A novel DCE-MRI protocol for the study of brain tumours at 3T

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Introduction Quantitative dynamic contrast-enhanced MRI (DCE-MRI) uses T_1 weighed acquisitions to record the time course of the uptake of contrast agent, allowing information related to microvascular function to be derived. DCE-MRI has been applied to characterise cerebral vasculature and perfusion, as well as tumour diagnosis and monitoring of treatment. However, the large majority of brain tumour DCE-MRI studies to date have been conducted at 1.5 T. Although the signal to noise ratio at 1.5 T is generally worse than at 3 T, the transition of methodology and clinical studies to 3 T has been hindered by difficulties in optimising T_1-weighted contrast in rapid imaging protocols and in accurate quantification of T_1 in the presence of the more severe RF inhomogeneities present at this field strength. Therefore, to exploit the potential of quantitative DCE-MRI at 3T, the development and optimisation of new scanning protocols is required. We have recently reported a successful DCE-MRI study at 3T for renal function [1], where a 3D Turbo field echo (TFE) sequence was employed at 3T in the abdomen. Our work adapts this protocol for brain tumour DCE-MRI studies at 3T. We also demonstrate that the protocol is applicable to brain studies at 1.5 T without modification, therefore providing a method for cross-platform studies.

Methods Four healthy volunteers (two males and two females) and a single patient with a low grade glioblastoma were scanned on a 3 T Philips Achieva and a 1.5 T Philips Intera system using a two part protocol: (1) a series of 8 3D inversion recovery (IR) TFE sequences at different inversion times, (2) A dynamic 3D RF-spoiled fast field echo (FFE) sequence to record the uptake of contrast agent. An 8 channel SENSE head coil was used at 3 T; a 6 channel SENSE head coil was used at 1.5 T. For the IR TFE T_1 measurement the data matrix was128x128 with an 80% scan percentage, field of view of 230 mm, flip angle 15 degrees, TR/TE = 3.2/1.09 ms, TI = 116, 200, 400, 700, 1000, 1500, 2300, 3900 ms, and 25 sagittal slices of 2.1 mm thickness. In the variable 3D FFE dynamic acquisition, TR/TE = 4.5/1.07 ms, 90 % scan percentage, and a 15 degree flip angle was used. Temporal resolution was 3.4 s per volume. The IR TFE data were fitted with a previously described relationship [2] using a 3 parameter non-linear least squares method.

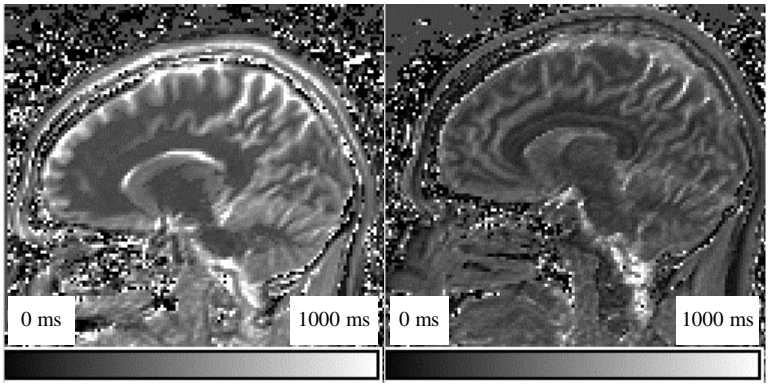

Figure 1. *T1 maps of a healthy volunteer's brain at 3 T (left) and 1.5 T (right).*

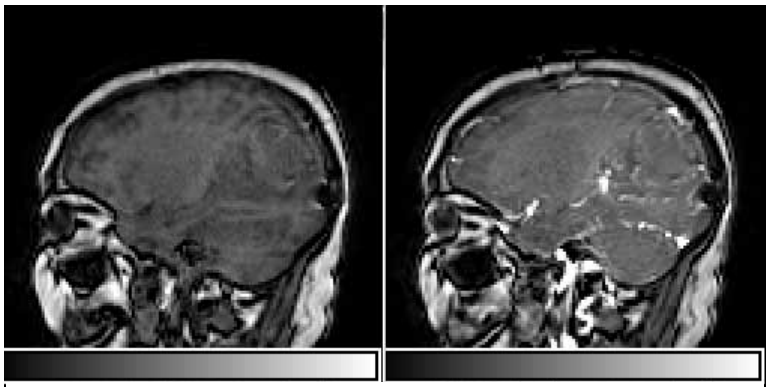

Figure 2. *T1-weighted images of a patient with Glioblastoma before (left) and 1 minute after Gd-DTPA injection.*

Results and Discussion T_1 maps generated using the IR-TFE method at 1.5 T and 3 T from one of the volunteers are shown in Fig. 1. T_1 values of different brain tissues are listed in Table.1, which are in general agreement with published literature [3]. Figure 2 shows images from the dynamic time series acquired in a patient with a low grade glioma using the 3D FFE sequence. Strong enhancement is clearly visible in the vessels, with lower, but clearly detectable enhancement in the tumour periphery, as is characteristic of such masses.

During the process of sequence optimisation, matrix size, scan percentage and SENSE factor were carefully chosen to ensure that that acquired images had the lowest possible level of artefact, whilst maintaining an acceptable temporal resolution. The SENSE factor employed is a critical in reducing temporal resolution, but taken too high can introduce unacceptable levels of image artefact. Similarly, the flip angle used in the IR-TFE and dynamic 3D FFE largely dictates the degree of T_1-weighting, but if taken too high can lead to artefacts and high SAR.

This is the first study, to the best of our knowledge, to demonstrate a high temporal resolution quantitative DCE-MRI protocol for the brain that can be applied at 3 T without detrimental effects due to RF inhomogeneity and that is equally suited for use at 1.5 T. We expect the protocol to be easily adaptable for effective quantitative DCE-MRI in tumour studies in other Body areas such as the abdomen and pelvis.

Table.1. T1 values from a healthy volunteer's brain measure at 3T and 1.5T

area	**3 T** (ms)	**1.5 T** (ms)
Corpus callosum	870 ± 60	550 ± 62
Internal Capsule	871 ± 86	662 ± 51
Thalamus	1226 ± 116	821 ± 108
Lateral ventricle	3676 ± 401	2012 ± 416
Centrum Semiovale	911 ± 29	615 ± 36

References

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