# Magnetic Resonance Imaging Spectroscopy In Diagnosis of Multiple Sclerosis

*Thesis*

*Submitted for Partial Fulfillment of Master Degree in Diagnostic and Intervential Radiology*

*By*

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***2019***


سورة البقرة الآية: ٣٢

# Acknowledgment

*First and foremost, I feel always indebted to* **ALLAH**, *the Most Kind and Most Merciful*

*I'd like to express my respectful thanks and profound gratitude to* **Prof. Dr. Mohamed El-Gharib Abu Al-Maati,** *Prof of Diagnostic and Intervential Radiology Faculty of Medicine - Ain Shams University for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work*

*I am also delighted to express my deepest gratitude and thanks to* **Assist. Prof. Dr. Mari Yafath Twadrous,** *Assistant Prof of Diagnostic and Intervential Radiology Faculty of Medicine - Ain Shams University, for her kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work*

**Ahmed Mohammed Rezk Metwaly**

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# List of Abbreviations

| Abb | Full term |
|---|---|
| $^{1}$H-MRS | Proton magnetic resonance imaging |
| ADC | Apparent diffusion coefficient |
| ADEM | Acute disseminated encephalomyelitis |
| CADASIL | Cerebral autosomal dominant arteriopathy with subcortical infarcts and leucoencephalopathy |
| CDMS | Clinically definite multiple sclerosis |
| CHESS | Chemical shift water suppression |
| Cho | Choline |
| CIS | Clinically isolated syndromes |
| C-MRI | Conventional magnetic resonance imaging |
| CNS | Central nervous system |
| Cr | Creatine |
| CSE | Coventional spin echo |
| CSF | Cerebrospinal fluid |
| CSI | Chemical shift imaging |
| CT | Computed tomography |
| DT | Diffusion tensor |
| DTI | Diffusion tensor imaging |
| DW | Diffusion weighted |
| DWI | Diffusion weighted imaging |
| EDSS | Expanded Disability Status Scale |
| FA | Fractional anisotropy |
| FDG | Flurodeoxyglucose |
| FLAIR | Fluid attenuated inversional recovery |
| fMRI | Functional magnetic resonance imaging |
| FSE | Fast spin echo |
| GABA | Gamma-amino butyric acid |

# List of Abbreviations Cont...

| Abb | Full term |
|---|---|
| Gd | Gadolinium |
| Glx | Glutamate-glutamine |
| HA | Hunter'sangle |
| Lac | Lactate |
| Lip MD | Lipid Mean diffusion |
| Mi | Myoinsoitol |
| MR | Magnetic resonance |
| MRI | Magnetic resonance imaging |
| MRS | Magnetic resonance spectroscopy |
| MTI | Magnetization transfer imaging |
| MTR | Magnetization transfer ratio |
| NAA | N-acetylaspartate |
| NAGM | Normal-appearing gray matter |
| NAWM | Normal-appearing white matter |
| NMSS | National multiple sclerosis society |
| PD | Proton density |
| PET | Positron emission tomography |
| PML | Progressive multifocal leucoencephalopathy |
| Ppm | Part permillion |
| PPMS | Primary progressive multiple sclerosis |
| PRESS | Point resolved spectroscopy |
| PRMS | Progressive relapsing multiple sclerosis |
| RRMS | Relapsing remitting multiple sclerosis |
| SD | Standard deviation |
| SE | Spin echo |
| SLE | Systemic lupus erythematosus |
| SPECT | Single Photon Emission Computerized Tomography |

# List of Abbreviations Cont...

| Abb | Full term |
|---|---|
| SPMS | Secondary progressive multiple sclerosis |
| STEAM | Stimulated echo acquisition mode |
| TDLS | Tumifactive demyelinating lesions |
| TE | Time of echo |
| TM | Maximum Time |
| TR | Time of repetition |
| VOI | Volume of interest |
| WBNAA | Whole brain N-acetyl aspartate |
| WML | White matter lesions |

# INTRODUCTION

Multiple sclerosis (MS) is a relatively common acquired chronic relapsing demyelinating disease involving the central nervous system, and is the second most common cause of neurological impairment in young adults after trauma. Characteristically, and by definition, multiple sclerosis is disseminated not only in space (i.e multiple lesions in different regions of the brain) but also in time (i.e. lesions occur at different times) ***(Sarbu et al., 2016).***

Multiple sclerosis (MS) is a chronic idiopathic disease of the central nervous system (CNS). Inflammation, demyelination and axonal injury are most typical pathological features, but their underlying pathogenetic mechanisms are still unclear ***(Barnett et al., 2009; Lassmann et al., 2007).***

In most of the cases MS starts between adolescence and the sixth decade, with a peak at approximately 35 years of age ***(Brust, 2006)*** and follows a relapsing-remitting course with clear defined relapses with no apparent clinical deterioration between the relapses. Each MS patient follows his/her individual disease course ***(Gilmore et al., 2010).***

MR is the most sensitive technique for detecting MS lesions and has proved to be an important paraclinical tool for diagnosing MS and monitoring therapeutic trials ***(American Journal of Neuroradiology, 2006).***

Conventional MRI detects brain abnormalities with great sensitivity but does not provide specific information about the pathology underlying the detected abnormalities. This could be explained in part by the non specificity of T2W hyperintensity which can rise from edema, mild (reversible) or severe (irreversible) chronic demyelination, inflammation, axonal loss and gliosis ***(Hock et al., 2013).***

These short comings prompted using additional MR techniques such as diffusion weighted imaging (DWI), magnetization transfer imaging (MTI), functional MRI and proton magnetic resonance spectroscopy( MRS) ***(Öz et al., 2014).***

MRS permits the invivo study of certain cerebral metabolites thus it offers the possibility of greater pathological specificity in lesional areas of MS as well as in normal appearing white matter and even in the gray matter ***(Naryana et al., 2005).***

# AIM OF THE WORK

This work aims to highlight the role of magnetic resonance spectroscopy in diagnosis and evaluation of MS patients, staging of disease activity and monitoring of treatment response.

Chapter 1

# ANATOMICAL BACKGROUND

## White matter tracts of the brain:

White matter is composed of bundles(axons which are ensheathed with mylein), which connect various gray matter areas (the locations of nerve cell bodies) of the brain to each other, and carry nerve impulses between neurons. Myelin acts as an insulator, which allows electrical signals to jump, rather than coursing through the axon, increasing the speed of transmission of all nerve signals ***(Klein et al., 2007).***

## White Matter (WM) Fiber Classification:

White Matter (WM) fiber tracts have been classified as follows: Association fibers, Projection fibers and Commissural fibers ***(Linnman et al., 2012).***

**Association fibers**: interconnect cortical areas in each hemisphere.

**Projection fibers**: interconnect cortical areas with deep nuclei, brain stem, cerebellum, and spinal cord.

**Commissural fibers**: interconnect similar cortical areas between opposite hemispheres.