High-Resolution Imaging of Normal Human Hippocampus at 7 Tesla

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Introduction:

Depiction of subtle structural anatomical and vascular changes in the hippocampus may improve the evaluation of patients with Alzheimer's and temporal lobe epilepsy, e.g. volume reductions, vascular changes and changes in iron content have been observed in postmortem studies of Alzheimer's patients. MRI can depict hippocampus anatomy with great detail in excised specimen [1,2], however in vivo MRI, at clinical field strengths has insufficient SNR and resolution to depict detailed anatomy. This study aims to evaluate and optimize 2D and 3D high-resolution imaging of the hippocampal region in healthy subjects at 7T, and to examine challenges due to RF and Bo inhomogeneity [3].

Methods:

Coronal, sagittal and/or axial images of 6 volunteers (18-52y) were acquired with a 7T MRI (Philips, Achieva, Cleveland) using a transmit/receive head coil. T2 weighted TSE images (TR/TE/turbo-factor of 2500-4500ms/50-80ms/4-8) had in-plane resolution of 0.35-0.45mm and 2-3mm slice thickness. 2D and 3D gradient echo images were acquired with mixed T2*/PD contrast, i.e. TE=12ms≈T2*, TR/flip =1000/40^o for 2D, and 30/7^o for 3D with flip angles selected slightly below the Ernst angle for moderate PD contrast and high SNR, and TR adjusted to give comparable scan times for 2D and 3D. Resolution was 0.45x0.45x2.5mm to 0.25x0.25x5.0mm for 2D, and 0.25x0.25x2.5mm or isotropic 0.45x0.45x0.45mm for 3D. Magnitude and phase images were reconstructed off-line from the time domain data, using IDL with high pass filtering to remove slowly varying field inhomogeneities [4,5]. Different Gaussian filters with relative widths from 0.5-6 were tested to assess susceptibility effects near air/tissue interfaces.

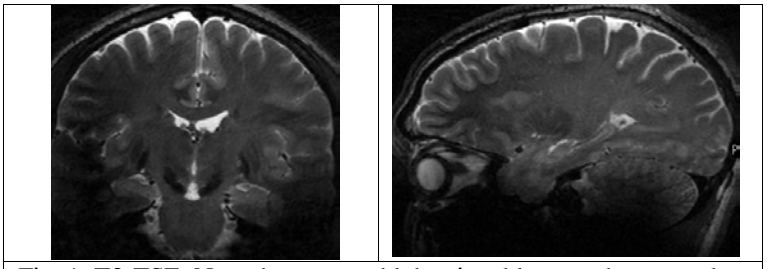

Fig. 1: T2-TSE. Note the temporal lobe signal loss on the coronal and central signal loss in the sagittal image due to RF

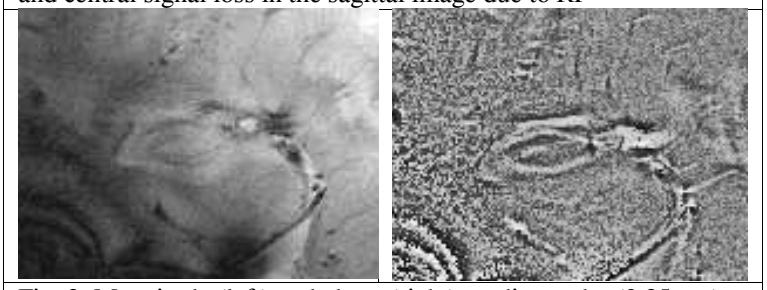

Fig. 2: Magnitude (left) and phase (right) gradient echo (0.25mm)

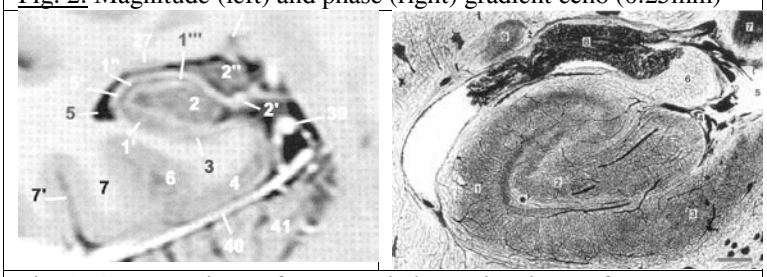

Fig. 3: Gross section (left) and India ink stain (right), (from [6]).

Results:

Detailed hippocampal anatomy can be seen in vivo on axial and sagittal T2-weighted images (Fig.1), as well as on T2*/PD weighted gradient echo magnitude and phase images (Fig.2). Comparison with published gross and india ink stained sections (Fig. 3 [6]) shows that many structures including the cornu Ammonis (1), hippcampal body (2), fimbria (2") and subiculum (3) can be differentiated. Phase images may be of particular interest, as hypointensity may reflect high vessel density (corresponding to dark areas on india ink stains), or high iron content [4]. While providing good depiction of the hippocampus, these images nevertheless show significant problems due to RF and Bo inhomogeneity. SNR is decreased by 30-40% in the hippocampus compared to superior brain regions due to RF inhomogeneity (e.g. for 3D TR/flip 30/7^o, 0.45x0.45x1.4mm, average SNR in hippocampus is 30 compared to 45 in cingulate gyrus). In the hippocampal area, a lower filter width of 2 compared to 4 in superior brain regions was needed to minimize banding due to air/bone/soft tissue susceptibility inhomogeneity even though the lower filter also diminishes soft tissue contrast.

Discussion:

The initial results from this study are very encouraging and indicate that 7T MRI may prove to be a tool for assessment of Alzheimer's and temporal lobe epilepsy, e.g. the 3D phase images will allow for measurement of hippocampus volume and vascularization. Future improvements may include the use of a larger RF transmit coil with multi-channel receive coils for improved RF coverage of this region, and Bo inhomogeneity correction methods [3].

References:

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