Magnetization Transfer Imaging of Brain : A Quantitative Results Obtained At 3.0T

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Introduction

Magnetization transfer (MT) effect is known to be more pronounced at the higher field and a quantitative comparison was made at 1.5T and 4.0T [1-2]. With FDA clearance, a 3.0T MRI becomes available on clinical environment. This makes the quantitative evaluation of MT effect at 3.0T important because this technique is expected for possible clinical applications such as neuro-degenerative diseases. In this study, we investigate MT effect of the brain at 3.0T and evaluate the off-resonance frequency dependence of the MT phenomenon.

Material and Methods

Subjects: five normal subjects (3 males, 2 females; age: 26-34 years; mean age: 30 years) were included in this study after obtaining written informed consent in accordance with protocols approved by the institutional review board.

MT Imaging: All studies were performed on a 3.0T SIGNA VHi scanner (General Electric, USA) equipped with gradient strength of 40 mT/m using standard head coil. The MT images were acquired using spin-echo sequence with optional off-resonance saturation pulse. The off-resonance pulse has flip angle of 1100 degree and peak B_1 value of 0.354 Gauss. The MT pulse was applied at frequencies from 400 Hz to 1600 Hz off from water resonance. The imaging parameters were : TR/TE = 450/14 msec, slice thickness = 5 mm, FOV = 21 cm , matrix size = 128×128, and the number of slices = 3 to ensure FDA approved levels of SAR. The MT ratio (MTR), which is defined as $(S_0\text{-}S_t)/S_0$, is calculated at various regions of brain. In MTR, S_0 is signal intensity without off-resonance saturation and S_t is the signal intensity with off-resonance saturation. For frequency dependence of MT effect, the M_s/M_0 curve at a given B_1 is also evaluated. Here, M_s is the signal intensity with saturation pulse at each offset frequency and M_0 is the signal intensity without saturation pulse.

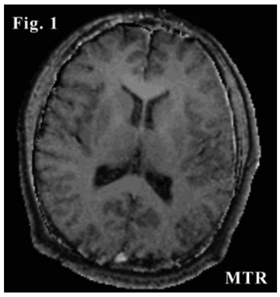
Results

MT effect on anatomic structures: Table 1 shows the MTR values for various regions of the brain, including white matter (WM), cortical gray matter, and thalamus. All anatomic structures of brain shows higher MTR values at 3.0T when compared to the reported values at 1.5T. Among brain regions, corpus callosum shows the highest MTR values and in general MT effect appears more pronounced in white matter than in gray matter. This is well shown in MTR map obtained at 3.0T (Fig. 1). For WM, the MTR increased by 14.8% from 1.5T to 3.0T. For comparison, the previously reported values at 1.5T and 4.0T are also presented in Table 1. The MTR values of cortical gray matter (CGM) is larger at 3.0T than at 4.0T. The authors [2] explained that this smaller MTR of CGM at 4.0T is probably due to the choice of imaging parameters which were employed in their study.

Off-resonance frequency effects: The frequency dependence of the MT effect of some regions of brain at 3.0T is shown in Fig. 2. As expected, the saturation of signal intensity (M_s) is less pronounced as the offset frequency is increased. The plot shows that the plateau of the frequency dependence is not reached up to 1600 Hz. For a given B_1 value, the width of M_s/M_0 curve is different for each anatomic structure. That is, corpus callosum has broadest width whereas putamen has narrowest width among shown structures. Therefore, the frequency dependence of the MT effect shows that the saturation of macromolecular pool in each anatomic structure is different.

Discussion

Our data revealed that MT effect is larger at 3.0T than at 1.5T and generates better contrast between gray and white matter. This result is consistent with the previous work at 4.0T although the physical basis for the increased MT effect at higher field is still unclear [2]. One of the possible explanations for increased MT effect at higher field is the model [3], which tells the MT effect is dependent on the square root of the ratio of T1 and T2. Since T1 value increases at higher field whereas T2 value is almost independent on field strength, the MT effect is expected to be pronounced at higher field. The width of MT saturation upon off-resonance frequency is broader than that of 1.5T. This seems to support the previous interpretation that the macromolecular component will be more easily saturated at the higher field. The increased MT effect at 3.0T has many clinical implications. The edema in stroke or multiple sclerosis plaque would benefit from the increased MT effect at 3.0T because these lesions might be more visible on MT contrast images with higher contrast between gray and white matter. Another clinical application is the MR angiography (MRA). MT is often used for the background suppression and thus the increase MT effect gives better suppression of stationary tissue signal to visualize the vasculature.



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	1.5T*	3.0T	4.0T*
White Matter	0.34±0.028	0.40±0.082	0.41±0.023
Cortical Gray Mat	0.28±0.027	0.33±0.048	0.30±0.029
External Capsule	---	0.35±0.064	---
Thalamus	---	0.38±0.076	---

Table 1. (*) from Ref [2]. (---) no data available