Introduction

Breast MRI has become an important tool for breast cancer detection and characterization. Current applications for breast MRI include evaluation of the extent of disease in patients with newly diagnosed breast cancer [1], screening of women at high risk [2, 3], evaluation of patients with metastatic axillary adenocarcinoma and an unknown primary site of malignancy [4], and assessment of silicone breast implant integrity [5]. Dynamic contrast-enhanced MRI (DCE-MRI) is highly sensitive for breast cancer, allowing detection of malignancy that is occult on physical examination, mammography, and sonography [1–4]. Despite its high sensitivity, challenges of breast DCE-MRI include the lack of standardized acquisition protocols, time required for image processing and interpretation, and variable specificity.

Computer-aided diagnosis (CAD) programs have been developed to address some of these obstacles and are increasingly used in clinical practice. Advantages of CAD systems include automated image processing and kinetic analysis for improved accuracy and time efficiency. The primary aim of CAD for breast MRI is to assist the radiologist in determining which lesions are benign and which are malignant. The shape of the DCE-MRI time–signal intensity curve an important measure in differentiating benign and malignant enhancing lesions [6], and is reported in clinical breast MRI assessments as part of the American College of Radiology MRI BI-RADS lexicon [7]. In contrast to conventional manual region of interest (ROI) approaches, CAD systems generate detailed kinetic data for all pixels in the lesion and can provide quantitative whole-lesion evaluation. Several studies have shown CAD evaluation of lesion enhancement kinetics to improve diagnostic accuracy [8–10], although a recent meta-analysis suggests that this benefit may be limited to less experienced radiologists [11].

Clinical Implementation of Breast MRI CAD

Breast MRI CAD systems are typically utilized in parallel with conventional PACS workstations and results are reviewed at the time of the clinical assessment. In general, CAD systems calculate initial and delayed phase DCE-MRI enhancement
characteristics on a pixel-by-pixel basis and present the information as a color overlay. Tumor pixels are selected if they meet an initial enhancement threshold, and are color-coded based on the shape of their time-signal intensity curve, typically: blue for persistent enhancement (increasing), green for plateau (stable), and red for washout (decreasing). The software packages provide a synopsis of whole-lesion enhancement kinetics, including: tumor volume, peak initial enhancement, and percentages of persistent, plateau, and washout delayed enhancement, as well as allowing for on the fly curve analysis of single pixels or ROIs. This information facilitates standardized reporting of lesion kinetics as recommended by the ACR MRI BI-RADS lexicon [7]. Additionally, CAD systems provide other clinically valuable tools including motion correction, subtractions, reformats, and maximum intensity projections (MIPs). Some breast MRI CAD systems also offer tools to assist in performing MRI-guided biopsies.

It is important to note that a number of factors can affect the accuracy of CAD measurements. Selection of CAD threshold settings can dramatically affect sensitivity and specificity [11]. Also, there is no standardized approach to breast MRI and variations in MRI technique, such as spatial and temporal resolution, timings of post-contrast series, signal-to-noise ratio, type of contrast agent, and field strength may require adjustment of CAD protocols to produce reliable results. Patient motion, background parenchymal enhancement, and treatment effects present additional challenges for automated CAD assessments.

Future Developments

New tools are under development for breast MRI CAD, with potential to further improve diagnostic accuracy. Morphology is known to be an important factor in assessing the likelihood of malignancy of breast lesions [12,13], and at least one commercially available system (DynaCAD, Invivo, Gainesville, FL) now incorporates evaluation of morphologic features in the automated assessment. Diffusion-weighted imaging shows promise as an adjunct to DCE-MRI for improved discrimination of benign and malignant lesions based on apparent diffusion coefficient values [14,15]. In light of this, breast MRI CAD manufacturers are beginning to add capabilities to interactively calculate and present DWI information along with DCE-MRI enhancement kinetics. Another system (SpectraLook, iCAD, Inc., Nashua, NH) takes a unique approach in calculating pharmacokinetic parameters ($K_{tran}$, $K_{ep}$, and $V_E$) rather than semi-quantitative metrics describing the enhancement curve. It remains to be seen whether these and other CAD advances will lead to more accurate detection and diagnosis of suspicious breast lesions.

References