REVIEW ARTICLE

MAGNETIC RESONANCE IMAGING OF THE BREAST: A PROBLEM SOLVING TOOL

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ABSTRACT

Approximately one in every nine Pakistani women is likely to suffer from breast cancer. This is one of the highest incidence rates in Asia. Mammography and ultrasound are the basic imaging techniques for the detection and localization of breast tumors. Breast magnetic resonance imaging (MRI) has become increasingly important in the detection and delineation of breast cancer in daily practice. The utility of diagnostic value of MRI is mainly on specific situations such as detecting multifocal, multicentric or contralateral disease unrecognized on conventional imaging, assessing for the response to neoadjuvant chemotherapy, detection of cancer in dense breast tissue, recognition of an occult primary breast cancer. The standard breast MRI protocol includes T2 sequences (anatomy and signal analysis), T1 gradient-echo sequences which can detect markers placed after biopsy, and injected dynamic 3D sequences for performing volume and multiplanar reconstructions, which are particularly useful for locating lesions. Good patient positioning is essential. These aspects limit movement artefacts which alter subtraction sequences; it must be compared with the native sequences. New functional imaging sequences are now appearing in an attempt to increase the specificity of MRI, which is one of its main limitations. Of these, magnetic resonance spectroscopy appears to be the most promising.

Key words: Magnetic resonance imaging; Breast Cancer; Mammography; Early detection; Diffusion-weighted imaging; Spectroscopy;

INTRODUCTION

Breast cancer is the most common malignant disease occuring in women with lifetime prevalence of 12.4 %. [1] Approximately one in every nine Pakistani women is likely to suffer from breast cancer. This is one of the highest incidence rates in Asia. Pakistani women show an incidence rate of 50/100,000 and in the neighbouring country India, with similar socio-cultural background the incidence rate is 19/100,000. [2]

The availability of MRI as a supplementary examination to mammography offers a clear clinical benefit to some women at high risk for breast cancer. [3] Magnetic Resonance Imaging (MRI) has a sensitivity exceeding 90% for detecting breast lesions and is superior in measuring lesion size compared to mammography and ultrasound. [4,5] Breast MRI is, therefore, nowadays is used for screening, in the preoperative and neoadjuvant setting. [6,7]

The main additional diagnostic value of MRI relies on specific situations such as detecting multifocal, multicentric or contralateral disease unrecognized on conventional assessment (particularly in patients diagnosed with invasive lobular carcinoma), assessing the response to neoadjuvant chemotherapy, detection of cancer in dense breast tissue, recognition of an occult primary breast cancer in patients presenting with cancer metastasis in axillary lymph nodes.8

IMATERIAL AND METHODS

This review included all articles that were used for the improvement of knowledge about MRI Breast. A literature search was conducted using the electronic databases of Pub Med, Google scholar, Elsevier from 1990 to 2014 for English-language articles. The search terms used were: Magnetic resonance imaging; Breast Cancer; Mammography; Early detection. The titles and abstracts of articles were examined. Full text and reviews of the articles were obtained when the abstracts matched the inclusion criterion.

MRI (1.5 Tesla UNIT) PROTOCOLS

HISTORY:

It is beneficial to have the patient a complete specific questionnaire aided by an experienced breast imaging assistant or a radiologist (Figure 1) like CHUM[23] has developed. This should include information on hormonal status (menopause, day of the menstrual cycle, pregnancy, breast-feeding), the person-al history of breast cancer (specifying the date of surgery, the date of the end of radiotherapy, the history of axial lymph node dissection, the chemotherapy or hormone treatment) and any family history.

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Figure 1: A sample of questionnaire/history form which should be asked from patients undergoing MRI breast.

Patients Name		SEX	AGE
Patients Current Complain			
Previous Mammogram/ultrasound			
Previous MRI Breast	yes/no findings	Where	When
Date of Last Menstrual Cycle		Regular	Irregular
Any previous surgical history			
If Post Menopausal At what age Menstrual cycle stopped: Naturally/surgically/drug effect:			
Personal medical History Already diagnosed Breast Cancer? Right/Left If yes what is the mode of treatment received? Surgery: yes/no with/without axillary disecction Chemotherapy: yes/no Radiotherapy: yes/no Current medications;			
Family History of Any Cancer ? BRCA1/BRCA2 positive yes/no Referred by			

SUITABLE PERIOD FOR EXAMINATION:
The best time for MRI breast examination is during the second week of the menstrual cycle because normal breast tissue may interfere with accurately interpreting the MRI study, the timing of imaging during the menstrual cycle is important. [3]

POSITIONING:
Correct positioning of the breast coil is essential to minimize the number of artifacts. Good patient positioning is essential and is obtained by using foam wedges for small breasts, ensuring there are no folds, and the correct position of the nipples. These aspects limit movement artefacts which alter subtraction sequences.

Standard protocol includes very uniform magnetic field in order to reduce artifacts related to non uniform fat suppression. Both breasts must be investigated to allow mirror reading by facilitating detection of the physiological glandular contrast uptake which can limit the diagnostic value of the examination by masking a certain amount of contrast uptake and limiting aliasing artifacts.

The use of an automatic injector is recommended. Slice thickness should be less than or equal to 3 mm with pixel size less than 1 mm on each side. Finally acquisition time should be less than 2 min as the mean enhancement time of a malignant tumor is between 90 and 120 sec.[9]

STANDARD SEQUENCES:
The morphological sequences used in breast MRI are unenhanced high-spatial resolution T2 weighted fast spin-echo sequence without fat saturation in the axial plane for detecting the presence of cysts or microcysts. The European recommendations EUSOBI undertakes a T2W sequence. According to Khul et al 10 T2W sequence can be performed without fat saturation because a T2 signal greater than that of non saturated fat has a higher predic-tive value for a benign cyst.5 T2-weighted sequences with fat saturation are useful for creating indirect MRI ductogra-phy images where there is a discharge and seem to optimise the detection of small cancers.[11]

T1-weighted sequences are useful for detecting the presence of a fatty component within a lesion, which is also a major aspect predicting its benign nature. T1 sequences are therefore performed without fat saturation. They also allow metal markers to be detected which may have been positioned at the end of biopsy. When the biopsy took place using stereotactic mammography orultrasound, the marker provides confirmation that the position of the biopsied lesion and of contrast uptake in the MRI is the same. This detection of the biopsy marker is based on detecting the magnetic susceptibility artefact on T1 gradient-echo sequences, created by the metallic nature of the marker. The longer the TE of the sequence the more this artefact is visible dynamic sequences must satisfy the two major classic requirements of perfusion imaging: good temporal resolution (< 2 minutes) and good spatial resolution (mm isotropic pixel).[12]

CONTRAST AGENT:

Intravenous injection of gadolinium chelates at the standard dose of 0.1 mmol kg-1 with an injection rate of 2 ml s-1 followed by saline flushing using an automatic injector. For dynamic studies performed both with and without fat saturation, image post-processing includes temporal subtraction; morphological in addition to dynamic analyses with representative curves.[10]

DIAGNOSTIC ACCURACY OF MRI:

Hrung et al.[13] performed a metaanalysis of 16 studies published between 1994 and 1997. The overall sensitivity of MRI for detecting breast cancer was 95% with a specificity of 67%. A meta-analysis performed by Peters et al.[14] comprising 44 studies, reported an overall sensitivity of breast MRI of 90%. The overall specificity was 72%, indicat-ing that 28% of the detected lesions were false-positive findings. Peters et al study focused on small, nonpalpable, early stage breast cancer, explaining the somewhat lower sensitivity compared to the meta-analysis of Hrung et al.

An additional value of MRI is the detection of DCIS lesions. In a retrospective study Kim et al [15] stated that MRI was more superior for the detction of size of DCIS than mammography. Hwang et al[16] showed MRI to be more superior to mammography in detecting invasive components in patients diagnosed with DCIS. MRI also showed higher sensitivity and negative predictive value for detection of residual DCIS.

In a meta-analysis of 11 studies, MRI had a significantly higher sensitivity than mammography when used in dense breasts.[17] However, MRI is not meant to replace mammography.

Figure3. Courtesy Menezes GLG et al . Breast MRI: Review and future perspectives *World J Clin Oncol* 2014 May 10; 5(2): 61-70 [8]

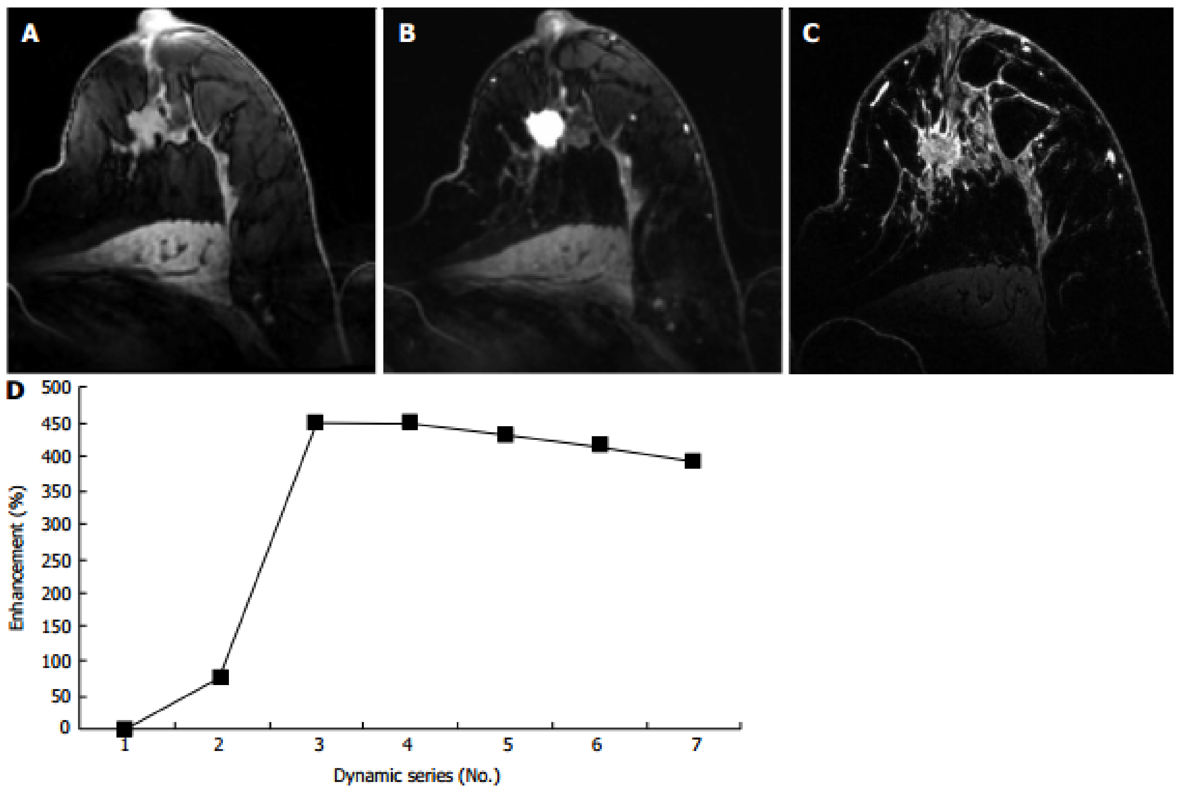

Figure 3 A 62-year-old patient with nipple withdrawal, finally diagnosed as ductolobular carcinoma. A, B and C: Axial T1-weighted gradient-echo images obtained at 7 T before and after contrast injection. An irregular mass with spiculated margins can be observed on pré-contrast imaging (A). An intense homogeneous enhancement (B) and a rapid wash-out kinetic curve (D) can be observed following contrast administration. In Figure 3C, an ultra-high-resolution T1-weighted gradient-echo sequence with fat suppression was performed, and the morphological aspects of the lesion can be more clearly seen.

SCREENING HIGH RISKS PATIENT:

MRI has an important role in screening high-risk patients. The American Cancer Society Guidelines for the Early Detection of Cancer advices annual breast MRI beginning at the age of 25-30 years in patients carrying particular cases, the European Society of Breast Imaging also recommends annual MRI screening.18

Additionally MRI can be beneficial in patients with dense breast parenchyma. Mammography has a high false negative rate in patients with dense breast tissue.[19-23] In a large multicenter study, Schnall et al.[24] proved that MRI has superior capability to detect additional occult cancer foci when compared to mammography, particularly in women with radiographically dense breasts and larger index cancers (18% vs 7.2%). Many other studies confirm that MRI has the highest diagnostic value when used in patients with heterogeneous or extremely dense breast parenchyma.[25,26,27]

The European Breast Imaging Society also advices the use of pre operative MRI in staging malignant lesions in patients with dense breast tissue. 18 Several guidelines recommend annual supplemental screening with MRI for women who are at high risk for breast cancer (lifetime risk 20%–25% or more). This includes women who carry mutations of the BRCA genes, their first-degree untested relatives, and women who received radiation to the chest between the ages of 10 and 30 years (e.g., treatment for Hodgkin lymphoma). Expert consensus does not currently support supplemental MRI screening for women with a lifetime risk of breast cancer that is less than 15%. There is considerable uncertainty over the use of MRI screening for women with intermediate risk (15%–20%), including those with dense breasts or a previous diagnosis of atypia (e.g., lobular carcinoma in situ, atypical lobular hyperplasia, atypical ductal hyperplasia) on breast biopsy.28,29

TECHNOLOGICAL DEVELOPMENTS

Another method which can improve specificity of breast MR is spectroscopy and DWI.

DIFFUSION WEIGHTED MRI (DWI):

DWI is a non-invasive MRI technique that measures the mobility of water molecules in tissue, providing information such as cellular density, viscosity, membrane integrity, and tissue microstructure, without the need of contrast injection [30-33]. DWI is able to differentiate between tissue types based on the use of the apparent diffusion coefficient (ADC). Malignant breast tumors usually have a higher cellularity and generally present with restricted water diffusion and lower ADC values when compared to benign lesions [34,35].

In a retrospective study, El Khouli et al 36 selected 93 women with 101 lesions (68 malignant tumors and 33 benign tumors) who underwent MRI using a 3.0 T magnet and both CE-MRI and DWI were performed. The association of DWI with ADC significantly improved the diagnostic performance and lesion characterization when compared to conventional 3D T1-weighted and CE-MRI at 3.0 T. Partridge et al [37]reported that ADC values of DCIS were lower when compared to benign lesions and invasive carcinoma. Rahbar et al[38] found 96% of pure DCIS lesions to be hyperintense in DWI.

Sharma et al [39] assessed the response of 56 patients with breast malignant lesions at four different times, before and after three cycles of Neo Adjuvant Chemotherapy. ADC has shown a statistically significant change in volume and diameter in responders (sensitivity 68% and specificity 100%) and the authors suggested ADC would be useful in predicting early tumor response.

BREAST SPECTROSCOPY:

Breast cancer spectroscopy is slightly behind in determining the suitability of this technique for clinical practice. In the mammary gland area Choline is considered the most important metabolite in proton MR spectroscopy. Many different metabolites overlap and contribute to the Cho peak, such as choline, phosphocholine, glycerophsphocoline, taurine and myoinositol, among others40-42. The Cho peak is centered at 3.2 ppm. Cholines are precursors of phospholipids which are components of cell membranes and increased Cho signals are associated with increased cellular turnover [43-45]. The use of breast MR spectroscopy to distinguish between benign and malignant lesions (using elevated tCho level as an indicator of malignancy) can potentially improve the accuracy of an MRI scan by offering increased specificity.

CONCLUSION

In addition to mammography, MR imaging is now becoming part of routine clinical practice for certain patient populations at high risk for breast cancer. Optimizing breast MR imaging technique is the first step toward maximizing diagnostic accuracy. Knowledge of the imaging appearances of invasive cancers and DCIS along with an awareness of the benefits and limitations of the various modalities, particularly mammography and US, in identification of MR imaging detected breast cancer is essential. DWI and spectroscopy used in conjunction with DCE-MRI increases the specificity for cancer detection and used alone holds promise of being useful for widespread cancer screening.

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