# Computer-Aided Detection Applied to Breast MRI: Assessment of CAD-Generated Enhancement and Tumor Sizes in Breast Cancers Before and After Neoadjuvant Chemotherapy[1]

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**Rationale and Objectives.** MRI has shown promise in assessing breast cancer patients undergoing neoadjuvant chemotherapy. Computer-aided detection (CAD) for MRI can automatically display tumor enhancement parameters. This study was performed to determine the utility of CAD applied to breast MRI in this patient population.

**Materials and Methods.** Fifteen patients with 16 newly diagnosed locally advanced breast cancers were evaluated with MRI before and after neoadjuvant chemotherapy. CAD assessments, including presence or absence of significant enhancement, enhancement profiles, and maximum sizes, were recorded. Pre-chemotherapy and post-chemotherapy enhancement profiles were compared. Sizes were compared to those measured by the radiologist and at final pathology.

**Results.** Prior to chemotherapy, all tumors demonstrated CAD-assessed significant enhancement. Following chemotherapy, 7/16 tumors showed no residual significant enhancement, but all had residual disease at pathology. In those patients with residual enhancement, comparison of the post-chemotherapy to pre-chemotherapy CAD enhancement profiles showed a significant decrease in percentage of washout enhancement ($P = 0.0147$) in patients with less than 5 mm of residual microscopic disease. Radiologist-measured tumor sizes demonstrated better correlation with sizes at pathology ($r = 0.60$) than did CAD-generated tumor sizes ($r = 0.32$).

**Conclusion.** CAD may be helpful in assessing changes in MRI enhancement profiles of tumors following chemotherapy. However, CAD-assessed significant enhancement following chemotherapy can be falsely negative for residual malignancy, and CAD tumor sizes are less accurate than those measured by the radiologist in predicting size of residual malignancy. CAD may complement but should not replace the radiologist's assessment of tumors in this patient population.

**Key Words.** Breast MRI; neoadjuvant; computer-aided detection.



The use of magnetic resonance imaging (MRI) in the detection and management of breast cancer is increasing. Breast MRI is highly sensitive in detecting breast cancer (1, 2) and can identify malignancy that is occult on physical examination, mammography, and ultrasound (3–12). However, breast MRI requires significant time for image processing and interpretation and has demonstrated variable specificity. To address these limitations, some clinical sites now employ computer-aided detection (CAD) programs for breast MRI. CAD systems can automatically perform many image-processing and analysis functions typically performed manually by the MRI technologist and the radiologist, and may improve diagnostic accuracy by improving specificity (13, 14).

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One emerging application of breast MRI is the evaluation of patients undergoing neoadjuvant chemotherapy for locally advanced breast cancer. Multiple studies in this patient population have shown that lesion size measured on MRI after neoadjuvant chemotherapy correlates well with residual malignancy at pathology, with correlation coefficients ranging from 0.70 to 0.98 (15–23). In addition, MRI has been demonstrated to be superior to clinical examination, mammography, and ultrasound in assessing the size of residual malignancy in these patients (17, 19–22). Studies have also found that decreases in MRI tumor size (15, 16) and in MRI early contrast uptake (16) may be useful in predicting response to neoadjuvant chemotherapy. One study has also suggested that MRI phenotype or pattern of enhancement may predict therapy response (24).

This study was performed to assess the potential contributions and limitations of CAD applied to breast MRI interpretation in breast cancer patients undergoing neoadjuvant chemotherapy. Specifically, we evaluated pre- and post-chemotherapy CAD-assessed presence of significant enhancement, CAD enhancement profiles, and CAD tumor sizes. To our knowledge, this is the first study to evaluate a commercially available CAD system for breast MRI in the neoadjuvant chemotherapy population.

## MATERIALS AND METHODS

### Design and Subjects

Retrospective review was performed of the MRI examinations and medical records of 15 consecutive patients with 16 locally advanced breast cancers treated with neoadjuvant chemotherapy at our institution between January 2001 and April 2003. All patients were participants in an ongoing trial evaluating PET and MRI in assessing response of breast cancer patients to neoadjuvant chemotherapy. This study was approved by the Internal Review Board of the University of Washington Medical Center, and all patients provided prospective informed consent for review of their imaging studies and medical records.

All patients were initially evaluated at our Breast Cancer Specialty Clinic by medical and surgical oncologists specializing in breast cancer treatment, and determined to be candidates for neoadjuvant chemotherapy based on breast cancer clinical stage and pathology features. All had undergone core needle biopsy prior to clinical assessment. Patients were evaluated with at least 2 breast MRI examinations, one prior to neoadjuvant chemotherapy, and one or more during or upon completion of chemotherapy prior to final surgery. The first and final MRI examinations for each patient were used for analysis.

### MRI Technique

All MRI studies were performed on a GE LX 1.5-T system (General Electric Medical systems, Milwaukee, WI) using a dedicated multi-channel bilateral breast coil (MRI Devices, Waukesha, WI). Following an axial localizer sequence, all images were acquired in the sagittal plane with a field of view of 18 to 22 cm, depending upon breast size. Initially, a pre-contrast fat-suppressed 3D gradient recalled echo sequence was performed, followed by a pre-contrast fat-suppressed 3D spoiled gradient echo (SPGR) sequence. Twenty milliliters of intravenous gadolinium were then administered at 1-2 mL/second by hand injection. Two post-contrast fat-suppressed 3D SPGR sequences were then performed, one immediate and one delayed. Prior to April 2002, unilateral examinations were performed, with repetition time (TR) 20 milliseconds and echo time (TE) 5 milliseconds, 1.2 mm slice thickness, and a 256 x 128 matrix. The immediate post-contrast sequence was completed within approximately 5 minutes and the delayed sequence was completed within approximately 10 minutes of contrast injection. From April 2002, bilateral examinations were performed (sequential alternating unilateral acquisitions), with TR 17 milliseconds and TE 2.3 milliseconds, 3.0 mm slice thickness, and a 256 x 192 matrix. The immediate post-contrast sequence was completed within approximately 2 (first breast imaged) to 4 (second breast imaged) minutes, and the delayed sequence was completed within approximately 4 (first breast imaged) to 8 (second breast imaged) minutes of contrast injection. For all studies, sagittal subtraction, axial and coronal reformats, and 3D maximum intensity projection images were generated.

### Unassisted Radiologist MRI Interpretation

Prospectively, all MRI examinations were interpreted by one or more dedicated breast imaging radiologists with breast MRI experience. Clinical information and prior imaging and pathology results were available at the time of interpretation. Studies were reviewed on a picture archive and communication system (PACS) system (General Electric Medical Systems, Milwaukee, WI). Lesions corresponding to sites of biopsy-proven cancers were identified and characterized using the American College of Radiology Breast MRI Lexicon (25). Dimensions of each lesion were determined using the PACS measuring