# Segmented ROI analysis of DTI in Stroke

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**Introduction**: The prediction of tissue recovery after ischemic stroke is based largely on measuring the volume of the lesion by DWI (used for DWI/PWI mismatch calculations), and the magnitude of ADC reduction. However, ADC may not be the best parameter to describe tissue integrity. To that end, measuring diffusion anisotropy might provide better insight into microstructural changes of the tissue. The need for follow up on DTI measures following stroke is driven by previous studies that have shown mixed diffusion anisotropy changes in acute stroke[1]. Follow up study might help to correlate between anisotropy changes in the acute phase and the potential for tissue recovery. The aim of the current study was to characterize the evolution of DTI measures (fractional anisotropy (FA), mean diffusivity as well as the principal diffusivities) after stroke from the acute to the chronic phases, in order to determine the most sensitive parameter that can predict tissue recovery.

**Methods**: Eight stroke patients were examined at two different time points following ischemic stroke. The first scan was done within 48 hours from the ischemic attack (acute phase) and the second exam was done between three to four months after the ischemic attack (chronic phase).

The patients were scanned with 1.5T or 3.0T MRI systems (GE, Milwaukee, USA). DTI protocol was acquired with the following parameters: TR/TE =4000/98ms, 24 slices of 5 mm thickness with gap of 1 mm were taken at each scan, FOV was 24, $\Delta/\delta$=31/25ms with b value of 1000 s/mm$^2$ measured at 6 non-collinear directions.

The acute examination was used for definition of segmented region of interest (ROI). Two sets of ROI were defined for each subject: one based on ADC grading, and the other on FA grading. The lesion was segmented into regions based on ADC or FA values (see Figure 1) to produce for each lesion 5 regions of interest. The segmented ROI of the acute phase was co-registered with the chronic phase examination using SPM2 so that we could measure each ROI segment outcome in the follow up examination. To avoid lesion location heterogeneity all measured values were normalized to the control contralateral values.

**Results**: Using FA segmented ROIs we found that ADC is similar in areas of high and reduced FA in both the acute and chronic phase (Figure 2B). In addition, areas with high FA in the acute phase showed better outcome in terms of FA at the chronic phase ($p<0.05$, Figure 2A). This observation was also manifested by significant reduced radial diffusivity at the acute phase (Figure 2C, $p<0.01$). No significant differences were observed in the parallel diffusivity at the acute or chronic phases in any ROI segment.

Using the ADC segmented ROIs we found that chronic ADC values are not correlated with acute ADC values (Figure 2E). Concomitantly, ADC grading did not correla te with FA changes between acute and chronic phases (Figure 2D).

Figure 1: Example of ROI's definition of the ischemic lesion based on FA grading (upper image) and ADC grading (lower image).

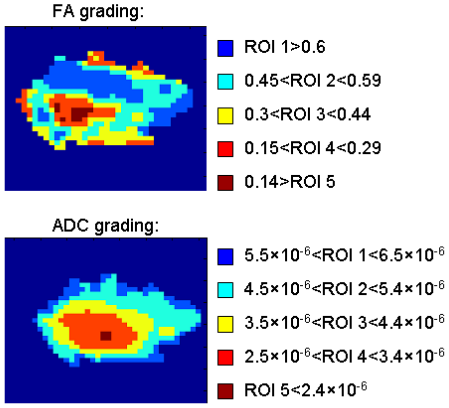
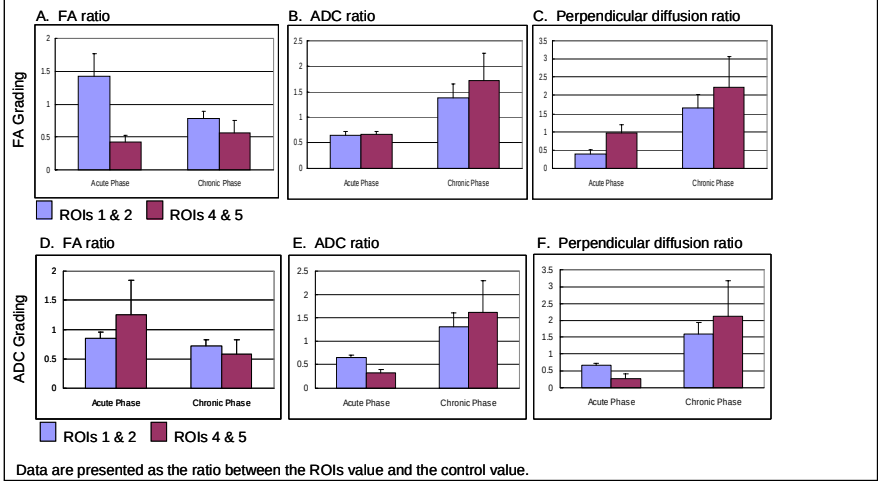



Figure 2: Comparison of changes in FA, ADC and radial diffusion values between ROIs 1 and 2 and ROIs 4 and 5 in the acute and chronic phase. Top raw represent FA segmented ROI analysis while lower raw represent ADC segmented ROI analysis.




Data are presented as the ratio between the ROIs value and the control value.

**Discussion and Conclusions**:

ADC measurements are routinely used today for evaluation of ischemic lesion core and penumbra. Areas of marked reduced ADC are believed to reflect the core of the lesion while slightly reduced ADC areas are associated with less intense damage[2]. In this study we showed, that segmenting the lesion using ADC measures does not necessarily predicts tissue damage at the chronic phase. In fact,areas of marked and slight ADC reduction in the acute phase showed similar behavior in the chronic phase in terms of ADC and FA measures. By contrast, FA measurement at the acute phase correlated better with FA measures at the chronic phase by means that areas with high FA at the acute phase remained in better condition than other areas at the chronic phase. This was also reflected in the ADC measurement of these areas at the chronic phase. Analysis of the principal diffusivities of the highly elevated areas revealed significant reduced radial diffusivity which might indicate on a compression effect of the tissue. Segmented ROI analysis might provide a better insight into the complicated diffusion changes that occur following stroke and will enable us to predict which areas are more prone to recover.

**References:** 1. Sotak CH. NMR in Biomedicine 2002;15:561-569. 2. Schaefer P.W, Ozsunar Y, He J, et al. AJNR Am J Neuroradiol 2003; 24:436–443.