Three Dimensional Carotid Wall Imaging at 3T using a new muti-channel surface coil

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Introduction: MRI has demonstrated the potential to depict and characterize carotid atherosclerotic plaques. Recently, studies have indicated that 3T imaging may allow for improved image quality than at 1.5 T [1,2] and that three-dimensional (3D) MRI methods – rather than conventional 2D methods – can be used to depict the arterial wall and plaque with black blood image contrast [3]. The purpose of this study was to compare the performance of a new paired 2-element phase array 3 Tesla carotid coil with 1.5T using 3D variable flip-angle turbo spin-echo (SPACE) acquisition.

Methods: Imaging Experiment Carotid wall imaging was performed in healthy volunteers on whole-body 1.5T and 3.0T clinical scanners (MAGNETOM Avanto and Trio, Siemens; Erlangen, Germany). At both magnetic field strengths, radiofrequency excitation was performed using the system's integrated body coil, while image reception was performed with a pair of dedicated 2 channel phased-array surface coils (Machnet, The Netherlands) placed adjacent to the subject's neck. Imaging parameters (identical for 1.5T and 3T) for the 3D SPACE sequences were: coronal slab orientation, slab thickness = 50.4 cm, slices per slab = 56, field-of-view = 151 × 220 mm^2, matrix = 174 × 256 (i.e., voxel size = 0.86mmx0.86mmx0.9mm), repetition time/echo time (T_R/T_E) = 1590/166 ms, echo train length = 66, receiver bandwidth = 445 Hz/pixel, number of signal averages = 2, acquisition time = 4.43 min, chemically-selective fat saturation pre-pulse. Based on the initial results at 0.9mm^3 (8 mins scan time) which demonstrated ample SNR, we additionally acquired a subsequent data set with higher spatial resolution (0.7mm^3) and reduced scan time (4 mins) using parallel acquisition acceleration (GRAPPA) factor = 2, in order to further explore the potential speed and resolution benefits of the coil and field strength combination (Figure 1)

Image Analysis Contrast between the carotid wall and the lumen were calculated at four arterial locations in the axial plane: (1) common carotid artery (CCA), (2) common carotid artery (CCA)-carotid bulb junction, (3) carotid bulb (CB), and (4) internal carotid artery (ICA). Contrast was defined by the relation $(S_W-S_L)/S_L$ where S_W and S_L denote the MR signal from the carotid wall and lumen, respectively. For each location, 95% confidence intervals for the differential contrast (3T minus 1.5T) were performed to identify whether contrast was higher at 3T relative to 1.5T. Contrast gain was defined as by the relation $C_{3T}/C_{1.5T}$ where C_{3T} and $C_{1.5T}$ denote the carotid wall-lumen contrasts at 3T and 1.5T, respectively.

Results & Discussion: Typical images of the carotid arteries acquired with the 3D SPACE technique on 1.5T and 3T are shown in Figure 1. Contrast gains at 3.0T relative to 1.5T ranged from 1.96 to 3.34 (mean +/- std = 2.80 +/- 0.73). The 95% confidence intervals for the mean difference in contrast between field strengths (3T minus 1.5T) at the CCA, CCA-CB junction, CB, and ICA were (-0.12,1.35), (0.99,1.53), (-0.65,2.31), and (0.81,1.26), respectively, indicating improved contrast in all 4 vessel locations at 3T. When contrast values over the all 4 vessel locations were averaged, the 95% confidence interval for the mean difference in contrast (3T minus 1.5T) was (0.40,1.47), indicating improved carotid wall-lumen contrast at 3T. Contrast values at the various locations are listed in Table 1. This significant contrast gain at 3T would most likely come from the improved signal from the higher field strength.

Conclusion: This pilot study demonstrates that with the new coils 3D SPACE technique offers improved carotid wall-lumen contrast at 3T relative to 1.5T with a clinically practical scan time. The higher contrast at 3T may improve plaque detection and characterization. The combination of dedicated carotid coils and 3D techniques like SPACE is a promising for carotid artery imaging at 3T.

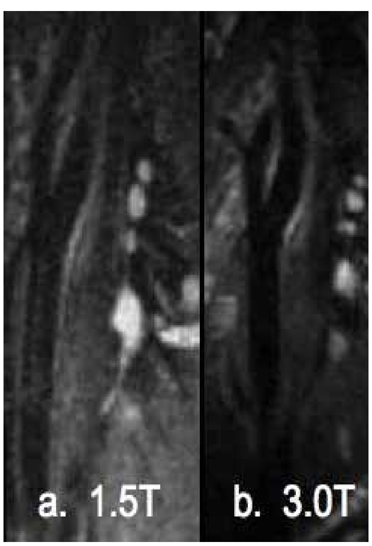

Figure 2. (a) 3D T2 –W sagittal reconstruction acquired with SPACE at 1.5 T. (b) 3D T2-W reconstruction acquired with SPACE at 3T. The 3T image demonstrates improved contrast between the arterial wall and the lumen.

Table 1	Contrast at 1.5T	Contrast at 3T	Contrast Gain at 3T (3T relative to 1.5 T)
ICA	0.52	1.62	3.14
Bulb	0.53	1.33	2.53
Bulb/CCA	0.64	1.92	2.99
CCA	0.48	1.11	2.33
Average	0.54	1.49	2.77

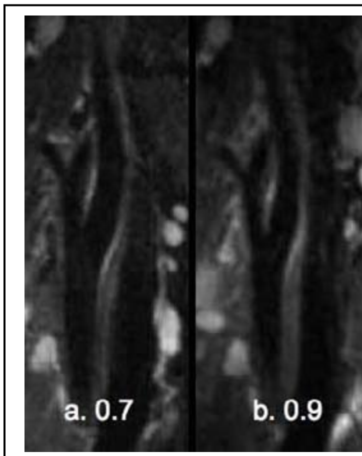

Figure 1. 3D T2-w SPACE data in a sagittal MPR showing the carotid bifurcation. a. (0.7mm isotropic resolution), 4 minutes scan time (b) (0.9 mm isotropic resolution), 8 minutes scan time. Despite the considerably shorter acquisition time the improvement in spatial resolution is clearly apparent in (a) with minimal loss of SNR.

References:
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