In Vivo Evaluation of Vessel Wall using 3D TrueFISP

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Synopsis
The purpose of this study was to investigate: 1) the use of 3D TrueFISP for volumetric imaging of the carotid vessel wall, 2) the ability of this technique to quantify vessel wall thickness, and 3) its ability to detect abnormal vessel wall thickening.

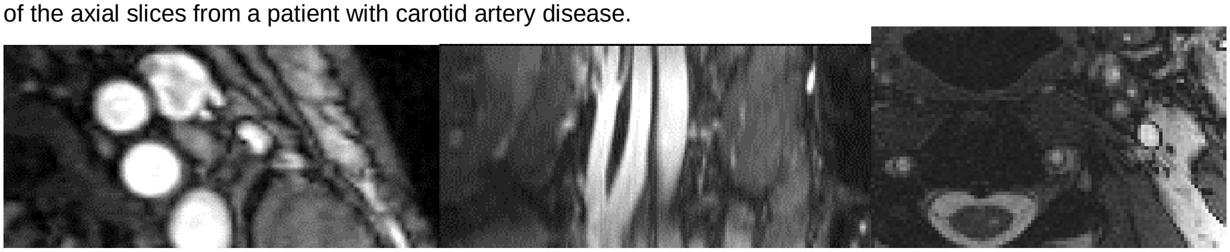
Introduction
In order to detect the early accumulation of plaque on the vessel wall, it is advantageous to have volumetric coverage in combination with near isotropic resolution. In the past, most studies of *in vivo* plaque and/or vessel wall imaging at 1.5 T have focused on 2D techniques due to their shorter scan times. 3D imaging does offer the advantage of covering a vasculature of interest volumetrically and with near isotropic resolution. However, 3D imaging may require relatively long scan times which make the images more vulnerable to motion artifacts. Furthermore, the vessel wall itself is not well depicted in conventional 3D time-of-flight sequences as they tend to suppress signal from stationary tissue. As an alternative, 3D TrueFISP may offer a way to acquire high resolution and volumetric images of the vessel wall *in vivo*.

Methods
Imaging was performed using carotid RF coils (Machnet B.V., The Netherlands) that were placed bilaterally adjacent to the carotid arteries. Images were acquired using a 1.5 T scanner (MAGNETOM Sonata, Siemens AG). 3D TrueFISP (TR/TE: 4.6/2.3 ms, in-plane resolution = 0.4 mm x 0.4 mm, slice thickness = 2 mm, 51 segments, 22 slices, with and without cardiac triggering, scan time = 2 min 24 sec) imaging was performed in 14 volunteers and 3 patients with known carotid artery disease. Prior to acquiring the study, a frequency scout was used to optimize the frequency offset. Furthermore, a flow velocity time plot was generated to select the optimal time delay for triggering. 2D dark blood turbo spin echo (TR/TE: R-R interval/14 ms, triggered to diastole, in-plane resolution = 0.4 mm x 0.3 mm, slice thickness = 3 mm, scan time = 43 sec) and 3D time-of-flight (TR/TE: 25/7 ms, in-plane resolution = 0.4 mm x 0.5 mm, slice thickness = 1.5 mm, scan time = 2 min 11 sec) were also acquired for comparison. Signal-to-noise measurements were made. In addition, the vessel wall thickness of the carotid arteries was measured by electronic caliper.

Results
The signal-to-noise ratio (SNR) was a) 2.8 +/- 0.3 for the 3D time-of-flight, b) 3.1 +/- 0.5 for the dark blood TSE, and c) 13.3 +/- 1.6 for the 3D TrueFISP. In addition to the increase in SNR, 3D TrueFISP gave superior delineation of the vessel wall as compared with the 3D time-of-flight. Compared with the 2D technique, 3D TrueFISP provided excellent multi-planar reconstruction along any plane and along the bifurcation, with better spatial resolution along the slice select direction, and was less affected by partial volume effect. Among all the subjects studied, the thickness of the vessel wall ranged from 0.3 mm to 2.7 mm. Young and healthy subjects tended to show thin vessel wall compared with patients with known carotid artery disease. The 3 patients demonstrated thickened vessel wall with thickness ranging from 1.7 to 2.7 mm.

Conclusion
In this study, we have demonstrated that despite challenges to 3D imaging of the vessel wall, 3D TrueFISP can be optimized to obtain high resolution and high quality images to quantify vessel wall thickness and to observe abnormal thickening/alterations in patients with atherosclerotic disease.

Figure legend
Figure 1a shows 3D TrueFISP imaging of the carotid artery of a normal volunteer acquired axially (2 mm slice thickness). Fig. 1b shows one of the multi-planar reconstructions along the direction of the vessel (reconstructed from the axial acquisitions). Fig. 1c shows one of the axial slices from a patient with carotid artery disease.



1a 1b 1c

References
1) Yuan C, Hatsukami TS, et al. J Vasc Invest. 1996; 7: 46–47.
2) Fayad ZA, Fuster V, et al. Circulation. 2000; 102: 506–510.
3) Fayad ZA, Nahar T, et al. Circulation. 2000; 101: 2503–2509.
4) Coombs BD, Rapp JH, et al. Stroke. 2001; 32: 2516–2521.
5) Helft G, Worthley SG, et al. Circulation. 2002; 105: 993–998.