



بسم الله الرحمن الرحيم

∞∞∞∞

تم رفع هذه الرسالة بواسطة / حسام الدين محمد مغربي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات : لا يوجد





A Comparative Study of the Effect of Electromagnetic Radiation Emitted from 2G versus 4G Cell Phones on the Thyroid Gland of the Adult Male Albino Rat.

Thesis

*Submitted for Partial Fulfillment of MD Degree
in Anatomy*

By

Mona Nabil Mohamed

*Assistant Lecturer of Anatomy and Embryology
Faculty of Medicine, Ain Shams University*

Under Supervision of

Prof. Soheir Ibrahim Saleh

*Professor of Anatomy and Embryology
Faculty of Medicine – Ain Shams University*

Ass. Prof. Mariam Asaad Amin

*Assistant Professor of Anatomy and Embryology
Faculty of Medicine – Ain Shams University*

Ass. Prof. Rehab Tolba Khattab

*Assistant Professor of Anatomy and Embryology
Faculty of Medicine – Ain Shams University*

Ass. Prof. Mary Refaat Isaac

*Assistant Professor of Anatomy and Embryology
Faculty of Medicine – Ain Shams University*

Dr. Maha Moustafa Ahmed Zakaria

*Lecturer of Anatomy and Embryology
Faculty of Medicine – Ain Shams University*

Faculty of Medicine - Ain Shams University

2022

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالَ

لَسْبِحَانَكَ لَا أَعْلَمُ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ
الْعَلِيمُ الْعَظِيمُ

صدق الله العظيم

سورة البقرة الآية: ٣٢

Acknowledgments

First and foremost, I feel always indebted to Allah the Most Beneficent and Merciful.

I would like to thank and express my deepest gratitude to Prof. Dr. Soheir Ibrahim Saleh, Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University, for her excellent and continuous guidance, patience, and encouragement. Without her support and instructions, this work would never be accomplished. Dr. Soheir focuses on every tiny detail and doesn't hesitate to share her insightful knowledge and expertise with anyone. That's why she is really one of a kind. As I look back, I think I have become more responsible, committed, and good in the research work because of her. She actually taught me every tiny detail in that work. Really, all the words in the world can't express how thankful I am to Dr Soheir. I will be forever grateful to her, and it was such a great honor to work under her supervision.

I would like to express my deep thanks to Ass. Prof. Mariam Asaad Amin, Assistant Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University, for her supervision and cooperation in this work.

I am also deeply grateful to Ass. Prof. Rehab Tolba Khattab, Assistant Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University, for her continuous support, care, valuable remarks, and sincere help.

Also, deeply grateful and indebted to Ass. Prof. Mary Refaat Isaac, Assistant Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University, for her valuable help, care, support, valuable remarks, and precious advice. Really, words can't express how grateful I am to her.

I am also grateful to Dr. Maha Moustafa Ahmed Zakaria, Lecturer of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University, for her care, support, and valuable remarks.

I am indebted and deeply grateful to Prof. Dr. Amany Mohamed Hosney El Shawarby, Professor of Histology and Cell Biology, Faculty of Medicine, Ain-Shams University who generously assisted us with the paper from this work. I can't express my plentiful thanks for her generous help, valuable remarks, and insightful knowledge.

Also, I would like to thank and express my gratitude to Prof. Ibtisam Bahei El-Din, Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University for her sincere help and valuable remarks in the paper of this work.

I would like to thank Prof. Hemmat Abdelkader Abdelhamid, Head and Professor of Anatomy and Embryology, Faculty of Medicine, Ain-Shams University for her continuous care, support, and encouragement.

My thanks to all my professors and colleagues in Anatomy department, Faculty of Medicine, Ain-Shams University.

Mona Nabil Mohamed

Dedication

I am dedicating this thesis to my lovely husband **Mohamed**, my kids; **Sara & Nada**, my **mother**, my **father**, and my sisters; **Noha & Soha** for helping, encouraging, supporting, and enduring me. To them all, I am deeply grateful and indebted.



List of Contents

Title	Page No.
List of Abbreviations	i
List of Tables	v
List of Charts	vi
Introduction.....	1
Aim of the Work.....	5
Review of Literature	6
Anatomy of the human thyroid gland.....	6
Histology of the human thyroid gland	9
Anatomy of the rat thyroid gland.....	11
Histology of the rat thyroid gland.....	13
Electromagnetic fields	17
History of mobile network generations	19
Evolution of the five network generations from 1G to 5G.....	20
The biological effects of EMR.....	26
Effects of mobile phone radiation on different body systems	27
Effects of mobile phone radiation on the endocrine system.....	33
Material and Methods	40
Results.....	47
Discussion.....	134
Summary & Conclusion.....	146
Recommendations.....	153
References.....	154
Arabic Summary.....	1

List of Abbreviations

Abb.	Full term
1G	The first generation
2G	The second generation
3D	Three-dimensional
3G	The third generation
3GPP	The third generation Partnership Project
4G	The fourth generation
5G	The fifth generation
ALP/ ALKP	Alkaline phosphatase
ALT	Alanine transaminase
AST	Aspartate transaminase
C cells	Parafollicular cells
C	Celsius
C5	The fifth cervical vertebra
Ca	Calcium
CARE	Committee of Animal Research Ethics
CDMA	Code Division Multiple Access
Cm	Centimeter
CVS	Cardiovascular system
DNA	Deoxyribonucleic acid
e.g.	Exempli gratia (for example)
ECG	Electrocardiogram
EDGE	Enhanced Data rates for GSM Evolution
ELF	Extremely low frequency
EMF	Electromagnetic field
EMR	Electromagnetic radiation
etc.	Et cetera (Et means, & Cetera means “the rest)
FDMA	Frequency Division Multiple Access
FSH	Follicle stimulating hormone
G	Generation
g	Gram
Gbit/s	Gigabits per second
Gbps	Gigabits per second

List of Abbreviations cont...

Abb.	Full term
GHz	Gigahertz
Gms	Grams
GOT	Glutamate oxaloacetate transaminase
GPRS	General Packed Radio Service
GPT	Glutamate Pyruvate Transaminase
GSM	The global system of mobile communications
H&E	Hematoxylin and Eosin
Hb%	Hemoglobin percentage
HF	The hyper frequency
Hrs	Hours
HSDPA	High-Speed Downlink Packet Access
Hz	Hertz
IBM	International Business Machines Corporation
IF	The intermediate frequency
IMT-2000	International Mobile Telecommunications 2000
IP	Internet Protocol
Kbit/s	Kilobits per second
Kbps	Kilobits per second
kg	Kilogram
KHz	Kilohertz
Km	Kilometer
Kv	kilovoltage
LH	Luteinizing hormone
LTE	Long-term evolution communication system
Mbps	Megabits per second
Mg	Milligram
MHz	Megahertz
mm	Millimeter
mm³	Cubic Millimeters
MMS	Multimedia Messaging Service
MRI	Magnetic resonance imaging

List of Abbreviations cont...

Abb.	Full term
MWCN	The world of Mobile Wireless Communication Networks
NADPH	Nicotinamide adenine dinucleotide phosphate
nm	Nanometer
NMRI	The Naval Medical Research Institute
P	Probability
PAR2	Protease-activated receptor 2
PH	Potential of hydrogen
RBCs	Red blood cells
rER	Rough endoplasmic reticulum
RF	Radiofrequency
RF-EMR	Radiofrequency induced- electromagnetic radiation
RFR	Radiofrequency radiation
ROS	Reactive oxygen species
SAR	Specific Absorption Rate
SD	Standard deviation
SGOT	Serum glutamic oxaloacetic transaminase
SGPT	Serum glutamic pyruvic transaminase
SMS	Short Message Service
SPSS	Statistical Product and Service Solutions
T1	The first thoracic vertebra
T3	Triiodothyronine
T4	Thyroxine
TEC	Total erythrocyte count
TEM	Transmission Electron Microscope
TGF-β	Transforming growth factor beta
TLC	Total leukocyte count
TSH	Thyroid stimulating hormone
TV	Television
Um	micrometers

List of Abbreviations cont...

Abb.	Full term
UMTS	Universal Mobile Telecommunication System
UWB	Ultra-Wide Band
W	Watts
WB	The whole body
WBCs	White blood cells
W-CDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

List of Tables

Table No.	Title	Page No.
Table 1:	Mean (μm) \pm SD of the mean follicular diameter of the thyroid gland in all groups	132
Table 2:	Mean (μm) \pm SD of the mean follicular cell height of the thyroid gland in all groups	133

List of Charts

Fig. No.	Title	Page No.
Chart 1:	Mean follicular diameter in μm of the thyroid gland in all groups.....	132
Chart 2:	Mean follicular cell height in μm of the thyroid gland in all groups.....	133

Abstract:

Introduction: The massive increase in cell phone use in the world increases worries about its possible side effects on the human health. The cell phones release nonionizing radiofrequency waves that can affect the thyroid gland due its anatomical position. Thyroid gland regulates the metabolic rate of the body and plays an important role in the human health.

Aim of the work: The present study aimed to compare the effects of electromagnetic waves emitted from 2G versus 4G mobile phone on the thyroid gland using the adult male albino rat as an experimental model.

Material and methods: 45 adult male albino rats were divided into 4 groups: Group I (Control), Group II (Sham exposed), Group III in which the rats were exposed to Nokia Asha 501 phones as sources of 2G radiation emitted by ringing for one hour per day for eight weeks and Group IV in which the rats were exposed to Lenovo B phones as sources of 4G-LTE radiation emitted by ringing for one hour per day for eight weeks. At the end of the experiment, thyroid gland specimens were processed for histological examination. Also, statistical and morphometric studies were done.

Results: Histological sections from groups III and IV showed signs of hypoactivity in the form of significant increase in the follicular diameter and significant decrease in the follicular epithelium height. In addition, some follicles showed signs of degeneration in the form of denuded follicles, exfoliated epithelium in the follicular lumen. Some follicular cells showed vacuolated cytoplasm and pyknotic nuclei. In the interstitial tissue between the follicles, dilated and congested blood vessels were noticed and there was apparent increase in the parafollicular and

mast cells. These results were confirmed by electron microscopic examination.

Conclusion: Electromagnetic radiation emitted from 2G and 4G cell phones resulted in pathological changes in the thyroid gland.

Key Words: Mobile, rat, thyroid.