

Readout-segmented EPI improves the diagnostic performance of diffusion-weighted MRI breast examinations at 3 Tesla

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Introduction:

To qualitatively and quantitatively compare the diagnostic value of diffusion-weighted imaging (DWI) based on standard single-shot echo planar imaging (ssEPI) and readout-segmented echo planar imaging (rsEPI) with a 2D-navigator echo [1] in breast cancer patients at 3T.

Methods and Materials:

Institutional Review Board approval and written, informed consent were obtained. Forty-seven patients with 49 histopathologically verified lesions were included in this study. In all patients and standard resolution phantoms DWI, by ssEPI and rsEPI with comparable imaging parameters, was performed on a 3T MR scanner (Trio, Siemens, Erlangen) in the same measurement time: three-scan trace diffusion schema; Stejskal-Tanner diffusion; $b=0\&850\text{ s/mm}^2$; fat suppression by inversion recovery & gradient reversal technique; TR/TE/TI=8000/minimum(67 or 59)/210ms; resolution $2\text{x}2\text{x}5\text{mm}^3$; 24 slices; 2:56 min.

Two independent readers visually assessed image quality and lesion conspicuity, and image properties (i.e. signal-to-noise ratio, contrast, geometric distortions) were quantified. Regions of interest (ROIs) were drawn in all lesions (28 malignant, 21 benign) and in the normal breast parenchyma to investigate differences in the apparent diffusion coefficient (ADC). The diagnostic accuracy was calculated based on an ADC threshold of $1.25 \times 10^{-3}\text{mm}^2/\text{s}$ [2]. The area under the curve (AUC) was determined.

Results:

There were significant differences between the ADC values for all tissue types ($p<.001$). There was no significant difference between the ADC obtained by both readers ($p=0.582$) or by either DWI method ($p=.791$). The mean difference and limits of agreement between the ADC values from both readers were 0.002 (-0.167/0.171), in units of $\times 10^{-3}\text{mm}^2/\text{s}$. The mean difference and limits of agreement between the ADC from the two DWI methods were -0.012 (-0.199/0.175), in units of $\times 10^{-3}\text{mm}^2/\text{s}$.

Each reader found a higher diagnostic accuracy for rsEPI (96%) than for ssEPI (90%). The AUC with 95% confidence intervals for the mean ADC obtained by both readers was significantly higher for rsEPI (0.981 with 0.852-0.992) than for ssEPI (0.867 with 0.701-0.925) ($p=0.026$).

The AUC was not different between the readers for rsEPI ($p=0.480$) and for ssEPI ($p=0.612$) (Figure 1).

Two independent readers rated the overall image quality ($p<.001$) and lesion conspicuity ($p<.001$) of rsEPI significantly higher than that of ssEPI (Figure 2,3). There was a high inter-rater correlation for image quality ($r=0.686$; $p<.001$), and lesion conspicuity for benign lesions ($r=0.821$; $p<.001$) and malignant lesions ($r=0.702$; $p<.001$). Geometric distortions observed on ssEPI were highest in prepectoral regions, moderate for retromamillary regions, and lowest for central breast regions ($p<.001$) (Figure 2,3). Geometric distortions for rsEPI were 3 times smaller (Figure 2,3).

The contrast of benign and malignant lesions for rsEPI was significantly better than for ssEPI ($p=.050$). There was a significant difference in contrast between malignant and benign lesions observed using rsEPI ($p=.024$), but not using ssEPI ($p=.157$). The SNR determined on rsEPI-based DWI was 44-48% lower than with ssEPI ($p<.001$).

Discussion and Conclusions:

DWI based on rsEPI provided significantly higher image quality and lesion conspicuity than ssEPI by reducing geometric distortions, image blurring, and artifact level at a clinical high-field (3T) MR scanner. Thereby, rsEPI reached a higher diagnostic accuracy for the differentiation of benign and malignant breast lesions in the same measurement time.

Fig. 1: ROC curves for differentiation of benign and malignant breast lesions based on ADC reflecting a better diagnostic performance of rsEPI compared to ssEPI. The highest diagnostic accuracy reached was with a sensitivity/specificity of 96%/95% for rsEPI (green circle) and 89%/90% for ssEPI (red circle).

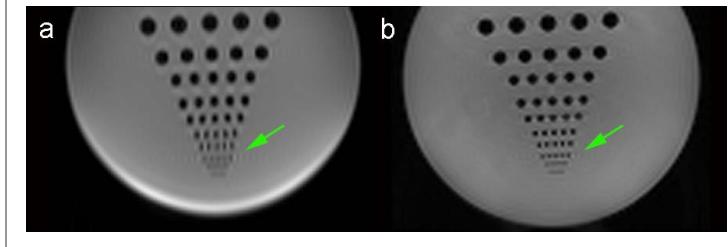
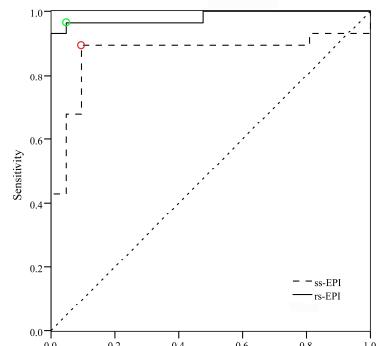
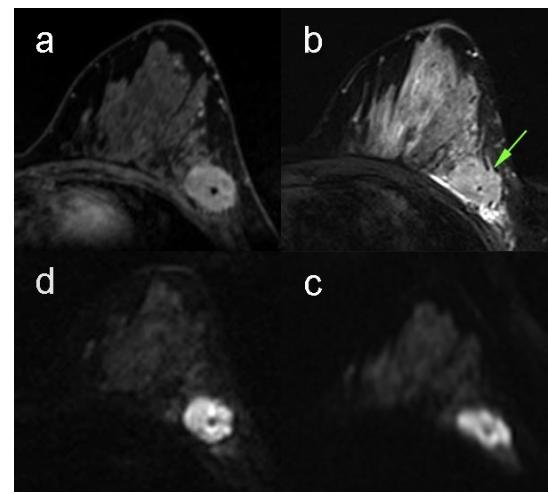


Fig. 2: Resolution phantom images acquired with (a) ssEPI and (b) rsEPI. The diameter of the structures inside the phantom ranged from 1 to 10 mm. Strong T_2^* blurring is clearly visible on (a) ssEPI compared to (b) rsEPI.

Fig. 3: Sample images of female breast cancer patient (age, 37 years; IDC grade III): (a) $T_1\text{w}$ contrast-enhanced; (b) $T_2\text{w}$ STIR; DWI ($b=850\text{ s/mm}^2$) with (c) ssEPI and (d) rsEPI. Significantly stronger geometric distortion artifacts visible on ssEPI (c) than rsEPI (d) and distortion-free reference (b). RsEPI (d) provides significantly higher anatomical detail than ssEPI (c) due to reduced T_2^* blurring.



References:

- [1] Porter, et al. MRM 2009; 62:468-475
- [2] Bogner et al. Radiology 2009; 253:341-351