**Measurement of the Mean ADC Values of Lipid, Hemorrhage and overall Wall Components using in-vivo Human Carotid Artery Diffusion Weighted Imaging**

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INTRODUCTION: The development of atherosclerotic plaques is a complex process. These plaques are composed of varying degrees of lipid, necrotic tissue, loose connective tissue, hemorrhage, and calcification1-6. The extent of lipid accumulation and the presence of intramural hemorrhage have been found to be associated with the degree of plaque vulnerability and risk of plaque rupture. However, lipids and hemorrhage are often difficult to distinguish from other plaque components by MRI, and the reported appearance of these tissues in different MR studies is inconsistent3-4. Reports use a variety of different sequences and criteria for their identification and measurement. Ex-vivo studies have found that diffusion weighted imaging(DWI) may provide a tool for the characterization of these components5-6. Recent ex vivo studies of carotid plaques found that DWI could detect lipids and hemorrhage with greater sensitivity than other MRI sequences7-8. We have reported in-vivo DWI of human carotid artery using 2D ss-IMIV-DWEPI sequence9. This study reports the ADC values of lipid, hemorrhage and overall wall composition as measured with in-vivo DWI, with histology used as the basis for comparison.

METHODS: All studies were performed on a Siemens Trio 3T MRI scanner with our custom made four element bilateral phased-array carotid coil. 2D TOF MRA was used to locate the carotid bifurcation and determine the extent of the lesion. Carotid arteries were scanned with 2D ss-IMIV-DWEPI. The imaging parameters were described on our previous work10. The in-plane spatial resolution for data acquisition was 1.0x1.0mm with display resolution 0.5x0.5 mm², after zero-filled interpolation. The apparent diffusion coefficient (ADC) map was calculated and displayed using IDL (Interactive Data Language etc.). Sequences obtained were 2D T1w, T2w, PD, 3D MPRAge, and DWI at the same locations. CTA was also obtained in vivo. T1w images were acquired with 2D TSE with the time efficient double inversion preparation sequence9. 2D T2w and PD images were acquired using the 2D TSE sequence. 3D MPRAge images were acquired with 0.5x0.5x1.0mm³ voxel resolution and were used to identify hemorrhage. Human carotid endarterectomy specimens were obtained and fixed in 10% buffered formalin. Following decalcification, specimens were serially cross sectioned and stained. MR images and histological slides were matched using the known location and distance between MRI and histological cross section.

RESULTS:

<table>
<thead>
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<th>Table 1 Mean value of ADC on Wall and Plaque Components</th>
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<tr>
<td>Wall Area</td>
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<td>ADC (10⁻³ mm²/s)</td>
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The mean ADC values of lipid, hemorrhage, and overall wall composition was calculated using ADC measurements from three different plaque locations (Table 1). Figure 1 displays the ADC map, and T1w and T2w images from this patient. Figure 2 shows T1w, T2w, PD and 3D TOF sequences at the same location indicated by the red arrow in figure 1. The ADC map in Fig 1 demonstrates clear contrast between normal and diseased arterial wall. The plaque indicated by red arrows in Fig 1 shows a bright signal on T1w, moderate signal on T2w and low ADC value (0.42x10⁻³mm²/s). Histology confirmed that this area represent lipid (light blue area on Fig 3). Fig 4 displays the T1w, T2w, and 3D MPRAge images and the ADC map from a subject with intramural hemorrhage. The hemorrhage is indicated by the red arrows and shows a very bright signal on 3D MPRAge with a moderate ADC value (0.91x10⁻³mm²/s). Histology confirmed that this area represent fresh hemorrhage (red area on Fig 5).

DISCUSSION: The results obtained indicate that an ADC map may be of substantial value in identifying lipid, hemorrhage, and overall wall plaque burden. Our ADC values obtained using the 2D ss IMIV-DWEPI technique match previously reported ADC value in an ex-vivo study5-6. No in vivo studies have reported ADC values for these plaque components. This technique can potentially be applied to further investigate the ADC of other plaque components.

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REFERENCES: