Global Magnetization Transfer Imaging: A high SNR Magnetization Transfer Method for Spinal Cord Imaging

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Introduction

Magnetization transfer (MT) imaging has been used as an early detector of white matter degeneration, e.g. in Multiple Sclerosis (1). The most standard method for making MT into a tractable measure of CNS pathology is by determining a Magnetization Transfer Ratio (MTR), which provides a quick approach to measure the amount of MT effect in a tissue by constructing percent difference images between two scans acquired with and without off-resonance irradiation (2-4). In the spine, it is difficult to obtain such ratios with sufficient SNR, while simultaneously achieving a resolution high enough to differentiate between gray and white matter pathology, especially in an axial plane. Confounding factors are its small diameter (low signal-to-noise ratio, SNR), its proximity to surrounding bone and flowing cerebrospinal fluid (CSF), and a high degree of mobility. A modified MT Imaging approach, called Global Magnetization Transfer (GMT), was devised to achieve a high resolution, model-independent imaging modality capable of distinguishing tissue types in the cervical spinal cord.

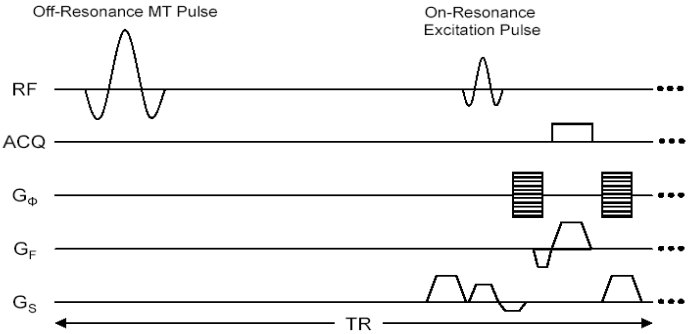

Figure 1: 3D-GRE Sequence for GMT Imaging

Methods

Ten healthy adults (mean age 37 y), were studied after written informed consent. Studies were performed on a 1.5-T Philips Intera-NT system (Philips Medical systems, Best, The Netherlands). Quadrature body coil, transmission, and two-element phased array coil, reception, were used. Flow-insensitive MT-weighted images were acquired using a spoiled 3D-Gradient Echo (3D-GRE),TR / TE /α = 50 ms / 13 ms / 7°, with a five-lobe sinc MT pre-pulse of 15 ms (Figure 1). Ten RF offsets were logarithmically sampled between 1 and 63 kHz, plus a reference scan (0° MT pre-pulse). Field of view = 225x225x48 mm, matrix = 512x512x32, total scan time 33 minutes. Signal normalization was achieved using an ROI manually selected within CSF of the reference scan for all slices. Pearson's Correlation under parametric assumptions was performed to evaluate the association between the mean CSF value taken from one slice of the reference scan and the mean CSF value manually selected from each of the MT weighted scans at the same slice for all volunteers. The GMT was then defined as the integral of the CSF normalized MT z-spectrum from 1 - 63 kHz..

Results and Discussion

Figure 2 shows a typical GMT image at the level of C2. Good gray-white contrast can be appreciated in all slices, visualizing the gray matter horns (butterfly-shaped) that separate the lateral and dorsal columns (dark). Note that the highly myelinated white matter is dark, the grey matter is less dark and the CSF is bright white. This approach need not be limited to the spine. While the MT z-spectrum was integrated to yield a high contrast mechanism, the selection of the CSF as an internal reference has many benefits outside the spine. By selecting the CSF as the reference, the SNR was appreciably increased and mis-registration artifacts apparent in the voxel-by-voxel division were minimized. In this study, the CSF was chosen from the reference scan, but since the CSF should contain no MT effect, a reference scan could be avoided altogether. In fact, there was a significant 97% correlation between the mean CSF value of the reference scan and the mean CSF value from all MT weighted scans from all volunteers ($p<0.0001$) implying that an internal reference need not come from a separate reference scan. Thus, selection of the CSF as an intensity reference immediately increases SNR without the added time spent in acquiring a reference scan. In many diseases, it is unclear which offset frequencies are most instructive for quantitative analysis of white matter integrity, and the GMT could be used to define the portions of the z-spectrum most sensitive to pathological changes. Once this frequency range is chosen, the scan time can be dramatically reduced while still achieving a high SNR imaging modality.

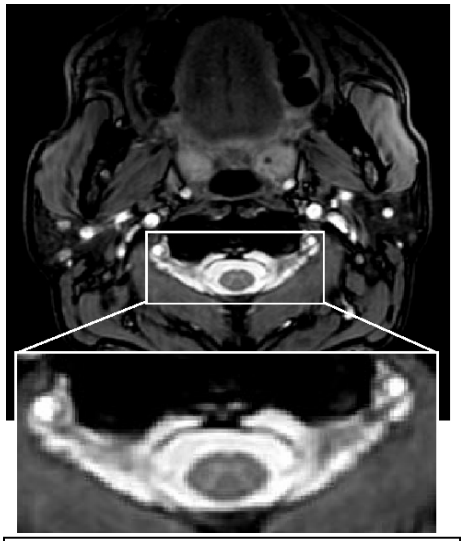

Figure 2: GMT Image at C2 of a Volunteer

References

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