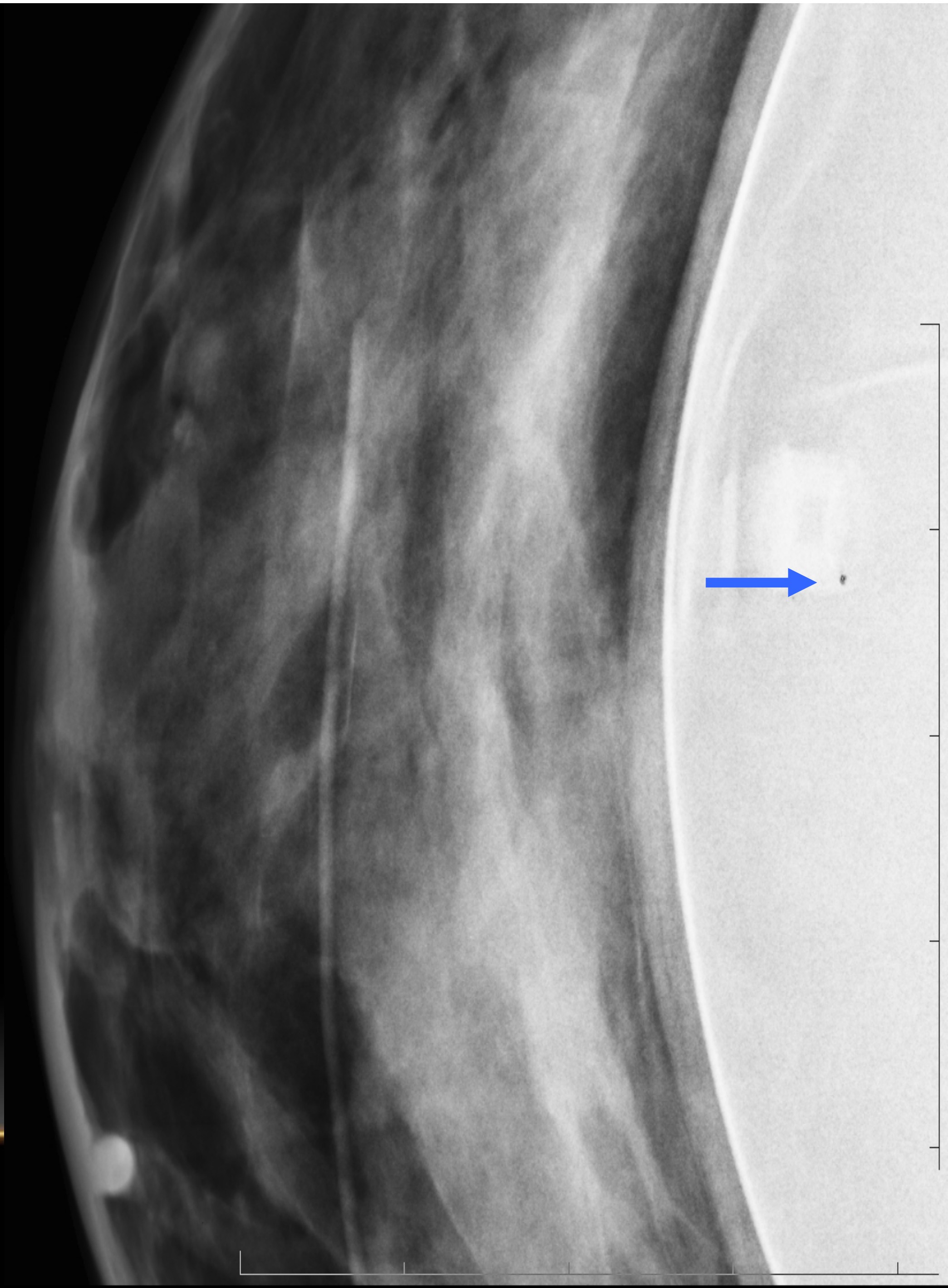


Fingerprints (short arrows) and calcifications (long arrows). Fingerprints can obscure detail when evaluating mammograms for calcifications.

ARTIFACTS IN DIGITAL MAMMOGRAPHY

- Detector based artifacts
- Machine based artifacts
- Patient related artifacts
- Processing and storage artifacts

- Dead pixel group projecting over an implant.



- The same dead pixel group seen in a standard LCC view.
- Individual dead pixels are mapped out by the service engineer.

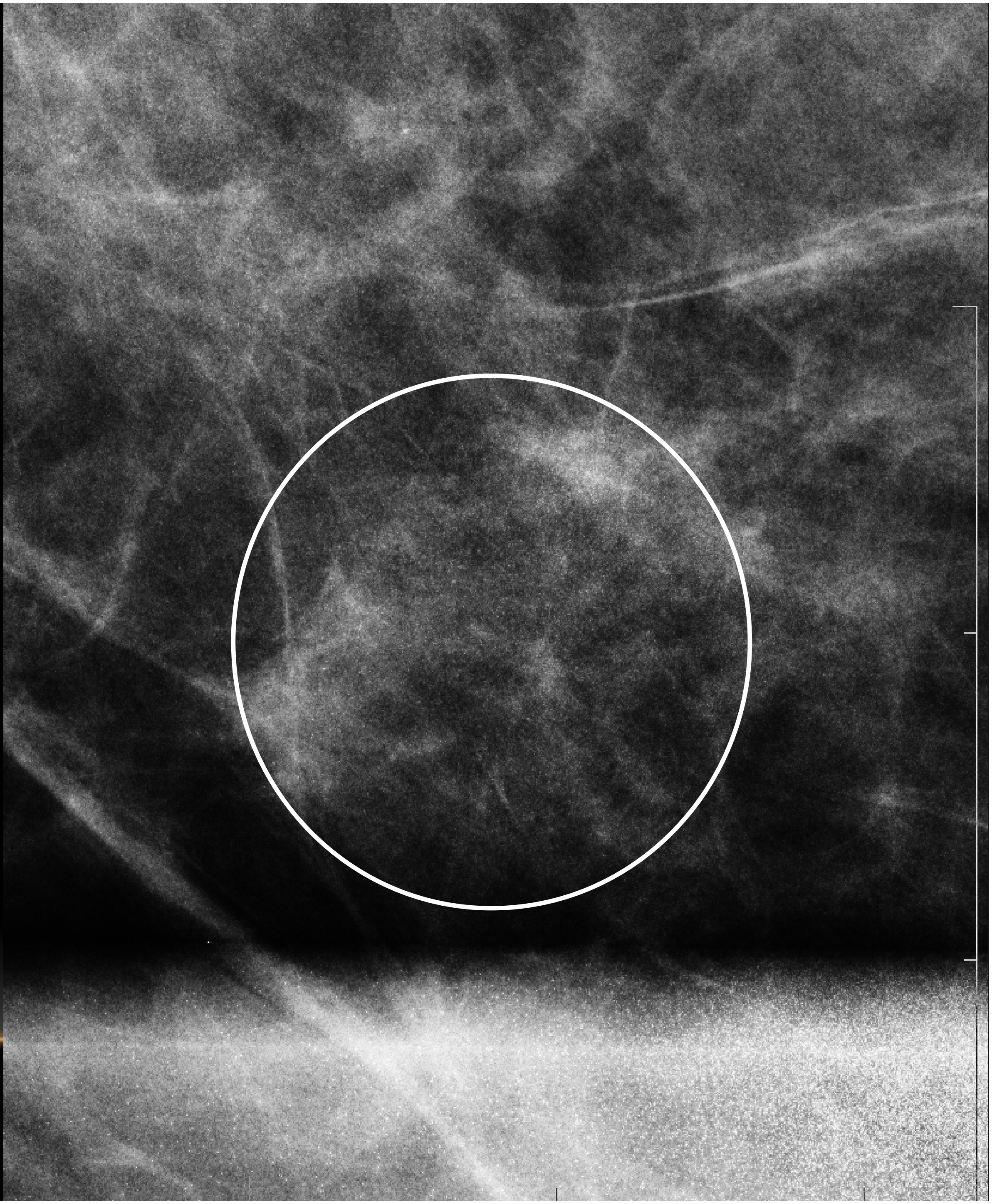
DEAD DETECTOR ELEMENT

- Not necessarily clinically significant
- Usually identified on weekly artifact evaluation images
- Requires service call to get detector element mapped out

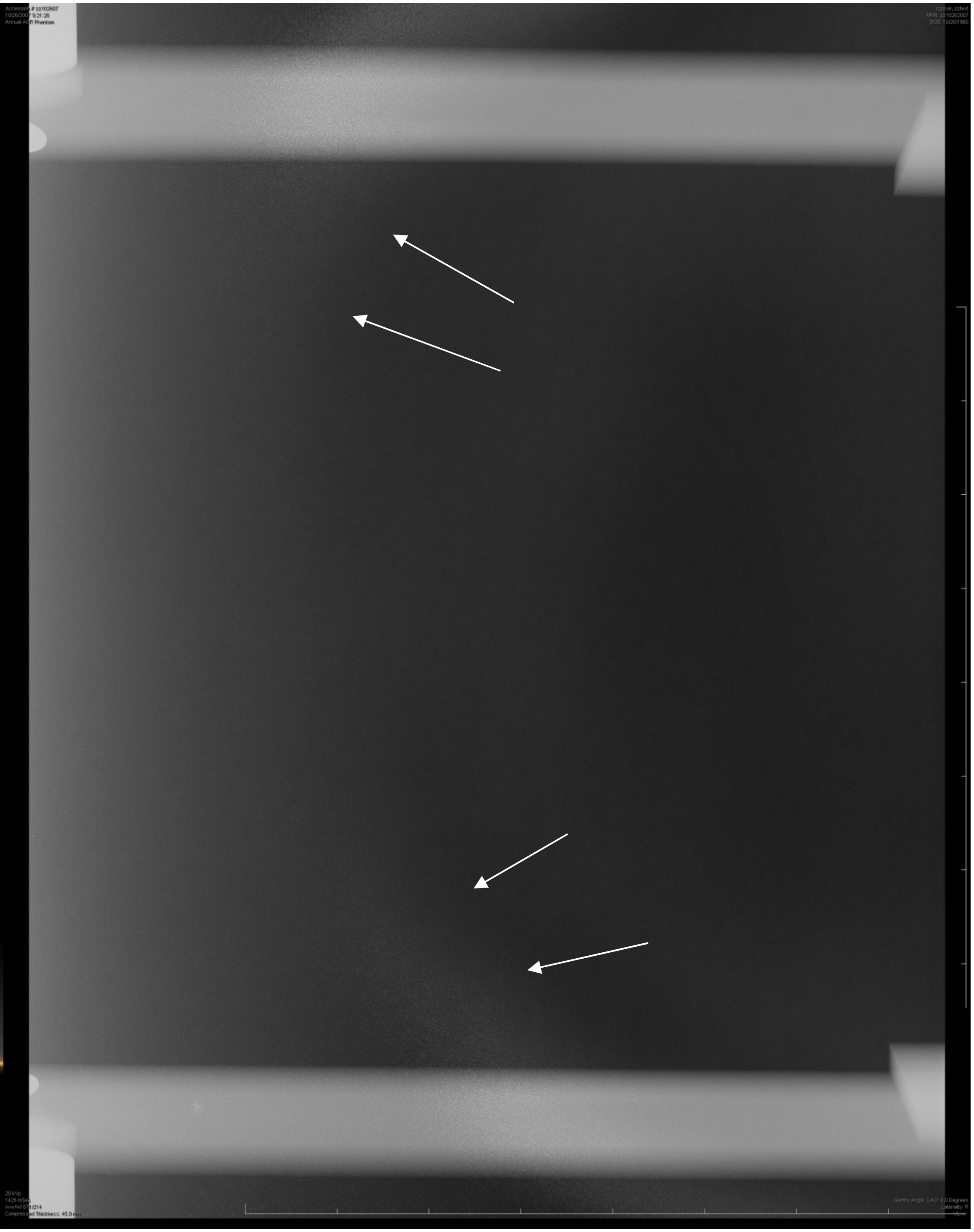
DETECTOR FAILURE

- As a detector gets damaged by exposure to radiation, pixels begin to be damaged and no longer operate properly. The following images show a detector at the end of its useful life. Note the many dead pixels and how they look like small scattered calcifications. Subsequent testing using a flat field phantom and the ACR accreditation phantom showed the damage to the detector. This detector was replaced.

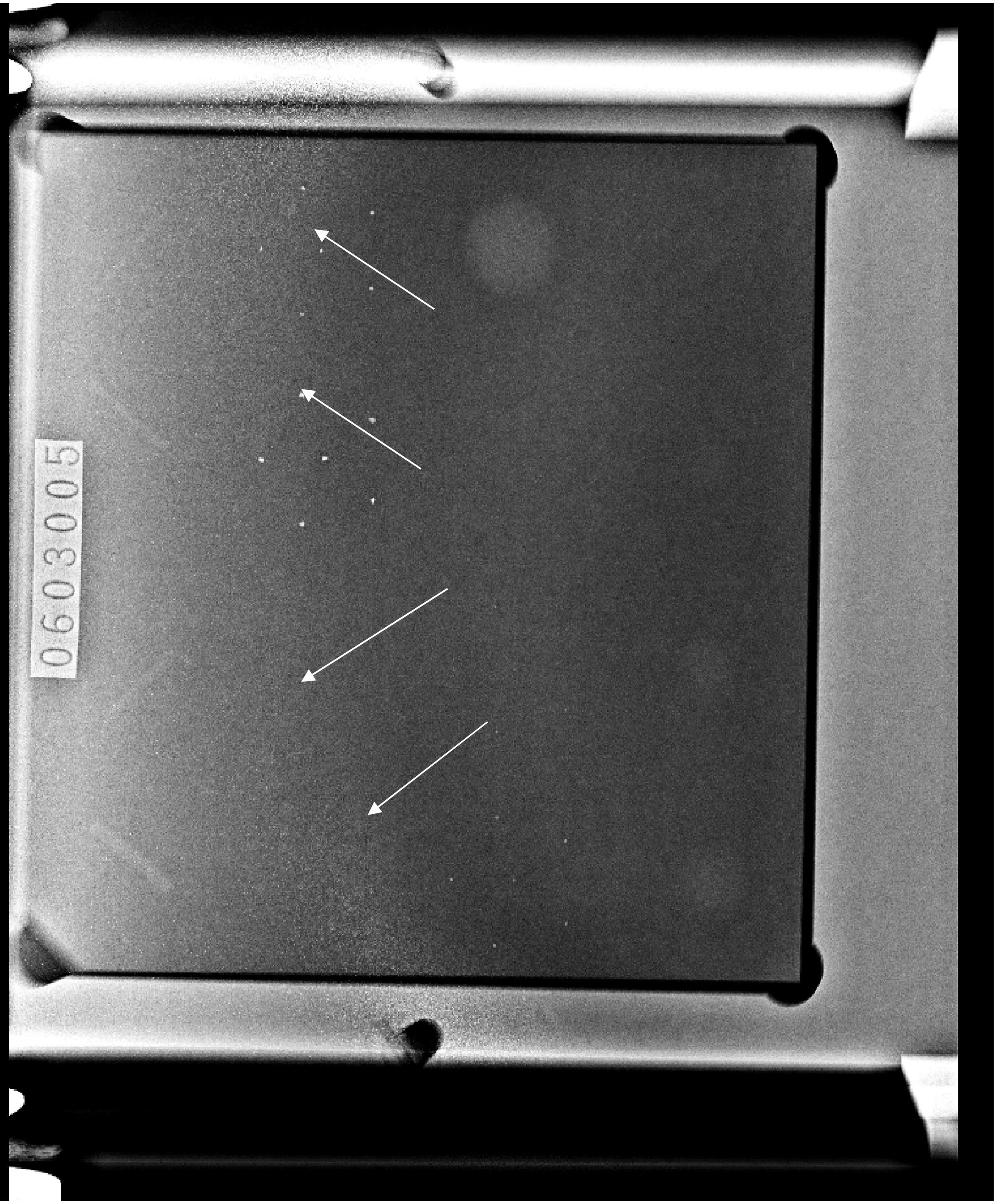
- FFDM detector failure showing large numbers of misread or dead pixels. These can look like clusters of micro-calcifications



Flat field image of a detector as it starts to fail. Note the white band of dead pixels.



- Magnification image of the ACR Accreditation phantom on a detector as it starts to fail. Note the white band of dead pixels.
- This room was taken out of service immediately and the detector replaced within a couple of days



DETECTOR FAILURE

- Many modes of failure
  - Dead lines
  - Inability to map out dead elements
- Usually requires intervention by service engineer
- Will require detector to be replaced

Failure of a line to read out during read out of the detector.

System corrected itself on repeat exposure.

DEAD LINES OR MISREAD LINES

- Technologist took image and noted an artifact
- Continued with exam
- Artifact disappeared on next image
- Retake of same projection was satisfactory
- Determined that gate line did not turn on
- Tech support had service engineer install new sequence file for readout

Banding Artifact

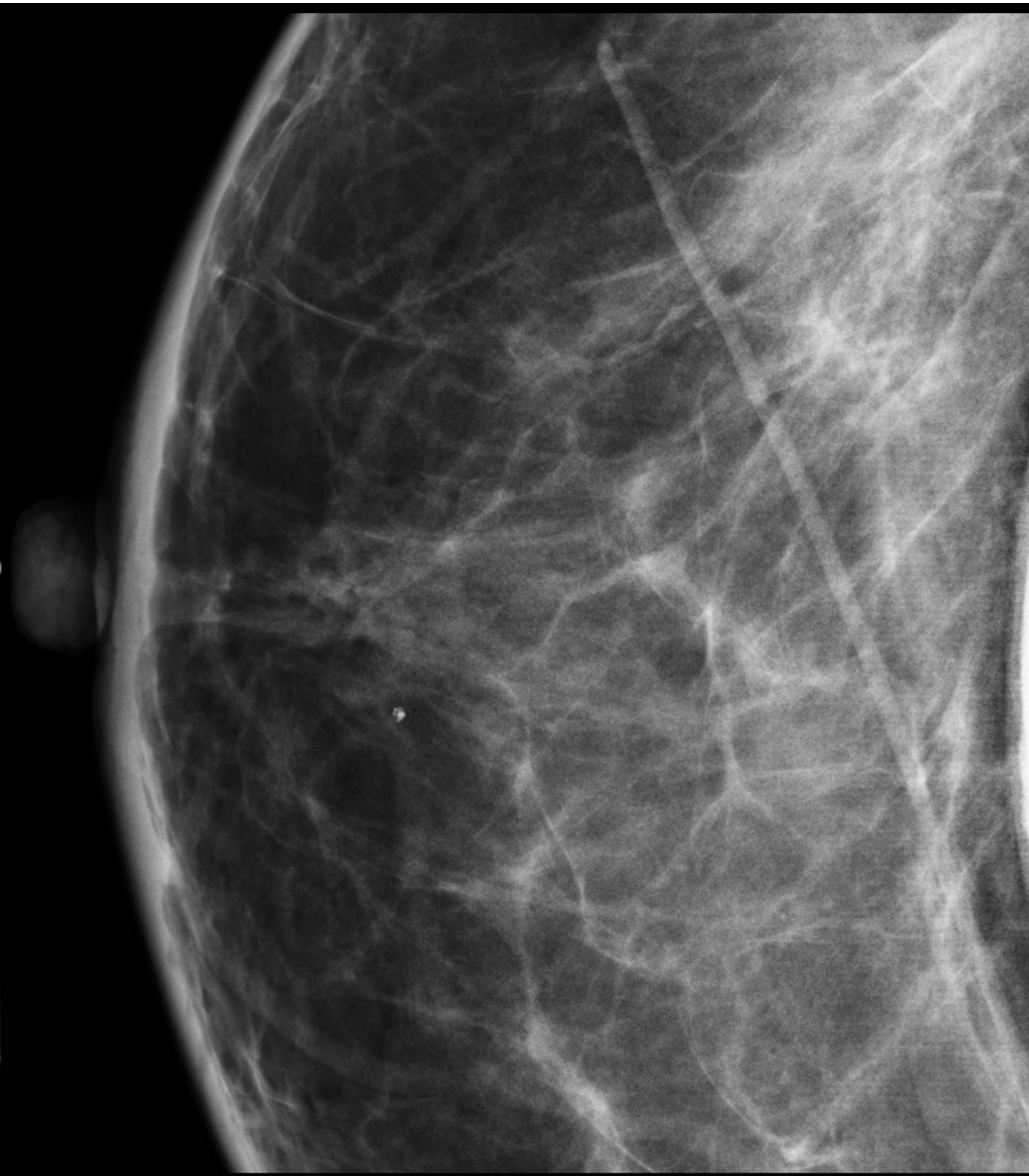
View: RCC

kVp: 29

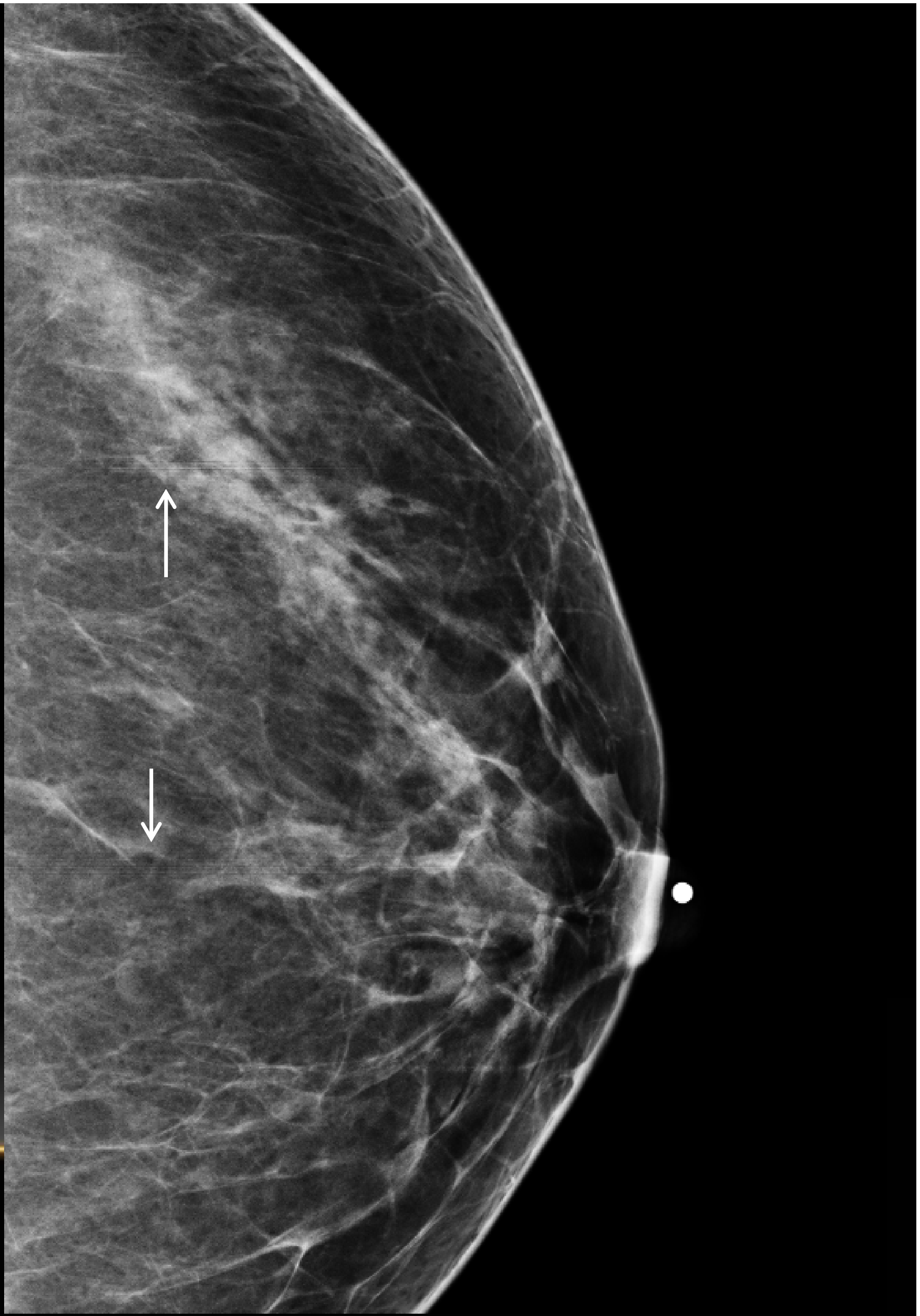
mAs: 65

Compressed Thickness: 7.9 cm

Compression Force: <10 lbs

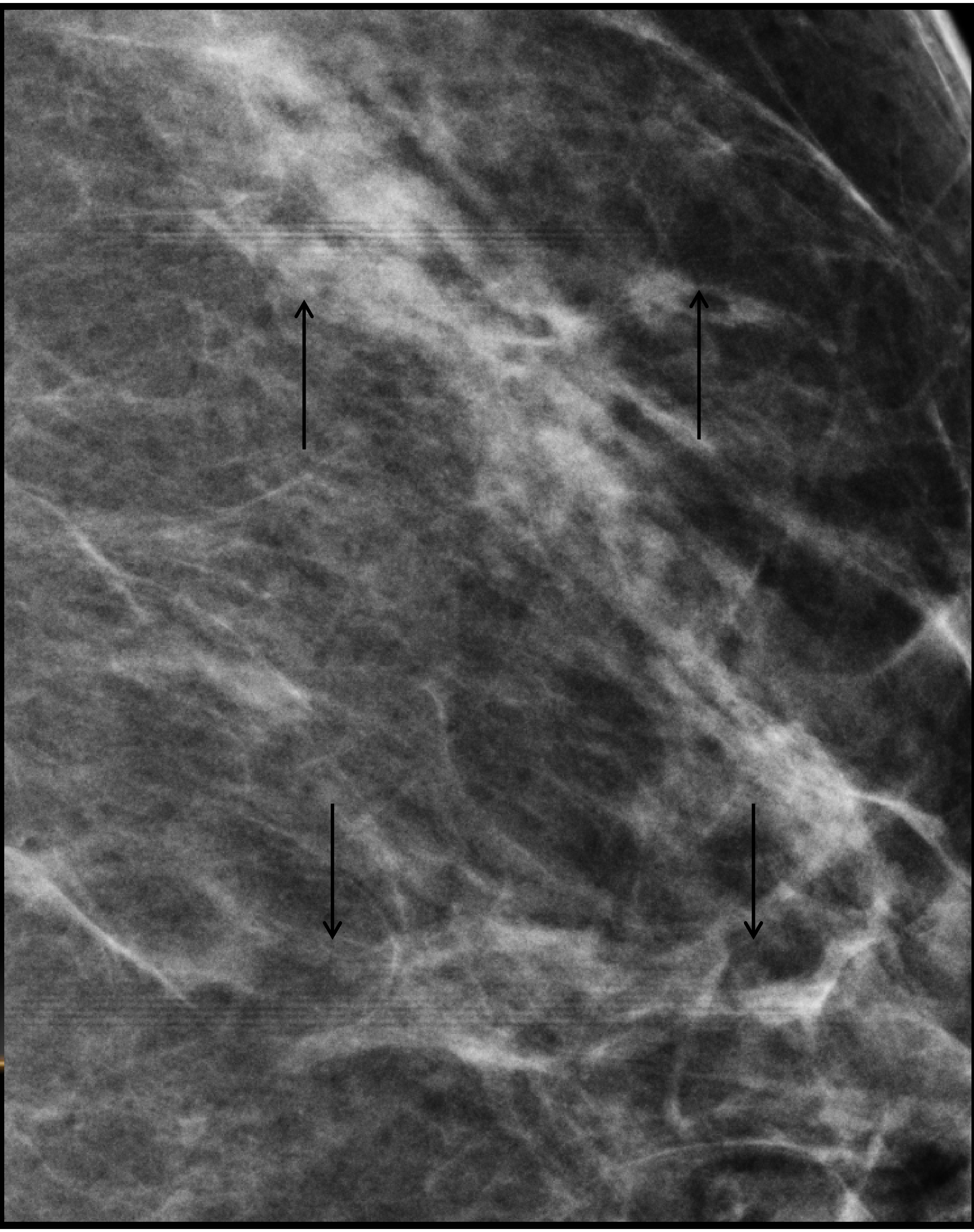


Tire Tracks



Tire Tracks

Caused by a shock to the detector during read out



BANDING ARTIFACT

Cause: According to Hologic this artifact is caused by either a shock to the detector during the readout phase or a problem with a mismatch between the frequency of the power supply for the detector and the readout of the detector.

The fix: if the artifact is not seen on multiple images and does not interfere with diagnosis nothing needs to be done immediately. We just watch that system more closely to see if it becomes a common occurrence. If it starts showing up more frequently say one image per day then we have the power supply for the detector replaced.

OTHER DETECTOR ARTIFACTS

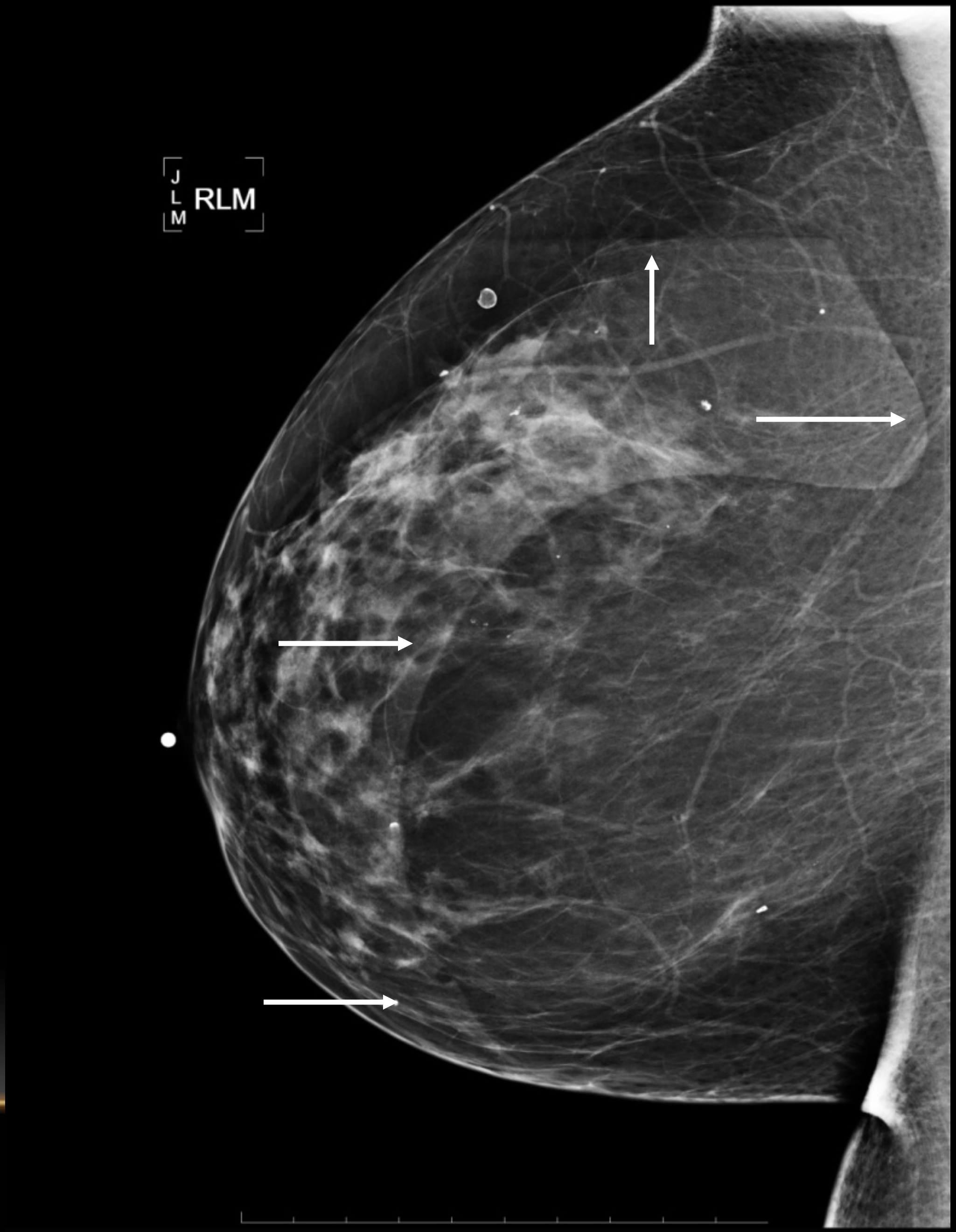
- Small dark spot
- Determined to be from detector
- Cannot be calibrated out
- Detector was replaced

GHOST IMAGE

- Selenium detector technology had ghosting problems
- Temperature of detector plays large part
- Ensure that detector is at proper temperature to prevent ghosting

Ghost of the previous MLO image is visible on this RLM.

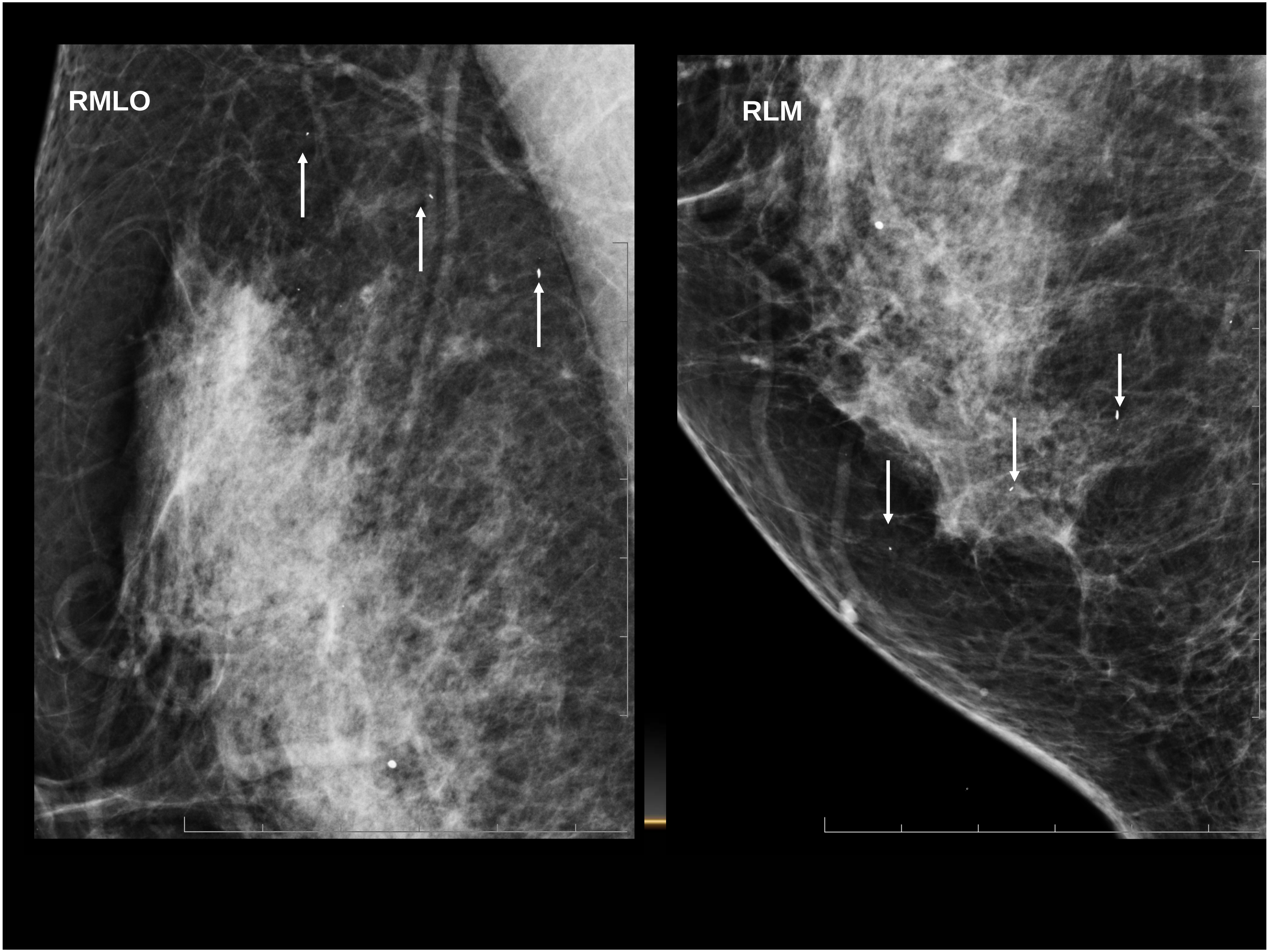
This ghost image was cause by incorrect detector temperature. Allowing the detector to warm up properly cleared the problem.



MACHINE BASED ARTIFACTS

Machine based artifacts are those artifacts that are related to components on the gantry but not part of the detector. Most of these artifacts come from dirt or dust on the compression paddle or problems with the tube filtration and the grid.

With digital systems, technique can also play a role in the look of the image. The image may process well and have the correct contrast and grey scale. But improper technique may cause high noise which may obscure small objects that need to be seen.



RMLO
RLM

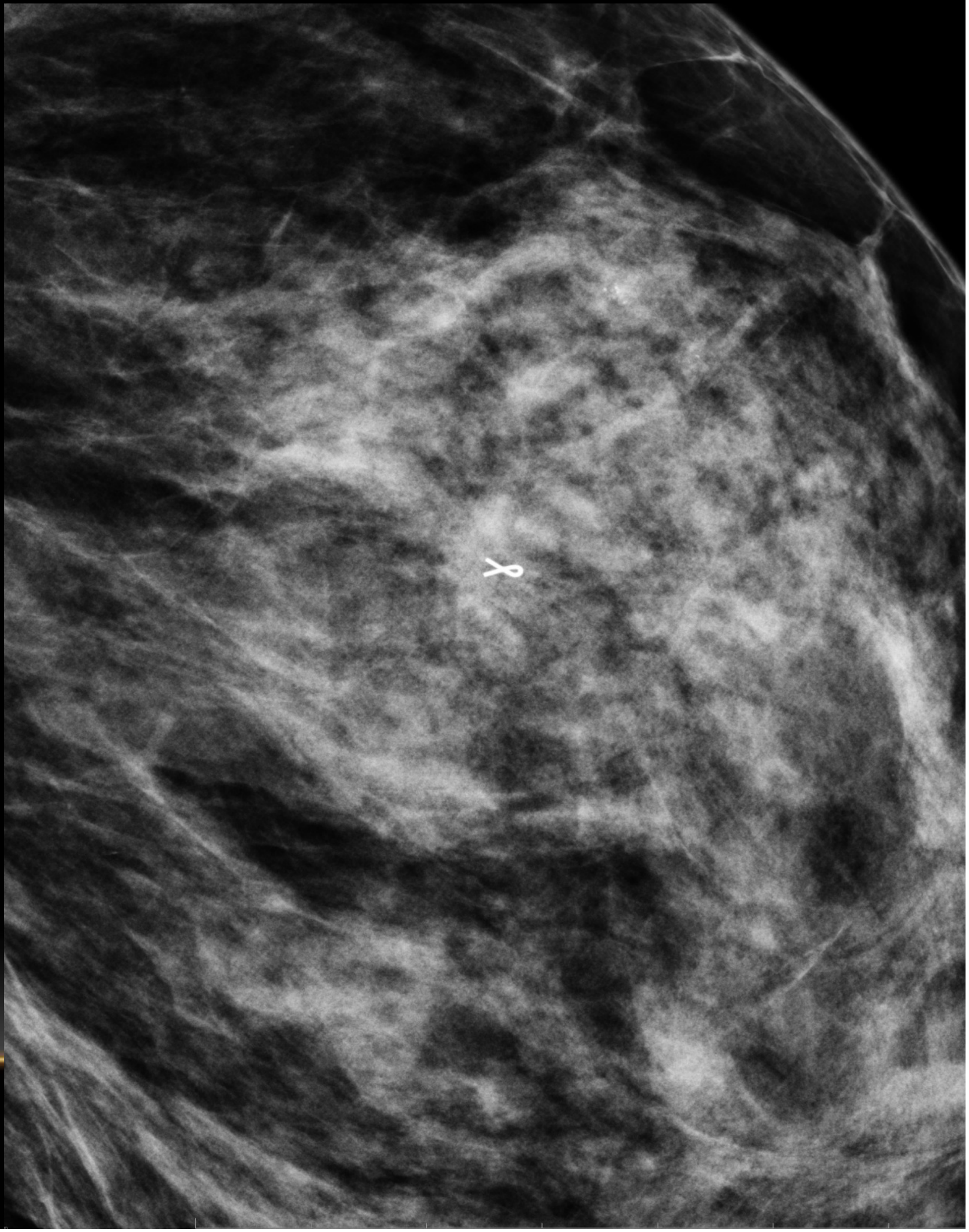
DUST OR DIRT ON COMPRESSION PADDLE

- Dust or dirt on the compression paddle may mimic calcifications or masses. Look for an artifact that is seen on two different images but in the same area of the detector (flipped and rotated).
- Regular cleaning of compression paddles will prevent this artifact

Gridlines on image (grid shadow)

These gridlines were caused by having the grid speed set incorrectly. This caused the grid to be stopped during the exposure, leaving the grid shadow on the image (cross hatch pattern in the region of the clip marker).

Required service call to have grid speed parameter reset



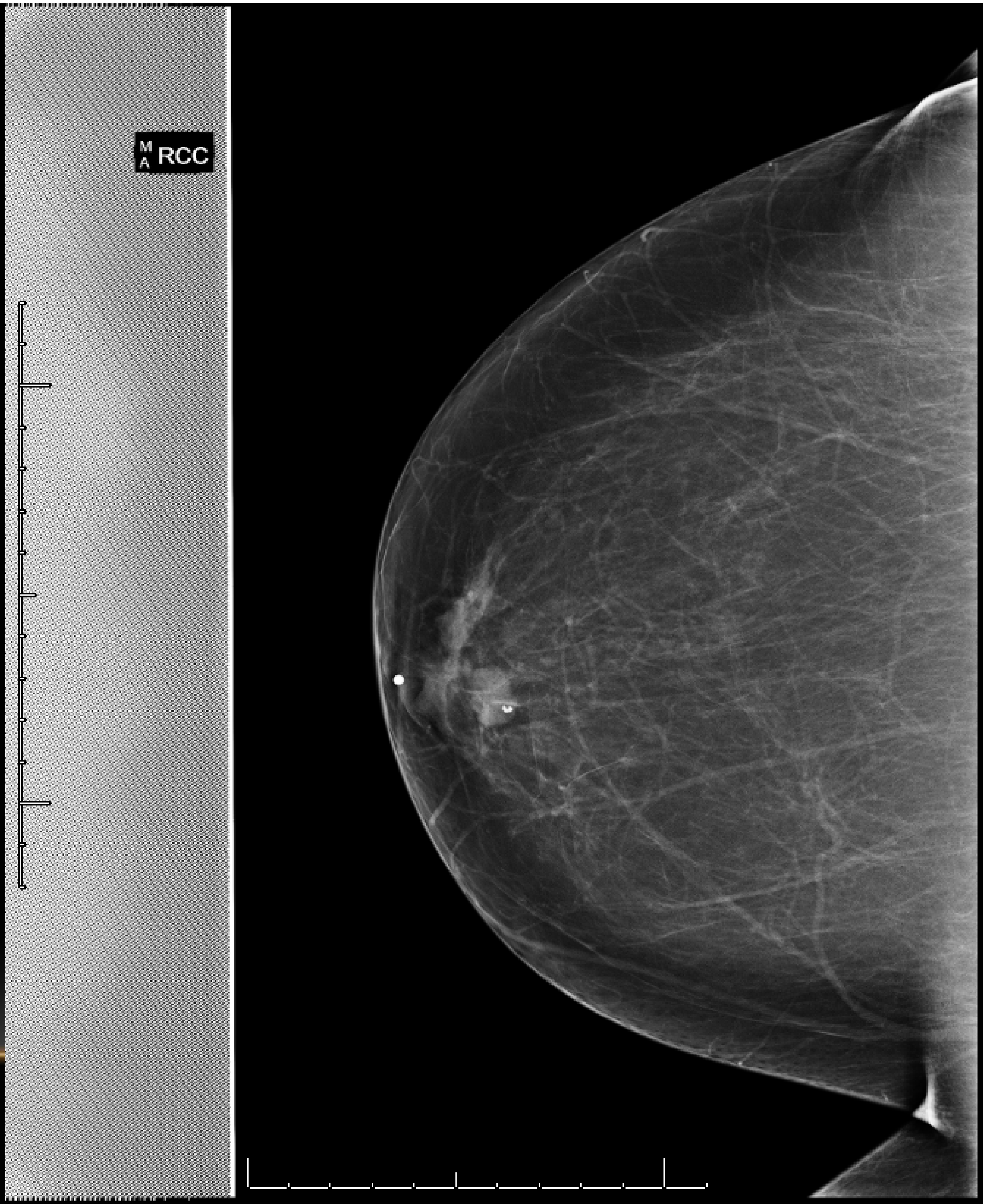
GRID ARTIFACT – STUCK GRID

Grid Artifact – Stuck Grid

- Replacement Detector
- Grid rails not affixed properly
- Rubbing of grid on breast support prevented grid from reciprocating
- Required replacement of detector array

Key

Grid stuck in retracted position



GRID LINES

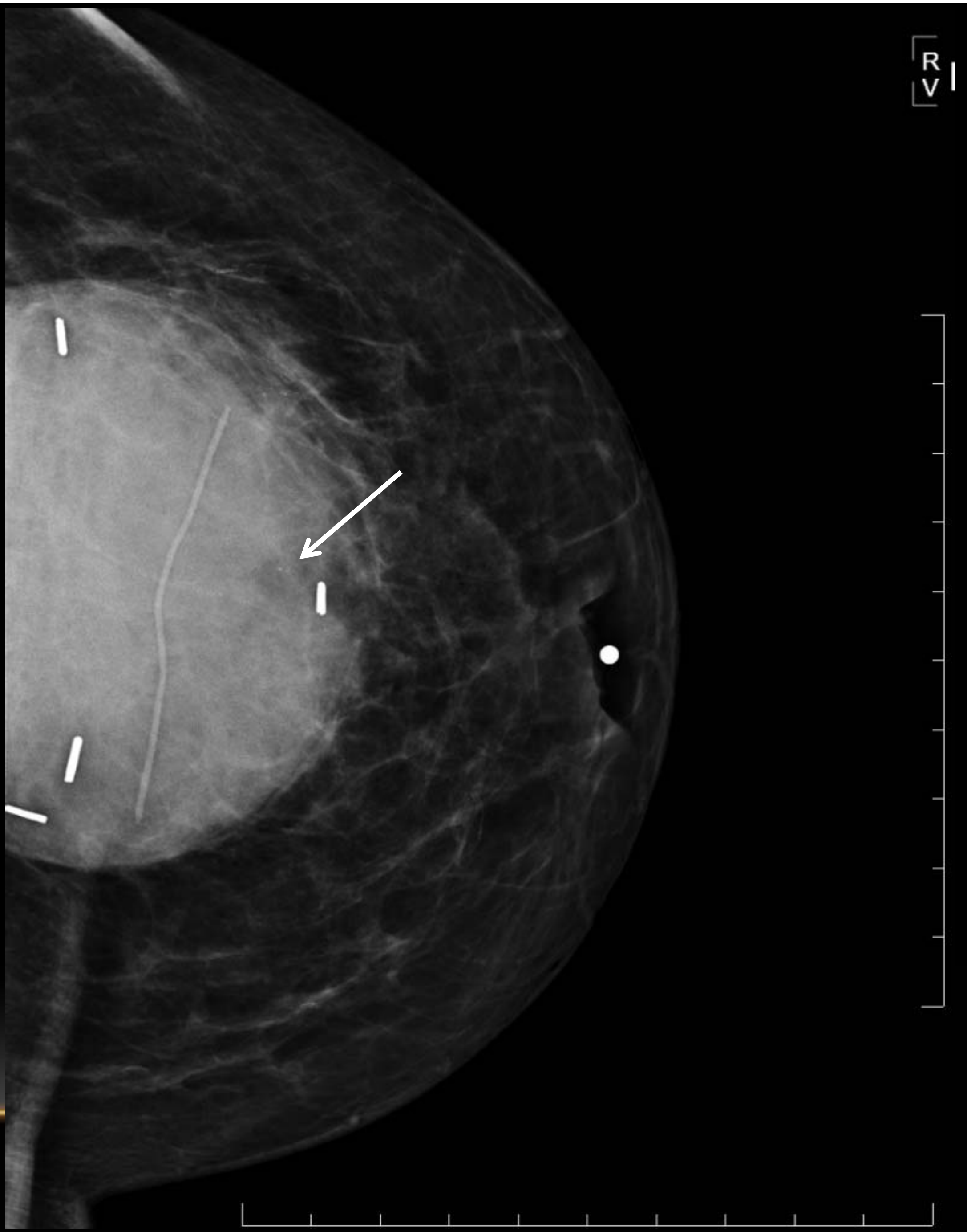
- Grid lines can be caused by either a stuck grid or inappropriate grid speed parameter setting.
- In our case this is usually visible to the radiologist.
- New Dimensions system – service engineer had to perform grid calibration with gantry rotated 90 degrees

- Edge of the compression paddle seen on the image.
- The compression paddle needed to be realigned so that its shadow was not longer visible along the chest wall edge of the image
- Check all paddles on during annual testing

TECHNIQUE PROBLEMS

- Clearly visible calcification seen through a hematoma on a standard LCC
- Noise on the LMCC image obscures the calcification. This image should be repeated at a higher kVp and with an exposure compensation of at least 2.

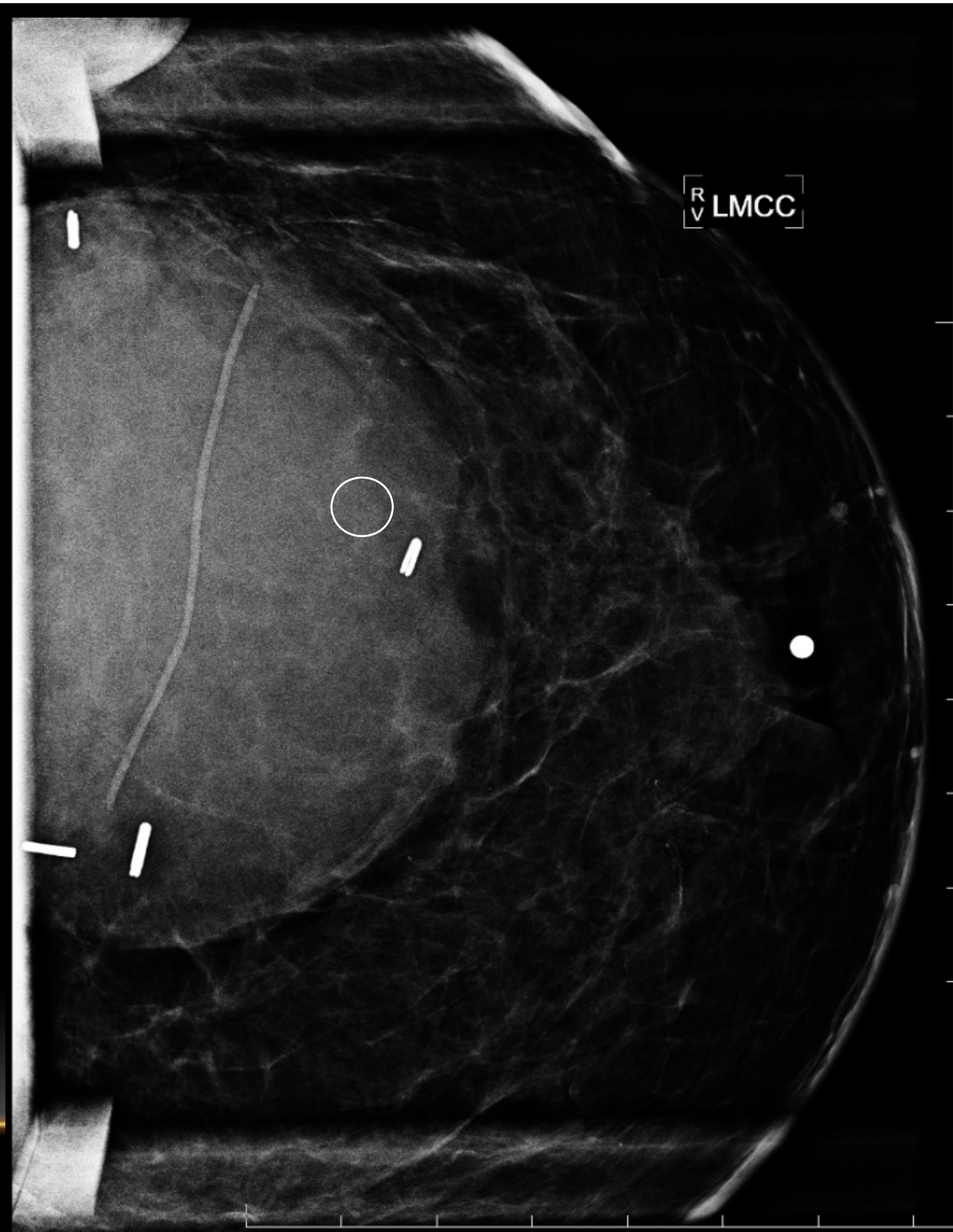
Radiologist wanted to see calcification more clearly and called for a magnification view



Magnification view

Magnification view done, but was underexposed in the area of interest.

Image noise obscures the calcification



UNDER EXPOSURE

- For immediate fix, have the technologist increase exposure compensation
- You can have the AEC recalibrated to give slightly higher exposures for the magnification mode as long as the system still meets the requirements for AEC tracking as required in the QC manual.
  - Hologic made this happen in the latest Selenia software upgrade.

AEC failure – Over Exposure

View: RCC

kVp: 32

mAs: 215

Exposure Index: 991

Compression Thickness: 7.2 cm

Compression Force: <10 lbs

Over Exposure - Correct Exposure

View: RXCCL

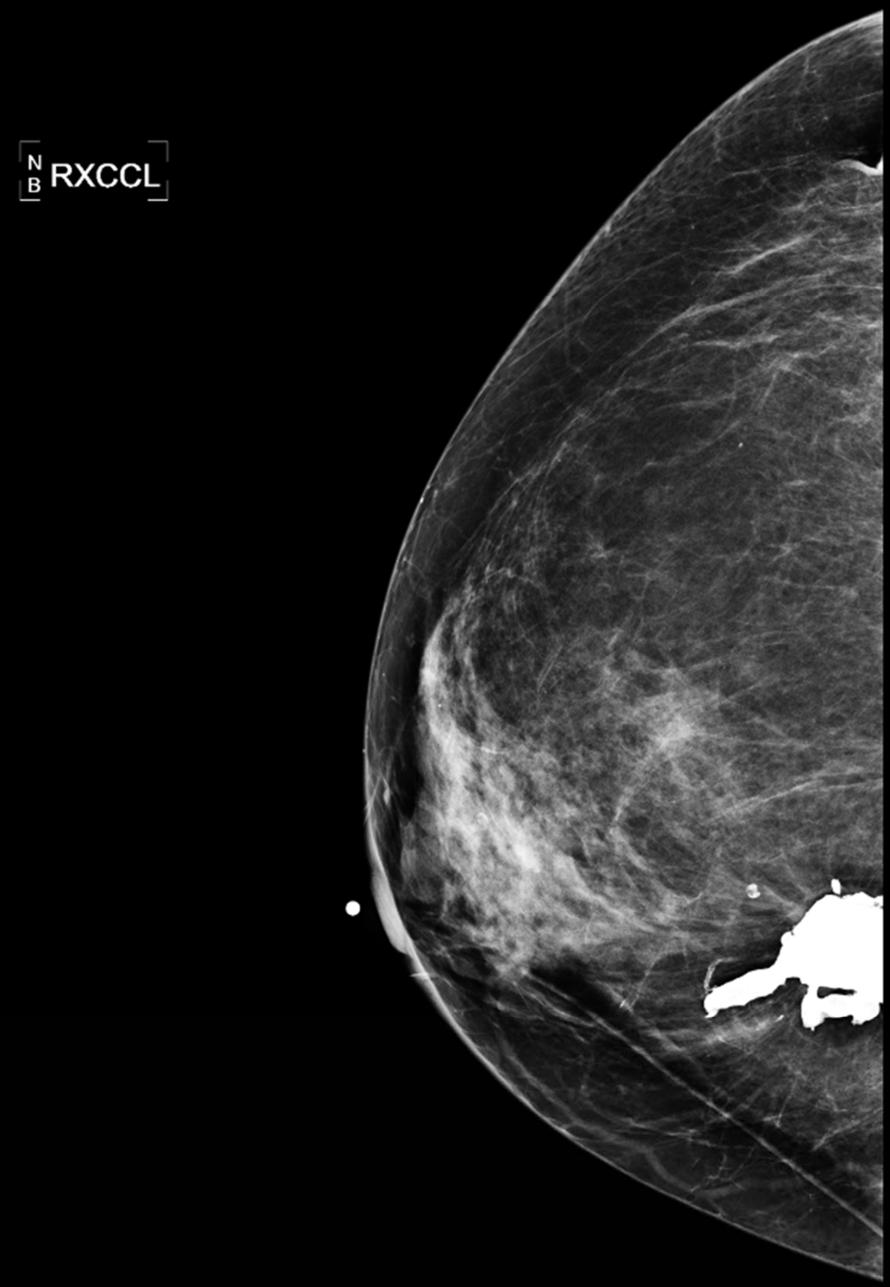
kVp: 30

mAs: 65.9

Exposure Index: 473

Compression Thickness: 58

Compression Force: 10 lbs



AEC FAILURE - OVEREXPOSURE

- What happened – Technologist had the system in Auto Filter mode which is the full automatic mode. The AEC algorithm tries to penetrate the most dense part of the breast which in this case was a large dense calcification. This lead to a very high mAs and a over exposure of the skin line of the breast. Due to the high skin line exposure the processing algorithm responsible for finding the skin line and processing it failed, causing the skin line to look burned out. Note the RXCCL which was properly exposed has a good rendering of the skin line.
- The technologist needs to have an understanding of how the AEC system works. To prevent this problem the technologist should have reviewed the previous images and realized that she needed to manually select the AEC sensor region, placing it outside the area of the large calcification.

In place view underexposed

View: LCC

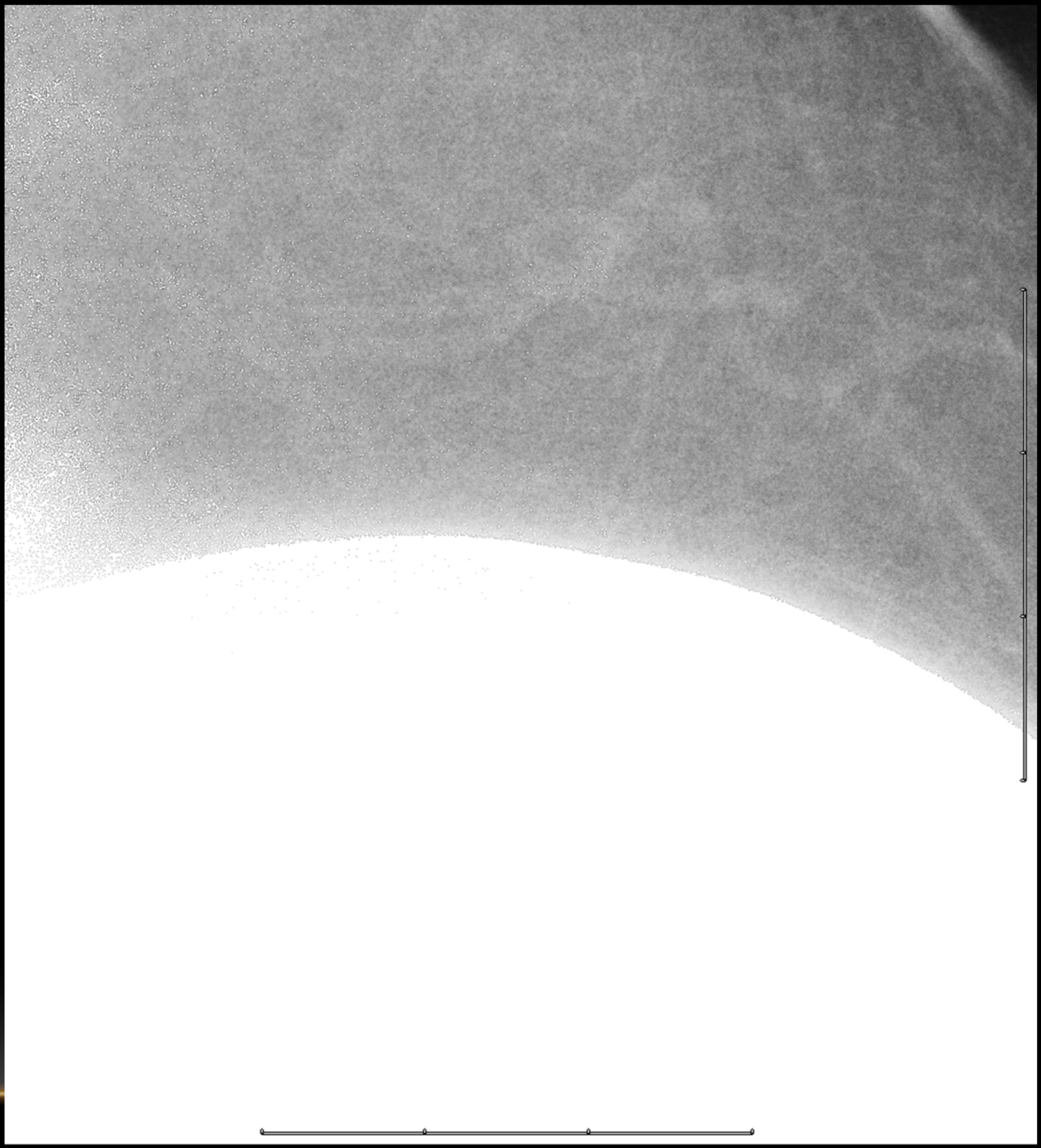
kVp: 28

mAs: 65

Compressed Thickness: 11.5 cm

Compression Force: < 10 lb

Exposure Index: 59



In place view underexposed – tech repeat

View: LCC

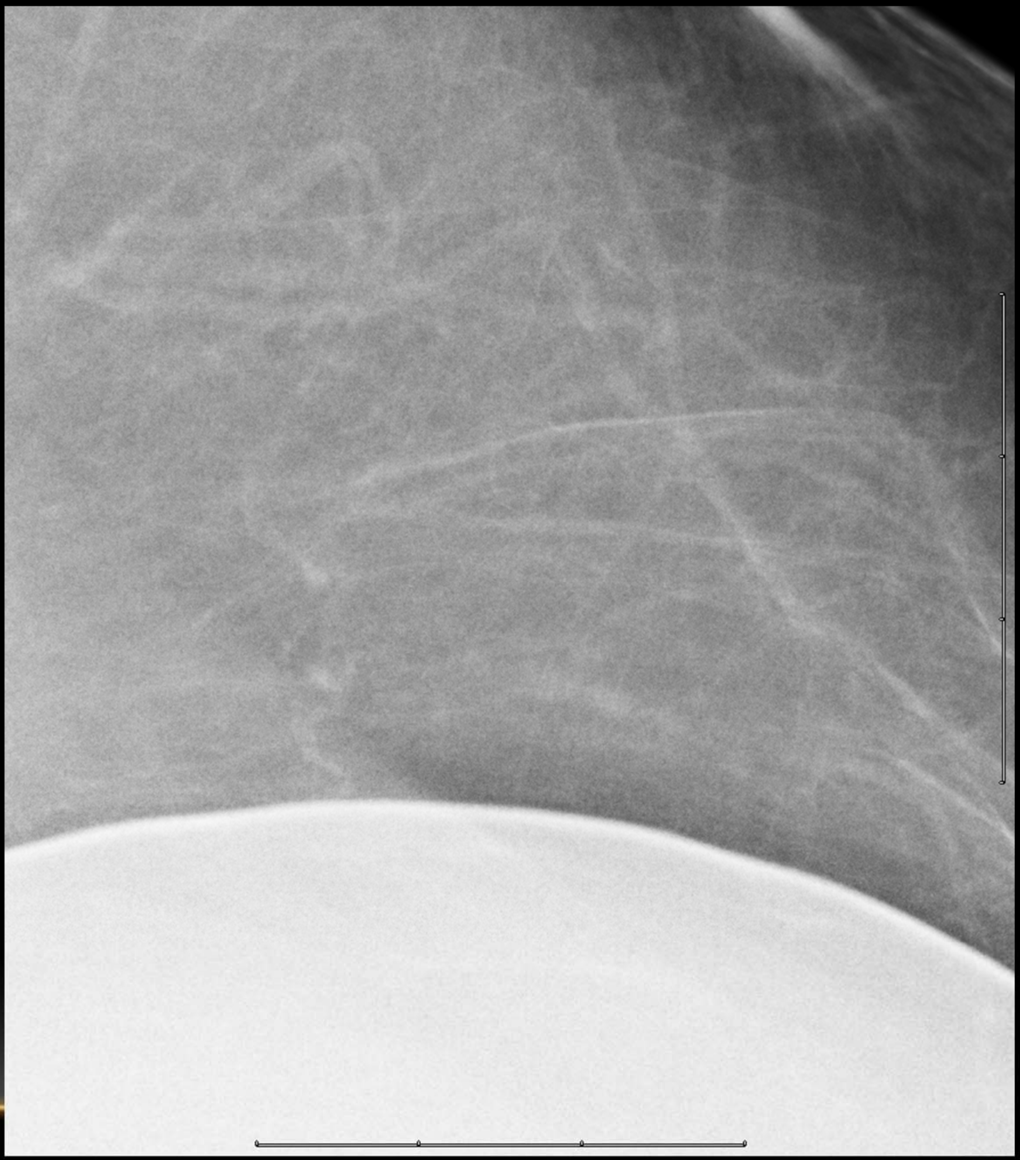
kVp: 30

mAs: 95

Compressed Thickness: 9.8 cm

Compression Force: 14.0 lb

Exposure Index: 99



IN PLACE VIEW UNDEREXPOSURE

- What happened – the technologists use a manual technique when performing in place views of the augmented breast. In the underexposed view the technologist used a technique that was not able to adequately penetrate the breast tissue around the implant. Many of the pixels were given a value of 0 and processed as completely white. On repeat of the view after call back the technologist used a higher technique and more compression. The caused all of the detector under the breast to be adequately exposed and thus process out properly

PATIENT RELATED ARTIFACTS

- There are many different types of patient related artifacts. The most common artifact is patient motion. Other types of artifacts include hair, gowns or other foreign objects laid over the breast during imaging. At other times the technologist may not notice that the patient has placed a hand on the breast support plate or compression paddle or that there are other foreign objects in the image field.

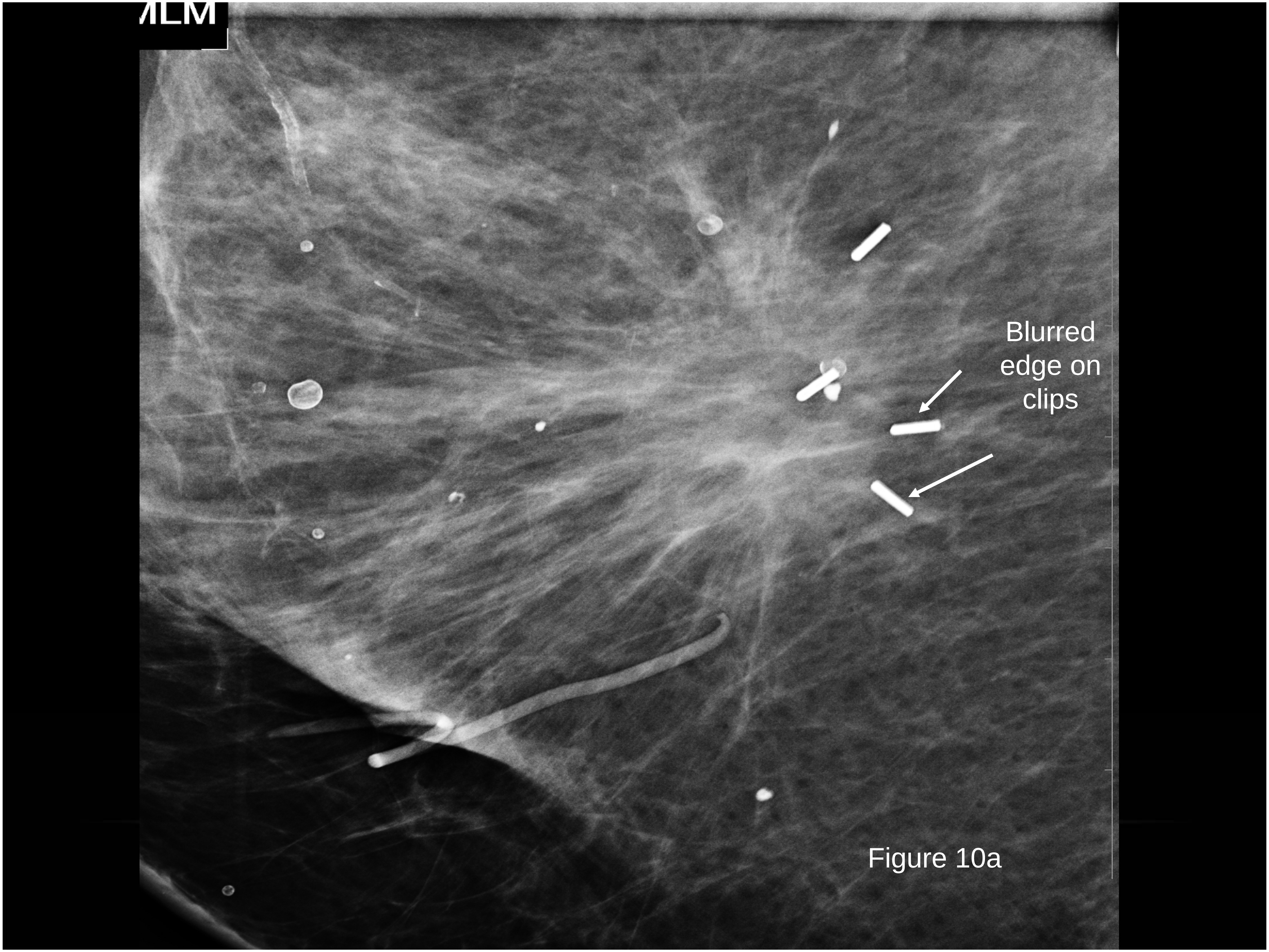
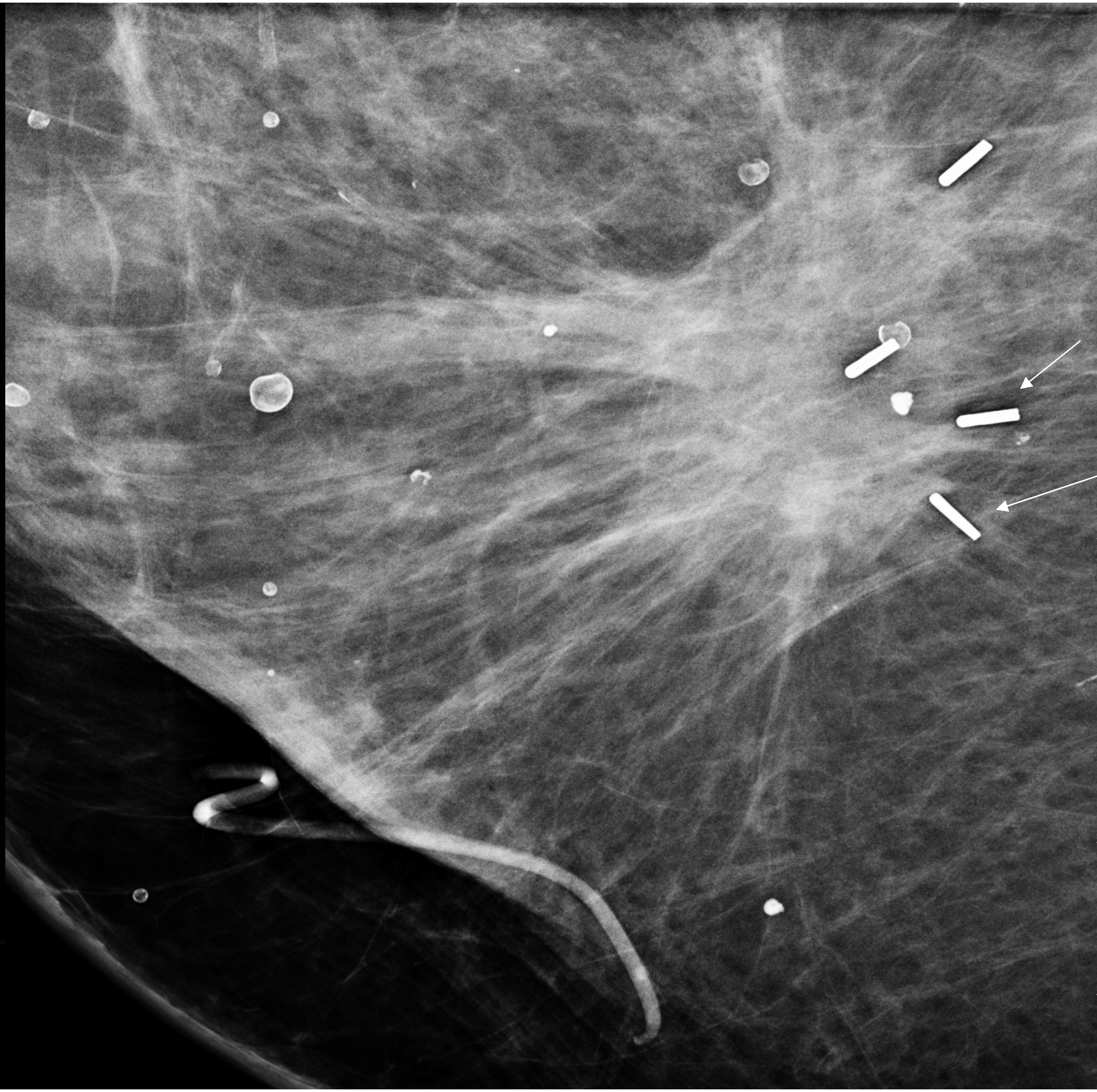


Figure 10a



Sharp well defined clip edges

MOTION ARTIFACT

- Most common patient related artifact
  - Need to have adequate compression
  - May need to increase kVp to lower exposure time