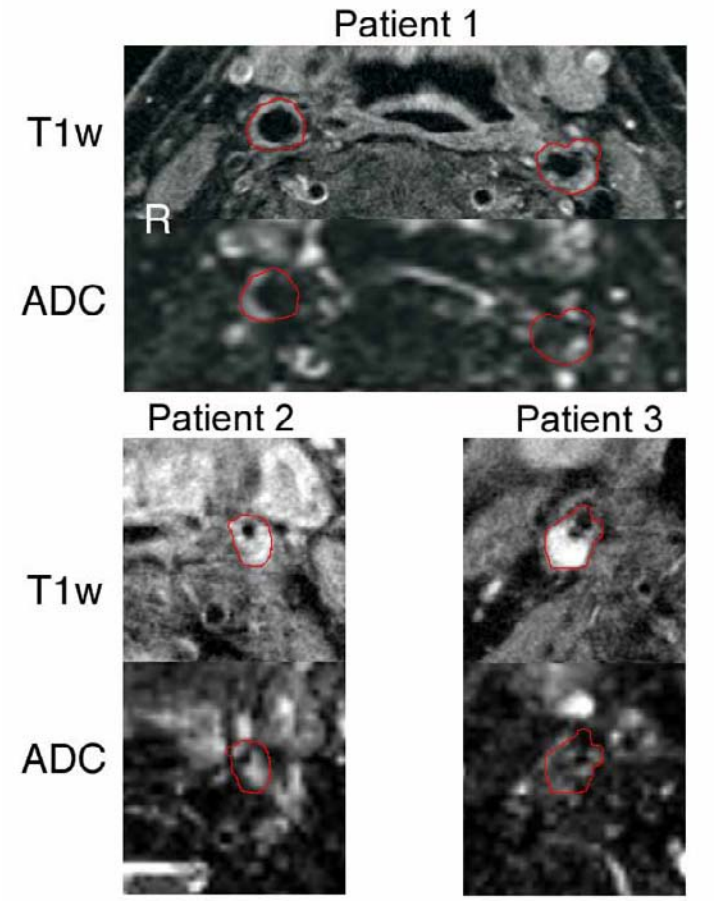
First Demonstration of Diffusion Weighted Imaging of In Vivo Carotid Plaque at 1.5T

K. Heberlein[1], R. O'Donnell[2], and S. Voros[2]

[1]Siemens Medical Solutions, USA, Atlanta, GA, United States, [2]Fuqua Heart Center of Atlanta; Piedmont Hospital, Atlanta, GA, United States

INTRODUCTION: Multi-contrast MRI has been shown to provide insights into atherosclerotic plaque composition. These methods have been verified using excised tissue samples obtained post-operatively from patients [1], and among one of the interesting results of this approach is the use of diffusion weighted imaging (DWI) in the characterization of carotid plaque. Diffusion weighting has been introduced as a method for obtaining dark blood suppression, yet may also provide a useful contrast for plaque characterization. DWI of the carotid arteries has been demonstrated recently *in vivo*, despite the difficulties of obtaining high quality images in the cervical carotid. Fast scanning with diffusion weighted spin echo EPI can be impractical in the cervical carotid due to strong susceptibility artifacts. Previously, others have shown a reduced FOV technique using local surface coils for high-resolution imaging in the carotid artery at 3 Tesla. However, this approach at 1.5T has not been previously shown. At 1.5 tesla it is expected that susceptibility problems are somewhat mitigated, allowing the use of conventional pulse sequences, although the reduction in SNR limits the resolution obtainable with single-shot EPI. Susceptibility artifacts are mitigated in the single shot EPI imaging using a parallel imaging acceleration factor of 2. This paper demonstrates for the first time that diffusion-weighted carotid imaging in patients at 1.5T is feasible and reliable.

METHODS: Three patients with carotid atherosclerotic plaques identified by carotid ultrasound were imaged under an IRB approved protocol. The protocol included dark blood T1, T2, PD and diffusion weighted imaging. The coil setup included a vendor provided head, neck and spine matrixes optimized for parallel imaging on 1.5 Tesla Siemens Avanto equipped with 32 receive channels. (Siemens Medical Solutions, Erlangen, Germany) The DWI protocol consisted of a 3-scan trace diffusion encoding scheme (b=500 sec/mm^2) acquired with dark blood saturation bands above and below the imaging slab (TR 2.2 sec, TE 86 ms, FOV 192 mm, matrix 128, Rate 2 GRAPPA, pixel size 1.5 mm, slices 11, thickness 3 mm, total scan time 4 min 46 sec). Quantitative ADC maps were generated online using vendor provided tools. The protocol also included high-resolution T1-weighted turbo spin echo (turbo factor 9) imaging acquired in the same imaging plane as DWI (TR 1.5 sec, TE 10 ms, FOV 150 mm, matrix 320, pixel size 0.47 mm, slices 11, thickness 3 mm, NEX 3, total scan time 3 min 33 sec). Using the T1-weighted images as guides, ROI's were generated in the plaque region to calculate the average ADC values in each patient.



RESULTS: Imaging results from the three patients are shown on the left. Using the T1-weighted images as a guide, ROI's were copied over to the ADC maps to outline the outer vessel wall of the carotid arteries. In the region of the plaque for patient 1 (left carotid) a distinct mottling is apparent in the T1w images which can also be seen in the ADC map. The right carotid shows partial wall thickening in the T1w image and a corresponding increase in ADC. The mean ADC values calculated in the plaque ROI for each patient are, 1.79x10^{-3}, 1.58x10^{-3}, and 2.53x10^{-3} mm^2/sec.

DISCUSSION: While DWI has become a standard protocol for clinical neuroimaging, many body and cardiovascular application are becoming apparent for this contrast mechanism. Diffusion imaging is sensitized to the tissue microstructure environment and represents structural organization beyond the resolution limits of MR. For atherosclerotic plaque, DWI generates a complementary contrast to standard T1w and T2w imaging. The results presented in this paper reinforce previous findings that DWI is indeed feasible in cervical carotid patients at both 1.5T and 3T using appropriate imaging methods and coil configurations. For this application a single shot imaging with a parallel acceleration factor of 2 provide sufficient image quality to detect ADC variations within the plaque. Further technical development in DWI techniques are needed to push the image resolution to that of T1w scanning, so that normative results in a healthy population can be obtained robustly in the much thinner vessel wall.

CONCLUSION: We demonstrate for the first time that diffusion weighted imaging in the carotids is feasible on standard clinical MR systems at 1.5T and preliminary evidence suggests that the contrast mechanism involved is clinically relevant to plaque composition analysis.

REFERENCES: 1. Clarke SE, Hammond RR, Mitchell JR, Rutt BK, Magn. Reson. Med. 50:1199-1208 (2003) **2.** Kim SE, Jeong EK, Kholmovski EG, Parker DL, Proc. Intl. Soc. Mag Reson. Med. 14 (2006)