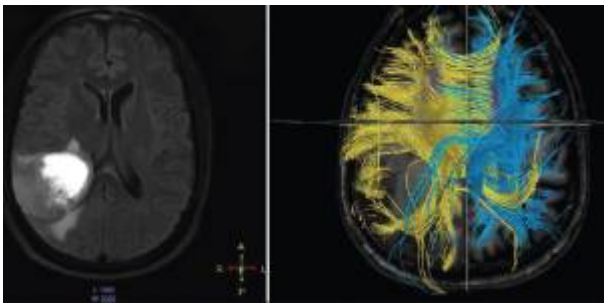
Diffusion tensor imaging for brain tumor resection



The ability of diffusion tensor MRI to detect the preferential diffusion of water in cerebral white matter tracts enables neurosurgeons to noninvasively visualize the relationship of lesions to functional neural pathways. Although viewed as a research tool in its infancy, diffusion tractography has evolved into a neurosurgical tool with applications in glioma surgery that are enhanced by evolutions in crossing fiber visualization, edema correction, and automated tract identification. In a paper of Henderson et al. the current literature supporting the use of tractography in brain tumor surgery is summarized, highlighting important clinical studies on the application of diffusion tensor imaging (DTI) for preoperative planning of glioma resection, and risk assessment to analyze postoperative outcomes. The key methods of tractography in current practice and crucial white matter fiber bundles are summarized. After a review of the physical basis of DTI and post-DTI tractography, the authors discuss the methodologies with which to adapt DT image processing for surgical planning, as well as the potential of connectomic imaging to facilitate a network approach to oncofunctional optimization in glioma surgery [1].

Preserving subcortical connectivity is crucial in optimizing functional outcomes of patients undergoing surgery for intraaxial tumors.

Diffusion tensor imaging (DTI) attempts to aid in the preservation of these subcortical networks by providing a framework for localizing these tracts in relation to the surgical target. DTI takes advantage of the anisotropic diffusion of water along white matter fiber bundles, which can be assessed with magnetic resonance imaging (MRI). Postprocessing platforms are used to map the tracts, which can then be integrated into neuronavigation. This permits the neurosurgeon to ascertain the location and orientation of major white matter tracts for preoperative and intraoperative decision making.

Diffusion tensor imaging (DTI) based on echo-planar imaging (EPI) can suffer from geometric image distortions in comparison to conventional anatomical magnetic resonance imaging (MRI). Therefore, DTI-derived information, such as fiber tractography (FT) used for treatment planning of brain tumors, might be associated with spatial inaccuracies when linearly projected on anatomical MRI.

Gerhardt et al., indicated that semi-elastic image fusion can be used for retrospective distortion correction of DTI data acquired for image guidance, such as DTI FT as used for a broad range of clinical indications [2].

The exact utility and practical application of DTI in brain tumor resection continue to be refined. On the one hand, the historical difficulty in obtaining DTI (especially with respect to postprocessing) has made its implementation in neurosurgical practices somewhat limited. Adding to this barrier, the majority of studies describing DTI are placed within a methodological framework that emphasizes the physics and computational analysis of the modality itself, a perspective that is less directly applicable to neurosurgeons wanting to apply DTI to clinical practice. On the other hand, fundamental questions about the utility of the tool have been raised by leaders in the field [3) 4) 5) 6) 7) 8) 9) 10)].

Conventional white matter (WM) imaging approaches, such as diffusion tensor imaging (DTI), have been used to preoperatively identify the location of affected WM tracts in patients with intracranial tumors in order to maximize the extent of resection and potentially reduce postoperative morbidity.

Preoperative diffusion tensor imaging (DTI) is used to demonstrate corticospinal tract (CST) position. Intraoperative brain shifts may limit preoperative DTI value, and studies characterizing such shifts are lacking.

For nonenhancing intraaxial tumors, preoperative DTI is a reliable method for assessing intraoperative tumor-to-CST distance because of minimal intraoperative shift, a finding that is important in the interpretation of subcortical motor evoked potential to maximize extent of resection and to preserve motor function. In resection of intra-axial enhancing tumors, intraoperative imaging studies are crucial to compensate for brain shift [11)].

Case series

A total of 34 patients were included in this study. Pre-operative contrast-enhanced magnetic resonance imaging and DTI scans of the patients were taken into consideration. Pre- and post-operative neurological examinations were performed and the outcome was assessed.

Preoperative planning of surgical corridor and extent of resection were planned so that maximum possible resection could be achieved without disturbing the WM tracts. DTI indicated the involvement of fiber tracts. A total of 21 (61.7%) patients had a displacement of tracts only and they were not invaded by tumor. A total of 11 (32.3%) patients had an invasion of tracts by the tumor, whereas in 4 (11.7%) patients the tracts were disrupted. Postoperative neurologic examination revealed deterioration of motor power in 4 (11.7%) patients, deterioration of language function in 3 (8.82%) patients, and memory in one patient. Total resection was achieved in 11/18 (61.1%) patients who had displacement of fibers, whereas it was achieved in 5/16 (31.2%) patients when there was infiltration/disruption of tracts.

DTI provided crucial information regarding the infiltration of the tract and their displaced course due to the tumor. This study indicates that it is a very important tool for the preoperative planning of surgery. The involvement of WM tracts is a strong predictor of the surgical outcome [12)].

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