Diffusion Tensor Imaging of Corticospinal Tract in Brain Neoplasms: Correlation with Motor Weakness

N. Morita[1,2], S. Wang[1], P. Kadakia[1], S. Chawla[1], M. R. Rosenfeld[3], D. M. O'Rourke[4], H. Poptani[1], and E. R. Melhem[1]

[1]Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]Radiology, Tokushima University Hospital, Tokushima, Tokushima, Japan, [3]Neurology, University of Pennsylvania, Philadelphia, PA, United States, [4]Neurosurgery, University of Pennsylvania, Philadelphia, PA, United States

Introduction

The goal of brain tumor surgery is to maximize the extent of tumor resection while minimizing postoperative neurological deficits resulting from damage to intact, functioning brain. Corticospinal tract (CST) is the major motor pathway and even a mild impairment or damage to it may result in sensorimotor deficits. Brain neoplasms can displace, infiltrate or disrupt white matter tracts. Thus, knowledge about the micro-structural integrity and location of the CST before surgery is of great importance. Diffusion tensor imaging (DTI) allows for the non-invasive mapping of the white matter tracts and tensor metrics such as fractional anisotropy (FA) and apparent diffusion coefficient (ADC) in the CSTs have been reported to be abnormal in patients with brain neoplasms[1]. The purpose of this study was to determine whether CST abnormality in patients with brain neoplasms correlates with clinical motor weakness.

Materials and Methods

Nineteen patients (16M/3F, age 39-70) with pathologically proven brain neoplasms (15 glioblastoma multiforme, 1 grade IV gliosarcoma, 1 anaplastic astrocytoma, 2 low grade astrocytomas) with lesions located adjacent to the internal capsule were included in this study. They were categorized as 12 normal and 7 abnormal based on clinical assessment of motor function. All patients underwent MR examination before surgery on a 3T Siemens Tim Trio scanner with a 12-channel phase-array head coil. DTI was acquired with a 12-direction single shot, spin-echo echo planar sequence with parallel imaging using GRAPPA and acceleration factor of 2. Imaging parameters were as follows: TR/TE = 4900/83ms, FOV = 22x22 cm^2, matrix = 128x128, b values = 0 and 1000 s/mm^2, slice thickness 3mm, no intersection gap. The data were post-processed off-line using DtiStudio, Version 3.0 (Johns Hopkins University, Baltimore, MD). The images were first corrected for motion and eddy-current artifacts using a 12-mode affine transformation with Automated Image Registration (AIR)[2] and FA, ADC maps were computed, subsequently. The CST was reconstructed by placing two regions of interest (ROIs) at the lower pons and cerebral peduncle based on FACT (fiber assignment by continuous tractography)[3]. CSTs were manually segmented from the cerebral peduncle to the internal capsule level using MRIcro. The segmented CSTs were used as the mask for the FA and ADC measurements. Upon normalization of the FA and ADC values to the contra-lateral normal side, the data were compared across the two groups using a two-tailed, unpaired Student t-test.

Results

Representative images for patients with abnormal (top row) and normal motor function (bottom row) are shown in Fig.1. Normalized FA (nFA) and ADC (nADC) values between the two groups are shown in Table 1. Patients with abnormal motor function demonstrated significantly reduced FA ($p < 0.001$) and increased ADC ($p < 0.01$) compared to the patients with normal motor function.

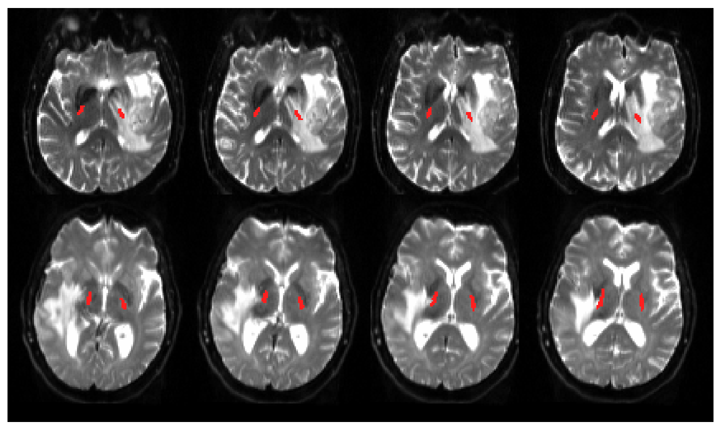

Fig.1 Corticospinal tracts (CST, red) overlaid on B0 images for a patient with abnormal motor function (top row) and a patient with normal motor function (bottom row). Both cases show deviated but well-preserved CSTs in the internal capsule. However, reduced FA and increased ADC from the CSTs were noted in the patient with abnormal motor function (top row).

Table 1: Normalized FA and ADC values between normal and abnormal motor function group

Motor function	nFA	nADC
Normal (n=12)	0.85 ± 0.08	1.23 ± 0.22
Abnormal (n=7)	0.65 ± 0.09*	1.49 ± 0.17*

Data are reported as mean ± standard deviation
*indicates statistically significant difference (p< 0.01)

Discussion

Previous studies have reported DTI findings in brain neoplasms by manually placing several ROIs along CSTs[4-6]. In this study, a semi-automatic method was applied along with the use of segmented CSTs as the mask, which might be a more robust way to characterize the underlying changes in CSTs. Observation of reduced FA and increased ADC in patients with abnormal motor function compared with the patients with normal motor function suggests that preoperative CST involvement determined by DTI was predictive of the presence or absence of motor weakness. The integrity of the CST microstructure can be evaluated with DTI metrics. This study indicates the potential of DTI in predicting the degree of CST involvement in brain neoplasms.

Reference

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