

Apparent Diffusion Coefficient Measurement of in vivo Atherosclerotic Plaque obtained from six human subjects using 2D ss IMIV DWEPI Technique on 3T System

S-E. Kim¹, E-K. Jeong¹, J. Hadley¹, J. A. Roberts¹, G. A. Trieman^{2,3}, L. C. Bell¹, and D. L. Parker¹

¹UCAIR Department of Radiology, University of Utah, Salt Lake City, Utah, United States, ²Surgical Service, VA Salt Lake City Health Care System, ³Department of Surgery School of Medicine, University of Utah

INTRODUCTION: Magnetic resonance imaging (MRI) has been shown to be useful for visualizing disease in the carotid artery and for measuring vessel wall area. Many publications show that images of the carotid artery with multiple contrasts can help with plaque component identification.^(1,2) Atherosclerotic plaque characterization by black blood MRI is generally based on the signal intensities and morphological appearance of plaque in T1, PD and T2 weighted images, but intraplaque thrombus is hard to distinguish from vessel wall or underlying plaque by these conventional contrasts. It is possible that the mobility of water proton in the thrombus may differ from that of wall or other components. Recently it has been reported that diffusion weighted imaging of excised human specimens can enhance the contrast between thrombus and vessel wall.^(3,4,5) In spite of the potential utility of DWI in the cervical carotid, motion and susceptibility problems generally make the application in vivo difficult. We previously presented the preliminary report of in vivo diffusion weighted imaging in normal volunteer study. In this work we report on results of diffusion weighted imaging and the apparent diffusion coefficient from six patient volunteers.

METHODS: All volunteer studies were performed on a Siemens Trio 3T MRI scanner (Siemens Medical Solutions, Erlangen, Germany) with our home built four element bilateral phased-array carotid coil. 3D TOF MRA was used to locate the bifurcation and lesion area. Carotid arteries of each subject centered at the bifurcation apex were scanned with 2D ss-IMIV-DWEPI. The imaging parameters were: receiver bandwidth = 1.086 kHz/pixel, FOV=160x40mm, imaging matrix = 162x33, 2 mm slice thickness, effective TE = 66ms, TR = 3s, 33 echoes per echotrain, 32 averages (magnitude) and interleave acquisition of 16 contiguous slices. The in-plane spatial resolution for data acquisition was 1.0x1.0mm with display resolution 0.5x0.5 mm², after zero-filled interpolation. Total scan time was 4:24 min for two b-values (0, 300 sec/mm²). Using the two b value images the apparent diffusion coefficient (ADC) map was calculated and displayed using IDL. T1w images were acquired with 2D TSE with our modified version of the double inversion preparation sequence⁽⁶⁾: TE/TR=9.5 ms /800ms, TI=600 ms, in-plane resolution 0.5x0.5mm², slice thickness = 2mm, and 11 echo echotrain. T2w images were acquired with 2D TSE with the same parameters used in T1 acquisition except TE/TR=65ms/2s.

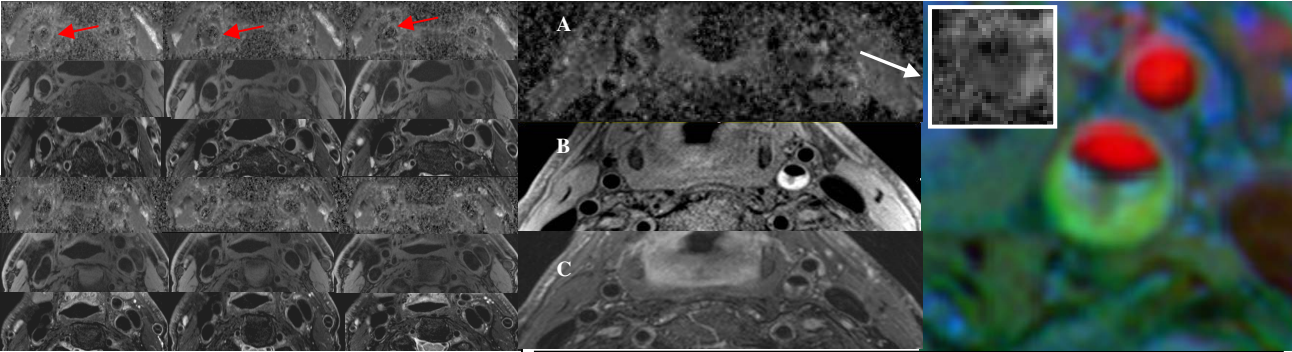


Figure 1: ADC map(1st & 4th row), T1w(2nd & 5th row), T2w(3rd & 6th row) from subject 5

Figure 2: ADC map, T1w, T2w and composite image from multiple contrast (3D TOF=red, T1w=blue, T2w=green) of same slice location

RESULTS: The mean plaque ADC of each subject was calculated using ADC measurement from three different plaque locations (Table 1). The mean vessel wall ADC for all subjects was $1.28 \pm 0.09 \times 10^{-3}$ mm²/s. Although our measured ADC values were slightly lower than the values reported in a recent ex-vivo study⁽⁵⁾ (1.5×10^{-3} mm²/s in wall, 1.0×10^{-3} mm²/s in thrombus), our values do match values reported by one other group⁽³⁾. Figure 1 displays the ADC map, and T1w and T2w images of six contiguous slices from subject 5. As shown by red arrows in Fig 1, the ADC map demonstrates clear contrast between wall and plaque area. Fig 2 displays the ADC map(A), T1w(B), T2w image(C) of one slice location of subject 6. Plaque area indicated by a solid white line in Fig 2-(A) shows a bright signal on T1w, moderate signal on T2w and low ADC value (0.29×10^{-3} mm²/s). Some plaque with high water content, such as necrosis or old thrombus may be very bright or of intermediate intensity with T2 weighting. Color image in Fig 2 displays the composite image obtained from three different contrast images including 3D TOF, T1w, T2w. The plaque area on the color map is spatially well matched with dark area of the ADC map (inside white box).

Table 1 Mean value of ADC of six subjects						
	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
ADC (10 ⁻³ mm ² /s)	0.29±0.09	0.49±0.08	0.52±0.09	0.58±0.10	0.67±0.11	0.87±0.10

DISCUSSION: The results obtained indicate that ADC map may be of substantial value as a new contrast for carotid plaque imaging. Although our ADC values obtained using the 2D ss IMIV DWEPI technique fall within the range of previously reported ADC value in an ex-vivo study, there is no previously known ADC value of each plaque component from an in-vivo study. The technique demonstrated here can now be used to further investigate the ADC in all types of plaque components.

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