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Significant alterations in integrity of distant white matter tracts in patients with left temporal tumors revealed by diffusion tensor imaging

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Keywords: diffusion tensor imaging | white matter | brain tumors | tractography

Introduction:

To determine the local and remote effects of tumors in the “eloquent” left temporal lobe on white matter integrity, we measured the extent of edema, overlap with ipsilateral tracts in proximity as well as distant tracts using fractional anisotropy (FA).

Methods:

Twelve patients with intracerebral tumors (gliomas or metastases) were evaluated preoperatively using 30-direction DTI sequences, registered, and tumor/edema volumes calculated, using EVE atlas of regions of interest, segmenting four bilateral tracts: corticospinal tract (CST; n=12); inferior fronto-occipital fasciculus (IFOF; n=9); inferior longitudinal fasciculus (ILF; n=10), and arcuate fasciculus (AF; n=9). The distance between the tumor (Fig. 1) and ipsilateral and contralateral tracts, the overlap between the tract and edema, and the histogram similarity were calculated. The student’s t-test determined statistical significance.

Results:

The distance from tumor to tract was least for the left ILF and IFOF, then the AF, and farthest for the CST (Fig 1). Edema overlap was greatest for ILF, then AF and IFOF, and least for CST (Fig 1). Tracts ipsilateral to tumor had reduced FA compared to contralateral CST, ILF, and IFOF (Fig 1, $p < 0.05$). Decreased FA for specific tracts between subjects was linked to edema overlap (Fig 2). The average distance from tumor to tract correlated with the cosine similarity of the FA (Fig 2, $R^2=0.967$).

Conclusions:

Temporal lobe tumors affected the FA values of fiber tracts in proximity (ILF, IFOF) as well as at a distance (CST), suggesting that FA values may be a sensitive indicator of widespread changes in the white matter, linked to the interconnected “hodological” view of the brain that underlies the human connectome. Future studies of neuroplasticity and neurocognitive effects of tumors and tumor surgery should include tracts remote from the tumor as well as those in immediate contiguity.

Learning Objectives:

- On average, tracts closer to brain tumors and with larger areas of edema overlap show more significantly reduced FA than more distal tracts.
- However, distal white matter tracts with little peritumoral edema overlap are still significantly affected by brain tumors.
- Surgeons should use FA values as a sensitive measure of tumor effect on white matter tracts in addition to distance from tumor to tract and edema overlap.

Keywords:

diffusion tensor imaging, tractography, white matter, brain tumors, connectome

References:

1. Abdullah KG, Lubelski D, Nucifora PG, Brem S. Use of diffusion tensor imaging in glioma resection. *Neurosurg Focus* 2013; 34:E1

How will your research improve patient care?

This research will allow surgeons to more finely evaluate the effect of brain tumors on white matter tracts both in proximity and distal from the lesion.

	CST (n=12)	ILF (n=10)	IFOF (n=9)	AF (n=9)
Avg tumor-tract distance (mm)	9.64	2.72	2.27	6.03
Avg edema-tract overlap (% of tract)	0.16	0.38	0.23	0.31
Avg ipsilateral vs. contralateral FA similarity	0.69 P < 0.05	0.36 P < 0.05	0.37 P < 0.05	0.39 -

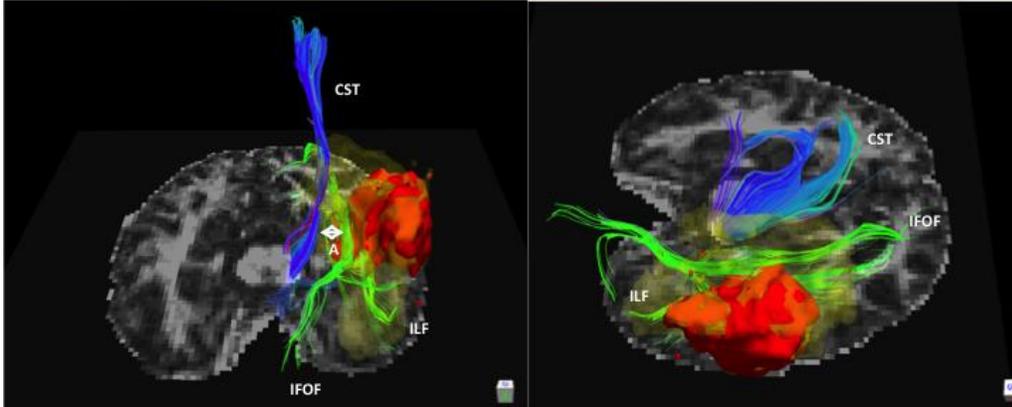


Figure 1. Top: The distance of the tract from the tumor, edema overlap and FA similarity of the CST ILF, IFOF and the arcuate in temporal tumor patients. Bottom: The left CST, ILF, and IFOF are depicted as well as the tumor (red) and the peritumoral edema (translucent yellow) for a single subject. Distance “A” represents the shortest-point distance between the tumor and the CST. There is significant edema overlap with the ILF and the IFOF, and minimal overlap with the CST.

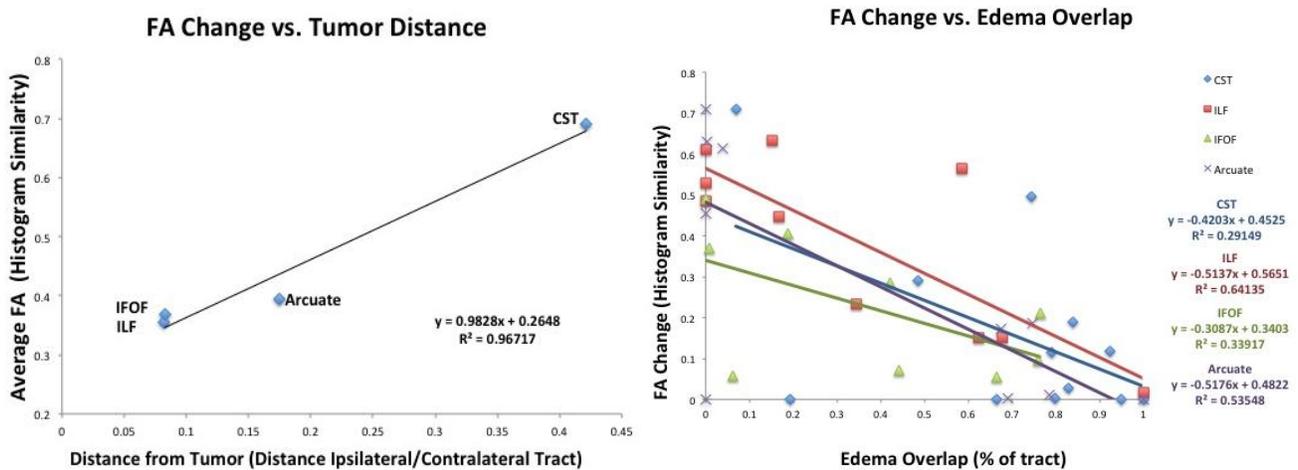


Figure 2. Left: FA in the same tract between individual subjects is correlated to increasing edema overlap Right: Average distance in all subjects between tumor and tract correlates with average change in fractional anisotropy (FA).

Learning Objectives:

- On average, tracts closer to brain tumors and with larger areas of edema overlap show more significantly reduced FA than more distal tracts.

- However, the integrity of distal white matter tracts, which have edema overlap, is still significantly affected.
- Surgeons and radiologists should use FA values as a sensitive measure of tumor effect on white matter tracts, as opposed to relying solely on anatomical relationships.

Improvement of Patient Care: This research will allow surgeons to more finely evaluate the effect of brain tumors on white matter tracts both in proximity and distal from the lesion.

Disclosure of Conflict of Interest: We declare no conflicts of interest for any of the authors involved.

IRB Disclosure: An IRB was approved from the University of Pennsylvania for this research.