Purpose: Diffusion-Weighted (DW) MRI has gained prominence in oncology as a technique which may allow quantitative assessment of tumour status and progression of disease. For widespread application in multi-centre trials, these techniques require assessment of the sensitivity and reproducibility of the technique; comparison between scanner platforms and performance assessment of common protocols should be carried out. The purpose of this study was to develop a phantom for quality assurance in multi-centre clinical trials which apply DW-MRI.

Methods: A modular Perspex phantom was designed and built to facilitate temperature controlled measurements of the Apparent Diffusion Coefficient (ADC). The phantom has capacity for five sample tubes within a 10 litre cylindrical vessel, an example image is shown in Figure 1; the samples may be removed and altered as required. The phantom is compatible with both head and body coils from major manufacturers and may be moved within the magnet bore to assess performance as a function of position.

Temperature control was achieved with the use of an ice/water mixture in the main vessel of the phantom. Temperature stability was monitored with a thermocouple. Control over the ADC of the sample was achieved with the addition of sucrose. The sample ADC, T1 and T2 were measured as a function of sucrose concentration (0 – 50% w/v) at 0 and 22°C. Sample T1 and T2 were altered with the addition of manganese chloride (MnCl2). The relaxivity properties of MnCl2 were assessed at 0 and 22°C as a function of MnCl2 concentration (0 – 0.04 mM). T1 mapping was achieved using a variable flip angle method. T2 mapping was achieved from a multi-echo spin echo sequence with 32 echo times ranging from 13.1 – 419.6 ms. ADC maps were acquired using a diffusion weighted SS-EPI acquisition with 10 b-values in the range 0 – 2730 mm² s⁻¹. Sodium azide (0.02% w/v) was added to each of the solutions as a bactericidal agent.

Results and discussion: Stable temperature control is achieved over a 2 hour period. Linear relationships were observed between sucrose concentration and measured ADC, T1 and T2. Linear relationships were observed between MnCl2 concentration and relaxation parameters, but not with sample ADC, see Figure 2. For the final design, concentrations of sucrose and MnCl2 were selected to provide physiologically relevant ranges of T1, T2 and ADC at 0°C; these are shown in Table 1.

Conclusion: A phantom suitable for inter-scanner comparison of ADC measurements has been developed based on previous work by Chenevert et al. This test object is being used to aid the validation of ADC as a biomarker for treatment response of tumours in multi-centre clinical trials.


Acknowledgements: We acknowledge the support of CRUK and ESPRC Cancer Imaging Centre in association with the MRC and Department of Health (England) grant C1060/A10334 and also NHS funding to the NIHR Biomedical Research Centre. C. Cummings and N. Smith, ICR workshop.