Assessment of the neovascularisation of carotid atherosclerotic plaque in symptomatic patients at 3T by DCE-MRI: Feasibility study

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Background: Carotid plaques may become unstable and rupture leading to transient ischaemic attack or stroke. Neovascularisation and increased endothelial permeability are found in symptomatic plaques and thought to reflect inflammation, and have been correlated with macrophage infiltration on histology[1,2]. In vivo assessment of plaque neovascularisation by DCE-MRI may potentially identify patients with vulnerable plaques. Imaging at 3T improves signal to noise and permits imaging at a higher temporal resolution than achievable previously. This potentially improves quantification.

Aim: The purpose of this prospective study is to assess the feasibility of DCE-MRI assessment of symptomatic carotid atherosclerotic plaques at 3T.

Method and materials: Following ethical approval and informed consent, 9 patients (8 men, 1 woman, mean age 71 range 55-84 years) presenting with a recent transient ischemic attack and awaiting carotid endarterectomy were enrolled prospectively. All patients had severe ipsilateral stenosis on Döppler ultrasound. DCE-MRI was performed following intravenous injection of 0.1mmol/kg Gd-DTPA (Magnevist, Schering) and saline chaser at 4mL/s using a phased array head and neck coil on a 3T scanner (Siemens TIM Trio, Erlangen, Germany). A proton density sequence (FA 2°; TA 18s, NEX 4, FOV 150mm, matrix256 x256, slice number 20; slice thickness 5mm) was performed initially for T1 quantification. A 3D VIBE dynamic T1W sequence was then performed at the level of the carotid plaque (TR 4.36ms, TE1.4ms, PAT 2, FA 20°, TA 5.3s, NEX 1, NEX 4, FOV 150mm, matrix256 x256; slice number 20; slice thickness 5mm; total 70 acquisitions). Images were processed using MRI software (Siemens, Erlangen, Germany). Motion correction and registration were applied prior to evaluation. Careful region of interest analysis of the greatest plaque area generated a gadolinium concentration-time curve from which semiquantitative parameters ($IAUGC_{60}$; peak gadolinium concentration (mmol); time to peak (s), maximal gradient) were obtained. Further quantification by kinetic modelling (Tofts model[3] and a population-averaged AIF[4]) generated the following parameters: K^{trans}, v_e, k_{ep} and v_p (**Fig. 1**)

Results: All studies were performed and evaluated successfully following motion correction and registration. Semiquantitative and quantitative data for all patients are summarised in **Table 1**. The mean (SD) are also shown. There were apparent differences in plaque vascularisation with two dominant gadolinium concentration-time curve shapes (**Fig. 2:** A rapid wash-in and wash-out (A) or rapid wash -in and slower wash-out (B), which was also reflected by the $IAUGC_{60}$, K^{trans} and k_{ep}.

Patient	$IAUGC_{60}$	Time to peak (s)	Peak Gd (mmol)	Max gradient	K^{trans}	k_{ep}	v_e	v_p
1	15.51	27.59	0.41	0.02	0.29	2.25	0.13	4.16exp−5
2	3.55	18.80	0.08	0.01	0.03	0.72	0.04	2.64exp−5
3	4.63	-	-	0.01	0.05	0.11	0.46	3.49exp−5
4	25.69	17.88	0.86	0.06	0.85	4.52	0.19	6.1exp−5
5	27.38	22.82	0.61	0.04	0.22	0.55	0.40	0.0154
6	12.07	33.84	0.27	0.01	0.12	0.59	0.21	3.57exp−5
7	12.99	20.39	0.28	0.02	0.08	0.35	0.26	0.018
8	8.57	17.15	0.27	0.02	0.26	3.65	0.07	2.64exp−5
9	27.25	20.74	0.77	0.06	0.71	3.72	0.19	3.81exp−5
Mean	**15.29**	**22.40**	**0.44**	**0.028**	**0.29**	**1.83**	**0.22**	**0.00374**
SD	**8.88**	**5.31**	**0.26**	**0.019**	**0.27**	**1.63**	**0.13**	**0.00695**

Conclusion: DCE-MRI at 3T of carotid atherosclerotic plaque is feasible though fewer patients from this population will be 3T-MRI compatible. The advantage of 3T is greater signal to noise which can be harnessed to improve sampling rate and improve quantification by different kinetic models. Patients with symptomatic carotid disease appear to have two different patterns of enhancement, one similar to but of lesser magnitude to an AIF.

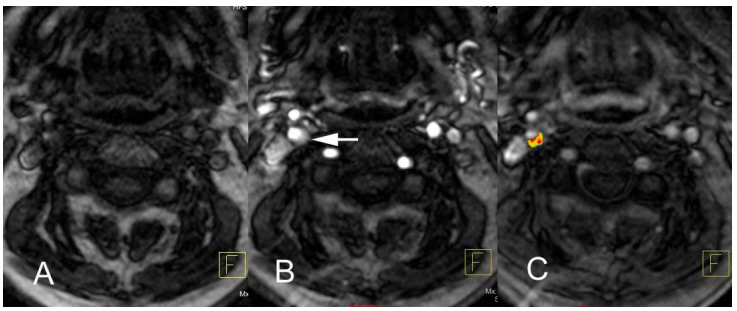

Fig 1. Pre-(A),post-contrast (B) & K^{trans} image of plaque

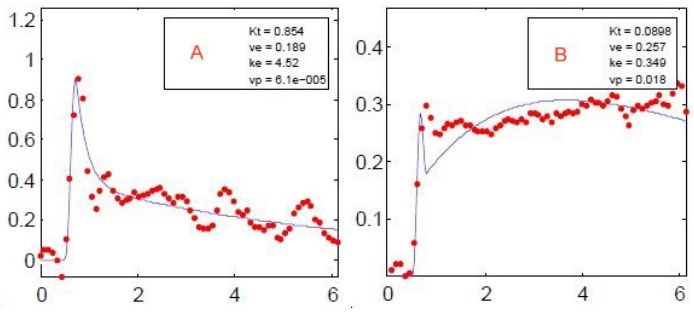

Fig. 2. Two different [Gd]-time curve patterns and fitted curves

References: 1. Kerwin WS et al. Radiology 2006; 241:459-68; 2. Kerwin WS et al, Magn Reson Imaging 2008;59:507-14
3. Tofts PS J Magn Reson Imaging 1997;7:91–101 4. Parker GJ et al Magn Reson Med. 2006 Nov;56(5):993-1000