



# **Comparison between B-scan Ultrasonography and Optical Coherence Tomography in Evaluation of Macular Oedema**

*Thesis*

*Submitted for Partial Fulfillment  
of Master Degree in **Ophthalmology***

*By*

***Amira Sabry Abd El Aziz***

*M.B., B.Ch*

*Faculty of Medicine, Ain Shams University*

*Under Supervision of*

**Prof. Dr. Hany Mohamed H. El-Ibiary**

*Professor of Ophthalmology*

*Faculty of Medicine, Ain Shams University*

**Prof. Dr. Lamia Salah Elewa**

*Professor of Ophthalmology*

*Faculty of Medicine, Ain Shams University*

**Dr. Ahmed Mohamed El-Bayoumy**

*Lecturer of Ophthalmology*

*Faculty of Medicine, Ain Shams University*

*Faculty of Medicine - Ain Shams University*

***Cairo 2018***

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

سبحانك لا علم لنا  
إلا ما علمتنا إنك أنت  
العليم العظيم

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 express my profound gratitude to **Prof. Dr. Hany Mohamed El-Ibiary**, Professor of Ophthalmology, Faculty of Medicine, Ain Shams University, for giving me the chance of working under his supervision. I appreciated his constant encouragement.*

*My deeply felt appreciation and sincere gratitude to **Prof. Dr. Lamia Salah Elewa**, Professor of Ophthalmology, Faculty of Medicine, Ain Shams University, for her kind supervision, guidance and great help throughout the present work.*

*I am also delighted to express my appreciation and gratitude to **Dr. Ahmed Mohamed El-Bauomy**, Lecturer of Ophthalmology, Faculty of Medicine, Ain Shams University, for his great efforts and continuous directions throughout the whole work.*

*I am immensely obliged to **Prof. Dr. Zeinab El Senbary**, Professor of Ophthalmology, Faculty of Medicine, Cairo University, for her great help throughout the practical part of this work.*

*Last but not least, I am indebted to my family and friends for their love, patience and support. It would not have been possible without them.*

*Amira Sabry Abd El Aziz*

# List of Contents

Title	Page No.
List of Tables .....	5
List of Figures .....	6
List of Abbreviations.....	10
Introduction.....	- 1 -
Aim of the Work .....	4
Review of Literature	
<b>Chapter 1:</b> Applied Anatomy of the Retina.....	5
<b>Chapter 2:</b> Macular Edema .....	21
<b>Chapter 3:</b> Diagnosis of Macular Edema .....	36
<b>Chapter 4:</b> Optical Coherence Tomography.....	42
<b>Chapter 5:</b> B-Scan Ultrasonography .....	56
Patients and Methods .....	72
Results .....	83
Discussion.....	98
Summary .....	103
Conclusion .....	106
References .....	107
Arabic Summary	

# List of Tables

Table No.	Title	Page No.
<b>Table (1):</b>	Etiologies of cystoid macular edema without leakage on fluorescein angiography.....	41
<b>Table (2):</b>	Right eye CRT measured by different OCT machines in healthy individuals .....	46
<b>Table (3):</b>	Description of data for the studied cases: .....	84
<b>Table (4):</b>	Relation between Ultrasound grade of macular thickening and the studied parameters. ....	88
<b>Table (5):</b>	Relation between final clinical determination using Biomicroscopy and the studied parameters.....	91
<b>Table (6):</b>	Relation between mean OCT central macular thickness ( $\pm$ SD) and the studied parameters. ....	94
<b>Table (7):</b>	Correlation between OCT central macular thickness and age of the studied cases.....	96
<b>Table (8):</b>	Diagnostic accuracy of ultrasound in prediction of final clinical determination results.....	97

# List of Figures

Fig. No.	Title	Page No.
<b>Figure (1):</b>	Anatomical and clinical terminology used to describe the regions of the retina .....	7
<b>Figure (2):</b>	Schematic showing regions of retina and corresponding histologic architecture .....	12
<b>Figure (3):</b>	A, Layers of the retina. B, Photomicrograph of same area. At top is inner portion of choroid with choriocapillaris .....	16
<b>Figure (4):</b>	Diabetic macular edema in an eye previously treated with panretinal photocoagulation .....	24
<b>Figure (5):</b>	Ischemic central retinal vein occlusion, Fundus photograph.....	25
<b>Figure (6):</b>	Retinal artery macroaneurysm, hard exudates at the macula due to chronic leakage.....	26
<b>Figure (7):</b>	Radiation maculopathy with retinal telangiectasia and hemorrhage .....	27
<b>Figure (8):</b>	Bilateral idiopathic parafoveal telangiectasia can often best be demonstrated with red-free photography .....	27
<b>Figure (9):</b>	Coats disease. Extensive vascular abnormalities and exudation.....	28
<b>Figure (10):</b>	Fundus photograph and fluorescein angiography of an eye with intermediate uveitis showing cystoid macula edema .....	32
<b>Figure (11):</b>	Autofluorescence angiography shows the cysts with a hyperfluorescence due to thinning of the macular pigments.....	39

# List of Figures cont...

Fig. No.	Title	Page No.
<b>Figure (12):</b>	Fluorescein angiography <b>A-C</b> shows the gradual filling of the individual cysts with fluorescein .....	40
<b>Figure (13):</b>	High definition OCT image of normal retinal layers .....	45
<b>Figure (14):</b>	Morphological patterns of DME on OCT .....	49
<b>Figure (15):</b>	Pseudophakic CME with cystic spaces and subfoveal subretinal fluid .....	50
<b>Figure (16):</b>	(A) CME in a case of non-ischemic CRVO. (B) After anti-VEGF therapy.....	52
<b>Figure (17):</b>	Vertical OCT scan shows a superior macular edema pattern in a case of superotemporal BRVO .....	53
<b>Figure (18):</b>	CME with intraretinal cystoid spaces and subretinal fluid associated with a broad epiretinal membrane.....	54
<b>Figure (19):</b>	VMT with vitreous attached nasally and detached temporally causing CME and disruption of ellipsoid layer .....	55
<b>Figure (20):</b>	Transverse B-scan position.....	64
<b>Figure (21):</b>	Transverse B-scan.....	64
<b>Figure (22):</b>	Dynamic B-scan screening of the posterior segment.....	65
<b>Figure (23):</b>	Longitudinal B-scan position.....	66
<b>Figure (24):</b>	Longitudinal B-scan.....	67
<b>Figure (25):</b>	Axial probe position .....	68

## List of Figures cont...

Fig. No.	Title	Page No.
<b>Figure (26):</b>	VuPAD™, Sonomed Escalon Inc. 2014, NY, USA. ....	74
<b>Figure (27):</b>	Spectral OCT SLO, Optos, 2012, Hialeah, FL, USA).....	76
<b>Figure (28):</b>	Example of one of the patients with normal Right eye, OCT showing central thickness 193 $\mu\text{m}$ . B-scan US showed no macular edema (grade 0). ....	79
<b>Figure (29):</b>	Example of one of the patients with right eye diabetic macular edema, OCT showed central thickness 378 $\mu\text{m}$ .....	80
<b>Figure (30):</b>	Example of one of the patients with left eye severe macular edema, OCT showed central thickness 976 $\mu\text{m}$ , B-scan US showed pronounced (grade 2) macular edema.....	81
<b>Figure (31):</b>	Gender distribution among the studied cases.....	85
<b>Figure (32):</b>	Laterality among the studied eyes.....	85
<b>Figure (33):</b>	Ultrasound grade of macular thickening of the studied eyes.....	86
<b>Figure (34):</b>	Slit-lamp Biomicroscopical detection of macular thickening among the studied eyes. ....	86
<b>Figure (35):</b>	Final diagnosis of the studied eyes. ....	87
<b>Figure (36):</b>	Relation between Ultrasound grade of macular thickening and the mean OCT central macular thickness. ....	89



## List of Figures cont...

Fig. No.	Title	Page No.
<b>Figure (37):</b>	Relation between Ultrasound grade of macular thickening and Biomicroscopical detection of macular edema.....	89
<b>Figure (38):</b>	Relation between Ultrasound grade of macular thickening and the final diagnosis of the studied eyes. ....	90
<b>Figure (39):</b>	Relation between Biomicroscopical detection of macular thickening and Ultrasound grade of macular thickening. ....	92
<b>Figure (40):</b>	Relation between Biomicroscopical detection of macular thickening and the mean OCT central macular thickness.....	92
<b>Figure (41):</b>	Relation between Biomicroscopical detection of macular thickening and final diagnosis of the studied eyes. ....	93
<b>Figure (42):</b>	Relation between mean OCT central macular thickness and the final diagnosis of the studied eyes.....	95
<b>Figure (43):</b>	Sensitivity and specificity of B-scan ultrasound in detecting macular edema. ....	97

# List of Abbreviations

Abb.	Full term
<b>μm</b> .....	micrometer
<b>3D</b> .....	Three Dimensional
<b>AE</b> .....	Anterior to the Equator
<b>AMD</b> .....	Age Related Macular Degeneration
<b>BCVA</b> .....	Best Corrected Visual Acuity
<b>BRVO</b> .....	Branch Retinal Vein Occlusion
<b>CF</b> .....	Counting Fingers
<b>CME</b> .....	Cystoid Macular Edema
<b>CNV</b> .....	Choroidal Neovascularization
<b>COST</b> .....	Cone Outer Segment Tip
<b>CRA</b> .....	Central Retinal Artery
<b>CRT</b> .....	Central Retinal Thickness
<b>CRV</b> .....	Central Retinal Vein
<b>CRVO</b> .....	Central Retinal Vein Occlusion
<b>dB</b> .....	Decibel
<b>DM</b> .....	Diabetes mellitus
<b>DME</b> .....	Diabetic Macular Edema
<b>DMT</b> .....	Diffuse macular thickening
<b>DR</b> .....	Diabetic Retinopathy
<b>DRT</b> .....	Diffuse Retinal Thickness
<b>E</b> .....	Equator
<b>ELM</b> .....	External Limiting Membrane
<b>ERM</b> .....	Epiretinal Membrane
<b>ETDRS</b> .....	Early Treatment Diabetic Retinopathy Study
<b>FA</b> .....	Fluorescein angiography
<b>FAF</b> .....	Fundus Autofluorescence
<b>GCL</b> .....	Ganglion Cell Layer
<b>HIF-1α</b> .....	Hypoxia-inducible factor 1-alpha
<b>HM</b> .....	Hand Motion
<b>HRVO</b> .....	Hemiretinal vein occlusion
<b>HTN</b> .....	Hypertension
<b>ICP</b> .....	Intra Cranial Pressure

## List of Abbreviations cont...

Abb.	Full term
<b>IL</b> .....	Interleukins
<b>ILM</b> .....	Internal Limiting Membrane
<b>INA</b> .....	Inferior Nasal Artery
<b>INL</b> .....	Inner Nuclear Layer
<b>IOP</b> .....	Intra Ocular Pressure
<b>IPL</b> .....	Inner Plexiform Layer
<b>IS/OS</b> .....	Inner segment/outer segment photoreceptor junction
<b>ITA</b> .....	Inferior Temporal Artery
<b>JRT</b> .....	Juxtafoveal Retinal Telangiectasis
<b>L</b> .....	Longitudinal Scan
<b>ME</b> .....	Macular edema
<b>MHz</b> .....	Megahertz
<b>Nd:YAG</b> .....	Neodymium:Yttrium Aluminum Garnet
<b>NFL</b> .....	Nerve fiber Layer
<b>OCT</b> .....	Optical Coherence Tomography
<b>ONL</b> .....	Outer Nuclear Layer
<b>OPL</b> .....	Outer Plexiform Layer
<b>PE</b> .....	Posterior to the Equator
<b>PHT</b> .....	Posterior hyaloid Traction
<b>PL</b> .....	Perception of Light
<b>PRP</b> .....	Panretinal Photocoagulation
<b>PVD</b> .....	Posterior Vitreous Detachment
<b>RAPD</b> .....	Relative afferent pupillary defect
<b>RMG</b> .....	Retinal Muller Glial cells
<b>ROP</b> .....	Retinopathy of prematurity
<b>RP</b> .....	Retinitis Pigmentosa
<b>RPE</b> .....	Retinal pigment epithelium
<b>RVO</b> .....	Retinal Vein Occlusion
<b>SD</b> .....	Spectral Domain
<b>SLD</b> .....	Super Luminescent Diode
<b>SLO</b> .....	Scanning laser ophthalmoscopy
<b>SNA</b> .....	Superior Nasal Artery

## List of Abbreviations cont...

Abb.	Full term
<b>SRD</b> .....	Serous Retinal Detachment
<b>SRF</b> .....	Subretinal Fluid
<b>STA</b> .....	Superior Temporal Artery
<b>T</b> .....	Transverse Scan
<b>TD</b> .....	Time Domain
<b>TNF-<math>\alpha</math></b> .....	Tumor necrosis factor- $\alpha$
<b>TRD</b> .....	Tractional Retinal detachment
<b>U/S</b> .....	Ultrasound
<b>UVR</b> .....	Ultra Violet Rays
<b>VA</b> .....	Visual Acuity
<b>VEGF</b> .....	Vascular endothelial growth factor
<b>VMT</b> .....	Vitreomacular Traction Syndrome

## INTRODUCTION

Macular edema is a common phenomenon in various diseases where fluid accumulates in between the retinal cells. The fluid originates from the intravascular compartment. The focal, diffuse, and cystic forms are all characterized by extracellular accumulation of fluid, specifically in Henle's layer and the inner nuclear layer of the retina. The compartmentalization of the accumulated fluid is likely to be due in part to the relative barrier properties of the inner and outer plexiform layers (*Tranos et al., 2004*).

The classic pattern of cystoid macular edema (CME) with the petaloid appearance originating from the fluorescein leakage from perifoveal capillaries may be seen in cases of advanced edema of various origins. This includes postsurgical CME as well as CME associated with one of the following conditions: diabetes, vascular occlusion, hypertensive retinopathy, epiretinal membranes, intraocular tumors (e.g., melanoma, choroidal hemangioma), intraocular inflammation (e.g., pars planitis), macroaneurysm, retinitis pigmentosa, choroidal neovascularization, and radiation retinopathy (*Tranos et al., 2004*).

Cystoid macular edema may have severe implications for the function of the retina, including decreased visual acuity and contrast sensitivity. Acute or chronic edema causes anatomical disruption that may result in cellular dysfunction and death.

Treatment of CME is important because chronic edema may result in degenerative changes in the macula and permanent loss of vision (*Brown et al., 2011*). In addition, large cystic changes in the retina may lead to thinning and loss of inner retinal tissue, or the formation of lamellar hole (*Tsukada et al., 2011*).

Early detection of CME is critical for diagnosis and management. Traditional methods of assessing macular edema include contact and noncontact slit lamp biomicroscopy, indirect ophthalmoscopy, fluorescein angiography (FA), and fundus stereo photography. However the interpretation of their results can be subjective, and subtle changes in retinal thickness in early CME may not be evident.

Optical coherence tomography (OCT) correlates well with retinal histology and can be used to quantitatively and qualitatively monitor retinal thickness over time. Compared to biomicroscopy and FA, OCT is more sensitive in detection of macular edema and subretinal fluid, and subclinical macular edema is often only detected by OCT (*Hee et al., 1995a*).

Fluorescein angiography and OCT have limitations. Both tests require the ocular media to be of sufficient clarity to image the retina. Yet in certain patients, opacities in the ocular media limit biomicroscopy, FA, and OCT. Furthermore, a high degree of patient cooperation is required to ensure reliable and accurate testing. However, certain patients, such as children,

often cannot tolerate a FA or follow the specific fixation instructions for OCT testing.

Ophthalmic ultrasonography is a well-accepted noninvasive diagnostic tool. Ultrasonography has the advantage of reliably imaging the posterior segment regardless of the ocular media status. Furthermore, ultrasonography is less dependent on patient cooperation for reliable testing than either FA or OCT (*Fisher et al., 1991*).