MR Protocols | Breast Imaging

In the detection of breast cancer, MRI offers high sensitivity while exposing the patient to no ionizing radiation. It is a painless exam, as minimal or no compression is needed, yet it provides both morphological and functional data.

MR is commonly indicated to:

- Identify clinically or mammographically occult tumor
- Stage and plan treatment
- Detect recurrent tumor
- Screen high-risk women
- Evaluate the integrity of breast implants

It is also a valuable tool for guided breast biopsy.

The following protocol was adapted from the Hong Kong Sanatorium & Hospital.

3 TESLA MRI

Compared with 1.5T, 3T imaging has the inherent advantage of providing a higher signal-to-noise ratio (SNR) and higher resolution or faster scans, although there are trade-offs among these as well as certain limitations. 3T MR has a high specific absorption rate (four times that of 1.5T), decreased B1 homogeneity, longer T1 relaxation time, and increased susceptibility artifact. Despite these potential obstacles, a study from Kuhl et al[1] showed that image quality was significantly higher at 3T than at 1.5T.

CLINICAL AND TECHNICAL CONSIDERATIONS

The clinical role of contrast-enhanced MRI in the detection of breast malignancy has been evaluated and established.[2] Published research[3] indicates breast MRI sensitivity of 77% and specificity of 77% at 1.5T.

Malignant tumors tend to have spiculated borders; they also tend to show faster contrast uptake and washout than benign tissue. Thus, morphology and enhancement kinetics are both important in determining a lesion's status. High spatial resolution improves visualization of lesion morphology, such as margins and internal architecture, whereas temporal resolution of less than a minute is ideal for depicting enhancement kinetics. Therefore, a complete breast MRI protocol must optimize and balance both.

Imaging both breasts is essential for detecting occult cancer in the contralateral breast, which occurs in approximately 3-5% of women with a diagnosis of breast cancer.[4] To avoid cardiac and respiratory motion artifacts through the breasts, imagers should not use anterior-to-posterior phase encoding during the axial or sagittal scan.

Most MRI breast imaging protocols for tumor evaluation include T2 as well as T1 pre- and postcontrast sequences with the use of fat-suppression techniques. T2 fat suppression may be useful for differential diagnoses[2] as cysts, effusion, and inflammatory processes all appear bright.

A T1-weighted sequence provides information on morphologic information, such as fat and glandular structures. For contrast-enhanced T1-weighted imaging, we use a 3D spoiled gradient echo sequence with a short repetition time, short echo time, and shallow flip angle. The higher inherent SNR of 3D imaging allows thinner sections to be acquired and increases overall spatial resolution in a given acquisition time compared with 2D imaging. 3D imaging may also be more robust in dealing with B1 variations2 and consequently allow for improved contrast-enhanced breast images at 3T.

Fat suppression is important in detecting cancer as enhancing lesions and fat both appear hyperintense on postcontrast imaging (Figure 1).

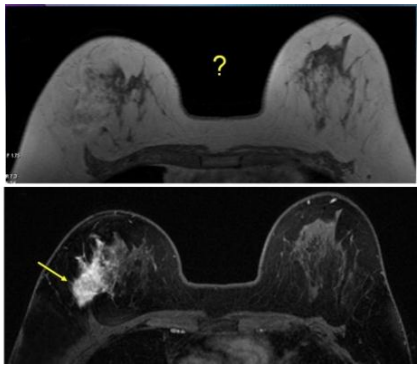

Figure 1. *Fat-suppression sequence highlights lesion after contrast injection (yellow arrow).*

A limitation of breast MRI is that dynamic contrast-enhanced (DCE) breast MRI has high sensitivity but relatively low specificity. Diffusion-weighted imaging (DWI) is based on the Brownian motion of water molecules, which is restricted in tumors. In most benign lesions, there is enough extracellular space and membrane permeability so that water molecules can move freely between and around cells, which results in a high apparent diffusion coefficient (ADC) value. However, in most malignant tumors, the cells are densely packed and water diffusion is restricted because of reduced extracellular space and reduced membrane permeability. This results in a low ADC value (Figure 2). If DWI is used in combination with other MR findings (margins and kinetic analysis), the modality's sensitivity and specificity can be improved to 92% and 86%, respectively.[5]

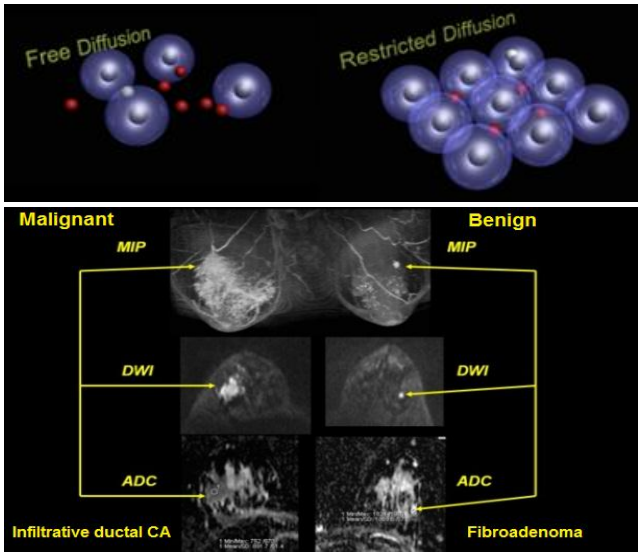

Figure 2. *The extracellular space and membrane permeability of benign tissue allow water to freely diffuse and result in a high apparent diffusion coefficient (ADC). The highly cellular environment characteristic of solid lesions and malignant tissue, with its reduced extracellular space and impermeable cell membranes, reduces water's ability to diffiuse and results in a low ADC value.*

Parallel imaging has improved the speed and quality of MRI over the past decade (Figure 3). In conventional MR imaging, all coils and amplifier channels collect the same image data. For parallel imaging with a four-channel breast coil, two different receiver coil channels simultaneously acquire different image data in the phase direction. Consequently, fewer k-space lines are acquired. Based on the sensitivity of each coil, an algorithm combines wraparound images with conventional images. Parallel imaging significantly reduces both the time of acquisition for a postcontrast dynamic scan and distortion artifact in a diffusion-weighted sequence. At our institution, the Hong Kong Sanatorium & Hospital, all 3T breast sequences are performed using parallel imaging with an acceleration factor of two to improve the speed and quality of images.

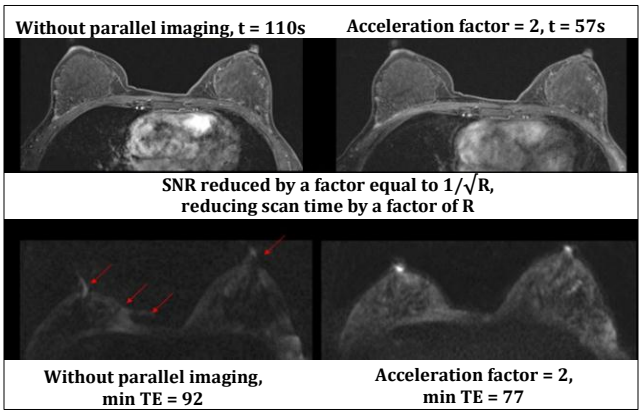

Figure 3. *Parallel imaging, clinical example.*

OPTIMIZED PROTOCOLS

Based on the technical and clinical considerations described above, Hong Kong Sanatorium & Hospital applies the following sequences as our 3T breast MRI protocol (Table 1).

FEATURES OF DYNAMIC CONTRAST-ENHANCED BREAST PROTOCOL

Using body array coil, patient lying supine

- Scout images
- Axial T2 haste and axial STIR to screen for any lymphadenopathy in neck and thoracic region

Using breast coil, patient lying prone

- Scout images
- Axial T2 with fat suppression, both breasts
- Sagittal T1 3D, both breasts
- Sagittal T2 with fat suppression, both breasts
- Axial DWI using b = 1000 sec/mm2 to improve specificity
- Precontrast axial 3D T1 with fat suppression, both breasts (mask images for subtraction)
- Postcontrast axial dynamic multiphase 3D T1 sequence with fat-suppression (6 acquisitions)
- Axial 3D T1 with fat suppression, both breasts (high-resolution scan)
- Sagittal 3D T1 with fat suppression, both breasts (high-resolution scan)

POSTPROCESSING

Maximum intensity projection (MIP) provides an excellent overview of image data and can steer the radiologist to suspicious lesions in the breast.

Multiplanar reformation (MPR) helps pinpoint the location of enhancing lesions in 3D. It allows the clinician to examine lesions' internal structure and margins from a different perspective.

Creating signal-intensity time curves is the most commonly used postprocessing tool. Placing an ROI on the most strongly and rapidly enhancing pixels (typically five to 20 pixels) in a lesion creates a time-intensity curve. Kuhl et al[6] classified these curves according to their shapes as type I, steady enhancement; type II, plateau of signal intensity; and type III, washout of signal intensity. Of 101 malignant and 165 benign lesions described with these signal intensity curves, they found that 83% of benign lesions were type I and 57% of malignant lesions were type III.

5 min	20 min	25 min	25 min	35 min
Patient Supine	**Patient Prone (Precontrast)**		**Postcontrast**	
Ax T2 Haste Ax STIR (Thorax scan for lymph-adeno-pathy)	Ax T2 FS TSE 1.0x0.7x 4.0 mm Sag T1 3D GRE 0.6x0.5x 2.0 mm Sag T2 FS TSE 0.9x0.7x 4.0 mm	Ax DWI B1000 2.3x1.8x3.0 mm	Ax T1 FS 3D GRE x 6 (1 min temporal resolution 1x0.7x1.8 mm)	Ax T1 FS High resolution 0.7x0.7x1.3 mm Sag T1 FS High resolution 0.6x0.6x1.3 mm
Body Array Coil	**4 Channel Breast Coil, PAT 2**			

Table 1. *3T breast protocol at Hong Kong Sanatorium & Hospital.*

PATIENT PREPARATION

When setting an appointment, except for urgent cases, premenopausal patients are informed that best results are obtained when the examination is performed between days 7 and 14 after the first day of their menstrual cycle to minimize hormonal influence on background enhancement. Before the scan, we evaluate our patients for contraindications for MRI using a standard questionnaire and safety screening procedure. Immediately prior to the examination, patients put on a gown and pants to prevent possible metallic artifacts from their clothing and to enable more comfortable positioning.

The technologist tells the patient of the approximate duration of the scan and the importance of keeping still during image acquisition. The patient is informed that she can communicate with the technologist via the intercom. She is also provided ear plugs to protect against noise created by the gradients.

PATIENT POSITIONING

The patient is placed in a prone position on the breast coil with a cushion placed under her head. The arms are positioned at the sides of the body or above the head. One possible disadvantage is that the axillary tail of each breast may not be fully covered by the breast coil. Ensure that each breast hangs as deeply as possible within the coil opening with the nipples centered and pointing straight down.

CONTRAST ADMINISTRATION

Applications of either a single dose of 0.1 mmol/kg body weight or a double dose of 0.2 mmol/kg body weight have been described. To date, no strong data are available to support an advantage for diagnostic accuracy from double dosing. Therefore, because of concerns regarding gadolinium deposition in tissue, which has been implicated in nephrogenic systemic fibrosis, a single dose of 0.1 mmol/kg (0.2 cc/kg) is used in our hospital.

Prior to the examination, an intravenous angiocatheter, at least 20 to 22 gauge, is inserted into the median antecubital vein, if possible. An injection rate of 2 cc/sec of contrast followed by a 25 cc saline flush using a power injector is preferred. Data acquisition starts right after the precontrast axial T1 fat-suppression sequence has finished with a 20-second delay.

References

1. Kuhl C, Jost P, Morakkabati N, et al. Enhanced MR imaging of the breast at 3.0T and 1.5T in the same patients; initial experience. Radiology 2006;239:666-676.

2. Schnall MD, Blume J, Bluemke DA, et al. Diagnostic architectural and dynamic features at breast MR imaging: multicenter study. Radiology 2006;238:42-53.

3. Leach MO, Boggis CR, Dixon AK, et al. Screening with magnetic resonance imaging and mammography of a UK population at high familial risk of breast cancer: a prospective multicentre cohort study (MARIBS). Lancet 2005;365:1769-1778.

4. Lehman CD, Gatsonis C, Kuhl CK, et al. MRI evaluation of the contralateral breast in women with recently diagnosed breast cancer. N Engl J Med 2007;356:1295-1303.

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