Benign Lesions

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11.1 Introduction

Benign breast lesions deserve attention because of their high prevalence. Breast cancer is the most common malignancy in women in developed countries; however, the vast majority of lesions that occur in the breasts are benign. Most of the patients who present with a clinical breast problem, usually have a benign lesion. Diagnosis of a benign disease of the breast is usually accomplished with mammography, ultrasound (US), magnetic resonance imaging (MRI) or needle biopsies, thereby eliminating the need for surgery [1–3].

Benign breast lesions have been comprehensively studied, and most of these lesions are not associated with an increased risk of breast cancer; therefore, unnecessary surgical procedures should be avoided [3–7]. It is very important for radiologists to recognize benign breast lesions and to distinguish them from both in situ and invasive cancer and, in certain cases, to assess a patient's risk of developing breast cancer so that the most appropriate treatment modality is established in every case [8–10].

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Contrast-enhanced digital mammography (CEDM), which uses an iodinated contrast agent that has preferential uptake in regions of increased vascularity, provides physiological information that complements the morphological information obtained through conventional mammography [11, 12].

Invasive carcinomas usually present as enhancing lesions on CEDM; however, this presentation is not specific, and there is a significant percentage of benign lesions that produces similar false-positive results on CEDM [12, 13]. Benign lesions usually present as a weak or medium enhancement, rather than the strong enhancement pattern that is a typical indicator of malignant transformation [14]. However, there is no reliable CEDM enhancement pattern that is helpful in defining false-positive lesions.

11.2 CEDM Benign Findings

Similarities between benign and malignant lesion characteristics on mammography and ultrasound are well known. Breast MRI has not managed to resolve the issues of lesion specificity; and even if the typical appearance of benign breast conditions is well established, there are cases where it is still extremely difficult to differentiate benign lesions from malignant tumours; CEDM is no exception to this rule. Ultrasound examination

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(US) is the usual supplemental imaging technique to evaluate enhancing breast lesions on CEDM. It is usually followed by an ultrasound-guided core biopsy whenever there is a suspicion of malignancy.

Accumulating evidence has shown that CEDM is emerging as a new technique for the early diagnosis of breast cancer with a diagnostic accuracy comparable to that of breast MRI [15].

CEDM has recently been introduced as an adjunct and a potential alternative to MRI with some advantages, such as lower costs, shorter acquisition times, easier availability and the absence of typical MRI contraindications such as claustrophobia or the presence of metallic implants and cardiac pacemakers [12, 15].

However, as with MRI, CEDM is associated with many false-positive findings, which are benign breast-enhancing lesions that, not only extend the length of the workup, but can also lead to additional imaging studies and increased patient anxiety. Additionally, these false-positive findings may lead to unnecessary biopsies and interventions [13, 14].

Attempts have been made to identify features of benign and malignant lesions by CEDM to reduce false-positive findings and thus improve specificity. Although there is still no evidence that the kinetics in CEDM is similar to that of breast MRI, based on our experience, the morphologic features and enhancement kinetics of breast lesions may be used as descriptive methods for reducing false-positive findings [11–13].

11.3 Benign Breast Lesions

11.3.1 Fibroadenoma

Fibroadenoma is the most common benign tumour of the breast and occurs in up to 25% of asymptomatic women [1]. It is usually a disease of the early reproductive life; the peak incidence is between the ages of 15 and 35 years. The lesion is a hormone-dependent neoplasm that persists during reproductive years, increases with pregnancy or with oestrogen therapy and decreases after menopause [8].

Although most frequently unilateral, multiple fibroadenomas occur bilaterally in 20% of cases [5].

Macroscopically, the lesion is a well-circumscribed firm mass usually <3 cm in diameter. If the tumour assumes massive proportions (>10 cm), more commonly observed in female adolescents, it is called “giant fibroadenoma” [5].

Microscopically, fibroadenomas consist of a proliferation of epithelial and mesenchymal elements.

Approximately 50% of fibroadenomas contain other proliferative changes of the breast, such as sclerosing adenosis, adenosis and duct epithelial hyperplasia. Fibroadenomas that contain these elements are called “complex fibroadenomas”. Simple fibroadenomas are not associated with any increased risk of breast cancer. However, women with complex fibroadenoma may have a slightly higher risk for subsequent cancer [16].

When a suspicious fibroadenoma is identified upon examination or imaging, it is recommended to have a percutaneous core biopsy for histologic confirmation, as ultrasound alone cannot differentiate between fibroadenoma and a phyllodes tumour [16].

If a biopsy-proven fibroadenoma is stable and asymptomatic, it can be observed with routine examination. If the fibroadenoma increases in size, surgical excision is recommended to rule out a malignant change or a phyllodes tumour [17].

11.3.1.1 Fibroadenoma Findings

Fibroadenoma is the most common sharply marginated breast mass among women in their teens, twenties and early thirties.

– *On mammography*, fibroadenomas appear as well-defined round, oval or lobulated masses, with the most common pattern of calcification devolving into coarser popcorn-shaped features. Calcifications may also present as crushed stone-like calcifications, which make differentiation from malignancy more difficult.

US is usually the next step towards characterization of the lesion.

– *On US*, a fibroadenoma appears as a well-circumscribed elliptic mass that is either hypoechoic or isoechoic and has uniform echogenicity.

The lesion is typically larger in the transverse than in the anteroposterior direction and has very well-demarcated margins. A fibroadenoma may have no effect on ultrasound transmission, or acoustic enhancement or shadowing may be observed in US images [18, 19].

– *On MRI*, fibroadenomas are hypointense or isointense lesions on T1-weighted images, and they are hypointense or hyperintense on T2-weighted images. Septations occur in approximately half of fibroadenomas and have been reported to be a strong indicator of this diagnosis. With gadolinium, the majority of fibroadenomas are hyperintense, with slow initial contrast enhancement followed by a persistent delayed phase, but some have rapid enhancement and either a plateau or a washout phase [5, 18, 19].
– *In our experience with CEDM*, fibroadenomas show a faint, homogeneous enhancement with well-defined margins, and a persistent enhancement is seen in the delayed phase. Non-enhancing internal septations, similar to those seen on MRI, may be observed (Figs. 11.1, 11.2, 11.3, 11.4, and 11.5).

11.3.2 Breast Cysts

Breast cysts are the most common non-proliferative breast disease and are seen in over one-third of women aged 35–50 years, with 20–25% having a palpable mass [5, 6].

Simple cysts are derived from the terminal duct lobular unit and are fluid-filled round or ovoid masses.

Ultrasonography is the preferred imaging modality for breast cysts, providing an accurate evaluation of cyst content and complexity. Ultrasonography allows for characterization into simple, complicated and complex cysts. Features that increase the likelihood of malignancy include a thickened cyst wall, thick septations, solid internal components and hyperechogenicity of the internal fluid.

Complex cysts are defined by ultrasound criteria as masses with the presence of intracystic solid components and thick walls or septa. Complex cysts have a relatively higher risk of malignancy ranging from 5 to 23% and should therefore be evaluated with a tissue biopsy [20].

11.3.2.1 Simple Cyst Findings

Simple cysts are the most common masses seen in the breast in young woman and result from dilatation and effacement of the terminal duct lobular unit.

They are benign and have no risk of malignancy. No intervention is necessary for simple cysts.

However, if they are large and cause pain, aspiration may be necessary for pain relief. If the fluid is clear, no investigation is needed; however, if the fluid is haemorrhagic, it should be sent for cytologic analysis [20].

– *On mammography,* they typically show a circumscribed round, oval or lobulated mass with well-defined margins.
– *On US*, ultrasonography is the preferred imaging modality for breast cysts, providing an accurate evaluation of cyst content and complexity. Ultrasonography allows for characterization as simple, complicated and complex cysts.

Simple cysts are well-circumscribed, anechoic, have a thin echogenic capsule, increased through transmission, have thin edge shadows and lack internal solid components.

– *On MRI*, these cysts follow fluid signals in all sequences, are iso- or hypointense to the breast parenchyma on T1-weighted images and are very hyperintense on T2-weighted images and do not enhance after gadolinium;

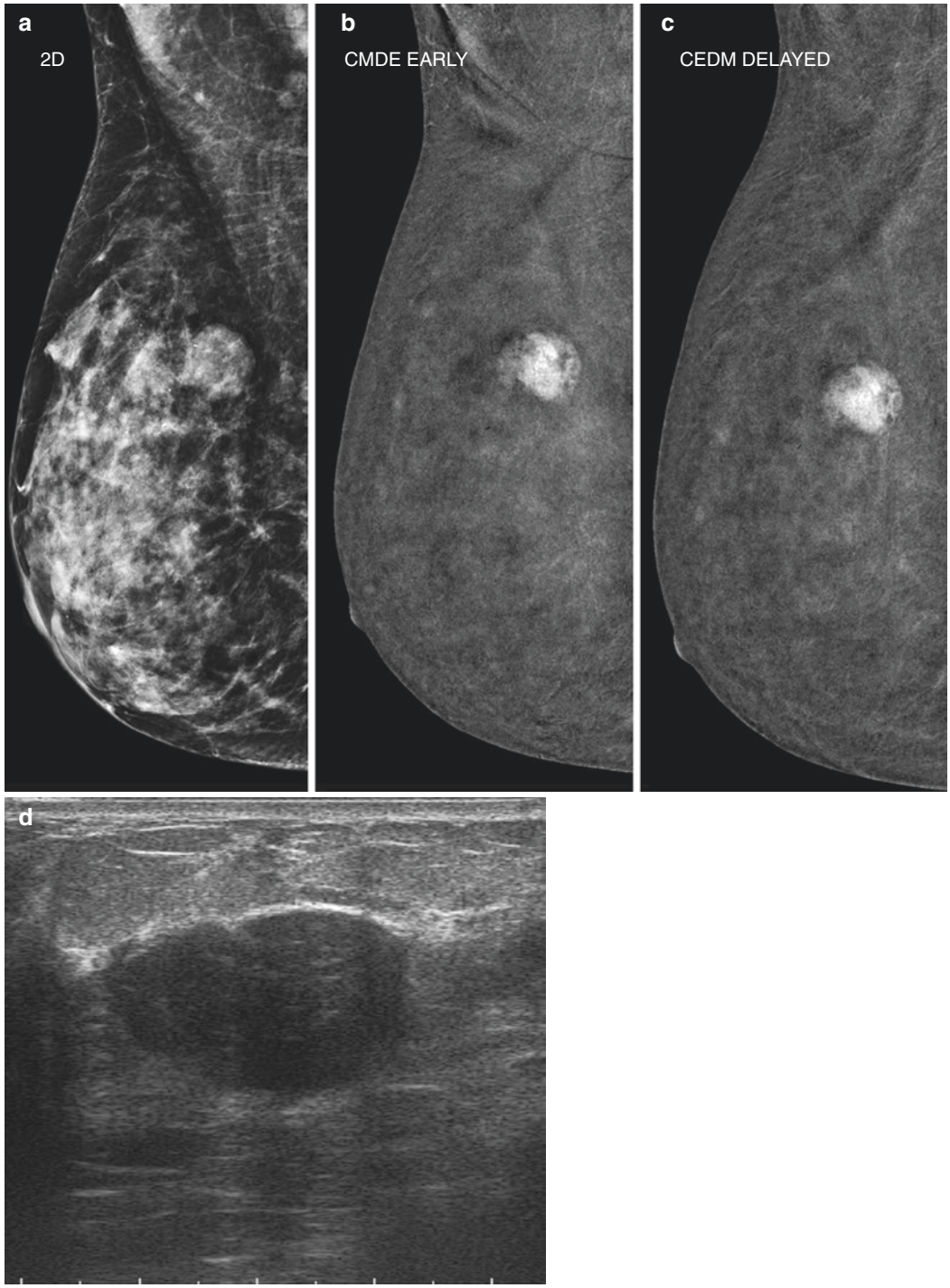


Fig. 11.1 An enhancing fibroadenoma. (**a**) Low Energy CEDM image (LE CEDM) in MLO view showing a well-defined round opacity in the upper quadrant of the right breast. (**b–c**) CEDM recombined images showing a solitary well-defined mass enhancement in the early phase, and it demonstrates a progressive and persistent enhancement in the delayed phase. (**d**) Ultrasound (US) shows a well-defined, oval, homogenously hypoechoic mass suggestive of a benign mass. *CEDM* contrast-enhanced digital mammography, *LE* low energy, *MLO* mediolateral oblique, *US* ultrasound

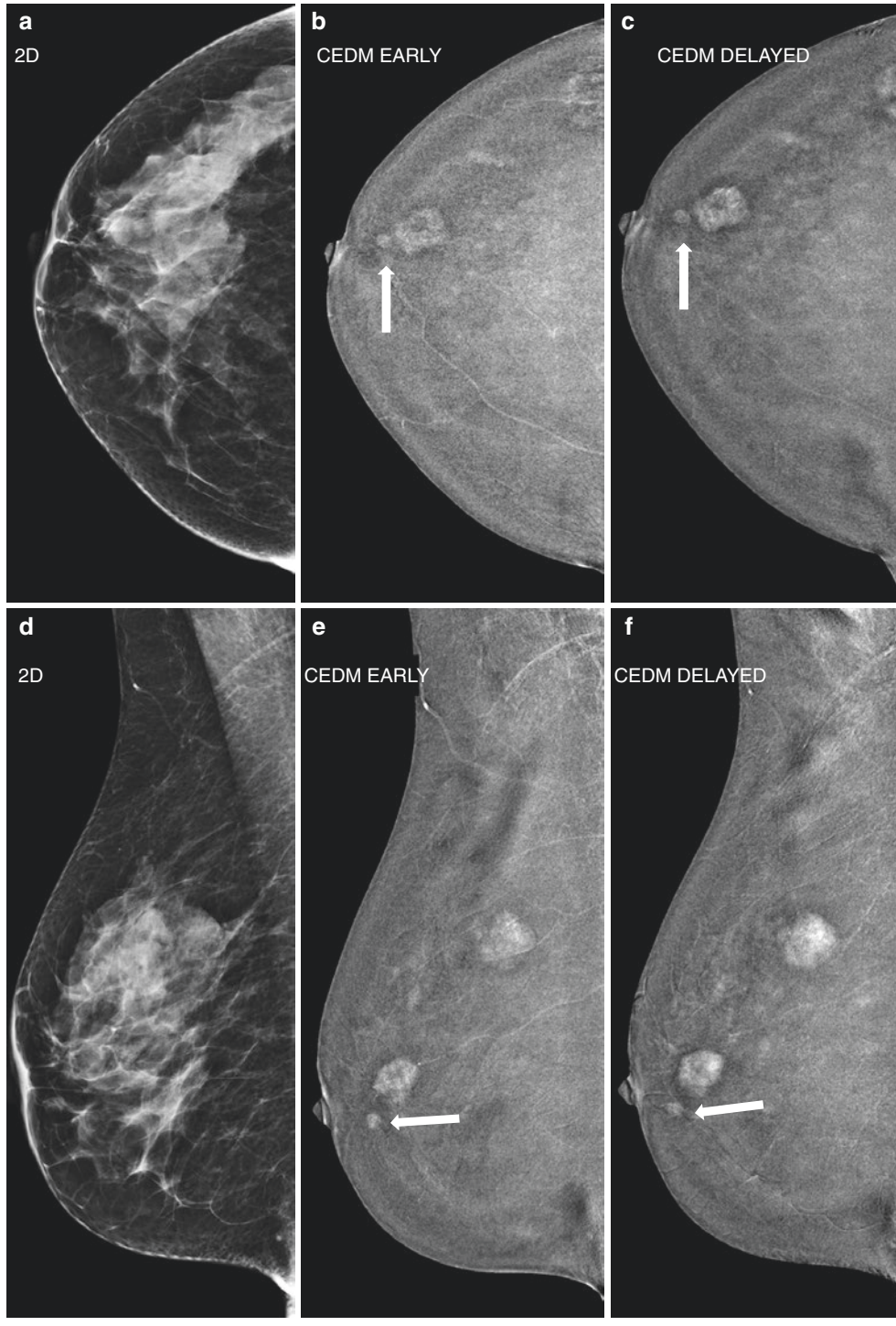


Fig. 11.2 Enhancing fibroadenomas and papilloma. (**a** and **d**) LE CEDM images in CC and MLO views show a round opacity in the upper outer quadrant of the right breast. (**b** and **e**) CEDM recombined images in early phase show three masses with well-defined margins, demonstrating a faint, early homogeneous enhancement, the two larger with internal septations are typical fibroadenomas, the smaller mass in the retroareolar zone is a papilloma (*white arrow*). (**c** and **f**) CEDM recombined images in delayed phase, in CC and MLO views, show the classic progressive and persistent enhancement of benign lesions. *CEDM* contrast-enhanced digital mammography, *LE* low energy, *CC* craniocaudal, *MLO* mediolateral oblique

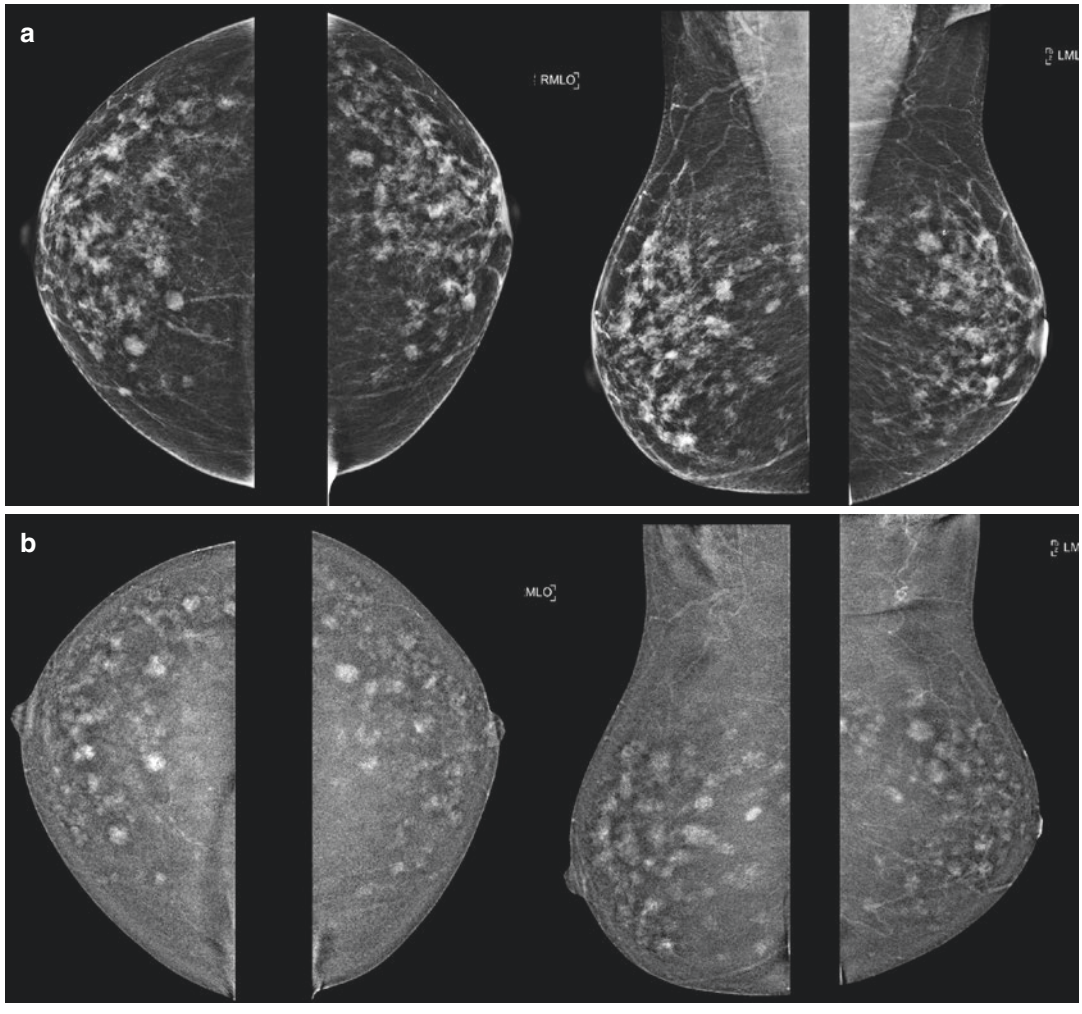
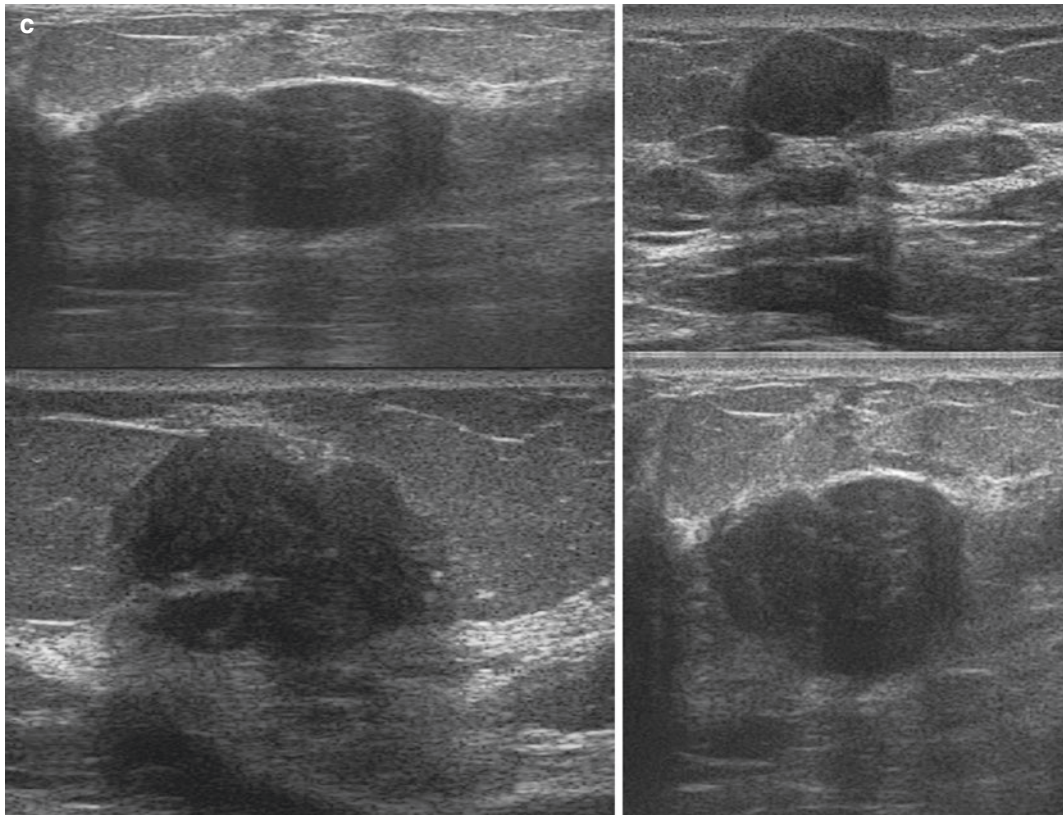


Fig. 11.3 Multiple fibroadenomas. (**a**) LE CEDM images in CC and MLO views show multiple bilateral opacities with well-defined margins. (**b**) CEDM recombined images demonstrate multiple well defined bilateral homogeneously enhancing masses. (**c**) Second-look US showed many hypoechoic nodules with benign features. An ultrasound-guided core biopsy revealed multiple fibroadenomas. *CEDM* contrast-enhanced digital mammography, *LE* low energy, *CC* craniocaudal, *MLO* mediolateral oblique, *US* ultrasound



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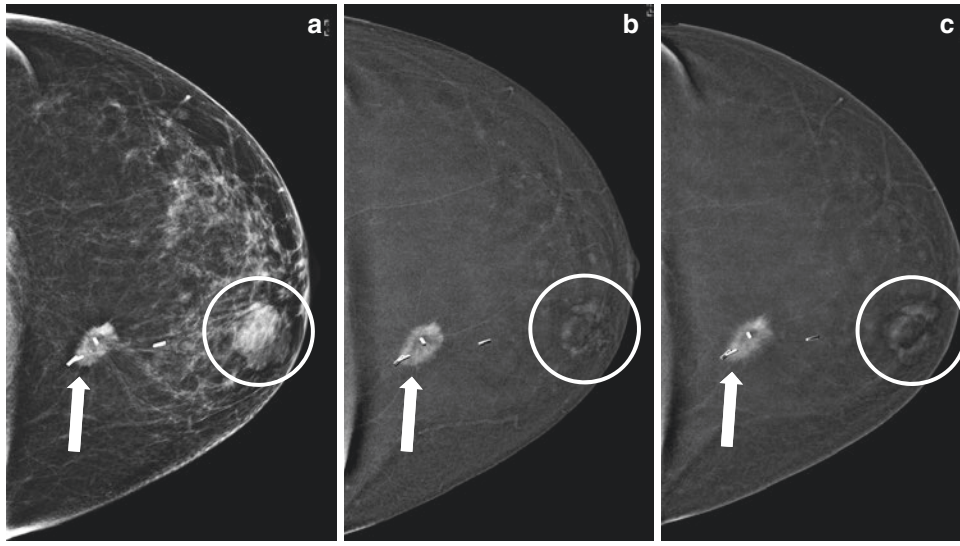


Fig. 11.4 Different enhancing patterns of benign and malignant lesions on CEDM in the same breast. (**a**) LE CEDM image in CC view of the left breast shows a deep opacity with ill-defined margins and another well-circumscribed opacity in the retroareolar region. (**b**, **c**) CEDM recombined images in early and delayed phases show an intense heterogeneous enhancement of the posteriorly located mass with spiculated and ill-defined margins (*white arrow*), whose pathology was invasive ductal carcinoma. The retroareolar oval mass with internal dark non-enhancing septations was consistent with a fibroadenoma (*white circle*). *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal

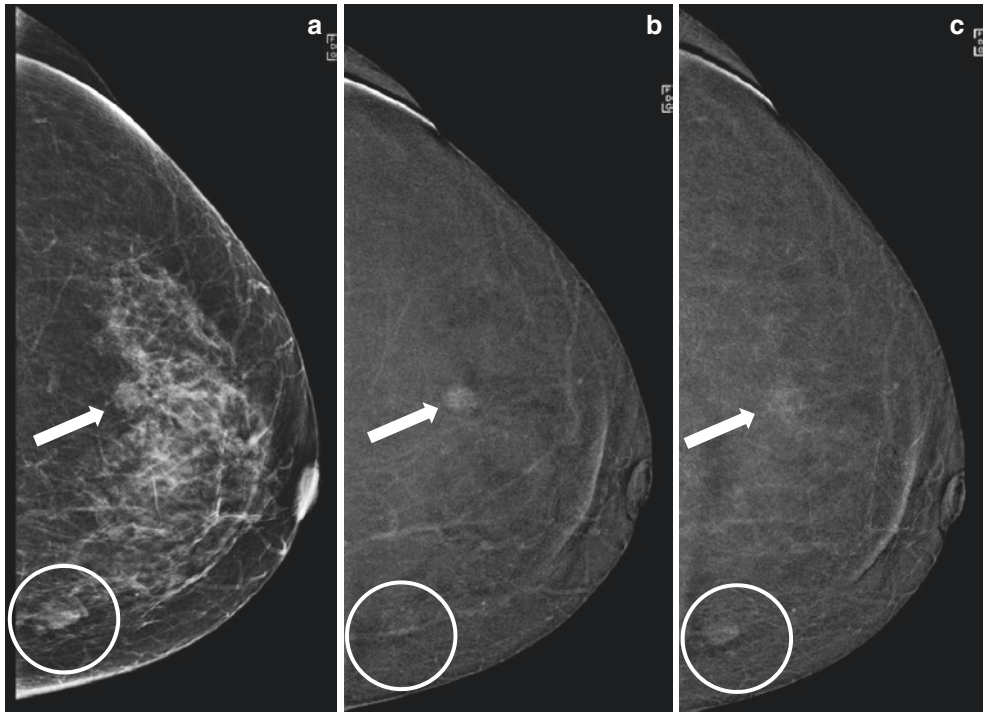


Fig. 11.5 Different enhancing patterns of benign and malignant lesions in the same breast on CEDM images. (**a**) LE CEDM image of the left breast in CC view demonstrates a well-circumscribed opacity in the inner quadrant posteriorly (*white circle*) and another opacity with ill-defined margins located more anteriorly and more centrally (*white arrow*). (**b**, **c**) CEDM recombined images in early and delayed phases show early enhancement and wash-out of the mass centrally located (*white arrow*) and a progressive delayed enhancement of the mass in the inner quadrant (*white circle*) which are typical enhancement features of invasive carcinoma (*white arrow*) and fibroadenoma (*white circle*), respectively. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal

however, the periphery of the cyst may enhance if there is surrounding pericystic inflammation [6, 8].

– *In our experience with CEDM*, the findings consist of round areas of radiolucency with regular margins in keeping with the absence of enhancement, with possible peripheral enhancement in recombined images, which is also called "rim enhancement". The enhancement could also be described as "eclipse sign", because it resembles a full solar eclipse (Figs. 11.6 and 11.7).

11.3.2.2 Complicated Cyst Findings

A complicated cyst is a cyst that contains low-level internal echoes or fluid-fluid or fluid-debris levels that include cell debris, proteins, cholesterol, blood and epithelial cells.

The risk of malignancy with complicated cysts is 0.2%, but they should be aspirated to confirm diagnosis after imaging [7, 8].

– *On mammography*, these complicated cysts show the same characteristic findings of simple cysts.
– *On US*, complicated cysts have most, but not all, of the ultrasonographic criteria of a simple cyst: they may have homogeneous internal echoes but lack solid components, thick walls or septa and do not demonstrate increased vascularity.
– *On MRI*, a complicated cyst may have intermediate or high signals on T1-weighted

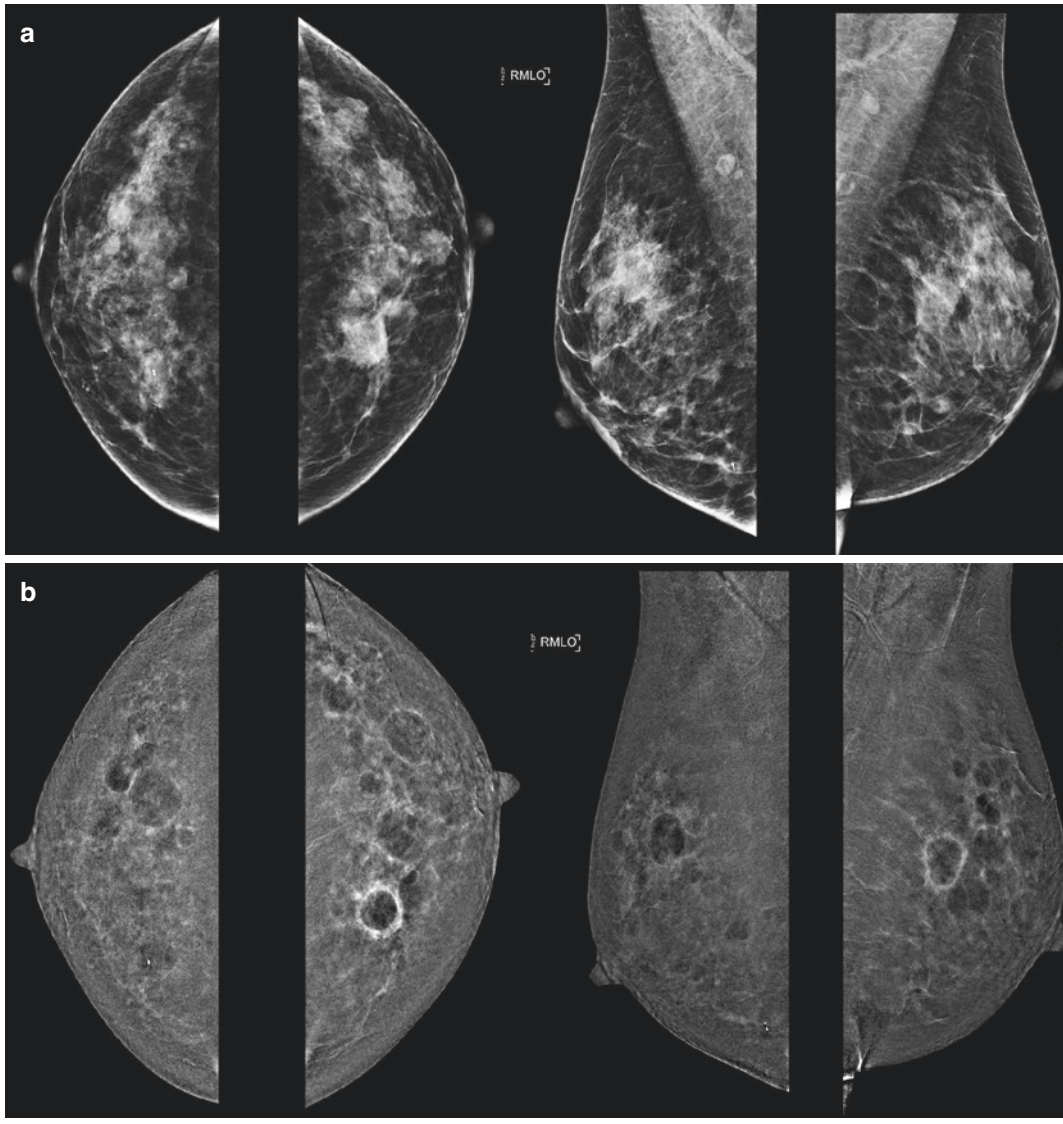


Fig. 11.6 Rim enhancement pattern of cysts. (**a**) LE CEDM images in CC and MLO views of both breasts show multiple scattered round opacities, with circumscribed margins. (**b**) CEDM recombined images show multiple bilateral radiolucent areas, surrounded by thin uniform wall enhancement in keeping with simple cysts. There are some, which have thick rim enhancement suggestive of cysts with peripheral inflammation. *CEDM* contrast-enhanced digital mammography, *LE* low energy, *CC* craniocaudal, *MLO* mediolateral oblique

images due to proteinaceous contents or blood products. Their appearance on T2-weighted images is variable depending on the cyst contents [17, 20, 21].

– *In our experience with CEDM*, the findings are similar to those observed for simple cysts; complex cysts appear as focal areas of radiolucency with thick irregular peripheral enhancement also called "rim enhancement" (Fig. 11.8).

11.3.2.3 Complex Cyst Findings

To avoid confusion with a complicated cyst, the current preferred term for complex breast cysts is a combination of solid and cystic mass. Complex

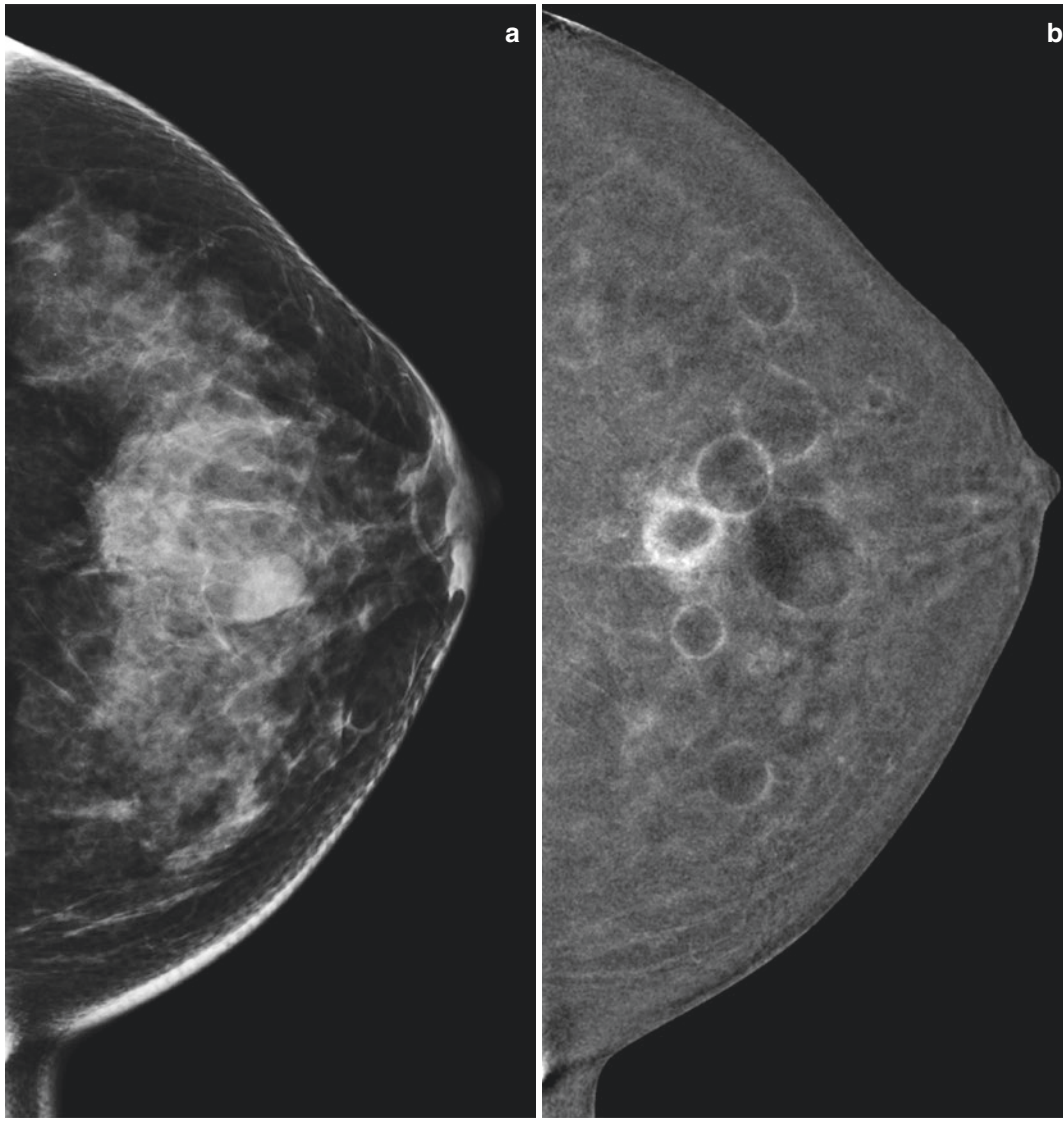


Fig. 11.7 Rim enhancement pattern of cysts. (**a**) LE CEDM image of the left breast in CC view shows multiple scattered round opacities, with circumscribed margins. (**b**) CEDM recombined image shows multiple radiolucent round areas in the left breast, surrounded by thin uniform rim enhancement in simple cysts, while sometimes a thick rim enhancement can be seen in case of cysts with peripheral inflammation. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal

cysts have a relatively higher risk of malignancy, ranging from 5 to 23%, and therefore should be evaluated with tissue biopsy [20].

The cysts that fall in these categories are galactoceles, haematomas, fat necrosis, abscesses, necrotic tumours, papillary tumours, atypical ductal hyperplasia and ductal carcinoma in situ (DCIS).

- *On mammography*, these cysts show the same characteristic findings as simple cysts.
- *On US*, these cysts contain thick wall, thick septae or intracystic masses that are characteristic of complex breast cysts [20].
- *In our experience with CEDM*, the findings are similar to those observed for simple cysts; complex cysts appear as focal areas of radiolucency

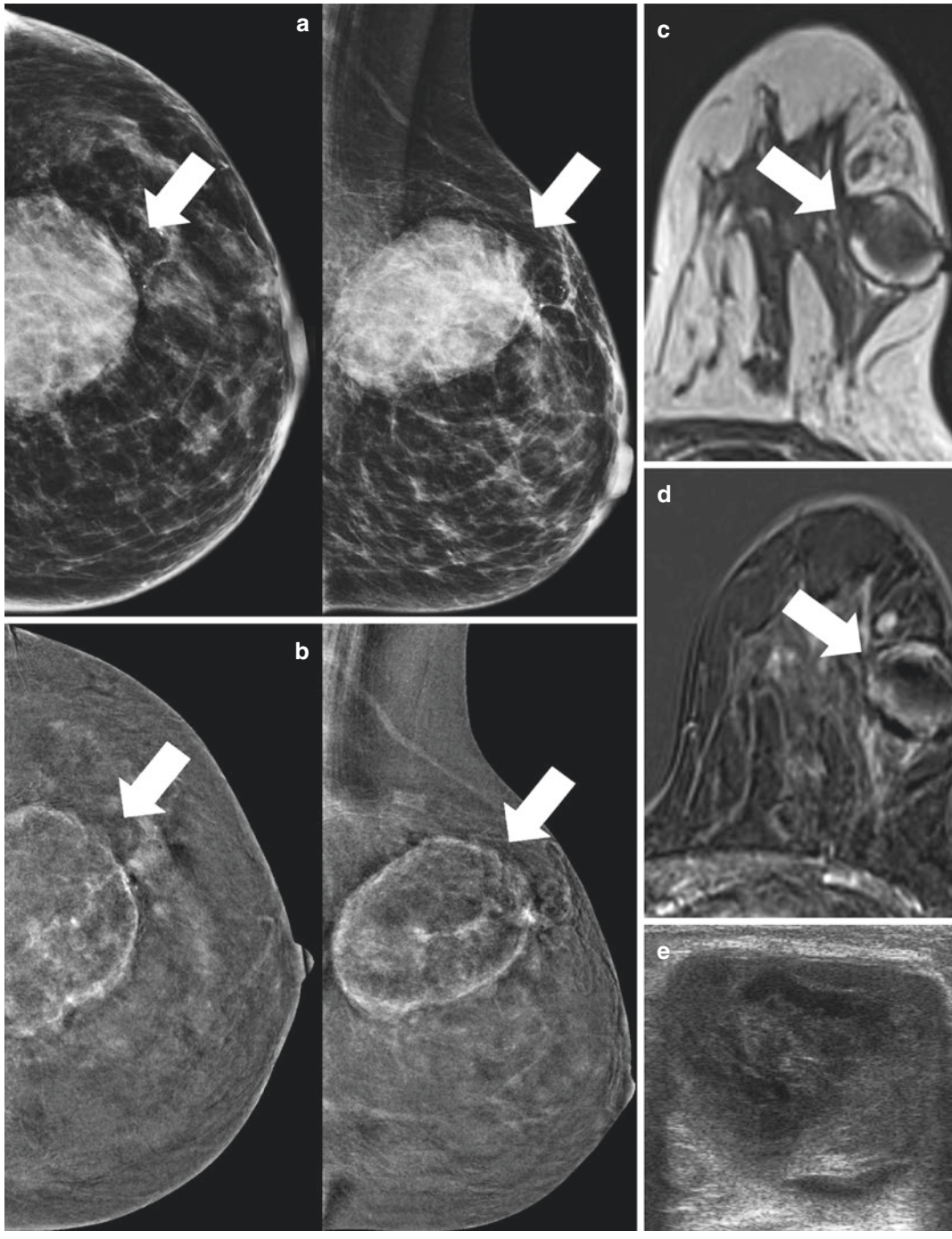


Fig. 11.8 Post-biopsy haematoma. (**a**) LE CEDM images, in CC and MLO views, of the left breast show a large, oval, post biopsy opacity suggestive of a breast haematoma. (**b**) CEDM recombined CC and MLO images demonstrate a large oval rim-enhancing lesion with slight central enhancement in keeping with complex cystic features. (**c**) MRI T1-weighted pre-contrast image shows a mass with inhomogeneous hyperintensity. (**d**) MRI FAT SAT T1-weighted post-contrast image shows rim enhancement. (**e**) US images show a well circumscribed elliptic mass with inhomogeneous echogenicity, compatible with a post biopsy haematoma. *LE CEDM* low energy contrast-enhanced digital mammography, *MRI* magnetic resonance imaging, *CC* craniocaudal, *MLO* mediolateral oblique, *US* ultrasound

with thick irregular peripheral enhancement also called "rim enhancement" (Fig. 11.9). Occasionally, we may also observe intracystic enhancement due to the associated solid components.

11.3.3 Fibrocystic Changes

Fibrocystic changes are the most frequently encountered benign breast findings and occur most often in women of reproductive age between 20 and 50 years. Patients often present with a history of bilateral, menstrual-related, tender and nodular breasts, most often localized to the upper outer quadrants [5–7, 10].

Exact pathogenesis in unclear but hormonal imbalance with oestrogen predominance seems to be a relevant factor in their development [7].

Fibrocystic changes have no single histologic definition. It includes several histopathological categories such as microcystic and macrocystic formations, hyperplasia of the ductal epithelium, apocrine metaplasia, papillomatosis, ductal ectasia, sclerosing adenosis and stromal fibrosis.

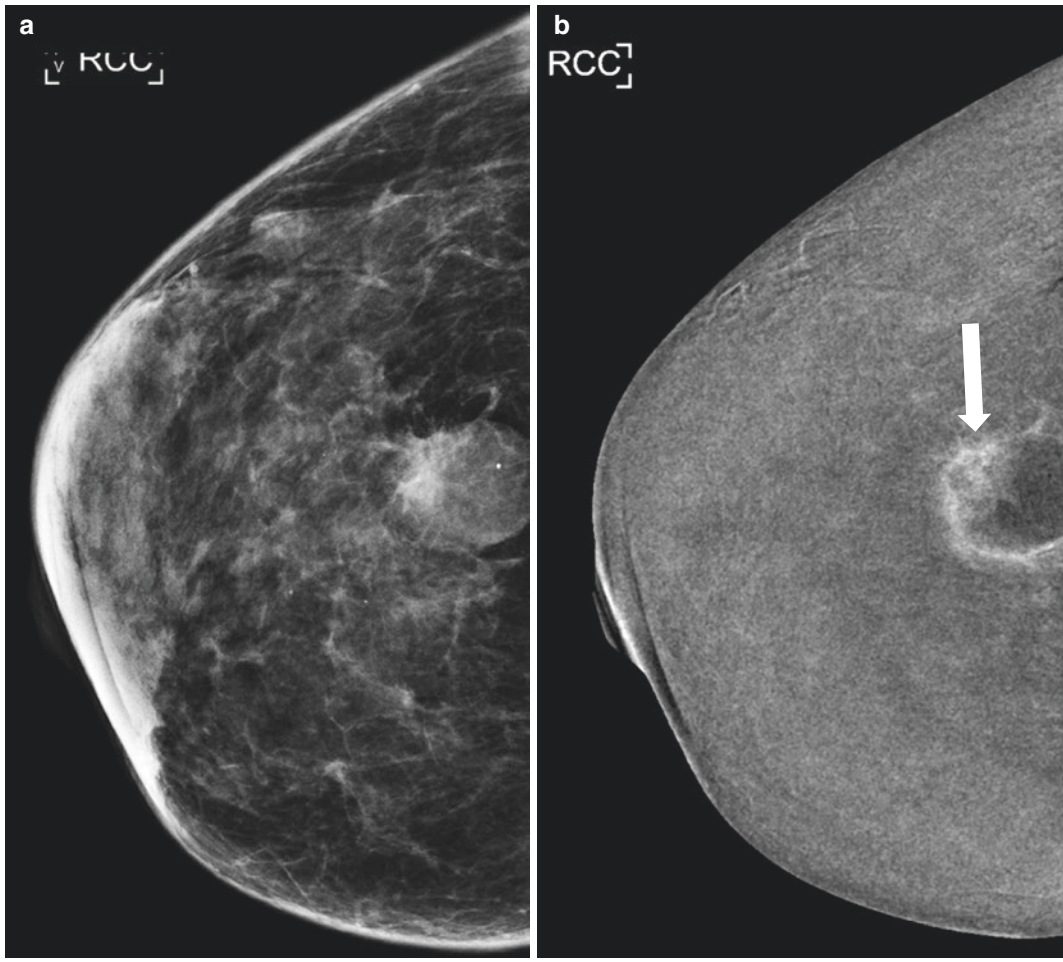


Fig. 11.9 Complex cysts. (**a**) LE CEDM image in CC view of the right breast shows a solitary, oval, central opacity with well-defined margins. (**b**) CEDM recombined image in CC view shows peripheral thin rim enhancement with an internal enhancing nodule. Pathology: Complex cyst containing a B3 solid mass, lobular intraepithelial neoplasia (LIN). *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique

As a result of these indistinct clinical and pathological findings, some authors have even questioned the validity of referring to fibrocystic change as a disease or even the use of the term [7].

Given the importance of determining if a clinical "fibrocystic lesion" is a risk factor for the subsequent development of breast cancer, lesions are further characterized under the histologic classification system proposed by DuPont and Page as non-proliferative lesions, proliferative lesions without atypia and proliferative lesions with atypia [16, 22, 23].

Breast cancer risk for these benign lesions is then classified according to histology. There is no elevated risk in women with biopsy-proven non-proliferative lesions. Proliferative disease without atypia and with atypical ductal/lobular hyperplasia is associated with a small increased breast cancer risk ranging from 1.2 to 2.0% and 3.7 to 5.3%, respectively [19, 22, 23].

11.3.3.1 Fibrocystic Changes Findings

Fibrocystic changes are usually defined as cystic degeneration of the breast parenchyma associated or not associated with fibrosis, adenosis and ductal or lobular hyperplasia [20].

Generally, fibrocystic changes consist of palpable lumps in the breast, associated with breast pain or tenderness, that fluctuate with the menstrual cycle.

- *On mammography,* findings associated with fibrocystic disease are asymmetrical densities, architectural distortions (sclerosing adenosis) and microcalcifications (adenosis, apocrine metaplasia, ductal hyperplasia) with opacities corresponding to cysts, focal fibrosis or nodular adenosis [18, 24, 25].
- *On ultrasound*, fibrocystic change consists of cysts (anechogenic for simple cyst, or echogenic for complicated or complex cysts, or often clustered microcysts), scattered echogenic foci due to microcalcifications (associated or not associated with cysts), solid masses and discrete masses due to fibrosis (homogeneous/inhomogeneous ovoid mass or irregular mass with shadowing) [24, 25].
- *On MRI*, fibrocystic disease demonstrates a wide spectrum of morphologic and kinetic features. Fibrocystic disease commonly occurs as a diffuse type of non-mass-like regional enhancing lesion, with a benign enhancement pattern. They may also present as a focal mass-type lesion with enhancement kinetics usually showing rapid up-slope mimicking a breast cancer [26].
- *In our experience with CEDM*, findings of fibrocystic change are seen as areas of non-mass-like parenchymal enhancement, usually of regional distribution, without specific characteristics, similar to their appearance on MRI that requires a second-look ultrasound to discriminate between benign or suspicious lesions (Figs. 11.10, 11.11, 11.12, and 11.13).

11.3.4 Hamartoma

Breast hamartomas are benign lesions also known as fibroadenolipoma or adenolipoma. They are uncommon tumour-like masses that have varying amounts of glandular, adipose and fibrous tissue. They present as encapsulated painless masses found upon screening mammography. The classic mammographic finding is a circumscribed area consisting of a mixture of both glandular tissue and lipomatous elements surrounded by a thin translucent zone [3, 27].

Hamartomas do not have specific diagnostic features upon histology with the exception of a nodular distribution of fat tissue within a fibrotic stroma that extends between individual lobules [3, 27].

11.3.4.1 Hamartoma Findings

- *On mammography*, hamartomas are typically seen as oval or round masses, inhomogeneous with radio-opaque and radiotransparent areas reflecting the presence of tissues that differ in density, well-defined by a thin radio-opaque pseudocapsule and surrounded by breast parenchyma displaced by the mass [27].

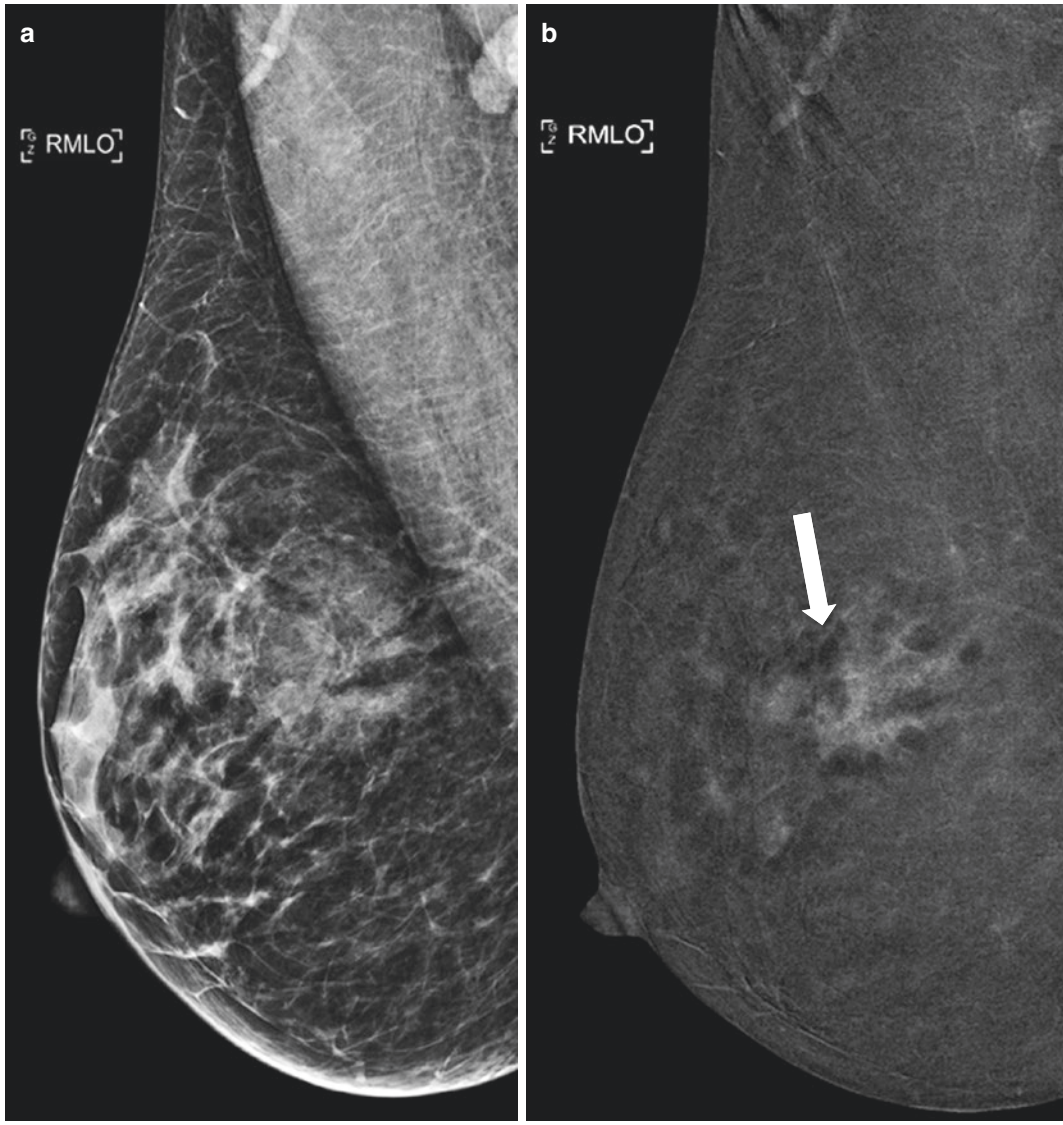


Fig. 11.10 CEDM images of different enhancement patterns of fibrocystic changes. (**a**) LE CEDM image in MLO view of the right breast shows a large opacity with ill-defined margins in the upper quadrant. (**b**) CEDM recombined image shows an intense heterogeneous area of non-mass enhancement that was biopsied with the histologic result of fibrocystic changes. *CEDM* contrast-enhanced digital mammography, *MLO* mediolateral oblique

The mass typically resembles a "slice of salami" with a "breast within a breast" appearance.

– *On US*, hamartomas appear as solid, well-defined, oval formations lying parallel to the skin plane. They are inhomogeneous with hypoechoic areas intermixed with hyperechoic band-like or nodular areas, reflecting the presence of adipose, epithelial and fibrous connective tissues. Because hamartomas resemble the normal breast tissue, it is sometimes difficult to delineate their margins [28–31].
– *On MRI*, hamartomas may present heterogeneous signal intensity on T1- and T2-weighted

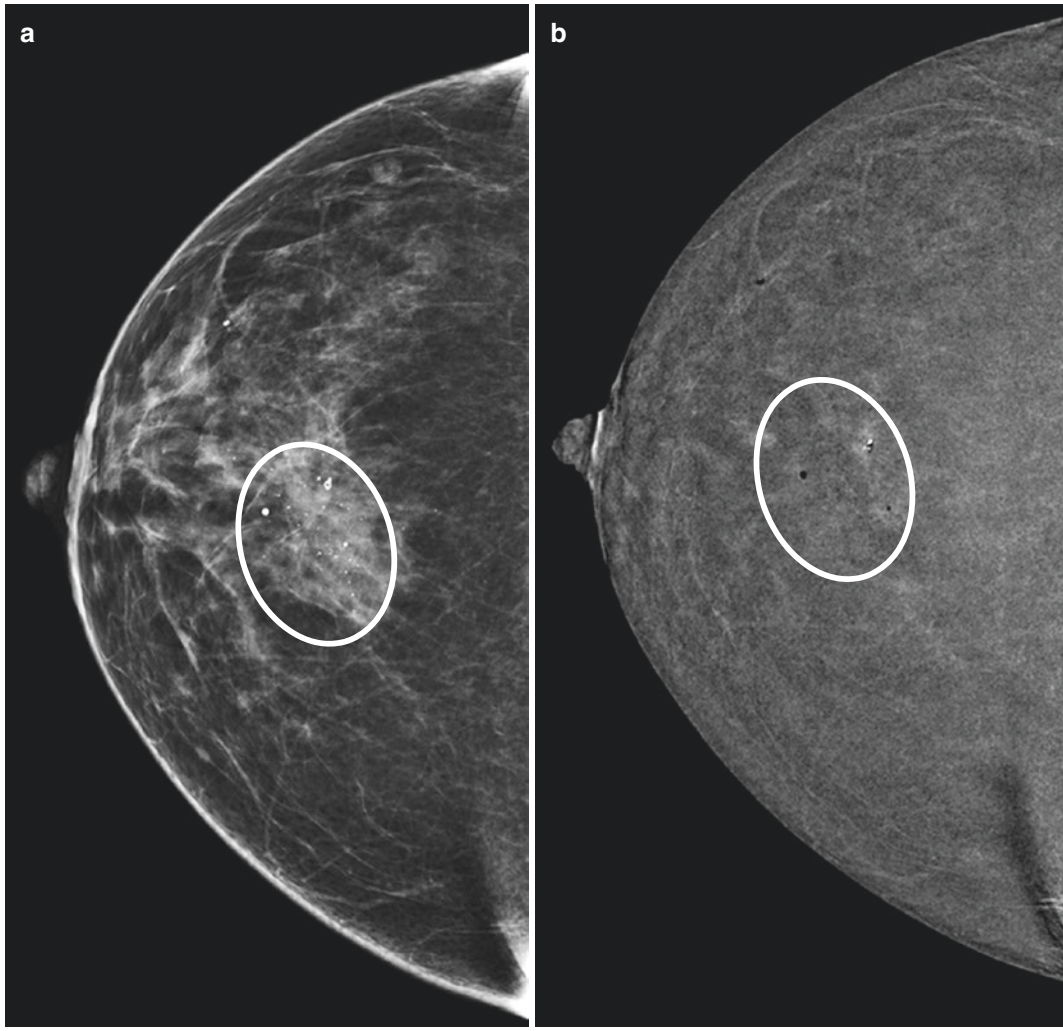


Fig. 11.11 CEDM images of different enhancement patterns of fibrocystic changes. (**a**) LE CEDM image in CC view of the right breast shows an opacity with ill-defined margins and calcifications. (**b**) CEDM recombined image shows no enhancement in the same area in keeping with non-enhancing fibrocystic change. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique

sequences, reflecting the presence of glandular and adipose tissue components and a thin capsule. After the administration of contrast medium, hamartomas show a gradual, progressive enhancement with a type I kinetic curve [32].

– *In our experience with CEDM*, similar to MRI, hamartomas demonstrate slow heterogeneous initial enhancement pattern with a persistent delayed phase on the recombined CEDM images (Fig. 11.14).

11.3.5 Intraductal Papilloma (Without Atypia)

Papillomas are hyperplastic epithelial lesions composed of a central fibrovascular core covered by epithelium. Papillomas may be central, involving larger subareolar ducts, and are usually solitary or peripheral papillomas that involve terminal duct lobular units and are usually multiple. The epithelial component of papillomas can harbour a spectrum of morphologic changes ranging

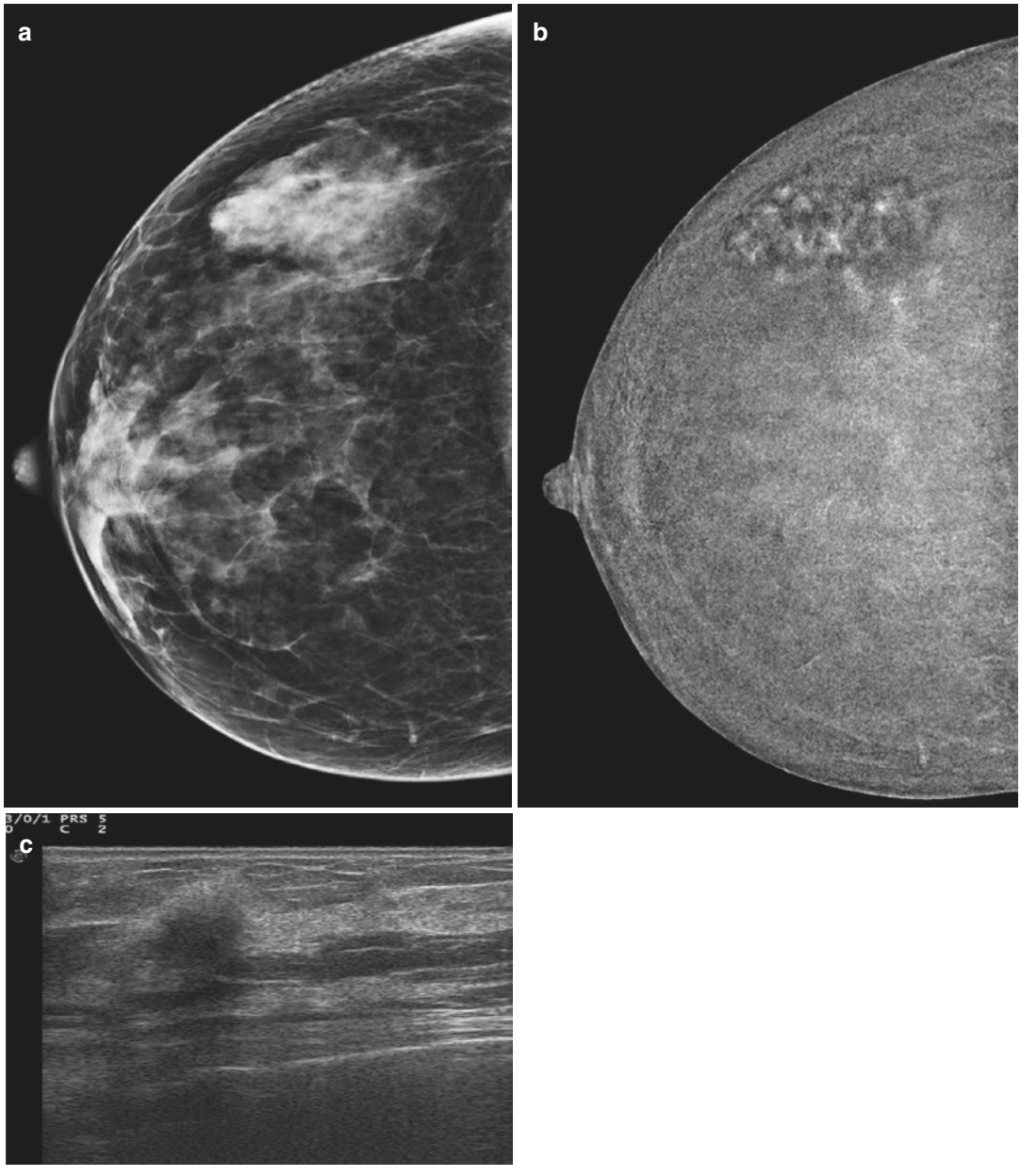


Fig. 11.12 CEDM images of different enhancement patterns of fibrocystic changes. (**a**) LE CEDM image in CC view of the right breast shows an asymmetric oval opacity at the upper outer quadrant. (**b**) CEDM recombined image shows a faint heterogeneous area of non-mass enhancement in the same quadrant. (**c**) US shows a pseudonodular area, which was subsequently biopsied with the histologic result of fibrocystic changes. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique, *US* ultrasound

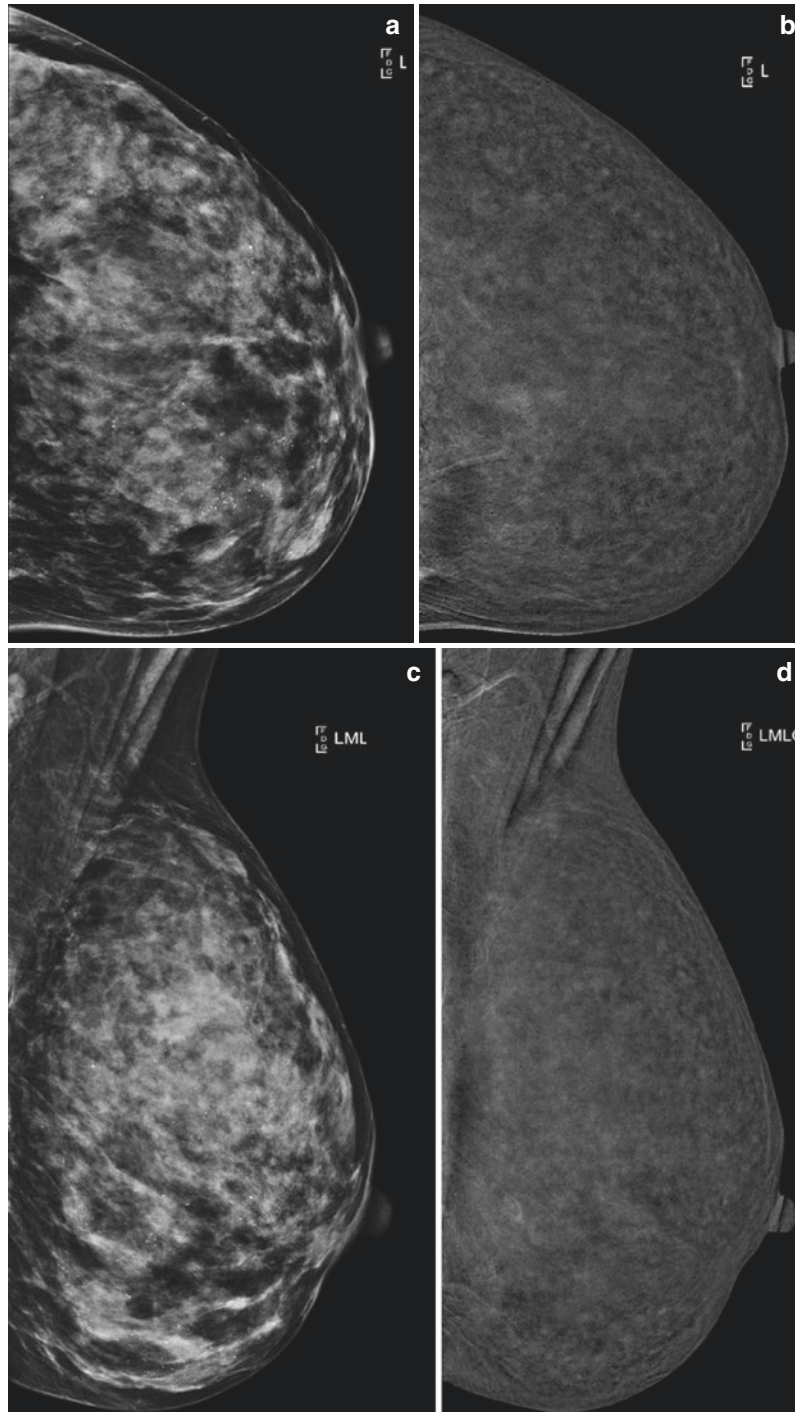


Fig. 11.13 CEDM images of calcifications with segmental distribution on fibrocystic changes. (**a** and **c**) LE CEDM images in CC and MLO views of the left breast show pleomorphic calcifications with segmental distribution, in the lower inner quadrant (**a**[1]). (**b** and **d**) CEDM recombined images in CC and MLO views show no enhancement in the same area (**b**[1]). Vacuum-assisted biopsy was performed and the pathology result was fibrocystic change. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique

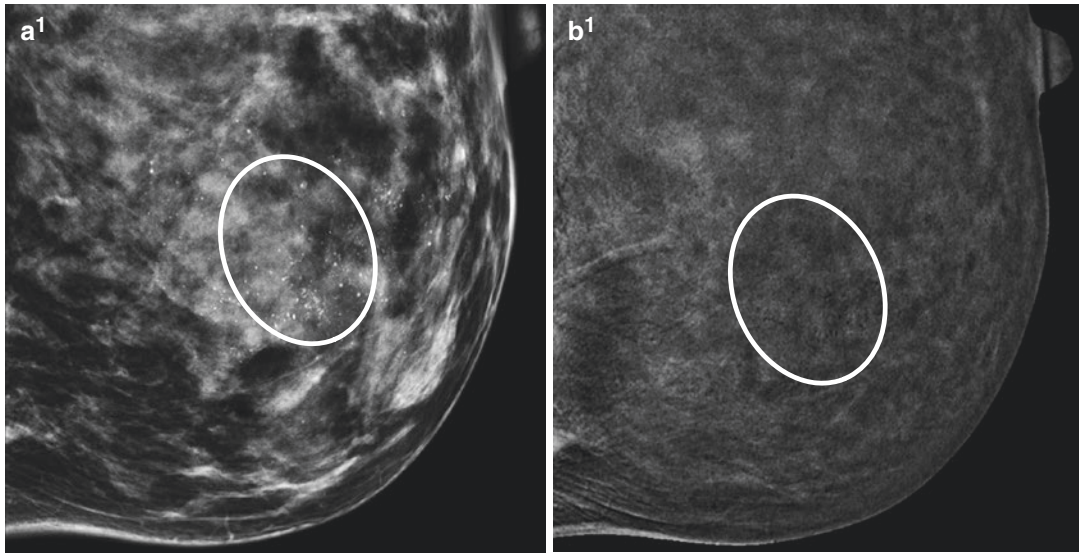


Fig. 11.13 (continued)

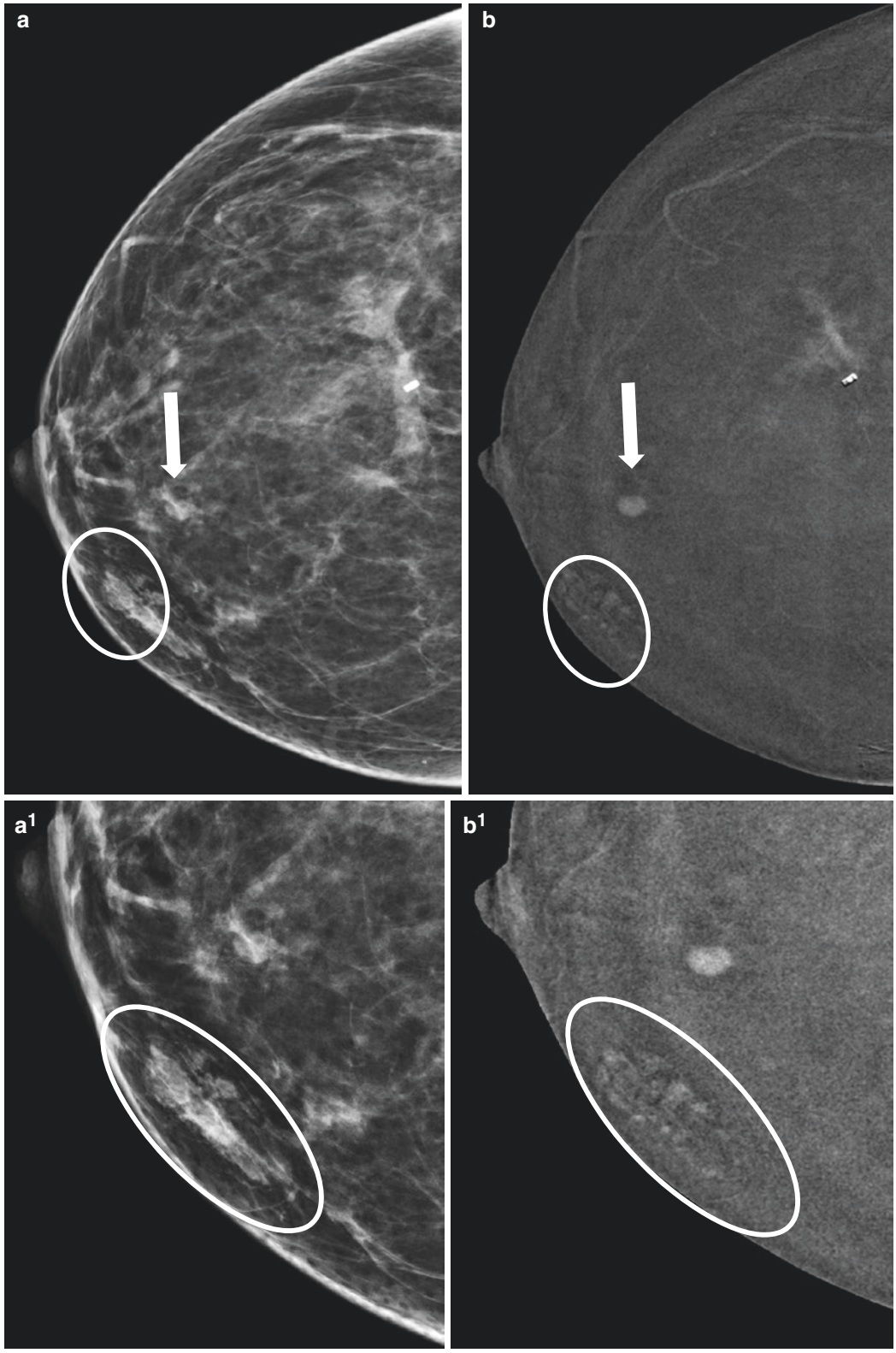
from metaplasia to hyperplasia, atypical hyperplasia and in situ or invasive carcinoma. Given this risk of atypia and malignancy, the traditional recommendation after core needle biopsy of papilloma is surgical excision. However, there are recent reports concerning the potential safety of observation in patients diagnosed with solitary papilloma without atypia upon biopsy [33–35].

11.3.5.1 Intraductal Papilloma Findings

Intraductal papilloma is usually a retroareolar or central benign lesion, often associated with bloody or clear nipple discharge [23].

- *On mammography*, when small and located in the retroareolar regions, intraductal papillomas can be occult due to the breast density. Larger lesions may appear as a round- or oval-shaped masses with well-circumscribed margins, associated with benign calcifications [36].
- *On galactography*, intraductal papillomas appear as well-defined mural-based filling defects with smooth or lobulated contours [36].
- *On US*, intraductal papillomas are seen as well-defined solid nodules or mural-based nodules within a dilated duct [36].
- *On MRI*, intraductal papillomas are shown as enhancing nodules with or without intraductal

Fig. 11.14 CEDM images of a hamartoma and other findings of benign and high risk B3 lesions in the same breast. (**a**) LE CEDM image in CC view of the right breast shows three findings: (1) (**a**[1]) an oval opacity (white circle) corresponding to a hamartoma in the inner quadrant. (2) a second lesion is a well-defined round mass (white arrow) corresponding to a fibroadenoma in the retro-areolar region. (3) thirdly, an area of distortion deeply in the central quadrant (**b**) CEDM recombined image show three different enhancing patterns from the inner quadrant to the outer quadrant: (1) (**b**[1]) A faintly enhancing oval mass with regular margins (white circle) corresponding to a hamartoma, (2) A round well-defined enhancing mass (white arrow) in keeping with a fibroadenoma (B2 lesion), (3) An area of non-mass enhancement corresponding to a radial scar (B3 lesion). *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal


a
b
a1
b1

components that may have high signal on T1-weighted images if the duct contains proteinaceous debris or haemorrhage. A round filling defect may be seen within the duct. Papillomas enhance avidly with gadolinium. The enhancement of these nodules may be uniform or irregular with either washout or plateau kinetics, making differentiation from invasive malignancies potentially difficult [36].
- *In our experience with CEDM*, intraductal papillomas demonstrate peri- or retroareolar, ductal and homogeneous enhancement in the recombined images (Figs. 11.15 and 11.16).

11.3.6 Fat Necrosis

Fat necrosis is a benign non-suppurative inflammatory process of the adipose tissue. It is important to diagnose because it can often mimic breast carcinoma. Fat necrosis is most commonly the result of trauma or surgery to the breast [3].

Examination and imaging of fat necrosis may be concerning for malignancy due to dense palpable masses, erythema, skin retraction and skin thickening.

It is sometimes necessary to biopsy the lesion to confirm diagnosis, although with experience it is possible to delineate this diagnosis particularly when oil cysts are present.

Conservative management is recommended unless there is a serious cosmetic distortion of the breast, in which case surgery can be considered [37].

11.3.6.1 Fat Necrosis Findings

- *On mammography*, fat necrosis can present as oil cysts x-ray transparency, coarse calcifications, focal asymmetries, microcalcifications or spiculated masses. The mass usually appears as a radiolucent mass with linear and curvilinear calcifications. Sometimes, the calcifications are of concern due to their shape and distribution: branching, rod-like, angular or pleomorphic-clustered calcifications are sometimes indistinguishable from those of malignancy.

Occasionally, the reparative fibrotic reactions may replace all of the radiolucent necrotic fat, resulting in the appearance of a focal asymmetric density, a focal dense mass or an irregular spiculated mass upon mammography [38].

- *On US*, fat necrosis may present as a solid mass or a complex mass with echogenic nodules, a complex mass with echogenic bands, an anechoic mass with posterior acoustic enhancement, an anechoic mass with shadowing or an isoechoic mass. The margins range from well-circumscribed to indistinct or spiculated.
- *On MRI*, fat necrosis usually shows signal of heterogeneous intensity on T1weighted sequences, which may be due to its haemorrhagic and inflammatory content. Calcifications are sometimes seen on MRI as areas of absence of signal. Fibrosis may appear as high, intermediate or low signal on T1weighted images. Post-gadolinium, fat necrosis can enhance and be focal or diffuse and homogeneous or heterogeneous. Enhancement depends on the intensity of the inflammatory process. The fat suppression sequence is important for identifying enhancing breast cancers or enhancing regions of fat necrosis because the high signal of fat interferes with the detection of enhancing lesions. Enhancement patterns may vary from slow, gradual enhancement to rapid enhancement [38].
- *In our experience with CEDM*, similar to MRI, fat necrosis appears as focal or diffuse areas of enhancement, with either a homogeneous or heterogeneous pattern of enhancement on CEDM recombined images (Figs. 11.17, 11.18 and 11.19).

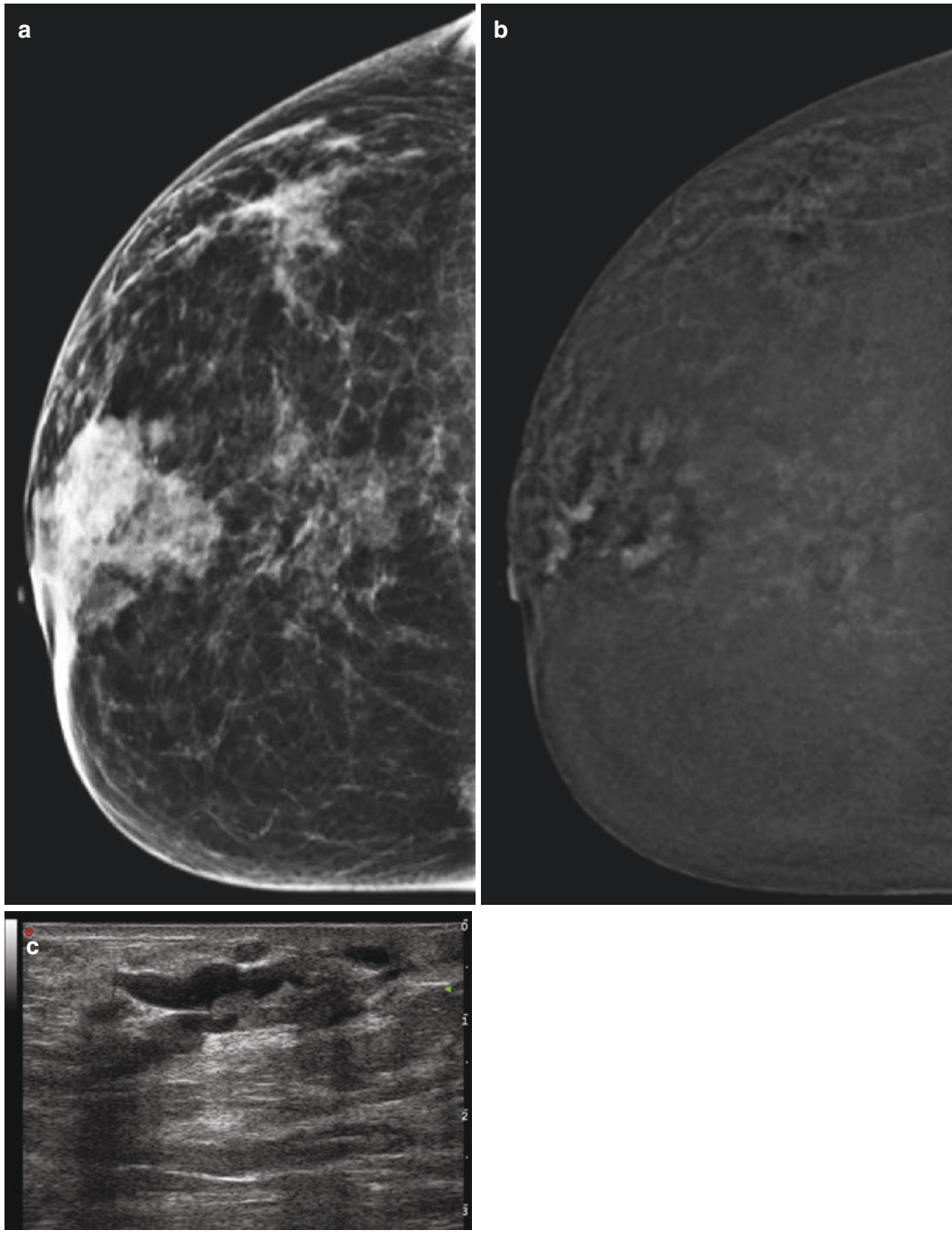


Fig. 11.15 CEDM images of intraductal papillomas. (**a**) LE CEDM image in CC view of the right breast shows a retroareolar irregular opacity. (**b**) CEDM recombined image in CC view shows a segmental area of non-mass enhancement in the periareolar region. (**c**) US demonstrates an anechoic dilated duct with an intraductal hyperechoic mass. US-guided biopsy was performed, and the pathology result was intraductal papilloma. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique, *US* ultrasound

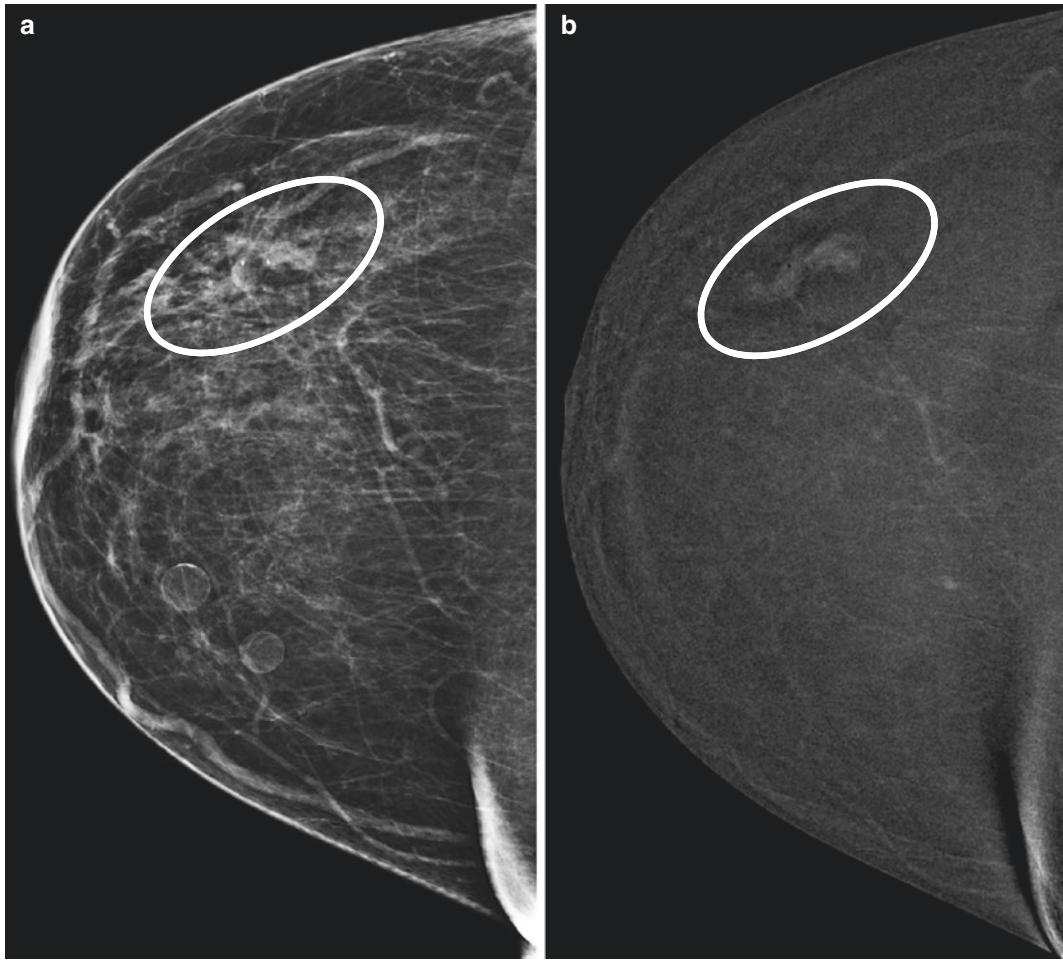


Fig. 11.16 CEDM images of intraductal papillomas. (**a** and **c**) LE CEDM images in CC and MLO views show an oval opacity in the upper outer quadrant of the right breast. (**b** and **d**) CEDM recombined images demonstrate a faint, ill-defined, elongated enhancing mass that was biopsied under sonographic guidance. The pathology was an intraductal papilloma. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique, *US* ultrasound

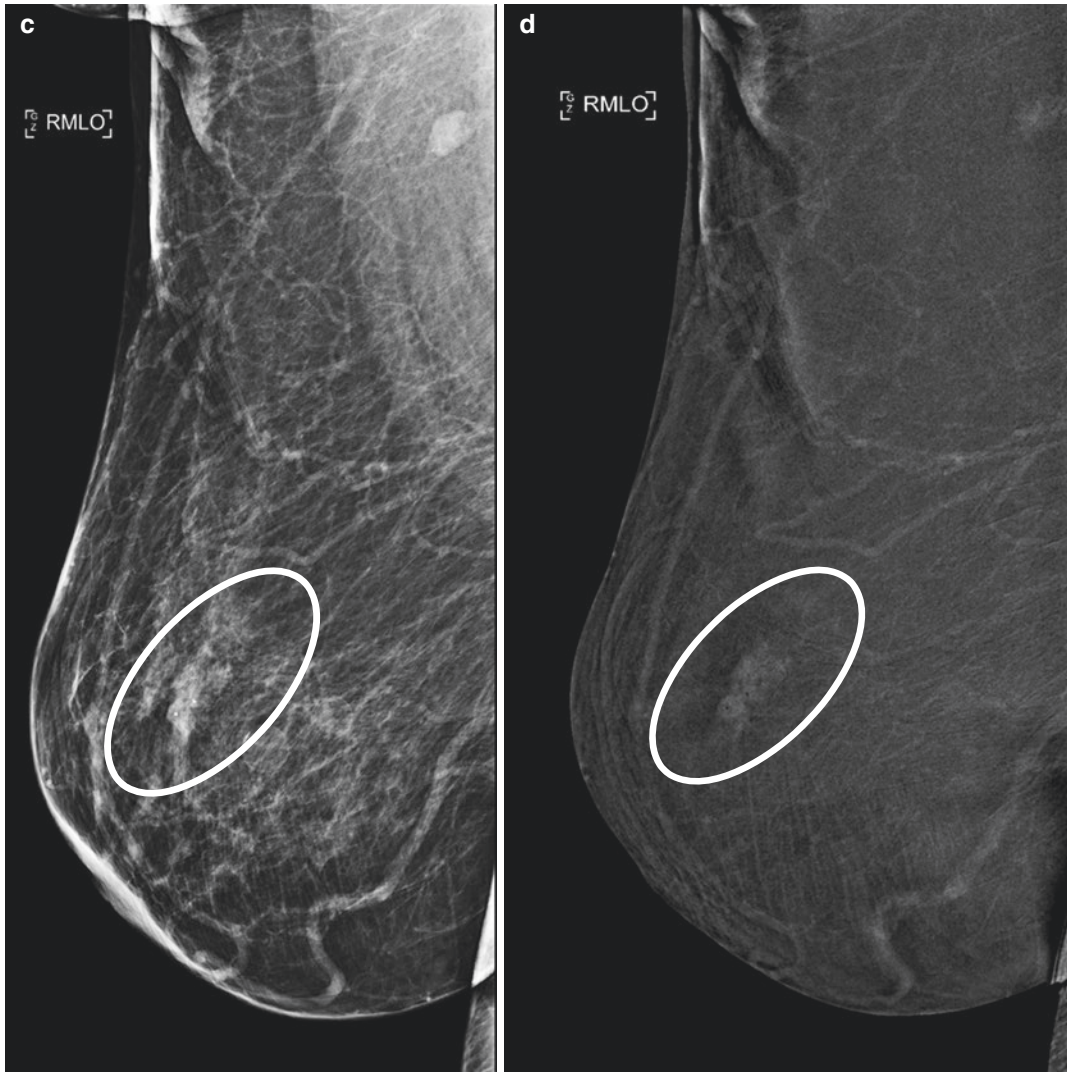


Fig. 11.16 (continued)

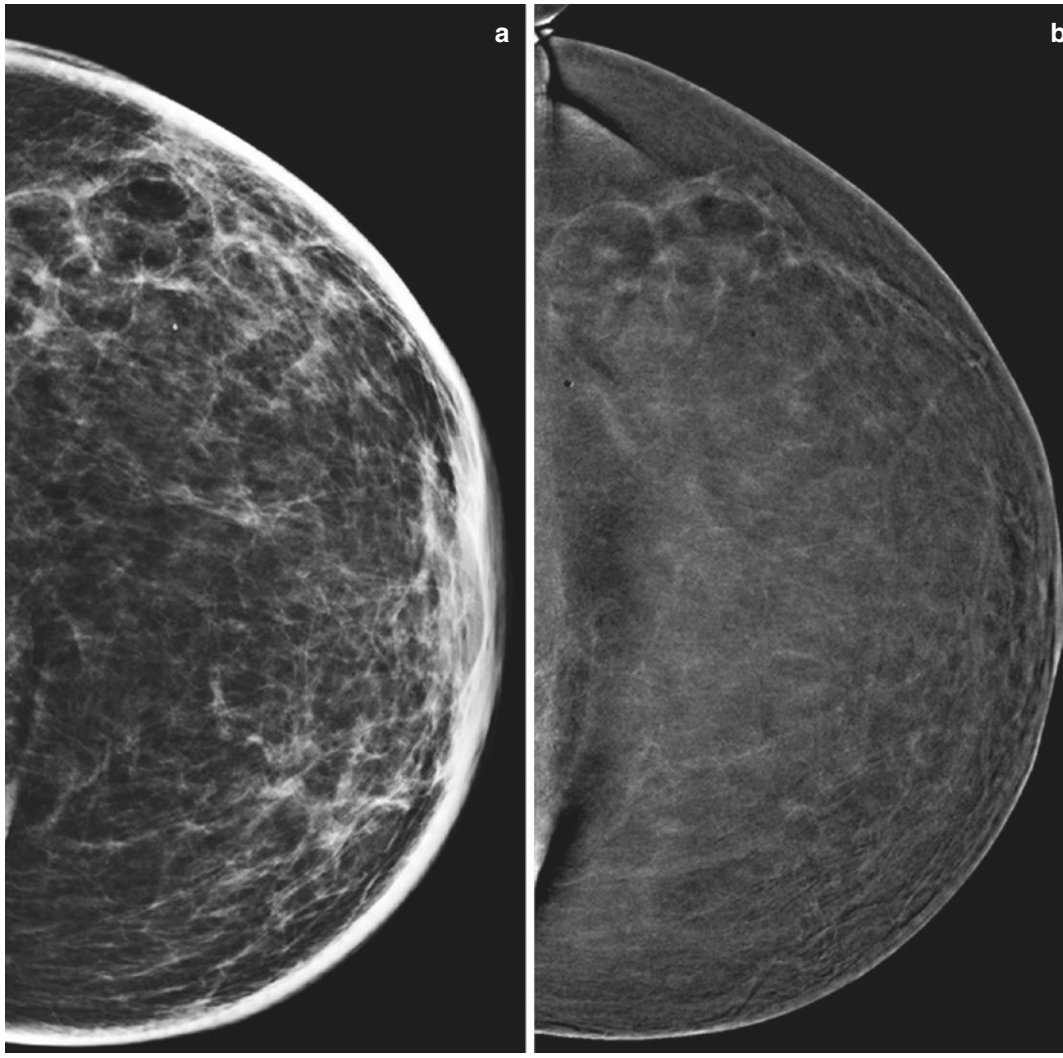


Fig. 11.17 CEDM images of different patterns of fat necrosis. (**a** and **c**) LE CEDM images of the left breast in CC and MLO views show a surgical scar of a previous quadrantectomy with a round area of radiolucency on the upper outer quadrant, better seen on the magnification view (**a**[1]). (**b** and **d**) CEDM recombined images demonstrate an area of radiotransparency surrounded by low-intensity peripheral enhancement in keeping with an oil cyst, better seen on the magnification view (**b**[1]). *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal, *MLO* mediolateral oblique

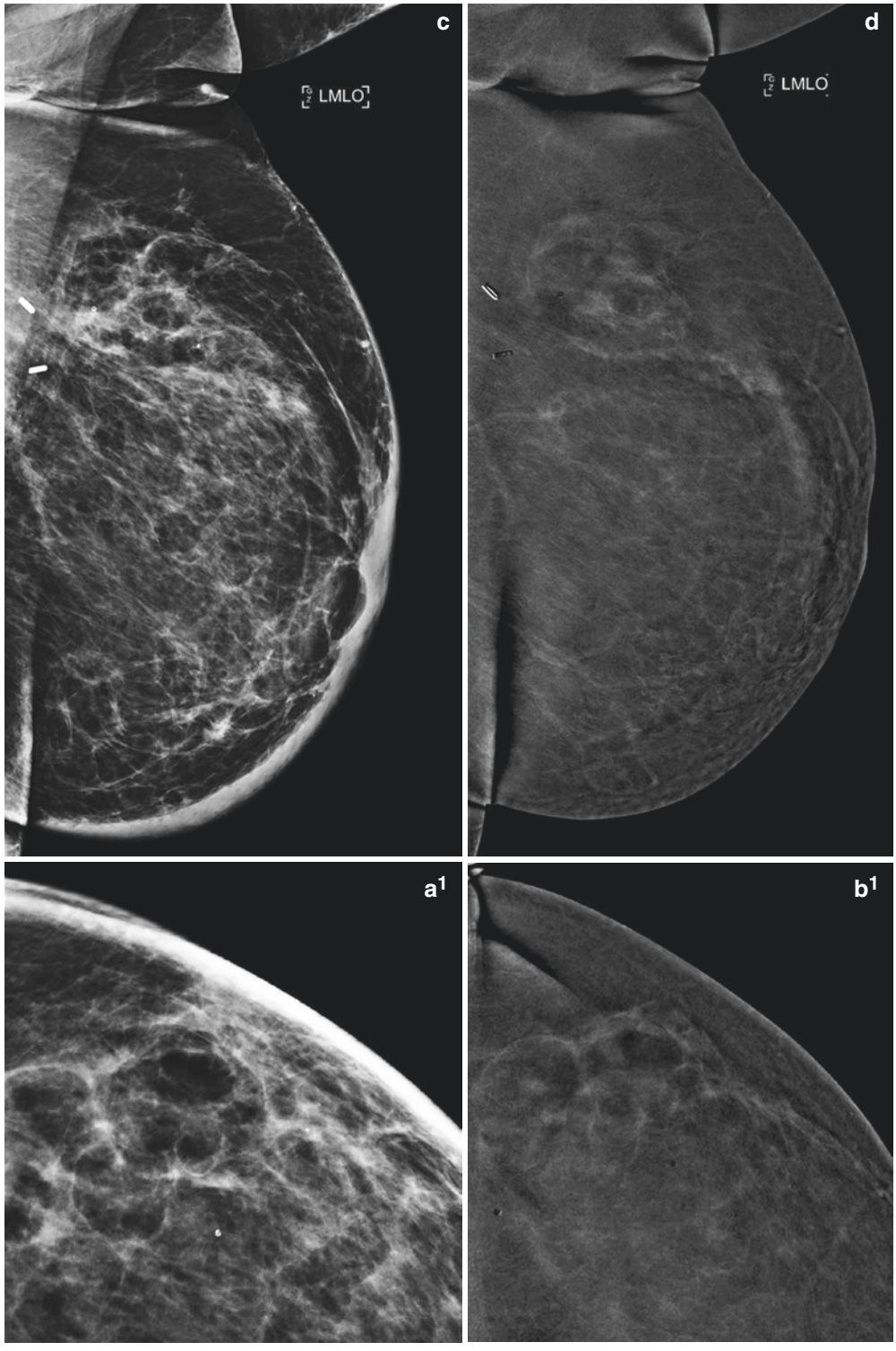


Fig. 11. 17 (continued)

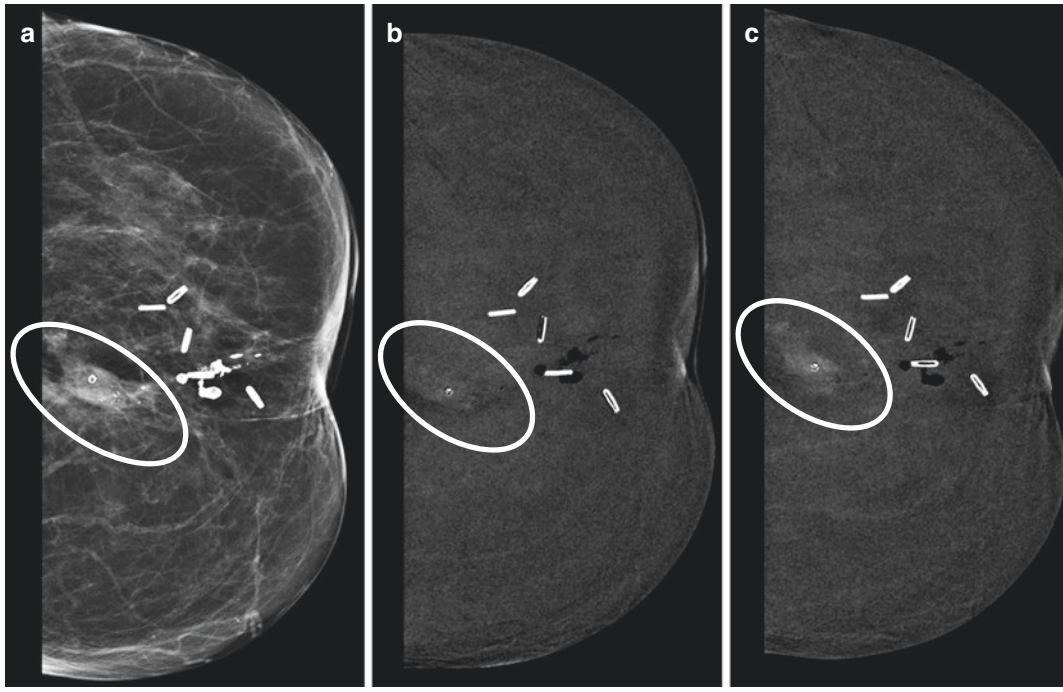


Fig. 11.18 CEDM images of different patterns of fat necrosis. (**a**) LE CEDM image in CC view of the left breast shows a surgical scar of a previous quadrantectomy with a posteriorly located opacity located in the central quadrant behind the surgical clips. (**b–c**) CEDM recombined images in early and delayed phases demonstrate a slow progressive enhancement corresponding to inflammation and fat necrosis. *CEDM* contrast-enhanced digital mammography, *CC* craniocaudal

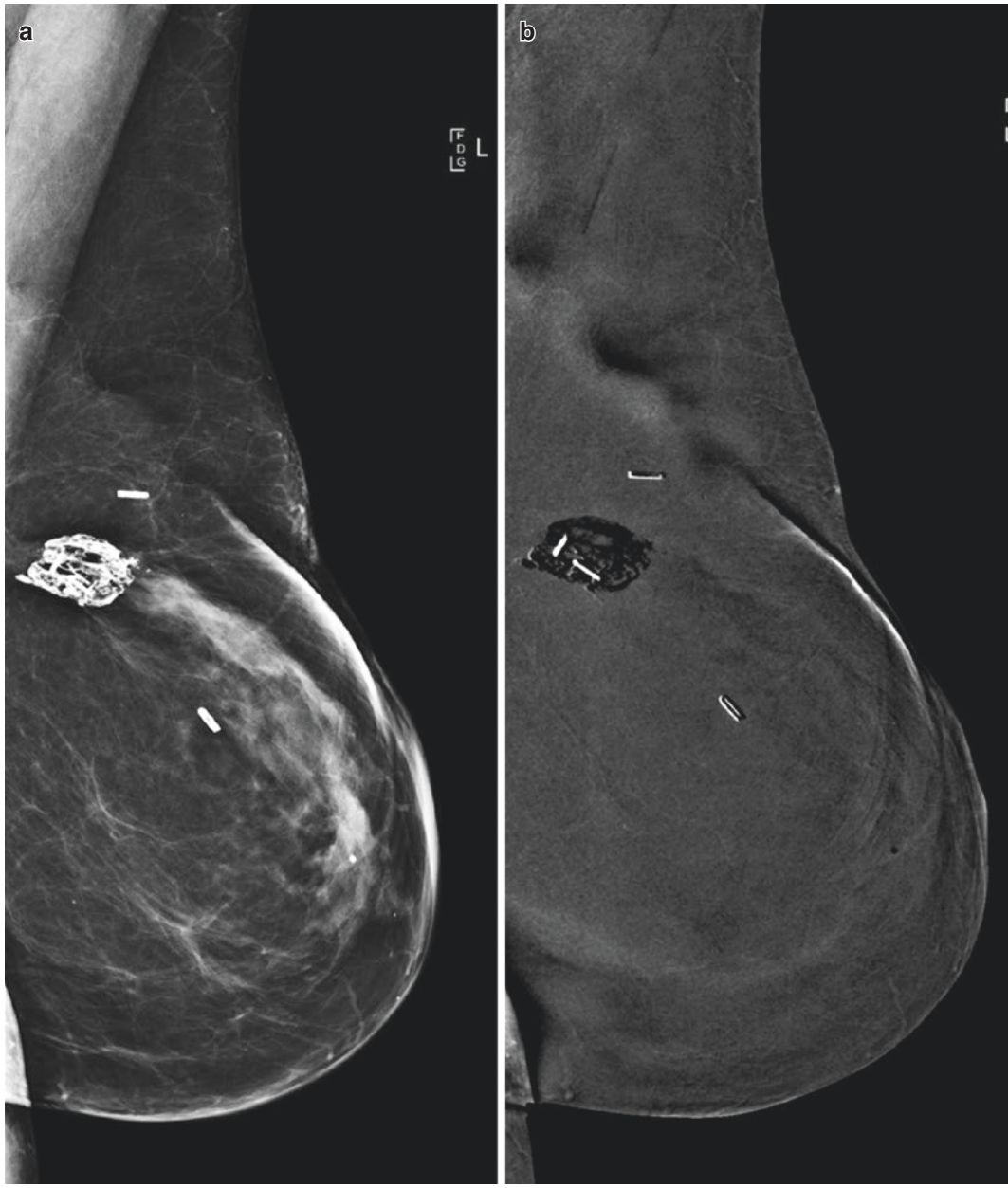


Fig. 11.19 CEDM images of different patterns of fat necrosis. (**a**) LE CEDM image in MLO view of the left breast shows a post quadrantectomy surgical scar with liponecrotic macrocalcifications in the upper outer quadrant near to the axilla. (**b**) CEDM recombined image in MLO view shows no enhancement of the area, with an artefact typically seen with coarse calcifications known as "negative contrast enhancement". *CEDM* contrast-enhanced digital mammography, *MLO* mediolateral oblique

Conclusion

Although the introduction of CEDM has increased both the sensitivity and specificity of the detection of breast cancer over digital mammography and ultrasonography, the specificity of CEDM, similar to breast MRI, is still limited because some benign lesions have features that are indistinguishable from cancers [39–41].

The specificity of CEDM can be improved by combining morphological and dynamic characteristics and correlating CEDM presentation with clinical, mammographic and ultrasonographic features, although in our experience biopsy is usually necessary for further differentiation in many of these benign enhancing findings [42].

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