

# **ROLE OF MAGNETIC RESONANCE DIFFUSION TRACTOGRAPHY IN INTRA- AXIAL BRAIN TUMORS**

**Essay**

*Submitted for Partial Fulfillment of Master Degree  
In Radio-diagnosis*

**By**

**Ali Ahmed Abd El Mohsen Attia**

**M.B., B.CH**

**Ain Shams University**

**Supervised by**

**Prof. Dr.\Mounir Sobhy Guirguis**

**Professor of Radiodiagnosis**

**Faculty of medicine – Ain Shams University**

**Dr.\Waleed Mohammed Abd El Hamid Hetta**

**Lecturer of Radiodiagnosis**

**Faculty of medicine – Ain Shams University**

**Faculty of Medicine  
Ain Shams University**

**2012**



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا  
عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

سورة البقرة آية (٣٢)



*In the name of **Allah**, the Most Gracious, the Most Merciful. All the praises and thanks to ALLAH for making this work possible.*

*I am deeply and forever indebted to **Professor Dr., Mounir Sobhy**. I sincerely appreciate his endless guidance and encouragement. It has been a privilege to be taught and guided by such a supportive and patient supervisor. His truly instinctive knowledge had inspired and enriched my work and research.*

*My sincere thanks to, **Dr. WALEED HETTA** for his continuous guidance and support.*

*My thanks and my love to all my professors and colleagues for their support.*

*Last but not least; I would like to thank my family for their endless love and support*

***Thanks***



*I would like to dedicate this Essay to my Wife and my Son; to them I will never find adequate words to express my gratitude.*

# LIST OF CONTENTS

<i>Title</i>	<i>Page</i>
<b>Introduction.....</b>	<b>1</b>
<b>Aim of work.....</b>	<b>3</b>
<b>Anatomical Aspects.....</b>	<b>4</b>
<b>Neuropathophysiology.....</b>	<b>28</b>
<b>Physical considerations.....</b>	<b>38</b>
<b>Technique for using 3D MRI tractography.....</b>	<b>46</b>
<b>Role of magnetic resonance tractography in assessment of patients with intra-axial brain tumors.....</b>	<b>54</b>
<b>Illustrative Cases.....</b>	<b>74</b>
<b>Summary and conclusion .....</b>	<b>88</b>
<b>References .....</b>	<b>90</b>
<b>Arabic summary</b>	

## *List of abbreviations*

<b>1H-MRSI</b>	Proton MR spectroscopic imaging
<b>3D</b>	3-Dimensional
<b>ADC</b>	Apparent Diffusion Coefficient
<b>ALIC</b>	Anterior Limb Of The Internal Capsule
<b>BOLD</b>	Blood Oxygen Level Dependent
<b>C</b>	caudate nucleus
<b>CC</b>	Corpus Callosum
<b>cg</b>	Cingulum
<b>Cho</b>	choline
<b>CNS</b>	Central Nervous System
<b>CPC</b>	Choroid Plexus Carcinoma
<b>CPP</b>	Choroid Plexus Papilloma
<b>CPT</b>	Choroid Plexus Tumors
<b>CSF</b>	Cerebrospinal Fluid
<b>cst</b>	Corticospinal Tract
<b>CT</b>	Computerized Tomography
<b>DT</b>	Diffusion Tensor
<b>DNET</b>	dysembryoplastic neuroepithelial tumour
<b>DTI</b>	Diffusion Tensor Imaging
<b>DTI-FT</b>	DTI Fiber Tracking
<b>DTT</b>	Diffusion Tensor Tractography
<b>DW</b>	Diffusion Weighted
<b>DWI / PWI</b>	diffusion/perfusion weighted image
<b>e ADC</b>	enhanced Apparent Diffusion Coefficient
<b>EPI</b>	Echo Planar Imaging
<b>FA</b>	Fractional Anisotropy
<b>FACT</b>	Fibre Assignment by Continuous Tracking
<b>fMRI</b>	Functional MR Imaging

<b>fx</b>	Fornix
<b>IC</b>	Internal Capsule
<b>icp</b>	Inferior Cerebellar Peduncle
<b>ifo</b>	Inferior Fronto-Occipital Fasciculus
<b>ilf</b>	Inferior Longitudinal Fasciculus
<b>iMRI</b>	Intraoperative MR Imaging
<b>LGN</b>	Lateral Geniculate Nucleus
<b>mcp</b>	Middle Cerebellar Peduncle
<b>ml</b>	Medial Lemniscus
<b>MR</b>	Magnetic Resonance
<b>MRI</b>	Magnetic Resonance Imaging
<b>MRS</b>	MR spectroscopy imaging
<b>MS</b>	Multiple Sclerosis
<b>NAA</b>	N-acetylaspartate OR Optic Radiation
<b>PLIC</b>	Posterior Limb of the Internal Capsule
<b>PMA</b> s	Primary Motor Areas
<b>PROPELLER</b>	Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction
<b>ROI</b>	Regions of Interest
<b>RT</b>	Radiotherapy
<b>scp</b>	Superior Cerebellar Peduncle
<b>sfo</b>	Superior Frontooccipital Fasciculus
<b>slf</b>	Superior Longitudinal Fasciculus
<b>SNR</b>	Signal-To-Noise Ratio
<b>SRT</b>	Stereotactic Radiotherapy
<b>st</b>	Stria Terminalis
<b>T2WI T2</b>	Weighted Image
<b>unc</b>	Uncinate Fasciculus
<b>WHO</b>	World Health Organization
<b>WM</b>	White Matter
<b>WMT</b>	White Matter Tractography

# LIST OF TABLES

<i>Table No.</i>	<i>Page</i>
<b>Table (1):</b> A simplified version of the WHO classification....	32
<b>Table (2):</b> A list of brain tumours divided according to infiltrative or circumscribed pattern of growth.....	37



## *List of Figures*

<i>Figure No.</i>	<i>Title</i>	<i>Page</i>
<b>Figure (1):</b>	Lateral view of the left side of the brain .....	5
<b>Figure (2):</b>	MRI axial T1 at level basal ganglia.....	7
<b>Figure (3):</b>	Schematic diagram of projection fibers.....	9
<b>Figure (4):</b>	Relationship between various nomenclatures of white matter tracts in the internal capsule. ....	9
<b>Figure (5):</b>	Corticospinal tract.....	10
<b>Figure (6):</b>	3D reconstruction results of the projection fibers .....	12
<b>Figure (7):</b>	Association fibers in sagittal view.....	13
<b>Figure (8):</b>	Association Fibers coronal view .....	14
<b>Figure (9):</b>	Directional map for Cingulum and other association fibres .....	15
<b>Figure (10):</b>	The trajectory of the superior longitudinal fasciculus and its identification in the color maps.....	16
<b>Figure (11):</b>	The trajectory of the inferior longitudinal fasciculus and its identification in color maps.....	18

<i>Figure No.</i>	<i>Title</i>	<i>Page</i>
<b>Figure (12):</b>	The trajectory of the inferior fronto-occipital fasciculus and its identification in color maps .....	19
<b>Figure (13):</b>	The trajectory of the uncinate fasciculus and its identification in color maps .....	20
<b>Figure (14):</b>	The trajectory of the superior fronto-occipital fasciculus and its identification in color maps .....	21
<b>Figure (15):</b>	Trajectories of the cingulum (green) and fornix / stria terminalis .....	24
<b>Figure (16):</b>	3D reconstruction results of commissural fibers .....	26
<b>Figure (17):</b>	Trajectories of the corpus callosum (magenta) and tapetum (peach) and their identification in color maps .....	27
<b>Figure (18):</b>	Colour-coded anisotropy axial DTI maps at the level of the posterior limb of the internal capsule .....	35
<b>Figure (19):</b>	Example for complete tract disruption. ....	36
<b>Figure (20):</b>	Line diagram demonstrating the concept of isotropic diffusion .....	40

<i>Figure No.</i>	<i>Title</i>	<i>Page</i>
<b>Figure (21):</b>	FA maps showing various fiber tracts .....	42
<b>Figure (22):</b>	Directionally encoded color maps show the anatomy of the various tracts.....	43
<b>Figure (23):</b>	Different image types used in DTI .....	45
<b>Figure (24):</b>	Schematic illustration of an ROI setting for sensory and pyramidal Tractography.....	47
<b>Figure (25):</b>	Schematic illustrations of sensorimotor tracts at four levels of the brain .....	48
<b>Figure (26):</b>	Propagation of a fiber in a vector field.....	49
<b>Figure (27):</b>	Principles of tract reconstruction using the “from ROI” and the “brute-force” approaches .....	50
<b>Figure (28):</b>	Schematic diagram of FACT fiber tract reconstruction based on DTI data.....	51
<b>Figure (29):</b>	Fiber reconstruction with a line propagation algorithm .....	52
<b>Figure (30):</b>	Pattern of main fiber tract involvement: displaced. ....	56
<b>Figure (31):</b>	Tract displacement. Left parietooccipital AVM. ....	58
<b>Figure (32):</b>	Tract displacement.....	59

<i>Figure No.</i>	<i>Title</i>	<i>Page</i>
<b>Figure (33):</b>	Pattern of main fiber tract involvement: invaded.....	60
<b>Figure (34):</b>	Pattern of main fiber tract involvement .....	61
<b>Figure (35):</b>	Complete tract disruption .....	62
<b>Figure (36):</b>	Pattern of main fiber tract involvement .....	63
<b>Figure (37):</b>	Pattern of main fiber tract involvement .....	64
<b>Figure (38):</b>	Patterns of Main Fiber Tract Involvement By Tumor.....	66
<b>Figure (39):</b>	Patient with Grade 3 oligoastrocytoma .....	72
<b>Figure (40):</b>	Patient with Grade 4 glioblastoma multiforme .....	72
<b>Figure (41):</b>	Patient with Grade 2 oligodendroglioma.....	73
<b>Figure (42):</b>	axial and sagittal MRI sequences in 83- year-old woman with right limb weakness.....	75
<b>Figure (43):</b>	Tractography images show the interrupted fibers around the tumor .....	75
<b>Figure (44):</b>	White matter tracts affected by a tumor situated in the left basal nuclei .....	77
<b>Figure (45):</b>	Tractograms of the corticospinal tracts .....	78

<i>Figure No.</i>	<i>Title</i>	<i>Page</i>
<b>Figure (46):</b>	Pre- (A) and postoperative (B and C) tractograms of the inferior fronto-occipital fasciculi .....	79
<b>Figure (47):</b>	axial MRI sequences and tractogram in a 16-year-old boy presented with seizures .....	81
<b>Figure (48):</b>	Tractograms of the projection fibers and corona radiata pre- and postoperatively .....	83
<b>Figure (49):</b>	Pre- and postoperative tractograms of the ipsilateral superior longitudinal fasciculus .....	84
<b>Figure (50):</b>	axial images showing focal mass lesion in the region of right corona radiata .....	85
<b>Figure (51):</b>	FA and color coded map showing the effect of the mass on the adjacent WMT .....	86
<b>Figure (52):</b>	WMT reconstruction of projection fibers of the internal capsule and corona radiata .....	87

## Introduction

Magnetic resonance tractography (MRT) is a valuable, noninvasive imaging tool for studying human brain anatomy and, as MRT methods and technologies advance, has the potential to yield new and illuminating information on brain activity and connectivity. (*Saad and Heidi, 2011*).

MRI diffusion tensor tractography, allows visualization of white matter tracts in vivo and to study white matter integrity. Virtual dissection of the living human brain can be used to visualize white matter bundles with relationship to intra axial brain tumors (*Aoki et al, 2007*).

The goal of surgical treatment is to remove as much tumor tissue as possible, while in the same time preserving the integrity of functionally gray and white matter structures, and thus avoids postoperative neurologic deficits. However, tumor infiltration of cortical areas and/or white matter tracts may preclude safe gross total resection. Consequently, knowledge of the relationship between tumor and cortical and white matter regions is helpful for preoperatively determining the extent to which a brain tumor can be surgically removed, and also for guiding the actual surgical procedure (*Talos et al., 2007*).

Identifying the location of the motor pathways has been much more challenging. Extensive white matter infiltration by primary brain tumors is a common occurrence (*Talos et al., 2007*). Moreover, resecting brain tumors involves the risk of

damaging the descending motor pathway. Diffusion tensor (DT)-imaged fiber tracking is a noninvasive magnetic resonance (MR) technique that help to visualize the white matter fibers such as corticospinal (pyramidal) tract, optic radiation and arcuate fasciculus with relationship to brain tumors and can delineate the subcortical course of the motor pathway (*Berman et al., 2007*).

Postoperatively, DTI is used to assess surgical outcome. White matter tractography (WMT) alteration patterns including deviation, deformation, infiltration, and apparent tract interruption are examined postoperatively. (*Lazer et al., 2006*).