Contrast Optimisation using Fast Field-Cycling MRI

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Introduction: Fast Field-Cycling (FFC) techniques have been combined with MRI to allow acquisition of T_1 dispersion curves of a sample, combined with the ability to image at a range of magnetic field strengths during an MRI scan [1]. Contrast agent relaxivity is strongly dependent on B_0, thus it is possible, using FFC, to select the field which maximises contrast enhancement in a T_1 weighted image. In this experiment the relaxivity properties of contrast agents in tissue-mimicking bovine serum albumin (BSA) were obtained using FFC relaxometry. FFC-MRI was then used to obtain images at fields showing maximum contrast between pure BSA and BSA containing different contrast agents. Two contrast agents 'Hemalbumin' and 'USPIO Sinerem' were investigated for possible use with FFC-MRI.

Methods: T_1 dispersion curves were obtained using both a commercial relaxometer (Stelar s.r.l., Italy) [2] and a home built FFC-MRI system. BSA was used as a tissue substitute [3], into which selected contrast agents were added. The samples chosen are labelled below; 1: Hemalbumin 0.1mM, 2:CuSO4 0.5mM, 3: MnCl2 0.1mM, 4: Hemalbumin 0.5mM, 5:CuSO4 1mM, and 6: USPIO Sinerem 0.12mM. These samples were chosen based on their dispersion properties in water. Dispersion curve information was then used to determine the magnetic field which would allow maximum signal enhancement caused by the contrast agents in BSA [4]. Imaging experiments were carried out using a home-built FFC-MRI system which allowed images to be produced at any field between 1 and 59 mT.

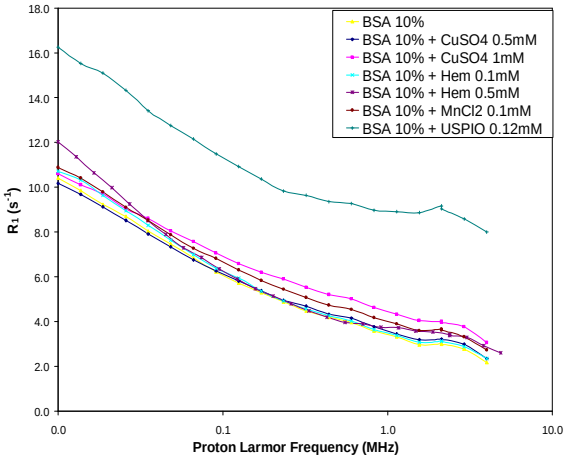

Figure 1: R_1 dispersion curves of contrast agents in BSA 10%

Results: Figure 1 shows the R_1 dispersion curves obtained from different contrast agents in BSA. This information was used to select the magnetic field which would result in maximum contrast enhancement between any two samples. Figure 2 shows images of the solutions at different field strengths: 59 mT on the left, and 1 mT on the right.

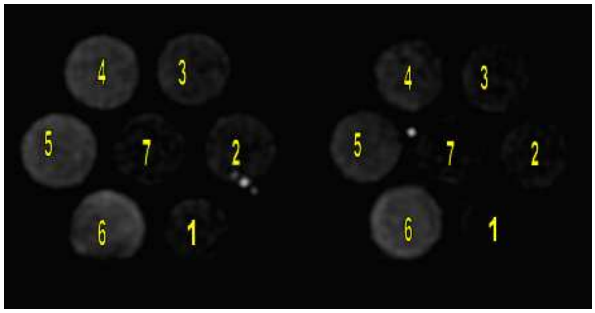

Figure 2: Images of phantom at 59 mT (left) and 1 mT (right). Numbers indicate the sample type, as listed under Methods.

Conclusions: The solutions used in this study were specifically chosen due to their high dispersion between 0 and 59 mT, thus showing wide changes in contrast when switching from low fields to high fields. This shows that FFC-MRI can be used to manipulate image contrast, potentially enabling agents to be "switched on and off" during a single scan. The properties of tissues though different to BSA have similar dispersion characteristics and are amenable to contrast optimisation via field cycling. The crucial advantage, and the power of FFC-MRI is that the evolution magnetic field can be set to any chosen value (within the limits of the instrument), while signal detection remains at a fixed magnetic field. This work shows that FFC-MRI, in combination with T_1 dispersion measurements, allows the optimisation of contrast as a function of evolution magnetic field strength.

References:

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