Multi-Slice Carotid Imaging with Regional Saturation and Rapid Extended Coverage: Comparison at 1.5T and 3.0T

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Introduction: Turbo spin-echo (TSE) sequences have been used to detect and characterize carotid atherosclerotic plaques at 1.5T. Characterization of carotid plaques, however, requires relatively high spatial resolution, which limits attainable signal-to-noise ratio (SNR). Imaging at 3T may improve SNR and spatial resolution. This work sought to compare the SNR efficiency of 3T and 1.5T for dark-blood TSE carotid wall imaging using equal resolution (0.47×0.47×3 mm^3), time-matched regional saturation (RSAT) and rapid extended coverage (REX) techniques (1). Higher resolution images (0.31×0.31×3 mm^3) were also acquired at 3T with RSAT and REX techniques.

Materials and Methods: Six healthy volunteers (4 males, 2 females, mean age = 37 years) were imaged on 1.5T and 3T whole-body scanners (Sonata and Trio, Siemens, Erlangen, Germany). Four channel phased-array coils consisting of two left and two right channels (1.5T: Machnet BV, The Netherlands; 3T: made in-house) were used for signal reception. In each volunteer, 12 cross-sectional slices through the carotid bifurcation were imaged using TSE. Two magnetization preparation methods were used to suppress the blood signal. The first method applied two RSAT bands (50 mm) before data acquisition of each slice during each TR, 10 mm above and below the imaging slices. The second method was a REX sequence in which four double inversion recovery blocks were applied before data acquisition within every TR [1]. Fat saturated proton density-weighted (PDW), T2-weighted (T2W), and T1-weighted (T1W) imaging was performed with both sequences. T1W REX was not performed at 3T. Imaging parameters are listed in Table 1. Higher resolution images were taken at 3T with the following imaging parameters: matrix = 384×384, NEX = 2, TE = 12 ms (PDW, T1W) and 53 ms (T2W), imaging time = 5'40'' (PDW, T2W) and 5'15'' (T1W) per scan. Signal intensity was measured in the carotid wall and lumen. Carotid wall SNR and carotid wall-lumen contrast-to-noise ratio (CNR) were calculated by dividing wall signal by the standard deviation of the air signal. A paired t test was used to determine the significance of SNR and CNR changes between 1.5T and 3T.

Table 1. Imaging Parameters

Parameter	1.5T	3T
FOV (cm^2)	12×12	12×12
Matrix	256×256	256×256
TR (ms)	2160[ab]/900[c]	4000[ab]/900[c]
TE (ms)	5.6[ac]/50[b]	9.7[ac]/49[b]
ETL	15[ab]/3[c]	9
ES (ms)	5.6	9.7
BW (hz/px)	488	200
SL (mm)	3 (10% gap)	3 (10% gap)
Slices	12	12
NEX	6[ab]/3[c]	2
TA (m:s)	3:56[ab]/3:54[c]	3:57[ab]/3:32[c]
[a]PDW, [b]T2W, [c]T1W		

Table 2. Carotid Wall SNR and Wall-Lumen CNR

Contrast	1.5T REX	1.5T RSAT	3T REX	3T RSAT
PDW	14±3 (10±3)	17±4 (12±4)	32±10 (25±9)	36±18 (28±16)
T2W	9±2 (5±2)	11±2 (7±2)	22±7 (17±6)	23±9 (17±7)
T1W	9±2 (5±2)	12±3 (8±2)	not acquired	30±13 (21±10)
PDW[h]	not acquired	not acquired	19±5 (14±5)	24±9 (17±7)
T2W[h]	not acquired	not acquired	12±3 (8±3)	15±6 (10±4)
T1W[h]	not acquired	not acquired	not acquired	19±7 (12±5)
all numbers given as mean ± sd; CNR values enclosed in parentheses [h]high resolution scans				

Results: MR imaging was successfully performed and the vessel wall was clearly delineated in all volunteers. Refocusing flip angle was specific absorption rate limited at 3T, with the RSAT and REX sequences employing an average of 167° and 163°, respectively. SNR and CNR results are shown in Table 2. On average, the SNR and CNR gains at 3T relative to 1.5T were roughly 2.2 fold and 2.6 fold, respectively ($p<0.01$). Representative images acquired from one volunteer are shown (in close-up) in Figure 1. In another volunteer, a suspected plaque was found (Figure 2). The delineation of the thickened wall (arrow) is substantially better in 3T images than at 1.5T. Two of the thirty high resolution 3T data sets were not analyzed due to severe motion artifacts.

Conclusion: The 3T RSAT and REX carotid wall imaging protocols in this study yielded consistently higher SNR than their time-matched counterparts at 1.5T. The SNR increases at 3T over the theoretically predicted value of 2 may have been due to the different surface coils used and to image parameter differences outlined in Table 1. The high resolution scans (0.31×0.31×3 mm^3) performed at 3T provided excellent depiction of the carotid wall with good SNR and CNR, albeit with a longer imaging time. This work suggests that 3T carotid wall imaging with RSAT and REX TSE benefits from higher wall SNR, improved wall-lumen CNR, and allows for higher spatial resolution than at 1.5T.

References: [1] Mani et al. (2004). *Radiology* 232:281-288.

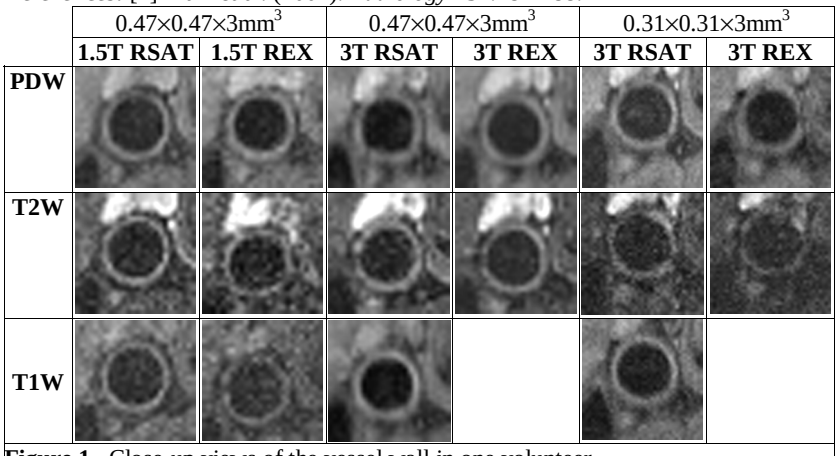

Figure 1. Close-up views of the vessel wall in one volunteer.

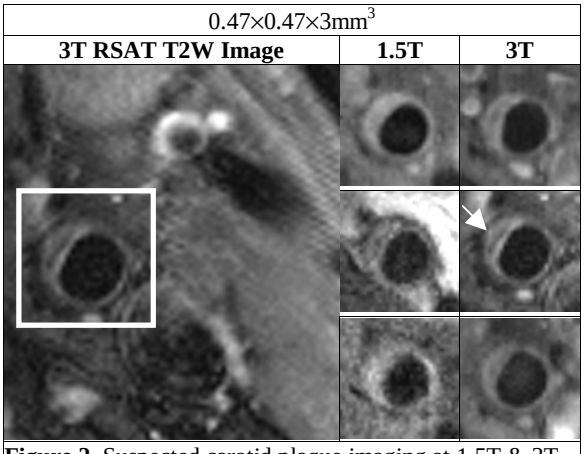

Figure 2. Suspected carotid plaque imaging at 1.5T & 3T.