T2* measurement of the pituitary with susceptibility artifact compensation at 3T

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Introduction: Preclinical diagnosis of iron overload in the pituitary gland is important for chronically transfused patients with hemoglobinopathies such as thalassemia.[1,2] T2* measurement is very sensitive for detecting iron deposition in several tissues[3] but severe susceptibility artifact (due to sphenoid sinus) makes T2* measurement in the pituitary gland difficult. Instead, T2 measurement or T2*-weighted imaging have been used to assess iron deposition in the pituitary gland.[1,2] In this study, we propose a T2* measurement method based on field map analysis and susceptibility artifact correction in the pituitary gland ultimately aimed at evaluating iron overload.

Methods: To investigate the distribution of the susceptibility induced gradients in the pituitary gland, isotropic 3D multi-echo gradient echo images (Fig. 1) were acquired at 3T clinical scanner (Siemens Tim Trio) with following parameters: TR=60ms, TE=3.1/7.3/11.5/15.7/19.9/24.1/28.4/32.6ms, voxel size=1x1x1mm^3, matrix size=256x256x104, flip angle=12˚. B0 field map was calculated from phase images of 1st and 2nd echo, and then susceptibility induced field inhomogeneity gradient maps (ΔGx, ΔGy, ΔGz) were estimated (Fig. 2, 3). Histogram analysis was performed by manually determining ROI from 12 sagittal slices including the pituitary gland. Based on field map analysis, x-direction was selected as the slice direction (sagittal imaging) for T2* measurement since it gave the narrowest field dispersion (Fig. 2). To minimize susceptibility artifacts in the pituitary gland, very high in-plane resolution (for Gy, Gz) and additional compensation gradients[4] (x-shim for Gx) were used. A 2D multi-echo gradient imaging for T2* measurement was performed at 3T with following parameters: TR=120ms, TE=5.4/13.6/21.9/30.1ms, flip angle=45°, voxel size=0.45x0.45x1.8mm^3, 3 slices with 0.4mm gap, 4 additional scans with different compensation gradients for 2nd, 3rd, 4th echoes, total scan time (5 scans) = 5 min 7 s. A healthy volunteer was scanned twice. The second scan was performed three days after the first scan. Compensated images were reconstructed from five scans[4] and then three slices were averaged for SNR improvement (Fig. 4). T2* maps were estimated using a mono-exponential fitting from uncorrected images (no compensation gradients) and corrected images.

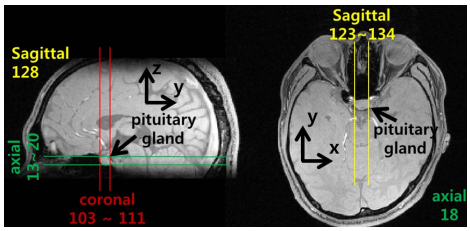

Figure 1. 3D 1mm isotropic gradient echo images at TE=3ms. 128th sagittal slice and 18th axial slice including the pituitary gland.

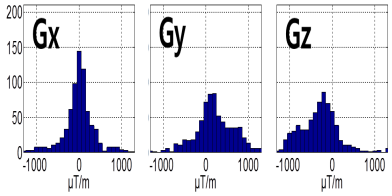

Figure 2. The histograms of the susceptibility induced field gradients in the pituitary gland (total 576 voxels).

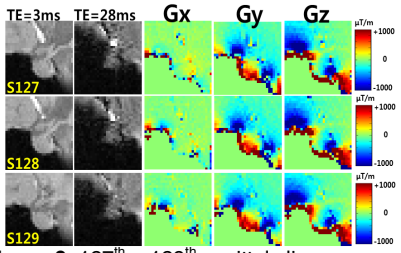

Figure 3. 127th ~ 129th sagittal slices including the pituitary gland. Magnitude images and ΔGx, ΔGy, ΔGz maps.

Results: Figs. 2 and 3 show that the ΔGx distribution is relatively homogeneous in the pituitary gland compared to those of ΔGy and ΔGz, particularly, in the mid sagittal slices (s127~s129). Therefore, sagittal imaging is advantageous to reduce susceptibility artifacts in 2D high-resolution imaging. While signal losses are prominent in the pituitary gland in the uncorrected magnitude images as TE increases, these signal losses are mostly recovered in the x-shim compensated corrected images (yellow arrow in Fig.5). The corrected T2* values in the pituitary gland (Fig. 6) show comparatively homogeneous distribution except in some parts of the inferior posterior regions (red arrow in Fig. 5) and the ROI T2* values (8x8 red box in Fig. 6) are agree well between the two scans.

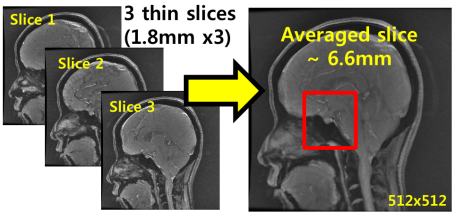

Figure 4. Obtained three high resolution (0.45x0.45x1.8mm^3) images (left) and the averaged slice (right).

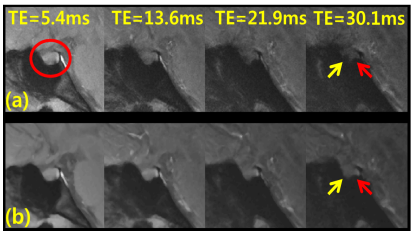

Figure 5. (a) uncorrected and (b) corrected (using compensation gradient) magnitude images at different echo times.

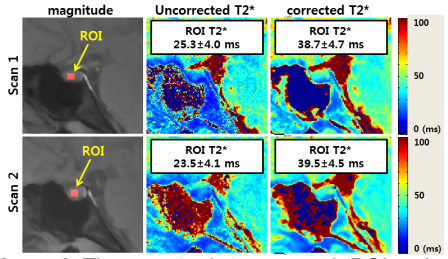

Figure 6. The magnitude images with ROI and the estimated T2* maps from 1st scan (top) and 2nd scan (bottom).

Conclusion: We present a method for T2* measurement in the pituitary gland. We analyzed field distribution using isotropic 3D GRE imaging data, and proposed T2* measurement method using high-resolution 2D GRE imaging with additional compensation gradients in the slice-selection direction. Our proposed method shows increased T2* measurement value which is due to the susceptibility correction in most pituitary gland regions and can be acquired within a reasonable scan time (5 min). To demonstrate applicability of our method, we will perform further scans and investigate the intra-subject reproducibility, inter-subject variation and head position dependency of the pituitary gland's T2*.

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