Characterizing Diffusion Along White Matter Tracts Affected by Primary Brain Tumors

Monica E. Lemmond[1,2], Lauren J. O'Donnell[1,2], Stephen Whalen[1,2], Alexandra J. Golby[1,2]
[1]Department of Neurosurgery, Brigham and Women's Hospital
[2]Harvard Medical School, Boston, MA 02115, USA

Introduction Primary brain tumors lead to changes in the diffusion properties of white matter due to edema, infiltration, tract displacement and destruction. Despite investigation of diffusion changes in white matter bordering tumors, these changes have not been quantitatively determined along the length of white matter tracts that may be affected by a tumor.

Mean diffusivity (MD), related to total water diffusion, is approximately constant in white matter but increases with edema. The diffusivity parallel and perpendicular to fiber tracts is altered in the region of a tumor;[1] however, the pattern of diffusion measurements along the tracts has not been investigated. Here we present two cases in which we measured the mean diffusivity, parallel diffusivity (D||), and perpendicular diffusivity ($D\perp$) along the length of surgically relevant tracts.

Methods Diffusion tensor images were acquired for two patients with gliomas affecting the corticospinal tract and one healthy control subject, using echo-planar imaging with the following parameters: gradient directions = 31, TR/TE = 14,000/30 ms, slice thickness = 2.6 mm, 128 X 128 matrix, FOV = 25.6 cm, b value = 1000. T2-weighted images were also acquired.

Tractography was performed in the entire white matter of each subject. A low anisotropy threshold was employed to allow tracking into the tumor region ($c_L = 0.1$). Using spectral clustering, fibers were organized into bundles.[2] As shown in **figure 1**, surgically relevant white matter tracts involved in the tumor region, and the corresponding healthy tracts on the contralateral side, were identified (tracts represented in yellow and tumor region represented in green). Measurements of diffusion parameters (MD, D||, and $D\perp$) were made in regions of interest at 2.6 mm intervals along the tracts. The inferior border of the T2-hyperintense region including the tumor was measured relative to the tracts. Tract identification and T2 interpretation were confirmed by a neurosurgeon (AJG).

Results In patient 1, MD and $D\perp$ were elevated in the region of the tract affected by tumor, extending approximately to the border of T2 hyperintensity **(figure 2)**. Differences in D|| between the affected and unaffected tracts, however, extended along the entire measured length of the tracts **(figure 3)**.

In patient 2, MD and $D\perp$ findings were similar to patient 1. D|| differences were found along the entire affected tract, with higher values within and lower values outside the tumor region, in contrast with patient 1 where D|| values were elevated along the entire tract.

In a healthy control subject, no differences in D|| measurements were observed in the corticospinal tracts **(figure 4)**.

Conclusions Tract specific measurements can be used to characterize diffusion changes in white matter affected by tumor. Changes in D|| were observed in both patients beyond the tumor region. In both patients there was an increase in MD, D||, and $D(\perp)$ within the tumor. Further study of diffusion changes along tracts may increase understanding of processes such as tumor infiltration and tract displacement.

References [1] Schonberg T et al. Neuroimage 1; 30(4): 1100-11 (2006); [2] O'Donnell L et al. AJNR, 27(5) (2006).

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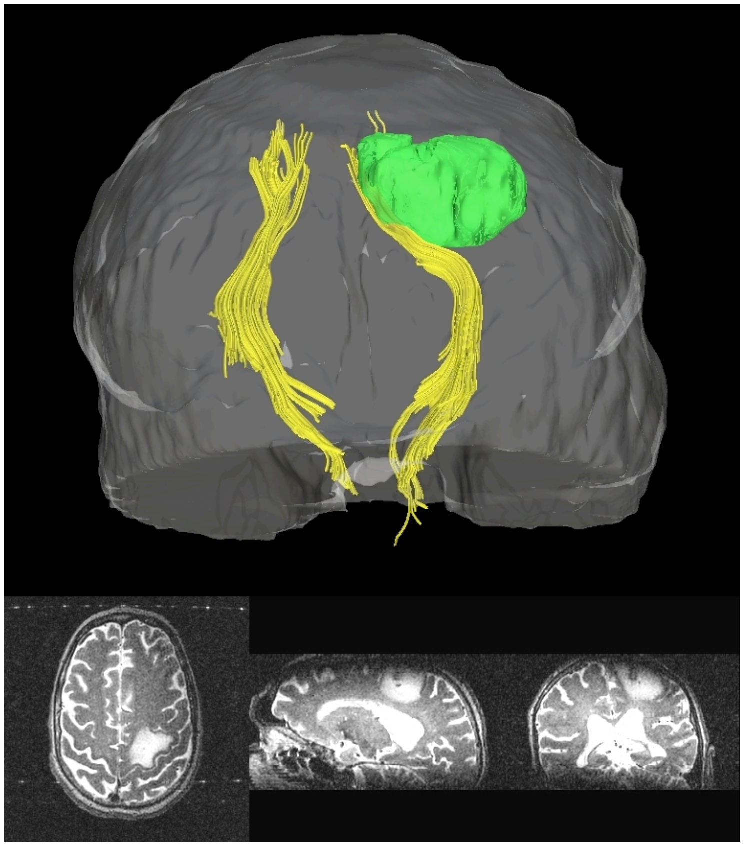
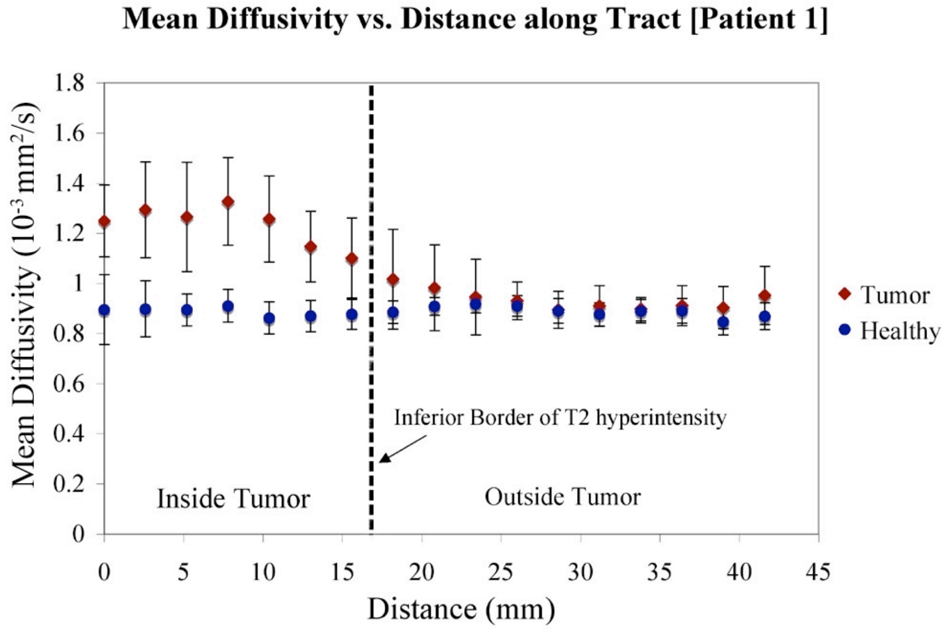
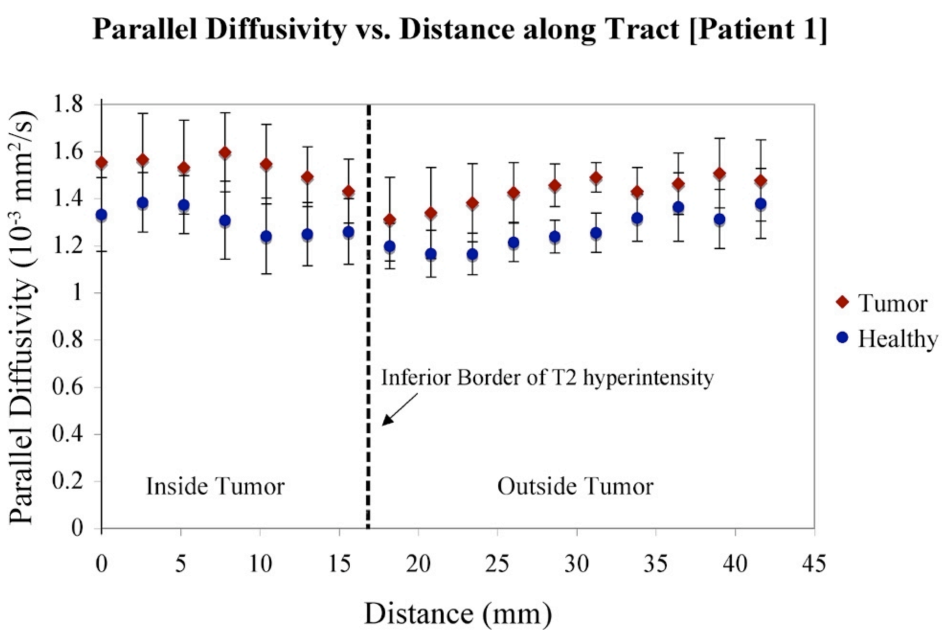
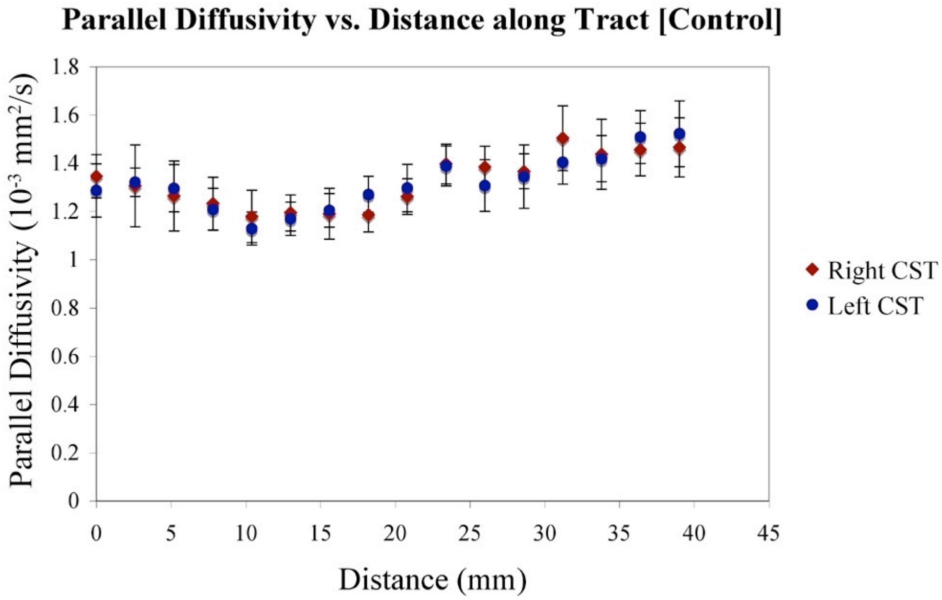



Mean Diffusivity vs. Distance along Tract [Patient 1]
Mean Diffusivity (10-3 mm2/s)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Inferior Border of T2 hyperintensity
Inside Tumor
Outside Tumor
0
5
10
15
20
25
30
35
40
45
Distance (mm)
Tumor
Healthy


Parallel Diffusivity vs. Distance along Tract [Patient 1]
Parallel Diffusivity (10-3 mm2/s)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Inferior Border of T2 hyperintensity
Inside Tumor
Outside Tumor
0
5
10
15
20
25
30
35
40
45
Distance (mm)
Tumor
Healthy



Category: *Neuroanatomy*
Sub-Category: *DTI studies, application*