

Clinical Experience with MR Breast Computer-Aided Detection and MR-Guided Vacuum-Assisted Breast Biopsy

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The use of magnetic resonance imaging (MR) for detection and management of breast cancer is increasing. Previous studies reported that MR can detect breast cancer that is occult on mammography, sonography, and physical examination (1 - 7). This report demonstrates two recent methods with breast MR, computer-aided detection (CAD) system and MR-guided vacuum-assisted biopsy.

Index words: Magnetic resonance (MR); Breast; Diagnosis; Computer-assisted

INTRODUCTION

The use of magnetic resonance imaging (MR) for detection and management of breast cancer is increasing. Previous studies reported that MR can detect breast cancer that is occult on mammography, sonography, and physical examination (1 - 7). This report demonstrates two recent methods with breast MR, computer-aided detection (CAD) system and MR-guided vacuum-assisted biopsy.

Case 1

A 46-year-old woman had a palpable lump at left breast. There was no familial history of breast cancer. Mammography showed a spiculated marginated, irregular shaped hyperdense mass at upper portion of the left breast (Fig. 1a). Breast ultrasonography showed a spicu-

lated marginated, irregular shaped hypoechoic mass located in 1 o'clock direction of the left breast (Fig. 1b). The mass was assessed as BI-RADS[®] (Breast Imaging Reporting and Data System) category 5 and ultrasonography-guided core needle biopsy was performed. The mass was pathologically verified as a mixed carcinoma of invasive ductal and mucinous carcinoma.

We performed additional breast imaging for breast cancer staging before treatment, low-dose breast CT at prone position with dynamic contrast enhancement, whole body PET-CT, and breast MR. Breast CT showed the mass in left breast was spiculated irregular shaped and peripheral rim-like enhancement (Fig. 1c) and whole body PET-CT showed a single hypermetabolic lesion (Max SUV = 6.28) in the left breast (Fig. 1d). MR imaging demonstrated an additional suspicious malignant enhancing mass at posterior aspect of main malignant enhancing mass, suggesting possibility of malignant daughter lesion or combined extensive intraductal component. These two masses showed same mixed color mapping of washout (red color), plateau (yellow color), and persistent (blue color) patterns on dynamic en-

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hancement study of MR-CAD system (Confirma™, Bellevue, WA, U.S.A.) (Fig. 1e).

This case showed usefulness of breast MR and MR CAD system for identification of accurate extent before breast cancer surgery and their characterization of ma-

lignancy.

Case 2

A 40-year-old woman has an incidentally detected mass on breast ultrasonography. She had no symptom

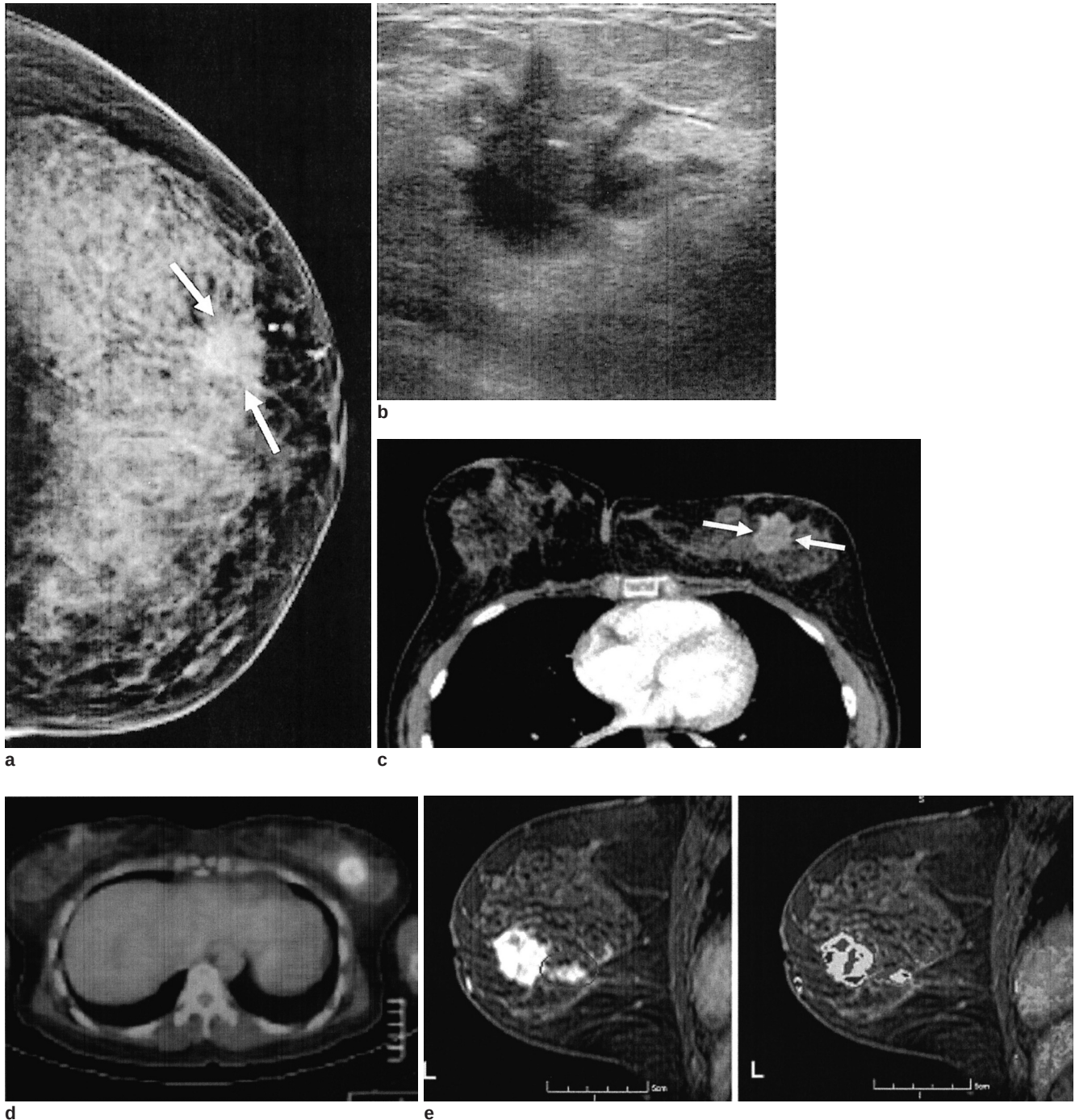


Fig. 1. A 46-year-old with a palpable lump at left breast. Mammography (a) and ultrasonography (b) demonstrate a spiculated, irregular shaped mass (arrows) at upper portion of the left breast. Postcontrast low-dose breast CT (c) with prone position shows an irregular shaped peripheral enhancing mass (arrows) in the left breast. Whole body PET-CT scan (d) shows a single hypermetabolic lesion (Max SUV=6.28) (arrows) in the left breast. Dynamic enhancement of MR CAD images demonstrate various blood flow pattern of the mass in left breast and an additional malignant enhancing mass (circle) at posterior aspect of the main malignant mass with same mixed color mapping of washout (red color), plateau (yellow color), and persistent (blue color) patterns (e).

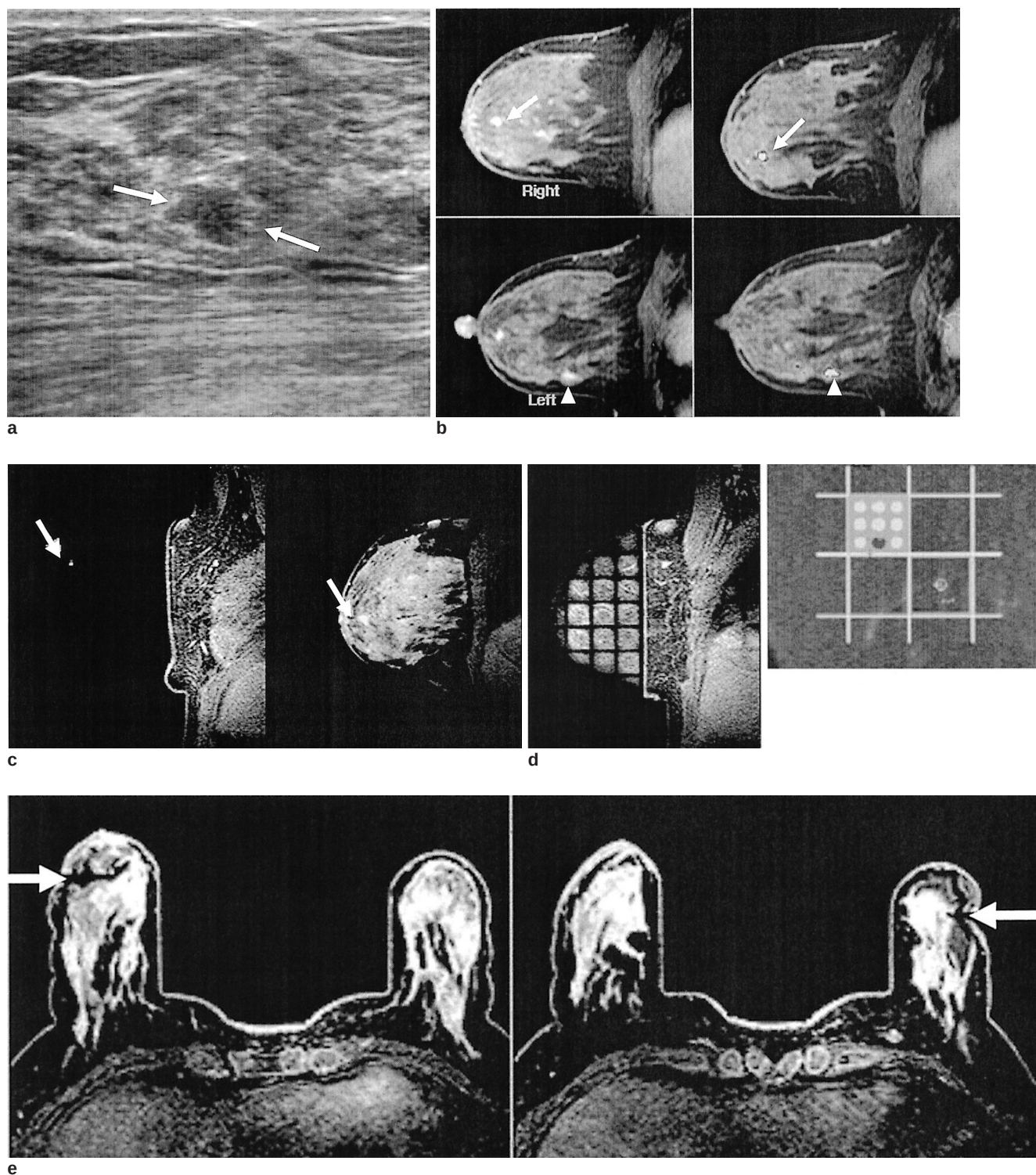
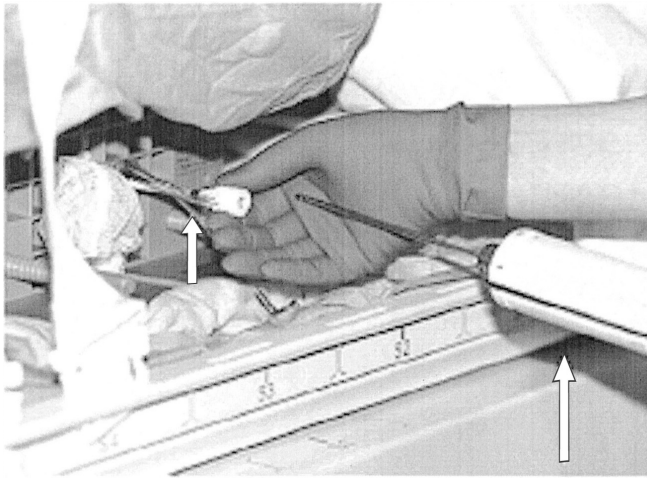
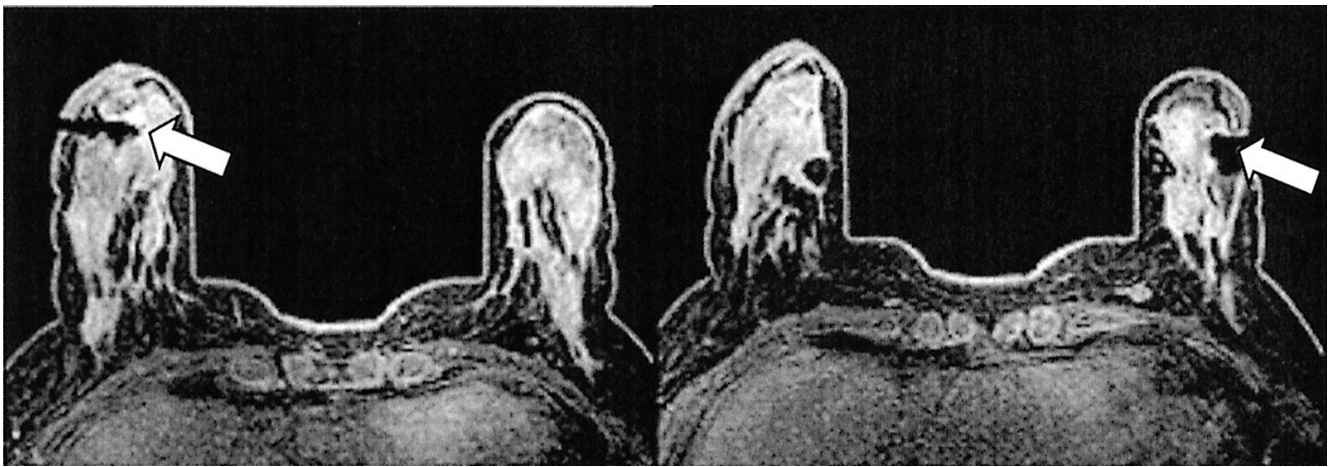


Fig. 2. A 40-year-old woman with no symptom. Screening breast ultrasonography (a) demonstrates a microlobulated marginated, irregular shaped isoechoic mass (arrows) in 10 o'clock direction of the right breast. On breast MR (b), two tiny enhancing masses (arrows in right breast and arrowheads in left breast) are seen and they are morphologically benign. However, they had suspicious malignant dynamic enhancement patterns on MR CAD system with mixed plateau and persistent patterns (mapping of yellow and blue colors). MR-detected two tiny masses in both breasts were performed MR-guided vacuum assisted biopsy. The MR images were reviewed on the monitor, and a vitamin E capsule (arrows) is placed on the skin surface and the lesions are marked on a reference diagram (c). MR CAD system automatically calculates and records the coordinates of x, y (site of insertion), and z (depth) between the lesion and reference with the vitamin E skin marker on the diagram (d). Axial T2 weight images are obtained to confirm accurate targeting through the region of the obturator and the lesion (e).



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Fig. 2. Coaxial introducer sheath is placed into breast through localization grid and a vacuum-assisted biopsy handpiece is placed into introducer sheath to perform biopsy (arrows) (f). Final axial T2 weighted images through the biopsied region are obtained to verify the location of the sampling defect (arrows) (g).



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and no familial history of breast cancer. The patient had dense breasts on screening mammography and additional screening breast ultrasonography was performed. Breast ultrasonography demonstrated a microlobulated marginated, irregular shaped isoechoic mass located in 10 o'clock direction of the right breast (Fig. 2a). This was assessed as BI-RADS[®] category 4 and ultrasonography-guided core needle biopsy was performed. The mass was pathologically confirmed as low-grade ductal carcinoma in situ.

Breast MR was performed for breast cancer staging before surgery. The mass that was pathologically proven malignant mass in right breast had a persistent dynamic enhancement pattern with blue color mapping on MR CAD system (ConfirmaTM, Bellevue, WA, U.S.A.). There were two additional enhancing masses in lower outer quadrants of both breasts. They were detected incidentally on breast MR and occult on other imaging modalities. They were morphologically benign masses

with circumscribed margin and oval to round shape. However, they had suspicious malignant dynamic enhancement patterns on MR CAD system with mixed plateau and persistent patterns (mapping of yellow and blue colors) (Fig. 2b).

MR-guided vacuum-assisted breast biopsy was performed for two additional lesions in both breasts. We used the 9G ATEC[®] vacuum-assisted biopsy device (Suros Surgical Systems Inc., Indianapolis, IN, U.S.A.). MR equipment was 3T Achieva X-series (Philips Medical Systems, Best, Netherlands). The patient was placed in prone position with the affected breast positioned in the dedicated breast coil (model OBC-63 Breast Array Coil, Philips Medical Systems). The breast was stabilized in a biopsy guidance grid (ATEC[®], Suros Surgical Systems) by providing moderate compression. A vitamin E capsule was taped to the skin in the center of the grid for reference. The biopsy guidance grid also allows determination of the x and y coordinates of the

target lesion. After then, unenhanced and contrast-enhanced fat suppressed T1 sagittal images were obtained to confirm the persistence of the enhancing lesion noted on the prior diagnostic MR images. The images were reviewed on the monitor, and the locations of the vitamin E capsule placed on the skin surface and the lesion were marked on a reference diagram (Fig. 2c). MR CAD system automatically calculated and recorded the coordinates of x, y (site of insertion), and z (depth) between the lesion and the vitamin E skin marker on the diagram (Fig. 2d).

The MR table was moved out of the bore of the magnet, the patient's skin was then sterilized with commercially available povidone-iodine and local anesthetic (1% lidocaine mixed with epinephrine solution) was injected. A sterile plastic coaxial sheath with a sharp inner metallic stylet was inserted to the calculated depth using the centimeter markers on the exterior of the sheath. Once the coaxial sheath was in place, the inner cutting stylet was removed and replaced with a plastic MR-visible obturator. With the coaxial sheath and obturator in place, the patient was returned to the bore of the magnet. Axial T2-weighted images were performed to confirm accurate targeting through the region of the obturator and the lesion (Fig. 2e). Once correct targeting was confirmed, the patient was moved out of the bore of the magnet and tissue sampling was performed using the vacuum-assisted breast biopsy device through the coaxial sheath (Fig. 2f). Sampling was performed preferentially in the direction of the lesion. When tissue sampling was complete, the probe was retracted and axial T2-weighted images were performed to verify the lo-

cation of the sampling defect (Fig. 2g).

At the completion of the biopsy, the coaxial system was removed. Manual compression was applied to achieve hemostasis. After then, we performed ultrasonography and skin marking for biopsy sites instead of marker clip insertion for scheduled surgical excision.

There was no complication associated with any of the biopsy procedures. Two lesions were pathologically diagnosed as atypical ductal hyperplasia in both breasts. Surgical excision with localization was performed for three lesions in both breasts. Two masses in right breast (10 o'clock direction that was detected on breast ultrasonography and breast MR and lower outer quadrant that was detected on only breast MR) confirmed as low grade ductal carcinoma in situ. One mass in left lower outer quadrant that was detected on only breast MR was verified as atypical ductal hyperplasia.

This case showed usefulness of breast MR, MR CAD system, and MRI-guided biopsy for detection and tissue sampling of multicentric breast carcinomas.

DISCUSSION

In this report, we introduced clinical experiences about MR breast CAD system and MR-guided vacuum-assisted breast. It is well accepted that MR sensitivity for invasive breast carcinomas is very high, but interpretation of breast MR imaging is challenged to achieve high specificity (8). Reading the large number of acquired MR images in a reasonable amount of time also becomes more important as the number of studies increases. CAD system has been defined as the discovery

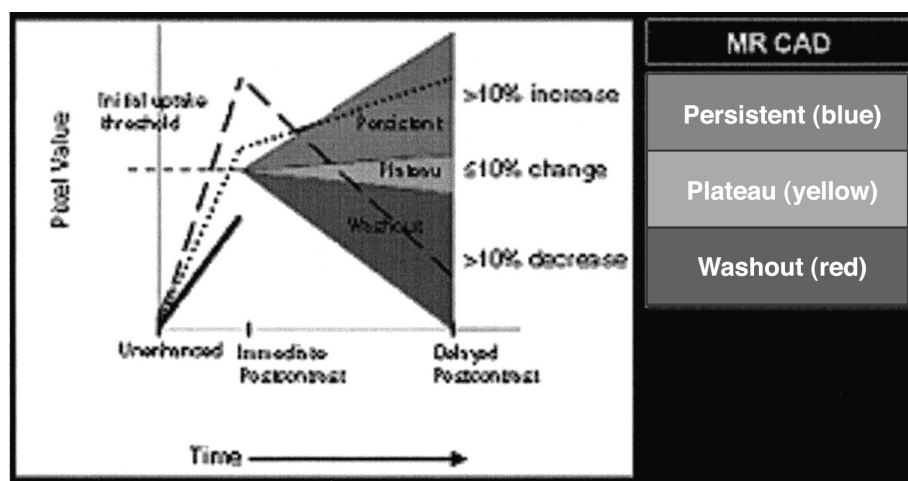


Fig. 3. Dynamic enhancement kinetics and angiogenesis mapping on MR CAD system (ConfirmaTM, Bellevue, WA, U.S.A.)

of features that may be related to malignancy (8).

As compared with CAD system for mammography, there are several fundamental differences in CAD system for breast MR (9). CAD system for mammography detects the lesion using morphology and has increased

sensitivity. On the other hand, CAD system for MR uses enhancement kinetics and then can reduce interpretation time and increase specificity. The kinetic features with the most clinical validation have been chosen by the American College of Radiology and included in the

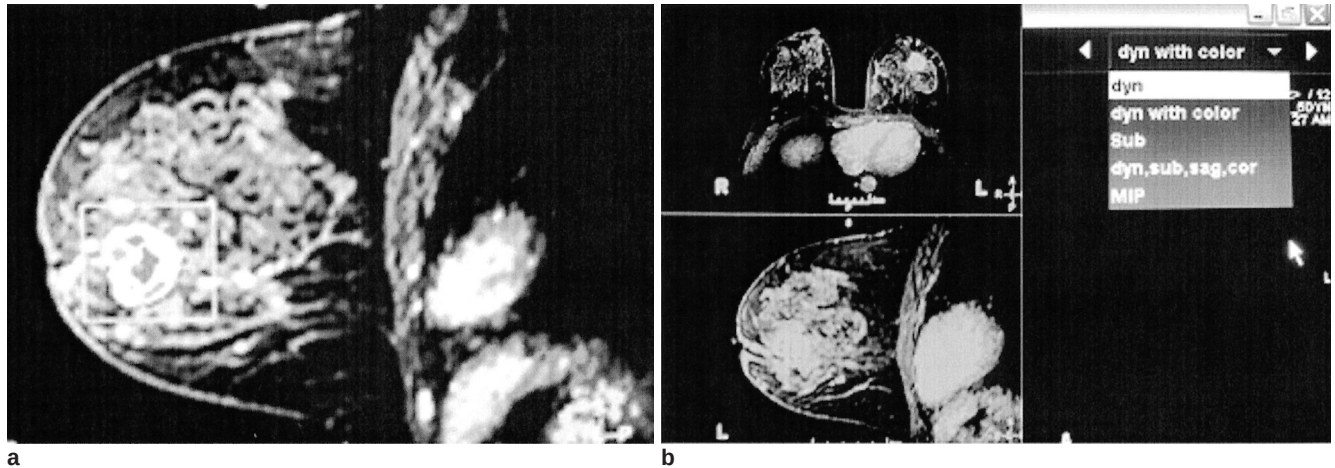


Fig. 4. Variable function of breast MR CAD system (ConfirmaTM, Bellevue, WA, U.S.A.)

(a) Angiogenesis mapping

(b) Multiplanar reformation

(c) Real-time acquisition of kinetic curves and 3D information

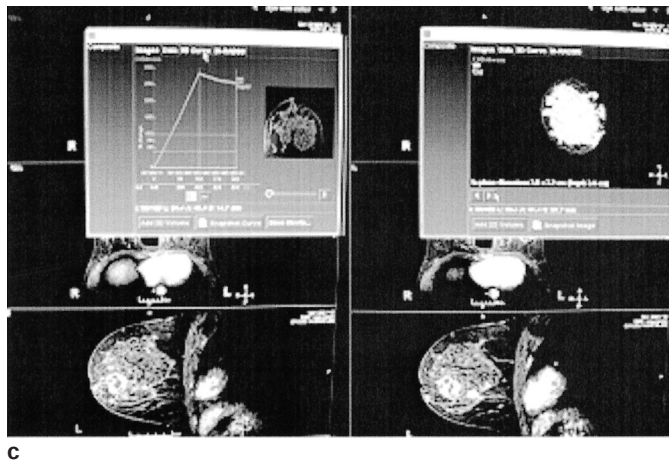


Fig. 5. Breast coil and components of the ATEC® breast biopsy and excision system (Suros Surgical Systems Inc., Indianapolis, IN, U.S.A.)

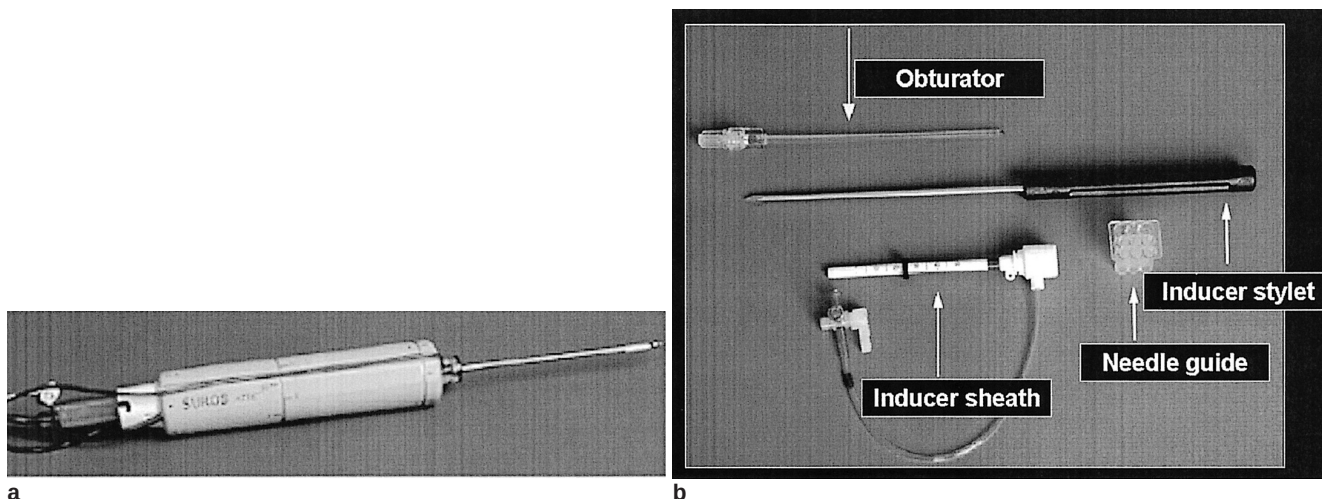


Fig. 6. Handpiece of ATEC® vacuum-assisted biopsy device and single-use MR-safe ATEC® introducer set (Suros Surgical Systems Inc., Indianapolis, IN, U.S.A.)

(a) Handpiece

(b) MR-safe introducer set

BI-RADS®-MR lexicon (10) The CAD system for breast MR was defined as the automated analysis of enhancement kinetics, highlighting features related to malignancy as the CAD stream angiogenesis maps (Fig. 3). Multiplanar reformatting allows to view in multiple planes (sagittal, axial, coronal) in order to localize lesions and their relationship to anatomy for surgery. In addition, CAD system provides variable informations such as kinetic curves, 3D volume data about malignancy with direct and reproducible way (Fig. 4).

In previous study by Lehman et al. (11), MR-guided vacuum-assisted breast biopsy could be performed successfully (100% technical success rate), and no complications were associated with any of the biopsy procedures. The average time to perform the single-site MR-guided procedures was 38 minutes. The multiple-site biopsies performed in a single breast averaged 59 minutes, and bilateral biopsies averaged 64 minutes. One case was reported that atypical ductal hyperplasia was upgraded to ductal carcinoma in situ after surgery. In another study by Liberman et al. (6), MR-guided vacuum-assisted breast biopsy could be performed successfully (96% success rate) and with a small risk of failure (one case with a minor complication of a hematoma).

Components of MR-guided vacuum-assisted breast biopsy include a breast compression grid that attaches to a breast coil, a single-use MRI-safe introducer kit, and a handheld vacuum assisted biopsy device hand-

piece (Figs. 5 and 6). Components of the ATEC® introducer set (Suros Surgical Systems) include a needle guide, a coaxial introducer sheath, a sharp nonferrous inner stylet, and a plastic localizing obturator (Fig. 6). These components provide access to the target lesion and verification of sheath placement. The combined introducer sheath and stylet allows access to the biopsy site while minimizing fluid egress. The non artifact-producing localizing obturator identifies the position of the sheath in reference to the target lesion on axial view and appears as a signal void on the image screen in the sagittal view. The tip of the obturator corresponds to the center of the sampling chamber once the obturator is removed and the sampling device is inserted through the sheath. The ATEC® vacuum-assisted breast biopsy handpiece is MR-compatible and has a rotating the handpiece allows to be positioned in any 360° position for sampling tissue. A pneumatic drive and vacuum tubing connect the handpiece to the console unit to provide a means by which to continuously sample tissue and aspirate and lavage the sampled tissue through the cutting chamber with lidocaine and saline. The tissue specimens are automatically delivered to a collection chamber.

This method of vacuum-assisted breast biopsy takes less time to acquire tissue (12 - 14). For example, MR-guided core needle biopsy of single lesions required 45 and 55 min on average in two prior published studies,

compared with 35 and 38 min for single lesions using MR-guided vacuum-assisted breast biopsy (13, 14).

CONCLUSION

MR CAD system is a promising technique to detect breast carcinoma and to assess the extent and occult multicentricity. In addition, MR-guided vacuum-assisted breast biopsy assisted with MR CAD system is a safe tissue sampling method for suspicious MR-detected lesions.

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