# Characterization of white matter change and the adjacent white matter with diffusion tensor MRI

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**Purpose:** Age-related white matter changes (WMC) can be visualized on MRI as T2-hyperintensities, which are considered to be related to cerebral small vessel diseases and are important substrates for cognitive impairment and functional loss in the elderly.[1, 2] Diffusion tensor imaging (DTI) technique provides information on the integrity of white matter tracts by estimation of the directionality-fractional anisotropy (FA). In WMC, the apparent diffusion coefficient (ADC) is elevated and FA is reduced.[3, 4] However, the studies on the effect of WMC regions and the adjacent white matter tissue on diffusion tensor imaging (DTI) parameters are scarce. To this end, the purpose of this study is to determine the FA, relative anisotropy (RA), volume ration (VR) and ADC in the regions of WMC and the adjacent white matter tissue.

**Methods:** Dementia-free subjects having confluent WMH as defined by the global score of the Age-Related White Matter Changes scale of $\geq 2$ were recruited. DTI data (70 slices, voxel size of 2×2×2 $mm^3$) were acquired from 16 patients (mean age 70.4 ± 5.5 years, 7 females and 9 males) using a 3.0T Philips Achieva MR scanner with 2D SE pulse sequence (TE/TR = 60/8900 ms) and diffusion weighting along 32 encoding directions with b values of 0 and 1000 $s/mm^2$. Parameter maps calculation was performed using DTI-Studio (http://dsi-studio.labsolver.org/). An affine registration was applied as a linear model to remove global transformation between images using FMRIB Software Library (FSL), the segmentation label map was generated using FreeSurfer (http://surfer.nmr.mgh.harvard.edu/). In order to investigate the DTI parameters on the regions of WMC and the adjacent white matter tissue, a region growing method based on Insight Segmentation and Registration Toolkit (ITK) programming environment was employed to achieve this. In this method, WMC regions were selected as the seed mark areas. The seed mark areas were expanded one voxel size region in three dimensions as the 1st expanded region. Then the 1st expanded region and WMC region were combined as the new seed mark areas to generate 2nd expanded region in the same way until the 5th expanded region was created. The WMC region and five expanded regions were labeled in the voxel expanded label map as in figure 1. DTI parameters of WMC region and the expanded regions were extracted on the DTI parameter maps by using the voxel expanded label map.

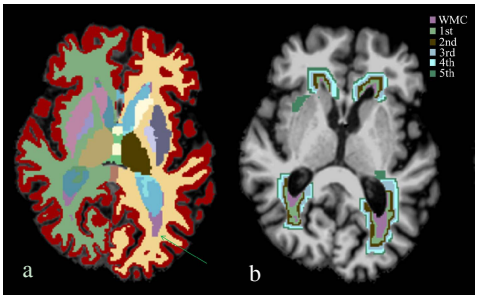


Fig. 1 (a) Generated segmentation label map and (b) voxel expanded label map overlaid on the anatomic image. WMC region was pointed out by green arrow.

**Results:** Figure 2 shows the mean FA, RA, VR and ADC of all patients from WMC region to 5th expanded region. The change patterns of FA, RA, and VR were similar. These three parameters were increased from WMC region to 2nd expanded region, and slightly decreased from 3rd to 5th expanded region. The WMC region presented the minimum while the 2nd expanded region showed the maximum parameter. The ADC was decreased monotonously from WMC region to 5th expanded region.

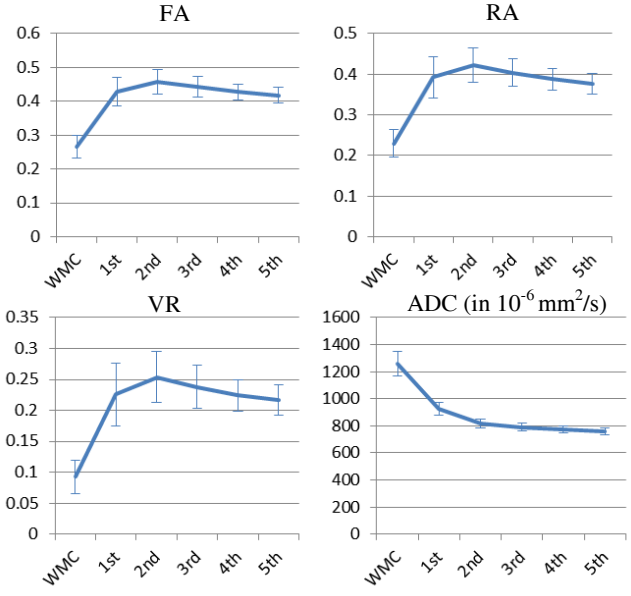


Fig. 2 The average values of FA, RA, VR and ADC of all subjects in WMC and expanded regions.

**Discussion:** The results indicate that FA, RA, and VR decrease while ADC increases in WMC region, which is consist with the previous study.[3,4] The adjacent WM also shows progressively change. FA, RA and VR increased from WMC region to 2nd expanded region, and slightly decreased from 3rd to 5th expanded region. FA and RA represent the ratio of the anisotropic to isotropic, while VR represents one minus the ratio of the ellipsoid volume to the volume of a sphere of radius λ, which is the mean of three eigen-values. In normal white matter, the highly directional white matter tracts result in a high degree of directional diffusion. In the white matter change region, the loss of these ordered axonal tracts result in lower FA, RA, VR and higher ADC. This progressively change indicates that even MRI signal change is not apparent in adjacent areas, the parameters of DTI could already be affected by WMC. It also shows that the WMC may be a progressively process and the WMC region may extend with the increasing of the WMC severity. This study is helpful to locate the exact region affected by WMC and to the further study of WMC.

**References:** 1. Xiong et al., Journal of Aging Research, 2011; 2. L. Pantoni, The Lancet Neurology, 9:689-701; 3. Jones et al., Stroke 1999, 30:393-397; 4. Stefan Ropele et al. Journal of magnetic resonance imaging 2009, 29:268-274.