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PICTORIAL ESSAY

Magnetic Resonance Imaging of Benign Breast Lesions

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ABSTRACT

Contrast-enhanced magnetic resonance imaging (MRI) is widely used for diagnosing various benign breast lesions. Such lesions can exhibit benign or suspicious MRI features, and may mimic malignancy. To facilitate patient care, radiologists should familiarise themselves with MRI features of benign breast lesions. This study discusses common benign breast lesions including breast cyst, fibrocystic change, breast abscess, intramammary lymph node, fat necrosis, fibroadenoma, solitary and multiple intraductal papillomas, stromal fibrosis, parenchymal scar, diabetic mastopathy, injection mammoplasty with granuloma formation, cutaneous lesion, and normal anatomic variant mimicking a mass.

Key Words: *Breast neoplasms; Magnetic resonance imaging*

中文摘要

良性乳腺病變的磁共振成像

羅麗雲、黃婷、馮寶恩、黎曉欣、佘凱琳、郭勁明、李昭文

對比增強磁共振成像（MRI）被廣泛用於診斷各種良性乳腺病變。這些病變的MRI徵象可以是良性、可疑或類似惡性。為便利患者護理，放射科醫師應熟悉良性乳腺病變的MRI徵象。本文討論常見的良性乳腺病變包括乳腺囊腫、纖維囊性變化、乳腺膿腫、乳腺內淋巴結、脂肪壞死、纖維腺瘤、單發和多發導管內乳頭狀瘤、間質纖維化、實質性疤痕、糖尿乳腺病變、注射乳房成形術的肉芽形成、皮膚病變和類似腫塊的正常解剖變異。

INTRODUCTION

Contrast-enhanced magnetic resonance imaging (MRI) is widely used for diagnosing various breast lesions, and has high sensitivity and negative predictive value. Some benign breast lesions (such as simple breast cysts and fat-containing lesions) have typical benign features and require no further evaluation. Others have less-specific features and can mimic breast cancer. Differentiation of benign from malignant breast lesions is important in patient care. This study discusses MRI findings of benign breast lesions including breast cyst, fibrocystic change, breast abscess, intramammary lymph node, fat necrosis, fibroadenoma, solitary and multiple intraductal papillomas, stromal fibrosis, parenchymal scar, diabetic

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mastopathy, injection mammoplasty with granuloma formation, cutaneous lesion of breast, and normal anatomic variant mimicking a mass.

BREAST CYSTS

Breast cysts are the most common and can be large, solitary or multiple, with the size varying with the menstrual cycle. They are caused by hyperplasia of the ductal epithelium and dilatation of ducts during the menstrual cycle not balanced by regressive parenchymal changes.[1] Simple breast cysts are fluid collections surrounded by a thin layer of apocrine epithelium.[1] They are T1-hypointense or -isointense to background fibroglandular tissue and typically T2-hyperintense with a round or oval shape and well-circumscribed margin, with no contrast enhancement (Figure 1). Complicated breast cysts include haemorrhagic cyst and inflamed cyst. Their T1-signal characteristics are variable, depending on the protein content of the fluid. Thin internal septation may be present (Figure 2). A rim of contrast enhancement may be present if there is inflammation, mimicking breast cancer. The lack of contrast enhancement of the central T2-hyperintense fluid-specific signal and the regular and smooth rim enhancement indicate an inflamed cyst rather than malignancy.

FIBROCYSTIC CHANGES

Fibrocystic changes are a result of exaggeration of normal menstrual cyclic changes to ductal epithelium and stroma. They include cysts, fibrosis, and adenosis, and can be further categorised into non-proliferative and proliferative subtypes.[2] The former is not associated with an increased risk of breast cancer. The latter is associated with a slightly increased risk when atypical ductal or lobular hyperplasia is present. Their MRI findings are highly variable, depending on the water and protein content of the breast tissue.[1] Fibrosis may be seen as architectural distortion and may contain clusters of small cysts (Figures 3 and 4) and appear as prominent stippled regional enhancement, a region of clumped enhancement, or even a heterogeneous large mass, making it difficult to differentiate from a carcinoma. The diagnosis of fibrocystic changes is supported by variation with menstrual cycle (least conspicuous during mid-menstrual cycle), bilateral involvement, and regional enhancement (versus ductal or segmental enhancement in breast cancers). Its kinetic enhancement curve shows medium rising or plateau.

Figure 1. Simple breast cyst: (a) T1-weighted and (b) T2-weighted images with fat suppression showing a small T1-isointense, T2-hyperintense lesion at L6H of the left breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction and maximum intensity projection showing no contrast enhancement.

Figure 2. Septated cyst: (a) T1-weighted and (b) T2-weighted images with fat suppression showing a small T1-hypointense, T2-hyperintense lesion with internal dark septa at R12H of the right breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction and maximum intensity projection showing no contrast enhancement of the lesion but an enhanced cancer mass at L2H of the left breast (arrowhead).

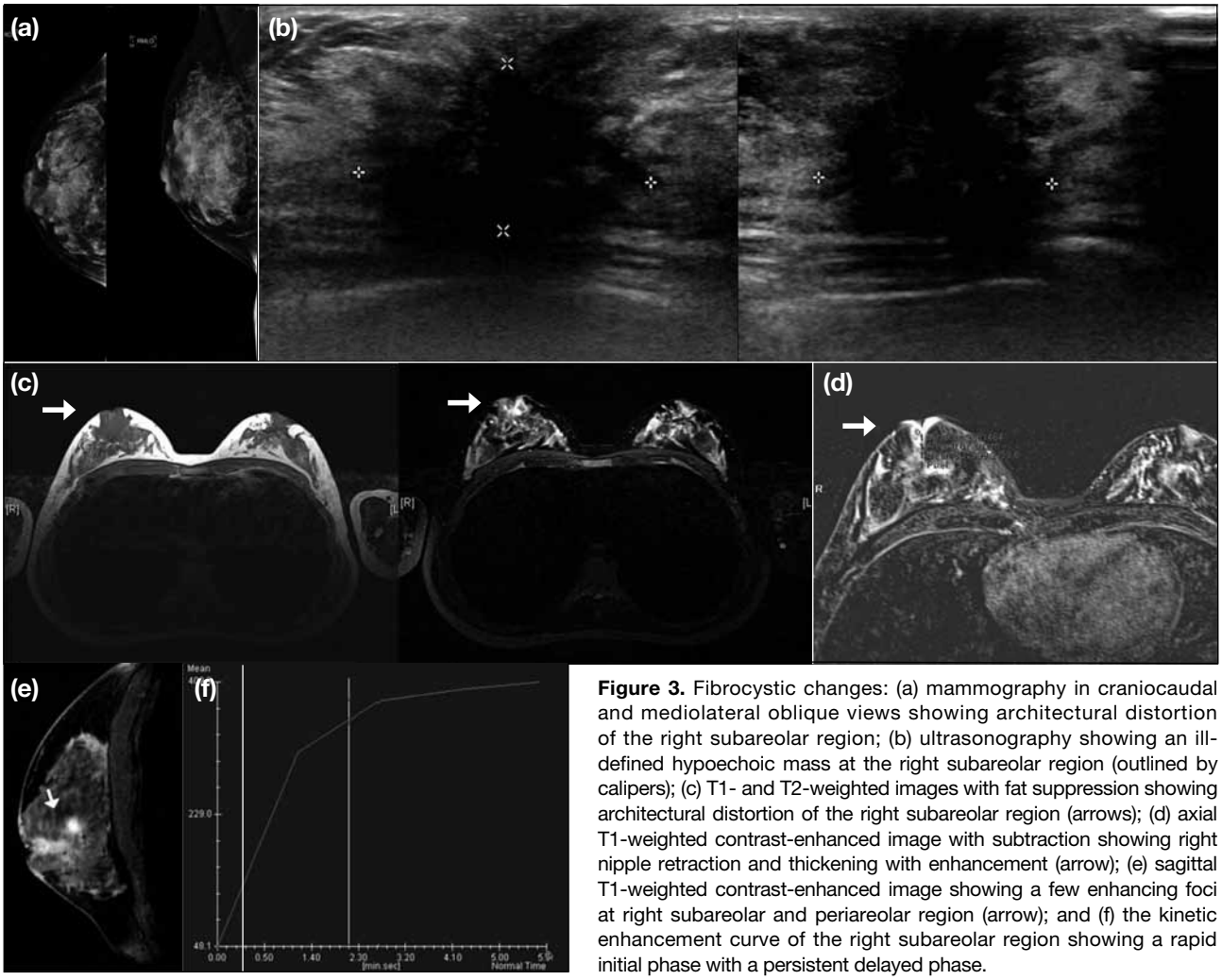

Figure 3. Fibrocystic changes: (a) mammography in craniocaudal and mediolateral oblique views showing architectural distortion of the right subareolar region; (b) ultrasonography showing an ill-defined hypoechoic mass at the right subareolar region (outlined by calipers); (c) T1- and T2-weighted images with fat suppression showing architectural distortion of the right subareolar region (arrows); (d) axial T1-weighted contrast-enhanced image with subtraction showing right nipple retraction and thickening with enhancement (arrow); (e) sagittal T1-weighted contrast-enhanced image showing a few enhancing foci at right subareolar and periareolar region (arrow); and (f) the kinetic enhancement curve of the right subareolar region showing a rapid initial phase with a persistent delayed phase.

Figure 4. Fibrocystic changes: (a) T1-weighted and (b) T2-weighted images with fat suppression showing a cluster of simple cysts and dilated ducts at the upper outer quadrant of the right breast (arrows), away from the known carcinoma at R6H. (c) T1-weighted contrast-enhanced image with subtraction showing asymmetrical enhancement (arrow).

BREAST ABSCESS

A breast abscess is a complication of unresolved mastitis caused by obstruction of a duct near the nipple-areolar complex. It can be classified as lactational and non-lactational subtypes. Clinically, it is a painful lump associated with inflammatory skin changes. Its T2-weighted signal characteristics depend on its water content and vary from isointense to hyperintense, with variable shape and margin. Its overlying skin oedema is T2-hyperintense; its content is T1-isointense content;

and its capsule is T1-hypointense (Figure 5).[3] The central content is non-enhancing, and surrounding inflammatory tissue may show moderate enhancement.[1] Complications such as sinus tract formation may occasionally arise (Figure 6). The irregular outline and rapidly enhancing rim of breast abscess may raise the concern of breast cancer.

INTRAMAMMARY LYMPH NODES

Intramammary lymph nodes are usually detected incidentally and may be present in up to 47% of breasts,[4] most commonly in the upper outer quadrant near the axillary tail.[1] Normal intramammary lymph nodes are round, oval, or reniform in shape with a well-circumscribed margin.[1,5] They typically contain a fatty hilum that shows signal drop in fat-suppressed sequence (Figure 7). A vessel leading to the fatty hilum may be seen.[1,5] They are T2-hyperintense and show contrast enhancement, while the fatty hilum remains non-enhanced. Their kinetic enhancement curve shows rapid enhancement and washout, overlapping with breast cancer.[1]

FAT NECROSIS

Fat necrosis results from prior insult to fat cells (blunt trauma, breast biopsy, breast surgery, and radiotherapy) leading to loss of vascular supply. Its histopathological findings change with time.[1] Initially, there are fat deposits of variable sizes surrounded by inflammatory cells and haemorrhage. Later, necrotic tissue is surrounded by granulomatous reaction and fibrosis. It shows a wide spectrum of MRI appearance,

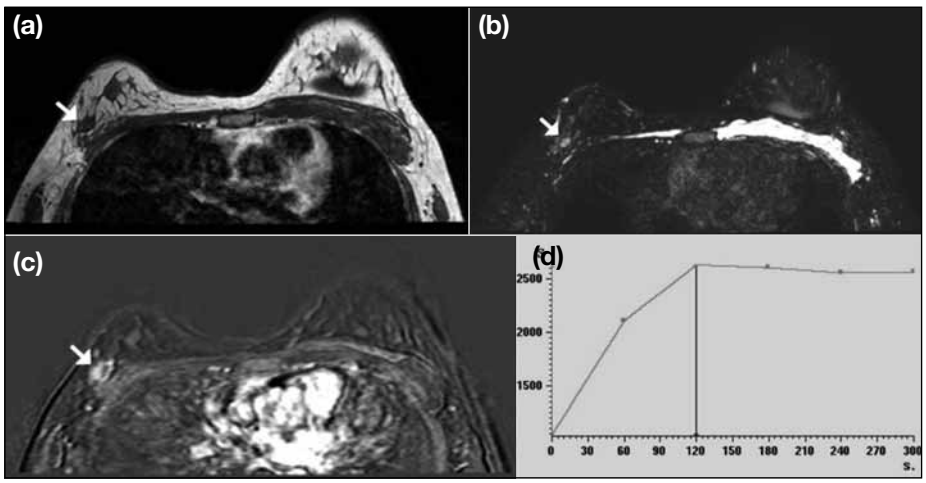

Figure 5. Tuberculous breast abscess after removal of an infected silicone implant: (a) T1-weighted and (b) T2-weighted images with fat suppression showing a T1-isointense, T2-hyperintense lesion at R11H of right breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction showing rim enhancement (arrow). (d) The kinetic enhancement curve is rapidly rising with delayed plateau.

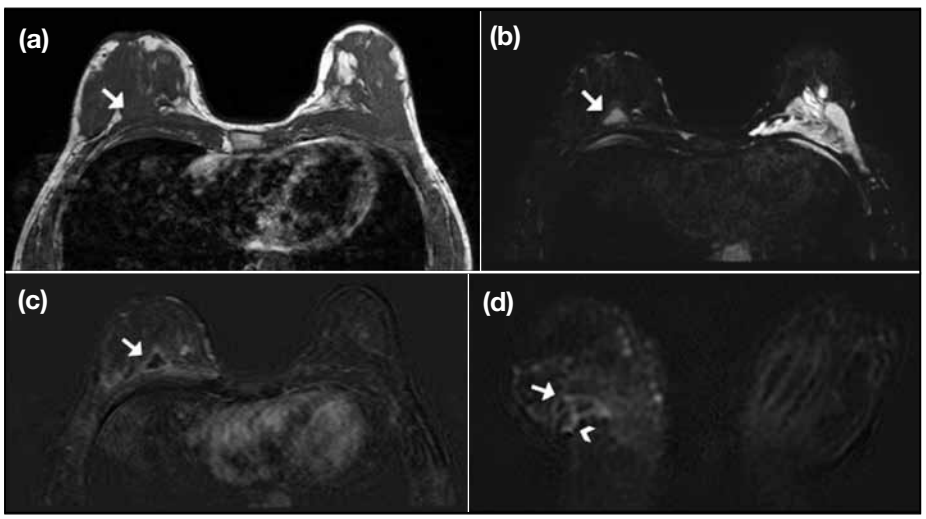

Figure 6. Breast abscess with sinus tract formation after bilateral polyacrylamide gel injection mammoplasty: (a) T1-weighted and (b) T2-weighted images with fat suppression showing a T1-isointense, T2-hyperintense lesion at deep central part of the right breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction showing rim enhancement (arrow), compatible with breast abscess. (d) Coronal T1-weighted contrast-enhanced image with subtraction showing an enhancing tubular structure (arrowhead) extending inferiorly from the lesion (arrow), compatible with sinus tract formation.

most commonly as a rim-enhancing mass, depending on its stage of maturation and degree of inflammation and fibrosis (Figure 8). It is typically associated with an oil cyst,[6] and demonstrates signal drop in T1-weighted fat-suppressed sequence (Figure 9). A fat-fluid level is a possible finding. Calcification may present as foci

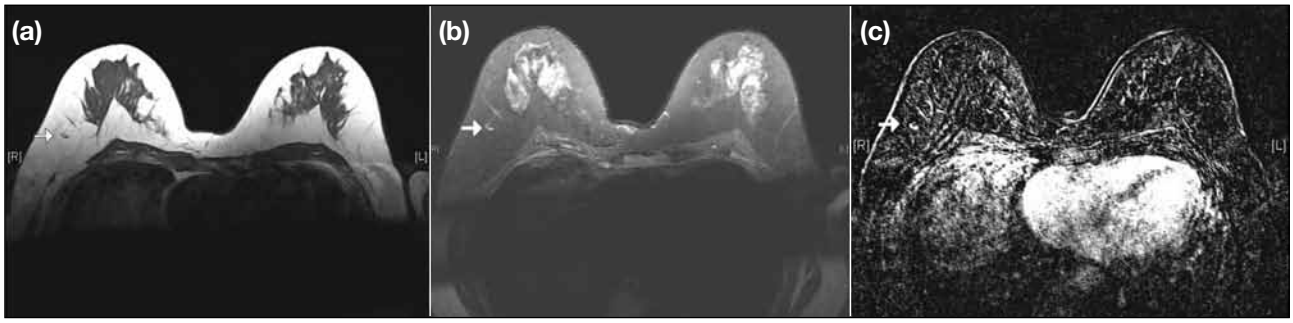

Figure 7. Intramammary lymph node: (a) T1-weighted and (b) T2-weighted images with fat suppression, and (c) T1-weighted contrast-enhanced image with subtraction showing an oval enhancing T1- and T2-hypointense lesion at the upper outer quadrant of the right breast (arrows). Fatty hilum is present, with low signal in fat-suppressed sequence.

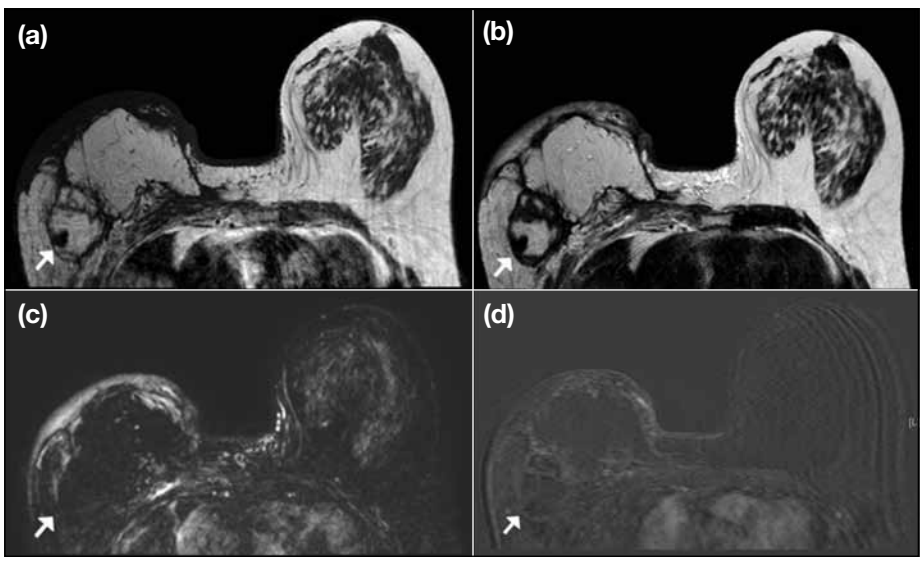

Figure 8. Fat necrosis after right mastectomy and chemoradiotherapy: (a) T1-weighted and (b) T2-weighted images showing a T1- and T2-hyperintense lesion at R8H of the right breast (arrows). (c) T2-weighted image with fat suppression showing a hypointense lesion, suggestive of a fat-containing lesion (arrow). (d) T1-weighted contrast-enhanced image with subtraction showing faint peripheral enhancement over the non-enhancing lesion (arrow).

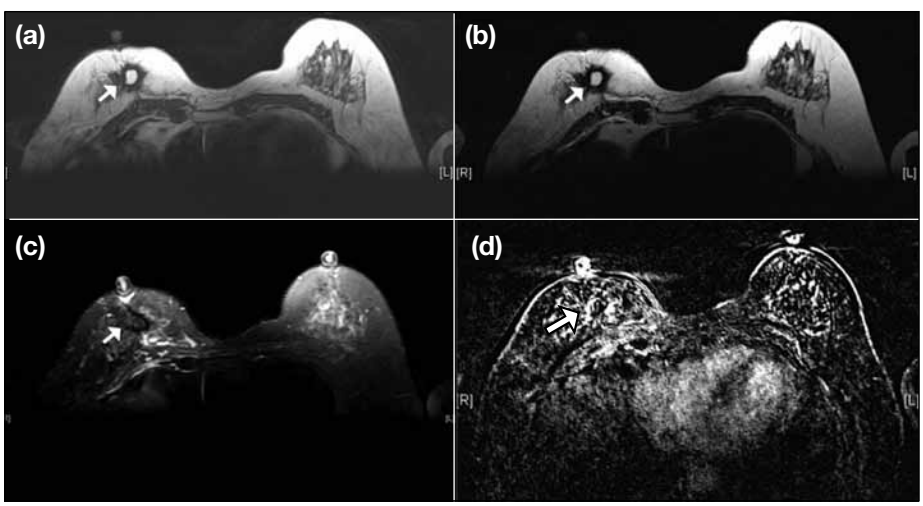

Figure 9. Fat necrosis with oil cyst formation after right breast lumpectomy: (a) T1-weighted and (b) T2-weighted images showing an oval T1- and T2-hyperintense lesion (arrows). (c) T2-weighted image with fat suppression showing the lesion to be hypointense indicating an oil cyst, with peripheral T1- and T2-hypointense rim indicating fibrosis (arrow). (d) T1-weighted contrast-enhanced image with subtraction showing mild enhancement in the peripheral fibrosis (arrow).

of signal voids. Fibrosis may appear as architectural distortion.[7] Rim enhancement is common.[6] The enhancing rim can be thin, thick, irregular, or spiculated, mimicking breast cancer. A superficial location and the presence of fat signal in the content suggest fat necrosis rather than breast cancer. Its kinetic enhancement curve varies from gradual to rapid enhancement with washout.[6,8] Mammography is useful to identify the characteristic combination of oil cysts, calcification, and architectural distortion.[1]

FIBROADENOMA

Fibroadenoma is the most common benign neoplasm of the breast and usually presents as solitary or multiple mobile painless solid breast masses. It is hormone sensitive and usually spontaneously involute after menopause. Histopathologically, it demonstrates multiphasic characteristics, with proliferation of the epithelial, stromal, and myoepithelial elements of the terminal duct-lobular unit,[9] depending on variation in the stromal and epithelial components and change with the patient age. It usually has a round or lobulated outline with well-circumscribed margin.[10] Its MRI signal characteristics and enhancement depend on fluid content and cellularity of the lesion that change according to the patient age.[10] In younger patients, fibroadenomas are more cellular or myxomatous and appear T2-hyperintense with uniform and homogeneous contrast enhancement (Figure 10). In 40% to 60% of enhancing fibroadenomas, there are non-enhancing internal septations.[1] In older patients, fibroadenomas become less cellular or sclerotic, and appear T2-isointense to -hypointense with less or no contrast enhancement (Figures 10 and 11). In lesions with no enhancement, a benign nature can be ascertained. The role of T1-weighted non-contrast-enhanced sequence is limited, as fibroadenomas are T1-hypointense and cannot be distinguished from background glandular tissue if located within the parenchyma.[1,10] Its kinetic enhancement curve is usually of slow rising or plateau patterns.[1,10]

PAPILLOMA

Papilloma can be solitary or multiple, central or peripheral, typical or atypical. A solitary papilloma is usually small (<1 cm) and located intraductally in a central duct near the nipple-areolar complex, and presents with bloody nipple discharge. Multiple intraductal papillomas usually arise from terminal ductal lobular units and are more commonly located

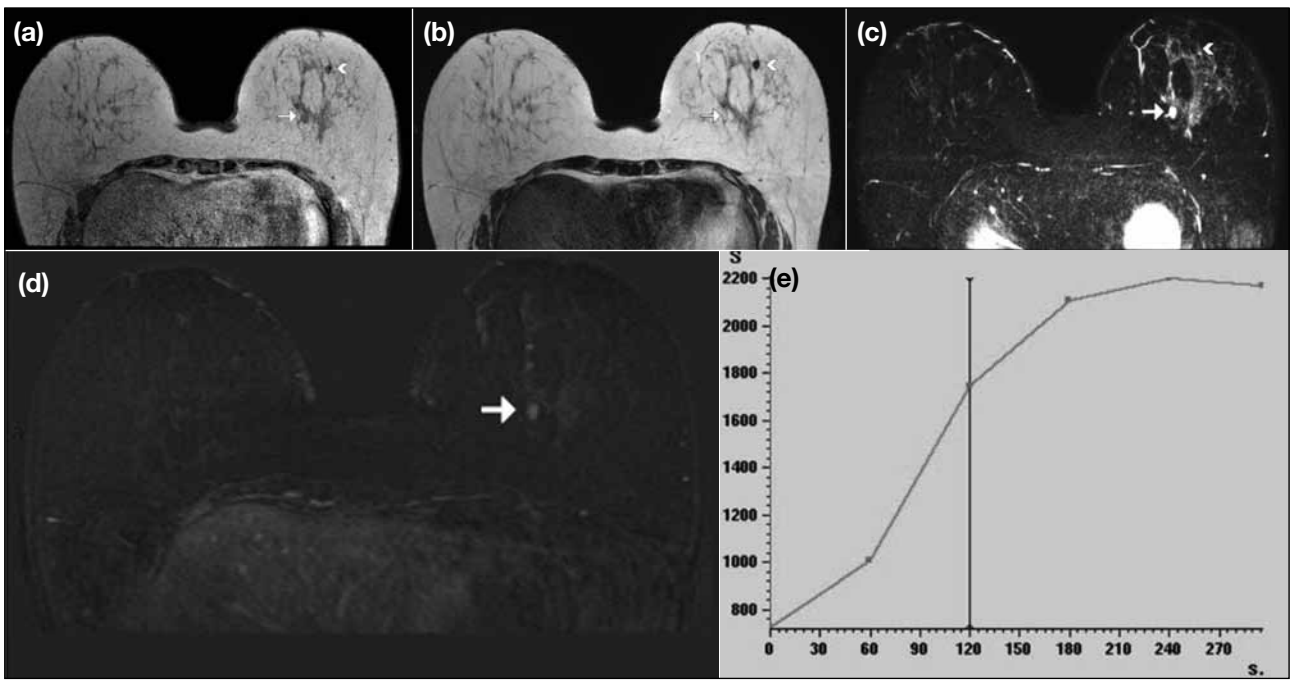

Figure 10. Co-existing myxomatous and sclerotic fibroadenomas: (a) T1-weighted, (b) T2-weighted, and (c) T2-weighted fat-suppressed images showing a well-circumscribed T1-isointense, T2-hyperintense nodule at central lower left breast (arrows) and a T1- and T2-hypointense nodule with internal dark eccentric focus suggestive of calcification at lower outer left breast (arrowheads), indicating myxomatous and sclerotic fibroadenoma, respectively. (d) T1-weighted contrast-enhanced image with subtraction showing uniform (arrow) and no contrast enhancement in the respective lesions. (e) The kinetic enhancement curve of the myxomatous fibroadenoma showing a rapid initial phase and a persistent delayed phase.

peripherally with bilateral involvement; they usually present as a palpable mass and rarely present with bloody nipple discharge, and are associated with an increased risk of developing breast cancer relative to the general population.[11] Histopathologically, papillomas are papillary proliferation within the ductal wall. Papillomas are composed of branching fibrovascular cores lined by a dual layer of myoepithelial cells and overlying ductal epithelial cells with focal hyperplasia.[1] Small papillomas are occult on non–contrast-enhanced MRI,[1,11] unless they are associated with dilated ducts. T2-weighted fat-suppressed images usually show a small intermediate signal intraductal mass within a T2-hyperintense dilated duct. T1-weighted contrast-enhanced fat-suppressed images usually show intense and uniform or irregular enhancement (Figure 12).[11] T1-weighted non-contrast-enhanced images usually show both the papilloma and dilated duct to be T1-hypointense, unless there is haemorrhage or high protein content, making it T1-isointense or hyperintense.

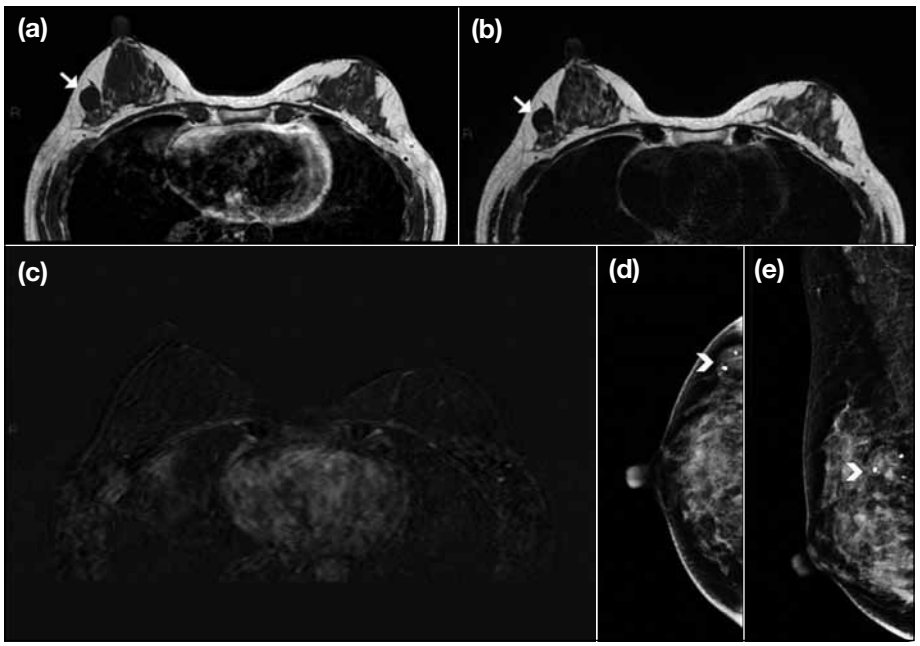

Figure 11. Sclerotic fibroadenoma: (a) T1-weighted and (b) T2-weighted images showing a T1-hypointense, T2-hypointense lesion at R9H of right breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction showing no contrast enhancement. Mammography in (d) craniocaudal and (e) mediolateral oblique views showing a well-circumscribed lesion (arrowheads) with benign macrocalcification.

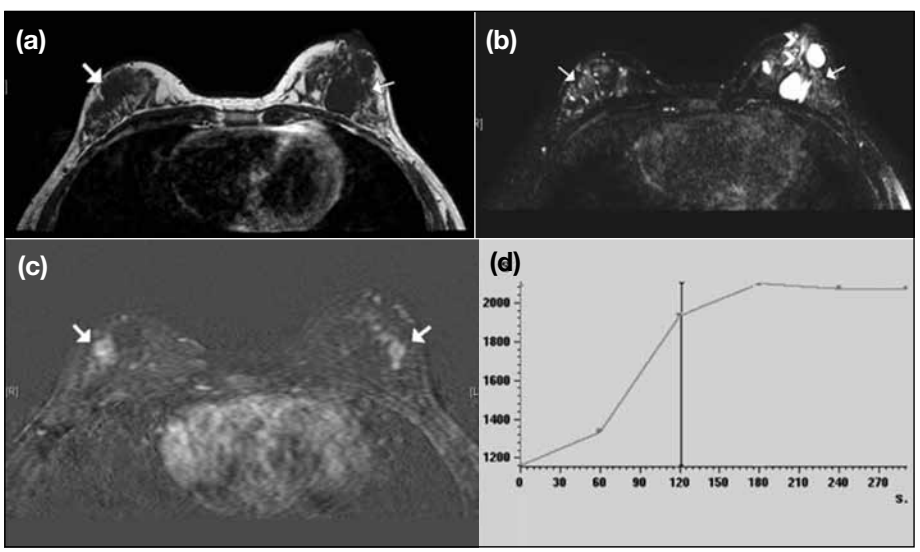

Figure 12. Bilateral multiple intraductal papillomas: (a) T1-weighted, (b) T2-weighted images with fat suppression, and (c) T1-weighted contrast-enhanced image with subtraction showing multiple enhancing T1-hypointense, T2-isointense nodules in both breasts (arrows), and a dilated duct in the left breast subareolar region (arrowheads). (d) Its kinetic enhancement curve showing a slow initial rise followed by a plateau.

STROMAL FIBROSIS

Stromal fibrosis is characterised by the proliferation of fibrous stroma that replaces the normal connective tissue, causing obliteration and atrophy of mammary ducts and lobules and localised fibrous tissue.[12] It may present as a palpable breast lump and can show variable configuration that sometimes mimics malignancy. Stromal fibrosis appears isointense to surrounding breast parenchyma in T1-weighted and T2-weighted images (Figure 13). The enhancement pattern is variable, and can appear as an irregular enhancing mass or area of non–mass-like enhancement.

PARENCHYMAL SCAR

Parenchymal scar is difficult to differentiate from tumour recurrence. Histopathologically, it is composed of granulation tissue with ingrowth of vessels and fibroblasts and inflammatory cells.[1] Its MRI signal

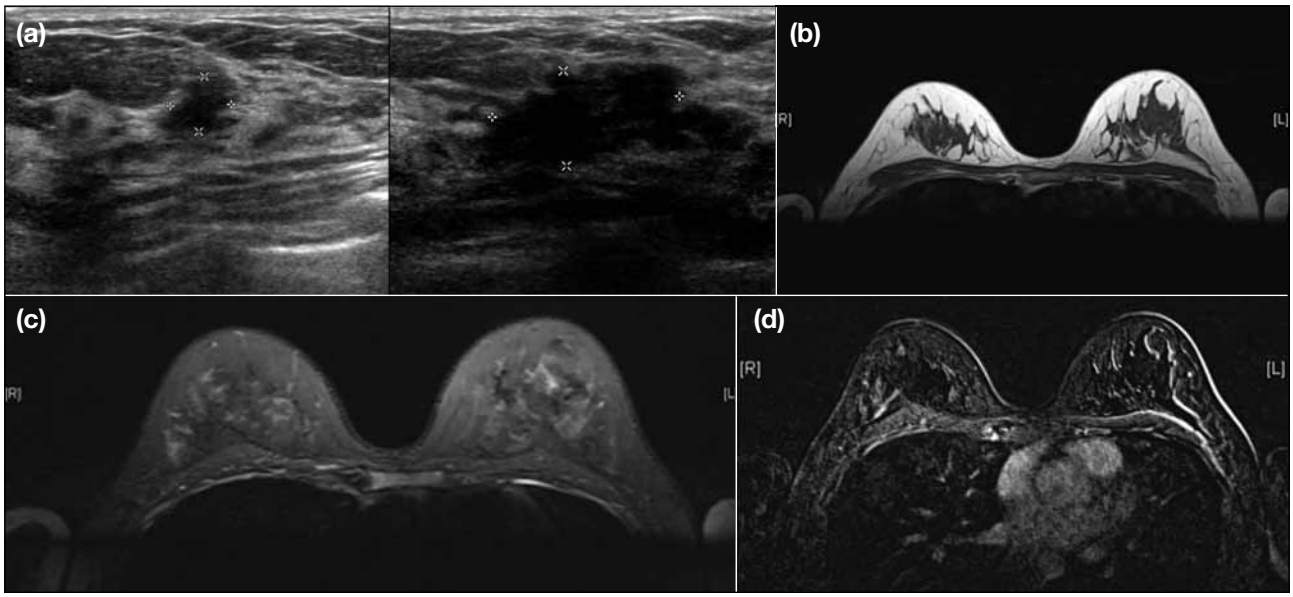

Figure 13. Stromal fibrosis: (a) serial ultrasonography 1 year apart showing an enlarging ill-defined hypoechoic lesion at L1H of the left breast (outlined by calipers). (b) T1-weighted and (c) T2-weighted images with fat suppression, and (d) T1-weighted contrast-enhanced image with subtraction showing no focal lesion or abnormal enhancing focus.

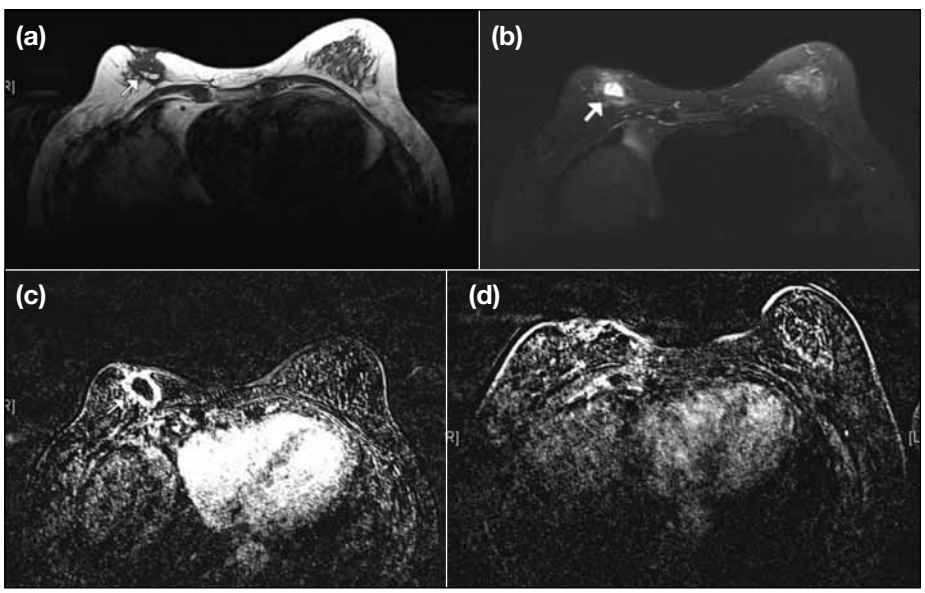

Figure 14. Stages of parenchymal scar after lumpectomy: (a) T1-weighted and (b) T2-weighted images with fat suppression showing an oval T1-hypointense, T2-hyperintense lesion at the operative site (arrows), compatible with a haematoma. (c) T1-weighted contrast-enhanced image with subtraction showing no enhancement in the oval lesion but a peripheral rim enhancement. (d) After 6 months, axial T1-weighted contrast-enhanced image with subtraction showing resolution of the haematoma.

characteristics change over time. During the early postoperative period, presence of granulation tissue causes mild-to-moderate enhancement of variable configuration at the operative site, with associated haematoma (Figure 14). At this early stage, the kinetic enhancement curve may overlap with that of tumour recurrence.[1] At 3 to 6 months after operation, a normal parenchymal scar demonstrates no contrast enhancement; this reliably distinguishes scar tissue from tumour recurrence.[1] Fibrosis and parenchyma distortion then become the predominant features.

DIABETIC MASTOPATHY

Diabetic mastopathy is a form of lymphocytic mastitis and stromal fibrosis of breast tissue associated with type-1 diabetes mellitus. Histopathologically, it consists of lymphocytic lobulitis, ductitis, and vasculitis with a predominance of B cells associated with stromal fibrotic changes.[13-15] It can be solitary or multiple. Its MRI signal characteristics are similar to stromal fibrosis (Figure 15). It has variable enhancement patterns ranging from non-specific diffuse stromal enhancement to gradual progressive enhancement with heterogeneous spotty enhancement in delayed images.[13-16] Biopsy should be considered when suspicious features are present.

SILICONE GRANULOMA

Silicone injection has been used for augmentation mammoplasty, although such use has never been approved by the U.S. Food and Drug Administration.[17] It complications include granulomas, migration of silicone, and systemic autoimmune reaction.[18] Complete

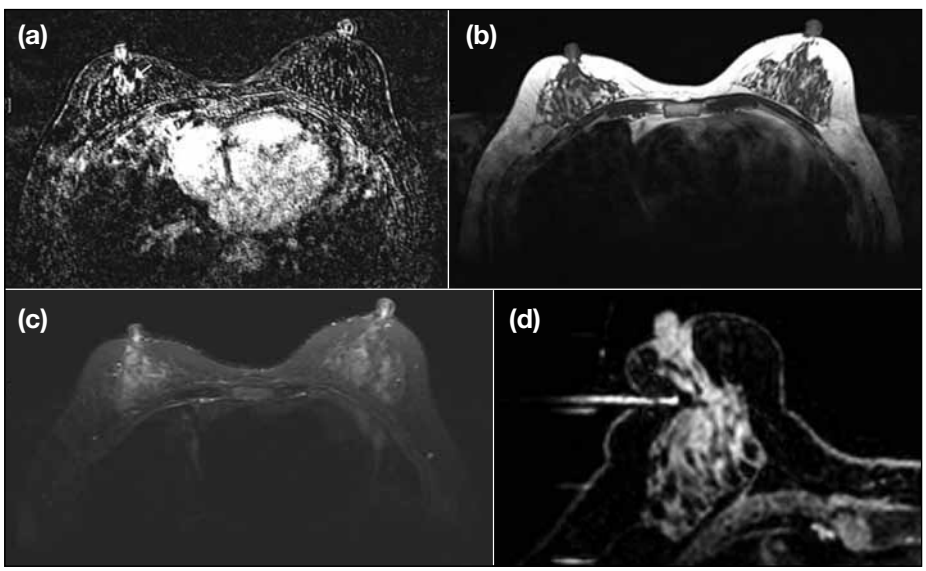

Figure 15. Lymphocytic mastitis: (a) T1-weighted contrast-enhanced image with subtraction showing an area of non-mass enhancement at the right retroareolar region (arrow). (b) T1-weighted and (c) T2-weighted images with fat suppression showing no focal lesion. (d) Magnetic resonance imaging–guided vacuum-assisted biopsy of the retroareolar lesion is performed.

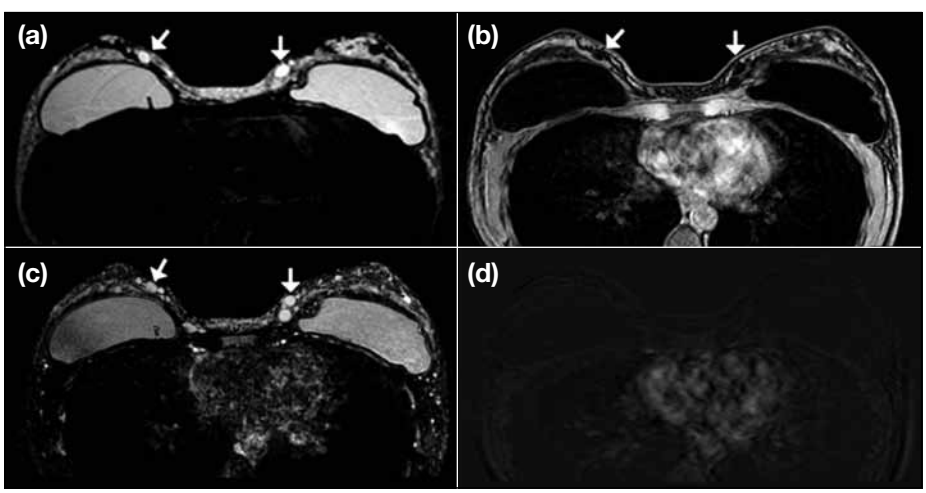

Figure 16. Silicone injection mammoplasty with migration: (a) silicone-excited and (b) silicone-saturated images and (c) T2-weighted image with fat suppression showing scattered well-circumscribed oval and round nodules with silicone signal intensity mainly in subcutaneous and subglandular layers (arrows), indicating bilateral single lumen retropectoral silicone implants. (d) T1-weighted contrast-enhanced image with subtraction showing no contrast enhancement in these nodules.

removal of silicone injected into breast tissue is difficult.[18] Silicone granuloma is associated with foreign body giant cell reaction and painful breast nodules.[17,18] Silicone itself is T1- and short-tau inversion recovery (STIR)–hypointense, whereas silicone granuloma is T1-hypointense and STIR-hyperintense with a hypointense rim.[18] Use of silicone-excited (silicone hyperintense and water suppressed) and silicone-saturated (silicone suppressed, water hyperintense) sequences are helpful to differentiate silicone from other breast lesions (Figure 16). Contrast-enhanced MRI is useful to differentiate silicone and silicone granuloma from breast cancer. Silicone granuloma usually shows no contrast enhancement; granulomatous reaction in silicone granuloma shows progressive enhancement in the kinetic enhancement curve, suggestive of a benign nature.[19]

POLYACRYLAMIDE GEL INJECTION

Polyacrylamide gel (PAAG) has been used for injection mammoplasty in China, Eastern Europe, and South America since 1997.[20,21] It is usually injected into the retroglandular region and appears as a large single collection (Figures 17).[20,21] Nonetheless, it is not uncommon for PAAG to be injected into different layers including intraglandular, intrapectoral, retropectoral, and subcutaneous locations.[21] PAAG in layers other than retroglandular region forms small locules and may present as breast nodules. Uncomplicated PAAG is of water signal that is T1-hypointense and T2-hyperintense (Figure 17). Occasionally, there may be internal T2-hypointense foci caused by air bubbles, impurities, or debris.[20] Foreign body granulomas resembling silicone granulomas are uncommon and fibrosis tends to be less severe.[20]

PARAFFINOMA

Paraffin oil was used for injection mammoplasty in the early 1900s and up to 1970s in the Far East.[22,23] Its short- and long-term complications include paraffinomas, inflammatory reactions, tissue necrosis, sinus tract formation, and pulmonary and cerebral embolism.

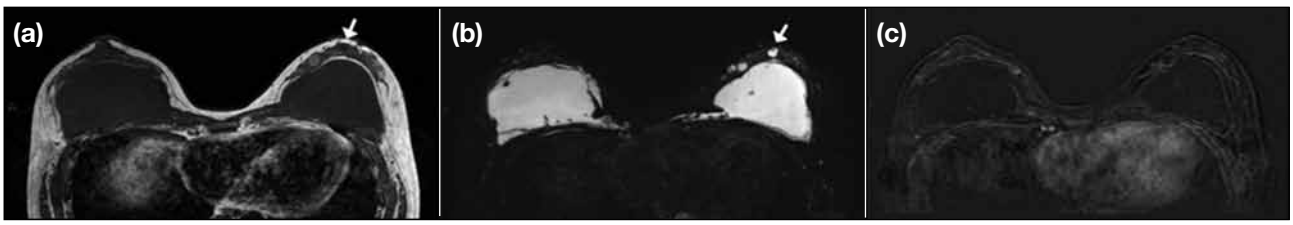

Figure 17. Polyacrylamide gel (PAAG) injection mammoplasty: (a) T1-weighted and (b) T2-weighted images with fat suppression showing large collection of water signal intensity in bilateral retroglandular regions and a small locule of PAAG signal at subcutaneous layer of the left breast (arrows). (c) T1-weighted contrast-enhanced image with subtraction showing no contrast enhancement in this nodule.

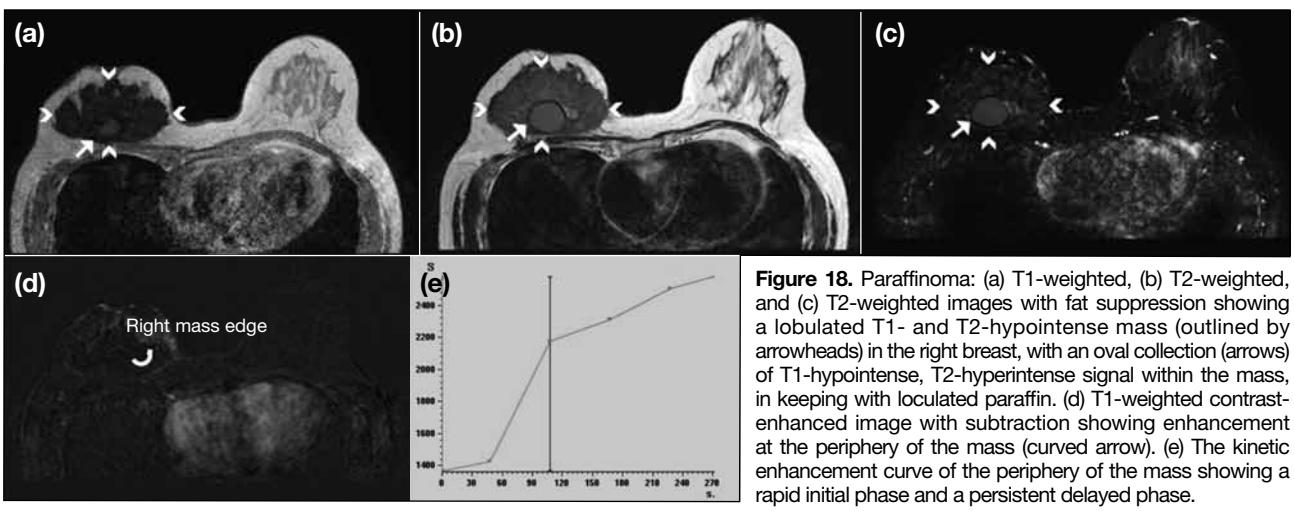

Figure 18. Paraffinoma: (a) T1-weighted, (b) T2-weighted, and (c) T2-weighted images with fat suppression showing a lobulated T1- and T2-hypointense mass (outlined by arrowheads) in the right breast, with an oval collection (arrows) of T1-hypointense, T2-hyperintense signal within the mass, in keeping with loculated paraffin. (d) T1-weighted contrast-enhanced image with subtraction showing enhancement at the periphery of the mass (curved arrow). (e) The kinetic enhancement curve of the periphery of the mass showing a rapid initial phase and a persistent delayed phase.

Paraffinoma is a result of foreign body reaction and fibrosis. Its latency period may vary from 2 years to several decades.[22] The MRI signal characteristics of paraffin injection–related changes depend on the length of the latency period. In cases with a latency period of <3 years, T2-weighted fat-suppressed images show T1-hypointense, T2-hyperintense changes.[22] In cases with a latency period of >20 years, it is hypothesised that paraffinomas have two components: a peripheral plaque-like fibrous component that is T1-isointense, T2-hypointense with minimal homogeneous enhancement, and a central paraffin-containing component that is non-enhancing and T1- and T2-hypointense with signal drop in fat-suppressed T2-weighted images (Figure 18).[23] After a long period, liquid paraffin may convert into a semisolid state that is relatively restricted and appears T1- and T2-hypointense.[23] Dystrophic calcification may be present in the cystic spaces, leading to artefacts around the low-signal rim of the paraffin-containing component.

CUTANEOUS LESION

Cutaneous lesion, such as skin mole (Figure 19) and sebaceous cyst, may show non-specific MRI signal characteristics, with T1-hypointense and T2-hyperintense signal. Correlation with the superficial location, physical examination, mammographic findings, and use of skin markers should enable differentiation from true breast lesions that arise from fibroglandular tissue.

STERNALIS MUSCLE

The sternalis muscle is a normal anatomic variant, and runs longitudinally from the inferior aspect of the jugular notch to the lower edge of the sternum. It lies anterior to the medial margin of the pectoralis major muscle. It can be unilateral or bilateral. It shows the same signal intensity as the pectoralis major muscles (Figure 20). Its diagnosis is made by its typical location, course, and signal intensity.[24]

CONCLUSION

For benign breast lesions, MRI signal characteristics can be benign or even diagnostic for some, and less specific and mimicking breast cancer for others. It is important for radiologists to be familiar with MRI findings of these benign breast lesions to facilitate patient care and allay unnecessary patient anxiety.

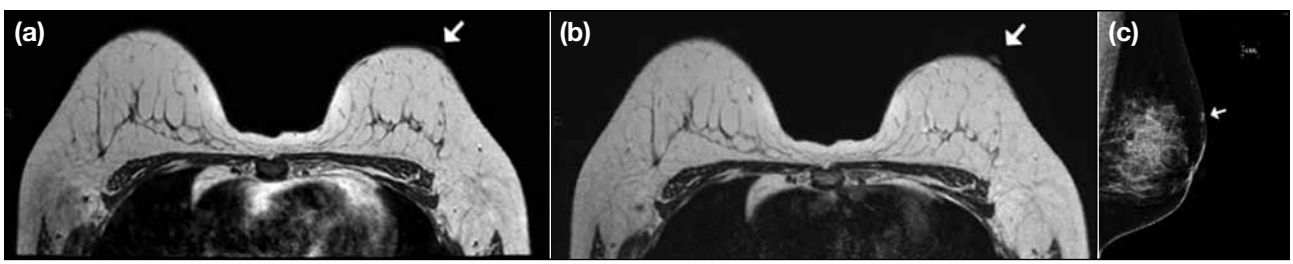

Figure 19. Skin mole: (a) T1-weighted and (b) T2-weighted images showing a 1-cm T1-hypointense, T2-hyperintense cutaneous lesion at L2H of the left breast (arrows). (c) Mammography in a mediolateral view showing a skin nodule at the upper outer quadrant (arrow).

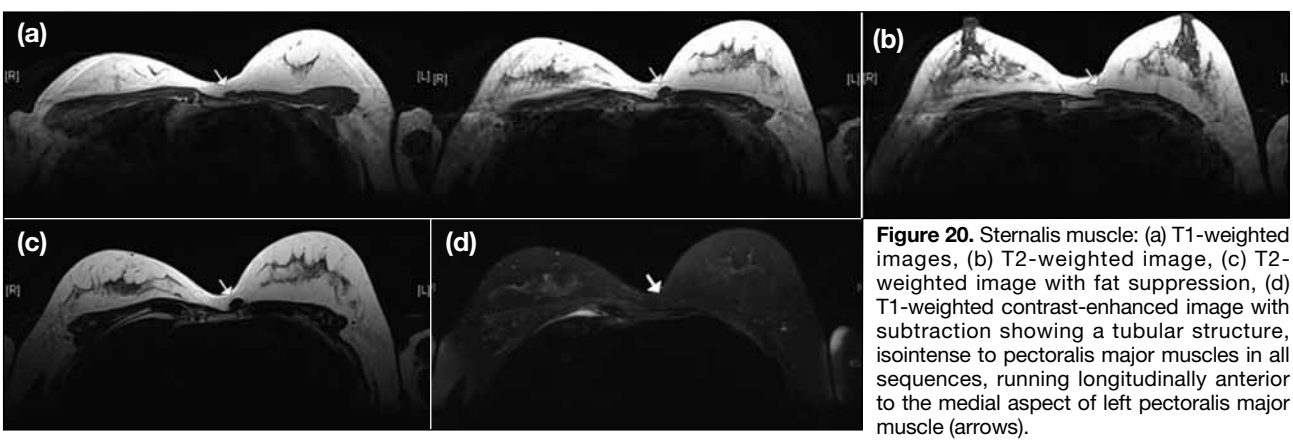

Figure 20. Sternalis muscle: (a) T1-weighted images, (b) T2-weighted image, (c) T2-weighted image with fat suppression, (d) T1-weighted contrast-enhanced image with subtraction showing a tubular structure, isointense to pectoralis major muscles in all sequences, running longitudinally anterior to the medial aspect of left pectoralis major muscle (arrows).

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