Chin Med Sci J
December 2017

Vol. 32, No. 4
P. 226-231

CHINESE
MEDICAL SCIENCES
JOURNAL

ORIGINAL ARTICLE

Surface-Based Morphometry of Human Brain: Intra-Individual Comparison Between 3T and 7T High Resolution Structural MR Imaging△

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Key words: MRI; ultra high field; morphometry; brain; cortex

Objective High resolution structural MR imaging can reveal structural characteristics of cerebral cortex and provide an insight into normal brain development and neuropsychological diseases. The aim of this study was to compare cortical structural characteristics of normal human brain between 3T and 7T MRI systems using surface-based morphometry based on high resolution structural MR imaging.

Methods Twelve healthy volunteers were scanned by both 3T with 3D T1-weighted fast spoiled gradient recalled echo (3D T1-FSPGR) sequence and 7T with 3D T1-weighted magnetization-prepared rapid gradient echo (3D T1-MPRAGE) sequence. MRI data were processed with FreeSurfer. The cortical thickness, white and gray matter surface area, convexity, and curvature from data of 3T and 7T were measured and compared by paired *t*-test.

Results Measurements of mean cortical thickness, total white matter surface area and gray matter surface area of 3T were larger than those of 7T (left hemisphere: P=0.000, 0.006, 0.020 respectively; right hemisphere: P=0.000, 0.000, 0.000 respectively). Surface-based morphometry over the whole brain demonstrated both reduced and increased measurements of cortical thickness, white and gray surface area, convexity, and curvature at 7T compared to 3T.

Conclusions Inconsistency of brain structural attribute between 3T and 7T was confirmed, and researchers should be cautious about data when using ultrahigh field MR system to investigate brain structural changes.

Chin Med Sci J 2017; 32(4):226-231. DOI:10.24920/J1001-9294.2017.031

Received: October 5, 2016.

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△Fund supported by National Natural Science Foundation of China (81171319), the Foundation for Medical and Health Sci & Tech Innovation Project of Sanya (2016YW37) and the Special Financial Grant from China Postdoctoral Science Foundation (2014T70960).

MAGNETIC resonance imaging (MRI) can reveal the development of normal human brain and abnormal changes of brain with high resolution. The high resolution structural imaging can further evaluate brain structural changes (eg. brain volume, cortical thickness, sulcus convexity, etc.) *in vivo*.[1] Assessment of structural difference mainly includes visual observation, voxel-based cortical thickness analysis, and voxel-based morphometry, which could reflect macroscopical structural characteristics.[2,3] Fine structural imaging of brain could reveal the intrinsic changes in brain development and brain disorders, which warrants further evaluation.

Ultrahigh field (7T) MRI has been used to study multiple sclerosis in recent years. It was thought to be a more valuable tool in assessing cortical damage because it detected much more cortical lesions than other MRI systems.[4,5] Cortical lesions were evaluated by visual observation of T2* and T2 turbo spin-echo (TSE) images and white matter attenuation (WHAT) images. Combined with computational neuroimaging, clinical functional MRI (fMRI) demonstrated that ultrahigh field MR systems provided a clinically relevant increase in sensitivity, although 7T images inevitably suffer from significant increases in ghosting artifacts, and artifacts from head motion.[6] A recent study revealed that there was a small difference in the mean cortical thickness among five healthy volunteers between 3T and 7T MRI system.[7] However, the sensitivity of structural imaging on 7T MRI has not been fully investigated.

Methods using MRI to evaluate brain structural changes include voxel-based morphometry, cortical thickness mapping and region-of-interest-based volumetry.[1,8,9] These methods could be used to detect changes of brain structure in a variety of brain disorders. However, for detection of subtle changes in brain structure over the whole brain, these methods were relatively insufficient.

Surface-based morphometry (SBM) analysis represents a group of brain morphometry techniques, which was used to construct and analyze surface attribute for brain structure.[10,11] It had been widely used to evaluate brain structural changes in mild cognitive impairment, Alzheimer's disease, attention-deficit hyperactivity disorder, etc.[12,13] Theoretically, image resolution is closely associated with magnetic field strength, and high field strength could improve the spatial resolution and signal noise ratio (SNR). However, ultrahigh field strength could also be apt to produce ghosting, head motion artifacts and heterogeneous signal intensity,[6] which could affect the evaluation of subtle structures. There haven't been enough data on using 7T MRI for evaluation of structural imaging. Therefore, the aim of this study was to investigate the brain structural differences of 7T MRI compared with 3T MRI using surfaced-based morphometry technique.

MATERIALS AND METHODS

Subjects

This study was approved by the ethics committee of our institutional review board. Written informed consent was obtained from all participants. Twelve healthy Chinese volunteers were recruited in the study, including 11 females and 1 male, aged 18 to 46 (mean 32±7.5) years old. No subjects had any history of neurodegeneration, psychiatric disorder, cranium trauma, inflammatory disease of central nervous system, using psychoactive drugs or hormonotherapy.

MRI acquisition

Images were acquired by a GE 3T MR system (SIGNA EXCITE, GE Healthcare) and a SIEMENS 7T MR system (SIEMENS MAGNETOM Investigational Device 7T syngo MR B15). For 3T MR system, we used a conventional eight channel quadrature head coil and a high resolution 3D T1-weighted fast spoiled gradient recalled echo (3D T1-FSPGR) sequence [repetition time (TR)=6.3 ms, echo time (TE)=2.8 ms, Flip angle=15°, field of view(FOV) = 24cm×24cm, Matrix=256×256, number of acquisition (NEX)=1]. For 7T MR system, we used a 24 channel quadrature head coil, and 3D T1-weighted magnetization-prepared rapid gradient echo (3D T1-MPRAGE) sequence [TR=2.2 ms, TE=3.2 ms, Flip angle=7°, FOV=22cm×32cm, Matrix =320×320, NEX=1]. The scan protocol was identical for all subjects.

MR image data processing

All MR structural image data were processed using FreeSurfer (V5.3.0, http://surfer.nmr.mgh.harvard.edu). The cortical surface was automatically segmented from high resolution structural images; gyral anatomy was aligned to the standard spherical template using surface convexity and curvature measures; the cortical thickness, white matter surface area, gray matter surface area, convexity, and curvature were estimated.[10,14,15]

In this study, we used different Gaussian smoothing kernel to evaluate the effect of full width at half maximum (FWHM) on statistics. Because the significant clusters became more concentrated with the increase of FWHM size (Fig. 1), and FWHM 5 mm made the significant clusters look like normal distribution, FWHM 5mm was selected and