Enhancement of the myelin rich regions in MR images in the mouse brain in vivo using IR-UTE with a cryo-coil at 9.4 T.

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Purpose

Many neurodegenerative diseases are associated with changes in tissues with short T2 and T1 relaxation times such as myelin [1]. However MRI of tissues with short T2 is challenging using conventional MRI techniques [2]. One of the methods providing high quality images and capable of quantification of a short T2 component is a sequence utilizing Levitt – Freeman's 90_0-180_{90}-90_0 composed refocusing pulse [3]. However, the minimum TE (TE_{min} ~ 4 ms) makes it still difficult to precisely evaluate the short T2 components associated with myelin water. Therefore it is beneficial to use an ultra-short echo time (UTE) sequence that allows imaging of the tissue with even shorter T2 times [1,2]. In this case myelin water is however obscured by a large signal with longer T2 and T1 times from relatively free water reservoirs. Using IR-prepared UTE should allow to null the long T1 component originating from these water compartments [4] (Fig. 1) and to properly detect brain structures with different amount of myelin water.

The purpose of our study was to investigate efficiency of the relative enhancement of myelin water component in the mouse brain using IR-UTE. We compared the results obtained with the birdcage coil and the Bruker CryoProbe.

Methods

Healthy C57BL/6J mice were used. A 9.4T/21cm horizontal bore Bruker Biospec MRI scanner was used. A room-temperature 35 mm diameter birdcage coil and the Bruker CryoProbe were compared. The standard 2D UTE sequence with the following parameters: TR/TE: 2500/0.351 ms, FA = 90º, FOV = 2 × 2 cm, 1 mm axial slice was applied using each coil. Using CryoProbe, we compared standard 2D UTE and IR-UTE (TR/TE: 2500/0.351 ms, FA = 90º, FOV = 1.5 × 1.5 cm and slice thickness of 1mm, with two inversion recovery times (TI): 500 ms and 1000 ms). In this case coronal slice was used in order to assure the same flip angle over the imaging plane. The Contrast-to-Noise Ratio (CNR) between different brain structures was calculated to compare the effectiveness of each sequence in enhancement of specific anatomical brain structures. The formula: CNR = (SI (tissue 1) – SI (tissue 2))/Noise was applied and calculated using ImageJ 1.46r software. The average signal intensities for three structurally different brain regions were calculated: 1. internal capsule (ic) representing WM, 2. dentate gyrus (DG) representing GM and 3. left ventricle (LV), dorsal third ventricle (D3V) and cerebral aqueduct (Aq) representing CSF (Fig 2C).

Results

An increase in CNR of approximately 2.5-fold was observed for the CryoProbe as compared to the birdcage coil. Only the CryoProbe was then used for studying CNR dependence on TI using IR-UTE. CNR enhancement is visible in images obtained with IR-UTE, when compared to 2D UTE (Fig 2), providing better contrast between the brain structures. WM region is significantly enhanced as compared to CSF and GM regions for both TI values. CNRs for WM and GM were -1.2, -1.7 and 1.1 for UTE 2D, IR-UTE (TI=500ms) and IR-UTE (TI=1000ms) respectively and corresponding values for WM and CSF were -1.4, -3.9 and 2.9.

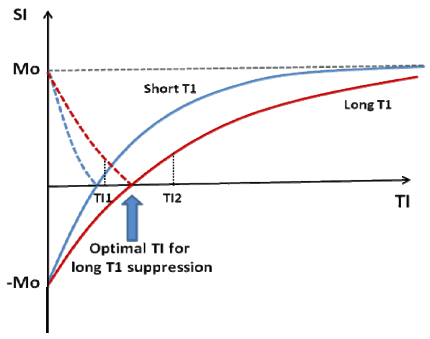

Fig. 1. A scheme of the short and long T1 relaxation after application of inversion recovery pulse. Dashed line represents actual signal decay on MR image.

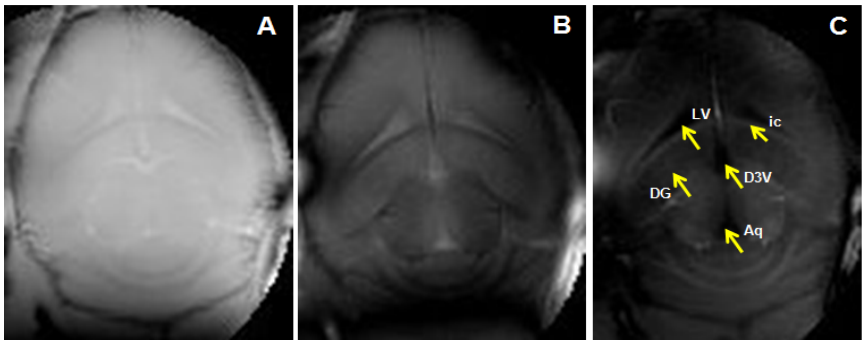

Fig. 2. Coronal MR images of a mouse brain *in vivo*: **A.** 2D UTE (TR/TE: 2500/0.351ms) **B**. IR-UTE (TR/TE: 2500/0.351ms), TI = 500 ms **C**. IR-UTE (TR/TE: 2500/0.351ms), TI = 1000 ms. (FOV=1.5×1.5cm, slice thickness = 1mm). The analysed brain structures are labeled with arrows in image **C**.

Conclusions

Our study demonstrated that combining the IR-prepared UTE sequence with the properly selected TI and the cryo-coil enables significant positive enhancement of the CNR from myelin rich WM regions of the mouse brain *in vivo*. The results indicate possibility of applying this approach for direct assessment of the myelin related brain pathologies in animal models of diseases.

References:

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