



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم



MONA MAGHRABY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم



شبكة المعلومات الجامعية التوثيق الإلكتروني والميكروفيلم



MONA MAGHRABY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



MONA MAGHRABY



Quantitative assessment of MRI lesion load in cerebral Multiple Sclerosis: A comparison of conventional sequences and Double Inversion Recovery

Thesis

*Submitted for Partial Fulfilment of Master Degree in
Radiodiagnosis*

By

Bassant Tarek Selim Ali

M.B.B.Ch.

Ain Shams University

Under supervision of

Prof. Dr. Ahmed Fathy Abdel-Ghani Al-Asmar

Professor of Radiology

Faculty of Medicine, Ain Shams University

Dr. Suzan Farouk Ibrahim Salib

Lecturer of Radiology

Faculty of Medicine, Ain Shams University

Faculty of Medicine

Ain Shams University

2021

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالَ

سَبِّحْ اِنَّكَ لَا تَعْلَمُ لَنَا
اِلَّا مَا عَلَّمْتَنَا اِنَّكَ اَنْتَ
الْعَلِيمُ الْعَظِيمُ

صدق الله العظيم

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. Ahmed Fathy Abdel-Ghani Al-
Asmar**, Professor of 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 **Dr. Suzan Farouk Ibrahim Salib**, Lecturer of
Radiology, Faculty of Medicine, Ain Shams University, for her
kind care, continuous supervision, valuable instructions,
constant help and great assistance throughout this work.*

Nassant Tarek

List of Contents

Title	Page No.
List of Abbreviations.....	i
List of Tables	iii
List of Figures	iv
Introduction	1
Aim of the Work.....	3
Review of Literature	
Anatomy of the Brain	4
Pathology of MS	23
Physical Principles of Magnetic Resonance Imaging	34
Patients and Methods.....	43
Results	47
Illustrative Cases	54
Discussion	62
Summary and Conclusion.....	65
References	67
Arabic Summary	—

List of Abbreviations

Abb.	Full term
ACA	Anterior Cerebral artery
ACHA	Anterior Choroidal artery
AICA	Anterior Inferior Cerebellar Artery
BBB	Blood–brain barrier
BMI	Body mass index
CIS	Clinically isolated syndrome
CNS	Central nervous system
CSE	Conventional spin echo
DIR	Double Inversion Recovery
DWM	Deep White Matter
EBV	Epstein Bar Virus
FLAIR	Fluid-Attenuated Inversion Recovery
GM	Grey Matter
HLA	Human leukocyte antigen
ICA	Internal Carotid Artery
IR	Inversion Recovery
MCA	Middle Cerebral Artery
MRI	Magnetic Resonance Imaging
MS	Multiple sclerosis
NAWM	Normal appearing White Matter
NMR	Nuclear magnetic resonance
NMV	Net magnetization vector
PCA	Posterior Cerebral Artery
PICA	Posterior Inferior Cerebellar Artery
PPMS	Primary progressive multiple sclerosis
RIS	Radiologically isolated syndrome
RRMS	Relapsing Remitting Multiple Sclerosis
SCA	Superior Cerebellar Artery
SE	Spin Echo

List of Abbreviations Cont...

Abb.	Full term
SPMS.....	Secondary progressive multiple sclerosis
STIR	Short-TI Inversion Recovery
T1WI.....	T1-weighted images
T2 TSE	Turbo spin-echo
T2WI.....	T2-weighted images
TCRs.....	T- Cell Receptors
TE	Time to Echo
TI	Inversion Time
TR.....	Repetition Time
WM.....	White Matter

List of Tables

Table No.	Title	Page No.
Table (1):	Eliciting the signal intensities of brain tissue on T1WI and T2WI.....	20
Table (2):	Demographic data for the study group.....	47
Table (3):	Total lesion load for the study group.	48
Table (4):	Cortical affection for the study group.	49
Table (5):	Juxta and subcortical affection for study group.....	50
Table (6):	DWM affection for study group.	51
Table (7):	Infratentorial affection for the study group.	52
Table (8):	Comparison of number of lesions detected between DIR versus T2 and DIR versus FLAIR for study group.	53

List of Figures

Fig. No.	Title	Page No.
Fig. (1):	Diagram showing the boundaries between the cerebral lobes.....	6
Fig. (2):	Diagram depicting the lateral and medial aspects of the different lobes of the brain.....	9
Fig. (3):	Diagram showing the different types of white matter tracts in the coronal view	10
Fig. (4):	Diagram showing the ventricular system in the sagittal view	12
Fig. (5):	Diagrammatic representation of brain stem and associated cranial nerves.....	14
Fig. (6):	Diagrammatic representation of the cerebellum and its connections to the brainstem	16
Fig. (7):	Mid sagittal diagram showing brain cisterns	17
Fig. (8):	The image showing the three major cerebral artery territories.....	18
Fig. (9):	Normal Anatomy of the cerebral venous system	19
Fig. (10):	Diagram of 4 axial slices depicting typical venous drainage patterns of the different areas of the brain	19
Fig. (11):	Axial T2WI of the brain at the level of the basal ganglia.....	21
Fig. (12):	Coronal T2WI image of the brain taken at the level of the basilar artery	21
Fig. (13):	Annotated mid-sagittal T2WI of the brain showing both supra and infratentorial structures	22

List of Figures Cont...

Fig. No.	Title	Page No.
Fig. (14):	Protons possess a positive charge and are constantly spinning around their own axes. This generates a magnetic field making protons similar to bar magnets	35
Fig. (15):	Conventional (single echo) SE pulse sequence	36
Fig. (16):	Repetition time (TR) and T1-weighting	37
Fig. (17):	Echo time (TE) and T2-weighting	38
Fig. (18):	Comparison of Spin Echo (SE) and Inversion Recovery (IR)	39
Fig. (19):	Selective nulling of tissue signal by choice of TI.....	40
Fig. (20):	Schematic of the FLAIR (a) and DIR (b) pulse sequences along with plots of the evolution of steady-state longitudinal magnetization (M _z) evolution over time (t)	41
Fig. (21):	Demyelinating lesions in (A) T2, (B) FLAIR and (C) DIR respectively.	42
Fig. (22):	Total lesion load DIR Vs T2 and DIR Vs FLAIR.	48
Fig. (23):	Cortical lesions DIR Vs T2 and DIR Vs FLAIR.	49
Fig. (24):	Juxta and subcortical lesions DIR Vs T2 and DIR Vs FLAIR.....	50
Fig. (25):	DWM lesions DIR Vs T2 and DIR Vs FLAIR.	51
Fig. (26):	Infratentorial lesions DIR Vs T2 and DIR Vs FLAIR.	52
Fig. (27):	Case (1)	54
Fig. (28):	Case (2)	56
Fig. (29):	Case (3)	58

List of Figures Cont...

Fig. No.	Title	Page No.
Fig. (30):	Case (4)	59
Fig. (31):	Case (5)	60
Fig. (32):	Case (6)	61

INTRODUCTION

Multiple sclerosis (MS) is the most common chronic inflammatory demyelinating disease of the central nervous system (CNS), that is characterized by focal demyelinating plaques and diffuse neurodegeneration, resulting in both physical and neurocognitive disability (*Vural et al., 2013*).

Although MS has been known as a white matter disease, MS lesions occur in all CNS parenchymal areas, including cerebral cortex and deep grey matter.

Approximately two million people worldwide are affected by this disorder, and it is the most common non-traumatic neurological disability affecting young adults (*Manogaran et al., 2016*).

Multiple Sclerosis (MS) is diagnosed according to the McDonald criteria which are clinical, radiographic and laboratory criteria. They were originally introduced in 2001 and revised multiple times, most recently in 2017. The McDonald Criteria have resulted in earlier diagnosis of MS with a high degree of both specificity and sensitivity, allowing for better counseling of patients and earlier treatment (*Thompson et al., 2017*).

Magnetic resonance imaging (MRI) has played a very important role in elucidating the pathophysiology, diagnosis and treatment of MS. According to the McDonald criteria for MS, the diagnosis requires objective evidence of lesions disseminated in time and space. As a consequence there is an

important role for MRI in the diagnosis of MS, since MRI can show multiple lesions (dissemination in space), some of which can be clinically occult, and MRI can show new lesions on follow up scans (dissemination in time) (**Vural et al., 2013**).

The FLAIR sequence is a sequence that suppresses the signal of cerebrospinal fluid (CSF) with a reverse cycle (inversion recovery) pulse and a high time Echo (TE values increase) T2- weight. This sequence increases the contrast of supratentorial lesions, in particular lesions that arise in juxtaposition to the CSF but is less sensitive in the posterior fossa (**Geurts et al., 2005**).

A T2WI relies upon the transverse relaxation (also known as "spin-spin" relaxation) of the net magnetization vector (NMV). T2 weighting tends to require long TE and TR times. T2-weighted conventional spin-echo or turbo spin-echo (T2 TSE) sequences are known to be more sensitive in the detection of infratentorial lesions but have difficulties detecting juxtacortical lesions. DIR sequence produces two different inversion pulses, which attenuates the CSF together with the whole white matter, thus providing a remarkable delineation between gray and white matter. MS plaques located in the grey matter are more easily delineated using DIR (**Wattjes et al., 2007**).