Relaxation Dispersion Contrast of Tissue at 1.5T

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Introduction: Relaxation dispersion imaging – also called "delta relaxation enhanced MR" (dreMR) – is a new imaging method which allows acquiring information about the magnetic field dependence of the relaxation rate (R_d=dR_1/dB, relaxation dispersion). This method has been applied to contrast agents before since these substances provide strong relaxation dispersion at 1.5T [1]. The relaxation dispersion of tissue without contrast agent is much smaller but still measurable and can be used to generate a completely new MRI contrast. Past experiments have proven relaxation dispersion to be an important tool for the investigation of molecular dynamics [2] but did not allow for spatially resolved measurements at clinical field strengths.
In this abstract we present the acquisition of relaxation dispersion images in a mouse without the use of contrast agent. The resulting contrast provides a relaxation dispersion weighting which highlights areas with strong dependence of the relaxation rate on the magnetic field strength.

Methods: dreMR imaging intends to display the change in relaxation rate when going from one B_0 field strength to another. The variable B_0 field is achieved by a field cycling coil which is placed at the isocenter of a conventional scanner [1]. It increases or decreases the B_0 field during the imaging sequence. Two images with contrast from high and low B_0 field are collected for subtraction. They are acquired with a saturation recovery multi spin echo sequence with exactly the same imaging parameters except for the B_0 field strength. The resulting image yields an intensity [1]

$$I = M_0[\exp(-R_1 T_{\text{evol}}) \times \Delta B R_{\text{d}} T_{\text{evol}}]$$

where I is the image intensity, M_0 the equilibrium magnetization at B_0 without offset field, R_1 the tissue relaxation rate at B_0 without offset field, T_{evol} the duration between saturation and image acquisition, ΔB the change in magnetic field B_0 and R_d the relaxation dispersion. The image intensity is directly proportional to the change in relaxation rate between high and low B_0 field.

Experiments: Relaxation dispersion images and maps have been acquired of several tissue types and biological samples. In this abstract we present a dreMR image of a mouse at 1.5T. The setup consists of a clinical 1.5T whole body scanner equipped with a field cycling coil capable of a ±90mT field shift. Parameters for the dreMR image are: 531µm in plane resolution, 3mm slice thickness, TR=2500ms, T_{evol}=450ms, TE=9.2ms, 40 averages, total acquisition time 4.4h. The long repetition time (TR) is owed to a lack of cooling capacity of the field cycling coil and could be reduced by a factor of five for coils with sufficient cooling. The mouse is immersed in formalin.
Figure 1 a) shows a high resolution, T_1 weighted TSE image of the mouse (without fat suppression) as anatomical reference. Figure 1 b) shows the same slice acquired as dreMR image with the parameters reported above, c) is a colored overlay of the dreMR image and the TSE image.

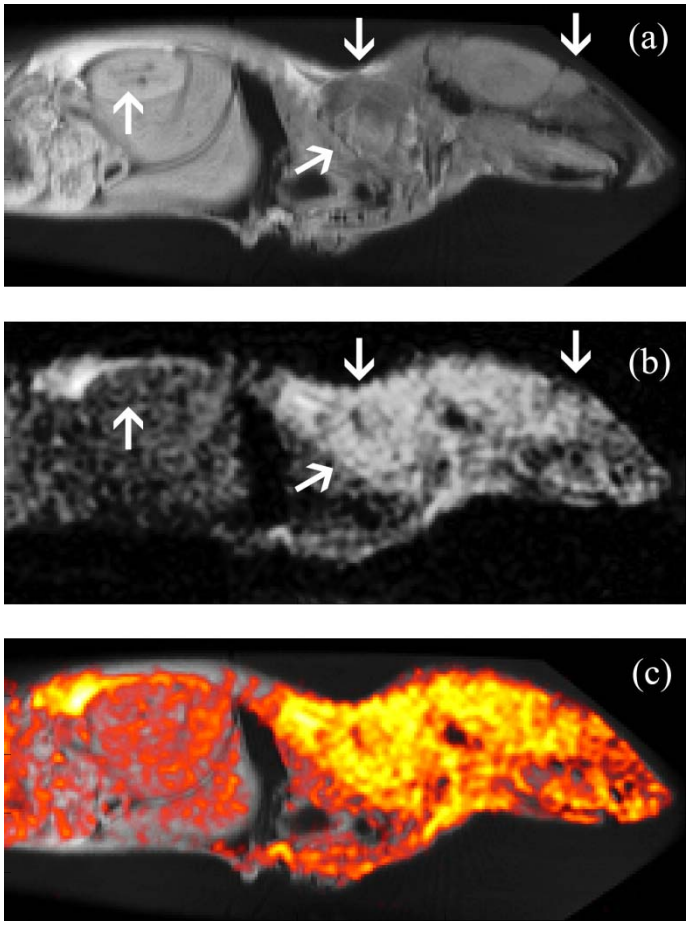

Fig. 1: a) high resolution, T1 weighted TSE image of a mouse, b) dreMR image of the same slice, c) colored overlay of dreMR image and TSE image, the white arrows indicate regions where the dreMR contrast substantially differs from T1 weighted contrast

Results: The dreMR image shows a contrast which significantly differs from the T_1 weighted contrast. Arrows in figure 1 a) and b) mark areas with examples for dreMR contrast being different from T_1 contrast. Strong dreMR signal corresponds to a large change in relaxation rate between 1.41T and 1.59T, low signal indicates a small change in relaxation rate. The signal of the formalin completely vanishes as liquids usually do not feature any relaxation dispersion at 1.5T. The new contrast is yet to be interpreted. Up to now very few reliable data on the relaxation dispersion of tissue at 1.5T is available, especially the comparison between multiple types of tissue and the comparison between healthy and pathologic tissue have not been carried out to a sufficient extend.

Conclusion: We have demonstrated the acquisition of relaxation dispersion weighted images of tissue. The image of a mouse yields intensity directly proportional to the change in relaxation rate induced by varying the field strength from B_0=1.41T to B_0=1.59T. Image contrast substantially differs from T_1 weighted contrast. This new contrast has to be interpreted in the context of relaxation dispersion – a parameter unknown to imaging so far but proven to hold very interesting information on molecular dynamics. We believe relaxation dispersion imaging can provide new insight into biological and clinical problems and increase the set of parameters to generate MR contrast. Furthermore the exact knowledge about tissue relaxation dispersion will be important for further dreMR experiments with contrast agents.

Acknowledgements: This work was performed with support from the BMBF under Award No 01EZ0816 and support from the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology.

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