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Meeting abstract

2135 Rapid 3D vessel wall imaging at 3 T: optimization and evaluation of diffusion preparation

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Introduction

Multi-contrast MRI is widely used to image the vessel wall and characterize the composition of atherosclerotic plaques. Standard protocols use 2D multi-slice fast spin echo (FSE) with either double inversion recovery (DIR) [1] or flow saturation bands preparation for blood suppression. 2D methods lack contiguous coverage and suffer from partial voluming affecting plaque quantitation. 3D methods cannot be robustly combined with DIR preparation due to lingering signal from stagnant flow. An alternative preparation dubbed "diffusion sensitizing gradients" (DSG) causes significant dephasing of flowing spins [2], and has also been applied in the carotids with 3D-SSFP imaging [3] which has a restricted set of contrast variations and 2D-FSE imaging [4]. In this work, we optimize and evaluate the performance of DSG in conjunction with 3D inner volume imaging (IVI) FSE [5,6] at 3 Tesla.

Methods

Experiments were performed on a Signa Excite 3 T scanner (GE Healthcare) using a 4-channel carotid array coil (Pathway MRI). The imaging sequence (Fig. 1) consisted of 3 modules: DSG (or DIR) preparation, fat saturation and 3D-IVI FSE imaging. Relevant scan parameters are summarized in Table 1. DSG preparation consists of 3 hard pulses 90_x-180_y-90_{-x} with gradients before and after the 180° pulse applied on all three axes, and spoiler gradients. The area of the DSG gradients applied on the z-axis was roughly 4 times as the area on x/y-axes. The 3D-IVI FSE imaging module is a variant of typical FSE imaging with excitation and refocusing pulses applied along orthogonal axes.

Optimization of DSG

Increasing the DSG gradient area (and hence the b-value) increases the dephasing of flowing spins, but also

Table 1: Sequence parameters for the various sequences

Parameters	3D IVI FSE +DSG prep	3D IVI FSE +DIR prep	2D Multi-slice + DIR prep
Selection Dimensions	∞ × 30 mm × 16 mm	∞ × 30 mm × 16 mm	∞ × ∞ × 16 mm
DIR Section Thickness	-	24 mm	7.5 mm
FOV	16 × 6.4 × 2 cm^3	16 × 6.4 × 2 cm^3	16 × 16 cm^2
Acquisition Matrix Size	320 × 128 × 8	320 × 128 × 8	320 × 320
Resolution	0.5 × 0.5 × 2.5 mm^3	0.5 × 0.5 × 2.5 mm^3	0.5 × 0.5 × 2.5 mm^3
Effective TE	5.8 ms	5.8 ms	5.8 ms
TR	1 R-R	1 R-R	1 R-R
ETL	10	10	10
ESP	5.8 ms	5.8 ms	5.8 ms

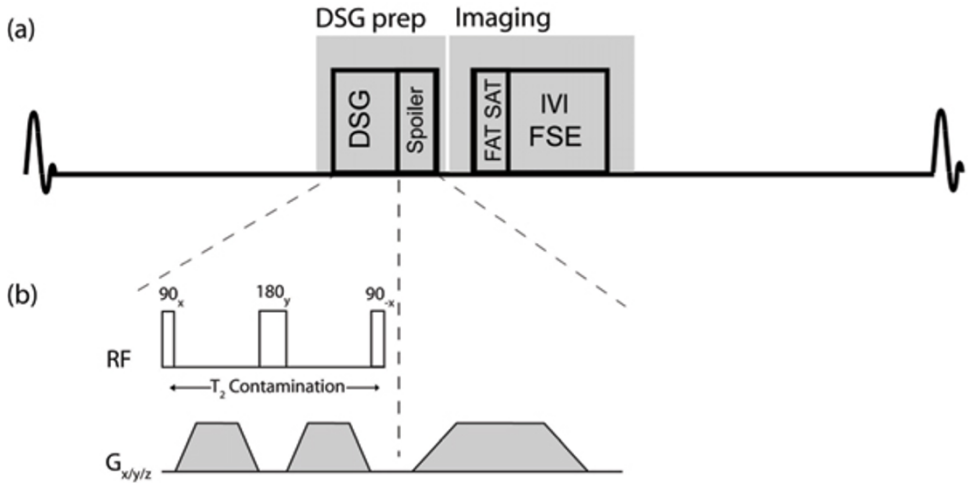

Figure 1
(a) ECG timing graph. (b) DSG prep. The proposed pulse sequence is cardiac gated and consists of diffusion sensitizing gradients preparation (DSG prep), fat saturation (FATSAT) and a 3D inner volume imaging-fast spin echo (IVI-FSE) acquisition.

increases the T2 weighting (reducing vessel wall signal). There is a known tradeoff between maximizing vessel wall signal and minimizing the luminal blood signal. In this study we optimized the contrast between the vessel wall and luminal blood as function of the b-value based on in-vivo measurements in one healthy volunteer. The DSG optimization procedure involved obtaining images with a range of b-values, segmenting the vessel wall and lumen, and identifying b-values that maximized lumen-wall contrast along with minimizing the lumen signal.

Evaluation of DSG

3D IVI FSE with DSG preparation was compared with 3D IVI FSE with DIR preparation and conventional 2D multi-slice FSE with DIR preparation in 1 healthy volunteer [Age: 33 Sex: M].

Results and discussion

The plot containing wall-lumen contrast as a function of the b-value is shown in Figure 2. Figure 3 contains a single T1-weighted slice of the carotid arteries just above the bifurcation from a healthy volunteer. Table 2 contains measurements of the luminal and vessel wall SNR along with CNR between the vessel wall and the lumen. DSG 3D and DIR 2D provided a comparable level of blood suppression, with both being significantly better than DIR 3D. These inferences are supported quantitatively by the luminal SNR measurements: (read DSG vs. DIR) 9.8 vs. 12.55. The vessel wall signal loss due to T2 decay was minimal with the optimal b-value of 3.6 s/mm2. Vessel wall SNR for the DSG preparation was 30.34 as compared to 33.2 from DIR preparation.

Conclusion

We demonstrate an 84-second acquisition of 3D bilateral carotid vessel-wall data with 0.5 × 0.5 × 2.5 mm 3 resolution over a 16 × 6.4 × 2 cm 3 FOV, with vessel wall-lumen CNR > 20. 3D acquisitions are combined with DSG preparation for robust blood suppression relative to DIR.

Table 2: SNR and CNR comparison.

	3D IVI FSE + DSG prep	3D IVI FSE + DIR prep	2D Multi-slice + DIR prep
Vessel Wall SNR	30.34	33.2	17.87
Lumen SNR	9.8	12.55	6.0
Wall-Lumen CNR	20.5	20.66	11.8

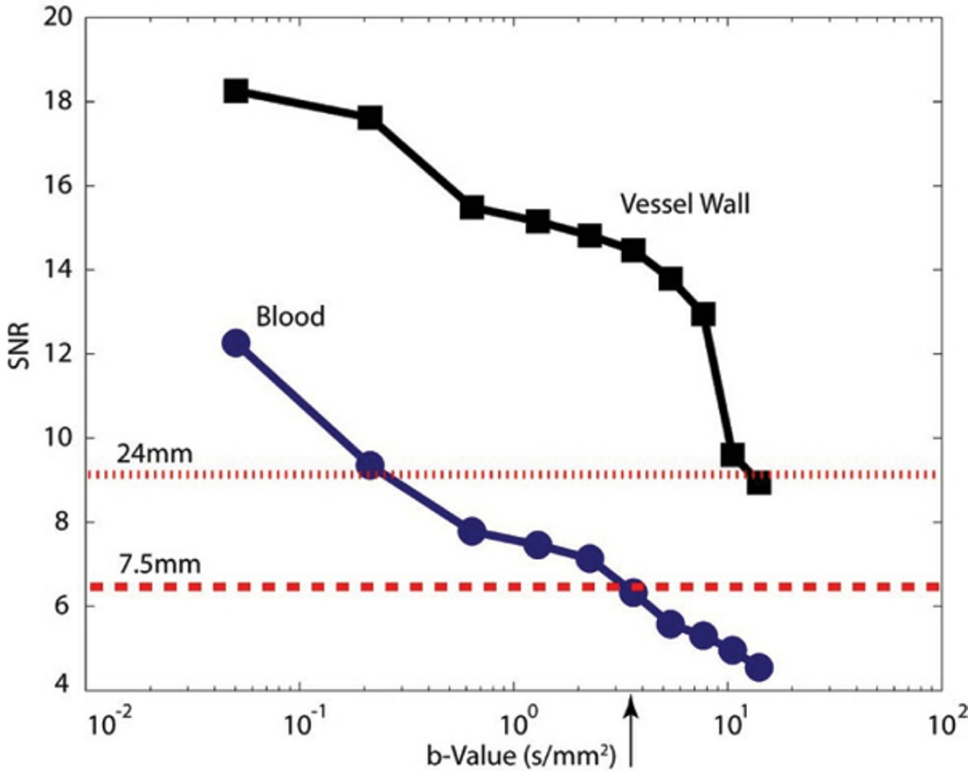

Figure 2
The effect of DSG prep on blood and vessel wall signal. The two red lines indicate the DIR blood signal at 24 mm (used in 3D mode) and 7.5 mm (used in 2D mode) inversion slab thicknesses. Blood signal (blue) decreases with higher b-value and is comparable to DIR blood signal (red) at 7.5 mm inversion slab thickness when b > 2 s/mm2. Vessel wall signal (black) experiences the expected attenuation due to T2 decay at low b-values, and greater attenuation when b > 10 s/mm2. Arrow on the b-Value axis indicates the optimal sensitization.

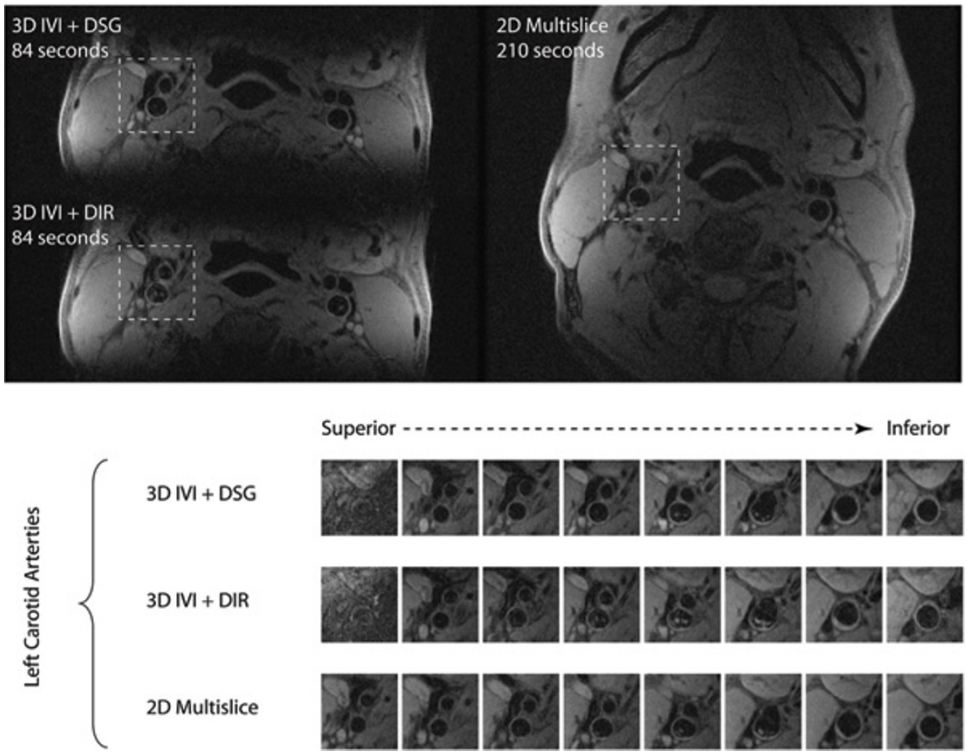

Figure 3
T1 weighted images from a health volunteer at the bifurcation of the right carotid artery using the proposed 3D IVI FSE + DSG preparation, 3D IVI FSE + DIR preparation, and conventional 2D Multislice methods. The 3D IVI + DIR approach shows artifacts from incomplete blood suppression. The most superior slice acquired using the 3D schemes suffer from noticeable aliasing artifacts.

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