Improved Motion-Sensitized Driven-Equilibrium (iMSDE) Prepared 3D GRASE for High Field Magnetic Resonance Imaging of Carotid Artery Wall

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INTRODUCTION: Current carotid artery wall imaging protocols commonly use 2D turbo spin echo (TSE) sequences. They are, however, compromised by long scan times, often leading to limitations in the number of slices that can be collected and the slice spatial resolution of the resulting images. In addition, at high magnetic field strengths the power deposited by the imaging sequence further limits the speed of data acquisition. Compared with 2D TSE, three-dimensional gradient and spin echo (3D GRASE) [(1)] imaging may provide higher resolution in the slice-select dimension with better SNR, and therefore may be advantageous in carotid wall MRI. Conventionally, double inversion recovery (DIR) or inflow saturation black-blood (BB) techniques have been employed to suppress the blood signal. However, the BB efficiency of these techniques can be compromised by artefacts caused by a low replenishing rate of turbulent blood. Additionally, multi-slice implementations of these techniques can reduce the blood suppression effect as the number of slices is increased within a single repetition time (TR) interval. Recently, the alternative BB preparation techniques of motion sensitive driven equilibrium (MSDE) and improved MSDE (iMSDE) have been proposed for vessel wall imaging [(2)]. The flow-crushing gradient pair introduced to create flowing-spin phase dispersion in the MSDE module has improved BB characteristics over DIR and inflow suppression, especially in 2D multi-slice or 3D multi-slab acquisitions. The purpose of this study is to combine the iMSDE BB module with a 3D GRASE imaging readout to create a robust clinically relevant protocol that is more time efficient in its data acquisition, less demanding in RF power deposition, and with improved BB characteristics at high field, in order to better differentiate vessel wall from lumen. T_1, T_2 and proton density weighted 3D GRASE images were acquired for comparison with the corresponding images from DIR and iMSDE 2D TSE techniques.

METHOD:

3D GRASE is a hybrid imaging sequence of 3D TSE and EPI. 3D GRASE acquires k-space more efficiently than 3D TSE, and therefore has less RF power deposition. Based on the phase-encode ordering, 2D GRASE is sensitive to ghosting caused by off-resonance effects, or by modulation via T_2 decay, or both. However, 3D GRASE suffers from much less T_2-decay ghosting than 2D GRASE since it is possible by judicious phase encode coverage strategies to decouple the off-resonant phase evolution and T_2 decay. Here we used an iMSDE-prepared multi-slab 3D GRASE sequence, acquired using a 3T Siemens Verio scanner, to study seven healthy volunteers with a 4-ch Siemens neck coil.

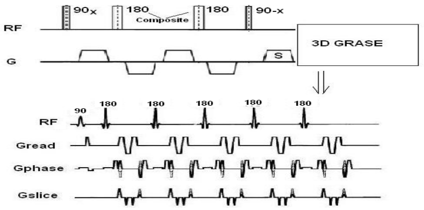

Fig. 1: iMSDE BB preparation (upper) and 3D GRASE readout (lower) vessel wall sequence

RESULTS: No breath-holds and no ECG triggering have been applied to all imaging acqusition.

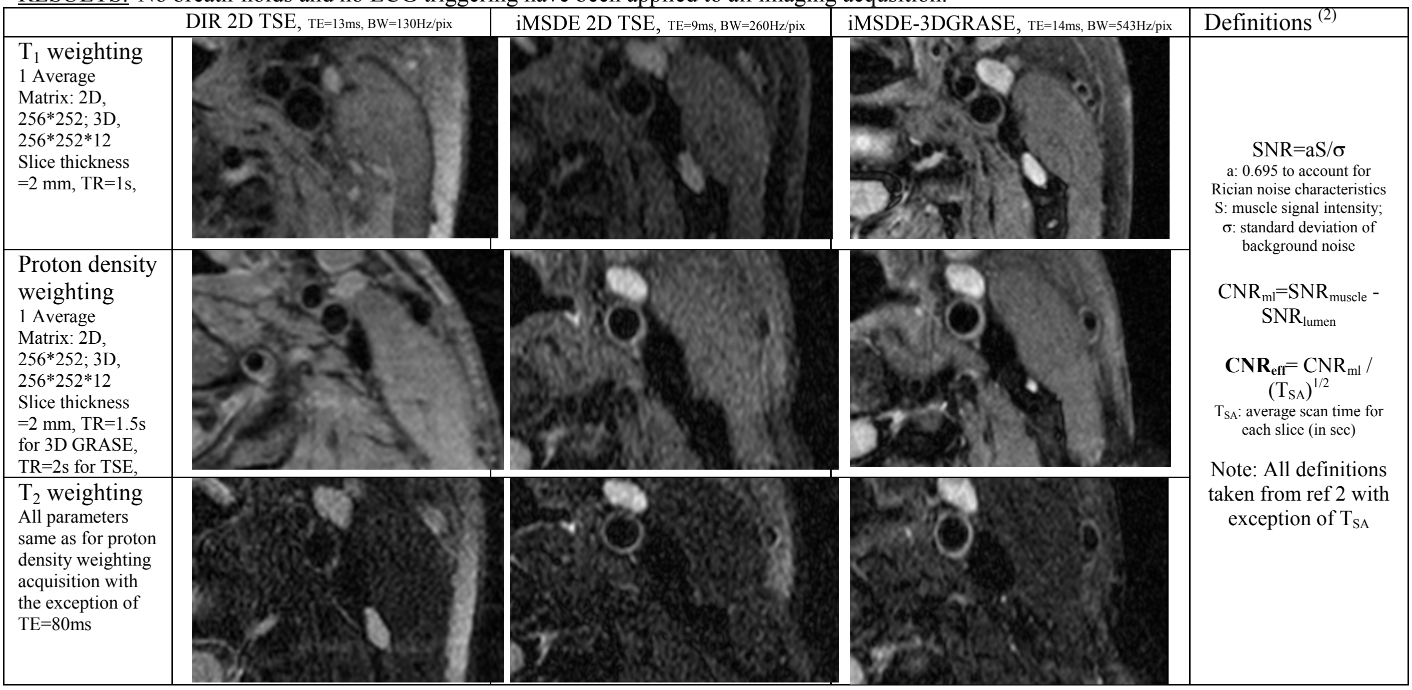

Figure 2: Image quality and BB suppression comparison of DIR 2D TSE, iMSDE 2D TSE and iMSDE 3D GRASE

DISCUSSION: It can be seen from Fig. 2 and from Table 1 that iMSDE-3D GRASE for black blood imaging is a robust clinically relevant imaging technique that is more time efficient in data acquisition, less demanding in RF power deposition, and with effective BB characteristics at high field, when compared to standard 2D DIR or MSDE acquisitions.

T_1 Weighted	SNR	CNR_{ml}	AcqTime(s)	Acq speed (Secs/Slice)	**CNR_{eff}** (CNR_{ml} /Acqspeed $^{1/2}$)
iMSDE_3DGRASE	8.5	7.4	144(2'24")	18	1.7
DIR_2DTSE	10	8.3	333(5'33")	37	1.3
iMSDE_2DTSE	5	4	72(1'12")	9	1.3
T_2 Weighted	SNR	CNR_{ml}	AcqTime(s)	Acq speed (Secs/Slice)	**CNR_{eff}** (CNR_{ml} /Acqspeed $^{1/2}$)
iMSDE_3DGRASE	3	2	183(3'03")	11.4	0.6
DIR_2DTSE	3	1	138(2'18")	46	0.2
iMSDE_2DTSE	2.4	<1.6	144(2'24")	9	0.5
Pd Weighted	SNR	CNR_{ml}	AcqTime(s)	Acq speed (Secs/Slice)	**CNR_{eff}** (CNR_{ml} /Acqspeed $^{1/2}$)
iMSDE_3DGRASE	10.8	8.1	219(3'39")	13.6	3
DIR_2DTSE	15.5	7	222(3'42")	74	1
iMSDE_2DTSE	5.2	4.9	144(2'24")	9	1.7

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