Evaluating the diagnostic performance of computed diffusion-weighted MR imaging in the detection of breast cancer

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TARGET AUDIENCE:

Radiologists and physicists with an interest in diffusion weighted (DW) MR imaging and breast MR.

BACKGROUND: Diffusion-weighted (DW) MR is gaining importance in breast imaging and provides complementary information to standard dynamic contrast enhanced (DCE)-MRI. DW MR has been shown to improve diagnostic specificity and confidence when combined with DCE-MRI[1]. A standard single-shot echo-planar DW MR sequence can be performed in a few minutes and b values of 0-850s/mm^2 and up to 1000s/mm^2 are currently favoured with at least three values desirable to ensure robustness and ADC reproducibility[2-4]. Normal breast fibroglandular tissue is often incompletely suppressed at b values in the range 850-1000s/mm^2 thereby limiting the contrast between malignant and normal tissues. Although imaging at b values >1000s/mm^2 is desirable, it can be limited on clinical systems due to low signal-to-noise ratio (SNR) and eddy currents induced distortions. Computed DW Imaging (cDWI) is a mathematical computation technique that builds on previously described principles[5] and calculates a high b value image from DW MR images acquired with at least two different lower b values. Computed b-value images of 2000s/mm^2 have been shown to improve the diagnostic performance in whole body malignancy[6]. More recently, computed b-values of >1000s/mm^2 was shown to improve image quality and tumour detection in prostate cancer[7,8]. However, to our knowledge, cDWI has not yet been investigated for the evaluation of breast malignancy.

PURPOSE: The aim of this study was to evaluate the diagnostic sensitivity of cDWI for the detection of breast cancer compared with DCE-MR imaging.

METHODS:

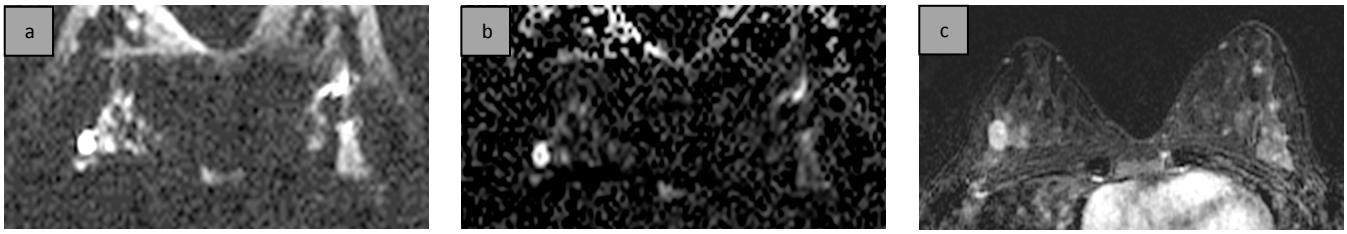
Research ethics committee approval was obtained for this retrospective review but patient informed consent was waived. 41 women median age 45 years (range 26-80 years) underwent breast MR between January 2011-March 2012, including 20 patients with breast cancer and 21 non-malignant cases on either a 1.5T Siemens Aera (n=23) or a 1.5T Siemens Avanto (n=18) (Siemens Medical Systems, Erlangen, Germany). A diffusion weighted sequence was obtained prior to a DCE sequence. Bilateral axial sections were acquired with 4 b values (0, 350, 700, 1150). A single shot echoplanar sequence, with SPAIR for fat suppression and sequence parameters repetition time (TR) 5600ms, echo time (TE) 86ms, 340mm field-of-view (FOV), 5mm slice thickness with 0 slice gap, bandwidth 1628Hz, 3 excitations with the gradients applied in a trapezoidal direction, a 1.8x1.8x5mm acquisition voxel and acquisition time 3.16 minutes was used on the Aera. A single shot echoplanar sequence with inversion recovery for fat suppression and sequence parameters TR 6300ms, TE 83ms, inversion pulse 180°, 340mm field-of-view, 5mm slice thickness with 0 slice gap, bandwidth 1628 Hz, 3 excitations with the gradients applied in a trapezoidal direction, a 2.7x2.7x5 acquisition voxel and acquisition time 5.34 minutes was used on the Avanto.

The image sets were reviewed by a radiologist (EO'F) with 3 years' experience who was blinded to the clinical diagnoses and all imaging findings. Four image sets were read on each patient in alphabetical order: (a) acquired b value of 1150s/mm^2, (b) computed b value of 1500 s/mm^2, (c) computed b value of 2000s/mm^2 and (d) DCE-MR. For each image set the following were assessed: malignant lesion detection using a 5 point scale (5= definite malignancy, 4= probable malignancy, 3=indeterminate, 2= probably not malignancy, 1=definitely not malignant). For cDWI and standard DW MR image sets quality (four-point scale: 4=excellent, 3=good, 2=moderate, 1=poor) and suppression of background signal (four-point scale as previously) were documented. Malignant lesion detection between the three DW MR image sets was compared with DCE-MR and final surgical histology. Mean scores for image quality and suppression of background signal from cDWI and standard DW MR image sets were calculated. The diagnostic sensitivity of the acquired (b=1150s/mm^2), computed (b=1500 and 2000s/mm^2) images and DCE-MR images were calculated and compared by using the McNemar test (MedCalc; MedCalc software, Mariakerke, Belgium) with the assumption that a score of 4 or 5 indicated malignant disease. P<0.05 was considered significant.

RESULTS:

Evaluation of breast images with a computed b value of 2000s/mm^2 resulted in higher overall diagnostic sensitivity of 82.4% (95%CI: 56.6%-96.2%) compared with images with an acquired b value of 1150s/mm^2 which achieved a sensitivity of 17.7% (95%CI: 3.8%-43.4%) (p<0.0001). Intermediate diagnostic performance was achieved using a computed b value of 1500s/mm^2 with a sensitivity of 64.7% (95%CI: 38.3%-85.8%). The diagnostic sensitivity of DCE-MR was 82.4% (95%CI: 56.6%-96.2%) equalling the tumour detection rate of cDWI at a b value of 2000s/mm^2. Computed DWI images at a b value of 2000s/mm^2 produced good image quality and high background suppression (mean scores 2.6 and 3.4 respectively), which were significantly higher than the comparative scores with an acquired b value of 1150s/mm^2 (mean scores 2.1 and 2.3 respectively (both p<0.0001)).

Figure 1: Comparative (a) standard DW MR image at a b value of 1150s/mm^2, a cDWI images at (b) a b value of 2000s/mm^2 and (c) a DCE-MR image showing a tumour in the lateral right breast. Using a cDWI b value of 2000s/mm^2 gives better suppression of the normal fibroglandular tissue



DISCUSSION AND CONCLUSION:

Computed DW MR imaging in the breast using b values up to 2000s/mm^2 significantly improves tumour detection and gives better image quality and background suppression of normal fibroglandular tissue when compared with acquired standard b value images of 1150s/mm^2. cDWI holds potential as an alternative fast, non-contrast diagnostic MR technique in breast cancer diagnosis. The sensitivity of tumour detection might be increased further when reading DW MR images in conjunction with standard DCE-MR images.

REFERENCES:

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