# Carotid Vessel Wall Imaging: A comparison between 1.5T and 3T

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## Introduction

Carotid atherosclerosis is a disease characterized by plaque formation leading to vascular stenosis and eventually to stroke, one of the leading causes of death in the industrialized world. Quantification of plaque volume and content is important as a means for risk assessment and monitoring of treatment with lipid-lowering drugs [1]. High-resolution MRI of the carotid arterial wall has great potential for noninvasive assessment of carotid atherosclerosis. However, the method is demanding since it requires imaging at submillimeter pixel size at high enough SNR for exact quantification of plaque architecture and content. Near the bifurcation the artery is located at a depth of 30-40 mm from the surface of the neck, hence phased-array surface coils with the required extended coverage along the length of the arterial segment that is prone to plaque build-up, have been shown to be preferable over the use of a head coil or larger single surface coils [2]. The purpose of this work was to investigate the improvement in performance at 3.0T relative to 1.5T and to demonstrate that the increased SNR can be traded for smaller voxel volumes.

## Materials and Methods

At each field strength two pairs of phased array coils were constructed consisting of two elements each (each element 5x5 cm$^2$). Coils were tuned and matched to 50Ω impedance on the neck at the respective frequencies. Imaging was performed at 1.5T and 3T on whole-body scanners at 63.64MHz and 123.22 MHz (Siemens Sonata and Trio, respectively). Both systems are equipped with the same 40mT/m gradients using body coil excitation with the phased array coils for reception. The parameters chosen for phantom imaging involve a turbo spin-echo double-inversion, black-blood sequence with a turbo factor of 17, TR/TE 2000/8.7 msec, slice thickness 2 mm, FOV 18x18 cm and matrix 256 x 256 (0.7x0.7 mm$^2$ pixel size). The coils were evaluated with the aid of a cylindrical container filled with saline, placed with its axis parallel to the main field, and with the coils placed on the left and right sides of the phantom parallel to the sagittal plane. SNR was calculated as the ROI signal mean divided by the SD of the background ROI and plotted as a function of depth from the surface. In vivo images of the carotid arteries were obtained using the double inversion black-blood pulse sequence [3] with fat saturation and 2-RR cardiac gating on two healthy volunteers with the same parameters as above but with FOV of 12 X12 cm based on the present clinical protocol used on 1.5T.

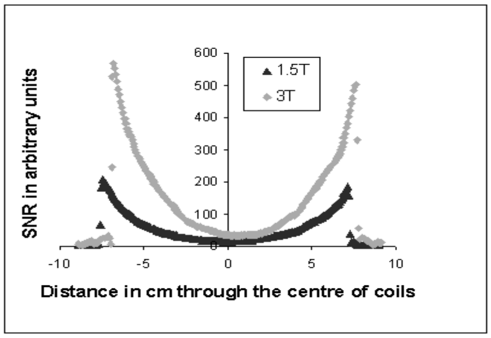

Fig.1: SNR profile along the coils' axis measured in a cylindrical saline phantom.

## Results

Phantom SNR for both field strengths is given in Fig.1, showing that SNR is higher at 3T by a factor of about 2.6-2.8 relative to 1.5T when measured for the two coils at a distance of 4 cm from the surface of the phantom. The greater than linear increase in SNR with field strength is due to the, impedance at the lower field arising substantially from the coil, whereas at higher field it is sample dominated. As a result the frequency dependence of the SNR would be expected to be between $\omega_o^{7/4}$ and $\omega_o$. This interpretation is supported by the finding that the ratios of loaded to unloaded Q ($Q_L/Q_U$ in phantom) were found to be 0.75 at 1.5T and 0.46 at 3T. *In vivo*, the gain in SNR was about 2, which is less than expected on the basis of the phantom experiments (Figs. 2 a, b). The likely cause for this discrepancy is the following: (i) the 3T coils were made on a relatively rigid former and so could not be placed as snugly to the neck; (b) the refocusing flip angle on the higher field 3T system had to be decreased from 180$^o$ to 160$^o$ to stay within SAR limits. The coil loading in the phantom and the neck was not significantly different. Finally, the increased SNR at 3T can be traded for improved resolution (384x384 matrix size), as shown in Fig. 3.

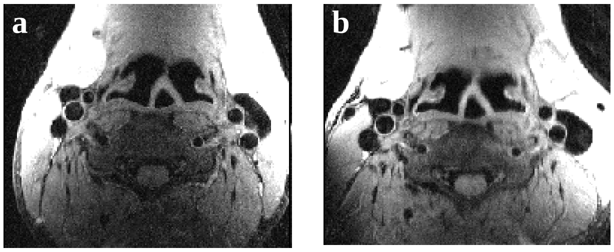

Fig. 2. Double-inversion black-blood carotid artery images distal to the bifurcation in a volunteer with 0.47x 0.47mm$^2$ pixel size**:** a)1.5T b) 3T

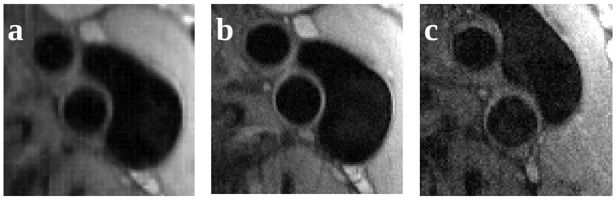

Fig. 3. Zoomed-in view of the carotid bifurcation in the same volunteer with a) pixel size 0.47x0.47 mm$^2$ at 3T b) pixel size 0.31x0.31 mm$^2$ at 3T c) same resolution as in b) at 1.5T.

## Conclusions

Carotid MRI using phased array surface coils provides a considerable increase in the SNR from 1.5T to 3T which can be traded for enhanced in-plane resolution and thus potentially improved precision in the quantitation of atherosclerotic plaques.

## References

1. Fayad Z *et al.*, Circulation 2000; **102**; 506
2. Hayes C E *et al.*, J Magn Reson Imag 1996; **6**; 109
3. Edelman R R *et al.*, Radiology. 1991; **181**(3); 655