Magnetic resonance imaging of invasive breast cancer

P Corr
FFRad (D) SA

S Panday
FCRad (D)

P Seolall
Nat Dip Rad (D)

H Booth
Nat Dip Rad (D)

Department of Radiology
Nelson Mandela School of Medicine
and Inkosi Albert Luthuli Hospital
Durban

Abstract

Breast MR is a sensitive but nonspecific imaging investigation to detect breast cancer. MR imaging strengths lie in the accurate staging of the primary tumour, detecting recurrent cancer following lumpectomy and radiation therapy, problem solving in cases where there are equivocal mammographic findings, and screening for breast cancer in younger women with familial breast cancer. Interpretation of MR images requires a meticulous imaging technique including the use of contrast enhancement and fat suppression MR sequences using a good breast coil.

Introduction

The role of MR imaging in the diagnosis of breast cancer is not clearly defined, however this modality is becoming important in breast imaging to solve problematic cases where the mammogram is inconclusive.[1] MR imaging is highly sensitive to the detection of focal breast masses, approaching 100%, but not very specific for cancer, varying from 37% to 70% in most series.[1] This is the reason why breast MR imaging is relegated to a second-line imaging investigation. To interpret MR breast studies accurately it is important to understand the MR appearance of normal breast tissue, the enhancement pattern following gadolinium contrast injection and the specific MR techniques used to obtain these images.

Technique

Phased array surface breast coils are essential to improve the signal-to-noise ratio (Fig. 1). We use spin echo (SE) T1 and T2 STIR sequences in the transverse planes. These are repeated following gadolinium enhancement using fat suppression in the transverse and sagittal planes. Fat suppression is essential as both normal breast glandular tissue and breast cancer enhance following contrast injection and this enhancement is easily obscured by the high intensity of normal fat on T1-weighted images (Fig. 2a-d). Normal breast glandular tissue enhancement is minimal during days 7 - 20 of the menstrual cycle.[2] This is the best period of time to image the breast in premenopausal women.[2] In perimenopausal women focal enhancement of involuting breast parenchyma is a normal appearance.[3]

Fig.1. Breast coil used at Inkosi Albert Luthuli Hospital. Both breasts can be imaged simultaneously in the prone position.

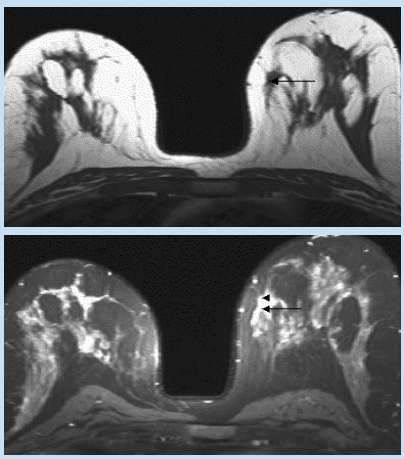
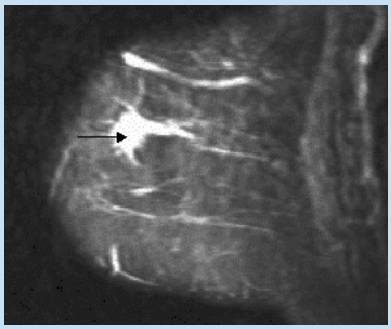
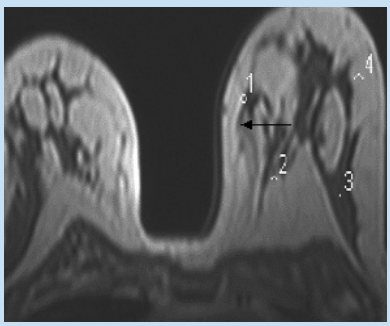


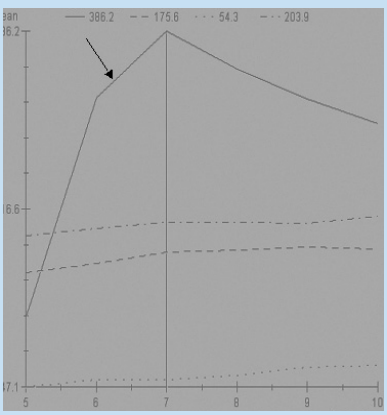
Fig 2a,b. Patient with a breast cancer involving the medial aspect of the breast (arrow) is more conspicuous on the fat-saturated T1 STIR post-contrast sequence.

Contrast enhancement

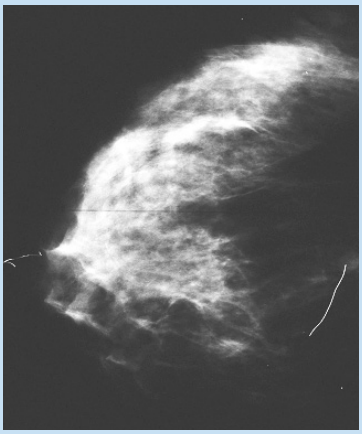
Gadolinium DTPA is injected intravenously as a bolus of 20 ml at 3 ml/sec (0.15 mmol/kg) and signal intensity is measured over 5 minutes. However breast cancer enhances within the first 120 seconds of a contrast injection while normal glandular tissue enhances later than 120 seconds (Figs 2c, d). A mean curve function using regions of interest (ROI) over the first 5 minutes post contrast injection is then generated automatically. Although the shape of the curve, which measures contrast enhancement as a change of signal intensity over time, is useful in improving specificity of a focal lesion, the curve cannot be used to localise lesions for biopsy. The curve can be broken down into 2 components: the initial rise in contrast enhancement and the delayed phase. The initial rise can be slow, medium or fast. The delayed phase can be persistent, plateau or washout in character. Breast cancer has a rapid initial rise in contrast enhancement due to tumour neovascularity (Figs 2c,d, 3a-e), however in one-third of lobular cancers and in patients with ductal carcinoma in situ (DCIS) there is a slow rise in enhancement. In the delayed phase there is persistent or plateau curve with breast cancer while normal glandular tissue shows a washout curve.

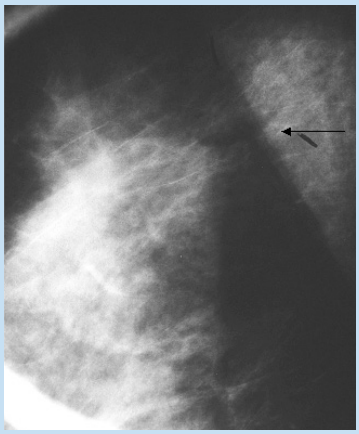




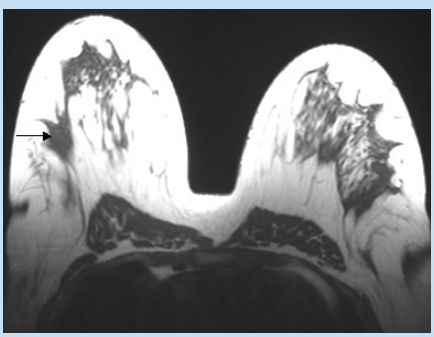


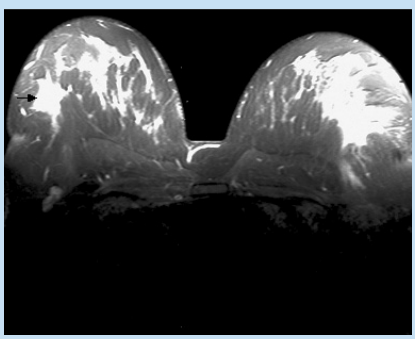
Figs 2c,d. T1 STIR post gadolinium-enhanced image of the same patient as in Fig.2a demonstrates focal enhancement of the cancer (region of interest 1) in Fig. 2d, and the corresponding curve for this lesion (continuous line curve, arrow) shows the rapid initial wash in rise and the delayed washout typical of cancer.



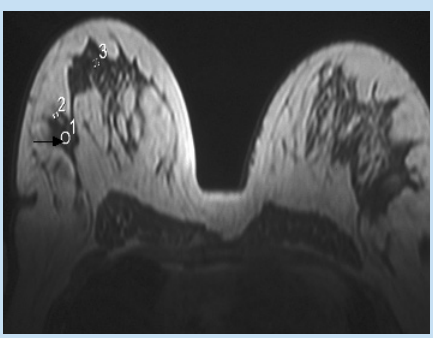


Figs 3a,b. Mammogram of the right breast of a 30-year-old woman who had a right lumpectomy for breast cancer demonstrates a dense parenchymal pattern with a suspicious mass in the outer lateral quadrant (arrow) on the magnified view,





Figs 3c,d. T1 and T1 fat-saturated contrast-enhanced transverse images of the right breast demonstrate the focal mass as a low-density spiculated lesion on T1 (arrow 3c) which enhances markedly after contrast injection (arrow 3d) which is suspicious for a new cancer.



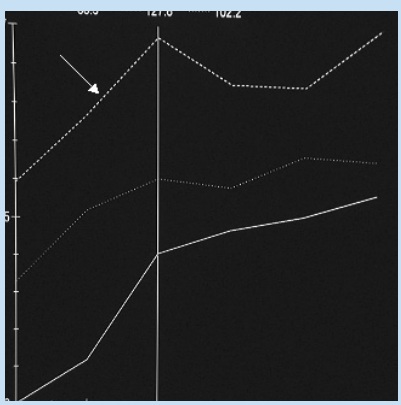


Fig. 3e. Dynamic contrast curve for region 1 over the suspicious lesion (arrow) demonstrates the typical curve for a cancer with a rapid initial rise and slow washout of contrast with time.

Morphological signs of breast masses

Focal mass

As in film screen mammography, the presence of a mass is confirmed by its mass effect and architectural distortion. Most malignant breast masses have a low intensity on T1 and T2-weighted scans. Simple breast cysts, fat necrosis and intra-mammary lymph nodes have a high intensity on T1-weighted scans. Myxoid fibroadenomas, fat necrosis and lymph nodes have a high intensity on T2-weighted scans.

It is important to appreciate that focal contrast enhancement may not be due to a focal mass but it could rather represent normal glandular tissue in a peri-menopausal patient, fibrocystic disease of the breast or localised DCIS. This is called 'non mass' enhancement.

Shape and margins of the mass

Masses may be round, oval, lobular,

irregular, smooth or spiculated as detected mammographically. However the most predictive sign of cancer on breast MR imaging is spiculation (positive predictive value of 80 - 91%) while the presence of a 'halo' of surrounding breast parenchyma, rim and central enhancement and ductal distribution of enhancement have a lower positive predictive value varying from 40% to 86%.[4]

Mass architecture and contrast enhancement patterns

Contrast enhancement within the mass can be focal, diffuse or segmental in nature. Segmental or branching enhancement represents ductal pathology and is commonly detected in DCIS. Focal clumped enhancement is also found in DCIS.

Heterogeneous focal enhancement is seen in cancers and fibroadenomas. Rim or edge enhancement is found in cancer. Masses with internal septations are found in fibroadenomas.

Interpretation of MR images

It is always good practice to assess a mass on its morphological appearances and use the contrast curves as secondary evidence. MR images must be read in conjunction with mammograms and ultrasound examinations.[1]

Indications for breast MR imaging

Preoperative staging

Determination of the size of the cancer and the presence or absence of multifocal and multicentric cancers is critical in determining the type of surgical procedure or treatment offered. MR is superior to both mammography and ultrasound in determining the true extent of a cancer and is the most accurate imaging investigation when compared with the histological tumour extent following resection.[5]

Postoperative assessment of residual cancer

The detection of residual cancer following lumpectomy is important if breast conservation is to be considered. Assessment of histological tumour margins and detection of residual malignant microcalcifications on postoperative mammograms are often inaccurate. MR imaging is more accurate with a sensitivity varying from 89% to 94%.[6] Specificity improves if the MR scan is performed at least 28 days following lumpectomy and at this time is 70%.[7] MR has been found to be useful in differentiating scar from recurrent tumour in those patients who have had lumpectomies and/or radiotherapy treatment. However it is important to remember that surgical scars can enhance up to 6 months postoperatively and if radiotherapy is given then up to 18 months post treatment.

Lobular breast cancer

MR is especially useful in detecting lobular cancer, which occurs in 10% of women with breast cancer. This cancer infiltrates along ducts without a desmoplastic response making it difficult to detect by mammography. Lobular cancer is often bilateral and multicentric making this cancer more easily detected by MR imaging.[1,8]

Cancer in mammographically dense breasts

MR imaging detects more extensive tumour as well as multifocal and multicentric cancer in patients with newly diagnosed cancer than mammography. This is especially true in those patients with mammographically dense breasts.[9] This has been demonstrated to change surgical management in up to 51% of patients.[10]

Screening in familial breast cancer

Breast MR imaging has been demonstrated to be more sensitive than screening mammography in the detection of familial cancer which may be multifocal in patients who are BRCA1 or 2 positive or who have a strong family history of breast cancer.[11] MR detects between 1% and 4% more cancers than mammography in these patients.[1]

Conclusions

Breast MR imaging is a new advance in the diagnosis of breast cancer and in screening for cancer in high-risk women. Attention to MR technique is essential for the correct interpretation of findings. As with all forms of breast imaging, there is a steep learning curve for the radiologist to take to become proficient in interpretation.

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