Mammography Machine

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Objective-

After studying this lectures the student should be able to:-

- Learn what is mammogram
- Some common uses of the procedure
- How should you prepare for the mammogram test
- Instrumental setup of the equipment, parts and their functions.
- How the procedure Work
- Differentiate between Analog and Digital mammography

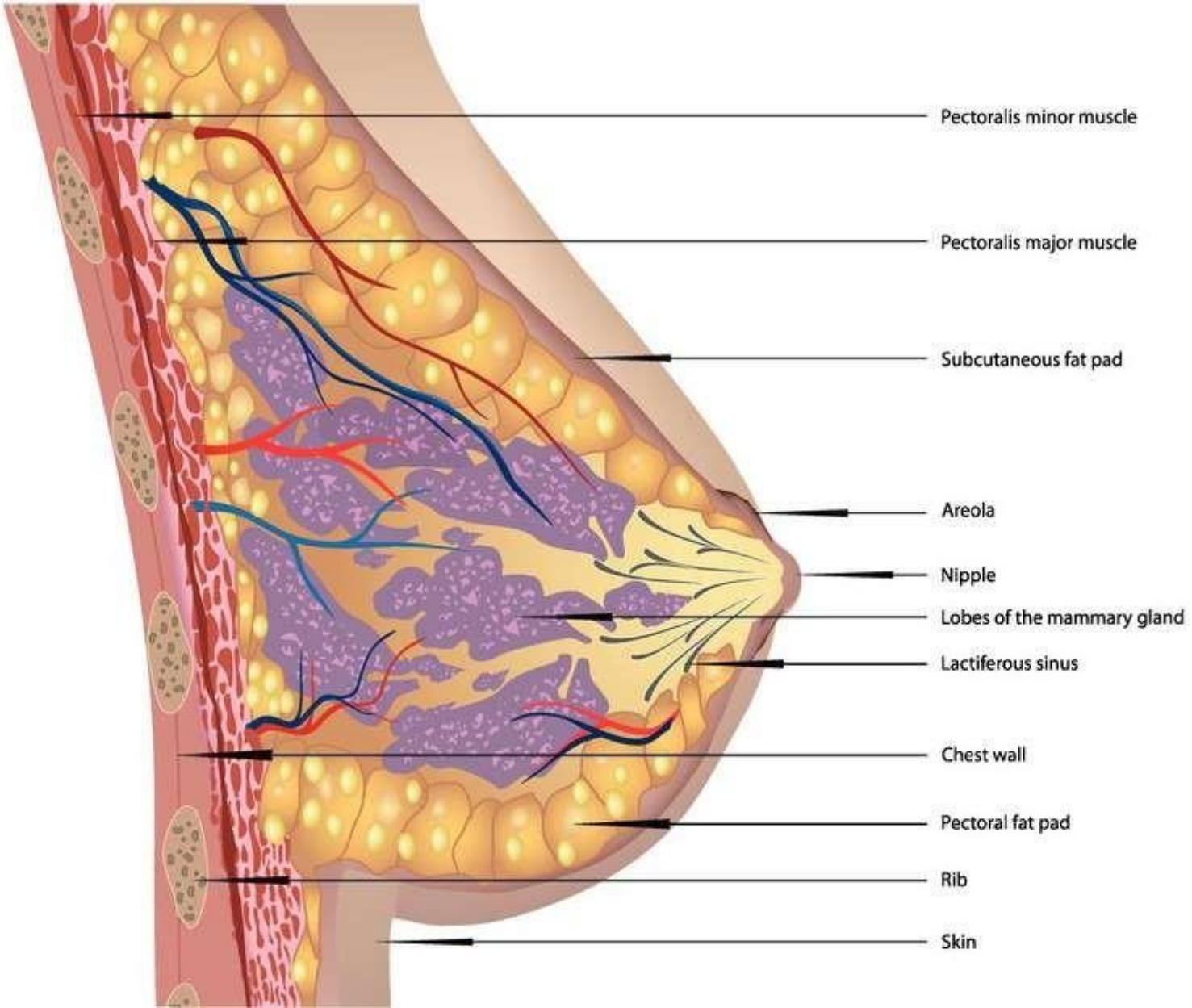

A

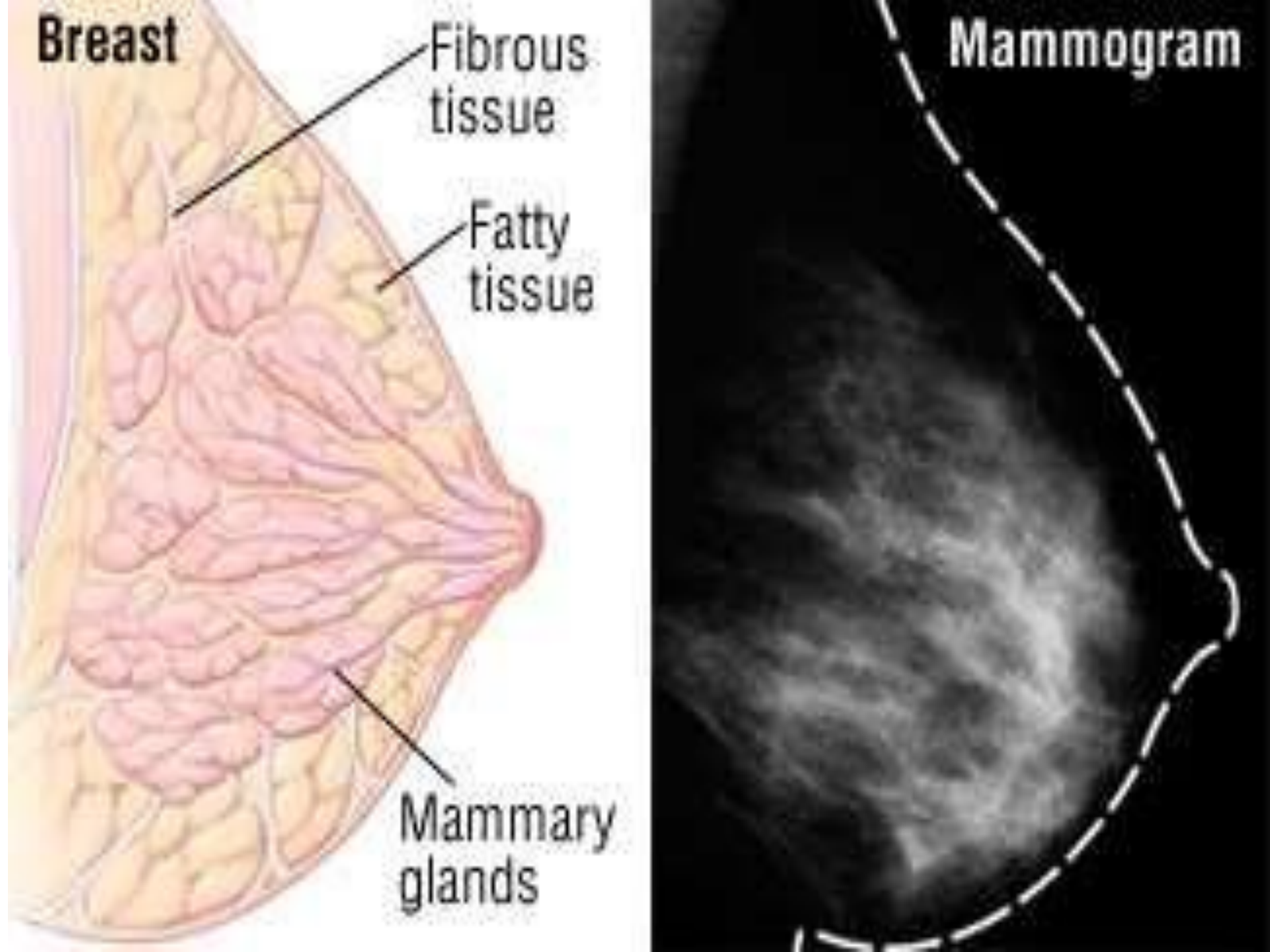
Mammography Introduction

- There are several breast imaging modalities available such as Ultrasound, CT, Digital Mammography ,MRI etc.
- Mammography remains the cornerstone of breast imaging .
- Only mammography when correctly performed and interpreted offers the necessary reliability to diagnose the curable forms of breast cancers.
- Ultra sound, MRI , CT are useful adjuncts once a lesion has been detected by physical examination or by radiographic mammography .

- Mammography is a radiographic examination designed for detecting breast pathology.
- Mammographic machine use low dose X-rays than usual X.ray to produce images of the breast called **mammogram**
- Provide information about breast morphology, normal anatomy, and gross pathology.
- **Mammography assists particularly in:**
  - Detecting breast cancer
  - To evaluate palpable masses and non-palpable breast lesions.

Breast Anatomy




Breast
Fibrous tissue
Fatty tissue
Mammary glands
Mammogram

INDICATIONS

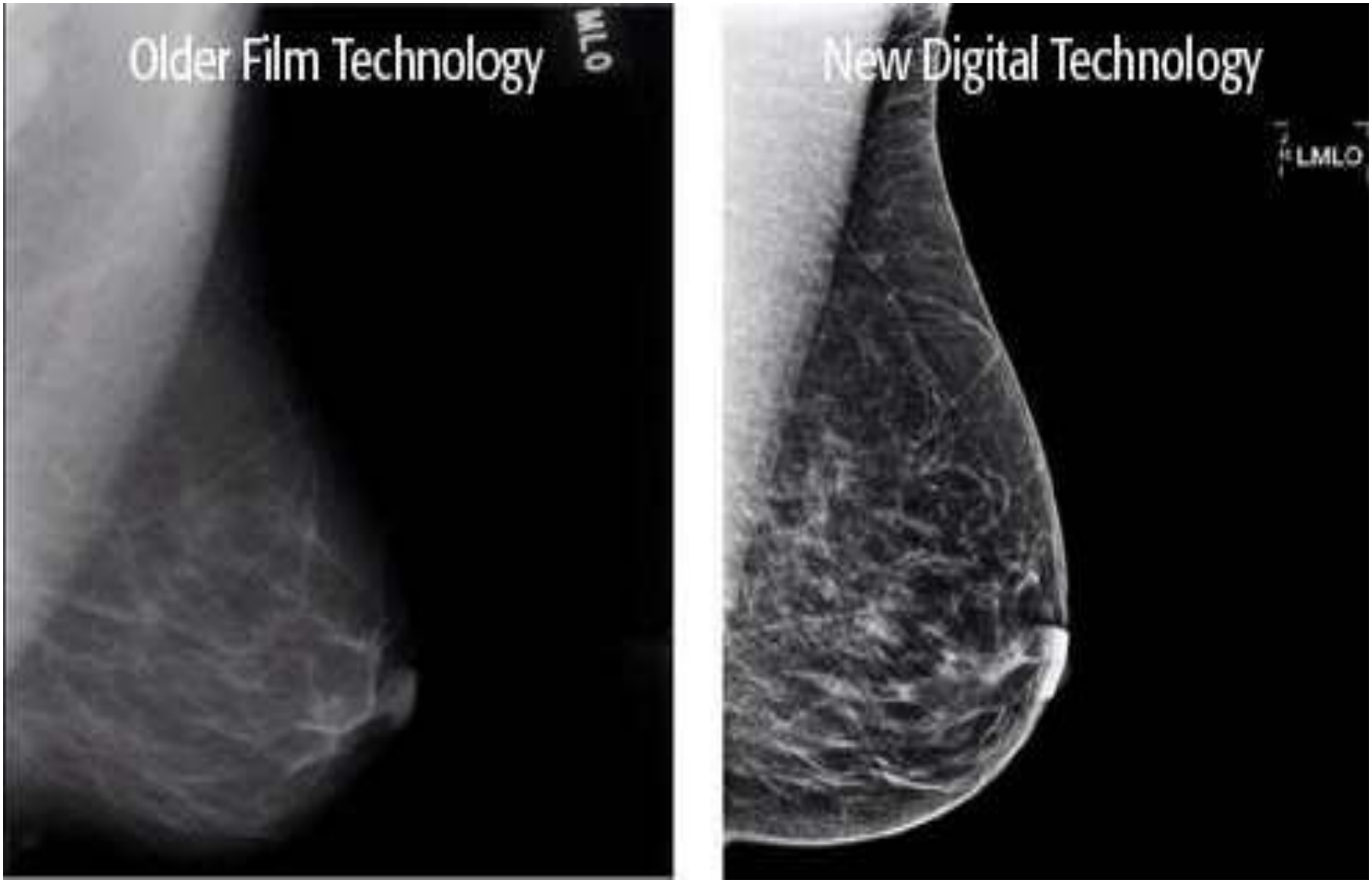
- Screening of asymptomatic women
- Screening of high risk women
- Investigations of benign breast diseases with eczematous skin,nipple discharge , skin thickening .
- Investigation of a breast lump
- Male breast evaluation.

How should I prepare?

Before scheduling a mammogram, the American Cancer Society (ACS) and other specialty organizations recommend that you discuss any new findings or problems in your breasts with your doctor. In addition, inform your doctor of any prior surgeries, hormone use, and family or personal history of breast cancer.

Do not schedule your mammogram for the week before your period if your breasts are usually tender during this time. The best time for a mammogram is one week following your period. Always inform your doctor or x-ray technologist if there is any possibility that you are pregnant.

What dose the equipment look like



Film vs Digital Image

Working Principle

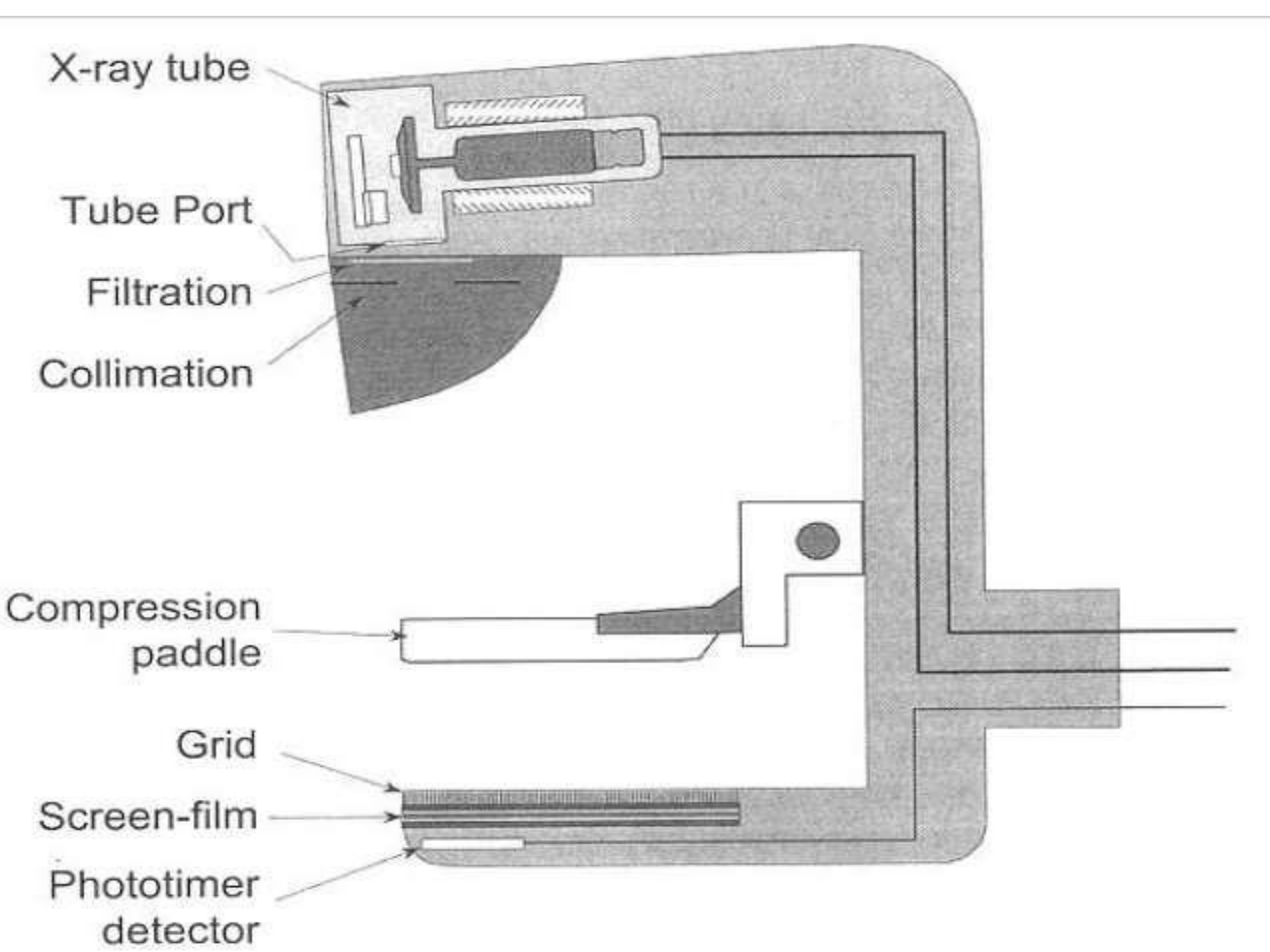
- Low energy X-rays are produced by the x-ray tube (an evacuated tube with an anode and a cathode).
- Cathode filament when heated, produces a stream of electrons, accelerated to high velocities by a high-voltage supply from the generator, collides with the target anode and convert electrons into X.rays
- X-rays exit the tube through a port window of beryllium.
- Additional filters are placed in the path of the x-ray beam to modify the x-ray spectrum.
- The x-rays that pass through the filter are shaped by either a collimator or cone apertures and then directed through the breast.

Instrumental setup

- **High voltage Generator:** modifies incoming voltage
- **X-ray tube:** produces an x-ray beam, fine focus of 0.2-0.5 mm with an additional 0.1 mm focus for magnification .
  - *Target*: Molybdenum and Rhodium
  - *Beryllium window*: Minimizes absorption of radiation within the tube .
  - *Molybdenum filter*: By transmitting only characteristic radiation ,absorbs unwanted radiation and forms a monoenergetic beam.

Instrumental setup

- **Compression device**: 1-4 mm thick plastic plate, used for compression of the breasts during imaging
- **Breast support:** used for placement of breast
- **Digital cassette:** to replace the traditional film cassette
- **Digital cassette reader:** producing a digital image from the cassette instead of developing film through a film processor.
- **Automated exposure control system**


X-ray tube
Tube Port
Filtration
Collimation
Compression paddle
Grid
Screen-film
Phototimer detector

Mammography X-Ray Tube

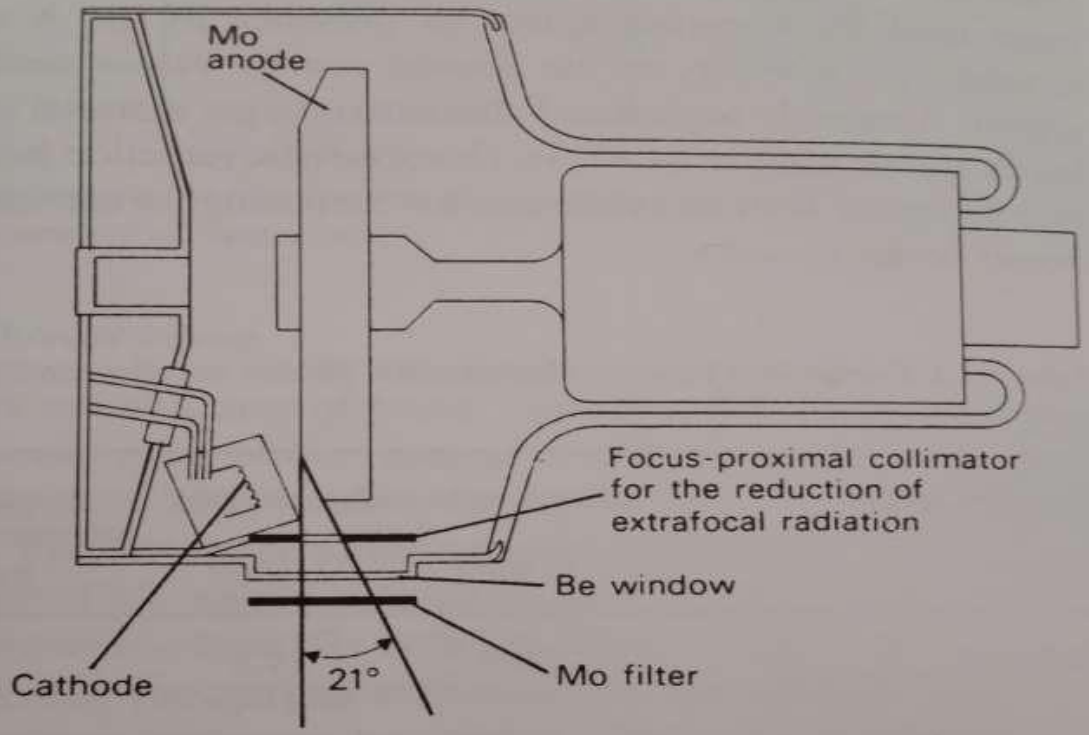


Fig. 11.2 Longitudinal section through mammographic X-ray tube. (*By courtesy of Siemens plc.*)

Mammography X-Ray Tube

Target materials consist of three main types.

- **Molybdenum**
- **Specialized Tungsten**
- **Rhodium**

- **Molybdenum**
  - **the best material to be used in mammography,**
  - **allows production of low energy spectrums of radiation**

- **Tungsten and Rhodium**
  - **are used for higher beam needs, in dense breast tissues.**

TARGET

- The xray tubes are designed with Tungsten ,molybdenum,Rhodium targets .
- Tungsten target is operated under 30 kVp with a 0.5 mm Al filter– Brehmsstrahlung and 12 keV L-shell characteristic xrays .
- Molybdenum target with Mo/Rh filter is more suitable for mammography .
- Rhodium target filtered with Rh filter gives a similar spectrum as molybdenum .
- Since the atomic number is higher , the brehmsstrahlung radiation is also higher than molybdenum .

FILAMENT

- Positioned within a focussing cup with two focal spot sizes .
- Filament types are either double wound/flat ribbon/circular filament .
- Focal spot size is very critical in mammography where high spatial resolution is required .
- Small focal spot is used with small anode angle , which permits the use of high mA factors .
- Usually the cathode is positioned towards the chest wall , which makes patient positioning east and takes care of the heel effect .

FILTERS

- Thin beryllium window or borosilicate glass window is used to reduce inherent filtration , since it offers low attenuation .
- For a tungsten target Xray tube , Mo or Rh filter is recommended .
- In case of Rhodium target Xray tube , Rhodium filter of 0.025 mm is used which gives high quality xrays with higher penetration .
- Combination is suitable for thicker and dense breast imaging .

Filtration

- Materials that are placed in the path of the X-ray beam in order to absorb those X-rays with energies above and below the desired spectrum.

- **Tube filtration types**:
- Molybdenum (Mo) (best used for lower kVp)
- Rhodium (Rh)
- Yttrium
- Aluminum (used for above 30 kVp)

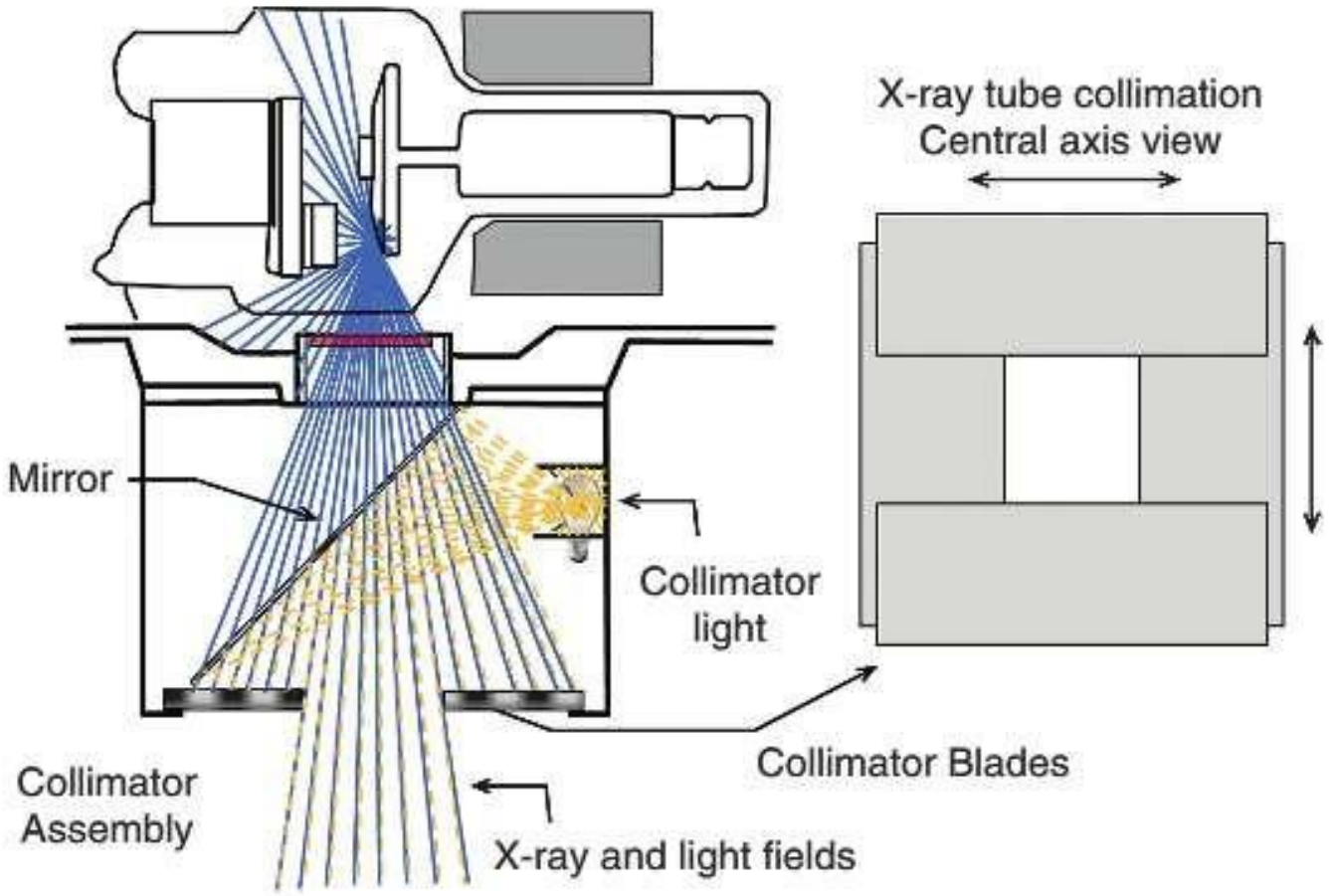
Collimation

Collimator : used to shape radiation field :

- Smaller radiation field means less scatter, collimate when you can!

- Smaller exposed area, better for patient dose

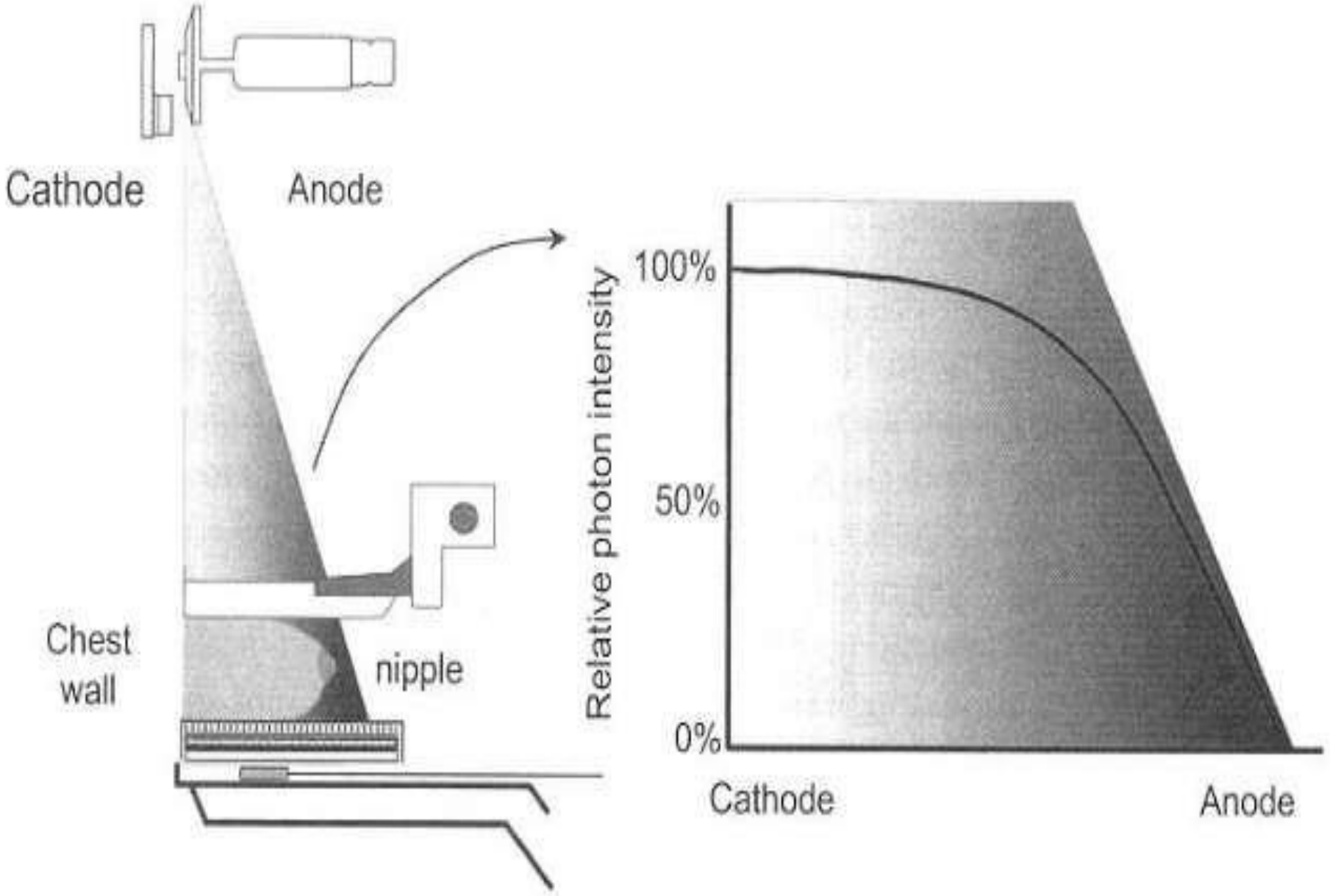
Cont.



■ **FIGURE 6-19** The x-ray tube collimator assembly is attached to the housing at the tube port, typically on a collar that allows it to be rotated. A light source, positioned at a virtual focal spot location, illuminates the field from a 45-degree angle mirror. Lead collimator blades define both the x-ray and light fields.

HEEL EFFECT

- Shape of the breast requires higher intensity of radiation near the chest wall, to create uniform exposure to the screen-film .
- The cathode is positioned toward the chest wall and the anode is toward the nipple .
- Permits easy positioning of the patient .
- Increases the intensity of radiation near the chest wall, where greater penetration is needed .
- The anode is often grounded with zero potential and the cathode is given higher potential .


Cathode
Anode
Chest wall
nipple
Relative photon intensity
100%
50%
0%
Cathode
Anode

COMPRESSION PEDDLE

(i) Decreases the thickness of the breast , thus reduces the scattered radiation –improves the contrast .

(ii) Decreases the kinetic blur .

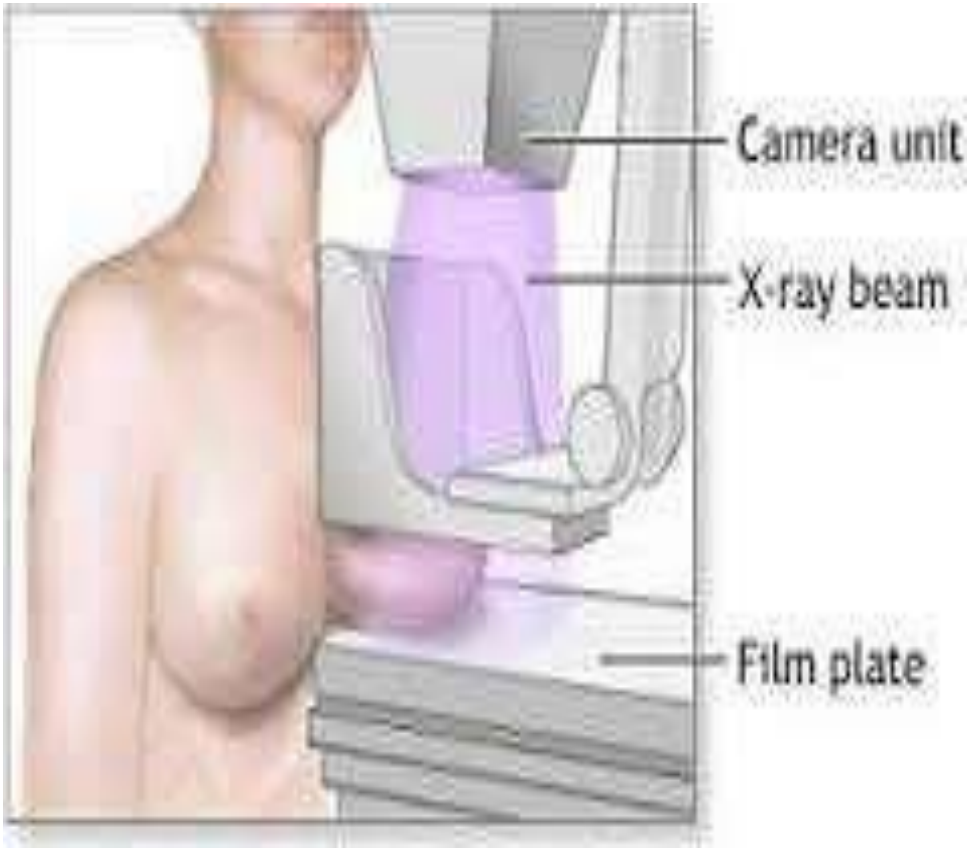
(iii) Reduces geometric unsharpness by homogenously bringing the object close to the film .

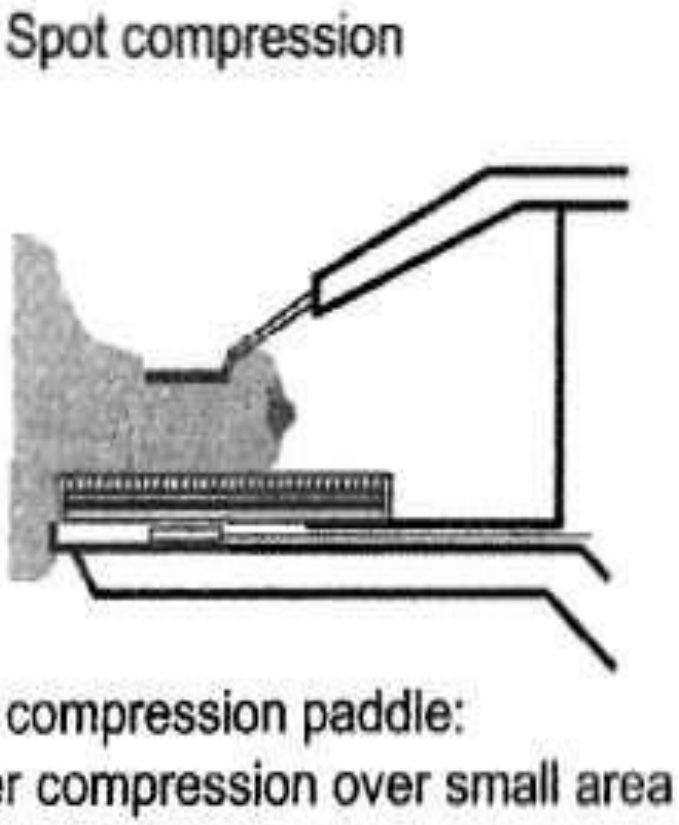
(iv) Makes breast thickness uniform in film density.

(v) Differentiates the easily compressible cysts and fibro-glandular tissue from the more rigid carcinomas

(vi) Separates the super imposed breast lesions .

(vii) Reduces radiation dose to the breast tissue .





-The compression device is parallel to the receptor surface .

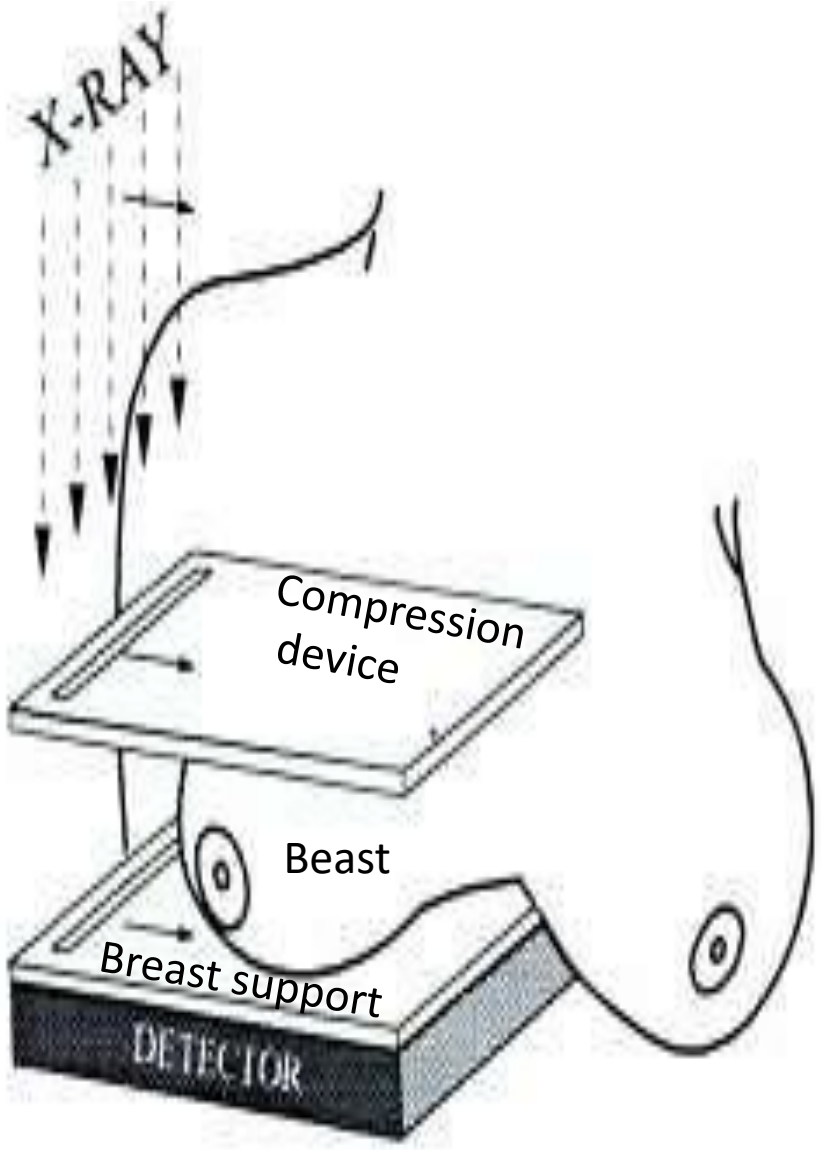
-Radiolucent plate that is flat and parallel to the support table .

- Should match the cassette size

IMAGE ACQUISITION DEVICES

- **CHARGE COUPLE DEVICE TECHNOLOGY**
- Digital detectors consist of a phosphor, which is optically coupled to the CCD.

- ADVANTAGE- The slit collimation of the X-ray beam results in a significant reduction in scatter.
- This eliminates the need for a grid, leading to potential dose savings .

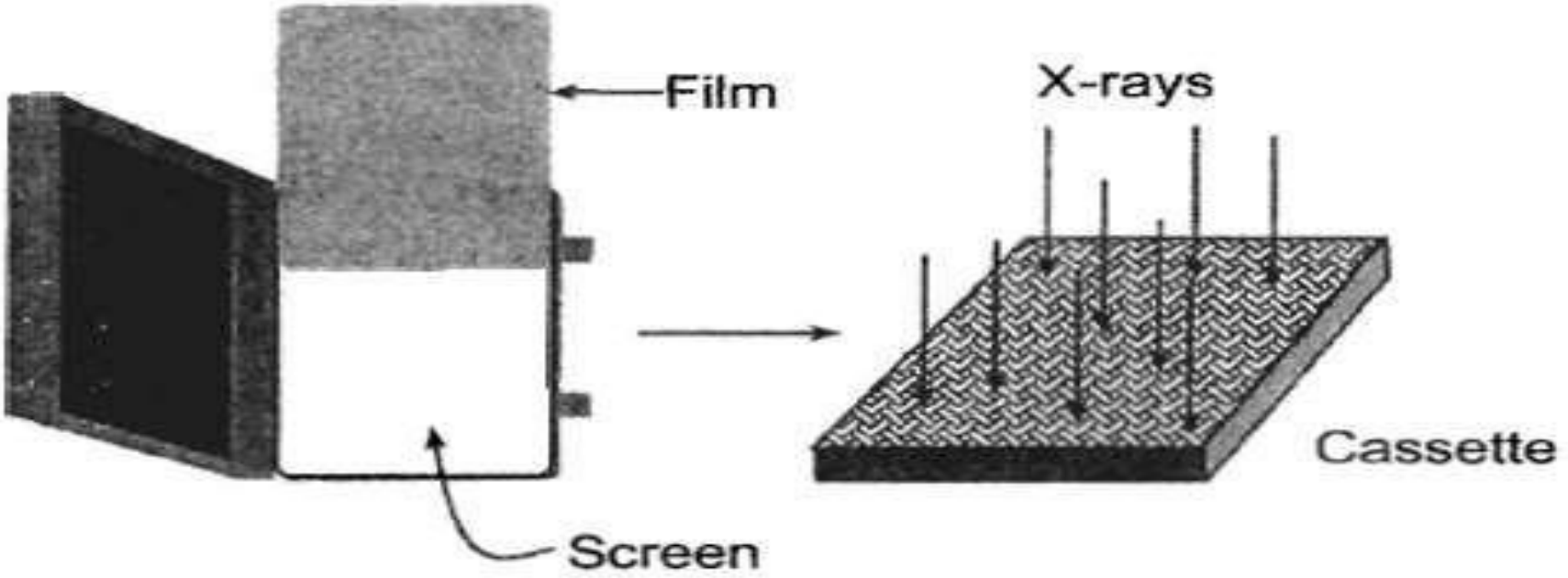


Selenium-based Detectors

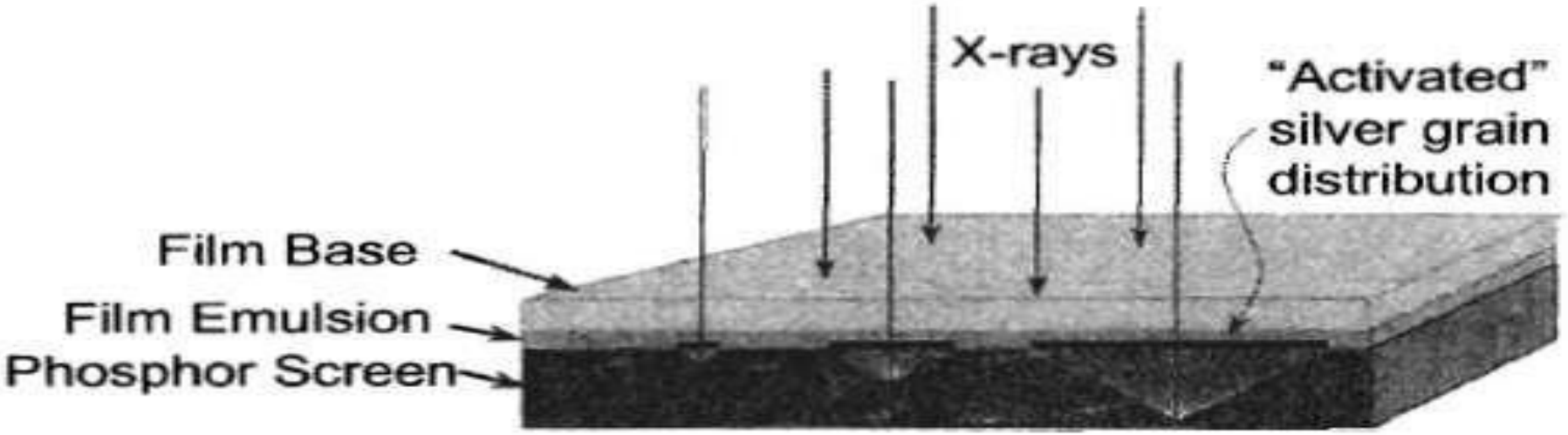
- Selenium based detectors consist of a thin layer of amorphous selenium deposited on the imaging plate.
- A uniform positive charge is built up on the surface of the selenium.
- When X-ray photons strike the surface of the selenium, electrons are freed.
- This leads to a partial discharge of the uniform surface charge pattern.
- The degree of discharge reflects the local radiation exposure, leading to a latent image in the form of a charge distribution pattern.
- This charge pattern is then “read” and the resultant electrical signal digitised.

SCREEN FILM SYSTEM

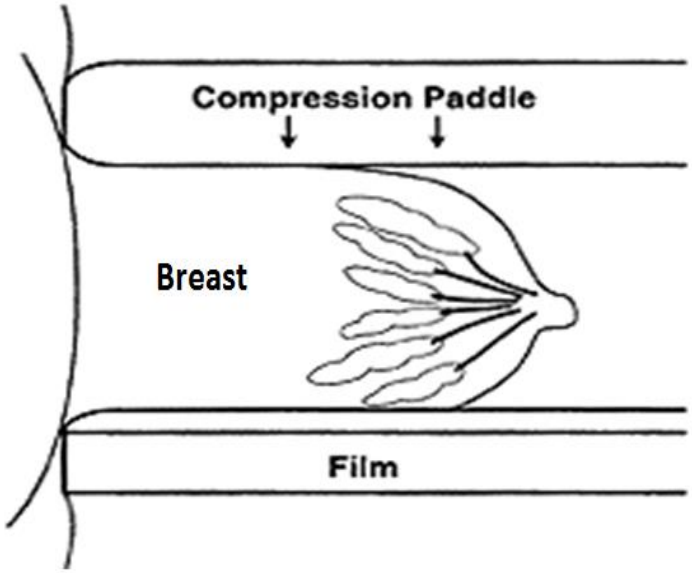
- The Xray film should have high resolution and small grain size and used along with single intensifying screen .
- The emulsion surface of the film must face the screen .
- Prevents loss of resolution due to light diffusion in the screen .
- **Gadolinium Oxysulfide activated with terbium is used as screen phospor .**



Single emulsion Film & Single phosphor screen



Breast Compression plate



In mammography the breast is compressed using a rigid transparent plastic compression plate which can be motor driven.

Why Breast Compression?

- Reduce or equalize the back of the breast thickness, making it more uniform so that the image is more easily interpreted.
- Another reason for compressing the breast is that the structures in the breast are very irregular and they overlap one another.
- Amount of breast compression applied during mammography potentially influences image quality.
- Discomfort experienced.
- Compress slowly and steadily

- Better spatial resolution: The breast is brought closer to the imaging receptor so that magnification and focal spot blurring is reduced.
- Reduced blurring due to patient movement, even at relatively long exposure times.
- Less scattered radiation in the image. The beam path length through the breast is shorter, so there is less material to do the scattering.

- The reduced path length makes practicable the use of lower energy (less penetrating) X-ray spectra. This gives greater subject contrast.

- Small areas of pathology buried in glandular tissue can be better visualized, as malignant tissues tend to be firmer.

Breast support plate

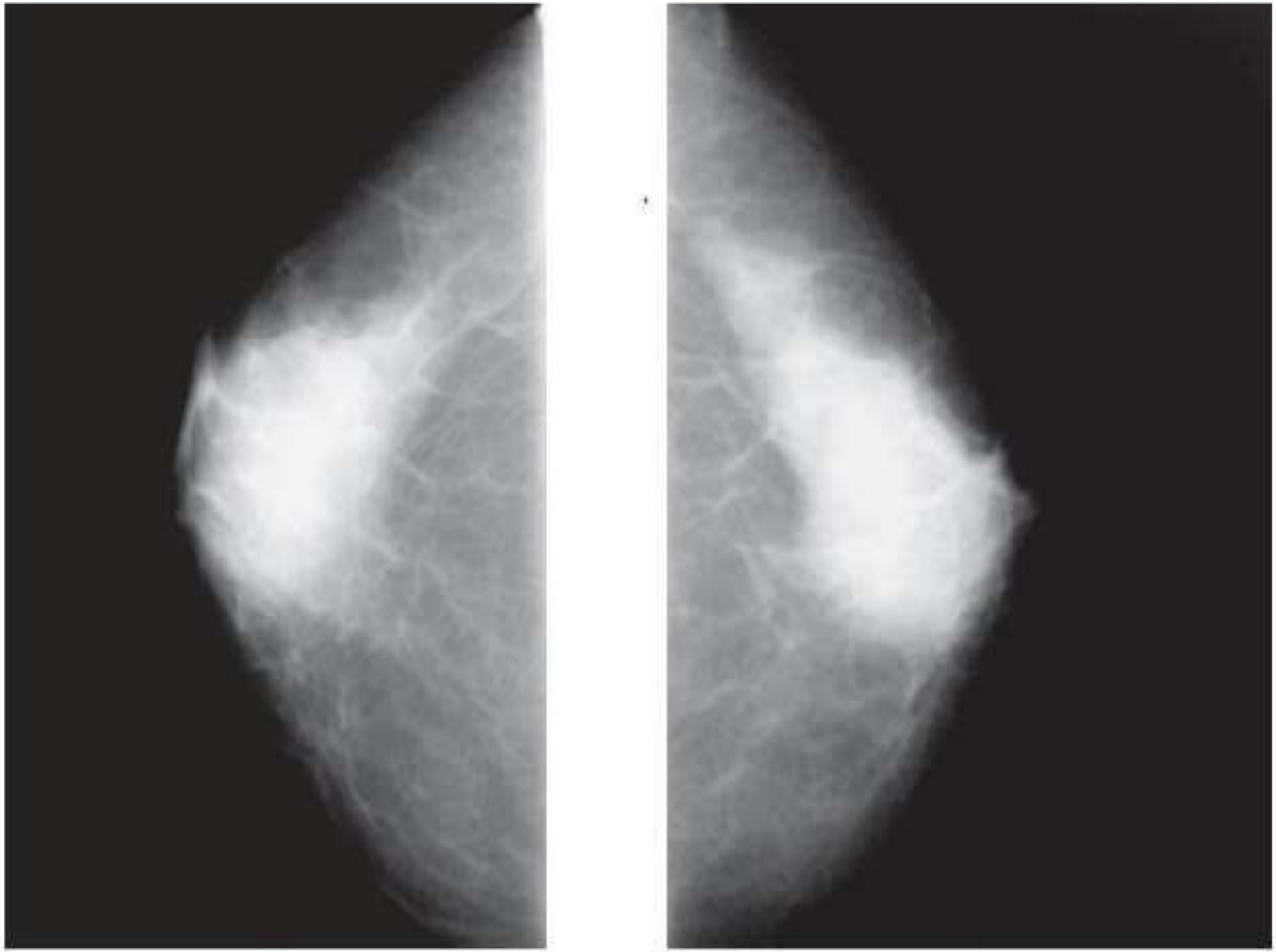
- plate that hold the breast :

- **Two parts:**
  - Upper part made from carbon fiber(free absorption)

  - Lower part made from lead (safe the patient abdomen from radiation hazard)

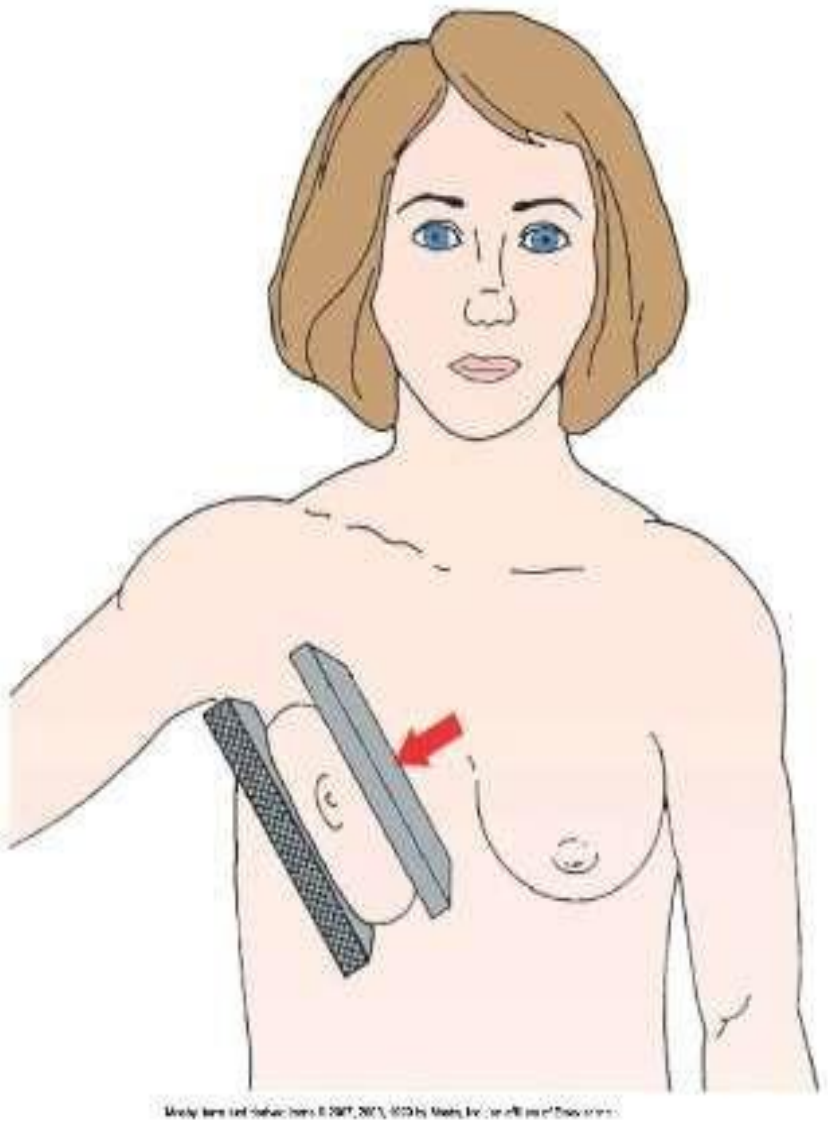
CRANIO-CAUDAL VIEW

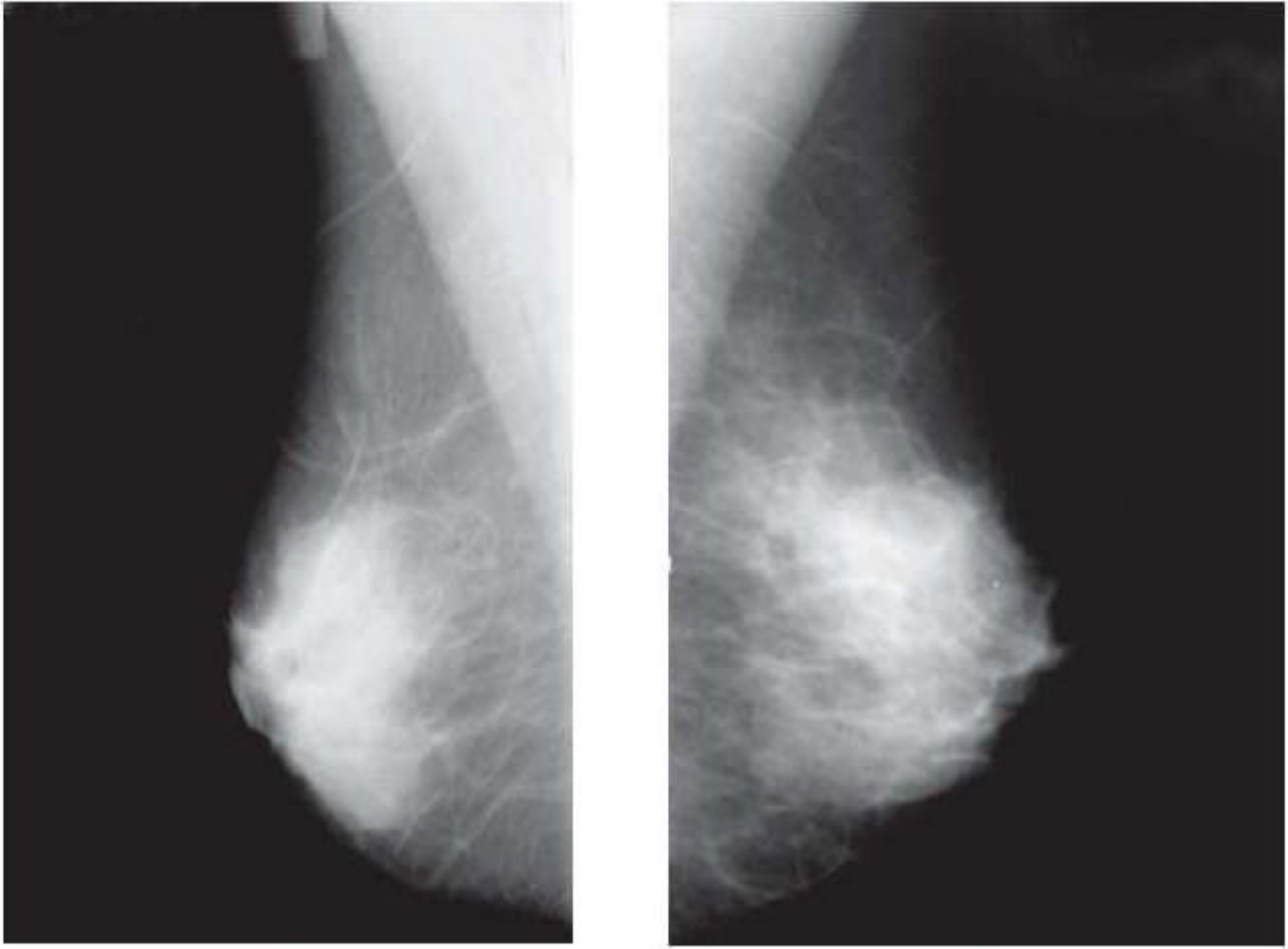
- The casette is placed under the breast at the level of the inframammary fold .
- The breast is then pulled until the inframammary fold is taut .
- Compression is applied and Xray beam is directed vertically from above .
- Postero medial aspect should also be included .



MEDIOLATERAL OBLIQUE VIEW

- Best view to image all of the breast tissue and the pectoral muscle .
- The C-arm of the mammographic unit is rotated to 45 degree so that the cassette is parallel to the pectoral muscle .
- The film holder is kept high up in the axillary fossa and the patient s arm is abducted at the elbow by 80degrees.
- The xray beam enters the breast from the medial side –compression is applied to the pectoralis major muscle .





A B

SUPPLEMENTARY VIEWS

1. Lateral projections (mediolateral/lateromedial)
2. Extended craniocaudal projection
3. Cone down compression view
4. 90 degrees lateral view and angled craniocaudal views
5. Tangential views in palpable masses
6. Spot and magnification views
7. Cleavage view
8. Modified compression technique .

- Adipose tissue comprises a large portion of most breasts and is radiolucent.

- The radiographically visible densities include:

(i) varying degree of ducts

(ii) lobular elements

(iii) fibrous connective tissues structures.

- The supportive connective tissue is highly cellular and richly vascularised with significant water density- constitutes the essence of breast opacity in mammography.

- Sexual hormones influence the degree of hydration of the adult breast.

- The breast is more radiolucent and better contrasted in the first part of the menstrual cycle

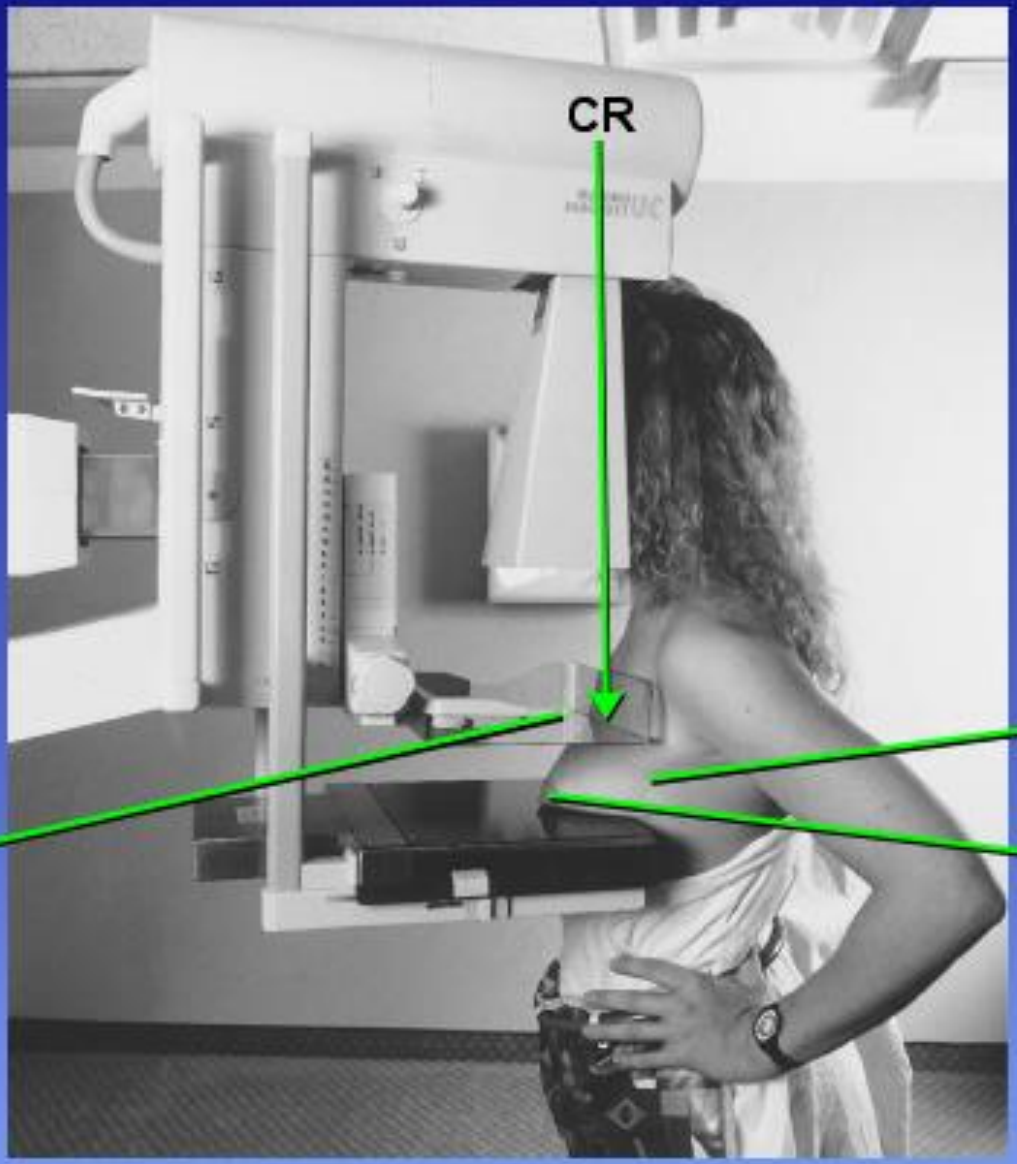
- Pregnancy and lactation make the glandular and connective tissue structures hypertrophic and more hydrated which leads to diffuse increase in breast density.

Mammography procedure

(1) Position breast in the mammography unit platform and gradually compressed with plastic paddle.
(2) Hold the breast still in order to minimize blurring of the image caused by motion. Reduce x-ray scatter to increase sharpness of picture.
(3) Allow a lower x-ray dose 0.4 milliSievert (mSv)
(4) Take images of top-to-bottom and an angled side view.
(5) Repeat process for the other breast. Compression is still necessary for tomosynthesis imaging in order to minimize motion, which degrades the images. During screening breast tomosynthesis, two-dimensional images are also obtained or created from the synthesized 3-D images.
(6) Hold the breast still and stop breathing for a few seconds while the x-ray picture is taken to reduce the possibility of a blurred image.
(7) When the examination is complete, patient may be asked to wait until the radiologist determines that all the necessary images have been obtained.

The examination process should take about 30 minutes.

Breast Positioning



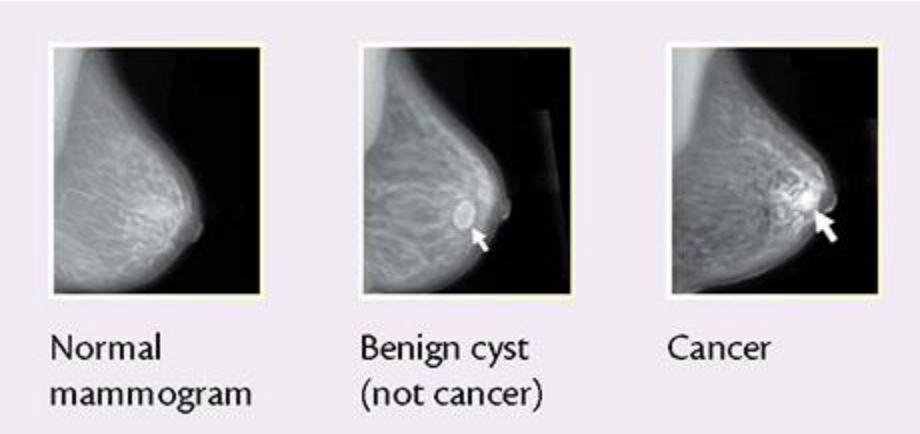
Types of mammography

- There are two main types of mammography:

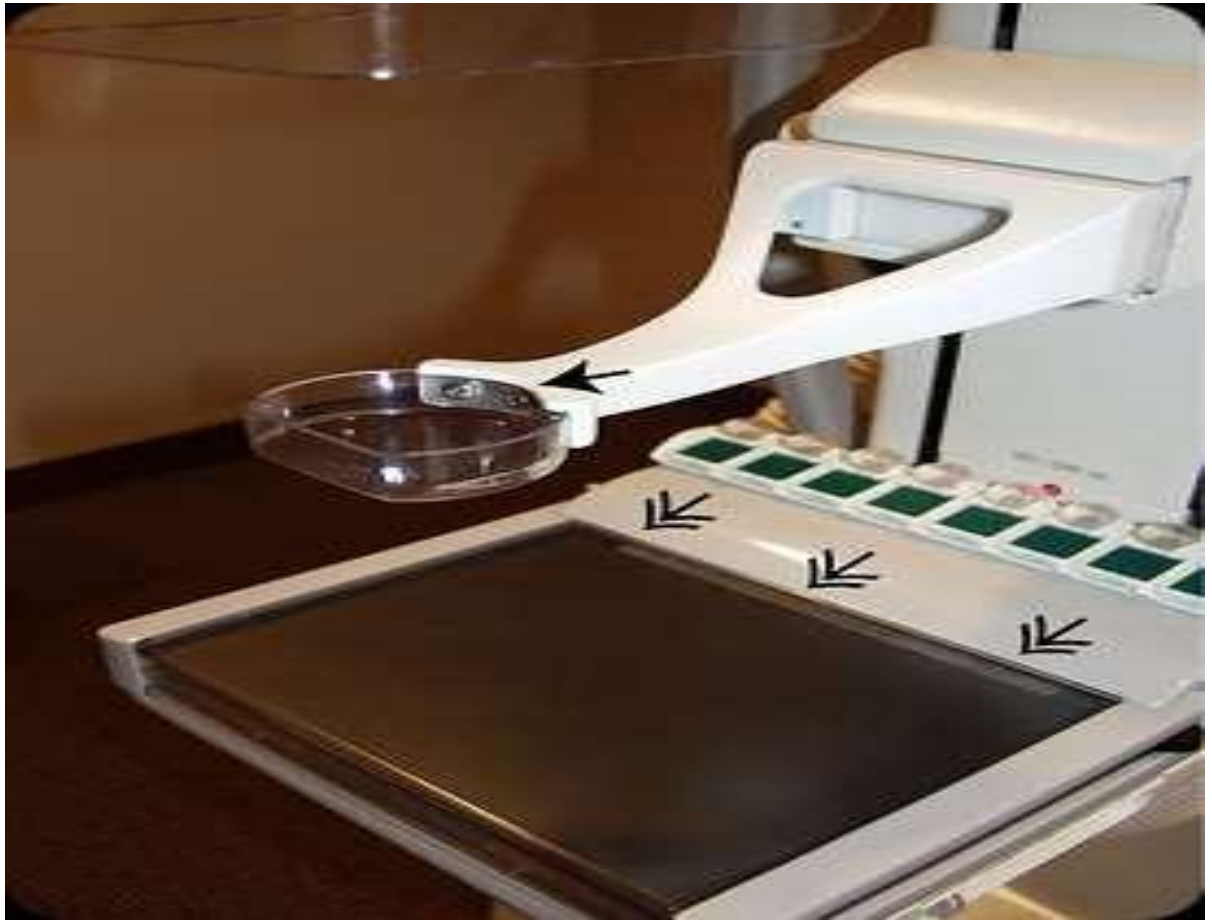
  1- Screening mammogram:

Screening mammogram is an x-ray of the breast used to find breast changes in women who have no signs of breast cancer.

It usually involves two x-rays of each breast. During the procedure, the breast is placed between two plastic plates and compressed to flatten and spread it. This may be uncomfortable; however, it is necessary to get a good picture of the breast tissue that can be examined by a radiologist.



2- Diagnostic mammogram:



Difference between screening and diagnostic mammogram

Screening mammograms	Diagnostic mammograms
are routinely administered to detect breast cancer in women who have no apparent symptoms. The goal of a screening mammogram is to detect breast cancer early. Detecting breast cancer early greatly improves a woman's chance for successful treatment and increases her treatment options	are used after suspicious results on a screening mammogram or after some signs of breast cancer alert the physician to check the tissue. Such signs may include: A lump, breast pain, nipple discharge or an abnormal area found on a routine screening mammogram.

Advances

1. **Digital mammography:**

- Also called full-field digital mammography (FFDM),

is a mammography system in which the x-ray film is replaced by solid-state detectors that convert x-rays into electrical signals.

DIGITAL MAMMOGRAPHY

- The stages in digital imaging :

1. Image capture by digital detector

2. Conversion of latent image into digital data set

3. Processing of image data

4. Display of processed image

5. Transmission and archival of data set

Advances

2. Computed aided detection:

- That can be obtained from either a conventional film mammogram or a digitally acquired mammogram.

3. Breast tomosynthesis:

- Also called three-dimensional (3-D) breast imaging, is a mammography system where the x-ray tube moves in an arc over the breast during the exposure.

Analog Mammography

VS.

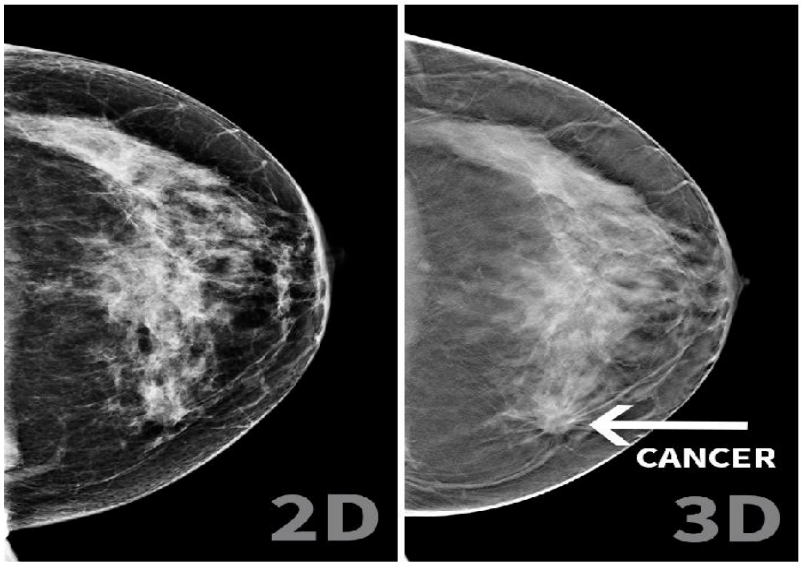
Digital Mammography

Analog mammography machines were the standard for many years. However, in 2000, **the FDA approved** the first full-field digital mammography unit, which improved image quality dramatically.

Then, in 2011, the first **3D mammography unit was introduced**. This type of mammography machine added further to the advancement and image quality

Tomosynthesis or 3D mammography

Digital breast **tomosynthesis** (tomo), also known as 3D **mammography**, is a revolutionary new screening and diagnostic breast imaging tool to improve the early detection of breast cancer. During the 3D part of the exam, an x-ray arm sweeps over the breast, taking multiple images in seconds.



ADVANTAGES OF DIGITAL MAMMOGRAPHY

1. Acquired in less than a minute as compared to conventional mammography .
2. Spot view digital systems are available to help guide breast biopsy .
3. Superior contrast resolution especially in dense breast tissues
4. Offers the possibility of three dimensional breast tomography using relatively low doses .

DRAW BACKS

- Until ways are found to increase the spatial resolution of digital mammography, conventional film mammography will remain better able to detect subtle tissue changes such as microcalcifications.

- In dense breast tissues even digital mammography may overlook some lesions that are masked by overlying structures

Differences Between Analog and Digital Mammography Machines

Analog mammography uses low dose radiation that produces high-quality Xrays and can detect tissue changes of 1-2mm in size.
It captures the X-ray beams on film cassettes, and the outcome is a film showing the breast from different angles, which is then hung on a viewing board.

digital mammography captures X-ray beams on a digital detector. This detector then converts the X-ray beams into electronic signals, which are transferred to a computer. In the end, the computerized images are available for review on a specialized high-resolution monitor.
Furthermore, the digital images can be analyzed by radiologists using the options and tools of the console/workstation.
For instance – magnifying, masking of light, inverting (negative of the image), and comparing them to previously obtained mammograms.

Advantages and Disadvantages of Analog Mammography Machines

Advantages of Analog Mammography Machines

- Analog mammography machines are more affordable than digital mammography machines.
- Analog images can be transformed into digital images with a CR and saved as DICOM.
- These machines do not have a digital detector, which is both fragile and expensive part, therefore, repairs are typically less costly.
- It is easy to find a company that will provide a service contract for analog mammography machines, as they are easier to maintain.

Disadvantages of Analog Mammography Machines?

- Analog images are less detailed than their digital counterparts.
- Analog mammography uses film. And thus, after obtaining the image, you need a CR reader (such as **Fuji Capsula XL II**) to convert the image into a digital one. As a result, it takes a longer time to receive the image.
- As there are two systems working together, if one breaks, the entire process will be “down.”
- It is more difficult to archive pictures produced by analog mammography machines unless you have a CR.
- The sales of analog mammography machines have been decreasing. Therefore, it can be a bit challenging to find parts for repairs if needed.

Fuji Capsula XL II

Advantages and Disadvantages of Digital Mammography Machines

Advantages of Digital Mammography Machines

- More efficient workflow as the images are available immediately on the computer.
- A monitor in the room instantly displays the image, which allows for repositioning of patients if necessary and therefore leads to fewer retakes.
- The digital detector provides crisps images, even of larger breast.
- You can easily transfer images electronically to a central location for diagnosis (Utilizing Picture Archiving and Communications System PACS).
- Easy analysis of images.
- Radiation doses are 30-40% lower than for analog systems.
- Earlier detection of cancer, also in those with denser breasts.
- Finally, it works very well with Computer-Aided Detection (CAD) devices.

Disadvantages of Digital Mammography Machines

- They are more expensive than analog mammography machines.
- The digital detector is delicate and if it breaks, it is costly to repair.
- More sensitive to ambient temperatures than analog units.
- Digital mammography machines provide lower spatial resolution.
- As they are more difficult to service, some manufacturers prefer not to provide service contracts.
- In very large breasts, there might be a need to take the digital images a patchwork pattern, which is harder to read.

Thank you