Clinical MR-Mammography:

Are Computer-Assisted Methods Superior to Visual or Manual Measurements for Curve Type Analysis? A Systematic Approach[1]

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Rationale and Objectives. Enhancement characteristics after administration of a contrast agent are regarded as a major criterion for differential diagnosis in magnetic resonance mammography (MRM). However, no consensus exists about the best measurement method to assess contrast enhancement kinetics. This systematic investigation was performed to compare visual estimation with manual region of interest (ROI) and computer-aided diagnosis (CAD) analysis for time curve measurements in MRM.

Materials and Methods. A total of 329 patients undergoing surgery after MRM (1.5 T) were analyzed prospectively. Dynamic data were measured using visual estimation, including ROI as well as CAD methods, and classified depending on initial signal increase and delayed enhancement.

Results. Pathology revealed 469 lesions (279 malignant, 190 benign). Kappa agreement between the methods ranged from 0.78 to 0.81. Diagnostic accuracies of 74.4% (visual), 75.7% (ROI), and 76.6% (CAD) were found without statistical significant differences.

Conclusions. According to our results, curve type measurements are useful as a diagnostic criterion in breast lesions irrespective of the method used.

Key Words. Computer-aided diagnosis, computer-assisted diagnosis, CAD, breast MRI, dynamic enhancement pattern, kinetics, curve type analysis, sensitivity and specificity.

Magnetic resonance mammography (MRM) is regarded as the most sensitive method for detection of breast cancer (1,2). To differentiate between benign and malignant lesions, repetitive measurements after bolus injection of contrast agents are performed. Several investigations have confirmed the initial report on this matter in 1989 (3–6). Additionally, successful attempts for a more sophisticated assessment of tumor enhancement characteristics using fast sequences or pharmacokinetic modeling of signal intensity time changes have been described. These techniques could also be combined, leading to good sensitivities and specificities. However, overlapping enhancement characteristics between benign and malignant lesions remain (7–10). For an increased diagnostic value of MRM, several morphologic criteria have been implemented into clinical routine (11–17). To standardize the process of reading a study, clinical scoring systems as well as a Breast Imaging and Reporting Data System (BIRADS) lexicon integrating morphological and kinetic criteria have been published (13,16,18,19). For this purpose, dynamic measurements using both a high temporal and spatial resolution seem to be feasible to assess both kinetic and morphological information. With restrictions, time curves can be regarded as quantitative data, which can be used as an objective basis for diagnosis. The most frequently used method to assess these data under clinical

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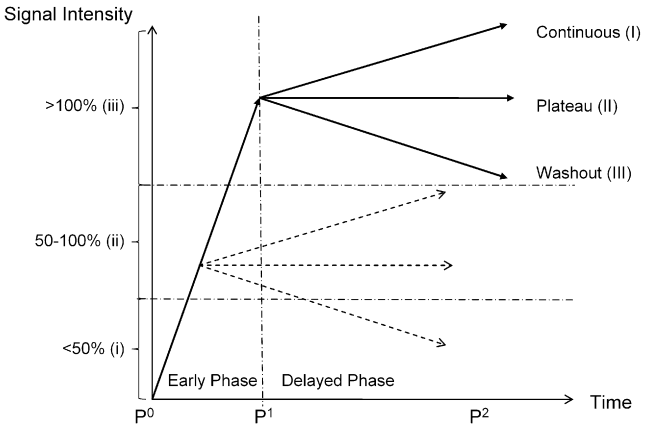

Figure 1. Time curve categorization scheme. Initial and delayed phase enhancements are divided by P^1, set to the first minute after contrast agent administration in this investigation. Initial enhancement can be described as not significant (<50%: i), intermediate (50–100%: ii) or strong (>100%: iii). Delayed phase enhancement can be described as continuous (I), plateau (II), or washout (III).

conditions is the placement of several regions of interest (ROI) in the strongest enhancing part of a lesion. This approach is described as time consuming and may lead to mistakes because of the inhomogeneity of lesions analyzed (20). There have been reports about visual assessment of curve types with good diagnostic results (12,13,21,22). This method is much faster compared to the ROI method, but has not been validated in systematic comparisons yet. In the last years, computer-assisted diagnosis (CAD) systems have been introduced (23–25). These systems offer the opportunity of semiautomatic time curve analysis and are believed to shorten and standardize the process of reading a study. Initial results in small patient groups found a comparable diagnostic value of CAD compared to ROI analysis (23,24,26). Furthermore, CAD analysis requires a dedicated workstation and dynamic data have to be computed before the radiologist is able to read a study. Shortening enhancement analysis is of special importance as enhancement characteristics are regarded as only one major diagnostic criterion among others to differentiate enhancing lesions (1,2).

Therefore, it is important to identify the best method to be used for contrast enhancement assessment in a clinical setting. This prospective investigation was performed to systematically identify and compare the diagnostic accuracy of visual, ROI, and CAD methods for time curve measurements in the same patient collective.

METHODS AND MATERIALS

Patients

Eligible for this investigation were all 329 consecutive female patients who underwent surgery of breast lesions after MRM in the gynecological department of our university between January 2005 and October 2006. Their age ranged from 15 to 83 years, with a mean value of 55.3 years. Indications for MRM were unclear or suspect findings in x-ray mammography or in ultrasound of the breast. Ninety-four patients had biopsy before MRM that confirmed 81 malignant and 13 benign lesions. Examinations after preoperative (neoadjuvant) chemotherapy were excluded from this work. No other inclusion or exclusion criteria were used. Ethical review board approval was obtained for this prospective analysis of previous acquired examinations. All patients gave their informed consent for the examination.

Magnetic Resonance Imaging Scanner and Imaging Technique

A 1.5 T Magnetom Symphony and a 1.5 T Magnetom Sonata (Siemens, Erlangen, Germany) were used. The standard imaging protocol in all examinations with the patient in prone position started with a native axial T1-weighted spoiled gradient echo sequence (Fast Low Angle Shot [FLASH], GeneRalized Autocalibrated Partial Parallel Acquistion [GRAPPA] factor 2, repetition time 113 ms, echo time 5 ms, flip angle 80°, 1.1 × 0.9 × 3 mm, slice thickness 3 mm, 33 slices). Afterwards, 0.1 mmol/kg body weight of gadopentetate dimeglumine (Magnevist, Schering, Germany) was administered intravenously as a rapid bolus (3 mL/second), performed by an automatic injector (Spectris, Medrad, Pittsburgh, PA), followed by 20 mL saline solution. Thirty seconds after contrast agent injection, dynamic scanning followed with the same sequence parameters under identical tuning conditions at 1-minute intervals for a total of seven measurements. The dynamic scan was followed by an axial T2-w turbo-spin-echo sequence in identical slice positions (GRAPPA factor 2, repetition time 8900 ms, echo time 207 ms, flip angle 90°, spatial resolution 0.8 × 0.7 × 3 mm, 33 slices, time of acquisition 2.15 minutes). Precontrast images were subtracted from the postcontrast dynamic images for improved lesion detection.

Time Curve Categorization

To compare visual assessed dynamic data with ROI and CAD measurements, time curves were categorized by one pre- (P°) and two postcontrast time points (P^1 early, P^2 delayed). A P^1 at the first and P^2 at the last time point of our image acquisition protocol (1 minute and 7 minutes, respectively) were considered. The initial signal intensity change between P° and P^1 was divided into three categories: (i) <50% (not significant), (ii) 50–100% (intermediate), and (iii) >100% (strong). The delayed time curve type (signal change between P^1 and P^2) was described by (I) continuous increase ($P^2 > (P^1 + 10\%*P^1)$), (II) plateau ($P^2 = (P^1 \pm 10\%*P^1)$),