

Anterograde and Retrograde Degeneration of White Matter Tracts Following Stroke

Z. Ben-Moshe¹, M. Kafri², N. Borenstein³, I. Bova³, and Y. Assaf⁴

¹Department of Neurobiochemistry, Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel, ²Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel, ³Department of Neurology, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel

Introduction

Rehabilitation following cerebral ischemia or stroke is not understood. Many factors affect the patient ability to recover, among them cortical plasticity and secondary tissue degeneration. Wallerian degeneration is one degenerative process that occurs to white matter tracts projecting below the lesion site. This degenerative process is well documented and studied by histology of animal models and by *in-vivo* MRI of human subjects. It is assumed that Wallerian degeneration of specific tracts will affect the ability of the subject to recover. To that end, it would be useful to estimate and quantify the degree of Wallerian degeneration per subject and try to correlate it with recovery status. In the current study we conducted a follow-up diffusion MRI study on stroke patients in order to quantify the degree of their Wallerian degeneration using fiber tractography and ROI analysis.

Methods

MRI was performed on a 3.0T GE Signa MRI scanner. 14 patients were examined at the first 48 hours and 2-3 months following stroke. The MRI protocol included, in addition to clinical high-resolution sequences, a DTI protocol with the following parameters: TR/TE= 10000/88ms, b value of 1000 s/mm² measured at least with 6 non-collinear gradient directions, matrix of 128x128 and FOV of 240mm². The number of slices varied from subject to subject and slice thickness was between 3-4 mm with no gap between slices.

Image processing included DTI analysis to extract the fractional anisotropy (FA) and apparent diffusion coefficient (ADC) maps as well as the parallel and perpendicular diffusivities (D_{\perp} and D_{\parallel}). Following the DTI calculation post-processing was done either by ROI analysis (at slice below and above the lesion site) or fiber tractography. For the fiber tractography seed ROI was placed at the location of observed Wallerian degeneration at the 2nd examination. The extracted values were normalized to the contralateral side.

Results & Discussion

Region of interest analysis of FA maps revealed significant Wallerian degeneration, as expected, below the lesion (Figure 1) although to variable extent across subjects. Among the 14 subjects, 5 of them showed very subtle degeneration according to the FA index while the other subjects had much more pronounced effect. Interestingly it was found that even above the lesion a reduction in FA values in observed indicating anterograde degeneration (Figure 1C). It should be noted that the anterograde degeneration was too much smaller extent than the retrograde one.

Attempt to use tractography to evaluate the degree of degeneration along the fiber path was complicated. First, at the follow-up examination, the lesion site has degenerated, in most subjects, and full tracking of the cortico-spinal tract necessitated reduction of the tractography criteria. Second, in order to follow on the specific fiber that underwent degeneration, a careful selection of the seed ROI was required. This procedure was not successful for all subject, but for the few it was (n=6) it allowed continuous quantification of the fiber integrity along the tract from the M1 cortex to the spinal cord (Figure 2). This kind of quantification could be useful for the estimation of the tract integrity and estimate on the ability of the subject to recover.

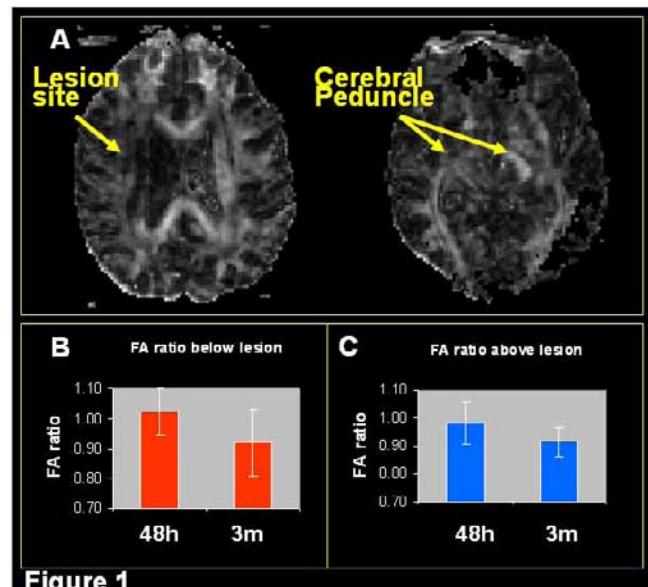


Figure 1

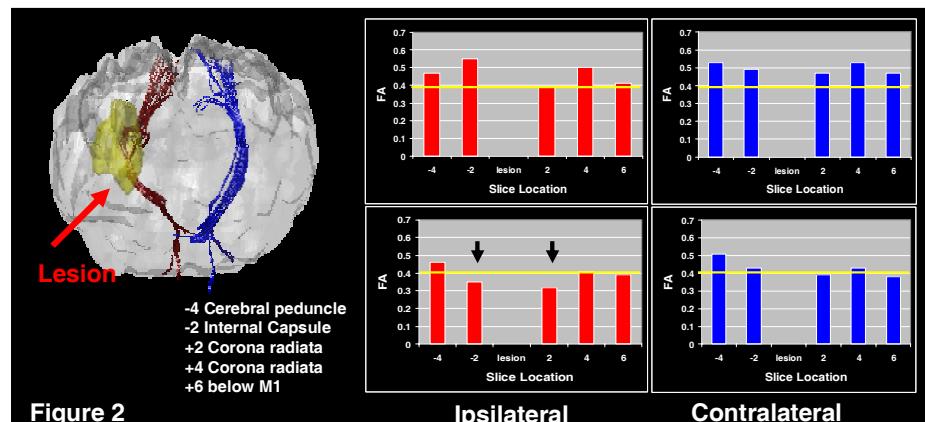


Figure 2

References

- 1) Kuhn MJ, Milkulis DJ, Ayoub DM, et-al., Radiology 1989, 172:179-182; 2) Thomalla G, Glauche V, Weiller C, Rother J. JNNP 2005, 76:266-8 ; 3) Werring DJ, Toosy AT, Clark CA, et al: JNNP 2000, 269: 272-79.; 4) Pierpaoli, C., Barnett, A., Pajevic, S., Chen, R., et al.. NeuroImage 2001, 13: 1174– 1185.