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How gliomas affect white matter tract bundles associated with the limbic cortex

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ABSTRACT

Introduction: While glioma incidence in the US has stabilized, prognosis remains poor. One underutilized MRI modality, Diffusion Tensor Imaging (DTI), could be used to better predict postoperative glioma resection outcomes. DTI measures the structural integrity of brain white matter tracts by measuring water diffusion. We examined whether lateralized gliomas affected the structure of limbic tract bundles, and whether those changes correlated with tumor location, size, and number of tracts within the bundle.
Methods: We conducted a retrospective study of 33 glioma patients who underwent preoperative DTI and examined the cingulum, fornix, and uncinate fasciculus. Using software (ITK-SNAP, DSI Studio), we obtained diffusion coefficients (fractional anisotropy (FA), mean diffusivity (MD)), tumor volume, lobe location, and tract number. With FA and MD as measures of axonal integrity, tracts of the non-tumor hemisphere(contralateral), the tumor hemisphere that is traversing the tumor (ipsilateral inclusive), and the tumor hemisphere without traversing the tumor (ipsilateral exclusive) were compared. Additionally, we correlated these hemispheric changes to tumor size, location, and FA/MD.
Results: In the cingulum, FA and MD are significantly different between contralateral and ipsilateral inclusive and between ipsilateral exclusive versus ipsilateral inclusive. Similar findings were found in the uncinate fasciculus MD. FA and MD of cingulum, fornix, and uncinate fasciculus are significantly correlated with the number of tracts within the tumor hemisphere.
Conclusion: Our study, one of the first to specifically examine limbic related tracts, shows that gliomas could increase white matter tracts numbers and impact structure. Localized impact on white matter integrity is in line with previous observations. These findings support DTI as a pre-op planning tool; white matter of significant limbic tracts are affected by gliomas and this change is measurable. We plan on further analyzing data to include how tumor location could affect white matter, and to incorporate patient post-op mortality and morbidity.

1. Introduction

Gliomas are the most common neoplasm in the central nervous system. They are diffusely infiltrative tumors, and their subtype is determined based on histopathology and genetic markers (MesfinDhahir). Grades I to IV are assigned based on cellular density, nuclear atypia, mitosis, endothelial proliferation, necrosis, and histopathologic criteria related to the tumor's degree of anaplasia (Marquet; Louis et al., 2021).

Glioma growth and the decision of whether to resect are based on a careful cost-benefit analysis predicated on understanding functional connectivity and risk of functional loss (Meyer, 2009). However, neural circuitry and the effects of glioma on circuitry are rudimentarily understood. Thus, there is significant need for further methodologies and modalities of classifying pathways and their correlation to function.

One underutilized MRI modality, Diffusion Tensor Imaging (DTI), a variant of diffusion-weighted imaging (DWI) could offer major contributions to the treatment and management of gliomas. Although once purely investigational, DTI could become more routine as technology advances and cost decreases. DTI measures the diffusion of water molecules. These measurements correlate with tissue orientation and thus allow us to visualize connectivity within different areas of the brain (O'Donnell and Westin, 2012).

More specifically, DTI relies on the principle that water diffuses in a three-dimensional space, and diffusion differs based on tissue structure and type (Le Bihan et al., 2001). Volume elements (voxels) are the means

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