The Role of MRI Diffusion Tensor Fiber Tractography in Brain tumor resection

Essay

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Introduction

The complexity of the human brain presents tremendous challenges in vivo understanding its inter-structure and functionality. The nature of the human brain imposes substantial difficulty in noninvasive studies in which magnetic resonance imaging (MRI) plays an important role ***(Basser et al., 1994).***

Intracranial space-occupying lesions located in the eloquent brain area remain a challenge from the perspective of surgical removal with preservation of brain function ***(Schulder et al.,1998).***

The goal of brain tumor surgery is to maximize tumor resection while preserving vital brain function. Methods for intraoperative identification of eloquent cortices leading to safe resection of adjacent brain tumors have been shown to be successful ***(Schulder et al., 1998).***

The question of brain surgery in the vicinity of important white matter tracts remains problematic. Transection of these tracts can lead to devastating neurologic deficits ***(Rezai et al., 1996).***

Knowing the location of a brain tumor and the status of the surrounding white matter tracts helps neurosurgeons predict or even avoid unnecessary complications secondary to post-op tract injury ***(Bittar et al., 1999).***

Image-guided neurosurgery is advancing rapidly with regard to the integration of functional and anatomic imaging data Integration of functional and anatomic magnetic resonance (MR) imaging allows visualization of the functionality of gray matter and spatial relationships to tumors. This integrated information is not only applied to presurgical planning but also installed into the neuronavigation system to provide strategies to prevent intraoperative damage of eloquent cortical brain areas. Major white matter tracts, including the corticospinal tract, must also be preserved to avoid postoperative neurologic deficit ***(Nimsky et al., 2004).***

DT-MRI is an extension of the conventional MRI with the added capability of tracking and measuring the random motion of water molecules in all three dimensions, usually referred to as self-diffusion or “Brownian motion”. Since water diffusion is influenced by the microstructure, architecture, and physical properties of tissues, DT-MRI can render the information about how water diffuses in biological tissues containing a large number of fibers, like muscles or brain white matter, into intricate three dimensional (3D) representations of tissue architecture ***(Le Bihan et al., 1986)***.

Tractography is a procedure to demonstrate the neural tracts. It utilizes special techniques of magnetic resonance maging (MRI), and computer-based image analysis. The results are presented in two- and three-dimensional images.

Tractography potentially solves a problem for a neurosurgeon in terms of minimizing functional damage and determining the extent of diffuse infiltration of pathologic tissue to minimize residual tumor volume. In this way, tractography facilitates preoperative planning. Tractographic images may help to clarify whether a tumor is compressing, abutting, or infiltrating the contiguous white-matter tracts ***(Dong et al., 2004).***

Diffusion-tensor (DT) MR imaging and fiber tractography can be used to visualize three-dimensional macroscopic fiber tract architectures. These techniques offer information about eloquent white matter tracts in patients with intracranial space-occupying lesions and postoperative reorganization of white matter. In addition, eloquent white matter tracts can be visualized intraoperatively by integrating DT fiber tractography and neuronavigation systems ***(Wakana et al., 2004).***

Aim of the Work

The aim of this study is to assess the role of Magnetic Resonance Imaging Tractography in Brain tumer resection.

Chapter (1)

Anatomy

Normal Axial MRI Anatomy of the Brain:

MRI scans are obtained parallel to the cantho-meatal line. These scans are divided into posterior fossa cuts and supra-tentorial cuts ***(Naheedy, 2002).***

Posterior fossa cuts:

This set of cuts includes four sections from the foramen magnum to the supra-sellar region.

1. Above the level of foramen magnum:

The inferior portion of the cisterna magna is seen outlining the posterior aspect of the cerebellar hemispheres. The cerebellar tonsils can be seen lateral to the medulla. The medulla oblongata contains the inferior portion of the fourth ventricle, called the apex, and its outlet foramina (Magendie, posteriorly in the midline and Luschka bilaterally). The upper medulla is characterized by a mushroom cap appearance. This section also contains the inferior cerebellar peduncles (restiform bodies) postero-laterally ***(Bradley, 2002).***

Most of the structures in the anterior and middle cranial fossa are parts of skull base and orbits. In the middle cranial fossa the foramen ovale and spinosum can be visualized, they transmit the third branch of the fifth cranial nerve and the middle meningeal artery respectively ***(Naheedy, 2002).***

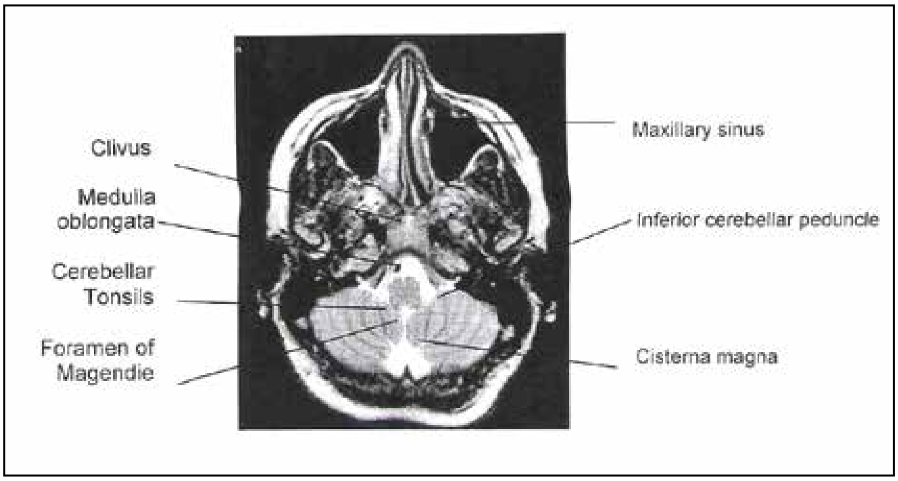

Fig.(1): Axial MRI anatomy; T2-WI above level of foramen magnum ***(Quoted from Naheedy, 2002).***

2. At the fourth ventricular level:

Posteriorly the fourth ventricle is outlined by the nodulous in the midline and the cerebellar hemispheres laterally. The larger lower basilar portion of the pons (basis pontis) is seen infront of the fourth ventricle. The pons is outlined by the anterior and lateral mesencephalic cisterns containing CSF ***(Naheedy, 2002)***.

The middle cerebellar peduncles (brachium pontis) are seen connecting the pons to the cerebellar hemispheres. The trigeminal nerves are seen at the antero-lateral aspect of the pons, while the facial nerves and vestibule-cochlear nerves are

Seen somewhat more inferiorly and laterally at the ponto-medullary junction ***(Bradley, 2002)***.

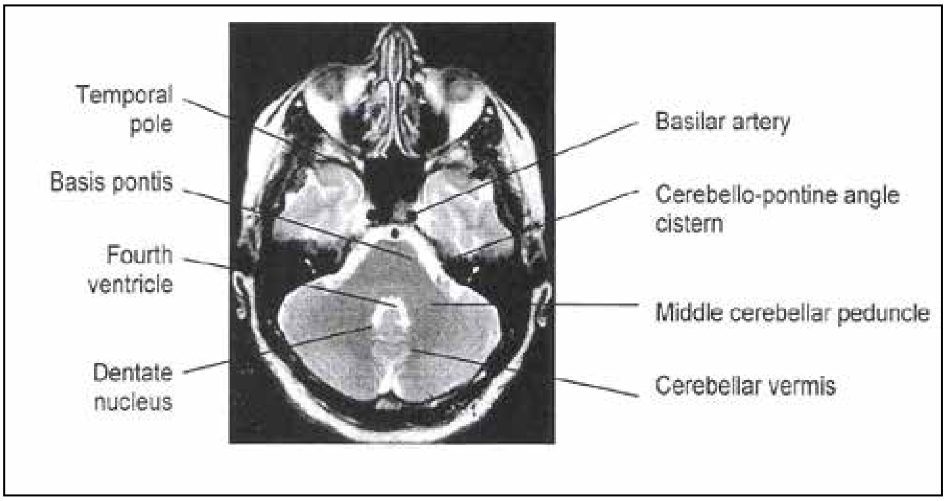

Fig.(2): Axial MRI anatomy; T2WI at the level ofthe fourth ventricle ***(Quoted from Naheedy, 2002).***

3. Above the fourth ventricular level:

With contrast studies, the transverse sinuses can be seen joining in the torcula. The superior cerebellar surface is seen with separation of the two hemispheres by the superior vermis. The "Mickey Mouse ears" of the cerebral peduncles recognize the midbrain antero-laterally and by the cerebral aqueduct posteriorly. The tegmentum is anterior to the aqueduct. The portion dorsal to the aqueduct is the tectum ***(Brudley, 2002)***.

In the middle fossa the temporal lobes are separated from the frontal lobes by the Sylvian fissure. The temporal horn,