High Resolution Diffusion-Weighted Imaging with Variable Density Spiral Acquisition of Carotid Vessel Wall

Shuo Chen[1], Hua Guo[1], Wenchuan Wu[1], Xihai Zhao[1], Chun Yuan[1,2], and Huijun Chen[1]

[1]*Center for Biomedical Imaging Research & Department of Biomedical Engineering, Tsinghua University, Beijing, China,* [2]*Department of Radiology, University of Washington, Seattle, WA, United States*

Introduction: Studies have demonstrated that carotid atherosclerotic vulnerable plaques are associated with cerebrovascular events, such as transient ischemic attack (TIA) and stroke. Plaque compositional characteristics including lipid-rich necrotic core (LRNC), fibrous cap rupture, and intraplaque hemorrhage (IPH) are believed to be linked to plaque vulnerability [1]. Therefore, effective identification of key plaque features will be helpful for prevention of ischemic stroke [2]. Previous studies documented that *in vivo* diffusion weighted imaging (DWI) might be useful for detection of LRNC [3]. However, conventional DWI images are acquired by an single-shot echo-planar imaging (EPI) sequence that has low spatial resolution and structure distortion. We propose a high resolution DWI sequence using variable density spiral acquisition for carotid plaque detection.

Purpose: This study sought to determine the feasibility of high resolution variable density spiral (VDS) [4-5] DWI in imaging of carotid artery atherosclerotic plaque and discriminate its key components.

Methods: An diffusion weighted interleaved VDS sequence was implemented on a 3.0T whole-body MR scanner (Achieva TX, Philips Medical System, Best, the Netherlands) with a custom-designed 36-channel neurovascular coil. During MR image acquisition of carotid arteries, cardiac synchronization trigger was applied by using peripheral pulse unit (PPU) to reduce the motion artifact introduced by cardiac pulse. Also, saturation bands were applied superior and inferior to the imaging location to suppress blood signals. MR images were acquired from one patient with carotid atherosclerotic plaques. All subjects provided informed written consent. The MR imaging parameters are as follows: spiral interleaves=60, readout window=7.1ms, TE=40ms, FOV=160×160mm^2, acquisition matrix=248×248, NSA=2, slice number=4, PPU trigger delay=550ms. The spatial resolution for data acquisition was 0.65×0.65mm^2, and slice thickness was 3mm. Diffusion images were acquired with b=0 and 250 s/mm^2 along the slice selection direction. The total imaging time was 4 minutes 2 seconds. Besides, both black blood T2-weighted (T2w) and T1-weighted (T1w) images were acquired cross-sectionally for structural information of carotid arteries with the following parameters: T2w: TSE, black-blood, MDIR[6], TR=4800ms, TE=50ms, spatial resolution 0.6×0.6×2mm^3; T1w: TSE, black-blood, QIR[7], TR=800ms, TE = 10ms, spatial resolution 0.6×0.6×2mm^3.

Results and Discussion: DWI images obtained using diffusion weighted VDS (DW-VDS) sequence are shown in Fig. 1. These images demonstrate that the vessel wall can be successfully delineated in DWI images with b=0 (Fig. 1c), b=250 s/mm^2 (Fig. 1d) and ADC map (Fig. 1b). Atherosclerotic plaque with large LRNC at right carotid bifurcation showing on T1w (Fig. 1a) and T2w (Fig. 1b) images can be clearly depicted on the ADC map (Fig. 1e). To better visualize vessel wall and plaque, blood signal was masked on diffusion weighed image and ADC map. The mean ADC value of the plaque is 0.29 ×10^{-3}mm^2/s and the mean ADC value of the less diseased vessel wall is 0.48 ×10^{-3}mm^2/s, indicating that the ADC value of the plaque is lower than that of vessel wall, same with previous study[8].

Conclusions: A high resolution diffusion weighted variable density spiral sequence was implanted on a Philips 3T clinical scanner and cardiac synchronization trigger was applied to reduce motion artifacts. Our preliminary results suggest that DW-VDS might be an alternative sequence for carotid vessel wall imaging and plaque components identification. Further study is needed for quantitative ADC analysis of key plaque components, such as LRNC and IPH.

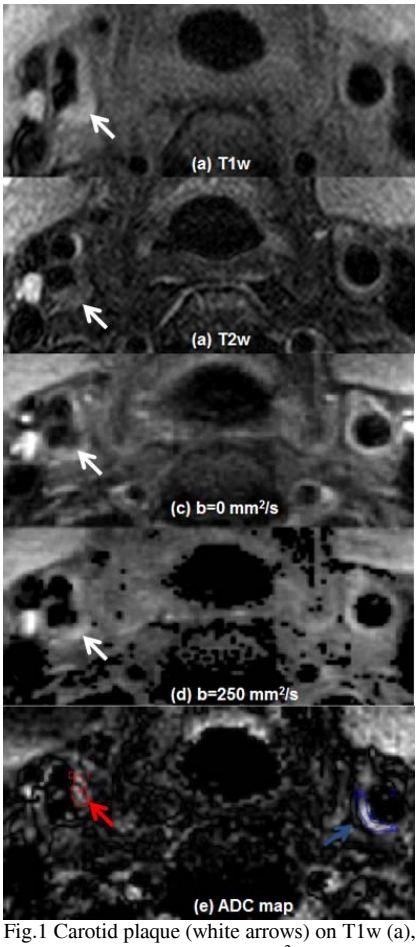

Fig.1 Carotid plaque (white arrows) on T1w (a), T2w (b),DW-VDS with b=0 mm^2/s (c), b=250 mm^2/s (d), and ADC map(e) (red arrow: plaque with red arrow, blue arrow: vessel wall).

References: [1] Yuan C, et al. Circulation. 2002;105:181-5. [2] Fayad Z, et al. Circulation. 2000;101:2503-9. [3] Sharon EC, et al. Stroke. 2006;37:93-7. [4] Chunlei Liu et al. MRM. 2005; 54:1412-22. [5] Wenchuan Wu et al. ISMRM. 2012. 5587. [6] Yarnykh VL, et al. JMRI. 2003;17:478-83. [7] Yarnykh VL, et al. MRM. 2006;55:1083-92. [8] Seong-Eun Kim, et al. J. Magn. Reson. Imaging 2009;30:1068–1077.