Double Inversion Recovery Imaging Improves to Evaluate Brain Tissue Volume Loss in Patients with Alzheimer¡¯s Disease Compared to That of 3D T1-weighted Imaging

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Target Audience: Clinicians and Physicists who work for a neurodegenerative diseases

Background: Brain tissue volumes, including in gray matter volume (GMV), can be usually obtained from brain tissue segmentation of a three-dimensional (3D) T1-weighted (T1W) image and be used in voxel-based morphometry (VBM) analyses to evaluate regional volume differences between controls and Alzheimer's disease (AD) (1). VBM studies of GMV in AD have illustrated regional gray matter atrophy (2). GMV studies are subjective to the outcome of the segmentation result. Recently, the diffeomorphic anatomical registration through exponentiated lie algebra (DARTEL) tool was developed to optimize the VBM processing of 3D T1WI (3). The double inversion recovery (DIR) sequence (4) can be designed to null simultaneously the signals from two different tissue types by a judicious choice of two inversion times, thereby allowing better visualization of the remaining tissues or minimization of partial volume effect (PVE).

Purpose: The objectives of this study, therefore, were: 1) to investigate whether DIR images can show GMV alternations between Alzheimer's disease patients and nondemented controls and 2) to compare whether comparison results of GMV between groups using DIR images show similar results of that obtained from 3D T1W images. We hypothesized that voxel-based statistical analysis of DIR images would identify regions of abnormal GMV loss in patients with AD and mild cognitive impairment (MCI) compared with elderly cognitively normal (CN) subjects.

Materials and Methods: Our institutional review board approved this study and informed consent was obtained from all participants. We included 25 subjects with mild or probable AD, 25 subjects with amnestic MCI, and 25 elderly CN subjects. Both 3D DIR and 3D T1W images were acquired using a 3T MRI system to obtain GMV from both 3D DIR and 3D T1W images. Two inversion times of DIR were 2930 ms for suppressing cerebral-spinal fluid (CSF) and 350 ms for suppressing the white matter in the brain. Imaging processing was performed with the DARTEL tool and Statistical Parametric Mapping-version 8 (SPM8) software (Wellcome Department of Imaging Neuroscience, University College, London, UK). Group differences of GMV among CN, MCI and AD were tested by voxel-wise, one-way analysis of variance (ANOVA) with subject's age and gender as covariates. The significant level was determined by p=0.05 with the multiple comparisons by the false-positive rate (FDR) method.

Results: GMV loss in the AD group compared with CN or MCI group was depicted in both DIR and 3DT1W images. However, DIR was much more sensitive to evaluate GMV loss compared to 3DT1W. Figure shows the areas of GMV loss in AD compared with CN or MCI subjects.

With DIR, GMV in AD compared with CN was decreased in the left and right amygdale, right hippocampus, and middle and inferior temporal gyrus, superior, inferior, and middle frontal gyrus. GMV in AD compared with MCI was decreased in the right and left amygdale, right and left precuneus, right caudate, right insula, right claustrum, superior, middle, and inferior temporal gyrus, and inferior and middle frontal gyrus.

With 3DT1W, GMV in AD compared with CN was decreased only in the right and left amygdale and left putamen. There was no GMV loss in AD compared with MCI.

Discussions: The DARTEL method provided optimization steps to process structural MR images. We found improvements when we used the DARTEL tool. Most of studies were used 3D T1W images to obtain brain tissue volume loss in AD patients. However, this study showed that DIR image was better than 3DT1W images. DIR can be suppressed both the white matter and CSF, simultaneously. Therefore, the partial volume effect in a certain voxel can be reduced with the DIR method compared to the 3DT1W sequence. In this study, GMV loss with DIR was found at the temporal lobe, including in the right and left amygdale and hippocampus, which was similar to previous studies with 3D T1W (2).

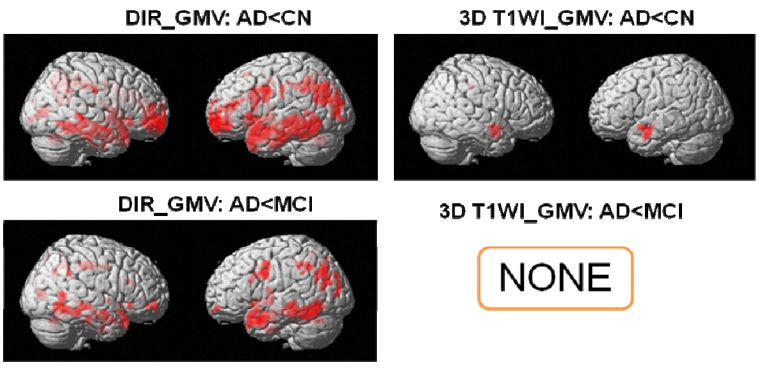

Figure. Results of comparisons of gray matter volume (GMV) of both DIR and 3D T1W images among CN, MCI, and AD groups in the brain (FDR=0.05).

Conclusion: DIR was identified GMV loss in patients with AD compared with MCI and CN. DIR imaging may be a useful imaging tool in the evaluation of brain tissue concentrations in patients with neurodegenerative diseases with minimizing the quality of tissue segmentation and the partial volume effect.

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