Elongated T_1 values in human brain and the optimization of MDEFT measurements at 4.7T

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Introduction

It is well understood that the modified driven equilibrium Fourier transform (MDEFT) gives an excellent T_1 contrast at 4T [1]. We obtained a 3D high resolution (1x1x1mm in all three dimensions) MDEFT image on the brain even at 4.7T with the optimized condition at 4T. T_1 values obtained in the human brain at 4.7T, however, were significantly increased compared with those at 4T. This suggested that the re-optimization of parameters of T_{MD}, flip angle, and the number of segmentation in the FLASH sequence should improve the CN ratio (CNR) between grey and white matters at 4.7T. The purpose of this study is to optimize the MDEFT measurement by both theoretical calculations and measurements on the phantom sample.

Methods

Experiments were performed on a 4.7Tesla/92cm system (Varian,PaloAlto). A standard ^{1}H TEM coil was used for RF transmission and reception. T_1 values of the human brain were acquired with an IR-prepared Turbo-Flash sequence using TR/TE of 9.0/4.0ms with FOV of 25.6x25.6cm, image matrix of 256x256, slice thickness of 2.5mm and flip angle of 10 degree. Human brain studies were conducted on four normal volunteers. Phantom samples for 3D MDEFT measurements were made from saline, whose T_1 and T_2 values were adjusted with $CuSO_4$ and agarose to simulate the values of grey matter, white matter and CSF observed at 4.7T. 3D MDEFT brain images were obtained using TR/TE of 10/3.7ms with FOV of 25.6x25.6x19.2cm, matrix size of 256x256x192 acquired in two segments, T_{MD} of 2.0s, and flip angle of 13 degree. Obtained data matrix was zero-filled to 256x256x256 before Fourier transformation.

Results and Discussion

We made T_1 measurements in the human brain at 4.7T. Obtained T_1 values of 1.63 ± 0.06s (n=4) and 1.07 ± 0.04s (n=4), for grey and white matters, respectively were significantly increased compared with those at 4T [2]. In MDEFT measurements the parameter of T_{MD}, a preparation period for the longitudinal magnetization, plays a decisive role for production of CN contrast. Theoretical calculation predicted that T_{MD} around 2.8s gave the best CNR per measurement time between the grey and white matters based on the T_1 values at 4.7T (Fig.1. black broken line). In the actual 3D MDEFT measurements on the phantom which simulated the T_1 and T_2 values at 4.7T the CNRs exhibited dependence on the T_{MD} consistent with the calculated prediction (Fig.1. solid line). Considering the total measurement time the T_{MD} value for brain measurements were compromised to 2.0s. Further to reduce the measurement time the number of segmentation in the FLASH part was reduced to two from four which was recommended at 4T. Flip angle was also optimized at 13 degree from the phantom measurements. No deterioration in the spatial resolution was confirmed in the modified condition using a phantom constructed from capillaries with a diameter of 1mm. A 3D MDEFT brain image (Fig.2.) demonstrated approximately 40% improvement in the CNR between grey and white matters compared with that measured with conditions optimized at 4T.

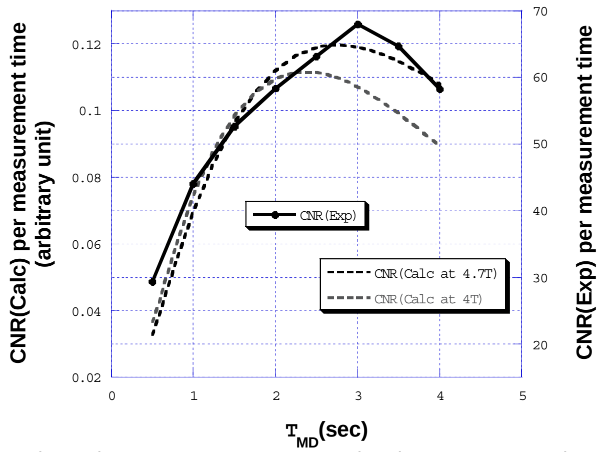

Fig.1. The CNR per measurement time between grey and white matters as a function of T_{MD}.
CNR=[S(GM)-S(WM)]/[noise x sqrt(T_{MD})]
Solid line : experimentally observed CNR on phantom at 4.7T.
Black broken line : calculated CNR at 4.7T.
Grey broken line : calculated CNR at 4T.

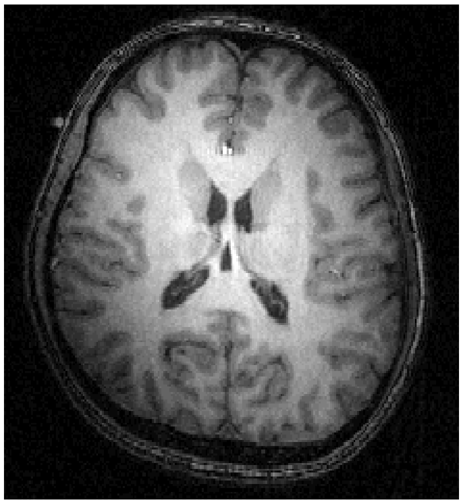

Fig.2. A transverse slice from the 3D MDEFT brain image at 4.7T. T_{MD} =2.0sec, flip angle=13degree, 2segments Spatial resolution was 1x1x1mm in all three dimensions.

References

1. Lee JH, Garwood M, Menon R, Adriany G, Andersen P, Truwit CL, Ugurbil K. Magn Reson Med. 1995,34(3):308-12.
2. Kim SG, Hu X, Ugurbil K., Magn Reson Med. 1994,31(4):445-9.