Accelerating contrast-enhanced MR mammography readout using the three-time-point method

S. Maderwald[1], E. A. Haut[1], C. Stockamp[1], A. Muehler[2], M. E. Ladd[1], J. Barkhausen[1]

[1]Department of Diagnostic and Interventional Radiology, University Hospital Essen, Essen, Germany, [2]3TP LLC, Southampton, New York, United States

Introduction:

The high sensitivity (above 90%) of MRM must be considered the major advantage of this technique; however, the considerable time necessary for reading and postprocessing, as well as the only moderate specificity (varying results: 37%-86%), must still be considered as important limitations. Studies by Degani et al. [1] and Furman-Haran et al. [2] developed a parametric method for diagnosis of breast lesions. This method is based on high-spatial-resolution images obtained at three judiciously selected time points (one pre-contrast and two post-contrast). The enhancement rate, defined by the intensity difference between the first two time points, is coded by color intensity, and the change in enhancement between the second and third time points is coded by color hue. Breast lesion identification and classification can be automated and enables differentiation between benign breast lesions and carcinoma. The aim of this prospective study was to evaluate the accuracy of the three-time-point (3TP) method for detection and characterization of breast lesions in contrast-enhanced MR mammography.

Methods and Materials

40 female patients (age range: 32-78 years; mean: 52 years) with suspicion of breast lesions were included into this study. All exams were performed using a 1.5 Tesla scanner (SIEMENS Magnetom Sonata) and a dedicated receive-only breast coil (Phased Array Breast Coil; Siemens, Erlangen). 0.1 mmol/kg bodyweight Gadopentate dimeglumine (Magnevist®; Schering, Berlin, Germany) was administered at 2 ml/sec using an automated injector (MEDRAD®, Pittsburg). The parameter settings for the 3D gradient-echo sequence were TR/TE 11/4.76 ms, flip angle 15°, FOV 370 mm^2, GRAPPA R = 2, matrix size 384 x 365, and a slice thickness of 2 mm. Six 3D data sets containing 88 slices and requiring 2 min per acquisition were obtained before (t0) as well as 0 (t1), 2 (t2), 4 (t3), 6 (t4) and 8 (t5) minutes following contrast injection.

A commercially-available implementation of the 3TP-method (3TP Imaging Sciences, 3TP LLC, Southampton, New York) was used for automated image analysis. The 3TP-method was used to analyze both a “primary” series (t0, t2, t4) and a “delayed” series (t0, t3, t5). The signal intensity changes between the three time points of the “primary” and “delayed” series were coded on a pixel by pixel basis. For example, for the “primary” series, the rates of enhancement in the time interval between t0 and t2 were coded by color intensity from dark to bright (slow to fast rate). The enhancement patterns during the second time interval between t2 and t4 were coded with three color hues: blue for an increase in signal intensity (benign); green for no significant change (± 10%) (uncertain lesion classification); and red for a decrease (wash-out) in signal intensity (malignant). This resulted in color hue and intensity coded images (Fig. 1). An automated motion correction was performed prior to color coding.

The results of the 3TP-method were compared to the standard reading procedure, which included comparison of pre- and post-contrast images on an interactive workstation and the analysis of enhancement patterns using the standard ROI-method [3]. All lesions were classified either as definitely malignant, uncertain, or definitely benign. For the 3TP-method, when a lesion showed both red and green pixels, the lesion was considered to be “red” (malignant). When a lesion showed both green and blue pixels, the lesion was classified “green” (uncertain). Additionally, the lesions were histopathologically verified in 16 of the 40 patients.

Results:

120 lesions were found in 40 patients (average 3 per patient, range 0 to 11). In 117 (97%) of all 120 lesions, the results of the ROI and the 3TP analysis were equivalent. Of the 29 histologically-proven malignant lesions, 8 were classified as high-intensity “red” by 3TP (Fig. 2) and 21 were classified as either high- or medium-intensity “green”. 2 of 77 “blue” lesions were proven benign by histopathology (Fig. 3). The results in the “delayed” series did not change lesion classification compared to the “primary” series.

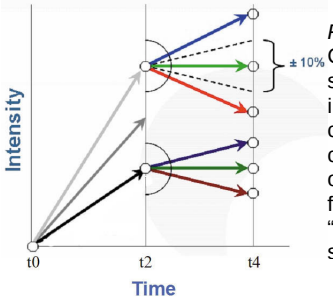

Fig 1: Color-coding scheme for interpreting the color hue and color intensity of 3TP images for the “primary” series.

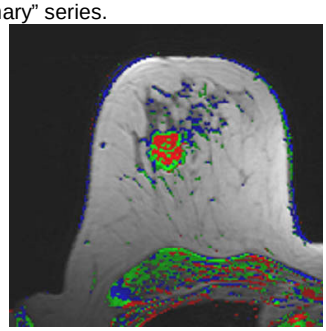

Fig 2: 64 year old woman with invasive ductal cancer in the right breast. 3TP MR image shows lesion of predominantly central bright red and peripheral green pixels.

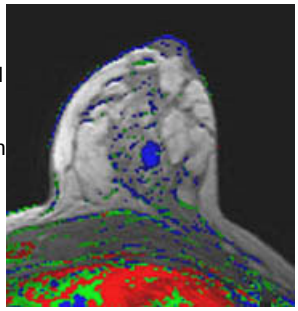

Fig 3: 35 year old woman with fibroadenoma in the left breast. 3TP MR image shows bright blue pixels in the whole lesion.

Discussion:

The blood vessel surface area and the extracellular volume fraction accessible to the contrast agent are the parameters that characterize malignant tumors and allow them to be differentiated from benign lesions. Both malignant and benign lesions demonstrated “green” behavior, but the intensity of the green and its distribution in space appeared to be different between benign and malignant lesions. In this study, the comparison between the results of the ROI-method and the 3TP-method led to an agreement of 97%, indicating that the 3TP-method reliably converts the kinetic information of the ROI-method into color overlay images. The evaluation of multiple enhancing breast lesions with the manual ROI-method is very time consuming and in clinical routine sometimes impractical, especially for very small lesions. The 3TP-method brings the information of many images into one easy-to-read format, and provides an automated, pixel-based method for lesion classification.

References:

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