High-resolution, fat-suppressed, diffusion-weighted MRI of the breast using a self-navigated multi-shot technique

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Introduction

With increasing resolution the readout time for conventional single-shot EPI lengthens to the point that blurring and geometric distortions impair image acquisition. The strong gradients needed for diffusion-weighting (DW) worsen this problem. Parallel imaging can partially reduce these distortions, which was recently shown for breast MRI, using ASSET[1]. Another approach is to use a multi-shot technique, such as SNAILS: a fat-saturated twice-refocused spin echo sequence with an analytically designed interleaved variable-density spiral readout trajectory, which has been applied successfully to high-resolution DWI in the brain[2]. Here we assess its technical feasibility in the body, for breast MRI, and compare it to ASSET-DW-EPI in healthy volunteers.

Methods

Free-breathing, axial, bilateral DW-data sets were acquired in 6 healthy volunteers on a 1.5T scanner with 5 G/cm gradients. **ASSET-DW-EPI** data sets were acquired using CHESS fat, at matrix (M)=256^2; TR/TE=2500/48ms, b=75,450s/mm^2, NEX=15, duration=2.43min; at M=128^2, TR/TE=2500/44ms, b=75,450s/mm^2, NEX=6, duration=2.13min; and at M=128^2, TR/TE=12000/72ms, b=0,75, 150,450,600,1000 s/mm^2, NEX=2, duration=2.37m. **SNAILS** data sets were acquired at M=256^2, 20 interleaves, TR/TE=2500/45ms, b=75, 450s/mm^2, NEX=1+2, acquisition duration 2.30min for bilateral breast acquisition or 5.0min for bilateral breast including both axillas; at M=256^2, 20 interleaves, TR/TE=3350/80ms, b=0,75,150,450,600,1000 s/mm^2, NEX=1, duration=6.42min; and at M=128^2, 6 interleaves; TR/TE=3350/80ms, b=0,75,150,450,600,1000 s/mm^2, NEX=1, duration=2.01min. For all sequences: slice-thickness/gap=5/0mm and FOV=24cm^2. Apparent diffusion coefficient (ADC) maps were calculated on a pixel-by-pixel basis by fitting signal intensities to the Stejskal-Tanner equation using a least-squares approach.

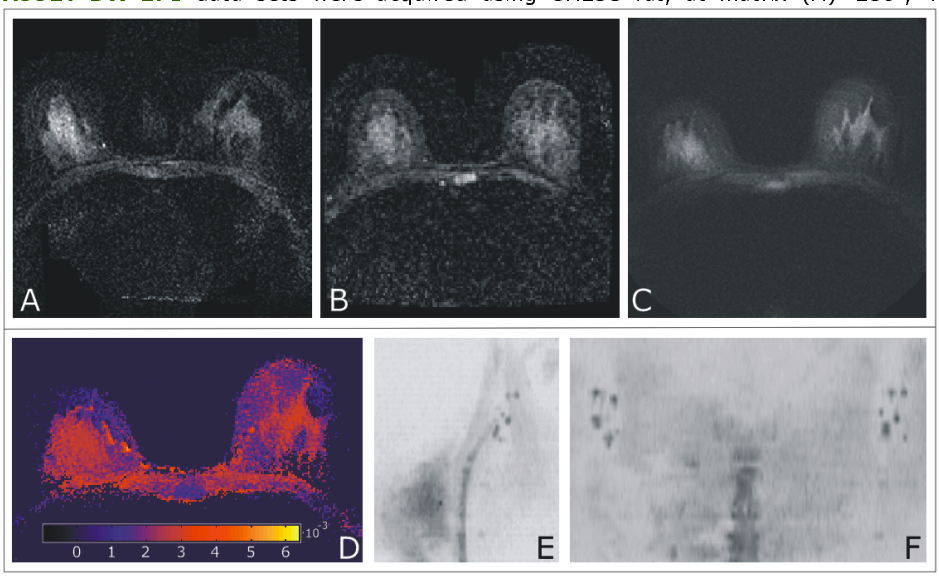

Fig 1. High-resolution DWI of the breast at 1.5T; **A.** 256x256 ASSET-DW-EPI, severely distorted, despite parallel imaging; **B.** 128x128 ASSET-DW-EPI; **C.** 256x256 SNAILS-DWI. **D.** ADC map from C. **E+F.** High-resolution SNAILS data set allows multiplanar reformats, clearly showing axillary lymph nodes on both unilateral sagittal MIP (E) and coronal chest-wall MIP (F).

Results & Discussion

Fig.1 A to C show ASSET-EPI and SNAILS diffusion-weighted images. ASSET allowed acquisition of 128x128 DW-EPI data sets, with minimal distortion. Even with ASSET, DW-EPI was not possible at a 256x256 matrix size. SNAILS allowed distortion free acquisition of 256x256 resolution images. In addition, the high resolution and relative insensitivity to motion of SNAILS, allowed for high quality multiplanar reformats, shown in Fig 1 with the 'PET-like' contrast-reversal now popular in DWI screening studies[3]. Table 1 shows the ADC values of fibroglandular tissue and pectoralis muscle. For SNAILS there was no significiant difference in ADC values measured at 256x256 or at 128x128 matrix size. For DW-EPI ADC values could not be reliably determined at 256x256 matrix size; The values obtained with DW-EPI at 128x128 resolution fall within the range of values reported in the literature, which vary mainly with varying b-value. The results suggest that with identical prescribed b-values, difference in sequence design can cause within-subject variation of ADC values. In our case these difference may be explained by the lower imaging gradients needed for spiral versus EPI acquisition.

Table 1 – ADC values in fibroglandular breast tissue and in pectoralis muscle

	Fibroglandular tissue (n=6)				
	SNAILS 256^2 b=75,450	SNAILS 256^2 b=0..1000	SNAILS 128^2 b=0..1000	DW-EPI 128^2 b=0..1000	DW-EPI 128^2 b=75,450
ADC ± SD (10^{-3} mm^2/s)	2.70 ± 0.12	2.04 ± 0.23	2.11 ± 0.24	1.77 ± 0.27	2.09 ± 0.64
	Muscle (n=6)				
	SNAILS 256^2 b=75,450	SNAILS 256^2 b=0..1000	SNAILS 128^2 b=0..1000	DW-EPI 128^2 b=0..1000	DW-EPI 128^2 b=75,450
ADC ± SD (10^{-3} mm^2/s)	2.13 ± 0.15	1.31 ± 0.21	1.39 ± 0.22	1.06 ± 0.14	1.84 ± 0.56

b=75,450: 2 b-values: 75 and 450 s/mm^2.
b=0..1000: 6 b-values: 0, 75, 150, 450, 600 and 1000 s/mm^2.

Conclusion

Free-breathing, high-resolution DWI of the breast using SNAILS, is feasible at clinically available gradient-strengths, within reasonable acquisition-times.

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