Diffusion weighted imaging of carotid atherosclerotic plaque in symptomatic patients at 3-tesla: Correlation with MRI, CT & histopathological predictors of plaque vulnerability

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Introduction: Carotid plaques may become unstable and rupture leading to transient ischaemic attack or stroke. Features of plaque vulnerability include active inflammation, thin cap with large lipid core, endothelial denudation with superficial platelet aggregation, fissured plaque, stenosis >90%, and intraplaque haemorrhage, which may be identified on imaging or histopathology[1-3]. Diffusion weighted imaging at 3T may potentially contribute to the identification of active plaques, by reflecting predictors of vulnerability.

Aim: The purpose of this prospective study is to assess the feasibility of DWI-MRI assessment of symptomatic carotid atherosclerotic plaques at 3T and to investigate the relationship between apparent diffusion coefficient (ADC) and imaging and histopathological features of vulnerable plaque.

Materials and methods: Following ethical approval and informed consent, 14 patients (12 men, 2 woman, mean age 71.2 years, range 54-88 years) presenting with a recent transient ischemic attack and awaiting carotid endarterectomy were enrolled prospectively. Exclusion criteria included patients with metallic implants, claustrophobia, patients in need of immediate surgery and patients not willing to participate. All patients had severe ipsilateral stenosis on Döppler ultrasound. Imaging was performed in using a phased-array head and neck coil on a 3-tesla scanner (Siemens TIM Trio, Erlangen, Germany). Morphological (3D TOF angiogram, T1 axial and T1, T2 & PD fat saturated axial sequences) and diffusion weighted sequences (single shot echo planar imaging; TR 3000ms, TE 87ms, slice thickness 5mm, FOV 200mm, matrix 128x128, signal averages 2, b-values of 0, 50, 100, 250, 500, 750s/mm^2) were performed (**Figure 1&2**). Images were assessed for the following features: presence of lipid core, plaque haemorrhage, and degree of stenosis. Apparent diffusion coefficient values were obtained for the plaque by careful region of interest analysis of the monexponentially fitted parametric maps generated on the standard commercial workstation (Leonardo, Siemens). Following surgery, immunohistochemical staining was performed for CD105 & VEGF (angiogenesis) and CD68 (inflammation). Correlation was assessed using Spearman rank correlation with significance at 5%.

Results: Imaging was successful in all 14 patients; surgery was performed in 10 patients. Mean (SD) for plaque ADC was 1.30 X10^{-3} (0.29)mm^2/s. There was no difference in ADC values for plaques with and without features of vulnerability on MRI (1.33 versus 1.32; p>0.99). There was no significant relationship between ADC and histopathological features though there was a trend towards a positive relationship with angiogenic markers : CD105 (r=0.54; p=0.08); VEGF (r=0.49; p=0.12) and CD68 (r=0.01; p=0.98).

Conclusion: Diffusion weighted imaging of carotid plaques is feasible, however, no definite correlation has been demonstrated between ADC and features of plaque vulnerability on MRI. A positive trend with histological measures of angiogenesis merits further investigation

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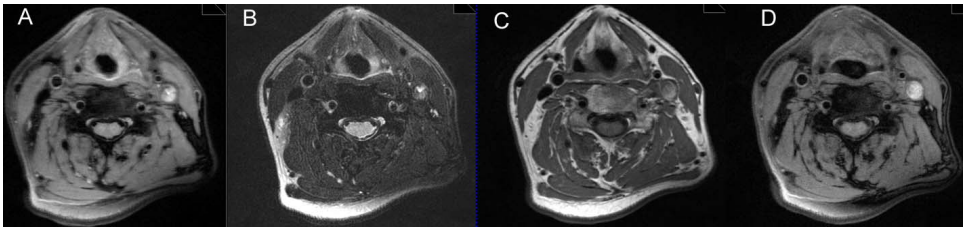

Figure 1. Morphological images: PD-FS (A), T2W FS (B), T1 (C) & T1 FS (D) axial images of a symptomatic occluding left carotid plaque

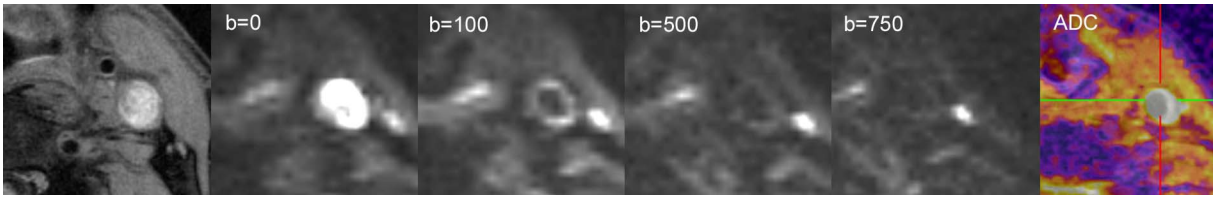

Figure 2. Corresponding b=0 - 750s/mm^2 & ADC images

References: 1) Saam et al. Radiology 2007; 244:64-77; 2) Kerwin WS et al. Radiology 2006; 241:459-68; 3) Kerwin WS et al, Magn Reson Imaging 2008;59:507-14