HDFT, endoscopic port surgery synergistic in management of deep brain tumors

by Johnathan Engh, MD; Sudhir Pathak, MS; Juan C. Fernandez-Miranda, MD

Deep brain tumors are often not considered for surgical removal because of concern of morbidity related to tumor access and visualization. However, it is known that surgical resection can improve both neurological and oncological outcomes for patients with brain tumors. The Neuroendoport[SM] is a minimally invasive access tool for deep tumor resection that has been implemented in the removal of deep brain tumors using a technique called endoscopic port surgery (EPS). It is a transparent cylindrical retractor, 11.5 mm in diameter and of varying length, which facilitates deep brain access with minimal brain trauma while still allowing for bimanual microsurgery to remove the tumor. At UPMC, a significant experience has been developed using the Neuroendoport to remove deep tumors.

Prior experience with endoscopic port surgery has demonstrated that high definition fiber tracking (HDFT), a MRI-based technique of white matter imaging, can be used to guide cannulation of a tumor using an endoscopic port, minimizing damage to functional surrounding nerve fascicles. This technique helps to ensure that critical fiber tracts, such as the corticospinal tract (CST), the optic radiations, or the arcuate fasciculus are not damaged by the port during deep brain surgery.

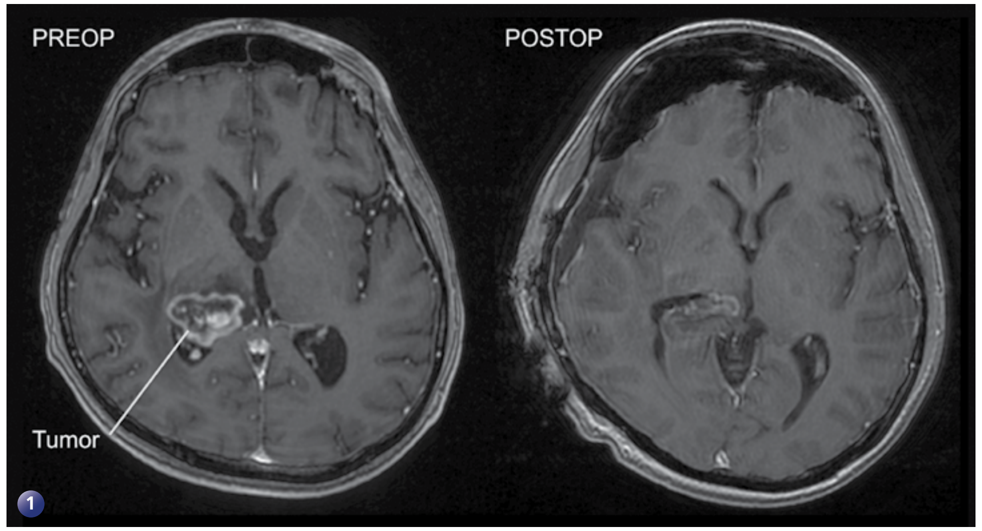


Figure 1: **Preoperative and postoperative T1-weighted axial sections with contrast showing a subtotal resection of a right posterior thalamic tumor.**

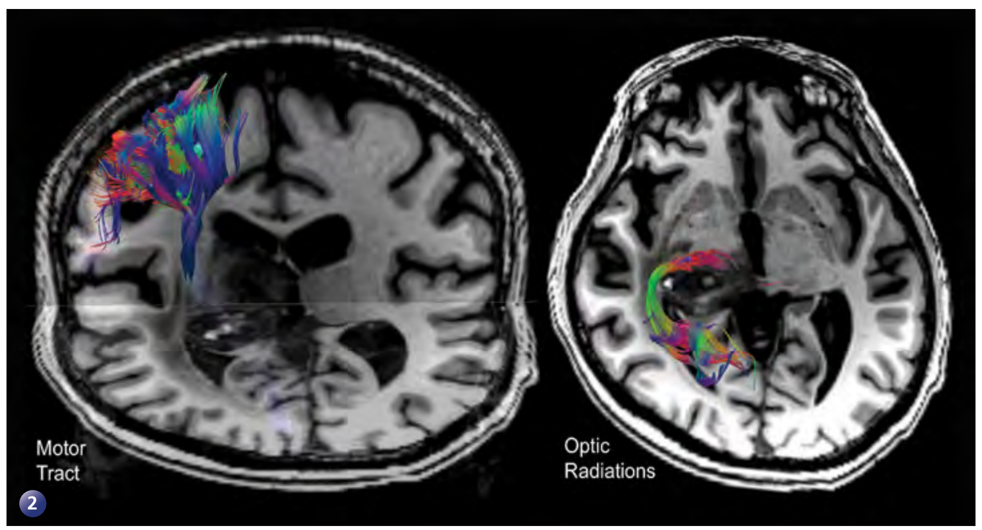


Figure 2: **HDFT reconstruction of the fiber tracts in this patient showed the location of the cortico-spinal (motor) tract just anterior and lateral to the tumor, and the optic radiations (visual system) just lateral and inferior to it. The surgical endoport trajectory was planned accordingly.**

Illustrative Case

A 47-year-old, right-handed woman was referred for a surgical evaluation of a right thalamic glioblastoma. The patient initially presented with headaches, left-sided numbness and left hemianopia. Following diagnostic biopsy, she underwent concomitant temozolomide chemotherapy with radiation therapy followed by temozolomide monotherapy. After six months of therapy, the patient was in her usual state of health until the past few weeks, during which she developed worsening headaches, worsening left-sided numbness and weakness, as well as some mild confusion and some intermittent visual hallucinations with lack of clarity of vision in the right visual hemifield. She was already blind in the left visual hemifield.

On examination, the patient was awake and alert. She was oriented x3. She had a slight left facial droop, left-sided pronator drift, minimal left-sided weakness on the order of 4 out of 5. She also had a mild proprioceptive deficit. She had a complete left hemifield cut, as well as some mild right visual field disturbance.

MRI scans demonstrated a peripherally enhancing, centrally necrotic mass within the right thalamus with significant surrounding T2 signal prolongation. HDFT scans were performed and the CST was isolated from these scans. Given the patient's neurologic deterioration, surgery was recommended via a transtemporal approach using EPS technique. HDFT images were used to guide tumoral cannulation, ensuring that the entry into the tumor was inferoposterior to the CST. Postoperative MRI and HDFT images confirmed an excellent tumor debulking with no additional loss of CST fibers, *(figure 2)*.

Post-operatively, the patient's headache and right visual field disturbances improved. Her left hemiparesis improved minimally. The left hemianopia remained. She returned home for rehabilitation prior to additional adjuvant therapy.

HDFT and EPS are synergistic in the surgical management of deep brain tumors. Such tools facilitate treatment options that are generally not feasible using conventional MRI scans and conventional microsurgical techniques. Further experience will help to delineate the breadth of applicability of this technique for challenging deep brain tumor patients. •

Intra-operative use of HDFT with image-guidance valuable in awake craniotomy for tumor resection

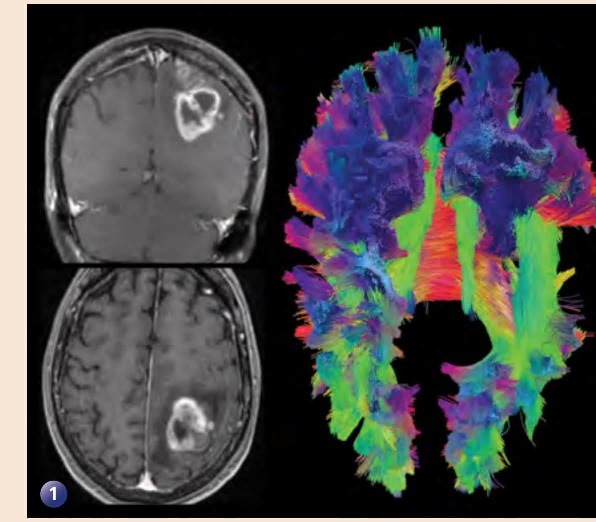
by Arlan Mintz, MD; Johnathan Engh, MD; Sudhir Pathak, MS; Juan C. Fernandez-Miranda, MD

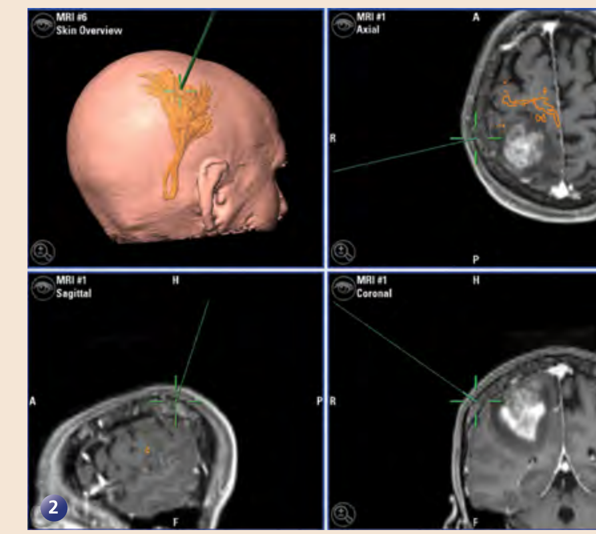
Current strategies for the surgical treatment of malignant brain tumors are directed towards maximal tumor resection while preserving neurological function. Injury to adjacent critical brain tissue can occur during the approach through the cortex and also via injury to eloquent fiber tracts that surround the tumor. However, fiber tract visualization surrounding the tumor is significantly limited using standard MRI imaging techniques, even with diffusion tensor imaging (DTI). In contrast, we have found that high definition fiber tracking (HDFT) provides fiber tracking imaging that is more robust in the setting of vasogenic edema and has the ability to deal with fiber crossings. Here, we present a case where we utilized HDFT within the operating room to visualize and preserve the motor fibers during tumor resection.

A 60-year-old physician presented with complaints of headache, left-sided incoordination and mild motor weakness. Magnetic resonance imaging (MRI) scans demonstrated a heterogeneously enhancing mass surrounded by substantial peri-tumoral T2 signal change, *(figure 1)*. Given the presumptive diagnosis of a high-grade glioma, surgical resection was recommended. The key concern was the presence of the tumor abutting and possibly involving the corticospinal tract (AKA motor tract) at the anterior portion of the tumor. Injury to these fibers would result in a significant risk for motor deficit. In order to better visualize peri-tumoral motor fibers, the patient underwent HDFT prior to surgical resection. We found that the motor fibers appeared to be displaced anteriorly by the tumor, which infiltrated much of the parietal lobe, *(figure 2)*.

We elected to resect the tumor via an awake craniotomy with cortical mapping, which would facilitate real-time monitoring for any neurologic deficit. The HDFT images were transferred into our image-guidance navigation software by an image uplink interface to allow them to be tracked during surgery. The fiber tract imaging was crossed referenced to the anatomical images of the T1 MRI. As expected, intra-operative cortical mapping identified that the motor cortex was anterior to the tumor. A cortisectomy was made immediately posterior to the motor cortex, and tumor was identified and the resection started using an ultrasonic aspirator. The navigation workstation showed the motor fibers either projected to the skin surface of the patient or overlaid on the structural MRI of the patient as the tumor resection proceed, *(figure 3)*. The anterior portion of the resection approached the motor fibers as visualized on HDFT on the image guidance system, but these fibers were all left intact. Post-operatively, the patient was neurologically stable and her motor symptoms improved to normal within weeks. Diagnosis was made of a glioblastoma multiforme, and the patient underwent adjuvant temozolomide with concurrent fractionated irradiation followed by temozolomide monotherapy. One year after surgical resection, her disease remained reasonably controlled, and her Karnofsky performance score was 90, with preserved motor function.

Uploading fiber-tracking data into image guidance is a difficult task, due to software compatibility issues. The use of an image uplink interface provides a solution to this problem, and we are now able to utilize image-guidance system with imaging of fiber tracts of interest with high fidelity and extreme accuracy. This ability to have in-depth analysis of peri-tumoral fiber tracts for tumors in and around the motor strip or speech areas imported into our navigation system allows for the ability to track and avoid these critical pathways. In the present case during the operation, we were able to correlate the findings of the awake cortical mapping with the localization of the motor fibers as provided by the HDFT-based image guidance. The use of HDFT combined with the techniques of awake craniotomy had a dramatic impact on the pre-operative planning and intra-operative tumor resection of this patient. •





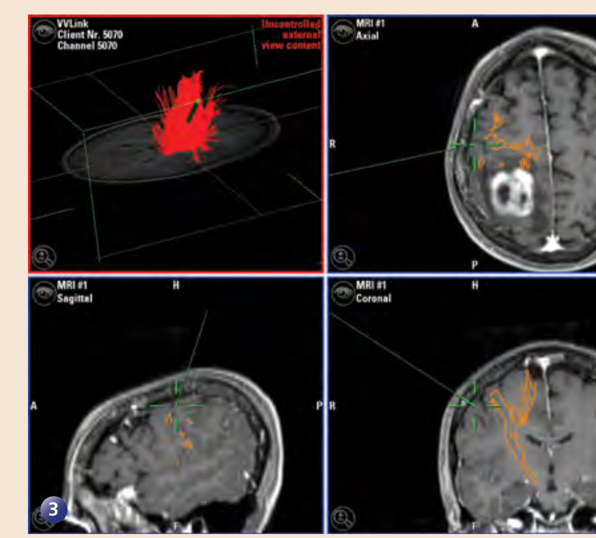


Figure 1: Upper panel: Preoperative coronal and axial T1 weighted sections showing a contrast-enhancing and necrotic tumor near the motor region. The HDFT reconstruction confirmed the spatial relationship of the tumor with adjacent fiber tracts. Figure 2: The cortico-spinal (motor) tract was segmented and incorporated into the intraoperative navigation system for accurate localization. Figure 3: the fibers of the motor tract (red) were identified during the operation, and their location was confirmed with the use of intraoperative cortical electrical mapping.