Behavior of DTI parameters as functions of distance from a tumor

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Introduction:

A localized injury such as a tumor or stroke in brain, can lead to non-local effects across the brain. When looking at the behavior of DTI parameters such as FA in white matter, we often see a complicated variation with distance from the site of injury, although ADC shows a more gradual and monotonic change with distance recovering to normal value far away. One may presume that since FA is related to white matter fibers that run longer distances and therefore the effects of the local injury can be non-local and shown through a non-monotonic variation of FA with distance. We observe that water-diffusion parameters have a dominant localized behavior as a response to injury. That is, the diffusion tensor eigenvalues vary monotonically from the site of the injury and assume a more normal value far away from the injury. Differerent eigenvalues may vary at different rates with distance. So due to their different rates of change, their combined effect on FA is to create a more complicated behavior with distance.

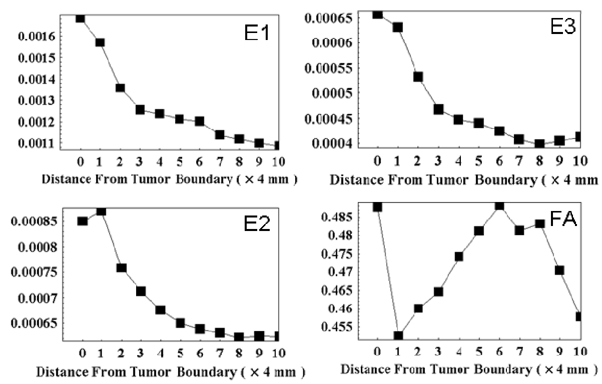

Fig1. The three eigenvalues (E1,E2,E3) and Fractional Anisotropy in white-matter for a single patient at first visit, plotted as functions of distance from the tumor boundary. Notice the monotonically falling behavior of the eigenvalues and more complicated behavior of FA.

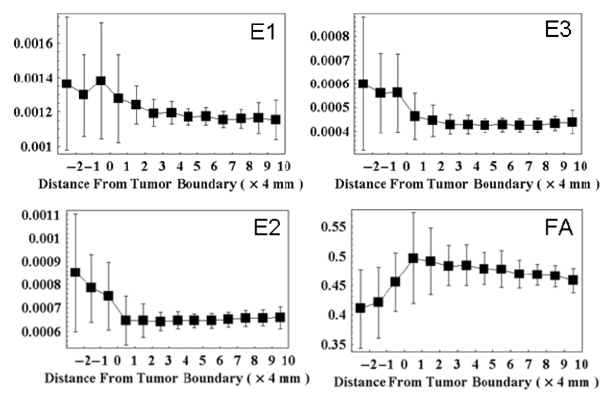

Fig2. Average over 16 patients of three eigenvalues (E1,E2,E3) and Fractional Anisotropy in white-matter at first visit, plotted as functions of distance from the tumor boundary. Notice that monotonically falling behavior of the eigenvalues is still present even after averaging, and FA shows non monotonic behavior. Averaging sums over distance dependent functions with multiple rates of variations with distance and even the eigenvalue curves can show more complexity, and even non-monotonicity when

Materials and Methods:

A. Image acquisition

DT-MRI data were acquired from 16 glioblastoma patients (recruited by an IRB approved phase 2 AZD2171 investigational study at the Dana-Farber/Harvard Cancer Center[1]) using a 3 Tesla MRI system (TimTrio, Siemens Medical Solutions, Malvern, Pennsylvania). (60 slices, TR 7500 ms, TE 84 ms, b-value of 700 s/mm2 in 42 directions as well as 7 low b value images (b ~ 0 s/mm2, 2 mm isotropic voxels, with a 128x128 matrix. T1 weighted contrast enhanced images were also obtained. The tumor region was outlined by an experienced radiologist on post-contrast T1-weighted images and then registered to DTI images.

B. Distance dependence of DTI parameters from the tumor boundary

Progressively expanding-equidistant 3D-shells (4 mm thick) were computationally generated both inside and outside the tumor with distance=0 defined at the tumor boundary. Shells were further divided into white and gray matter parts. Values of FA, ADC and eigenvalues at a certain distance from tumor boundary are defined as their averaged values within the shell at that distance.

Results:

Figure 1 shows behavior as a function of distance for FA and the three principle eigenvalues (E1,E2,E3) of the diffusion tensor in the white-matter for a single patient.

Figure 2 shows the average over 16 patients. Variation of eigenvalues is generally monotonic with distance. FA shows a more complicated behavior with distance due to interplay of the different rates of variation of the individual eigenvalues.

Conclusions:

A local injury can affect the rates of variation with distance of different eigenvalues differently, even though the effect monotonically falls off, which creates a complicated change in FA with distance..