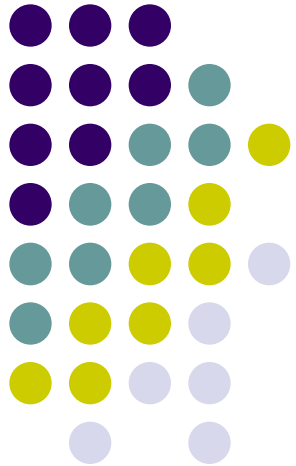
Radiology and imaging of the mammary gland.



Normal anatomy

- ***Normal Structures***
- Normal breast is composed:
- mainly of parenchyma (lobules and ducts)
- connective tissue
- fat
- Lobules are drained by ducts. There are about 15 to 20 lobes in the breast. The lobar ducts converge upon the nipple.

Parenchyma

- The lobules are glandular units and are seen as ill-defined, splotchy opacities of medium density. Their size varies from 1 to several millimeters, and larger opacities result from conglomerates of lobules with little interspersed fat.

- . The breast lobes are intertwined and are therefore not discretely identifiable. This parenchymal tissue is contained between the premammary and retromammary fascia.
- The amount and distribution of glandular tissue are highly variable. Younger women tend to have more glandular tissue than do older women.

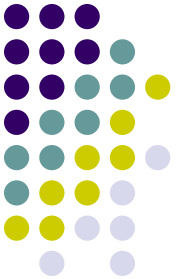
Connective tissue

- Trabecular structures, which are condensations of connective tissue, appear as thin (1 mm) linear opacities of medium to high density. Cooper's ligaments are the supporting trabeculae over the breast that give the organ its characteristic shape, and are thus seen as curved lines around fat lobules along the skin-parenchyma interface within any one breast.

Fat

- The breast is composed of a large amount of fat, which is lucent, or almost black, on mammograms. Fat is distributed in the subcutaneous layer, in among the parenchymal elements centrally, and in the retromammary layer anterior to the pectoral muscle.

Lymph Nodes

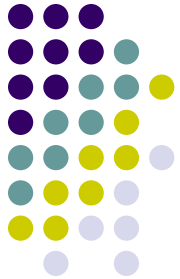


- Lymph nodes are seen in the axillae and occasionally in the breast itself.

Veins

- Veins are seen traversing the breast as uniform, linear opacities, about 1 to 5 mm in diameter

Arteries



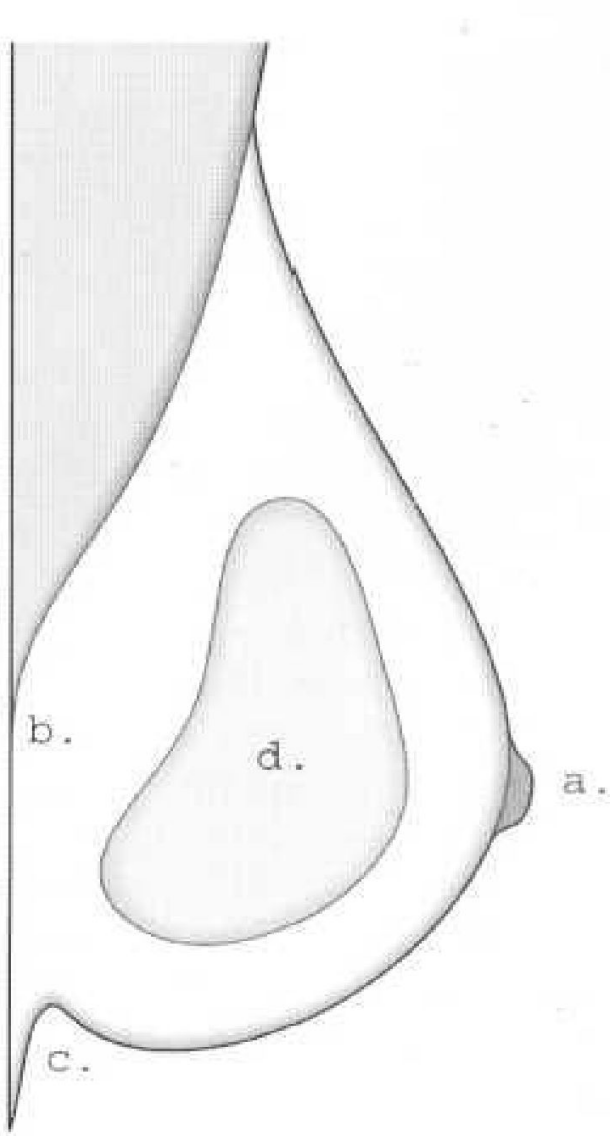
- Arteries appear as slightly thinner, uniform, linear densities and are best seen when calcified, as in patients with atherosclerosis, diabetes, or renal disease.

Skin

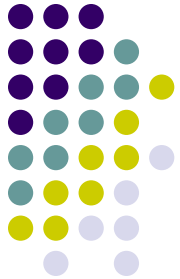
- Skin lines are normally thin and are not easily seen without the aid of a bright light for film-screen mammograms. Various processing algorithms with digital mammography allow better visualization of the skin.

Normal variants

- The normal anatomical variants of the brest result from the embryological development of the brest from the band of ectoderm on the ventral surface of the embryo extending from clavicle to groin, the `nipple line'. An area of accessory breast tissue is commonly seen in the axillary tail, or occasionally in the inframammary fold. An accessory nipple may occur at any site along the nipple line. Congenital absence or hyperplasia of the pectoralis muscle may occur and is seen in Poland's syndrome.


b.
d.
a.
c.

The dense breast



- Diffuse increase in the density of the breast tissue is caused
- by oedema (see the `Oedematous breast' below)
- by an increase in the glandular tissue
- or fibrous tissue
- This is commonly seen in benign breast change, and may be accompanied by evidence of cysts, and in women who are taking hormone replacement therapy (HRT) for menopausal symptoms.

- The increased density of the parenchyma seen as a result of HRT has been shown to be associated with a decrease in the sensitivity of screening mammography for cancer detection. Diffuse increase in parenchymal density is also occasionally seen due to loss of fat due to severe weight loss or cachexia, or lack of fat due to lipodystrophy.

Mammography

- The film-screen mammogram is created with x-rays, radiographic film, and intensifying screens adjacent to the film within the cassette; hence the term ***film-screen mammography***.
- The digital mammogram is created using a similar system, but replacing the film and screen with a digital detector.

- The routine examination consists of two views of each breast:

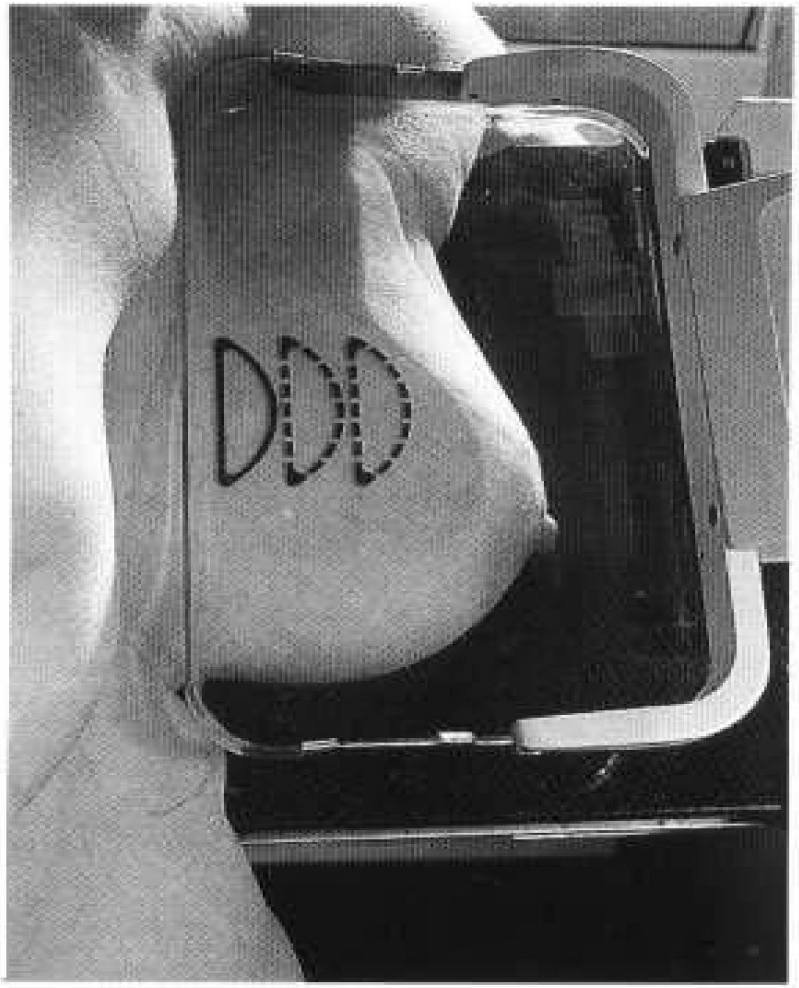
- *the craniocaudal (C-C) view*

- *the mediolateraloblique (MLO) view*, with a total of four films.

- The C-C view can be considered the "top-down" view, and the MLO an angled view from the side.
- The patient undresses from the waist up and stands for the examination, leaning slightly against the mammography unit.
- The technologist must mobilize, elevate, and pull the breast to place as much breast tissue as possible on the surface of the film cassette holder.

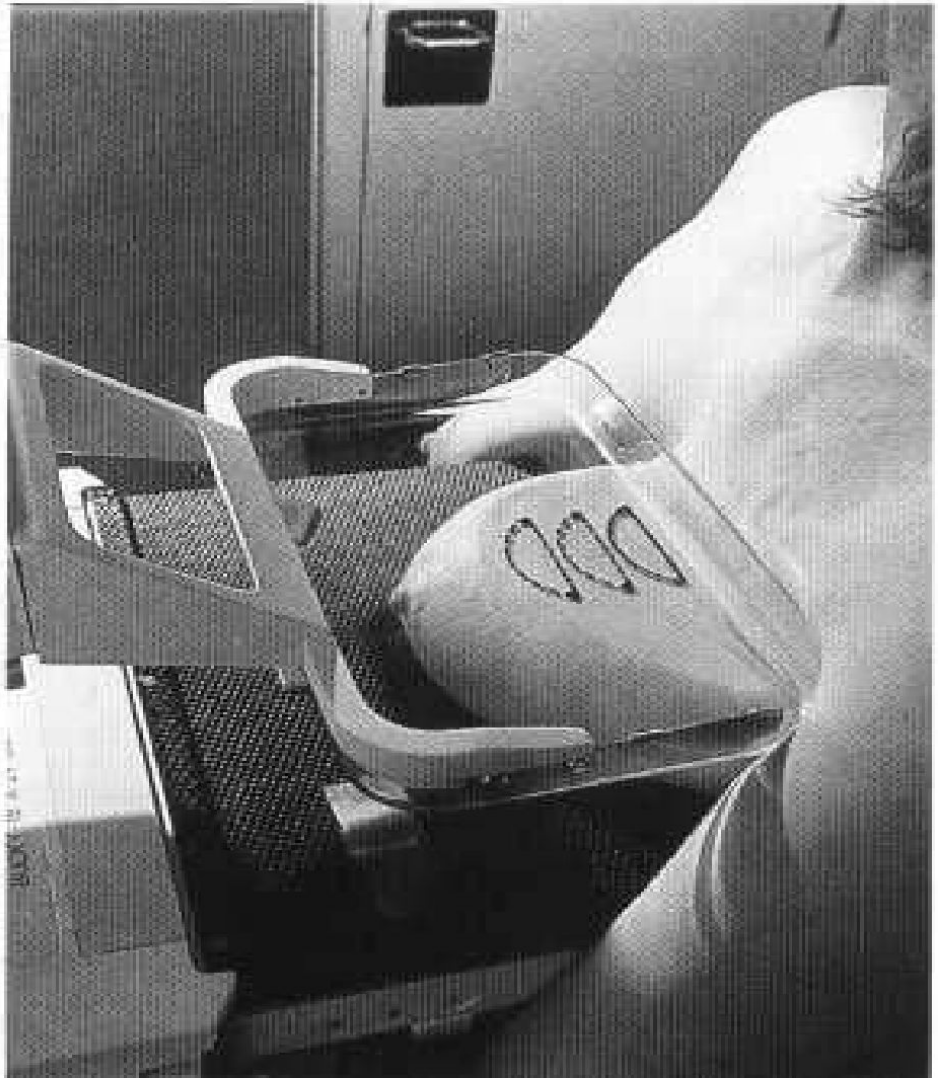
- A flat, plastic compression paddle is then gently but firmly lowered onto the breast surface to compress the breast into as thin a layer as possible.
- This compression achieves both immobilizations during exposure and dispersion of breast tissue shadows over a larger area, thereby permitting better visual separation of imaged structures

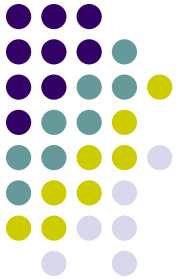
Positioning for the lateral oblique view.



46.2

Positioning for the craniocaudal view.





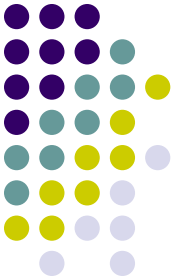
- Compression may be uncomfortable, and may even be painful in a small proportion of patients.
- However, most patients accept this level of discomfort for the few seconds required for each exposure, particularly if they understand the need for compression and know what to expect during the examination.
- Mammography has proved to be more cost-effective, while maintaining resolution high enough to demonstrate early malignant lesions, than any other breast imaging technique.

Compression

- Firm compression is essential for high-quality mammograms and is applied using a powered system operated by a foot control. It is important that there is even compression of the entire breast.

- The effects of compression are:
- (i) reduced dose;
- (ii) reduced scatter-improved contrast;
- (iii) reduced geometric unsharpness;
- (iv) reduced movement unsharpness;
- (v) reduced range of breast thickness;
- (vi) reduced tissue overlap improved resolution.

Mammography projections and normal appearances



- The standard examination for women undergoing either symptomatic mammography or their first screening examination consists of a lateral oblique and a cranio-caudal view of each breast.
- The ***lateral oblique* view** is usually obtained with the tube angled at 45° to the horizontal, but tube angulation from 30° to 60° may be needed depending on the build of the woman.

- More breast tissue is demonstrated on the lateral oblique projection than on any other projection.
- Careful positioning is essential for satisfactory demonstration of the breast.

- The standard ***craniocaudal film*** is obtained with a vertical X-ray beam and the nipple should be in profile. The craniocaudal projection demonstrates the subareolar, medial, and lateral portions of the breast. However, tissue in the posterolateral aspect of the breast may be incompletely demonstrated.

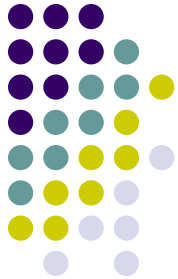
Supplementary views

- For demonstration of tissue in the most posterolateral part of the breast, an extended craniocaudal view is used with the patient rotated medially to bring the lateral aspect of the breast and axillary tail over the film. When the posteromedial portion of the breast is not satisfactorily demonstrated, an extended craniocaudal view with lateral rotation of the patient is obtained.

Magnification views

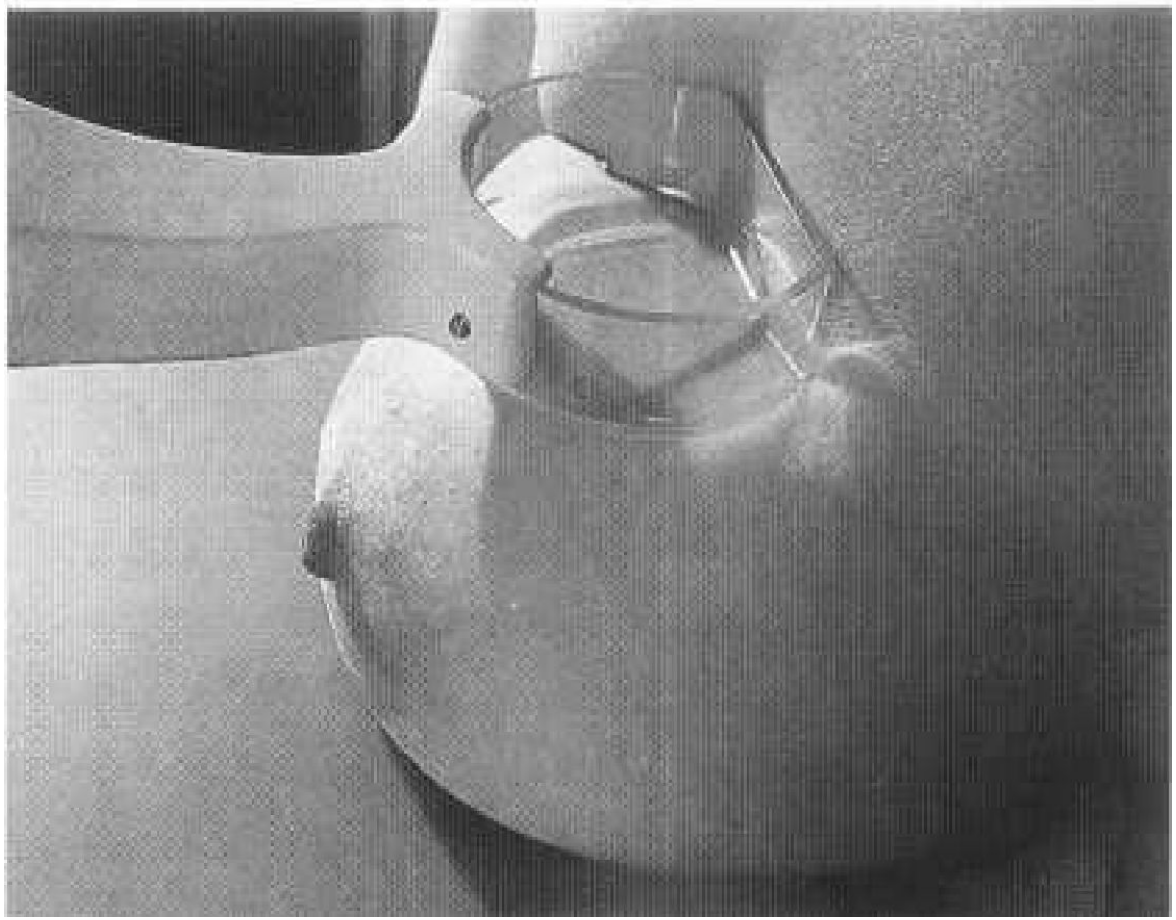
- ***Magnification views*** are obtained by increasing the object-film distance, producing an `air gap', and using a fine focal spot to increase resolution. A magnification factor of 1.5 is usual and the increased resolution obtained is particularly helpful for detailed analysis of microcalcifications and the margins of small mass lesions.

Localized compression views

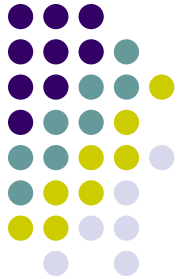


- ***Localized compression views*** are obtained by using a small paddle compression device and may be used together with magnification. By compressing one area of the breast, tissue overlying a small lesion is displaced, allowing better demonstration of its features. The technique is also very helpful in analysing asymmetrical soft-tissue shadows, either by confirming that the shadow has the appearance of normal glandular tissue or by demonstrating that an underlying lesion is present.

Positioning for a localised compression view

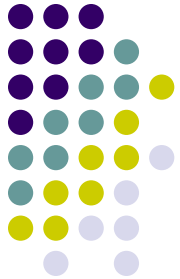


Screening Mammography



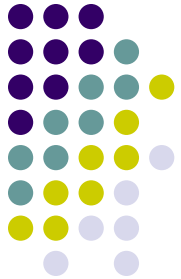
- The standard mammogram (along with appropriate history taking) makes up the entire screening mammogram. The indication for this examination is the search for occult carcinoma in an asymptomatic patient. Physical examination by the patient's physician, known as the clinical breast examination (CBE), is an indispensable element in complete breast screening.
- Such patients should be referred for diagnostic mammography.

Diagnostic Mammography



- The diagnostic mammogram begins with the two-view standard mammogram. Additional maneuvers are then used as appropriate in each case, dictated by history, physical examination, and findings on initial mammography.

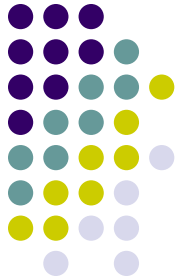
Indications for diagnostic mammography are:



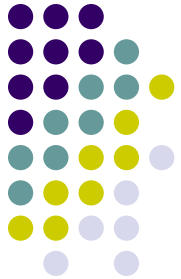
- (1) a palpable mass or other symptom or sign (e.g., skin dimpling, nipple retraction, or nipple discharge that is clear or bloody)
- (2) a radiographic abnormality on a screening mammogram.

- Additionally, patients with a personal history of breast cancer may be considered in the diagnostic category.

Indications of mammography



- • Screening asymptomatic women aged 50 years and over
- • Screening asymptomatic women aged 35 years and over who have a high risk of developing breast cancer:
- -women who have one or more first degree relatives who have been diagnosed with premenopausal breast cancer
- -women with histologic risk factors found at previous surgery, e.g. atypical ductal hyperplasia



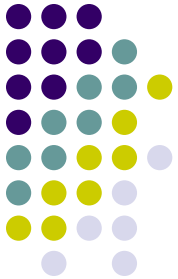
- • Investigation of symptomatic women aged 35 years and over with a breast lump or other clinical evidence of breast cancer
- • Surveillance of the breast following local excision of breast carcinoma
- • Evaluation of a breast lump in women following augmentation mammoplasty
- • Investigation of a suspicious breast lump in a man

Patient Preparation

- For the mammogram, two-piece clothing is most convenient as the patient will need to undress from the waist up. Patients should not apply antiperspirant to the breast or axilla because it may cause artifacts.

- Mammography is generally limited to ambulatory, cooperative patients because of the difficulties in proper positioning and because mammography units are not portable. If a debilitated patient has a palpable mass, then ultrasound would be a reasonable first step, followed by bedside needle aspiration or biopsy if the mass is solid. Screening mammography in markedly debilitated patients rarely has clinical utility.

Computer-Aided Detection



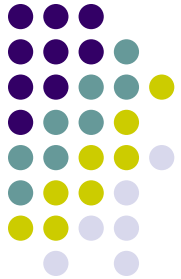
- Computer-aided detection (CAD) utilizes complex algorithms to analyze the data from a mammogram for suspicious:
- calcifications
- masses
- architecture distortion

_ Ultrasonography

- **Technique**
- High-quality images of the normal and abnormal breast can be obtained with modern ultrasound equipment. At the minimum, a 7.5 MHz linear array probe should be used, though digital broadband-width transducers using higher frequency (mid-range exceeding 7.5 MHz) are now widely available and allow higher resolution imaging. The patient is examined in the supine oblique position.

- The side being examined is raised and the arm placed above the head to ensure that the breast tissue is evenly distributed over the chest wall. In addition to conventional orthogonal scanning directions, canning in the radial and antiradial planes are of value in demonstrating ductal abnormalities.

The indications for ultrasonography are:



- (1) a mammographically detected mass, the nature of which is indeterminate
- (2) a palpable mass that is not seen on mammography
- (3) a palpable mass in a patient below the age recommended for routine mammography
- (4) guidance for intervention.

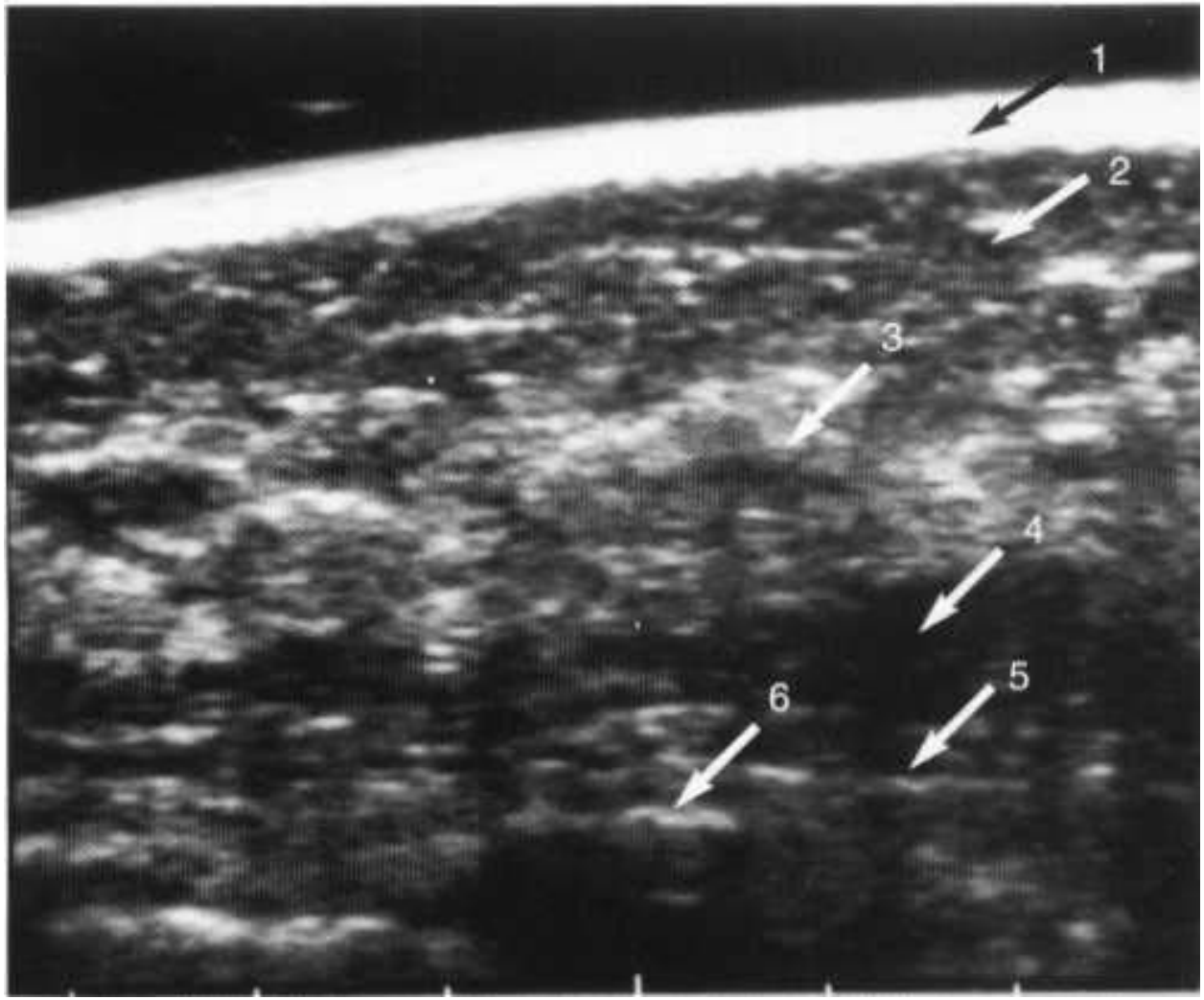
- Ultrasonography is a highly reliable technique for differentiating cystic from solid masses. Although certain features have been described as indicative of benign or malignant solid masses, this determination is more difficult to make and less accurate than the determination of the cystic nature of a mass.

A limitation

- ***A limitation*** of ultrasonography is that it is very operatordependent.

- Also, it images only a small part of the breast at any one moment. Therefore, an overall inclusive survey is not possible in one image, and lesions may easily be missed.

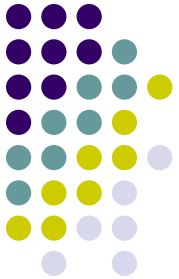
Normal breast ultrasound: 1 = skin; 2 = subcutaneous fat; 3 = glandular tissue; 4 = retromammary fat; 5 = pectoralis muscle; 6 = rib.



Magnetic Resonance Imaging

The role of MRI in mammography continues to expand, with common applications including:

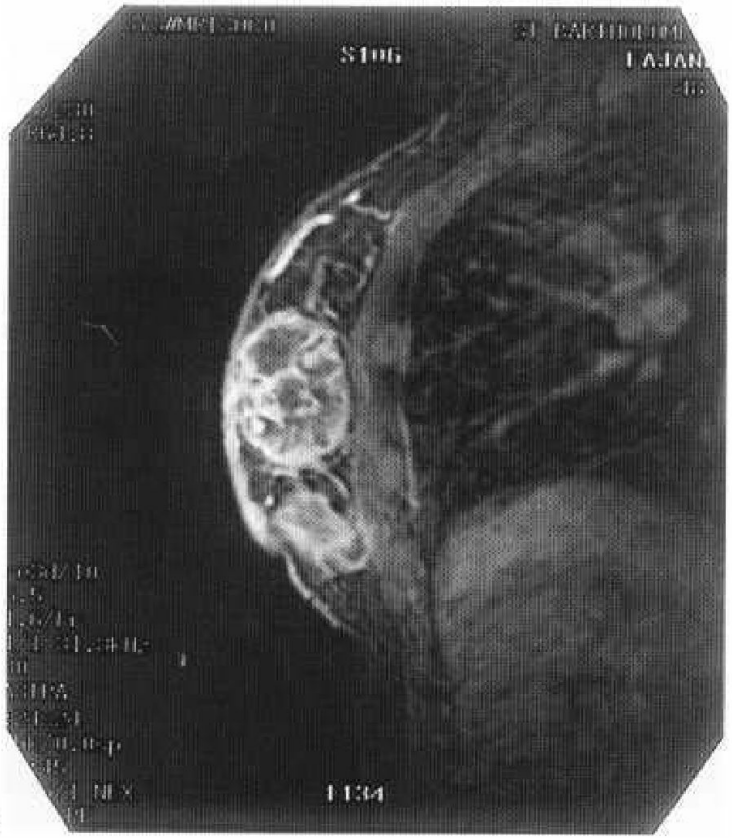
- (1) staging of and surgical planning for breast tumors
- (2) searching for a primary tumor in patients who present with cancerous axillary lymph nodes
- (3) evaluating tumor response to neoadjuvant chemotherapy
- (4) differentiating tumor recurrence from posttreatment changes in patients with previous breast-conserving surgery and radiation



- (5) screening of high-risk patients
- (6) evaluating implants
- (7) evaluating difficult (dense or fibrous) breasts

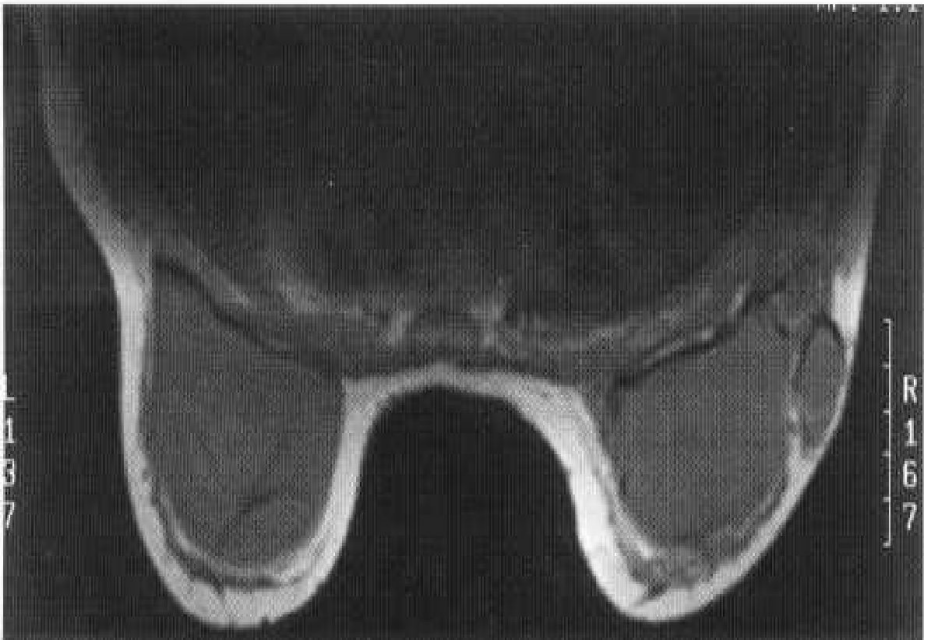
- In addition, the technology for MR-guided breast biopsies is increasingly available.
- MRI can show whether a lesion is solid or contains fat or fluid. Dynamic scanning after administration of intravenous contrast shows whether structures enhance and at what rate.

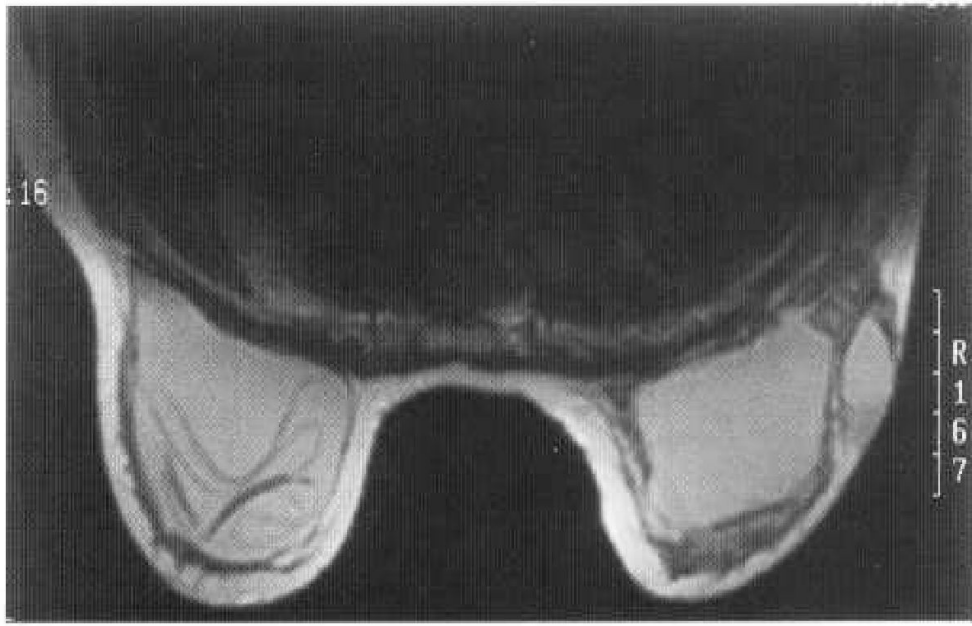
A



B

Axial T1 -weighted (A) and T2 -weighted (B) i mages in a patient with bilateral single lumen silicon implants. Note extracapsular rupture of the right breast implant, with a collection of silicon lying in the lateral aspect of the breast. There is intracapsular rupture of the left breast implant, with a classical linguine sign.





B

_ Ductography

- Ductography, or galactography, uses mammographic imaging with contrast injection into the breast ducts.

The indication

The indication for use is a profuse, spontaneous, nonmilky nipple discharge from a single duct orifice.

- If these conditions are not present, the ductogram is likely to be of little help. The purpose is to reveal the location of the ductal system involved.
- The cause of the discharge is frequently not identified.

- The patient lies in supine position while the discharging duct is cannulated with a blunt-tipped needle or catheter under visual inspection and with the aid of a magnifying glass. A small amount of contrast material (usually not more than 1 mL) is injected gently by hand into the duct. Several mammographic images are then made. The procedure requires about 30 minutes and is not normally painful.

A ductogram showing small filling defects due to an intraductal carcinoma (arrows).

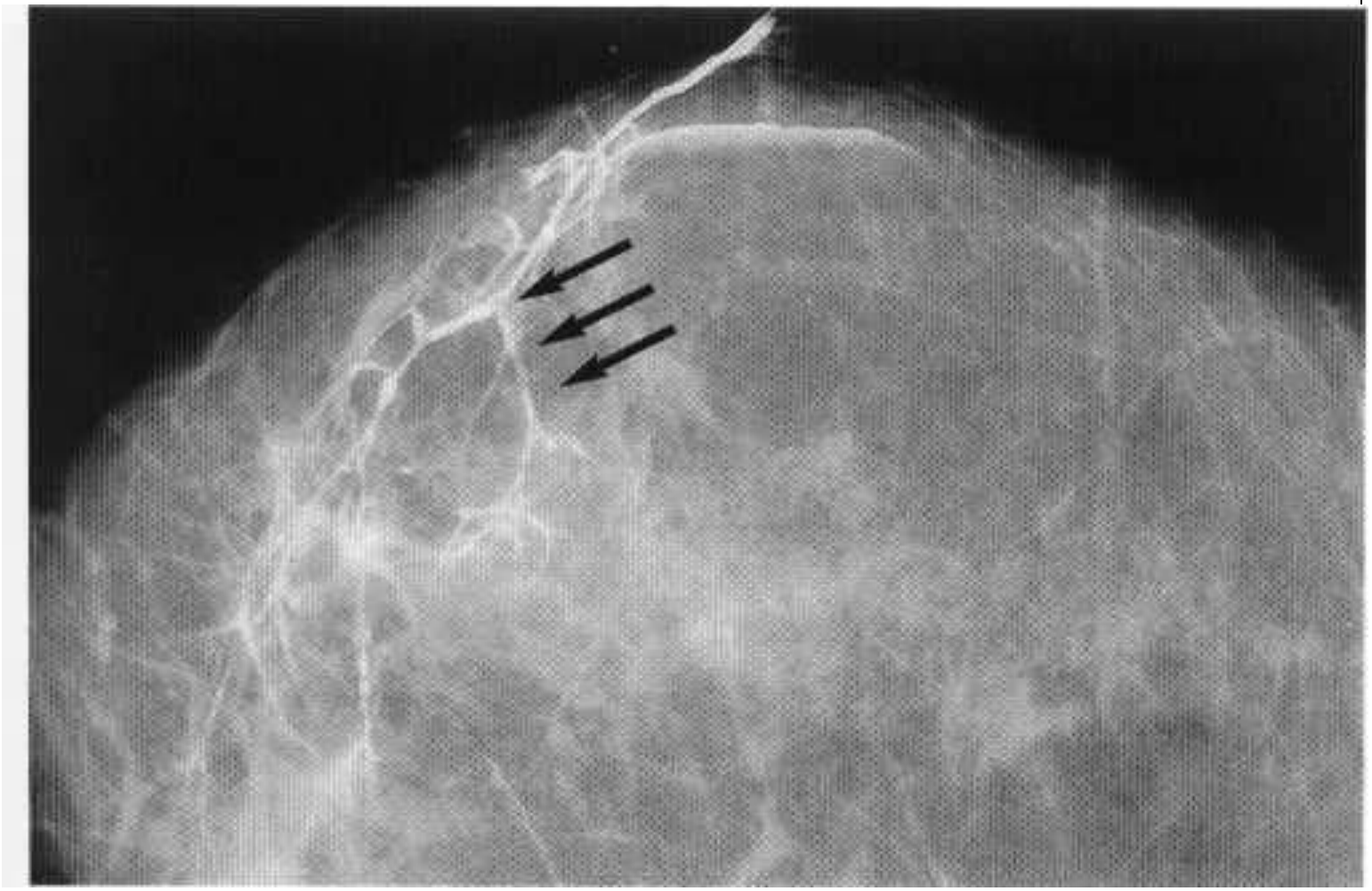
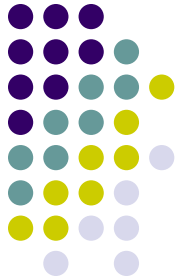
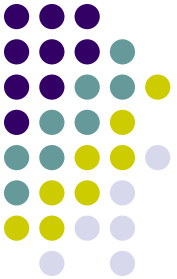


Image-Guided Needle Aspiration and Biopsy



- ***The first indication*** is aspiration of cystic lesions to confirm diagnosis, to relieve pain, or both. Nonpalpable cysts require either ultrasound or mammography to be seen. A fine needle (20- to 25-gauge) usually suffices to extract the fluid. The cystic fluid is not routinely sent for cytology unless it is bloody.
- ***The second indication*** concerns solid lesions.

Needle biopsy is used in this case

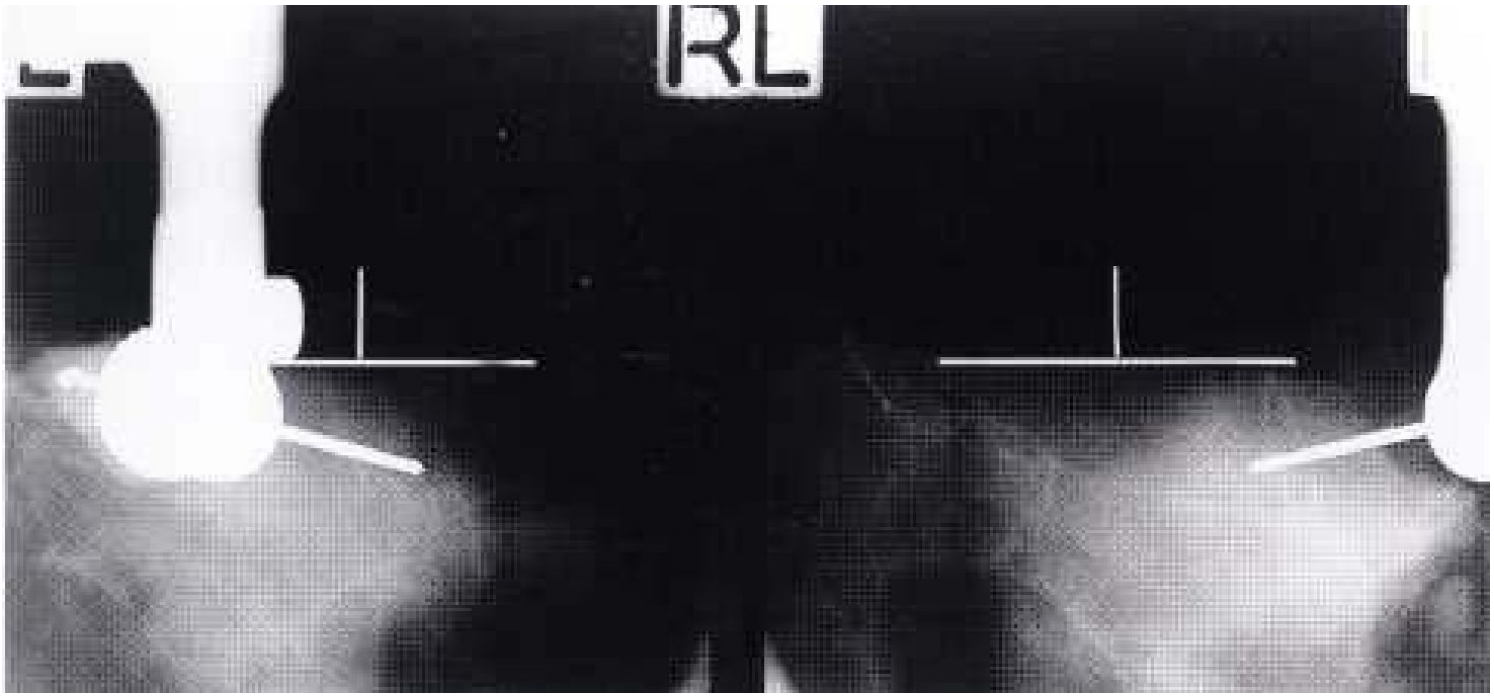


- (1) to confirm benignity of a lesion carrying a low suspicion of malignancy mammographically
- (2) to confirm malignancy in a highly suspicious lesion prior to initiating further surgical planning and treatment
- (3) to evaluate any other relevant mammographic lesion for which either follow-up imaging or surgical excision is a less desirable option for further evaluation

Guidance for needle biopsy can be accomplished with stereotactic mammography, ultrasound, and MR.

1 4G needle and automated biopsy device used for ultrasound
and stereotactic core breast biopsy.

Stereotactic-guided fine needle aspiration. The check pair of films shows the tip of the needle positioned within the small cluster of microcalcification on both views.



Stereotactic core biopsy. Stereo film pair showing 'post fire' position of needle during biopsy of microcalcification

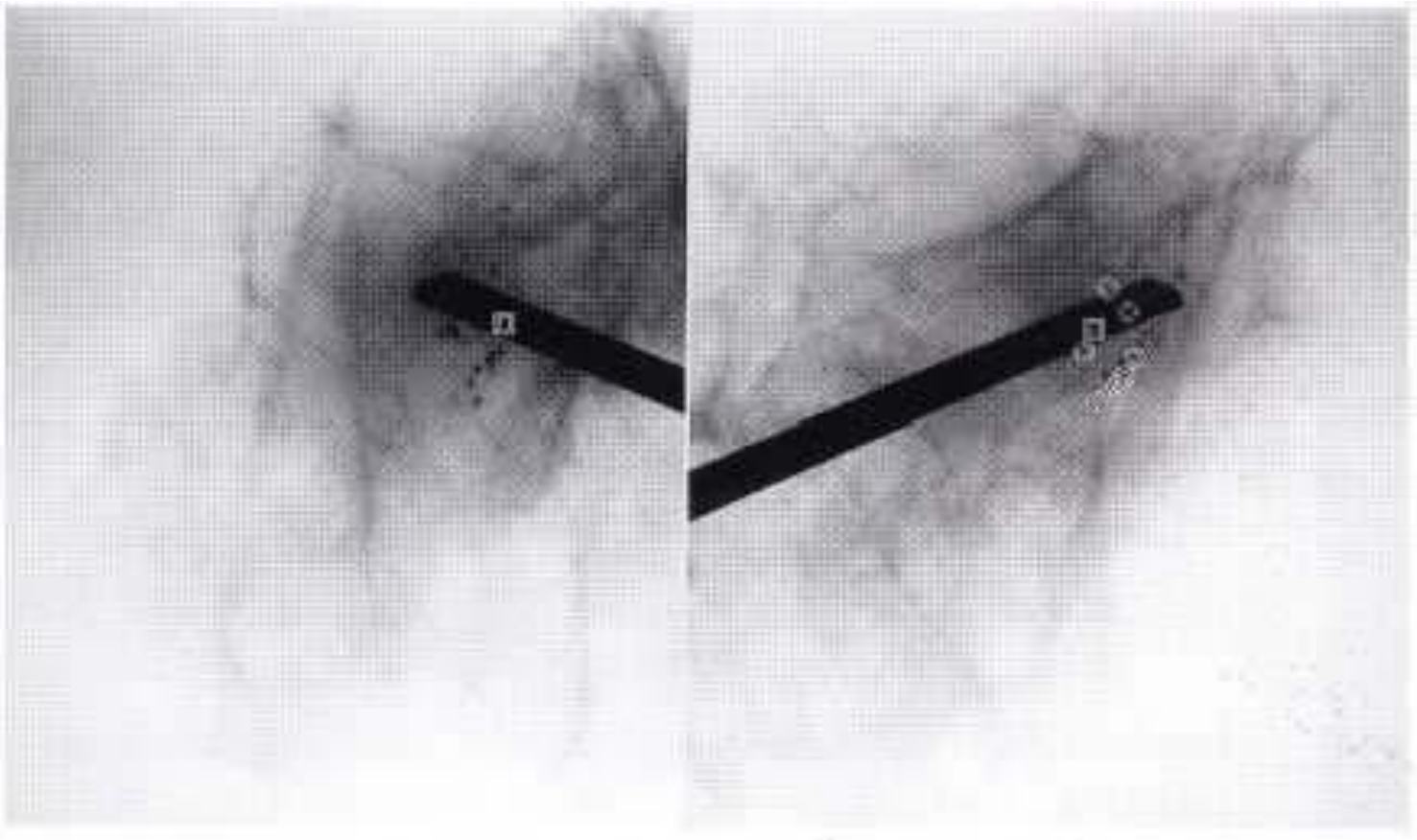
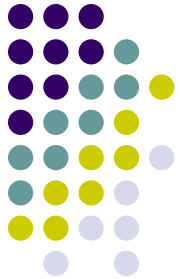


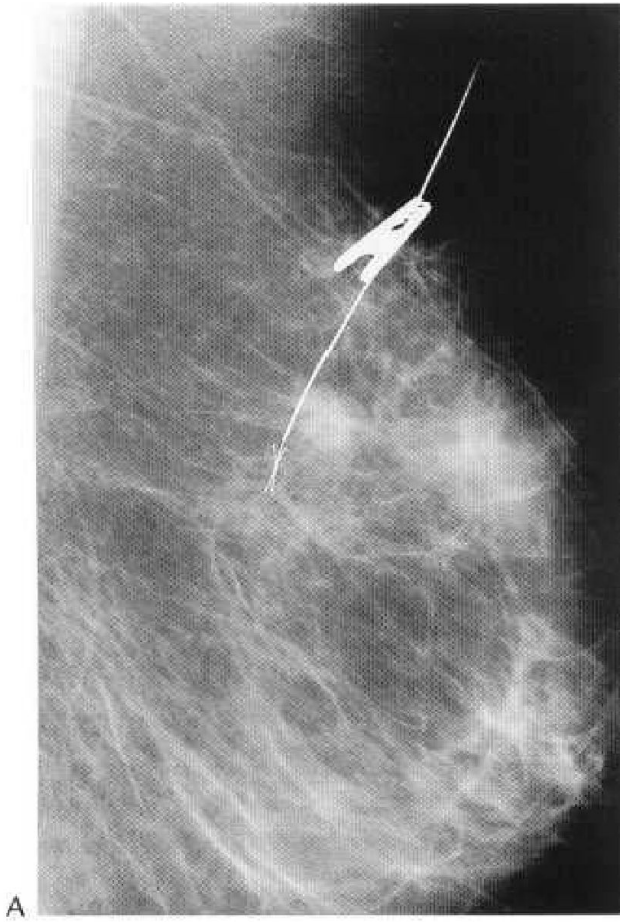
Image-Guided Needle Localization

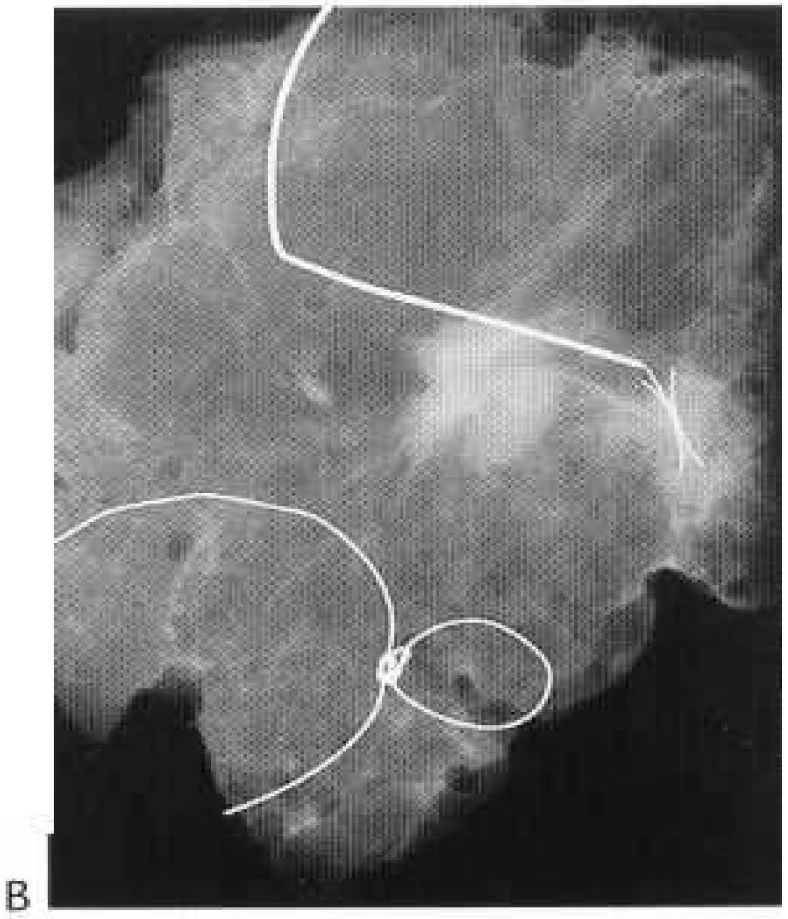


- When a nonpalpable breast lesion must be excised, imaging is used to guide placement of a needle into the breast, with the needle tip traversing or flanking the lesion. Either ultrasonographic or mammographic guidance can be used, and the choice again depends on lesion characteristics and personal preference.

- Once the needle is in the appropriate position, a hook wire is inserted through the needle to anchor the device in place. This prevents migration during patient transport and surgery. After needle placement, the patient is taken to the operating theater for excision of the lesion by the surgeon.

Wire localisation and surgical excision of a nonpalpable carcinoma. (A) The position of a spiculate mass in the upper part of the left breast is marked with a localising wire. (B) Peroperative specimen radiography confirms that the mass has been excised.

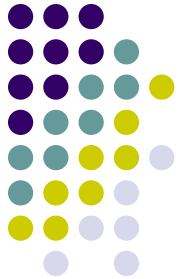




Patient Preparation

- Patients for whom stereotactic biopsy is being considered should be able to lie in prone position without moving for about 1 hour.

Approach to the Palpable Lump

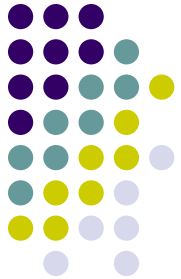


- When a breast lump is found, several questions must be answered before proceeding with breast imaging.
- ***First,*** given that lumpy breasts are a normal variant, when is a lump significant?
- Experts in CBE advise palpation with the flat surface of two to three fingers, and not with the fingertips. With this technique, nonsignificant lumps will disperse into background breast density, but a significant lump will stand out as a dominant mass.

- ***Second,*** is the lump new or enlarged? A new lump is more suspicious than a lump that has not changed over a few years.

- ***Third***, how big is the lump? Tiny pea-sized or smaller lumps, particularly in young women, are often observed closely with repeated CBE, because small breast nodules are extremely common, frequently resolve spontaneously, and are usually benign. Repeating CBE in 6 weeks allows for interval menses, which frequently causes waning or resolution of the lump. If the lump persists, diagnostic mammography is indicated.

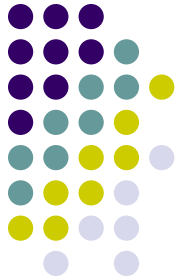
- ***Fourth***, how old is the patient? If the patient is less than 35 years of age, then radiation is avoided unless specifically indicated, because the younger breast is more sensitive to radiation.
- For patients over the age of 35 years, breast imaging begins with a diagnostic mammogram at the time a lump is deemed to be significant. The mammogram provides a view of the lump, as well as of the remainder of the involved breast and the opposite breast, where associated findings may aid in diagnosis and treatment planning.



- If the patient is below 35 years of age, a significant lump is usually first examined with ultrasonography to determine whether a simple cyst is present. If there is no cyst, and the patient is below 30 years of age, the radiologist may choose to obtain a mammogram, but the density of the breast in such a young patient may limit the usefulness of radiomammography, so the mammogram may be limited to one breast or to a single view.

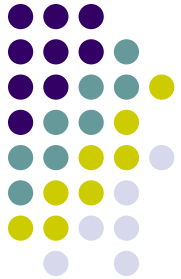
- For women between the ages of 30 and 40 years, judgment is needed as to whether other imaging is indicated. Several factors should be weighed, including age, family history of breast carcinoma, reproductive history, and findings at CBE.
- If the primary care physician is uncertain of the significance of the findings of CBE, evaluation by a breast specialist may be helpful prior to requesting radiologic tests.

Bi - rads assessment categories



- category 0 - need additional imaging evaluation
- category 1 - negative
- category 2 - benign finding, noncancerous
- category 3 - probably benign finding, short interval follow-up suggested
- category 4 - suspicious abnormality, biopsy considered
- category 5 - highly suggestive of malignancy, appropriate action needed

Circumscribed mass



- A circumscribed mass is analysed according to the following features:

- ***I. Density:***
- (i) radiolucent
- (ii) mixed density
- (iii) radiopaque (soft-tissue density)

- ***2. Contour:***
- (i) sharply outlined capsule - `halo' sign
- (ii) ill-defined outline

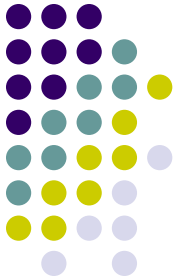
- ***3. Interval change***

- ***4. Number:***
- (i) single
- (ii) multiple.

Radiolucent lesions

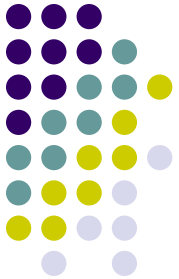
- Lipoma
- Oil cyst
- Galactocele.

Mixed density lesions



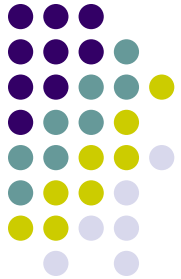
- *adenolipoma hamartoma*
- *galactocele*
- *hematoma*
- *lymph node*

Radiopaque (soft-tissue density) lesions



- ***Benign lesions***
- * Cyst
- * Fibroadenoma
- * Papilloma
- *Phyllodes tumour
- * Abscess
- * Lymph node
- • rheumatoid arthritis
- • sarcoidosis
- * Sebaceous cyst

Malignant lesions



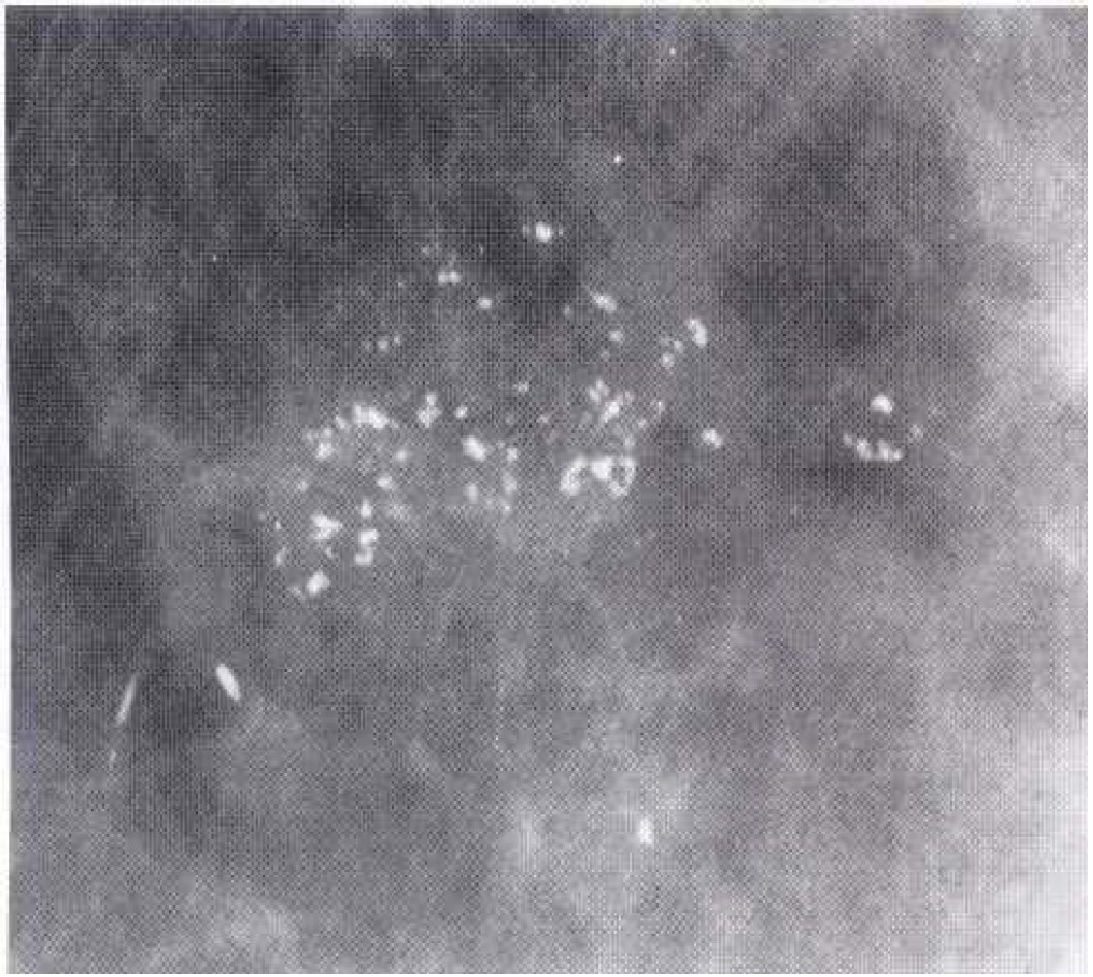
- * Mucinous carcinoma
- * Medullary carcinoma
- * Papillary carcinoma
- * Invasive ductal carcinoma
- * Intracystic carcinoma
- * Metastasis
- • melanoma
- • lung
- • ovary
- * Lymphoma
- * Sarcoma
- * Pathological lymph node
- • breast cancer
- • Phyllodes tumour
- • lymphoma
- • metastasis
- Recurrent breast cancer

Calcifications

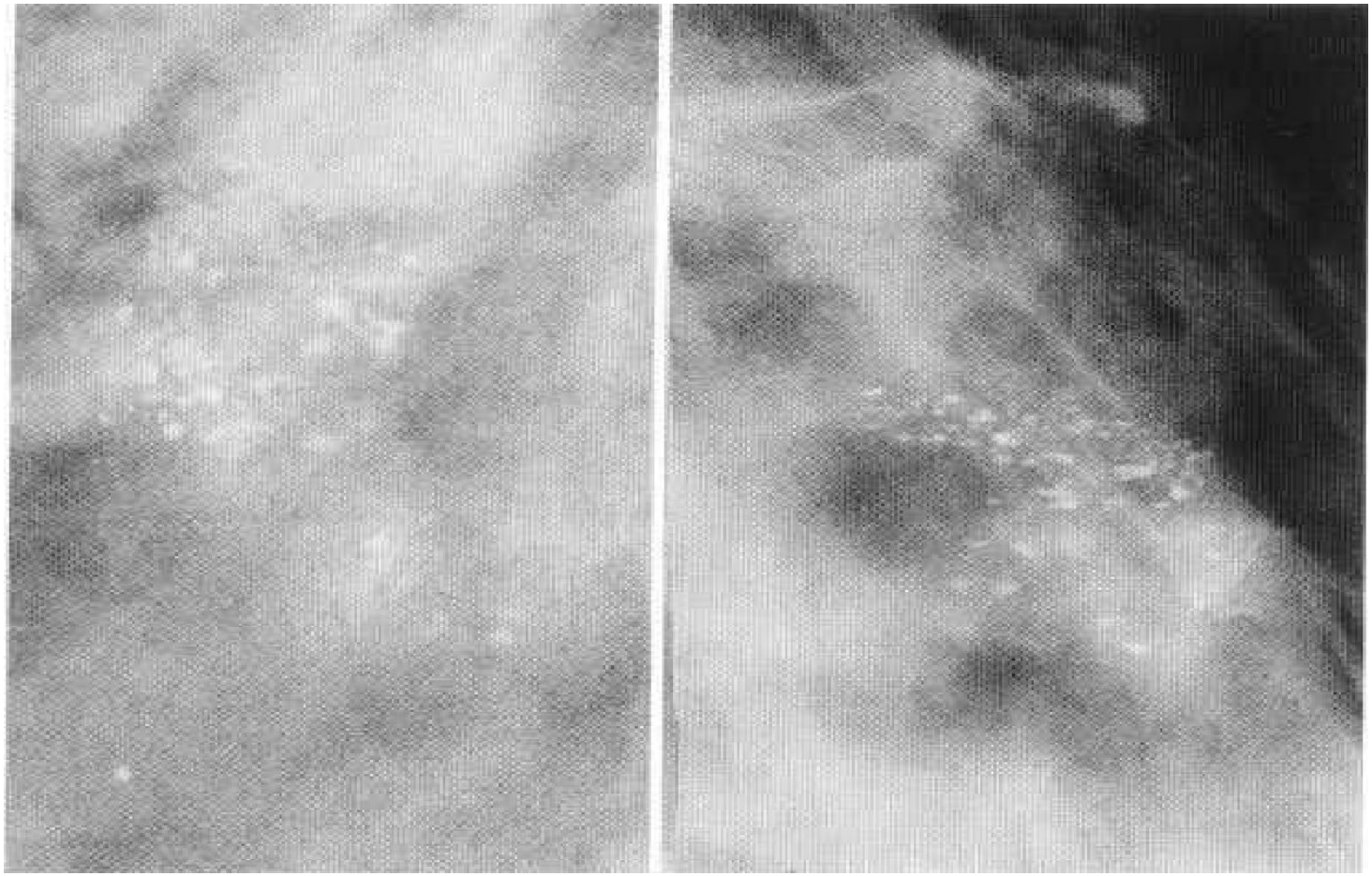
- ***Arterial*:** curvilinear, parallel line calcifications along the course of a blood vessel.
- ***Skin calcification*:** multiple small ring-shaped calcifications.
- **Fibroadenoma:** coarse `popcorn' type calcification associated with a soft-tissue mass. Less commonly the calcifications may he fine, irregular or curvilinear `eggshell' type related to the periphery of the lesion.

- ***Cyst***: curvilinear calcification may occur in the wall of a cyst.
- ***Carcinoma:*** the calcification particles of ductal carcinoma in situ are typically variable in density and shape: linear, casting, branching, and irregular shapes may be present, with variation of the density from particle to particle.

Ductal carcinoma in situ. Irregular pleomorphic microcalcification

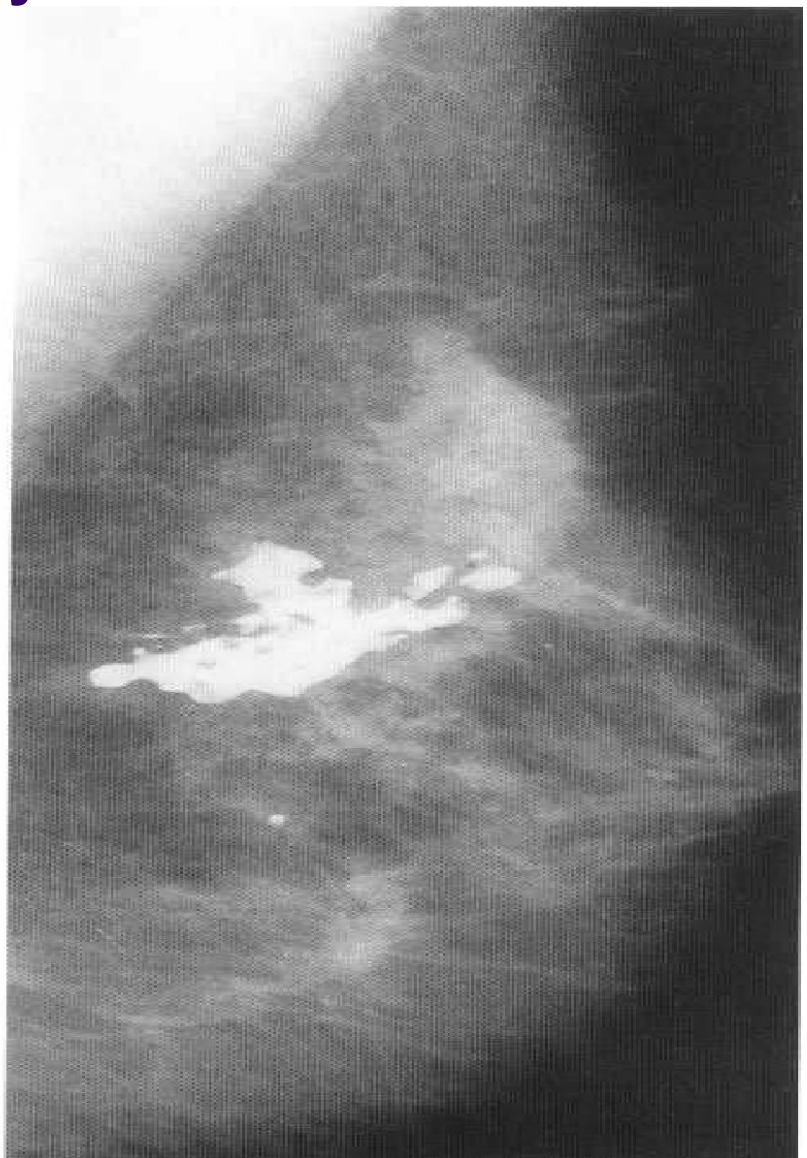


Milk of calcium in benign cystic change. On the craniocaudal view the calcifications appear as round 'smudge' shadows (A). On the lateral view the calcifications show a straight upper border, the 'tea cup' sign (B).



Skin calcification. Multiple small ring-shaped calcifications

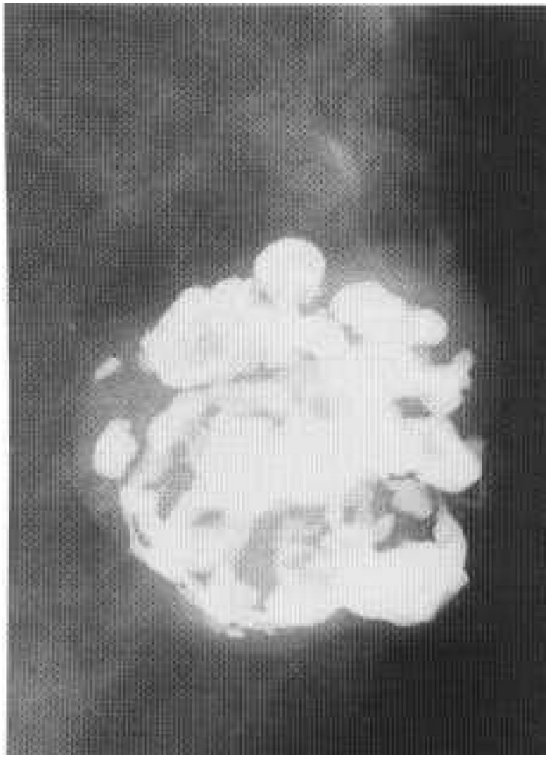
Course calcification due to fat necrosis from previous surgery



Renal failure. Extensive stromal and vascular calcification.

Coarse 'popcorn' calcification in a fibroadenoma.

Curvilinear mural calcification of a cyst.



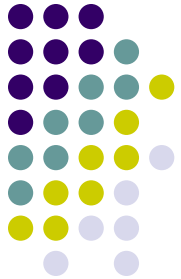
46.60

Spiculate mass

- A spiculate mass is the commonest mammographic appearance of invasive breast carcinoma.
- 1. It consists of a central soft-tissue tumor mass from the surface of which spicules extend into the surrounding breast tissue. There is often associated distortion of the surrounding breast tissue with straightening of the trabeculae due to retraction.

- 2. Large or superficially positioned tumors may be associated with localized skin thickening and retraction.
- 3. Deeply positioned tumors may be associated with tethering of the pectoralis muscle.
- 4. Irregular microcalcifications due to associated ductal carcinoma in situ may be found within the tumour or in the surrounding breast tissue, sometimes extending to the nipple.

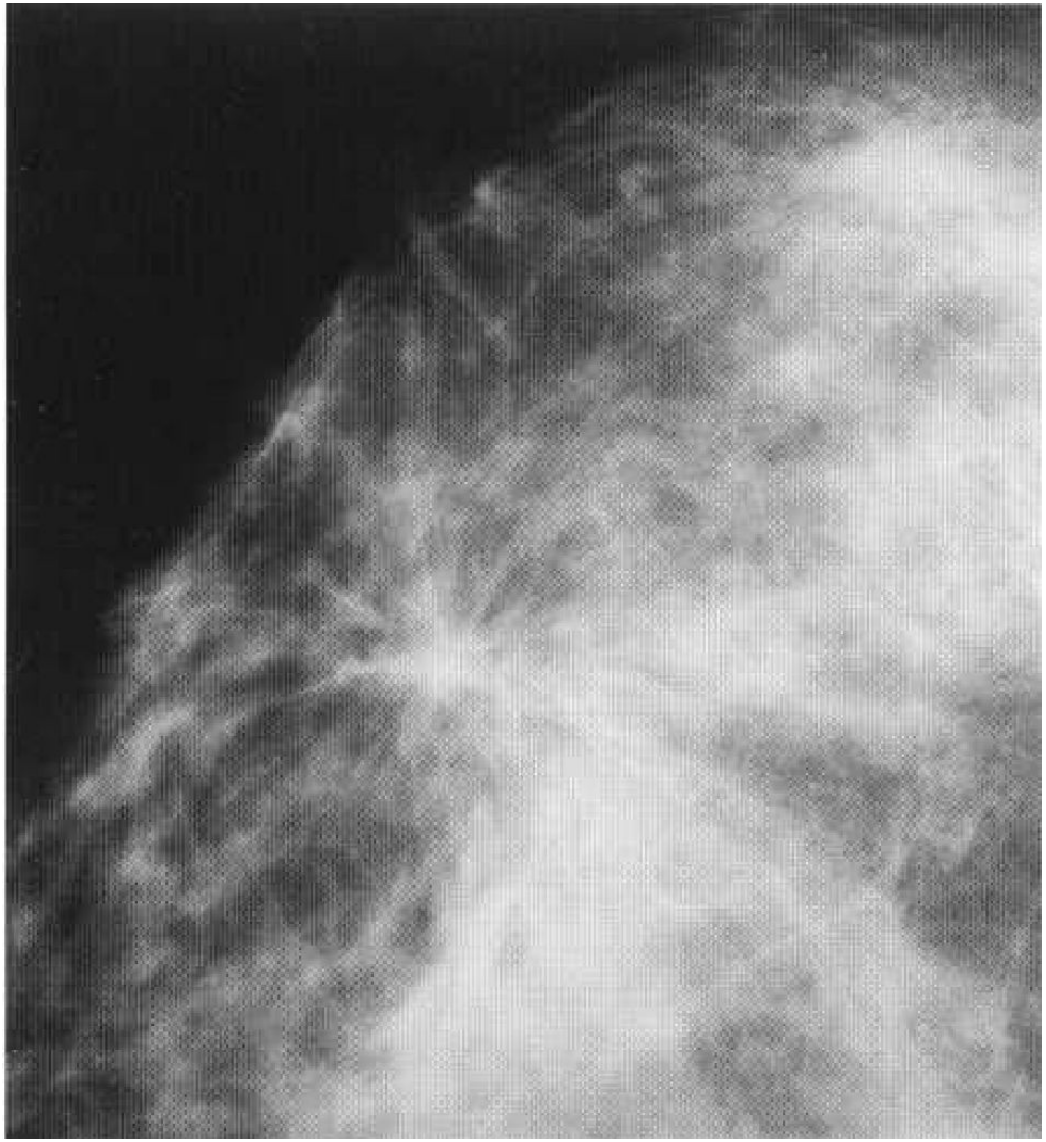
The typical ultrasound features are

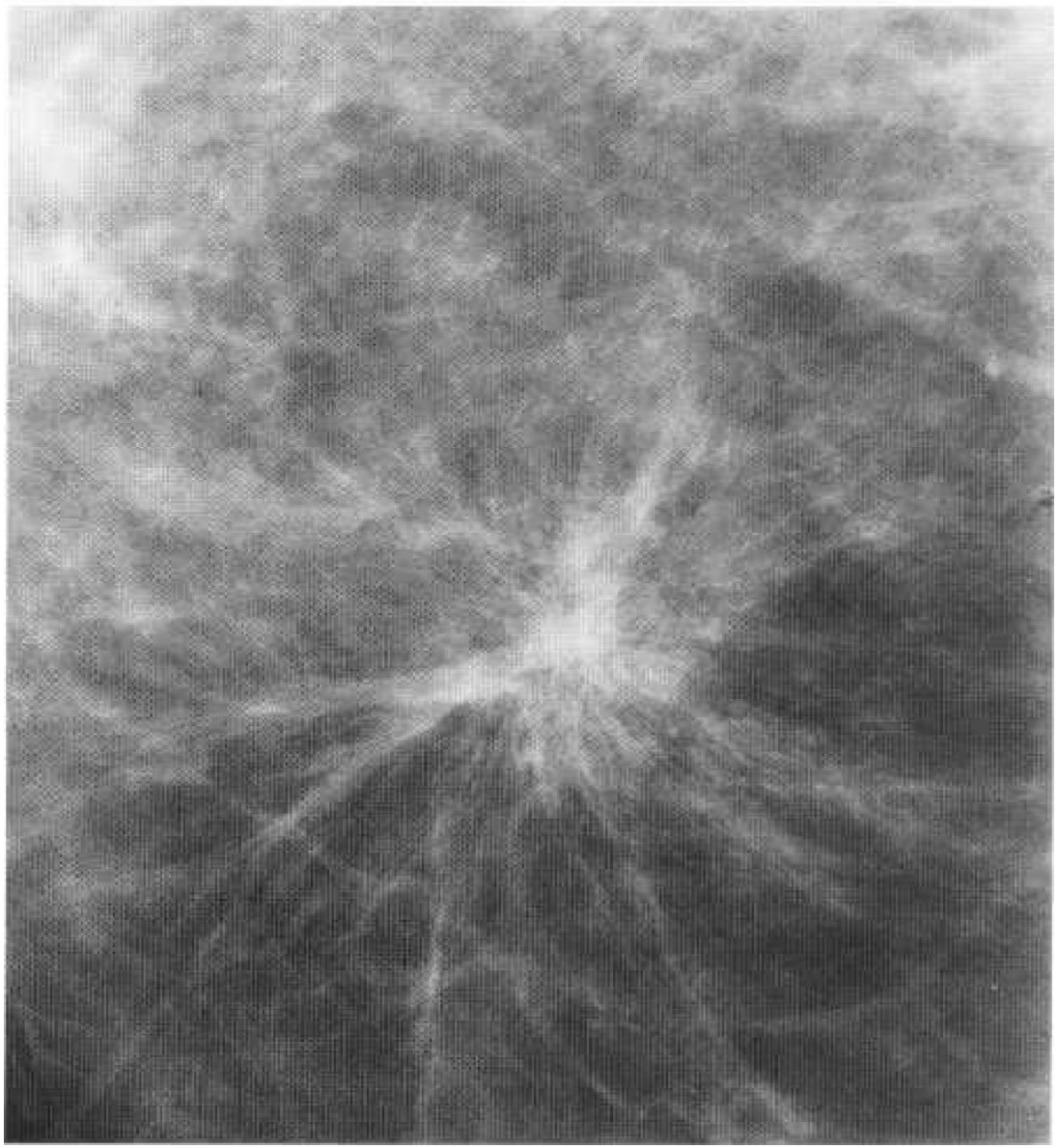


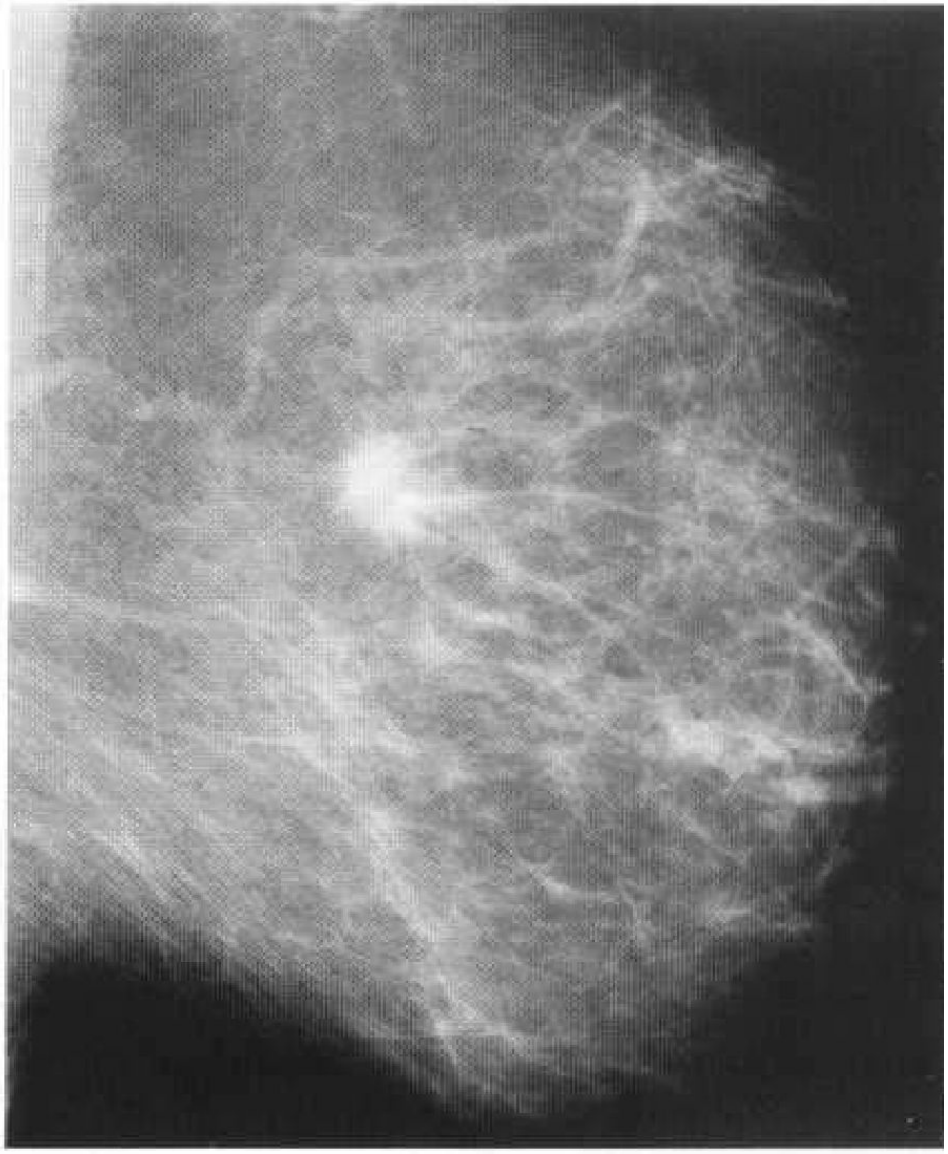
- Most spiculate carcinomas of I cm diameter or more can be demonstrated by ***ultrasound.***

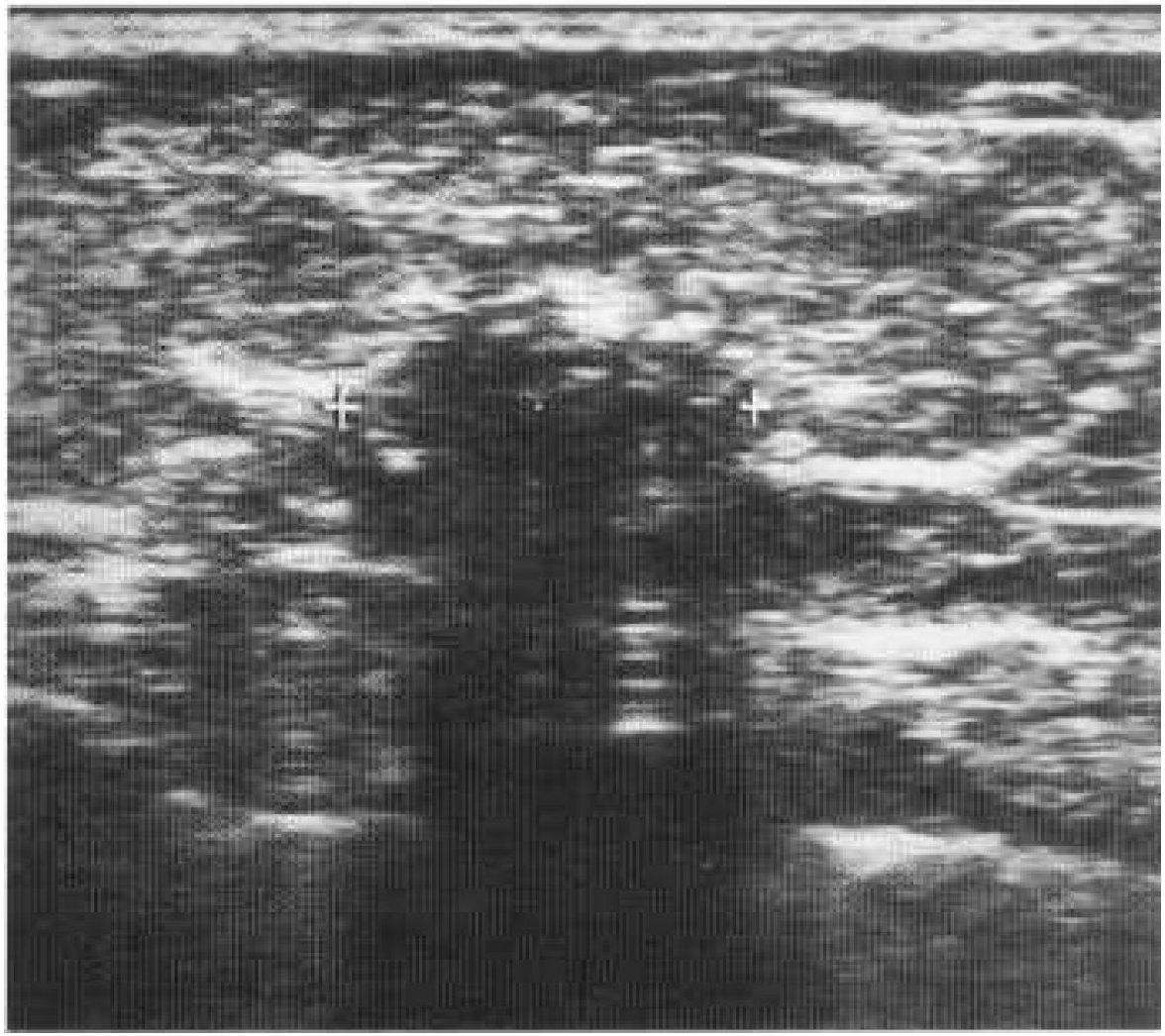
- of an echo-poor mass, with poorly defined margins and posterior acoustic shadowing
- distortion of the surrounding breast tissue may be visible and a rim of increased reflectivity around the tumour mass may be seen

- the presence of these signs, however, is variable: acoustic shadowing may be absent; an echo-poor mass may not be visible with very small tumors.
- similar suspicious ultrasound appearances may be caused by a sclerosing fibroadenoma or benign complex sclerosing lesion

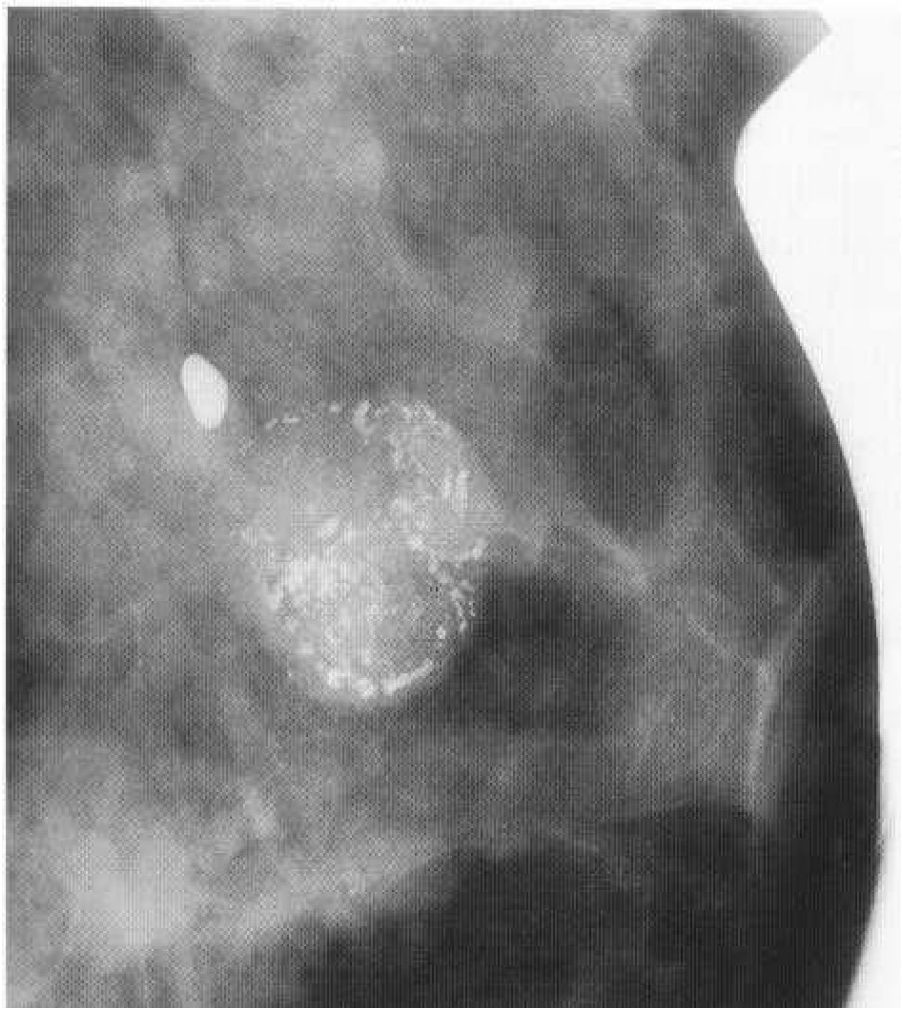




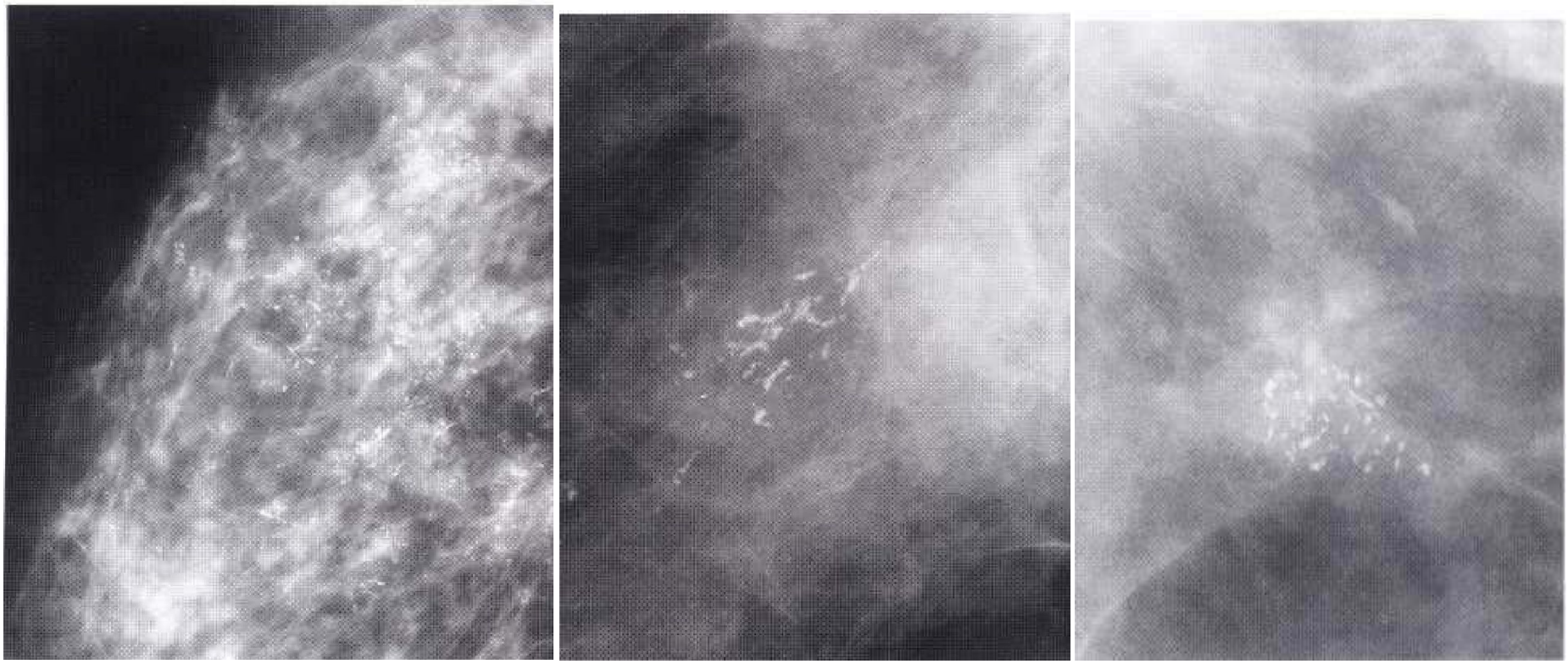




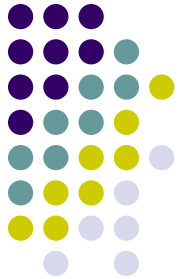
Non-invasive intracystic carcinoma.



Ductal carcinoma in situ-high-grade comedo type. (A-C) Irregular linear branching microcalcification.



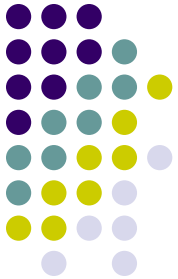
Interval cancers are classified radiologically as follows:



- I. ***True interval***: there is no evidence of the cancer on the screening films but the cancer is demonstrated on clinical mammograms at presentation.
- 2. ***Occult:*** there is no evidence of the cancer either on the screening mammograms or on the clinical mammograms.
- 3. ***False*** negative: there is evidence of the cancer on the original screening films which corresponds with the abnormal signs shown on clinical mammograms at the time of diagnosis.

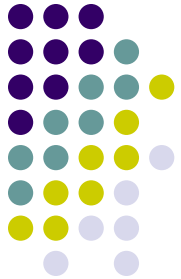
- 4. ***Minimal sign:*** there are subtle features on the screening mammograms which correspond to the position of the carcinoma shown on the clinical films but are only recognisable on retrospective review or for which recall would not have been indicated.
- 5. ***Unclassified:*** mammography was not performed at the time of diagnosis and therefore the presence of mammographic signs of malignancy on the previous screening films cannot he verified.

Fibroadenoma

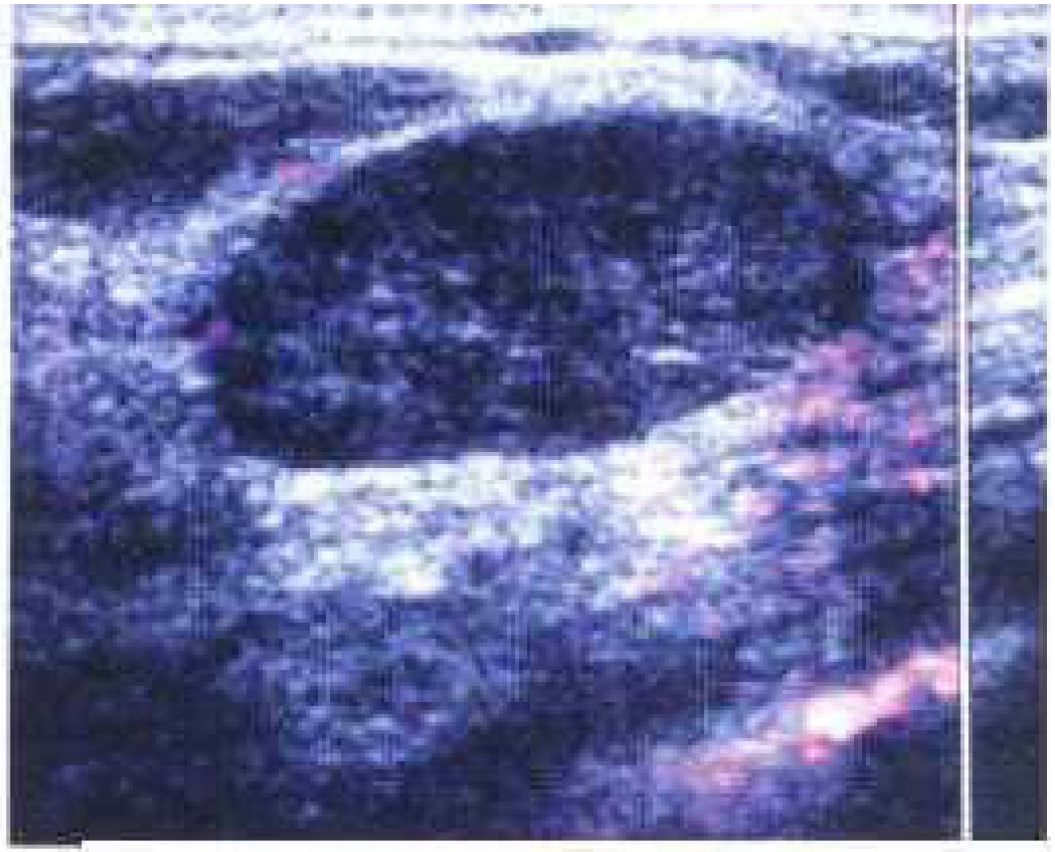


- **Fibroadenoma** are characteristically
- sharply outlined
- low soft tissue density lesions, sometimes with a lobulated outline
- they are usually solitary but may be multiple with increasing age, they may undergo
- fibroadenoma can, however, show very fine calcifications with some pleomorphism which can raise the suspicion of malignancy
- fibroadenoma do not arise de novo in women aged 40 years or more but may grow in menopausal women who are taking HRT

The typical ultrasound appearance of a fibroadenoma is



- a well circumscribed round or oval mass showing posterior acoustic enhancement and with a homogeneous internal echo pattern
- the ultrasound findings alone therefore cannot be used to confirm the diagnosis of a circumscribed solid lesion found on mammography



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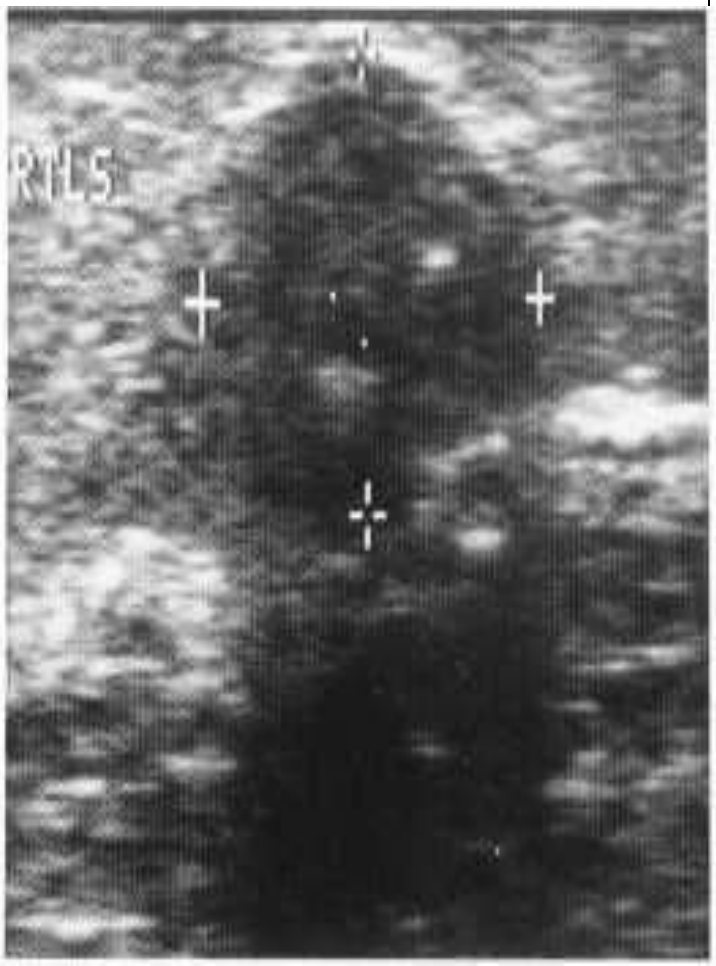

Cyst

Cyst are the most common cause of a discrete breast mass.

- they are often multiple and bilateral
- they are common between the ages of 20 and 50 years, with a peak incidence between 40 and 50 years
- simple cysts are not associated with an increased risk of malignancy and have no malignant potential
- On mammography they are seen as well-defined, round or oval masses. Sometimes a characteristic halo is visible on mammography

- Cysts can be readily diagnosed with ultrasound.
- They have:
- well-defined margins
- are oval or round in shape
- show an absence of internal echoes indicating the presence of fluid
- the area of breast tissue behind a cyst appears bright on ultrasound (posterior enhancement) due to improved transmission on the ultrasound beam through the cyst fluid When these features are present, a cyst can be diagnosed with certainty. Aspiration is easily performed under ultrasound guidance to alleviate symptoms or when there is diagnostic uncertainty. Cytology on cyst fluid is not routinely performed unless there are atypical imaging features or the aspirate is bloodstained

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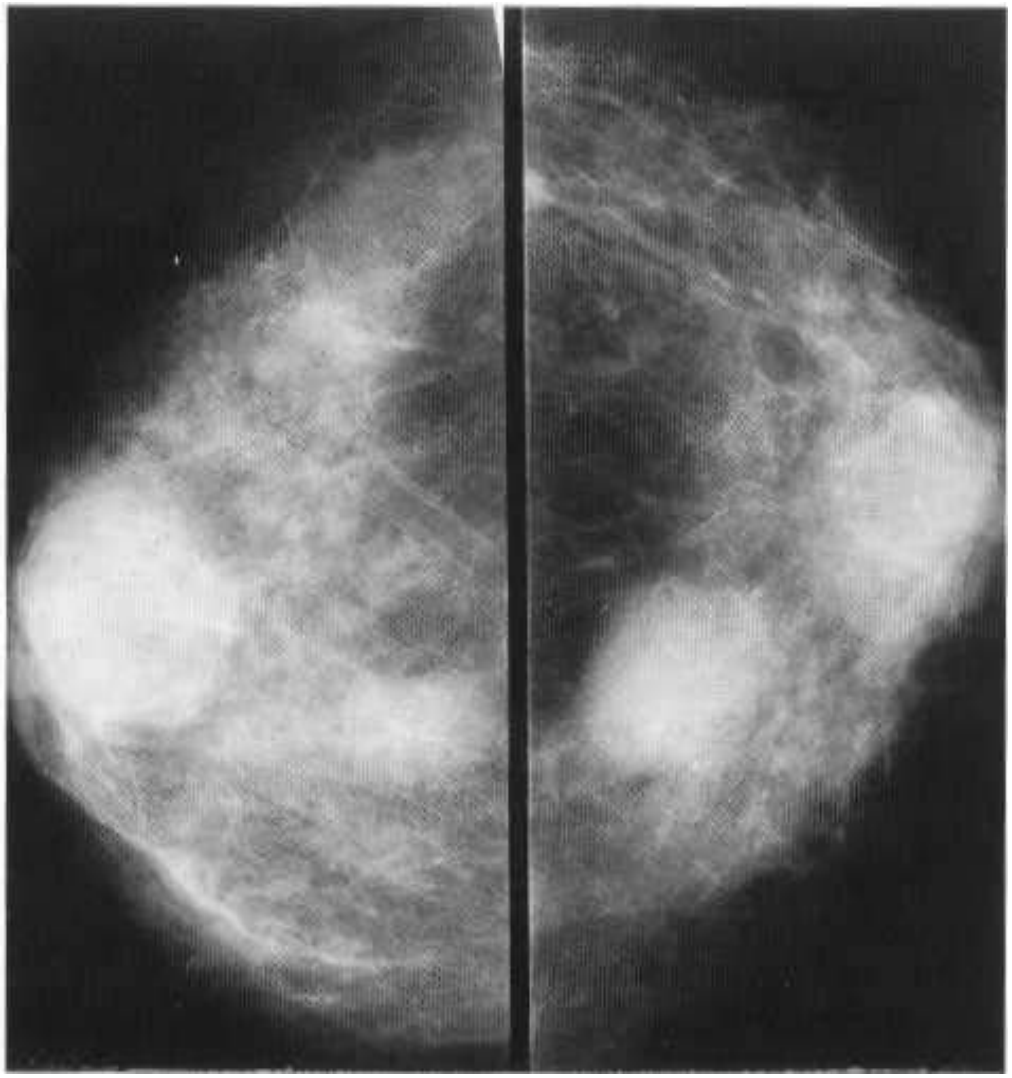
- Cytology on cyst fluid is not routinely performed unless there are atypical imaging features or the aspirate is bloodstained

Cysts



Ultrasound shows the typical
features of a simple cyst - a well-defined anechoic lesion with posterior acoustic accentuation