Retinal Nerve Fiber Layer Measurements in Myopia Using Optical Coherence Tomography

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ABSTRACT

Objective: To evaluate the relationship between retinal nerve fiber layer (RNFL) thickness measured by optical coherence tomography (OCT) and the degree of myopia.

Methods: A total of 28 eyes of 14 healthy subjects with myopia, 9 eyes with low myopia (spherical equivalent [SE] between -0.75 D and -3.00 D) and 19 eyes with moderate to high myopia (SE >-3.0 D), were included. Total average and mean quadrant RNFL thicknesses were measured by Stratus OCT. Associations between RNFL measurements and spherical equivalent refraction were evaluated by linear regression analysis.

Results: Twenty two out of 28 eyes were classified as below normal limits with reference to the normative database of the RNFL thickness. There was a significant correlation between refraction and average RNFL thickness ($p=0.04$), indicating that for every decrease of 1.00 D in refraction (more myopic), there was a 2.86 μm decrease in the average RNFL thickness. The most frequently abnormal sector was at the nasal quadrant, where 78% of myopic eyes were below normal limits. A significant correlation was seen between refraction and nasal RNFL thickness ($p=0.02$), showing a decrease of 3.37 μm in the nasal RNFL thickness for every 1.00 D decrease. There was also a significant correlation between refraction and inferior RNFL thickness ($p=0.007$). For every decrease of 1.00 D in refraction, there was a decrease of 6.27 μm in the inferior RNFL thickness. There were no significant correlations between the refraction and the superior and temporal RNFL thickness ($p = 0.12$ and 0.64, respectively).

Conclusion: There was a decrease in the average RNFL thickness as the refractive error became more myopic, suggesting the need for the Stratus OCT RNFL normative database to have corrective factors for refractive error among myopic patients. Although both the nasal and inferior quadrants positively correlated with myopia, majority of the nasal quadrant showed below normal thickness based on the Stratus OCT normative database. A careful interpretation of RNFL measurements, especially the nasal quadrant, should be done among myopic subjects to avoid mislabeling them as glaucoma suspects.

Keywords: Myopia, Retinal nerve fiber layer, Optical coherence tomography, Stratus OCT, Refractive error

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Myopia is a common ocular abnormality worldwide with a prevalence in adults of 22.7% and 26.2%, as reported in the Baltimore Eye Survey and the Beaver Dam Study, respectively.[1–2] Among adult Chinese in Singapore, it was estimated that 38.7% of adult Chinese were myopic and 9.1% were high myopes.[3] From the clinical and socioeconomic standpoints, these are major concerns especially among East Asian countries where there are projections for increasing prevalence rate and severity of the condition.[4]

One of the potentially blinding ocular diseases found to have a strong relationship with myopia is glaucoma[5] which is characterized by progressive degeneration of retinal ganglion cells, one of the common ocular diseases seen among Filipinos. An important approach in the detection of early structural change in glaucoma is based on assessment of the retinal nerve fiber layer (RNFL) using the optical coherence tomography (OCT). Numerous studies have confirmed that RNFL measurement is sensitive in detecting glaucoma, and the extent of RNFL damage correlates with the severity of functional deficits in the visual field.[6–8] Some patients can lose up to 40% of their RNFL before any visual field defect is detected.

The Stratus OCT utilizes a normal population database for RNFL measurements, developed by the manufacturer and packaged within the software. However, it did not include individuals with moderate or high degrees of myopia and there were only 11 Asians out of the 328 subjects included in the establishment of the normative reference values for RNFL thickness measurement.[9] RNFL thinning is indicative of glaucomatous damage; however, it remains uncertain whether RNFL thickness would vary with the degree of myopia where eyes have longer axial lengths and stretched-out retina.

Conflicting data existed regarding the influence of myopia on peripapillary retinal nerve fiber layer (RNFL) thickness. Some studies showed no association whereas others found significant correlations.[9] This study investigated if there is a significant relationship between the degree of myopia and RNFL thickness as measured by optical coherence tomography.

METHODOLOGY

Adult Filipinos, between 18-39 years of age, with myopia of ≥0.75 D and no ocular or systemic conditions that can affect the refraction , were recruited from July 2012 to August 2012 at the outpatient department of the Department of Ophthalmology, University of Santo Thomas Hospital. Subjects less than 18 years old, spherical equivalent <-0.75 D, diagnosed glaucoma or glaucoma suspect with CD ratio ≥0.5, those with frank presbyopia, and those with ocular diseases such as cataract and any form of retinopathy were excluded.

All subjects underwent complete ophthalmologic examination consisting of visual acuity determination, refraction, applanation tonometry, slit lamp evaluation, stereoscopic biomicroscopy of the optic nerve head at the slit lamp using a 90 D lens, and fundoscopy.

OCT was performed with the Stratus OCT (Carl Zeiss, Meditec Inc.). RNFL thickness was measured with the fast RNFL scanning protocol (256 A-scans). Average measurements of three sequential circular scans with a diameter of 3.4 mm centered on the optic disc were recorded. All the scans had signal strength of at least 7. Parameters including average RNFL thickness and mean RNFL thickness in each quadrant were generated automatically in the analysis report of the Stratus OCT.

Correlations between refraction (spherical equivalent) and RNFL thicknesses were determined by linear regression analysis and expressed as the Pearson coefficient of correlation (r), with $p<0.05$ considered statistically significant.

RESULTS

Twenty-eight eyes of 14 myopic subjects were included in the study. The mean age and spherical equivalent were 25 years (range, 22–35) and -3.50 D (range, -0.75 to -6.00), respectively.

The average RNFL thickness in myopic eyes with -0.75 D to -3.00 D was 102.44 μm (range, 91.65 to 116.28 μm) and in myopic eyes with >-3.00 D 97.91 μm (range,77.67 to 117.51 μm).

A significant proportion of myopic eyes (78%) were classified as below normal limits, with reference to the normative database of the retinal nerve fiber layer measurement of the Stratus OCT (Table 1).

TABLE 1. Average RNFL thickness and RNFL quadrant thickness in 28 myopic eyes.

	RNFL (µm)				
REFRACTION (SE)	AVE THICKNESS	SUPERIOR	NASAL	INFERIOR	TEMPORAL
-3.75	98.04	132	50	130	80
-3.25	102.82	143	58	146	64
-3.25	105.59	109	46	128	140
-4.00	117.51	117	72	151	131
-2.50	94.53	124	57	137	60
-2.25	91.76	121	57	132	57
-6.00	89.21	104	51	131	70
-5.75	77.67	105	39	106	61
-3.50	116.03	112	49	158	145
-1.50	105.75	131	45	146	101
-3.50	94.15	131	52	117	76
-4.25	102.17	140	61	127	81
-2.75	110.14	143	63	140	94
-2.00	110.19	139	63	151	88
-4.00	100.91	121	55	153	74
-4.00	103.43	128	70	156	70
-3.25	99.22	119	47	128	104
-2.75	91.65	133	39	105	89
-0.75	102.19	113	76	140	79
-1.00	99.50	115	55	149	79
-3.00	116.28	166	50	154	94
-3.75	107.54	143	43	145	99
-5.50	92.13	118	51	111	89
-5.75	96.23	122	49	124	89
-3.50	81.93	96	50	112	70
-3.25	101.44	123	50	148	85
-6.00	91.46	108	29	95	134
-4.50	82.84	105	29	110	88

There was a significant correlation between refraction and average RNFL thickness (p=0.036) (Figure 1). For every 1.00 D decrease in refraction (more myopic), there was a 2.868 µm decrease in the average RNFL thickness (Table 2).

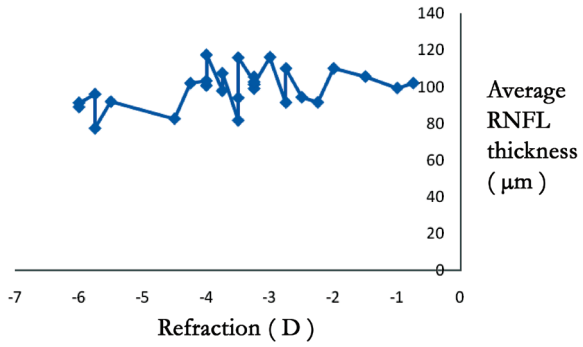


Figure 1. Refraction (SE) and average RNFL thickness (µm) in 28 myopic eyes.

TABLE 2. Correlation of RNFL thickness (µm) and refraction (D) in 28 myopic eyes.

RNFL thickness (µm)	Coefficient	ρ value	F value
Average	2.868	0.036	4.887
Superior	3.258	0.126	2.498
Inferior	6.277	0.007	8.433
Nasal	3.370	0.024	5.730
Temporal	-1.555	0.641	0.223

There was, however, no significant correlation between the refraction and the superior and temporal RNFL thickness (p = 0.13 and 0.64, respectively) (Figures 2 and 3; Table 2).

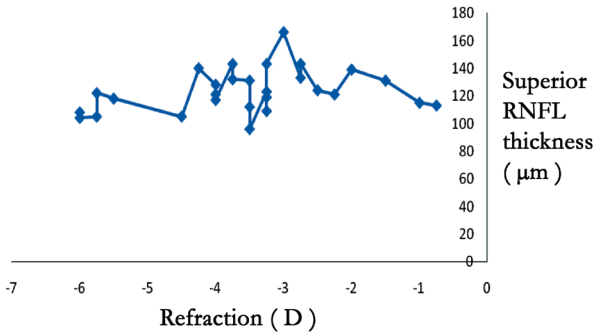


Figure 2. Refraction (SE) and superior RNFL thickness (µm) in 28 myopic eyes.

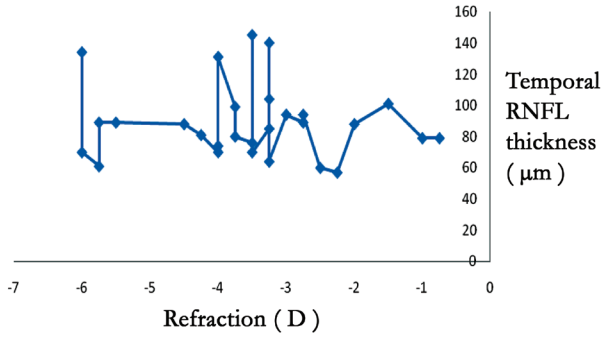
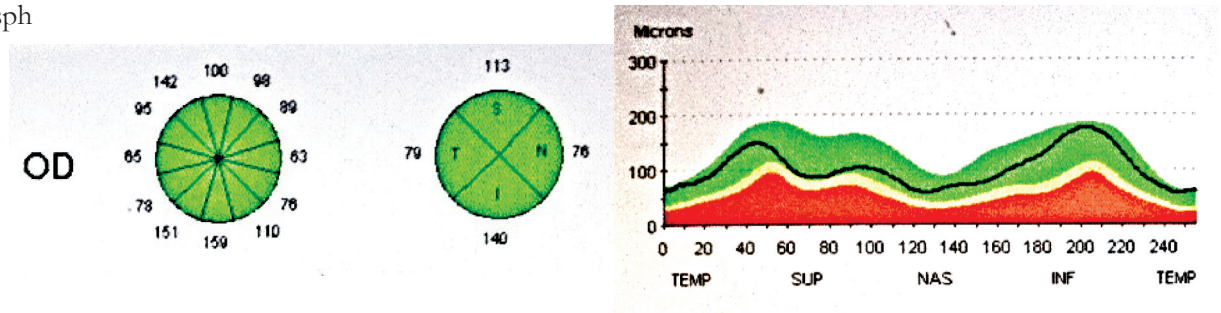
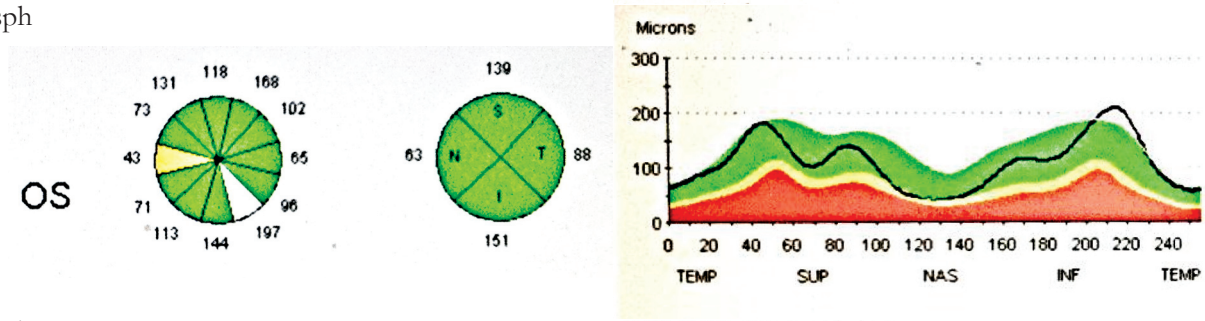


Figure 3. Refraction (SE) and temporal RNFL thickness (µm) in 28 myopic eyes.

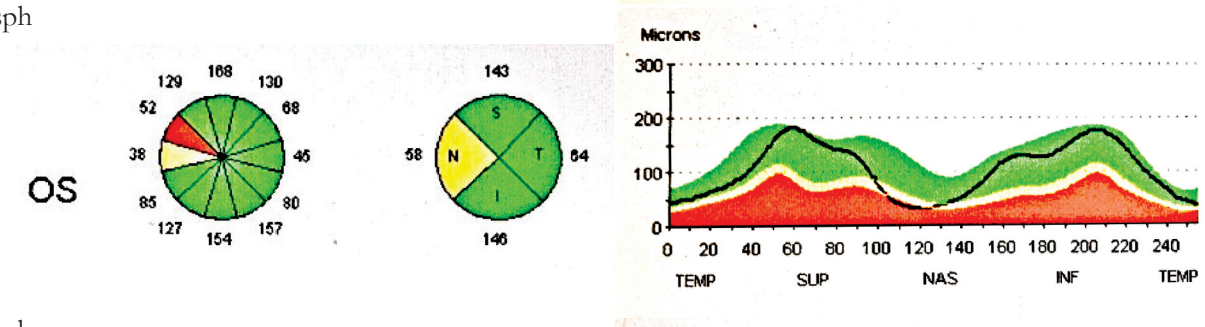
-0.75 sph



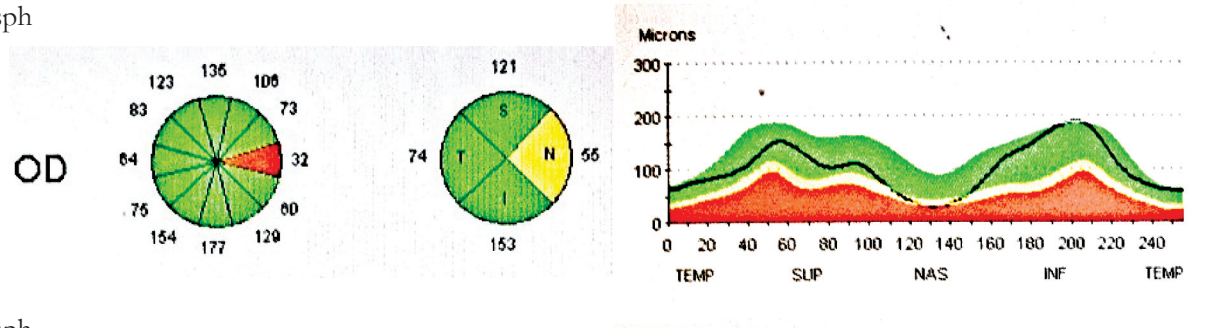
-2.00 sph



-3.25 sph



-4.00 sph



-5.75 sph

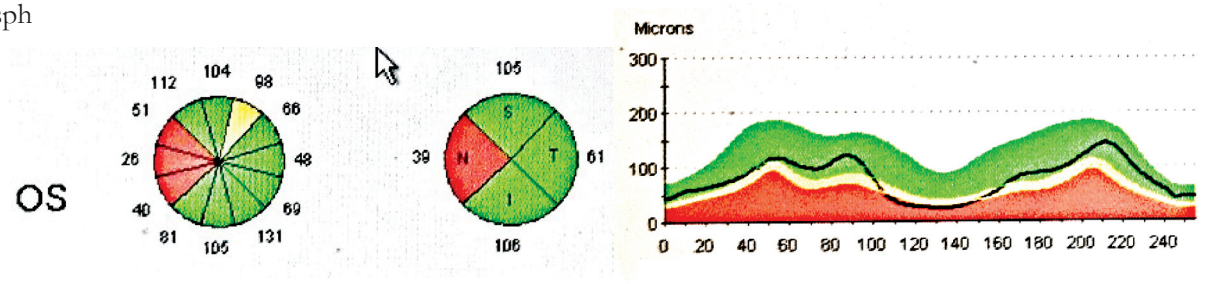


Figure 6. Representative retinal nerve fiber layer scans from normal subjects with different degrees of myopia.

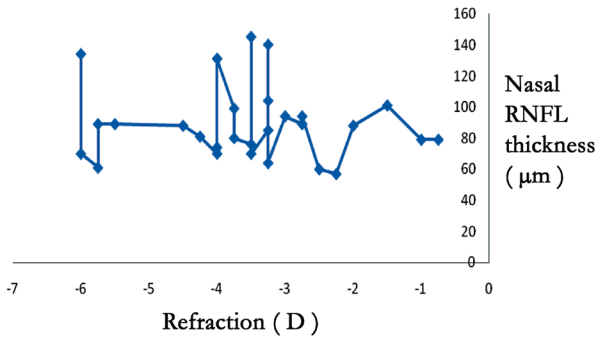


Figure 4. Refraction (SE) and nasal RNFL thickness (µm) in 28 myopic eyes.

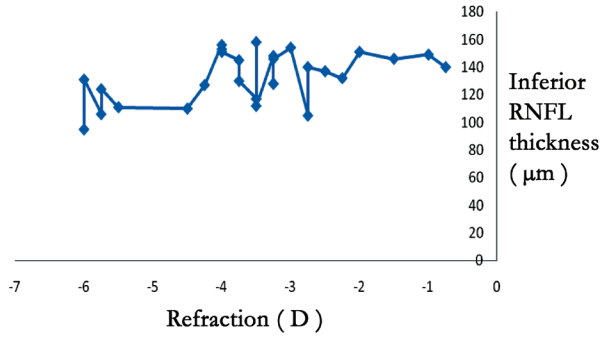


Figure 5. Refraction (SE) and inferior RNFL thickness (µm) in 28 myopic eyes.

The most frequently abnormal sector was at the nasal quadrant, where 78% of the myopic eyes were below normal limits. A significant correlation was seen between refraction and nasal RNFL thickness (p=0.02). There was a corresponding decrease of 3.37 µm in the nasal RNFL thickness for every 1.00 D decrease in refraction (more myopic) (Figure 4 and Table 2).

There was also a significant correlation between refraction and inferior RNFL thickness (p=0.007). For every decrease of 1.00 D in refraction (more myopic), there was a decrease of 6.278 µm in the inferior RNFL thickness (Figure 5 and Table 2).

Representative RNFL scans of the different degrees of myopia are shown in Figure 6.

DISCUSSION

Our findings indicated that the average retinal nerve fiber layer thickness decreases as the refraction becomes more myopic. These data supported the findings of Schweitzer[10] and Leung[11] that there is a positive correlation between refraction and RNFL thickness. This is in contrast to the results found by Hoh[12] where the mean RNFL thickness did not vary with the degree of myopia when investigated by OCT.

In our study, we found that there was a decrease in the RNFL thickness at the nasal quadrant, 78% of which were below normal limits based on the normative database of the Stratus OCT. A positive correlation between the degree of myopia and the nasal RNFL thickness was observed. There was a decrease of 3.37 µm for every 1.00 D decrease in refraction. This data supported the findings of Leung[11] that Chinese myopic subjects have thin nasal RNFL, a finding not found in the largely Caucasian population where Rauscher noted that thin RNFL in myopic subjects occurred preferentially at the superior and inferior quadrants.[9] We also found that there was a positive correlation between the degree of myopia and RNFL thickness at the inferior quadrant but the majority were within normal range and only 3% were below 95%.

The Stratus OCT used in this study provided superior image quality and higher resolution scanning of the RNFL compared to earlier models. Although newer generation OCTs are now available, the Stratus OCT remains to be widely used in the Philippines.

The Stratus OCT provides a database with age-matched controls for comparative analysis aiding the detection of ocular diseases involving the RNFL but the validity of applying this database to healthy myopes is yet to be verified.[11] The study of Rauscher[9] pointed out that extremes of refractive error were excluded and the normative database lack the exclusionary criteria based on refractive error. Moreover, there were only 11 Asian eyes out of 328 included in the study establishing the database where majority were whites (205 eyes). Statistical analyses were done between RNFL thickness and age, right vs left eye, and gender, but not the ethnicity. Therefore, it would be of interest to examine whether there is a significant difference in RNFL thickness measurements between Asians and non-Asians.

Several explanations for RNFL thinning in

myopia have been reported.[10] Myopic globe elongation may seem to stretch and thin the RNFL because of mechanical forces.[11] Myopic retinal degeneration may account for decrease RNFL thickness and a larger disc with normal ganglion cells may provide a greater surface area for axon distribution.[13]

On the other hand, the decreased RNFL thickness among myopes could represent a predisposing factor for future development of glaucoma that could partly explain the increase incidence among myopes in some studies like the Blue Mountain Eye Study where data showed strong relationship between open-angle glaucoma and myopia.[5]

In conclusion, RNFL measurements may vary with refraction. There is a decrease in the average RNFL thickness as the refractive error becomes more myopic which may suggest the need for the Stratus OCT RNFL normative database to have corrective factors for refractive error among myopic patients and to verify these data with the use of the new generation Cirrus OCT.

Although both nasal and inferior quadrants positively correlate with myopia, majority of the nasal quadrant showed below normal thickness based on the Stratus OCT normative database. A careful interpretation of RNFL measurements, especially the nasal quadrant, should be done among myopic subjects to avoid mislabeling them as glaucoma suspects.

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