Can Fiber Tractography in Capsular Stroke Affected Brain Predict Immediate Neurological Functional outcome?

J. R. James[1], A. A. Khan[2], D. P. Gordy[1], M. A. Khan[1], J. Huang[2], A. P. Auchus[2,3], and R. Buciuc[1,2]
[1]Radiology, University of Mississippi Medical Center, Jackson, MS, United States, [2]Neurology, University of Mississippi Medical Center, Jackson, MS, United States, [3]Neurology, G.V. (Sonny) Montgomery VA Medical Center, Jackson, MS, United States

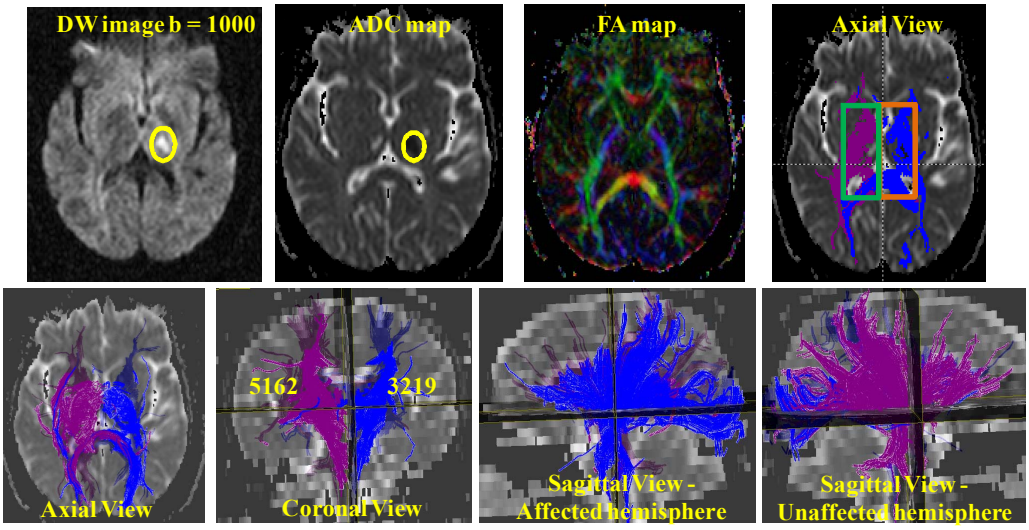
Introduction: Diffusion Tensor imaging (DTI), a non-contrast MRI technique for tensor measurements and fiber tractography, is well known to assess degeneration of fiber tracts in stroke affected brains. Very little attention has been given to potential clinical significance of DTI in conjunction with the neurological scores and deficits. Purpose of this study was to determine if DTI can predict the functional outcome in stroke patients with the neurological scores at the onset of symptoms.

Methods: Clinical and MR imaging data were collected from 25 patients (age=55±10yrs) presented with acute infract in the posterior limb of the internal capsule (diameter ≥ 1.2cm). Prior to MRI, functional assessment of the patients was performed that included neurological tests examining the facial palsy, motor, and sensory scores being assigned using the National Institutes of Health Stroke Scale (NIHSS). MRI scanning of the brain was done on a 1.5T Siemens SONATA using routine head protocol sequences. In addition, DTI sequence was performed using echo-planar-SE at b=0,1000s/mm^2 along 12 non co-linear directions with TR/TE=6200/104ms, slice thickness/slice gap=4.0/0.8mm, matrix size=256x256, imaging time=2.08min.

Data collected from the scanner was transferred to a PC based s/w DTI-studio *(S. Mori, John Hopkins)* for quantitative analysis. Maps of apparent-diffusion-co-efficient (ADC), fractional anisotropy (FA) and fiber tractography were computed. Rectangular region-of-interest (ROI) was drawn from the fornix to anterior-lateral caudate head to posterior aspect of the pulvinar to the midline 3rd ventricle on T_2 weighted diffusion images. Mirror-ROI was drawn on the contra-lateral hemisphere to compare the difference in fiber number and density, FA and ADC in the stroke hemisphere. Pearson's correlation was used to assess association between % relative fiber loss and the clinical NIHSS scores obtained from the patient. Statistical analysis was performed in SPSS 13.0 *(Abacus Concepts Inc., Chicago, Illinois, USA)*. Statistical significance was based on $p \leq 0.05$.

Results and Discussion: A clear delineation of white matter tractography exhibiting highly anisotropic diffusion behaviors was observed in the FA maps computed from DTI images. Stroke affected hemisphere exhibited significantly lower ($p \leq 0.005$) fiber count (range: 2.8 to 38.3%), fiber length (range: 2.77 to 17.84 mm) and density of fibers (range: 120 to 141) compared to the normal hemisphere. This indicates that some motor functions associated with the disrupted fibers on the stroke area were affected. Interestingly, FA and ADC computed along the existing fibers in the stroke region showed no significant difference with the contra lateral fibers *($p \geq 0.05$),* whereas mean ADC in the stroke region was significantly lower than the contra-lateral side *(p-value=0.007)* signifying restricted diffusion of water molecules. FA plays an important role in setting a threshold parameter for termination of fiber generation. Since FA values on both hemispheres were similar, there is no concern of disruption to the existing fibers in the affected area.

Pearson's correlation tests showed an excellent correlation between the % relative fiber loss and i) facial palsy ($p = 0.037$), ii) motor arm ($p = 0.043$), iii) motor leg ($p = 0.049$), iv) total motor ($p = 0.037$), v) motor + sensory ($p = 0.045$) and vi) sum of all NIHSS scores ($p = 0.030$) obtained from the patient. Linear regression analysis showed a positive trend between the % fiber loss and the examined individual scores and combined NIHSS scores ($R^2 = 0.77$). These results signify that DTI in capsular stroke affected patients has high correlation with motor function.



Representative MR slice for DW image and corresponding ADC and FA maps exhibiting restricted diffusion in the internal brain capsule. A pair of rectangular ROIs were drawn for fiber quantification on the affected and unaffected brain hemispheres on axial slices. Extracted 3D fiber tracts arising in the ROIs are shown on the axial, coronal and sagittal brain views demonstrating significantly lesser number of fibers in the affected region. Total number of fibers in each region is also shown on the coronal slice.

Conclusion: 3D white matter tractography has enabled to quantify water diffusivity pattern along the direction of the fibers using the intrinsic property of the water molecules under MR gradient influence. Application of this sequence non-invasively and its positive correlation to the clinical NIHSS scores will help a great deal in predicting short term and /or long term neurological deficits in stroke affected patients.