Macular Thickness Evaluation by Optical Coherence Tomography and Its Relation with Axial Length in Various Degrees of Myopia

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Abstract
Background/aim:
Myopia is a the most common refractive errorwith seious complications and degeneration the retina and choroid associated with its higher grades may lead to blindness. The aim of this study was to evaluate macular thickness by optical coherence tomography and its relation with axial length and various degrees of axial myopia.
Material and methods: *110 eyes of patients with different degrees of myopia aged from (18 to 40) years underwent a comprehensive ophthalmologic examination, which included uncorrected visual acuity (UCVA), subjective refraction and OCT measurements.*
Results: *high significant positive correlation was found between central macular (foveal) thickness and axial length on studying all cases as one group which give more accurate statistical results.*
Conclusion: *In myopia, increasing axial length and degree of myopia are positively correlated with an increase in central (foveal) macular thickness according to this study.*
Key words : *Macular thickness, myopia, OCT measurements, uncorrected visual acuity.*

I.   Introduction

Myopia is a serious eye disorder and the complications of myopia especially high myopia are considered the most contributing factors leading to blindness (1) .

Although myopia can be successfully treated with an appropriate optical correction, it is still a high risk factor for a number of retinal pathologies and one of the major causes of visual dysfunction and blindness (2) .

Myopia is characterized by elongation of the axial length (AL). The mechanism and pathology is still unknown, but several studies have reported that the progression of AL elongation is stable and slow , except at the onset of myopia occured, when the AL has the fastest rate of change (3).

Myopia is accompanied with pathological retinal pathologies such as macular and retinal degeneration, foveoschisis, macular hole, and rhegmatogenous retinal detachment (4).

Excessive AL elongation leads to further kinds of high-myopia-related complications, such as lacquer crack formation, choroidal neovascularization, and also chorioretinal atrophy (5).

Although retinal changes are caused by mechanical stretching due to axial elongation (6)(Kaneko et al 2014). The degree of myopia can be defined by the spherical equivalent (SE) of the refractive error used in many studies (7).

Although recently, assessment of macular thickness was subjective, relying on slit lamp stereoscopic biomicroscopy of the fundus. Now presently, OCT makes that assessment reliable and more objective . The Spectral domain OCT gives highly accurate repeatable scans and can detect either minor subtle changes in the retina of myopic eyes (8).

OCT makes it highly accurate to measure retinal thickness. OCT uses laser with lower coherence interference measurement which can measure tissues and distances with the resolution of $\leq 10\mu m$. Currently, OCT is the best method used to measure retinal thickness and retinal nerve fiber thickness at different diopter (9) .

It can also reveal otherwise minor undetectable retinal changes in asymptomatic patients. Therefore, it provides information which is not readily available by conventional imaging methods or fundus examination (10) .

Therefore, it is important evaluating structural changes associated with macular myopia to develop strategies preventing progression of myopia and its complications.

II.   Materials And Methods

This study was carried out in the department of ophthalmology Aswan university Hospital on 110 eyes of patients with different degrees of myopia aged from (18 to 40) years. Patients who have previous intraocular or refractive surgery, previous ocular trauma, evidence of corneal opacity or neurological condition that could affect the vision were excluded from the study. Written informed consent was obtained from each patient . Age, sex, and other relevant medical history information were obtained and patients whose eyes met the inclusion and exclusion criteria were selected.

The subjects voluntarily agreed to participate in the study after the study's purpose and methods were explained.

Patients were divided into four groups according to their refraction:

Emmtropic group with spherical equivalent range
from (+1.00 D) to (- 0.50 D).

Low myopic group with spherical equivalent range
from (-0.50 D) to (-3.00 D).

Moderate myopic group with spherical equivalent range
from (-3.00 D) to (-6.00 D).

High myopic group with spherical equivalent (> - 6.00 D).

**The different degrees of myopic groups were classified according to American Optometric Association,
Care of patient with myopia (11)** *(Grosvenor 2006).*

All patients included in this study were subjected to the following: examination:

All patients who visited Ophthalmology department clinic underwent a

comprehensive ophthalmologic examination, which included:

First, uncorrected visual acuity (UCVA) was measured using Snellen eye chart at 6 meters (m). Following this, objective refraction was calculated using the auto refractometer (Topcon KR-800; Topcon Corp., Tokyo, Japan) for calculation of spherical equivalent (SE; spherical refractive power plus one half the cylindrical refractive power in the negative form), also give us corneal curvatures: Flat (Kf), Steep (Ks), Average (Kav).

Next, subjective refraction was used to determine the best optical correction (BCVA), and then all visual acuities were calculated in Logarithm of Minimum Angle of Resolution (LogMAR). Intraocular pressure (IOP) measurement by applanation tonometer was measured, slit-lamp biomicroscopy, examination on dilated fundus was done using indirect ophthalmoscopy, and axial length measurement using (A scan Biometry) was obtained. Macular thickness (central & average) analysis was done using SD-OCT device (Topcon 3D OCT-2000FA, version 8.30- Japan).

OCT measurements:

The patients were seated and properly positioned, their eyes were dilated by administering 1% (Tropicamide, Alexandria-Egypt) eye drop, the scanning laser image was focused, the same operator performed OCT scanning using 3-D OCT- 2000, color fundus photographs were taken immediately after OCT scanning, 3-D imaging data were acquired by using a raster scan protocol of 512×128 (horizontal $\times$ vertical) axial scans per image, each 3-D raster scan covered a 6×6- mm area centered at the fixation point in the posterior pole. Mean sectoral thicknesses were displayed in the nine macular sectors determined by the ETDRS. The inner and outer rings had diameters of 1 to 3 and 3 to 6 mm, respectively, and were segmented into superior, inferior, temporal, and nasal quadrants **.** As calculated by preloaded software was used to calculate the average macular thickness, central macular thickness.

Statistical Analysis:

Data were collected, coded, revised and entered to the Statistical Package for Social Science IBM SPSS (Version 20.0. Armonk, New York, 2011). The data were presented as number and percentages for the qualitative data, mean, standard deviations and ranges for the quantitative data with parametric distribution and median with inter quartile range (IQR) for the quantitative data with non-parametric distribution.

Chi-square test and Fisher exact test were used in the comparison between two groups with qualitative data when appropriate. Pearson r correlation: Pearson r correlation was used to measure the degree of the relationship between linearly related variables. Post Hoc Test: An integral part of One Way Analysis of Variance (ANOVA) test; was used in comparative between groups.The results were calculated at the 95% confidence interval, $P < 0.05$ significance level and $P < 0.01$ advanced significance level.

III. Results

110 eyes of patients with different degrees of myopia aged from (18 to 40) years participated in the present study. They were selected from the department of ophthalmology Aswan university Hospital.

No study participant left the research project for any reason. No side effects or complications were observed during the study. Baseline characteristics of the patients are shown in Table 1. There was no statistically significant difference between studied groups as regards demographic data (Table 1).

There was high statistically significant increase in UCVA, BCVA measured by LogMar among high myopic cases in comparison to other studied groups (Table 2) as confirmed with post hoc test (Table 3).

There was high statistically significant increase in high myopic cases in comparison to other studied groups with refraction (Spherical Equivalent) (Table 4) as confirmed with post hoc test (Table 5).

There was no significance difference between studied groups considering Flat Corneal Curvature (Kf), Steep Corneal Curvature (Ks) and Average Corneal Curvature (Kav) (Table 6).

Comparing to other studied groups, there was high statistically significant increase regarding Axial Length (AL), Central Macular Thickness by OCT among individuals of high myopic group, there was no significance difference between studied groups considering Average Macular Thickness by OCT (Table 7) as confirmed with post hoc test (Table 8).

As regards to Myopic fundus changes, high myopic group showed higher statistically significant changes compared to other studied groups (Table 9).

Axial Length was found to be positively correlated to central macular thickness by OCT (P: 0.001), while no correlation was found between Axial Length and Average macular thickness by OCT (Table 10).

IV. Discussion

According to present study there was no statistically significant difference between studied groups as regards sex, this result coincide with other studies that reported no significant difference in progression between myopic males and females (12). While other studies found Differences in progression between myopic males and females (13) .

The majority of the study population was between 18 - 40 years of age, there was no statistically significant difference between studied groups as regards age, which not coincide with those studies which evaluated the role of age in myopia progression (14).

This difference in our study might be due to the regional variation of the study population. According to visual acuity (LogMar) comparison between studied groups there was highly statistically significant increase in high myopic cases in comparison to other studied groups as regards UCVA Log mar (decrease in visual acuity), BCVA log mar (correcting low acuity). This coincides with other studies of aberrations which reported that the optical quality of the eye worsens with increasing myopia (15, 16).

Also it was reported that there is high significant correlation between the visual acuity (VA) measurements and the prevalence of myopia in which reduced VA used as a predictor for myopia (17).

There was no significance difference between studied groups considering flat corneal curvature (Kf), steep corneal curvature (Ks) and average corneal curvature (Kav) in present study, this was in agreement with a previous study in which there was no significant mean differences (P>0.05) between the various degrees of myopia and corneal curvature (18).

As large proportion of the relartion between Axial Length (AL) and myopia is due to genetic effects that indicates that AL and myopia may share common genes (19).

When doing comparison between different studied groups as regard Axial Length in the current study, there was highly statistically significant increase in the group included high myopic cases. This coincide with most studies of ocular shape which indicate that myopic eyes exhibit greater expansion in the axial, or anterior-posterior, direction than in the transverse or coronal direction, with the result that the retinal contour in myopia is shaped like a prolate ellipse rather than a sphere (3,20,21,22).

The best reason explain that the acuity is reduced in patients with myopia is the expansion of posterior pole accompanied with the amount of myopia that leads to drop of the peripheral acuity to half from the emmetropic level corresponded to a 1.29-fold increase in the axial length, when these factors are considered (corneal curvature, anterior chamber depth (ACD), lens thickness, vitreous chamber dept)as well as the axial length which determine the myopic refractive error (23).

In contrast to the results of the present study, other studies reports show a negative correlation between AL and myopia (24) .

According to the current study, there was high statistics fundus changes result in high myopic group in comparison to other studied groups. This coincide with results which reported that chorioretinal atrophy in the posterior pole or peripheral fundi is most common in patients with myopic eyes more than individuals with non myopic eyes (25), which progressively gets thinner with increasing age and degree of myopia, as reported from other studies (26) .

In current study there was highly statistically significant increase in high myopic cases in comparison to other studied groups with OCT central macular (foveal) thickness, this coincide with recent OCT studies which reported that the foveal thickness in individuals with myopia is higher than that of non myopic eyes and increases with the progression of myopia (27,28) .

A study was conducted to measure the macular thickness in patients with high myopic eyes used SD-OCT in 82 young and middle-aged Chinese myopic individuals and confirmed that an increase in the degree of myopia, the central subfield thickness (CST) known as (foveal thickness) was reported to increase with the increase in myopia (2).

Increased foveal thickness in patients with myopic eyes has been reported also in many other studies (29,30,31).

In contrast to the results of the current study, a study was conducted on basis of optical coherence tomography confirmed that the fovea get thinner with increasing myopia (34) . While in other study no correlation was found between the degree of myopia and macular thickness (35).

According to the current study, there was positive correlation between AL, OCT central macular (foveal) thickness. Which coincide with the other studies, there was an increase of foveal thickness with increase in AL, but this finding was found to be statistically non-significant (36, 37).

In other studies, there was also an increase of foveal thickness with increase in AL and refractive error but this finding was found to be statistically significant. In Chan et al,2007 the authors hypothesized that this finding may be due to subclinical vitreoretinal traction not yet detected by OCT . In Aung et al,2005 the authors proposed that this increase in thickness may be due to pathologic subfoveal chorioretinal changes (32,35,38,39,40) .

In contrast to this study researchers reported that foveal thickness was not correlated with increasing AL .

V.   Conclusion

Myopia is the most common refractive error. It's classified etiologically into axial and refractive myopia. Axial myopia is the result of an extensive elongation of eye with respect to its refractive component, many researchers believe that since in axial myopia the globe elongate and sclera stretch, so the macula must thin. In high myopia peripheral retinal changes and macular hole formation may occur, predisposing to retinal detachment. The optical coherence tomography is an effective optical ultrasound allowing accurate measurement of retinal macular thickness with a detailed macular topographic analysis. The aim of this study was evaluating macular thickness by optical coherence tomography and its relation with axial length and various degrees of myopia. In this study macular thickness in myopes was correlated with axial length.

Ophthalmological evaluation including visual acuity, refraction (Adjusted to spherical equivalent (SE)), slit lamp biomicroscopy examination, keratometry examination for cornea, A-Scan biometry for determination of axial length as well as optical coherence tomography (OCT) for determination of macular thickness were done to 110 cases aged (18 - 40) year. Any previous intraocular, refractive surgery, ocular trauma, evidence of corneal opacity or neurological condition that could affect the vision were excluded in the present study when subdiving the cases of study into emmetropic control cases, low myopic cases, moderate myopic cases, high myopic cases there was increasing statistically significant results in high myopic cases group in: axial length, central macular thickness, fundus changes, reduce visual acuity.

Finally high significant positive correlation was found between central macular (foveal) thickness and axial length on studying all cases as one group which give more accurate statistical results.

VI.   Conclusion:

In myopia, increasing axial length and degree of myopia are positively correlated with an increase in central (foveal) macular thickness according to this study.

Acknowledgment

Table 1: Comparison between studied groups as regards demographic data (Sex & Age).

		Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		Chi square test/ One way ANOVA	
		No	%	No	%	No	%	No	%	$x^2/f*$	p value
Sex	Female	13	65.0%	17	56.7%	13	43.3%	17	56.7%	2.512	0.473 (NS)
	Male	7	35.0%	13	43.3%	17	56.7%	13	43.3%		
Age	Mean± SD	30.40 ± 5.34		31.33 ± 5.26		28.23 ± 4.34		30.53 ± 5.15		2.095*	0.105 (NS)

X2: Chi square test.   F: One way ANOVA.   SD: Standard Deviation.
P > 0.05: Non significant (NS).   P < 0.05: Significant (S).   P < 0.01: Highly significant (HS).

Table 2: Comparison between studied groups as regards VA (logMAR) using snellen chart.

		Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		One way ANOVA	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	f	p value
logMAR	UCVA	0.09	0.10	0.31	0.11	0.74	0.15	0.99	0.04	367.988	<0.001 (HS)
	BCVA	0.00	0.00	0.07	0.10	0.08	0.13	0.23	0.08	22.201	<0.001 (HS)

VA: Visual acuity.   logMAR: Logarithm of minimal angle of resolution.   UCVA: Uncorrected visual acuity.   BCVA: Best corrected visual acuity.   F: One way ANOVA   SD: Standard Deviation.
P > 0.05: Non significant (NS).
P < 0.05: Significant (S).
P < 0.01: Highly significant (HS).

Table 3: Post hoc test of UCVA and BCVA.

	Post hoc test P value	
	UCVA	BCVA
Emmetropic cases vs mild myopic cases	0.001	0.078
Emmetropic cases vs moderate myopic cases	0.001	0.035
Emmetropic cases vs high myopic cases	0.001	0.001
Mild myopic cases vs moderate myopic cases	0.001	0.601
Mild myopic cases vs high myopic cases	0.001	0.001
Moderate myopic cases vs high myopic cases	0.001	0.001

P > 0.05: Non significant (NS).
P < 0.05: Significant (S).
P < 0.01: Highly significant (HS).
UCVA: Uncorrected visual acuity.
BCVA: Best corrected visual acuity.

Table 4: Comparison between studied groups as regards refraction and spherical equivalent.

	Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		One way ANOVA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	f	p value
Spherical Equivalent	-0.01	0.50	-1.52	0.44	-4.37	0.80	-7.98	3.46	91.685	<0.001(HS)

F: One way ANOVA.   SD: Standard Deviation.
P > 0.05: Non significant (NS).   P < 0.05: Significant (S).   P < 0.01: Highly significant (HS).

Table 5: Post hoc test of Spherical Equivalent.

	Post hoc test
	Spherical Equivalent P value
Emmetropic Cases vs Mild Myopic Cases	0.007
Emmetropic Cases vs Moderate Myopic Cases	0.001
Emmetropic Cases vs High Myopic Cases	0.001
Mild Myopic Cases vs Moderate Myopic Cases	0.001
Mild Myopic Cases vs High Myopic Cases	0.001
Moderate Myopic Cases vs High Myopic Cases	0.001

P > 0.05: Non significant (NS).
P < 0.05: Significant (S).
P < 0.01: Highly significant (HS).

Table 6: Comparison between studied groups as regards Flat Corneal Curvature (Kf), Steep Corneal Curvature (Ks) and Average Corneal Curvature (Kav).

	Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		One way ANOVA	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**f**	**p value**
Corneal Curvature Kf (Flat)	43.28	1.50	43.61	1.33	43.09	1.33	43.58	0.79	1.163	0.328 (NS)
Corneal Curvature Ks (Steep)	44.35	1.59	44.68	1.88	44.21	1.27	43.75	7.44	0.258	0.856(NS)
Corneal Curvature K av (Average)	43.84	1.49	44.25	1.57	43.73	1.23	44.50	1.00	2.057	0.110(NS)

F: One way ANOVA.   SD: Standard Deviation.
P > 0.05: Non significant (NS).
P < 0.05: Significant (S).
P < 0.01: Highly significant (HS).

Table 7: Comparison between studied groups as regards Axial Length (A.L), OCT (Average Macular Thickness) and OCT (Central Macular Thickness).

	Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		One way ANOVA	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**f**	**p value**
Axial Length (A.L)	22.88	0.57	23.11	0.48	24.46	0.58	25.25	1.28	51.355	0.001(HS)
OCT (Average Macular Thickness)	263.74	10.46	262.35	10.64	261.63	12.82	257.98	15.12	1.023	0.385
OCT (Central Macular Thickness)	179.30	21.97	180.40	11.76	192.97	18.64	235.87	39.78	30.662	0.001(HS)

F: One way ANOVA.   SD: Standard Deviation.
P > 0.05: Non significant (NS).   P < 0.05: Significant (S).   P < 0.01: Highly significant (HS).

Table 8: Post hoc test of Axial Length and OCT (Central Macular Thickness).

	Post hoc test P value	
	(A.L)	**OCT (Central Macular Thickness)**
Emmetropic Cases vs Mild Myopic Cases	0.332	0.398
Emmetropic Cases vs Moderate Myopic Cases	0.001	0.017
Emmetropic Cases vs High Myopic Cases	0.001	0.001
Mild Myopic Cases vs Moderate Myopic Cases	0.001	0.001

Mild Myopic Cases vs High Myopic Cases	0.001	0.001
Moderate Myopic Cases vs High Myopic Cases	0.001	0.009

P > 0.05: Non significant (NS).
P < 0.05: Significant (S).
P < 0.01: Highly significant (HS)
(A.L): Axial Length.

Table 9: Comparison between studied groups as regards fundus.

		Emmetropic Cases No=20		Mild Myopic Cases No=30		Moderate Myopic Cases No=30		High Myopic Cases No=30		Chi square test	
		No	%	No	%	No	%	No	%	x2	p value
Fundus	Normal	20	100.0%	30	100.0%	30	100.0%	15	50.0%	46.316	<0.001(HS)
	Myopic cresent	0	0.0%	0	0.0%	0	0.0%	2	6.7%		
	Tigroid Fundus	0	0.0%	0	0.0%	0	0.0%	9	30.0%		
	Lacquer Cracks	0	0.0%	0	0.0%	0	0.0%	4	13.4%		
	Prepapillary moypic atrophy	0	0.0%	0	0.0%	0	0.0%	2	6.7%		

X2: Chi square test.
P > 0.05: Non significant (NS).   P < 0.05: Significant (S).   P < 0.01: Highly significant (HS).

Table 10: Correlation between Axial Length, OCT (Average Macular Thickness), and OCT (Central Macular Thickness).

	(A.L)	
	r	p value
OCT (Average Macular Thickness)	-0.187	0.050
OCT (Central Macular Thickness)	0.682	0.001

r: Pearson r correlation.   (A.L): Axial length.
P > 0.05: Non significant (NS).   P < 0.05: Significant (S).   P < 0.01: Highly significant (HS).

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