Role of Diffusion Tensor Imaging in evaluation of Alzheimer's Disease

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By
Shereif Ahmed Momtaz Mostafa Haykal
M.B., B.Ch.

Supervised by

Dr. Lobna Abdelmoneim Habib
Assistant Professor of Radio diagnosis
Faculty of medicine, Ain-shams University

Dr. Yosra Abdelzaher Abduallah
Lecturer of Radio diagnosis
Faculty of medicine, Ain-shams University

Faculty of medicine
Ain-shams University
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مقدمة من

طبيب / شريف أحمد ممتاز مصطفى هيكل

بكالوريوس الطب و الجراحة العامة

تحت إشراف

أ.د/ لبنى عبد المنعم حبيب

أستاذ مساعد الاشعة التشخصية

كلية الطب- جامعة عين شمس

د/ يسرا عبدالظاهر عبدالله

مدرس الاشعة التشخصية

كلية الطب- جامعة عين شمس

كلية الطب

جامعة عين شمس

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Shereif Ahmed Momtaz Haykal

Contents

List of Abbreviations

3 D	Three dimensional
A β	Amyloid-β
AD	Alzheimer's Disease
ADC	Apparent Diffusion Coefficient
aMCI	Amnestic Mild Cognitive Impairment
COH	Mean regional intervoxel coherences
CP	Cerebral Peduncle
CSF	Cerebrospinal Fluid
CT	Computed Tomography
DT	Diffusion Tensor
DTI	Diffusion Tensor Imaging
DTT	Diffusion Tensor Tractography
DW	Diffusion Weighted
EC	Entorhinal Cortex
EEG	Electroencephalography
EPI	Echo Planar Imaging
FA	Fractional Anisotropy
FACT	Fiber Assignment by Continuous Tracking
FOV	Field Of View
GE	Gradient Echo
HF	Hippocampus
HPC	Hippocampus
ICp	Posterior limb of Internal Capsule
ILE	Inferior Longitudinal Fasciculus
MCI	Mild Cognitive Impairment
MD	Mean Diffusivity
MPRAGE	Magnetization Prepared RApid Gradient Echo
MR	Magnetic Resonance
MRI	Magnetic Resonance Imaging
NC	Normal Control

NCI	No Cognitive Impairment
NFTs	Neurofibrillary Tangles
NPs	Neuretic Plaques
OA	Non-demented older adult
PCC	Posterior Cingulate Cortex
PWM	Parahippocampal White Matter
RA	Relative Anisotropy
ROI	Region Of Interest
SLE	Superior Longitudinal Fasciculus
SPGR	Spoiled Gradient
T	Tesla
T1WIs	T1 Weighted Images
T2WIs	T2 Weighted Images
TBSS	Tract Based Spatial Statistics
TE	Echo Time
TI	Inversion Time
TR	Repetition Time
WB	Whole Brain
WM	White Matter

List of Figures

List of Tables

Introduction

Alzheimer disease (AD) is the most common neurodegenerative disease and the most common cause of dementia. The number of those affected by AD is rapidly increasing as the world's population ages. It is estimated that by the year 2050, the number of people with AD will increase threefold, to about 60 million worldwide ***(Barakos and Purcell, 2012).***

AD is clinically characterized by cognitive impairment, including memory dysfunction, severe enough to interfere with activities of daily living. However, cognitive symptoms and brain abnormalities may be present many years before a clinical diagnosis of AD can be made. This preclinical phase of AD is the subject of intense investigation, since prompt diagnosis could allow early drug therapy, thereby improving the chances for a positive clinical response ***(Ramani et al., 2006).***

Although the cause of AD is not clear, histopathologically the disease is characterized by two abnormal structures in the brain: neuritic plaques and neurofibrillary tangles. Both plaques and tangles seem to interfere with normal neuronal functioning ***(Barakos and Purcell, 2012).***

The microscopic histological changes in the neurodegenerative diseases are inevitably associated with progressive regional and global brain atrophy, which could be assessed using conventional CT and MR imaging. However,

neuroanatomical changes over time may be too mild, diffuse, or topographically complex to be detected by simple visual inspection or even with manually traced measurements of regions of interest ***(Barkhof et al., 2011).***

In addition to the examination of grey matter in AD, there is increased interest in white matter changes in these conditions. Reports of pathological white matter changes have been documented in at least 50% of patients with AD ***(Stebbins and Murphy, 2009).***

MRI T2 signal decay rate has been used to document increased white matter damage in patients with AD. Although T2 weighted MRI scanning is sensitive to white matter damage, it does not provide information on the microstructural integrity of white matter ***(Bartzokis et al., 2003).***

DTI is an MRI scanning technique that allows for the examination of white matter microstructural integrity based on the directionality of diffusion in the brain. DTI indices show a significant association with cognitive functions typically impaired in AD, including mental status ***(Fellgiebel et al., 2008).***

Studies of DTI in dementia have consistently shown altered diffusion (tract) properties in accordance with the pattern of neurodegenerative pathology. By using DTI and fiber tracking, tract-specific pathology can be demonstrated, which may be specifically linked to the clinical syndrome at hand ***(Barkhof et al, 2011).***

Aim of the work :

The aim of this study is to illustrate the role of diffusion tensor imaging (DTI) in the diagnosis and follow up of Alzheimer's dementia.

Chapter 1

Anatomy of Brain White Matter Tracts

The nerve fibers which make up the white matter of the cerebral hemispheres are categorized on the basis of their course and connections. They are either:

- **Association fibers**, which link different cortical areas in the same hemisphere
- **Commissural fibers**, which link corresponding cortical areas in the two hemispheres
- **Projection fibers**, which connect the cerebral cortex with the corpus striatum, diencephalon, brain stem and the spinal cord ***(Standring et al., 2008)***.

Gross Anatomy of White Matter Tracts:

Association Fibers:

Association fibers interconnect cortical areas in each hemisphere. They consist of axons arising from small pyramidal cells, primarily from cortical layers II and III. These fibers vary in length from short to long, and project in the ipsilateral hemisphere. Association fibers that connect various cortical areas make up most of the subcortical white matter. These fibers gather to form fasciculi that connect different lobes, but, like a two-way highway, fibers merge into and exit these fasciculi all along their course ***(Patestas and Gartner, 2006).***