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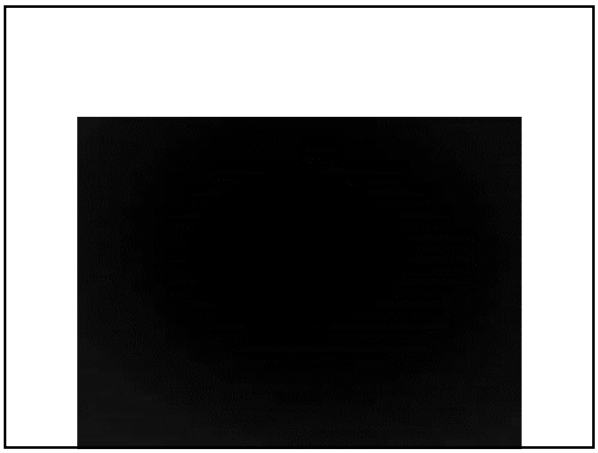
Deborah Thames BSRS RT (R)(M)(QM)

Caring for her at every stage of life.

Theory & Technology and advancement in 3D imaging

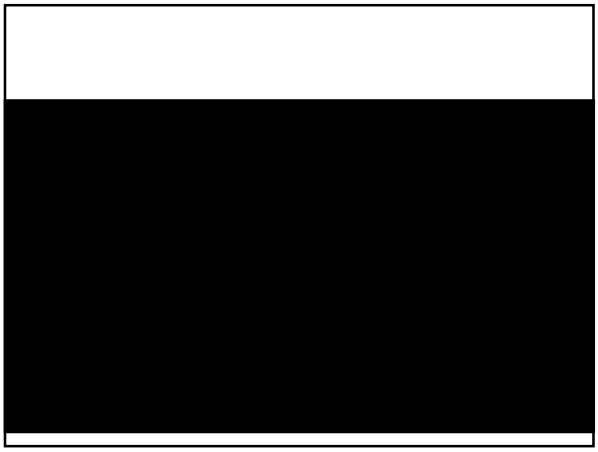
DBT



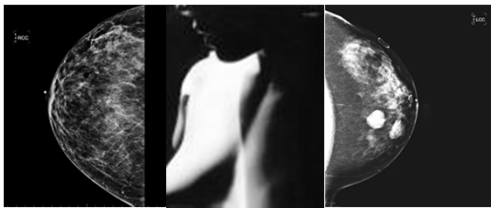
Imaging Modes

Three imaging modes available:

- Conventional full field digital mammography (2D only)
- Tomosynthesis imaging (3D only)
- "Combo imaging"(2D plus 3D)
  - Conventional 2D image plus tomosynthesis scan acquired during same compression, resulting in co-registered 2D and 3D images and both datasets are available for review



Mammography



Five FFDM approved for Tomo Hologic, Ge Senoclair and GE Pristina, Siemens, and Fujifilm

Why 2D Digital Mammography

2D FFDM it appears to be slightly more sensitive than digital breast tomosynthesis for the detection of calcification.
Diagnostic performance as measured by area under the curve using BI-RADS was not significantly different.
With improvements in processing algorithms and display, digital breast tomosynthesis could potentially be improved for this purpose.

Potential Benefits of 3D

- Increased breast cancer detection
- Decreased workup rate for non-cancer cases
- Improved lesion margin visibility
- Precise lesion localization

Mammography Screening Requirements for the United States

Systems must be capable of:

- Imaging the whole breast
- Image all types of breasts
- Image all lesion types, mass, calcification, distortion
- Fast and reasonable cost
- Low radiation dose

Potential Benefits and why we need 3D imaging

Reduce recall rate of patients by reducing confusion which arises from tissue overlap.

Biopsy rate decreased as there is improvement in separation and visualization of parenchymal structures.

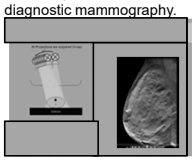
Time will possibly show improvement in cancer detection particularly in patients with dense breast tissue.

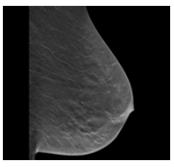
Fewer images required for diagnosis equals a reduction in dose.

Compression is a must at this time. NO changes yet but in future may be possible.

Why Breast Tomosynthesis?

Breast tomosynthesis provides a 3D imaging capability that allows the more accurate evaluation of lesions by enabling better differentiation between overlapping tissues.
A lower recall rate, higher positive predictive value for a biopsy recommendation.
Higher cancer detection rates, fewer recalls, fewer biopsies, and improved radiologist confidence are expected to result from the use of this technology.
Breast tomosynthesis should be valuable in both screening mammography and diagnostic mammography.





Rationale for using *2D plus 3D*

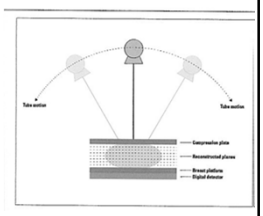
- Comparison of current images with prior images is standard mammography practice and critical to perceive subtle changes which may be associated with a cancer.
- Obtaining a 2D exam along with the 3D exam will allow direct comparison of current 2D images with prior 2D images.

Tomo Visualization of Features

- In General
  - In-plane objects look similar to 2D but with less interfering superimposed parenchyma
- Features appear fuzzy until bring in the plane slice
- Persistence of shadows depends on object size

Tomosynthesis

Digital mammography provides images with improved dynamic range and SNR, as well as the ability to adjust image brightness and contrast after acquisition. Despite these improvements it is limited in the same manner as film/screen due to superimposition in a 2D image.



Invasive Cancer (numbers of CA)

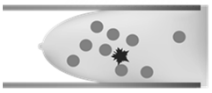
	2D	2D +3D	diff
• Invasive CA	56	81	45%
• <15 mm	37	59	59%
• LN neg	44	63	43%
• Distortion	8	16	100%
• Calcs	6	6	0

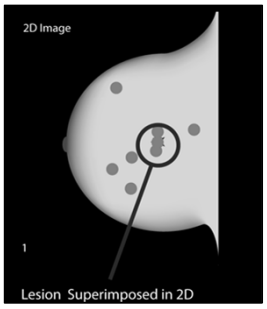
Skaane, Radiology 2013

Why is There a Need for 3D Tomosynthesis

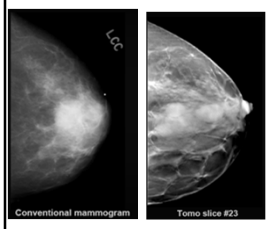
In 2D FFDM:

- Tissue superimposition hides pathologies in 2D
- Tissue superimposition mimics pathologies in 2D





Why Breast Tomosynthesis?



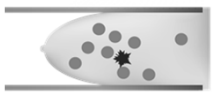
Tomosynthesis should resolve many of the tissue overlap reading problems that are a major source of the need for recalls and additional imaging in 2D mammography exams.

The biopsy rate might also decrease through improved visualization of suspect objects.

Some pathologies that are mammographically occult will be discernible through the elimination of structure noise and tomosynthesis may therefore allow improved detection of cancers.

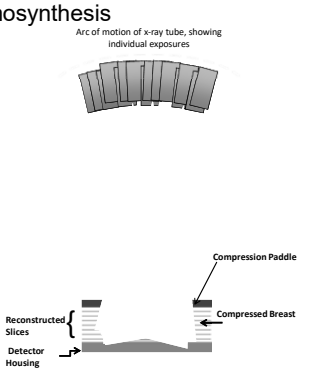
Projections are the basis of the "displayed "Slices".

- While stabilizing the breast, images are acquired at a number of different x-ray source angles.
- Objects at different heights in the breast display differently in the all projections.

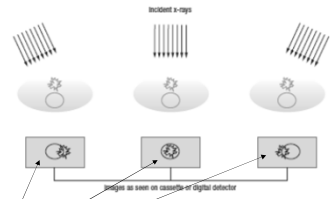


3D Breast Tomosynthesis

- A 3D screening modality that preserves the very high resolution of 2D FFDM
- Multiple images of the breast are acquired at different angles during a sweep of the x-ray tube
- Allows radiologists to see around overlapping structures

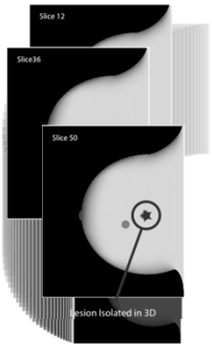


The final step in the tomosynthesis procedure is reconstructing the data to generate images that enhance objects from a given height by appropriate shifting of the projections relative to one another.



Two objects (a spiculated lesion and ellipse) superimpose when the x-rays are at 0º, but the off-axis acquisitions shift the objects' shadows relative to one another in the images.

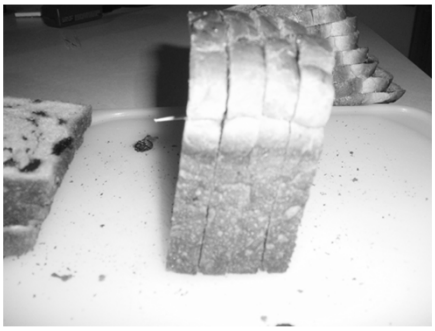
Why Digital Breast Tomosynthesis (3D)?



- 3D improves visibility by reducing tissue superimposition

Note that additional acquisitions are not required to enhance the visibility of objects at any given height—one set of acquired data can be reprocessed to generate the entire 3D volume set.

Think of it as Raisin Breast



Calcifications

- Segmental and clustered calcifications are more easily and quickly appreciated with 2D because they can traverse multiple slices in 3D.
- By minimizing structure overlap, 3D optimally demonstrates masses and architectural distortion.

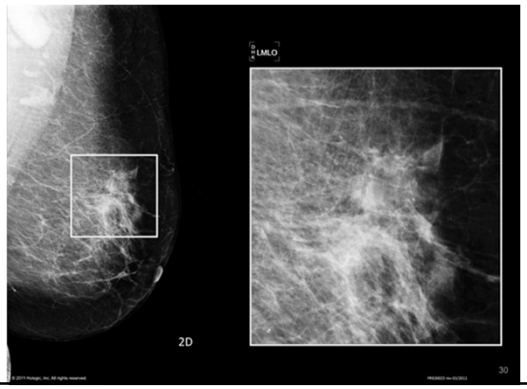
Slabbing

May not perceive calcifications as a cluster

Radiologist have ability to slab information

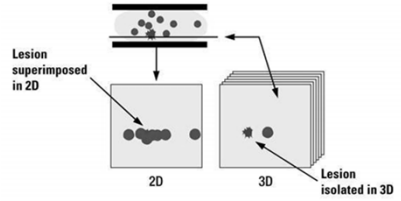
Look at a 10mm slab vs a 1mm slice

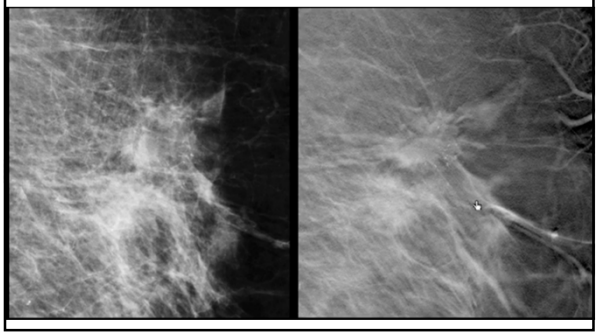
Example case with Calcs



The Solution is 3D Breast Tomosynthesis

Tomosynthesis is a three-dimensional mammographic examination that **can minimize the effects of structure overlap** within the breast

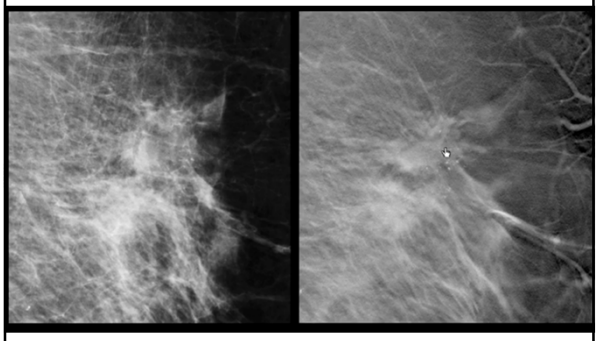




2D Imaging vs. 3D Imaging

- **2D**
  - Either molybdenum or tungsten x-ray tube
  - 20 to 39 kVp
  - Moly or rhodium or silver filters
  - 100 mA
  - HTC grid
- **3D**
  - Tungsten x-ray tube
  - 20 to 49 kVp
  - Aluminum filter
  - 200 mA
  - No grid

  No GRID-when the tube is off axis you would see grid lines)



Breast Tomothynthesis

The 3D image quality and depth resolution directly depend on the number of projections, angle size and reconstruction algorithm.

How Does Hologic's 3D Breast Tomosynthesis Work?

- Tube moves in a **15 º** arc
- **15** low dose images are acquired
  - 1 image at each degree
  - Four second sweep
- Images are reconstructed into **1 mm** slices
- In **combo-mode** imaging, the 2D and 3D are taken in the same compression, with no additional positioning for the patient.

How Does Fujifilm Cristalle Tomosynthesis work

- Tube moves in a **40 º** and 15 **º** arc
- **?** low dose images are acquired
  - 1 image at ? degree
- Images are reconstructed into **1 mm** slices
- In **combo-mode** imaging, the 2D and 3D are taken in the same compression, with no additional positioning for the patient.

How Does GE Senoclaire/Pristina Tomosynthesis work

- Tube moves in a **25 º** arc
- **9** low dose images are acquired
  - 1 image at 2.8 degree
- Images are reconstructed into **1 mm** slices
- In **combo-mode** imaging, the 2D and 3D are taken in the same compression, with no additional positioning for the patient.

Performing the Acquisition

The breast is compressed in a standard way.

While holding the breast stationary, the x-ray tube is rotated over a limited angular range.

A series of low dose exposures are made every degree, creating a series of digital images.

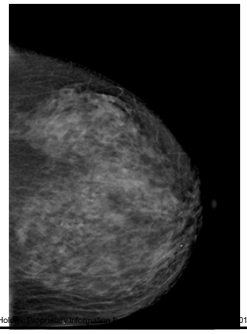
How Does Siemens Inspiration Tomosynthesis work

- Tube moves in a **50 º** arc
- **25** low dose images are acquired
  - 1 image at 2.0 degree
- Images are reconstructed into **1 mm** slices
- In **combo-mode** imaging, the 2D and 3D are taken in the same compression, with no additional positioning for the patient.

3D Tomosynthesis Dataset: 2D + 3D (Combo Acquisition)

Arc of motion of x-ray tube, showing individual exposures

Projection image acquired during sweep



Projection Image

- Must have projection image to create slices
- Reconstruction images are born of projection image
- Projection image is checked for motion by technologist
- Slices are from detector to paddle in all views. Example
  - CC-foot to head
  - MLO-lateral to medial

Tomosynthesis Dataset: 2D + 3D (Combo Acquisition)

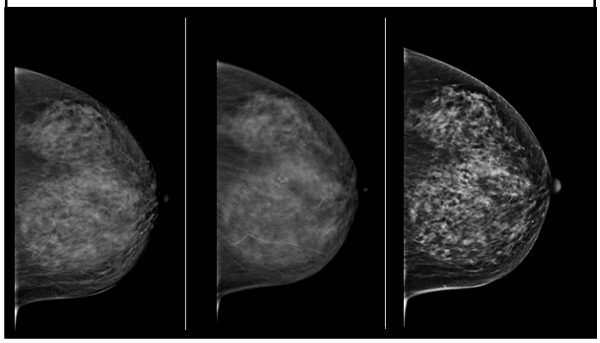
Projection Images

15 images/15° arc

Projection Image

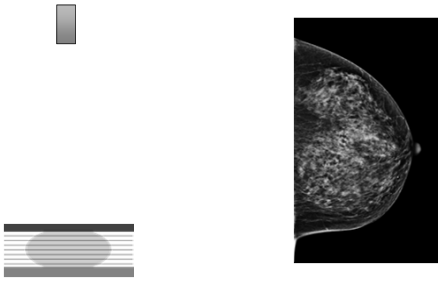
Reconstructed Tomosynthesis Slices

Two Dimensional Mammogram



Tomosynthesis Dataset: 2D/3D (Combo Acquisition)

Finishing with the 2D exposure



The x-ray tube can move in a continuous or step-and-shoot motion.

With continuous motion x-ray exposures must be short enough to avoid image blurring due to focal spot motion

If step-and-shoot motion is employed, the gantry must come to a complete stop at each angular location before turning on the x-rays, otherwise vibration will blur the image

Hologic has continuous motion

1mm slices: Number of slices dependent upon compressed breast thickness that are reconstructed from projection images

5cm compressed breast

- 50 1mm slices + 5
- Always adds 5 to clear the paddle

Angular Range

Larger angular range gives increased reconstructed slice separation

Smaller angular ranges keep more structures in focus in a given slice

- It might be desired for resolving closely lying structures but could impair the appreciation of a cluster of microcalcifications because the individual calcifications would appear in different slices or the appearance of spiculations lying in more than one narrow plane

Angle of View

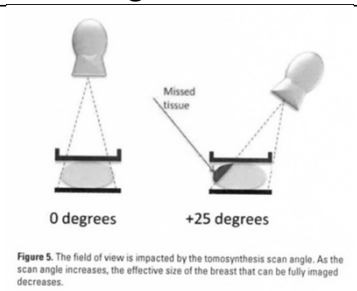


Figure 5. The field of view is impacted by the tomosynthesis scan angle. As the scan angle increases, the effective size of the breast that can be fully imaged decreases.

Image Reconstruction

Image reconstruction is computing high-resolution images whose planes are parallel to the breast support plates

Reconstructed with slice separation of 1mm

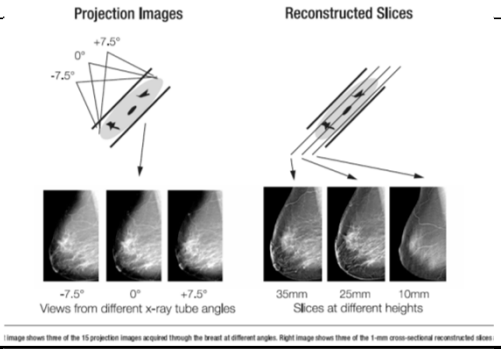
A 5cm compressed breast tomosynthesis study will have 55 reconstructed slices

Reconstruction time must be 10 seconds or less

Siemens Tomosynthesis

With **True** 3D Breast Tomosynthesis, Siemens has opened up a new chapter in mammography diagnostics. High spatial resolution and the largest acquisition angle allow for excellent resolution depth and superior reconstruction results. This leads to fewer artifacts and greater image detail, thereby improving diagnostic capabilities immensely

Image Reconstruction



Modes of Acquisition

- The unit must perform existing 2D digital mammography images
- Tomosynthesis images must be able to be taken in all standard projections not just the CC and MLO
- Take a normal 2D mammogram and tomosynthesis image in the same compression

Display

Similar to CT reconstructed slices

View one at a time or display as a cine loop

2D images can also be viewed

2D and 3D acquired in the same compression are completely co-registered

Co-Registration

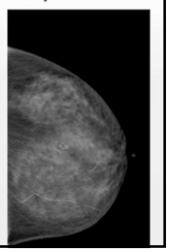
The positioning and compression are exactly the same on the 2D and 3D

allows the radiologist to view the 2D image and the tomosynthesis slices with perfect co-registration on top of each other or side by side.

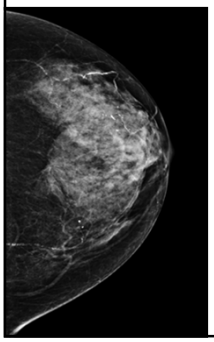
What does a tomo exam look like?

- 1 mm /slice
- 40-60 slices
- Navigate with mouse
- Slices numbered from breast platform out

Reconstructed Tomosynthesis Slices



Co-registered: same positioning 2D and 3D

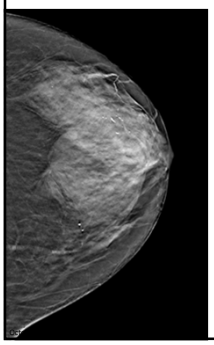


2D image

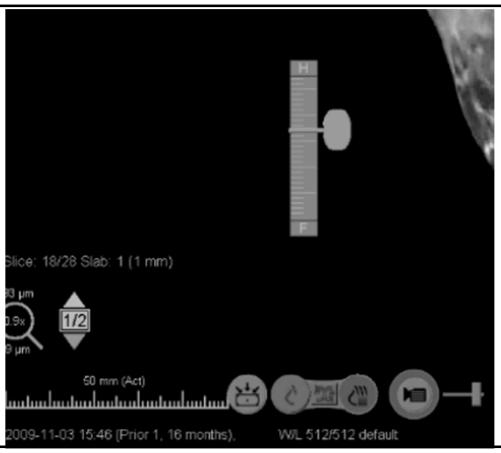
Scrolling

CC image, showing scrolling

Co-registered



Tomosynthesis image



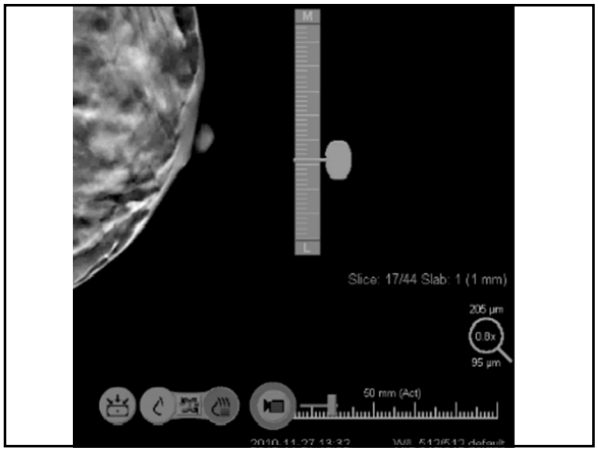
Co-registration of 2D & 3D breast images

For Radiologists

- Facilitates comparison to priors and images from other facilities
- Single compression allows **co-registration** of 2D and 3D images

For Administration

- **Reimbursement is available for 2D image** and 2D CAD, allowing the facility to continue to generate revenue while offering latest technology
- Patient **throughput is not impacted**



Co-registration of 2D & 3D breast images

For Technologists

- 2D and 3D scan acquired with **a single positioning/view**
- Workflow is same as FFDM; **no learning curve**

For Patients

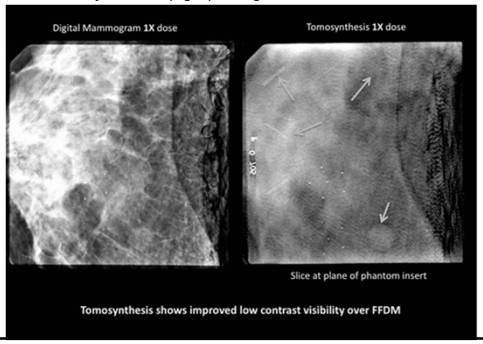
- The clinical trials proved a reduction in recall rates.
- Reduced recalls can lead to **reduced anxiety & reduced inconvenience**
- No noticeable difference in breast screening experience

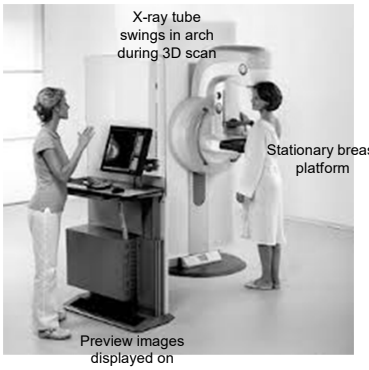
RADIOLOGIST READ TIME

Equated to going from film screen to digital
Now digital 2D to 3D-same learning curve

CAD is applied to 2D images and then compared to slices what was marked on CAD

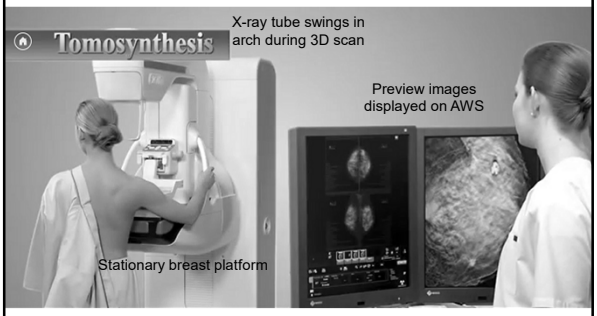
Visibility of low contrast objects are reduced
Even at 4x a conventional dose the digital mammogram (middle) shows inferior low contrast visibility to a tomosynthesis (right) using ¼ the dose

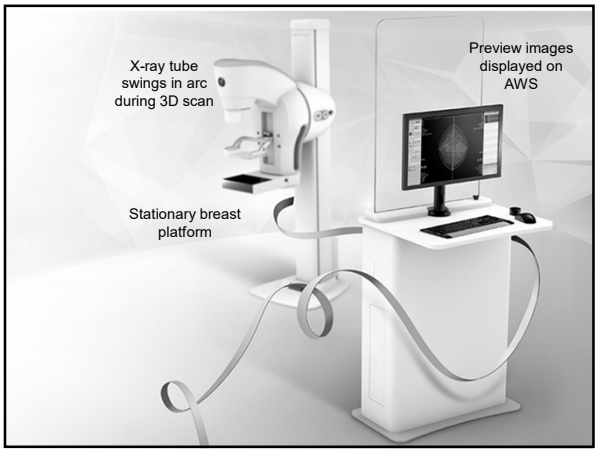




3D Breast Tomosynthesis System

Fujifilm Cristalle





The Future of Breast Imaging

What is co-registration?

Positioning and compression are exactly the same on the 2D and 3D

Allows the radiologist to view the 2D image and the tomosynthesis slices with perfect co-registration on top of each other or side by side.

What is the dual acquisition mode called?

Combo-mode

What is the projection image?

The images acquired during the tomo sweep

These images are used to create the individual slices

The tomo slices are born of the projection image

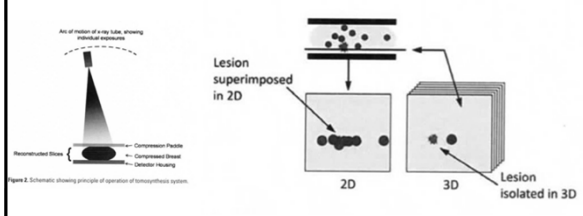
Tomosynthesis DBT

How many tomo slices are there in a routine tomo acquisition?

Depends on the compressed breast thickness

1mm slices plus 5 to clear the paddle

Eliminating Superimposition by Reading the Slice(s) plus 2D



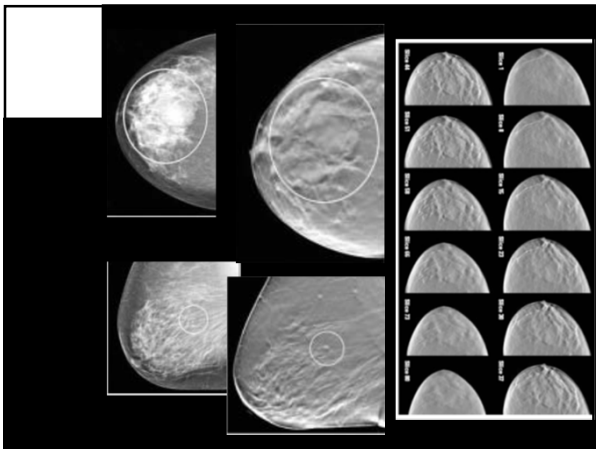
Eliminating Superimposition by Reading the Slice(s) plus 2D

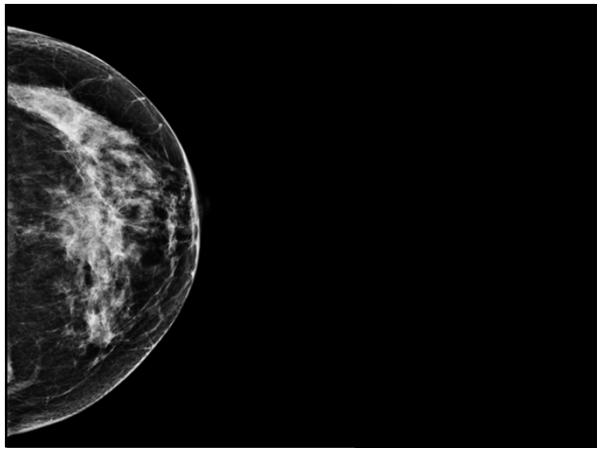
Clinical Image Review

Why is tomosynthesis going to revolutionize breast imaging?

Images and data courtesy of:

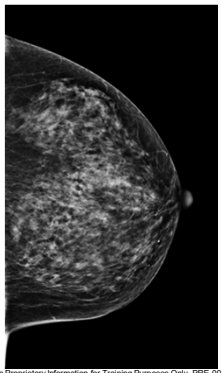
- Hôpital Privé d'Antony, Paris France
- Massachusetts General Hospital, Boston MA USA
- Netherlands Cancer Institute – Antoni Van Leeuwenhoek Hospital, Amsterdam Holland
- Centre de Radiologie et d'Echographie du Docteur Joussier, Paris France
- Dartmouth Hitchcock Medical Center, Lebanon NH USA
- Magee Women's Hospital, Pittsburgh PA USA

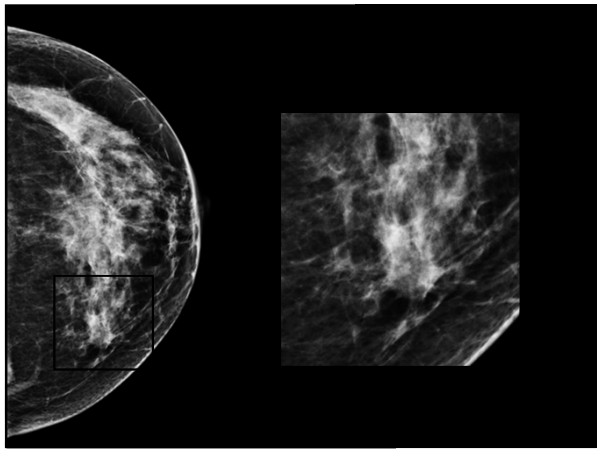


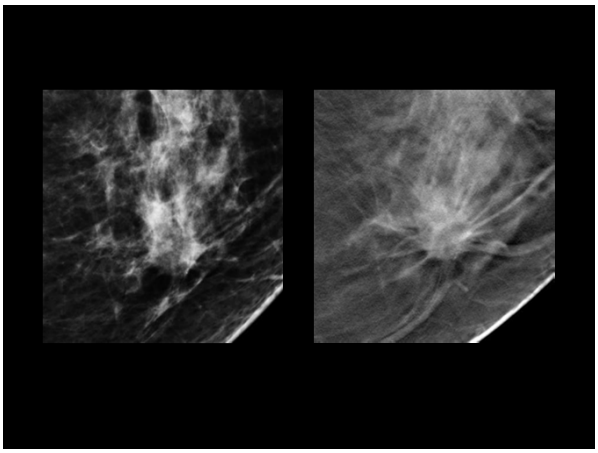


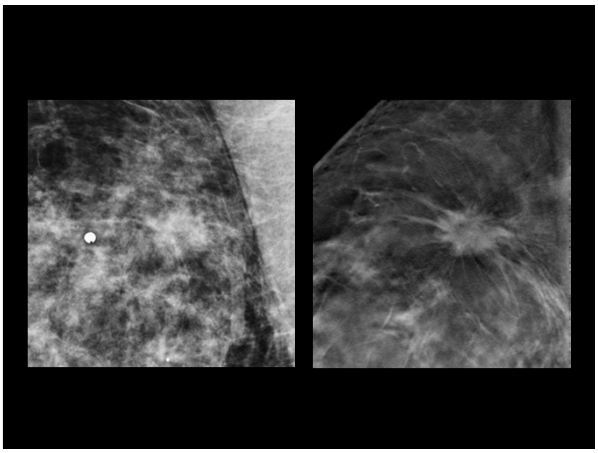
Tomosynthesis Dataset: 2D/3D (Combo Acquisition)

Finishing with the 2D exposure







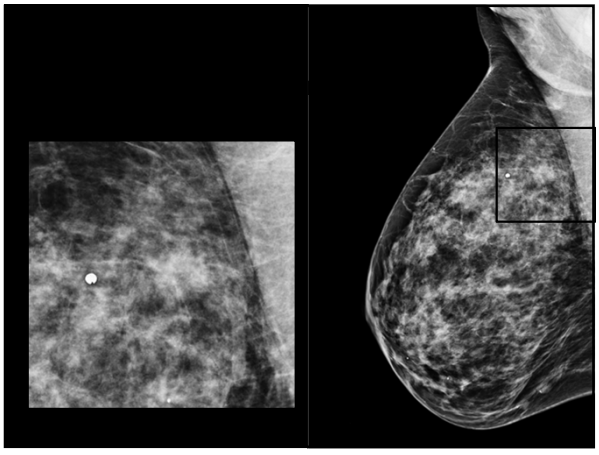


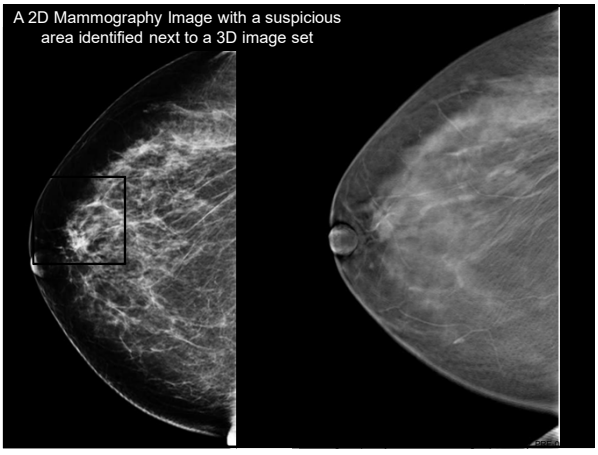
Example 2

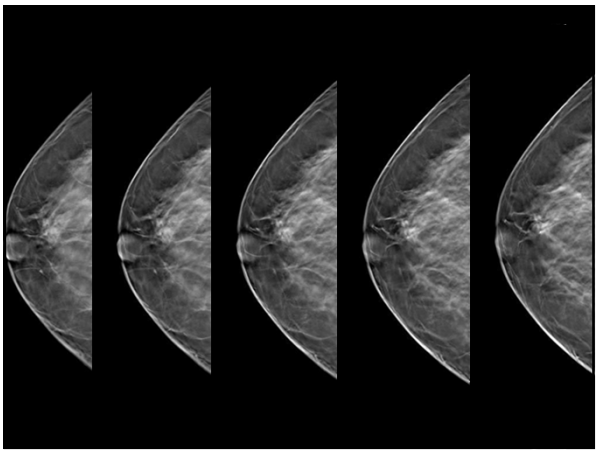
October 2011

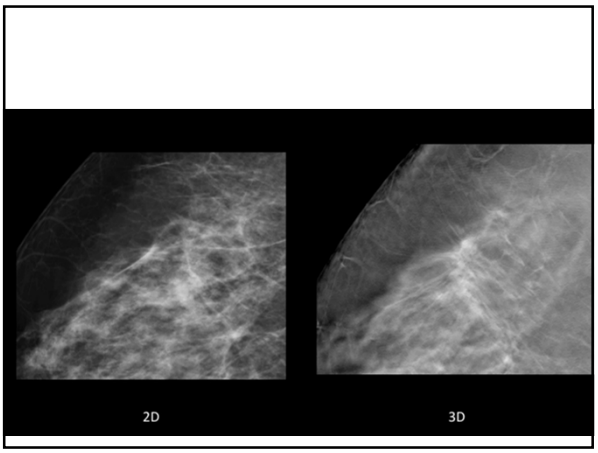
Example 3
Superimposed Tissue Examples

October 2011

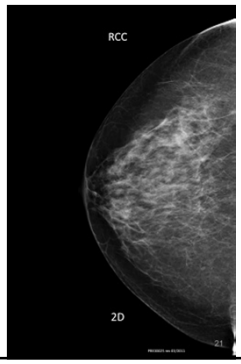


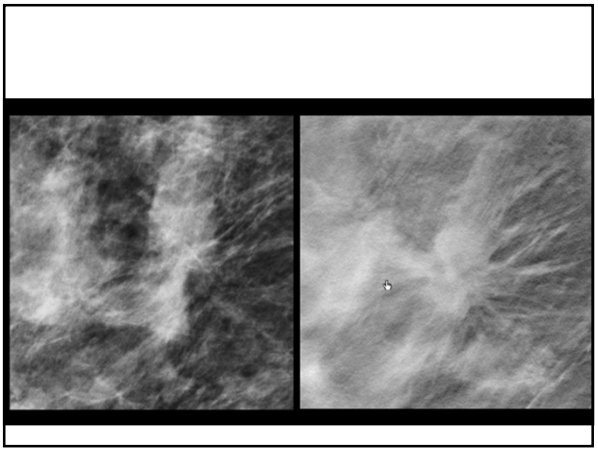


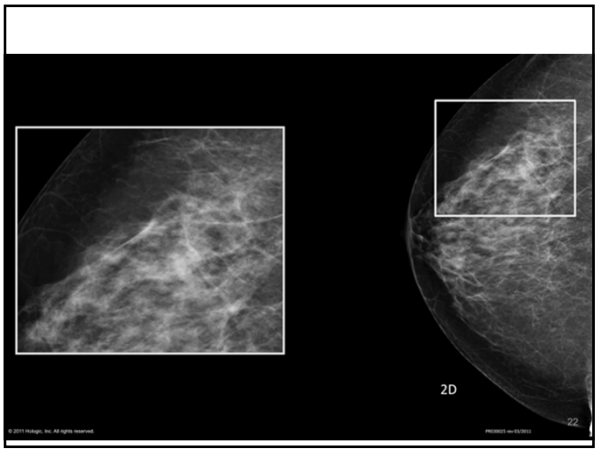




More Examples







Tomosynthesis: Concepts and Rationale

- Online November 2011
- University of Pittsburg Medical Center
- Dr. Jules Sumkin
- Dr. Margarita Zuley

FFDM vs F/S

- So why is digital better
  - Dynamic range
  - Contrast resolution
  - Can change image appearance and size at soft copy workstation

Technical Considerations

- Dose per view
- Angle of arc
- Processing algorithms

Why digital is not always better….

- Processing algorithms may play a role
- Reduced spatial resolution lp numbers are lower
- Learning curve - interpretation

Calcifications and Tomo

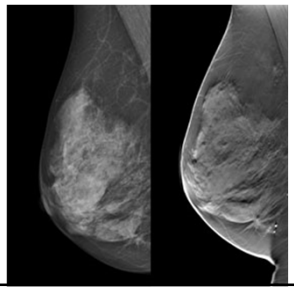
- Confident improvement will be made and will be able to see calcifications as well as on FFDM

Screening with tomo

- Reduce recall rate
- Up to 2 times the dose if do combo

Diagnostic

- Useful in lesion characterization



Tomosynthesis Compared to Ultrasound

No studies have been published directly comparing the performance of tomosynthesis to ultrasound in breast cancer screening. Nonetheless, several observations may be made about this. Tomosynthesis, like ultrasound, has a superior performance in dense breasts relative to mammography. However, unlike ultrasound, where the recall rate of 2D and ultrasound was 4 times that of 2D mammography alone as was seen in the ACRIN 6666 trial, tomosynthesis improves sensitivity without increasing the recall rate. Further clinical research will be needed to identify the respective roles of tomosynthesis and ultrasound, particularly in screening women with dense breasts.

2D Tomo

2D Tomo

Lets talk PACS

- Previously, could only view Tomo Cine mode on Hologic Secur View monitors only.
- PACS has finally caught up with technology
- Some clinics can use their PACS system converting the CT Header but is very limited.

PACS

(Picture Archiving and Communication System)

- Is a medical imaging technology which provides economical storage of, and convenient access to, images from multiple modalities (source machine types).
- Electronic images and reports are transmitted digitally via PACS; this eliminates the need to manually file, retrieve, or transport film jackets.

PACS

- The universal format for PACS image storage and transfer is DICOM (Digital Imaging and Communications in Medicine).
- A PACS consists of four major components: The imaging modalities such as X-ray plain film (PF), computed tomography (CT) and magnetic resonance imaging (MRI), a secured network for the transmission of patient information, workstations for interpreting and reviewing images, and archives for the storage and retrieval of images and reports.

PACS

- Combined with available and emerging web technology, PACS has the ability to deliver timely and efficient access to images, interpretations, and related data. PACS breaks down the physical and time barriers associated with traditional film-based image retrieval, distribution, and display.

PACS

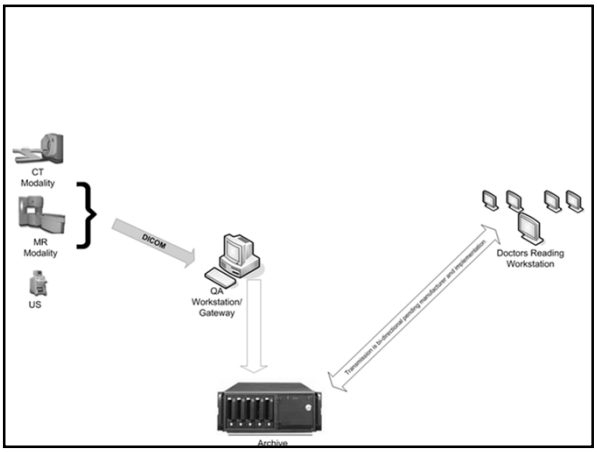
Electronic image integration platform: PACS provides the electronic platform for radiology images interfacing with other medical automation systems such as Hospital Information System (HIS), Electronic Medical Record (EMR), Practice Management Software, and Radiology Information System (R(S)

- PACS has four main uses:
- Hard copy replacement: PACS replaces hard-co based means of managing medical images, such as film archives. With the decreasing price of digital storage, PACSs provide a growing cost and space advantage over film archives in addition to the instant access to prior images at the same institution. Digital copies are referred to as Soft-copy.

- Radiology Workflow Management: PACS is used by radiology personnel to manage the workflow of patient exams
- PACS is offered by virtually all the major medical imaging equipment manufacturers, medical IT companies and many independent software companies. Basic PACS software can be found free on the Internet.

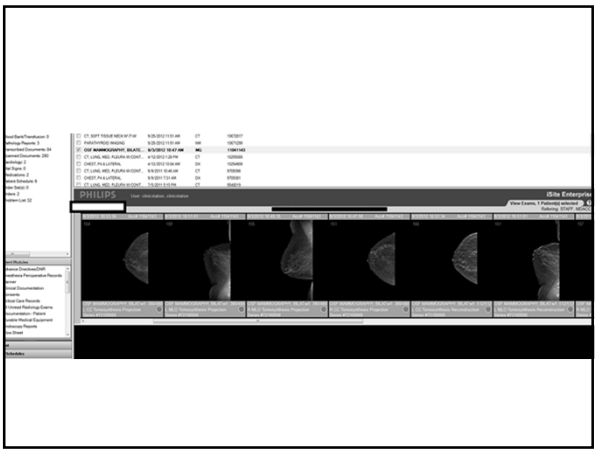
PACS

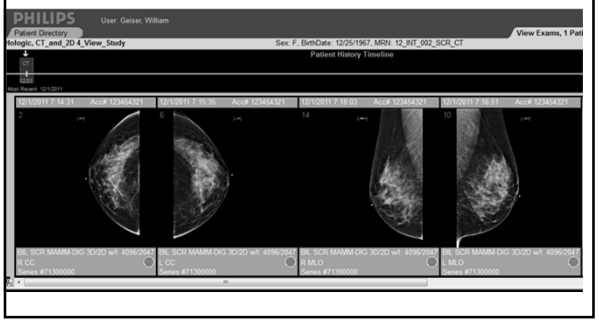
- Remote access: It expands on the possibilities of conventional systems by providing capabilities of off-site viewing and reporting (distance education, tele diagnosis). It enables practitioners in different physical locations to access the same information simultaneously for tele radiology.

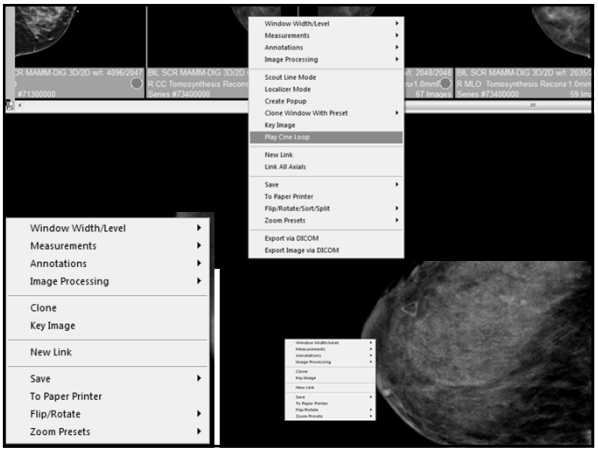


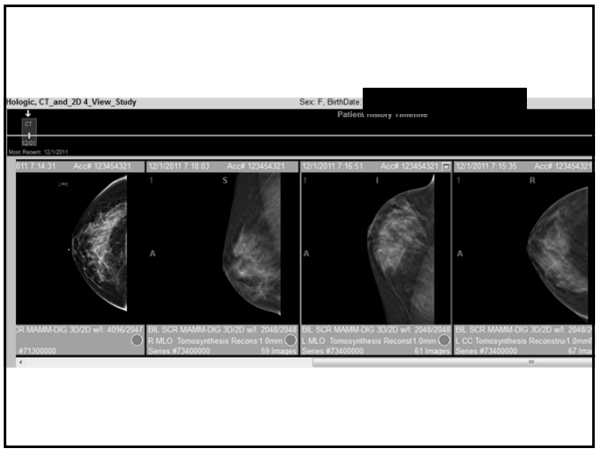
Using your own PACS system

- The changes in DICOM HEADER is instead of having an image number for mammo's, it has a slice number. That way pacs system will stack the images instead of laying them side by side. That way they are stacked so you can scroll through them slice by slice.
- So the physicist will change the presentation state in PACs that flips and inverts only the left side. The right side is always correct because it reads RIGHT, LEFT ANTERIOR POSTERIOR and will read it RIGHT LEFT SUPERIOR INERIOR for mammo.
- The presentation state will be saved but when the radiologist open the case they have to right click and click presentation stage because the images will still come across backwards and upside down as in the slide presentation I have given you.
- Our PACs system is not upgraded. We are still using DICOME normal 3.5.86 Not sophisticated.
- The new PACS are sophisticated and have a DICOM BT(Breast Tomosynthesis) which are like DICOM 4.0. like Sectra PACS









Advanced PACS

SECTRA BREAST TOMOSYNTHESIS PACKAGE

With the Sectra Breast Tomosynthesis Package you can include reading of tomosynthesis images in your regular mammography reading workflow. This significantly increases efficiency as the need to move to a dedicated modality workstation is eliminated. Sectra is one of the first imaging vendors to offer support for import and review of this completely new DICOM format.

A complete solution

In order for you to take full diagnostic advantage of the tomosynthesis format you need to be able to seamlessly scroll through the slices during review. This requires monitors that feature high update frequencies as well as the high resolution needed for mammography reading. The Sectra Breast Tomosynthesis Package includes support for monitors that meet these demands.

A turnkey solution

With the Sectra Breast Tomosynthesis Package, Sectra's vendor-neutral multi-modality Breast Imaging PACS is prepared for seamless transfer of the new images from the modality into your reading workflow. Display protocols ensure that they are hung according to radiologists' preferences for optimal viewing and comparison.

True multi-modality capabilities

Sectra Tomosynthesis Package extends the multi-modality capabilities already available in Sectra's breast imaging workstation, IDS7/mx. The user can benefit from images from any modality, including ultrasound, MRI and tomosynthesis, displayed side-by-side with the mammograms.

Advanced PACS

Unsurpassed workflow efficiency

Sectra provides strategic distribution with leading mammography software providers such as MagView®, Merge CADstream™, MRS, PenRad™ and Volpara™. These products are integrated with Sectra Breast Imaging PACS for efficient bi-directional workflow and allow users to maximize their investment by providing all necessary mammography tools on one workstation.

Breast Density Analysis

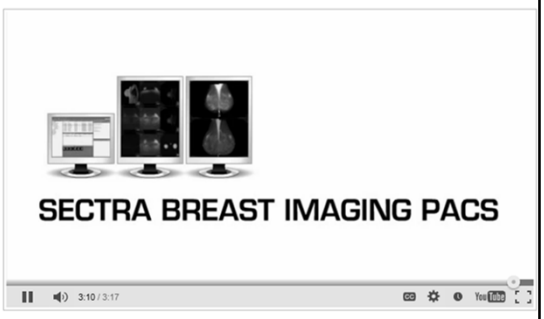
Sectra Breast Imaging PACS offers full integration to Volpara™ to assess volumetric breast density automatically and objectively. This provides physicians a BI-RADS™ equivalent breast density score, facilitating quick and accurate response to the new legal requirements.

Maximizing throughput

High-volume reading is supported by effective pre-fetching of priors and automatic display protocols that require minimal manual interference. To further optimize reading throughput, all digital breast images, regardless of modality vendor, are automatically displayed in the same size with correct orientation and alignment, facilitating comparison of current and prior images.

Bottom line…

- Tomosynthesis is “under construction”



But will be finished one day…

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Key features

- Use such features as auto-zoom, auto-align, quadrant zoom, display protocols and pan in the tomo stack.
- Scroll slice by slice, browse quickly and cine through the stack.
- Orient yourself in the stack with orientation indicators: Head, Feet, Medial or Lateral. A visual position indicator with slice numbers will also show the user's location in the stack.
- Compare 2D and 3D views by toggling with a single click, which saves valuable time.