

# **Diffusion-Weighted MR Imaging for Brain Tumor Characterization**

*Essay*

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قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا  
عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ  
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## *List of Abbreviations*

ADC.....	Apparent diffusion coefficient
CPA .....	Cerebello-pontine angle
CSF .....	Cerebro-spinal fluid
DENTs.....	Dysembryoplastic neuroepithelial tumors
DTI.....	Diffusion tensor image
EPI .....	Echo-planner image
FA .....	Fractional anisotrophy
GBM .....	Glioblastoma multiforme
HASTE .....	Half-fourier single shot turbo spin echo
JPA.....	Juvenile pilocytic astrocytoma
MD.....	Mean diffusibility
PCNSL.....	Primary central nervous system lymphoma
PNETs.....	Primitive neuro-ectodermal tumors
PXA .....	Pleomorphic xanthoastrocytoma

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# Introduction

Physical Aspects of Diffusion:



## Introduction and Aim of the Work

### Introduction

MR imaging is now a well established tool for evaluation of brain tumors but conventional MR technique continue to have important limitations. These limitations include inability to reliably distinguish exact limits of tumor extension and discriminate recurrent tumor and radiation necrosis (*Wong et al., 2000*).

In the past few years, a number of advanced MR imaging techniques have been developed that provide new methods for the assessment of brain tumors. One of these techniques is diffusion MR imaging which is now recognized as an important new mean for assessing tumors and tumor therapies (*Covarrubias et al., 2004*). Diffusion techniques are being used to characterize tumors by helping distinguish tumor types, assess tumor grade, and attempt to determine tumor margins. In addition, the role of these techniques for evaluating response to tumor therapy is markedly gaining acceptance (*Provenzale et al., 2007*). This includes diffusion tensor imaging (DTI) which is a technique that has been developed more recently than isotropic (trace-weighted) DW imaging (*Kealey et al., 2004*).

Diffusion-weighted (DW) imaging may allow the cellularity of tumors to be graded noninvasively; because cells constitute a relative barrier to water diffusion, compared with extracerebral space. Tumors that are more cellular would be



## Introduction and Aim of the Work

expected to show less of an increase in ADC than tumors that are less cellular (*Sadeghi et al.*, ۲۰۰۳).

### Aim of the Work

To demonstrate the value of diffusion-weighted MR imaging as an emerging techniques for imaging of brain tumors.



# Gross Anatomy of the Brain

The cranial cavity is the interior of the skull that accommodates the brain and its associated structures. The cranial cavity is separated into supratentorial and infratentorial compartments by a rigid sheet of dura (the tentorium cerebelli). The supratentorial compartment is the larger of the two and is occupied by the cerebral hemispheres. The infratentorial compartment is occupied by the brainstem and the cerebellar hemispheres (*Stark and Bradley, 1999*).

## The Cerebral Hemispheres

The cerebral hemispheres fill the cranial vault above the tentorium cerebelli. Right and left hemispheres are connected by the corpus callosum and otherwise partly separated by the median longitudinal fissure. The hemispheres consist of cortical grey matter, white matter, basal ganglia, thalamus, hypothalamus, pituitary gland and the limbic lobe. The lateral ventricles form a cavity within each hemisphere (*Ryan and McNicholas, 1998*).

The cortex is thrown into a complicated series of tortuous folds, the gyri, the grooves between them are the sulci or fissures. Some of the larger sulci are used to divide the surface of the hemisphere into lobes; each cerebral hemisphere is divided into five lobes namely frontal, parietal,



temporal, occipital lobes in addition to a buried area called the insula. The limbic lobe is seen on the medial surface only (*Ghali, ۱۹۹۷*).

There are three surfaces for each hemisphere, separated by three borders. The superior border separates the medial and lateral surfaces, the inferolateral border separates the inferior and lateral surface, and the inferomedial border separates the medial and inferior surfaces (*Rao, ۱۹۹۲*).

### **Surface Features:**

#### ***Supero-lateral surface:*** (Fig.۱)

This surface presents ۲ main deep fissures namely the lateral sulcus and the central sulcus. The lateral sulcus (fissure of Sylvius) begins on the inferior surface of the hemisphere and extends to the superolateral surface passing backwards over the temporal lobe. It ends by dividing into three rami namely anterior ascending and posterior rami. The posterior ramus is the longest and conducts the middle cerebral vessels (*Ghali, ۱۹۹۷*).

The central sulcus is a prominent sulcus that starts in or near the superomedial border a little behind the mid-point between the frontal and occipital poles. It runs sinuously downwards and forwards for about ۸-۱۰ cm to end a little above the posterior ramus of the lateral sulcus. This separates the frontal and parietal lobes (*Standring et al., ۱۹۹۵*).



## Anatomy.....

The frontal lobe includes all the cortex anterior to the central sulcus and superior to the lateral sulcus. Three sulci over the lateral surface of the frontal lobe divide it into superior, middle and inferior frontal gyri. Two small sulci (namely the anterior and ascending rami of the lateral sulcus) divide the inferior frontal gyrus into orbital, opercular and triangular gyri. On the dominant hemisphere these areas of the cortex bounding the short sulci on the inferior frontal gyrus represent motor speech area of Broca (*Standring et al.*, 1990).

The parietal lobe includes all the cortex from the central sulcus to a line from the parieto-occipital boundary to the posterior end of the lateral sulcus. There is no clear lateral demarcation between the parietal and occipital lobes. The lateral aspect of the parietal lobe is subdivided into three areas by the postcentral and transverse (intra-parietal) sulci. The postcentral sulcus separates the postcentral gyrus from the remainder of the parietal lobe. The transverse sulcus divides the parietal lobe into superior and inferior parietal gyri (*Standring et al.*, 1990). Areas with known function include the sensory cortex and parietal association cortex.

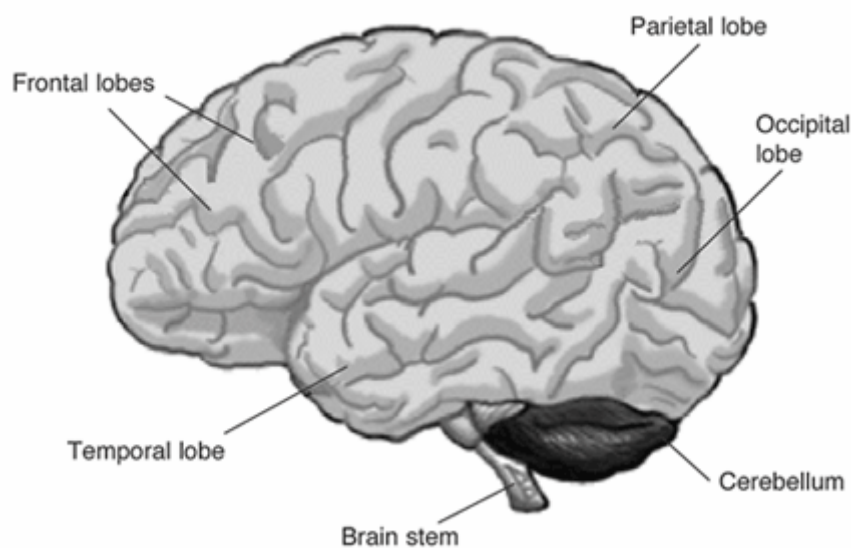
The temporal lobe lies inferior to the lateral sulcus and is separated from the occipital lobe by an arbitrary line drawn from the preoccipital notch to the parieto-occipital sulcus. Two horizontal gyri separate the superolateral surface into superior, middle and inferior temporal gyri. Areas associated with known function include the auditory cortex and the temporal association cortex (*Ryan and McNicholas*, 1998).



## Anatomy

The occipital lobe is behind the arbitrary line joining the preoccipital incisure to the parieto-occipital sulcus. The lateral surface of the occipital lobe is composed of a number of irregular lateral occipital gyri which are separated into groups by a more constant lateral occipital sulcus. Areas with known function include the visual cortex and visual association cortex (**Ryan and McNicholas, ١٩٩٨**).

The insula is the cortex buried in the floor of the lateral sulcus and is crossed by the branches of the middle cerebral artery. The parts of the frontal, parietal, and temporal lobes that overly the insula are called the operculum (**Ryan and McNicholas, ١٩٩٨**).



**Fig. (١):** Principal lobes of the cerebrum view laterally (*Quoted from Standring et al., ١٩٩٥*).