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Current Applications of Diffusion Tensor Imaging and Tractography in Intracranial Tumor Resection

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Abstract: In the treatment of brain tumors, surgical intervention remains a common and effective therapeutic option. Recent advances in neuroimaging have provided neurosurgeons with new tools to overcome the challenge of differentiating healthy tissue from tumor-infiltrated tissue, with the aim of increasing the likelihood of maximizing the extent of resection volume while minimizing injury to functionally important regions. Novel applications of diffusion tensor imaging (DTI), and DTI-derived tractography (DDT) have demonstrated that preoperative, non-invasive mapping of eloquent cortical regions and functionally relevant white matter tracts (WMT) is critical during surgical planning to reduce postoperative deficits, which can decrease quality of life and overall survival. In this review, we summarize the latest developments of applying DTI and tractography in the context of resective surgery and highlight its utility within each stage of the neurosurgical workflow: preoperative planning and intraoperative management to improve postoperative outcomes.

Keywords: diffusion tensor imaging; tractography; glioma; resection; intracranial electrical stimulation

Biopsy Confirmed Glioma Recurrence Predicted by Multi-Modal Neuroimaging Metrics

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Abstract: Histopathological verification is currently required to differentiate tumor recurrence from treatment effects related to adjuvant therapy in patients with glioma. To bypass the complications associated with collecting neural tissue samples, non-invasive classification methods are needed to alleviate the burden on patients while providing vital information to clinicians. However, uncertainty remains as to which tissue features on magnetic resonance imaging (MRI) are useful. The primary objective of this study was to quantitatively assess the reliability of combining MRI and diffusion tensor imaging metrics to discriminate between tumor recurrence and treatment effects in histopathologically identified biopsy samples. Additionally, this study investigates the noise adjuvant radiation therapy

introduces when discriminating between tissue types. In a sample of 41 biopsy specimens, from a total of 10 patients, we derived region-of-interest samples from MRI data in the ipsilateral hemisphere that encompassed biopsies obtained during resective surgery. This study compares normalized intensity values across histopathology classifications and contralesional volumes reflected across the midline. Radiation makes noninvasive differentiation of abnormal-nontumor tissue to tumor recurrence much more difficult. This is because radiation exhibits opposing behavior on key MRI modalities: specifically, on post-contrast T1, FLAIR, and GFA. While radiation makes noninvasive differentiation of tumor recurrence more difficult, using a novel analysis of combined MRI metrics combined with clinical annotation and histopathological correlation, we observed that it is possible to successfully differentiate tumor tissue from other tissue types. Additional work will be required to expand upon these findings.

Keywords: glioma; diffusion tensor imaging; generalized q-ball imaging; treatment-related effects; multiple resections

In progress:

DTI Analysis: Tumor Impact on Language Related White Matter Tracts

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Abstract: Despite a growing understanding of brain neoplasm biology, clinical management and tumor surgical resection of brain tumors remain the primary treatment options. Diffusion tensor Imaging (DTI), a non-invasive method used to characterize brain neoplasms, has been widely used for analyzing effects on white matter tracts. DTI metrics and tractography can provide physicians with useful information on extent of resection, tumor localization, and clinical management. Here, we propose a retrospective study with two aims. The first is to characterize pathological changes on localized to white matter language tracts caused by brain neoplasms through a DTI-derived tractography approach. The second is to identify clinically relevant biomarkers that can ultimately aid physicians in management and resection of brain neoplasms. We began by extracting ipsilateral and contralateral language related white matter tracts using DSI studio. Then we used ITK-SNAP software to perform tumor segmentations. Using ITK-SNAP, we performed volumetric analysis on the segmentations. Then we conducted statistical analysis using paired t-test to compare tract counts in the ipsilateral and contralateral groups and we derived a Spearman Correlation of tumor volume versus percent of tract loss due to tumor infiltration. No significant correlation was observed for percent of tract lost as a function of tumor volume. Next steps will be to incorporate DTI coefficients, tract geometry, and network parameters in the analysis.

Keywords: tumor localization; diffusion tensor imaging; white matter language tracts; brain neoplasm; tumor volume