# Accuracy and Validity of DTI Motor Tracks Determined from Subcortical Stimulation in Brain Tumor Patients

J. I. Berman[1], M. S. Berger[2], S. Chung[1], S. S. Nagarajan[1], R. G. Henry[1]

[1]Radiology, UC San Francisco, San Francisco, CA, United States, [2]Neurological Surgery, UC San Francisco, San Francisco, CA, United States

**Introduction:** Diffusion tensor imaging (DTI) fiber tracking of the pyramidal tract has been demonstrated to show connectivity between functionally mapped cortex and known anatomical landmarks. However, the accuracy and validity of fiber tracks' position within white matter structures between motor cortex and anatomical landmarks has not been verified. Localization of the motor tract in deep white matter structures is important for surgical planning. Intraoperative subcortical stimulation is an invasive technique performed by neurosurgeons used during tumor resections to identify the location of the motor tract within white matter. In this study, fiber tracks constructed preoperatively are compared with the location of subcortical motor stimulations to evaluate the validity and accuracy of DTI fiber tracking of the human motor tract.

**Methods:** MR scans of 6 glioma patients were performed on a 1.5T GE Signa machine one day prior to surgical resection. DTI was performed with b=1000s/mm$^2$, TR/TE = 10000/100ms, slice thickness between 2 and 2.3 mm, no gap, voxel volume between 4.5 and 9 mm$^3$, 6 NEX, and six diffusion gradient directions. Magnetic source imaging (MSI) was performed on 5 of the patients to identify somatosensory cortical sites.

DTI fiber tracking of the pyramidal tract was performed presurgically by continuously following the primary eigenvector [1]. Fiber tracks were launched from the cerebral peduncle and targeted with regions drawn in the posterior limb of the internal capsule and the precentral gyrus. The DTI echo planar volume was registered to high-resolution FSE MR images with a 12-parameter model. Fiber tracks were overlaid on FSE images for use during surgery with the stereotactic navigation system (Medtronic, Broomfield, CO).

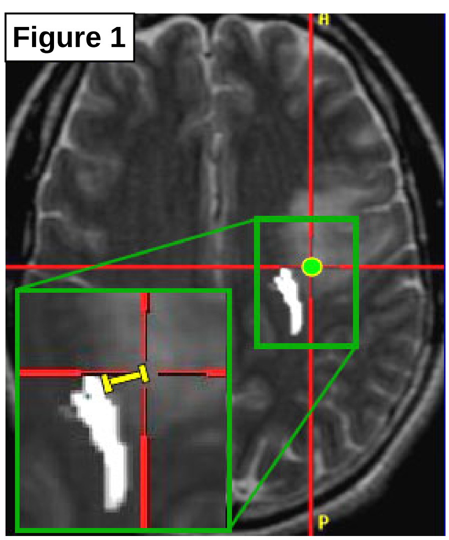
Direct electrical stimulation of subcortical white matter within the resection cavity was performed with a 5mm wide bipolar electrode to find points that elicited a motor response [2]. These points were stereotactically identified on the FSE MR images and screen saves from the navigation system were saved. The distance between the stimulation site and the closest border of the presurgical motor fiber tracks was measured (Figure 1).

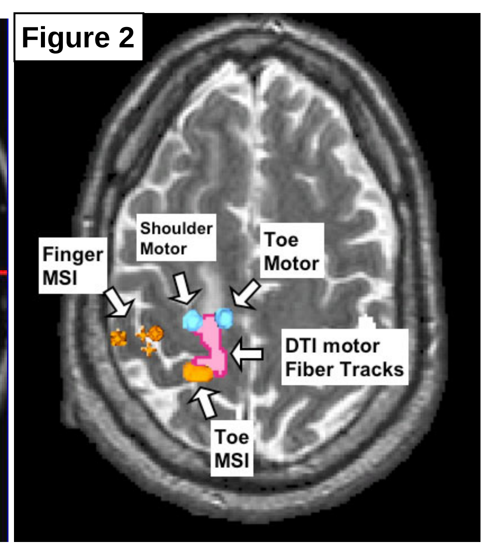
**Results and Discussion:** 11 subcortical stimulation sites (4 upper extremity, 4 face or mouth, 3 lower extremity) were identified on six patients. The average distance between stimulation sites and DTI fiber tracks was 8.6 ± 3.6 mm. The distance measured is affected by brain shift, the penetration of electrical stimulation, and variability in the location of fiber tracks. Brain decompression during resection can shift brain structures towards the electrodes and therefore give an artifactual offset to the fiber tracks. In addition, stimulation is known to penetrate brain tissue on the order of 5 to 10 mm. Since the resection is stopped when a motor tract is detected, the stimulation range sets a minimum distance between an observed stimulation site and fiber tracks.

**Conclusion:** This work suggests the validity of the spatial distribution of DTI fiber tracks. DTI fiber tracks were constructed presurgically and matched the gold-standard for localizing the motor pathway within an acceptable margin of error. Thus, DTI fiber tracks of the motor tract can be used as a tool for identifying the motor tract and planning surgical resections.

**Figure 1:** Face motor subcortical stimulation site (at cross hairs) and DTI fiber tracks (white) on screen save from surgical navigation system. Yellow bar shows measured distance between stimulation site and DTI fiber tracks.

**Figure 2:** MSI sites (orange) and subcortical motor stimulations sites (blue) are projected onto axial slice with presurgical motor DTI fiber tracks (red). All sensory and motor sites are within 1cm of level shown. The four finger MSI sites are in the post central gyrus and lateral to the toe sensory MSI site. The motor fiber tracks and subcortical stimulations are in the precentral gyrus.




**References:**

1) Mori, S., et al. Ann Neurol., 45: 265-269.
2) Berger MS, Ojemann GA. Intraoperative Monitoring Techniques in Neurosurgery. New York, McGraw-Hill, 1994, pp 113-127.

Funding from NIH/NCI CA100331