

Assessment of Macular Thickness in Myopic Eyes Using Spectral Domain Optical Coherence Tomography

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Abstract:

Methods: The cross sectional study was carried out at LRBT Tertiary Hospital, Karachi. The study was conducted from July 2023 to June 2024. One hundred and seventy-seven patients with a mean age 28.62 ± 12.30 years and axial length 26.46 ± 1.92 mm were included. The inner macular thickness (para-fovea) and outer macular (peri-fovea) at four distinct locations i.e. the temporal, superior, nasal, and inferior quadrants, as well as the fovea itself were measured with the help of spectral optical coherence tomography. Axial length was measured with the help of A-scan. Data was analyzed using SPSS version 16.

Results: There is a negative weak correlation ($r = -0.21$) was reported between the axial length and inner macula (para fovea) at inferior quadrant thickness in total myopic patients ($p < 0.05$). While positive moderate correlation ($r = 0.48$) was found between axial length and foveal thickness in total myopic patients. Foveal thickness was significantly higher in high myopic group as compared to low myopic ($p < 0.05$). Positive weak correlations were found between inner macular thickness ($r = 0.15$) and axial length at inferior ($P < 0.05$) and temporal quadrant ($r = 0.21$) ($p < 0.05$). While nasal ($r = 0.25$) ($P < 0.05$) and inferior quadrant of ($r = 0.19$), at outer macula of low myopic subjects ($p < 0.05$). In high myopic group, negative weak correlation ($r = -0.29$) was reported between inner thickness of macular and axial length at nasal quadrant ($p < 0.05$). *Al-Shifa Journal of Ophthalmology 2025; 21(3): 150-159. © Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan.*

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Introduction:

Myopia is highly prevalent refractive error, one of the major cause of impaired vision that affects many individuals throughout the world, particularly in Asian nations.¹ Its prevalence has reportedly been increasing. 4578 million people are expected to be myopic by 2050.² affecting 50% of the world's population.³ 36.5% prevalence of myopia is found in Pakistan according to national blindness and visual impairment survey.⁴ Many ocular diseases like glaucoma, cataracts, retinal detachment, and degenerative macular neovascularization are associated with myopia, contributing to a potentially blinding condition.⁵ Axial lengthening AL of the globe leads to myopic eyes. The retina may become thinner if it is stretched beyond its normal diameter.⁶

Lattice degeneration, tilted disc, peripapillary atrophic areas, posterior

staphyloma, and disruption in the Bruch's membrane are among the retinal changes associated with highly myopic individuals.

⁷ Posterior staphylomata developed as a result of axial lengthening of the eye. Some individuals with high myopia experience several complications that impact their visual acuity.⁸ Macular hole formation, macular neovascularization, and chorioretinal atrophic areas are common in high myopic eyes.⁹

Optical coherence tomography (OCT) was used to assess the changes IN retina associated with the progression of myopia. Using OCT, it has been shown that myopes have a thinner outer macula (perifoveal). Although a similar weakening of the inner macula (parafoveal) has been hypothesized, measurements of this area's thickness differ among myopic people.¹⁰

Epidemiological studies using optical coherence tomography on two different Asian adult populations in Singapore and Japan revealed that when myopia increased, the average macular retinal thickness remained constant.^{11,12} On the other hand, Mrugacz, Bakunowicz-Lazarczyk, and Sredzinskakita in Poland studied children with myopic eyes and found that with increases in myopia, foveal and parafoveal macular thickness decreases. In Singapore, Luo et al and their colleagues studied the relationship between macular parameters on optical coherence tomography and ocular biometry among seven to nine pediatric years and found that the overall macular thickness was decreased in all quadrants except the inferior and superior quadrants.¹² Further, a negative relationship between the AL and the exterior ring macula's average thickness was identified.¹³ Similar results were obtained by Xie and colleagues in their investigation of early adult myopes, which showed that the inferior region's outer macula was thinner than the other macula areas.¹⁴ On the other hand, it has been observed that the fovea thickens as myopic refraction and AL increase. Parafoveal and perifoveal macular thicknesses have been

reported to be the lowest in high myopic eyes when compared to low myopes and emmetropes. Myopia is divided into low, moderate, and high myopia.¹⁵ Additionally, these investigations revealed that people with extremely myopic eyes had thicker foveas.

The literature has extensively investigated outer macular thinning, particularly in Chinese eyes. Similarities are seen in the prevalence of myopic eyes among Pakistani population to that of the Chinese eye though at a comparatively lower rate, however it is anticipated that Pakistani eye is also an Asian eye, so it will follow the same trajectory. Results on the thickness of the foveal region in myopic patients have been inconsistent. Knowing if the fovea or the surrounding regions are changing structurally is helpful from a clinical standpoint, since it is typical for a myope to experience retinal thinning as a result of myopic progression.

Knowing the specific areas experiencing thinning enables the clinician in differentiating between the most probable explanations for any decrease in a myopic patient's visual acuity. The fovea may itself contribute to reduced visual acuity if it represents the expected "thinned area." However, if thinning of the fovea is not cause of reduced vision, the ophthalmologist should explore other potential causes.

Study aimed to evaluate the foveal thickness in the inner and outer macular quadrant and its correlations with axial length and degree of myopia across the temporal, nasal, superior, and inferior regions in myopic Pakistani eyes.

Methodology:

A cross sectional study was conducted in Pakistani subjects with a certain defined axial length were included and categorized into two groups; Group A Low myopes (axial length between 24-26.5mm) and Group B high myopes (axial length above 26.5mm). Non probability consecutive sampling was done to enroll participants.

The study was carried out at the LRBT Eye Hospital Korangi from July 2023 to June 2024. Inclusion criteria includes the age range of 16 to 80 years and willing to give consent for study. This study was approved by hospital ethical review committee.

After detailed history all subjects underwent visual acuity assessment using Snellen chart followed by automated refraction (NIDEK) and spherical equivalent was calculated, anterior segment examination was done by slit lamp, bio microscopy and posterior segment examination was done by indirect ophthalmoscope and 90 diopter lens. Axial length was measured by A scan (Pac scan). Macular thickness was measured by Spectralis OCT (Heidelberg Engineering) with scan rate of 40,000 scans at a depth of 7 μ m. according to ETDRS macular thickness was calculated in nine sectors of three concentric rings of 1mm, 3mm and 6mm. fovea was represented by central 1mm circle. Each parafoveal (3mm) and perifoveal (6mm) area was subdivided into superior, inferior, nasal and temporal quadrant. To overcome the examiner bias, single researcher was performing the measurements and the right eye was examined in all subjects. Patients with any other ocular disease (other than refractive error) history of ocular trauma or ocular surgery, systemic disease like hypertension and diabetes, macular pathologies e.g. Fuchs spot, foveoschisis, CNV etc. and patients with media opacities or structural deformities who cannot participate in OCT examination were excluded

Sample Size was calculated by Wan Nor Arifin Sample Size Calculator (Available online at

<https://wnarifin.github.io/ssc/sscorr.html>) by using correlation coefficient method. After depicted 0.209¹⁶ as value of correlation (r) between macular thickness (Foveal) and axial length. Keeping 80% power of study with 5% significance level, the calculated sample size was found to be 177.

Data was analyzed by using IBM SPSS version 16. Normality of data was checked through Shapiro Wilks test and data found to be normally distributed. Mean $\pm$ SD was calculated for numeric variables. Frequency and percentage was calculated for qualitative variables. Mean difference between two groups was done for macular thickness (Superior, nasal, inferior, temporal parafoveal and perifoveal region) by using Independent sample t-test. Correlation between variables was calculated by using Pearson correlation (r). P-value<0.05 was considered as statistically significant.

Results:

One hundred and seventy seven patients were enrolled in the study. Out of which, 73 were included into high degree of myopia whereas 104 were divided into low degree of myopia. The mean age of high myopic patients was 32.51 $\pm$ 1.46 year, significantly higher than low myopic patients, 25.8 $\pm$ 9.44 (p<0.05). There is no significant difference was reported in gender allocation between high and low degree of myopes. (p>0.05)

Our results reported mean and SD of variable included such as AL, SE and various quadrant of macular thickness in respective degree of myopes. The mean axial length was 26.46 $\pm$ 1.92 mm in all patients while mean SE was -8.77 $\pm$ 3.75 were found in all patients. The mean foveal thickness was 265.4 $\pm$ 25.16 in all participants as shown in table 1.

Table 2 reported that parafoveal and perifoveal regions did not show any statistical significant mean differences between the groups A (high myopic patients) and B (low myopic patients). However macular thickness in central region was slightly high in high myopic (2.79 $\pm$ 2.70) patients as compared to low myopic patients (2.54 $\pm$ 1.58) (p<0.05). In parafoveal region, the highest thickness was observed in nasal quadrant region of high myopic group compare to low myopic (p>0.05). Similarly, in perifoveal, the highest thickness was also observed in

nasal quadrant region of high myopic as compared to low myopic. ($p>0.05$)

Table 3 report relationship between axial length with macular thickness of highly myopic patients, low myopic patients and total myopic patients.

Correlation was also assessed between macula thickness in each of quadrants and AL in total myopic patients. Results showed that foveal thickness is highly significantly correlated with axial length ($p<0.05$) as it was the only quadrant that reflected positive moderate correlation, (a rising in thickness with rising AI). In the parafoveal inferior quadrant, a negative correlation was observed (As the AL increase, thickness is decreased). This relationship was highly significant. None of the other remaining macular region thickness has either negative or positive correlation with length of axial. ($p>0.05$).

The relationship between various myopic degree's and thickness of macular was also evaluated. In low myopic category, axial length was significantly correlated with most of the quadrant of parafoveal and perifoveal region of macula. The axial length is significantly positively correlated with parafoveal inferior as well as temporal region while other two regions were not statistically correlated with axial length. A similar nature of correlation also reported in perifoveal region, where weak significant correlation found in nasal and inferior quadrant thickness with low myopia ($p<0.05$)

On other hand, in high myopic cases, negative and weak correlation was found between nasal quadrant and axial length only. ($p<0.05$).

Table 1: Descriptive statistics of axial length, refractive error, and optical coherence tomography measurements in the studied participants

Studied Variable	Mean $\pm$ SD	Range
Axial length	26.46 $\pm$ 1.92	24.04-31.07
Cylindrical Power	-1.20 $\pm$ 1.00	-3.50-0.00
Spherical Equivalent	-8.77 $\pm$ 3.75	-19—3.50
Spherical Power	-8.17 $\pm$ 3.56	-18—3.50
Fovea	265.4 $\pm$ 25.16	217-339
Parafoveal Superior Quadrant Thickness (μ m)	326.11 $\pm$ 17.20	287-362
Parafoveal Inferior Quadrant Thickness (μ m)	320.37 $\pm$ 15.50	289-353
Parafoveal Nasal Quadrant Thickness (μ m)	327.82 $\pm$ 16.24	295-361
Parafoveal Temporal Quadrant Thickness (μ m)	313.54 $\pm$ 19.77	285-396
Perifoveal Superior Quadrant Thickness (μ m)	290.8 $\pm$ 26.49	225-372
Perifoveal Inferior Quadrant Thickness (μ m)	284.4 $\pm$ 25.79	245-369
Perifoveal Nasal Quadrant Thickness (μ m)	310.37 $\pm$ 21.03	279-364
Perifoveal Temporal Quadrant Thickness (μ m)	280.77 $\pm$ 33.33	207-424

Table 2: Comparison of various macula regions thickness across varying degree of myopia

Regions In Macular	Group A	Group B	p-value*
Foveal	252.5±27.1	278.2±23.2	0.001
Parafoveal (Inner macula)			
Superior Quadrant Thickness (μm)	326.90±16.15	325.79±17.35	0.66
Inferior Quadrant Thickness (μm)	320.48±15.61	319.91±15.49	0.08
Nasal Quadrant Thickness (μm)	326.51±15.56	327.55±16.40	0.66
Temporal Quadrant Thickness (μm)	314.09±19.65	313.55±20.06	0.40
Peri-foveal (Outer macula)			
Superior Quadrant Thickness (μm)	292.45±24.57	290.70±26.88	0.972
Inferior Quadrant Thickness (μm)	285.27±25.79	284.38±26.18	0.139
Nasal Quadrant Thickness (μm)	310.69±21.26	310.5±21.33	0.097
Temporal Quadrant Thickness (μm)	282.72±31.68	280.50±33.79	0.713

*Independent sample t-test

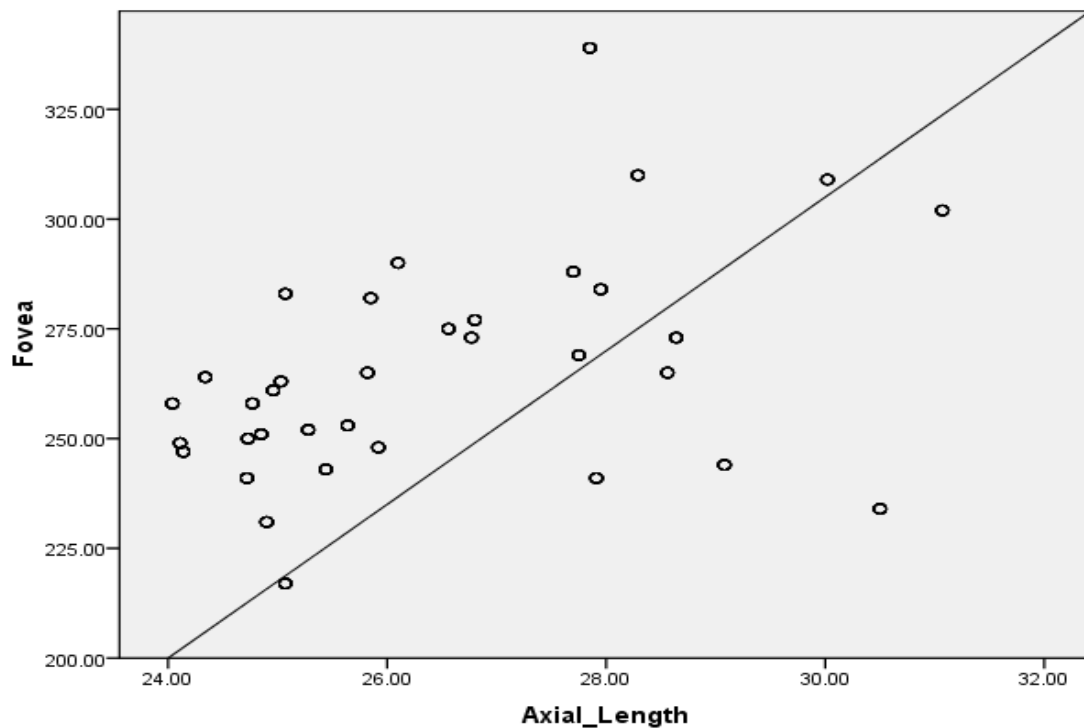


Figure 1: Scatterplot against axial length and central macular thickness.

Table 3: Correlation of axial length and macular thicknesses across low, high and total myopia groups.

	Low Myopia		High Myopia		Total Myopia	
	Correlation (r)	P-value	Correlation (r)	P-value	Correlation (r)	P-value
Macular thickness						
Foveal thickness (um)	0.23	0.001	-0.09	0.27	0.48	0.001
Parafoveal (Inner macula)						
Superior Quadrant Thickness (um)	-0.06	0.37	-0.158	0.08	-0.07	0.18
Inferior Quadrant Thickness (um)	0.15	0.04	0.005	0.952	-0.21	0.001
Nasal Quadrant Thickness (um)	0.01	0.89	-0.29	0.001	0.047	0.415
Temporal Quadrant Thickness (um)	0.21	0.03	0.047	0.605	-0.044	0.44
Peri-foveal(outer macula)						
Superior Quadrant Thickness (um)	0.14	0.05	0.059	0.51	-0.002	0.972
Inferior Quadrant Thickness (um)	0.19	0.009	0.008	0.92	-0.085	0.140
Nasal Quadrant Thickness (um)	0.25	0.001	0.15	0.092	0.096	0.097
Temporal Quadrant Thickness (um)	0.14	0.05	-0.06	0.49	0.021	0.714

Discussion:

Myopia is the highly prevalent refractive disorder in various countries, problem related to severe myopia is a leading cause of vision loss. Myopia is estimated to affect 70-90% of Asians, 30-40% of Europeans and Americans, and 10-20% of Africans. A major complication of myopia is the development of a myopic macular hole. As a result, our research has thoroughly examined myopic maculae and sought to link them with various factors.¹⁷

We conducted this study to examine the correlation between macular thickness and axial length in low myopia, high myopia and total myopic patients. The findings demonstrate that macular profiles varied significantly with axial elongation over a numerical range. Before the invention of OCT it was believed that atrophy of the

retinal pigment epithelium at the posterior poles was the cause of myopic alterations in the macula although findings from current OCT studies suggested that foveal thickness in myopic patients is superior to low myopic patients and with the advancement of myopia it increases²⁻³. In the present research, the high myopia group had considerably longer ALs than the normal group, similar to the scatter plot that showed a strong correlation between higher myopia and longer ALs in the study by Kubo et al.

According to earlier studies conducted by Xie et al., Wakitani et al. it was suggested that the axial length elongation in myopic patients causes mechanical stretching of the sclera in the posterior pole.¹⁸⁻¹⁹ In myopic eyes, this results in vitreous traction on the fovea. Therefore, an early indicator of

vitreoretinal traction may be due to elongation of foveal thickness with higher degree of myopia. This partial vitreous traction in myopic patients has been linked to conditions like myopic traction maculopathy, foveoschisis and retinal detachment.²⁰ They further interpret that the foveal thickness increased with the help of experimental model attributing it to lack of vasculature in the foveal region.²¹ It caused the foveal pit to be more deformable in response to intraocular pressure and retinal stretching due to ocular growth.²² In contrast, due to its greater elasticity, the parafoveal region passes through stretching and peripheral thinning.

Our results showed that foveal thickness and axial length were positively correlated i.e. as thickness grows as axial length elongates. However the correlation was statistically insignificant in the high myopic cases. Although patients with high myopia had a significantly higher foveal thickness than those with mild myopia ($p < 0.05$). This shows that the importance of rise in foveal thickness with elongation of myopia. Results were consistent to the findings from research conducted by Xie R et al. that reported that foveal thickness remained same in low myopia group and emmetropia but higher in high myopic cohort.¹⁸ Additionally, results from observational study conducted by Choi et al.,²³ reported that thickness of fovea elevated as the level of myopia progress, whereas peripapillary retinal nerve fiber layer reduced. Similarly, high myopic patients have thinner sclera and retina but there results were inconsistent. Although Wakitani et al revealed that thickness of macula was insignificantly correlated with axial length.¹⁹ On the contrary, our study reported that thickness of macula was significantly correlated with axial length in low myopia group ($p < 0.05$) but not in high myopia group ($p > 0.05$).

Macular thickness is necessary for identifying various disorders of ocular which results macular thinning or thickening. When it comes to precisely

measuring retinal thickness, OCT is extremely important.²⁴ With a resolution of $\leq 10 \mu\text{m}$, it can detect distances and tissues using laser lower coherence interference measurement. Optical coherence tomography is currently the most effective technique for measuring thickness of retina and retinal nerve fibers at various axial and diopter lengths.²⁵ In our current Pakistani study, we found that the increase in axial length or myopia degree was closely related to myopia. Spectral domain optical coherence tomography was used to determine the macular area thickness of retina in myopia patients. Our findings showed that the retina gets thinner as myopia and axial length rise. The central foveal thickness raises as the axial length increases and the retina's thickness decreases. A potential cause could be the outer segment elongation of the photoreceptor cell and unhealthy fixation of the fovea central in high myopia patients.²⁶ Lam examined the association between thickness of macular and myopia with the help of stratus optical coherence tomography and found no notable insignificant difference in inner ring macular thickness in high myopic group.²⁶ In present research, macular thickness and the relation with axial length as assessed by the optical coherence tomography found to be consistent with previous epidemiological researches. On the other hand, Wu found the average retinal thickness assessed by third-generation optical coherence tomography in both macular regions was significant thinner in high myopia cases compared non-myopic.²⁷

In our research while analyzing difference between two groups (A and B), we observed that high myopes had thinner inner macula thicknesses in most of the quadrant except the fovea. This finding was statistically insignificant in every quadrant of outer and inner macula. Ido et al.²⁸ found that insignificant difference between different myopic groups (i.e. low and high myopes). However, our study contradicts

this finding as we found significant difference between macular thickness of two groups ($p < 0.05$). Chan et al. showed that only the outer macular area (which is thinner in high myopes) showed a significant difference between low and high myopes. The importance of these findings requires further research between various degrees of myopic patients.²⁹

In participants with complete myopia, we examined the relationship between the axial length and various macular areas. We observed a negative correlation of axial length with fovea, which is also highly significant. Similarly, the outer macula inferior quadrant is negatively correlated with length of axial as shown in table no 3. Chan et al. reported that only the perifoveal region, not the parafoveal region, showed a significant negative correlation.²⁷ While our study showed a positive correlation in perifoveal region of low myopia group but negative correlation found in Temporal Quadrant of high myopia group ($p > 0.05$). Kim et al. reported that significance was observed only in the perifoveal region³⁰ while Chew et al.³¹ found that parafoveal region is negatively correlated. This result differed from Ido et al. study,²⁸ they found that there is no statistically significant change in retinal thickness of macular quadrant as axial length increased. The Humphrey 2000 was applied in our research, which is one of the earliest time domain optical coherence tomography, contrary to other studies. The disparate results could be the reason for it.

Our research strength is to represents a novel approach to determine the relationship between ocular biometry and OCT-defined parameters in Pakistani population. Our study's limitations include additional confounding variables that affect retinal thickness but were not thoroughly examined, such as age, gender, and ethnicity. Additionally, this study did not assess additional ocular characteristics that are related to myopic alterations, including lens thickness, vitreous length, anterior chamber depth and corneal curvature.

Conclusion:

Our research indicated that foveal thickness increases as myopia progresses, and a significant positive correlation found between axial length and fovea in low myopes and total myopes. In order to avoid the myopic progression, parents and young age group should be educated of factors including accurate refractive correction, the use of bifocal lenses to address accommodative lag, maintaining adequate lighting during reading and outdoor physical exercise. Since OCT and other screening programs are useful for early identification young individuals should be motivated to engage in screening programs.

Conflict Of Interest / Disclosure

There was no conflict of interest.

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