# Diffusion Spectrum Tractography in Patients with Brain Tumors

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## Abstract

Knowing the location of a brain tumor and the status of the surrounding white matter tracts helps neurosurgeons predict or even avoid unnecessary complications secondary to post-op tract injury. In this work, we applied diffusion spectrum imaging to patients with brain tumors and demonstrated its capacity to provide detailed information about the relationships between tumors and the affected tracts.

## Introduction

Knowing the location of a brain tumor and the status of the surrounding white matter tracts helps neurosurgeons predict or even avoid unnecessary complications secondary to post-op tract injury [1]. Recent advance in diffusion tractography techniques has shown its potential to meet this need. Diffusion tensor imaging (DTI) tractography in patients with brain tumors has been reported [2]. The tracts beside the tumors are often compressed and distorted. The complex geometry of fiber tracts would compromise the accuracy of DTI in defining local fiber orientation. Previously we proved that diffusion spectrum imaging (DSI) could determine local fiber orientations accurately, especially in regions of complex fiber structures [3]. Reconstruction of tractography from DSI data from normal subjects clearly showed distinct axonal fiber tracts at the criss-cross regions [4,5]. In this work, we applied DSI to patients with brain tumors and demonstrated its capacity to provide detailed information about the relationships between tumors and the affected tracts.

## Materials and Methods

Patients were scanned with a 3T MRI system (Trio, Siemens, Erlangen, Germany) before surgery. An echo planar imaging (EPI) diffusion sequence with twice-refocused balanced echo was used to acquire diffusion-weighted images. Isotropic spatial resolution was obtained by making both in-plane and through-plane resolution to be 2.3 mm. The DSI experiment was performed by applying 203 diffusion gradient vectors, each corresponded to one of the isotropic 3D grid points in the q-space. The maximum diffusion sensitivity bmax = 4000 s/mm$^2$, and TR/TE = 6500/150 ms. Approximately 45 to 50 transaxial slices were acquired encompassing the whole brain. The experiment completed in 30 min.

DSI analysis was based on the relationship that the echo signal S(**q**) and the diffusion probability density function P(**r**) were a Fourier pair, i.e., S(**q**) = FT{P(**r**)} [6]. The orientation density function (ODF) was determined by computing the second moment of P(**r**) along each radial direction. The main orientation of diffusion probability was then determined by the local maximum vectors of ODF [7]. Tractography was based on a simple algorithm that was adapted for DSI data. The first three DSI vectors of each voxel over the whole brain were used as the seeds. All fiber orientations of the nearest voxels were used to decide the proceeding orientation for the next step; the most coincident orientation less than 22° was chosen. A new starting point was then obtained to repeat tracking procedure. The proceeding length for each step was 0.5 voxel length. The tracking stopped if there was no coincident orientation in the nearest voxels.

In order to visualize the relationships between tumors and fiber tracts, tumor contours were traced manually and 3D surface of the tumors was rendered. All tracks over the whole brain or selected tracts passing through a specific region were shown and fused with the tumor outlines.

## Results

A total of thirteen patients were studied up to the preparation of this abstract. Here we demonstrate tractography in two patients. The first patient had a tumor in right occipital lobe (Fig. 1). The tumor displaced right inferior longitudinal fasciculus downward and corona radiate anteriorly. The callosal fibers in the splenium were displaced upward. The second patient had a tumor in left frontal lobe. The tumor displaced the callosal fibers medially. The left superior longitudinal fasciculus was stretched, displaced medially and upward by the tumor.

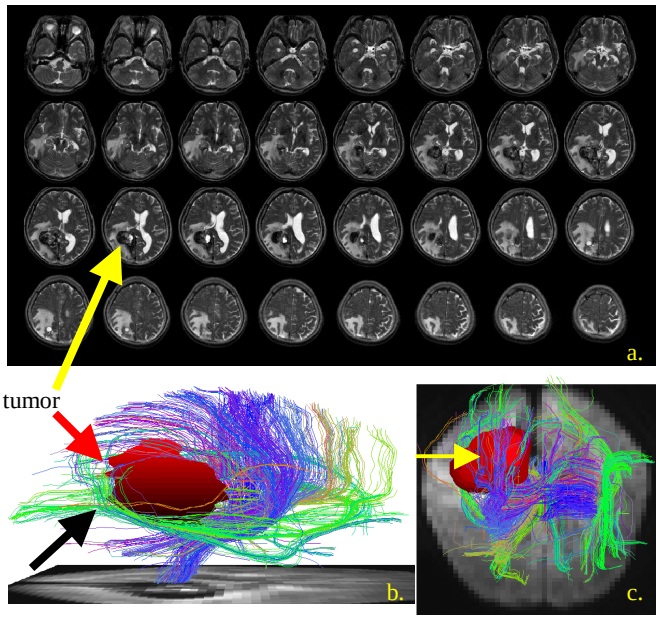


Fig. 1: a) T2-weighted images show a tumor in the right occipital lobe (yellow arrow). b) Tractography viewing from the tumor side. The tumor (red arrow) displaces the inferior longitudinal fasciculus downward (black arrow) and corona radiate anteriorly. c) Tractography viewing from the top. Callosal fibers in the splenium are displaced upward (yellow arrow).

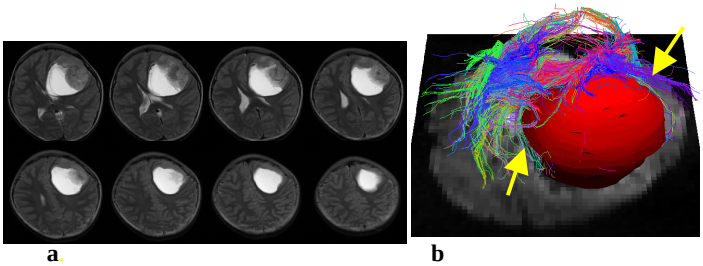


Fig. 2: a) T2-wighted images show a tumor in left frontal lobe. b) Tractography viewing from the tumor side. The tumor (in red) displaces the callosal fibers medially. The left superior longitudinal fasciculus is stretched and displaced medially and upward by the tumor (yellow arrows).

## Conclusions

We have applied the DSI tractography to patients with brain tumors and visualized the change of the fiber tracts by the tumors. Further works on the clinical benefit of tractography in the pre-surgical planning are currently undertaken. Besides tractography, functional MRI can also be acquired to study the relationships between the affected fiber tracts and the function of the connected cortical regions.

## Reference

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