

Correlation of Axial Length of the Eyeball with Peripapillary Retinal Nerve Fibre Layer Thickness Measured by Optical Coherence Tomography in Myopes – A Study Report

Dr. Kousik Sarkar¹, Dr. Bharoti Sarmah Puzari²

¹ Post Graduate Trainee, Upgraded Department of Ophthalmology, Assam Medical College & Hospital, Dibrugarh, Assam, India

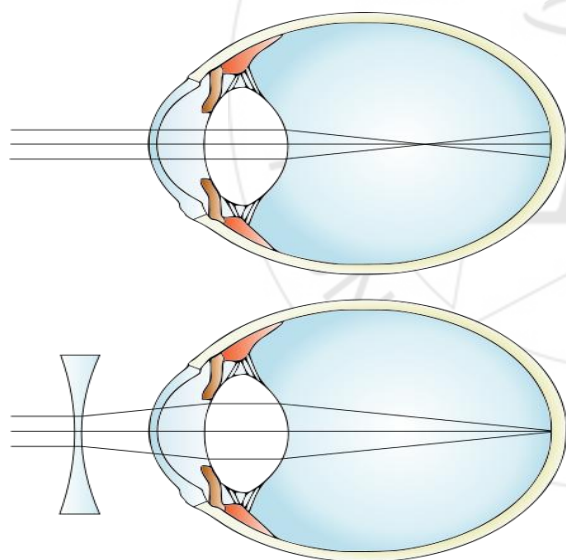
² Associate Professor, Upgraded Department of Ophthalmology, Assam Medical College & Hospital, Dibrugarh, Assam, India

Abstract: Myopia is the most common type of refractive error, in which axial myopia is the most common variety. Axial myopia results in stretching of the globe and stretching of all coats of the eye. Usually retinal nerve fibre thinning occurs in glaucomatous eyes. But in our study we found that there is thinning of retinal nerve fibre layer with increase in axial length in myopic eyes.

Keywords: Myopia, Axial length of eye, retinal nerve fibre layer thickness, SD-OCT, correlation co-efficient

1. Introduction

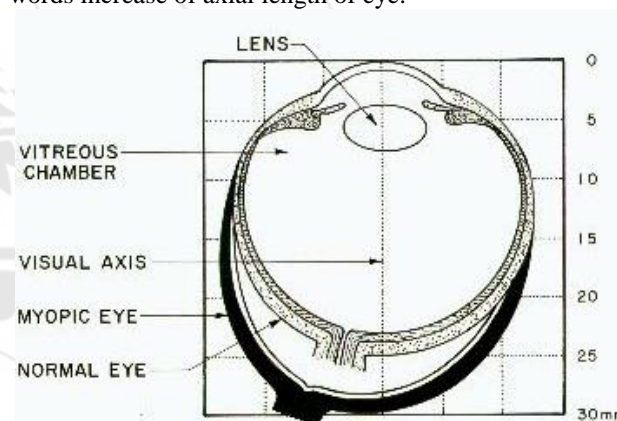
Myopia is a form of refractive error wherein parallel rays of light coming from infinity, come to a focus in front of sentient layer of the retina when the eye is at rest.



It occurs when the refractive power of the eye is too great compared to the length of the eyeball and this may occur because the eye has a greater refractive power, a longer axial length or a combination of both. In fact, the axial length is nearly always too long compared to the refractive power and the myopic eye is importantly a long eye. [1]

The axial length (AL) of the eye is the distance between the anterior surface of the cornea and the fovea in retina. 1 mm error in AL measurement results in a refractive error of approximately 2.35 D in a 23.5 mm eye. [2]

All of the proposed theories of development of myopia are mainly aimed at development of Axial myopia or in other words increase of axial length of eye.



OCT provides an assessment of the RNFL thickness by passing a near-infrared illumination (840 nm) beam into the eye and studying its reflectivity patterns by computer-assisted software. No reference plane is required to calculate RNFL thickness because OCT provides an absolute cross-sectional measurement of the retinal substructure, from which the RNFL thickness is calculated. RNFL is seen as red-colored high-reflectivity zone adjacent to optically zero-reflective vitreous. Measurement of nerve fiber thickness will be done along the 3.4-mm-diameter circle around the optic nerve head. [3]

Although retinal nerve fibre layer thinning is indicative of glaucomatous damage, it remains uncertain whether retinal nerve fibre layer thickness would vary with the refractive status of the eye.

It is therefore important to investigate whether any correlation exists between retinal nerve fibre layer thickness and axial length in myopia.

Aims and Objectives

- To evaluate the peripapillary retinal nerve fibre layer (RNFL) thickness by spectral domain optical coherence tomography (SD-OCT) in myopes.
- Correlation of axial length and peripapillary RNFL thickness in myopes.

2. Methodology

• Sample Size and Selection of Subjects

90 myopic patients attending to the out patient department of Assam Medical College and Hospital , Dibrugarh, Assam for refractive error evaluation fulfilling the inclusion and exclusion criteria, during the study period and 180 eyes of them were evaluated. Informed consent was obtained from each of the patients after explaining the purpose of the study.

• Inclusion Criteria

- 1) Myopic patients attending to ophthalmology department in AMCH
- 2) Age of patients between 15 years to 40 years

• Exclusion Criteria

- 1) Those with a history of severe ocular trauma, intraocular or refractive surgery, or any ocular or retinal diseases that could have affected the optic nerve head or RNFL.
- 2) Diagnosed cases of glaucoma or those with intraocular pressure (IOP) >21 mm Hg in either eye; those showing evidence of a reproducible Visual field defects in either eye, as detected using the Humphrey Visual Field analyzer

- Patients were divided into three groups according to myopic refractive error:

Low myopia (<-3.00 D)
 Moderate myopia (-3.00 to -6.00 D)
 High myopia (> -6.00 D)

And Axial length

AL < 24 mm
 AL 24-26 mm
 AL > 26 mm

- Visual acuity was measured
- Refractive correction was done
- Best corrected visual acuity was measured
- Intraocular pressure was measured by applanation tonometry and visual field evaluation of suspected glaucoma cases was done by Humphrey visual field analyser.
- Axial length was measured by A-scan ultrasonography
- Average 360 degree and quadrant wise RNFL thickness was measured by SD-OCT
- ‘p’ value was calculated by one way ANNOVA test and <0.05 was regarded as significant.
- To analyze correlation between Axial length and RNFL thickness Pearson correlation co-efficient (r) analysis was done.

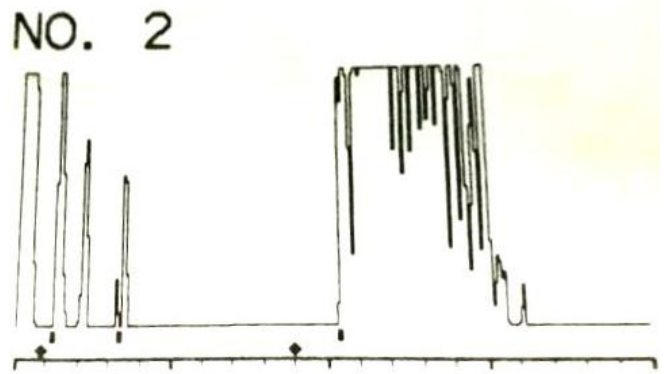


Figure 1: Graphical representation of ultrasound A-scan

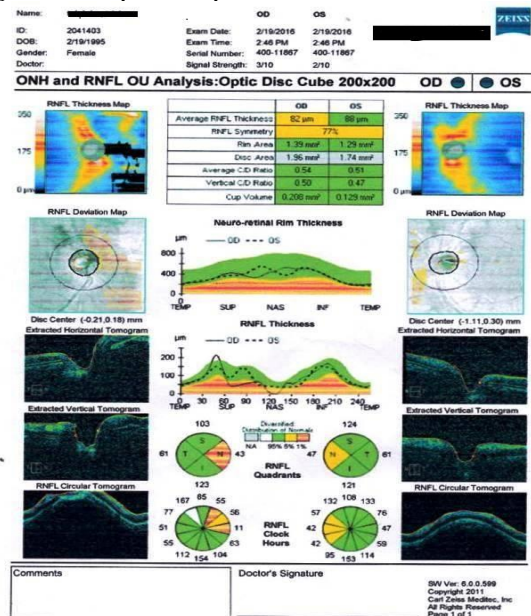


Figure 2: SD-OCT of optic nerve head and RNFL

3. Results & Observations

Table 1: Distribution of eyes according to degree of myopia

Degree of myopia	No. of eyes	Percentage (%)	Mean refractive error (D)
Low myopia	95	52.78	-3.52±2.40
Moderate myopia	52	28.89	
High myopia	33	18.33	
Total	180	100	

Total 180 eyes of 90 patients were evaluated. Low myopia was found in 95 eyes (52.78%), moderate myopia in 52 eyes (28.89%), and high myopia in 33 eyes (18.33%). So there was a preponderance of low myopia in this study group. Mean refractive error was -3.5± 2.40 D.

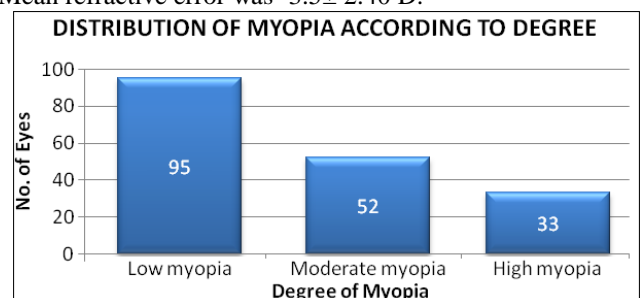


Figure 3: Bar diagram showing distribution of myopia according to degree

Table 2: Grouping all eyes according to axial length

Axial Length	No. of eyes	Percentage (%)	Mean Axial length (mm)
<24 mm	87	48.33	24.53±1.51
24 – 26 mm	57	31.67	
>26mm	36	20	

87 eyes (48.33%) were found having axial length <24 mm, 57 eyes (31.67%) having axial length between 24-26 mm and 36 eyes (20%) found to have axial length more than 26 mm. Mean Axial length was 24.53 ± 1.51 mm. (mean±SD).

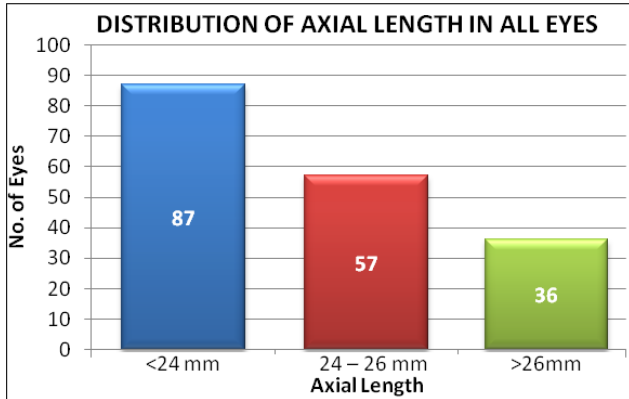


Figure 4: Bar diag showing distribution of AL in all eyes

Table 3: Average 360 degree and quadrant wise mean RNFL thickness measurement in different degree of myopia

Quadrant	RNFL thickness (µm)		
	Low myopia	Moderate myopia	High myopia
Average 360 degree	99.72 ± 5.80	89.04 ± 5.33	77.97 ± 7.13
Superior	125.17 ± 10.30	110.01 ± 8.71	95.06 ± 11.02
Inferior	130.38 ± 9.82	116.40 ± 10.33	100.24 ± 11.24
Nasal	70.37 ± 6.65	60.096 ± 6.47	51.70 ± 4.83
Temporal	72.95 ± 4.34	69.56 ± 4.80	64.88 ± 6.16

Average 360 degree and quadrant wise mean RNFL thickness decreased with increase in degree of myopia. There was a significant association between thinning of average 360 degree and quadrant wise RNFL thickness with increasing degree of myopia (p < 0.0001).

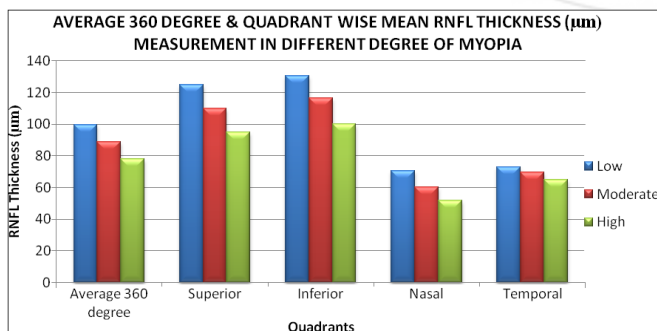


Figure 5: Bar diag. showing RNFL thickness in different degree of myopia

Table 4: Average 360 degree and quadrant wise mean RNFL thickness measurement of subgroups classified on axial length

Quadrant	RNFL thickness (µm)		
	Axial length <24 mm	Axial length 24-26 mm	Axial length >26 mm
Average 360 degree	100.72 ± 5.01	89.40 ± 4.69	78.28 ± 6.92
Superior	126.44 ± 9.81	110.51 ± 8.32	95.94 ± 10.91
Inferior	131.82 ± 8.97	116.736 ± 9.32	100.24 ± 11.24
Nasal	71.23 ± 5.38	60.67 ± 6.04	51.22 ± 4.86
Temporal	73.18 ± 4.67	69.68 ± 4.05	65.25 ± 6.25

Average 360 degree and quadrant wise mean RNFL thickness decreases with increase in axial length in myopic eyes. But decrease of RNFL in temporal quadrant is less than other quadrants. There was a significant association between thinning of average 360 degree and quadrant wise RNFL thickness with increase in axial length (p < 0.0001).

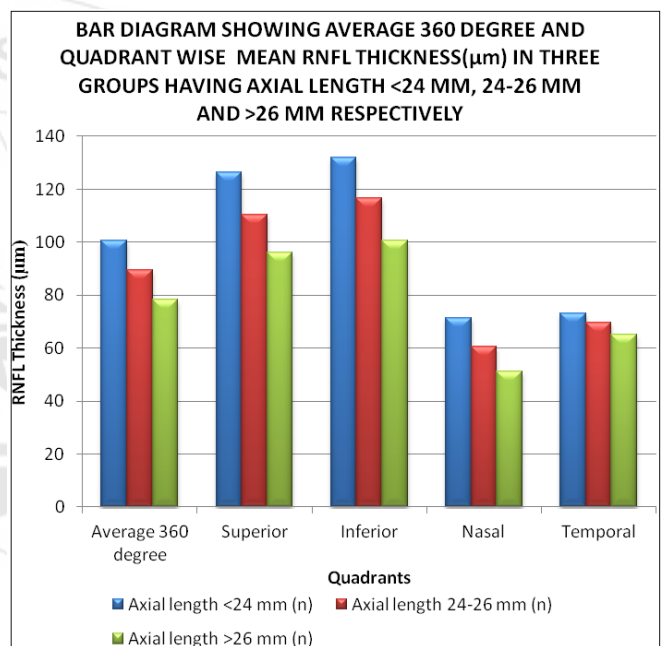


Figure 6: Bar diag. showing RNFL thickness in eyes classified according to axial length

Table 5: Pearson correlation analyses between retinal nerve fibre layer thickness and axial length in total sample

RNFL thickness	Axial length	
	r	P
Average 360 degree	-0.935	<0.0001
Superior	-0.874	<0.0001
Inferior	-0.868	<0.0001
Nasal	-0.842	<0.0001
Temporal	-0.607	<0.0001

Significant negative correlation was found between axial length and average 360 degree mean retinal nerve fiber layer thickness (r=-0.935, p < 0.0001).

Analysis at individual quadrants of retinal nerve fiber layer thickness showed that each quadrant had significant negative correlation with the axial length i.e. correlation between the axial length and superior RNFL thickness was - 0.874 (p < 0.0001), correlation between the axial length and inferior

RNFL thickness was -0.868 ($p < 0.0001$), correlation between the axial length and nasal RNFL thickness was -0.842 ($p < 0.0001$), and the correlation between the axial length and inferior RNFL thickness was -0.607 ($p < 0.0001$). There was comparatively weak negative correlation between axial length and nerve fibre layer thickness in temporal quadrant.

4. Discussion

Significant association ($p < 0.0001$) found between thinning of RNFL with increasing degree of myopia & increase in Axial length of eye.

Kamath AR, Dudeja L. et al. (2014), have done a study and found a decrease in RNFL thickness in each quadrant with increasing degree of myopia. [4]

Kim et al. in 2010 did a study on 48 myopic subjects, found RNFL thickness was thicker in low myopic group than moderate/ high myopic groups for superior, nasal and inferior quadrants (all p values, 0.020). [5]

Leung et al. in 2006 studied 115 eyes of 115 healthy subjects (75 eyes with high myopia and 40 eyes with low to moderate myopia). They found that the average 360 degree RNFL thickness decreases with increasing axial length ($p = 0.001$). [6]

Rauscher et al. in 2009 showed RNFL thickness decreased with higher axial length ($p < 0.001$). [7]

Bundez et al. (2007) studied retinal nerve fiber layer (RNFL) in the normal human eye as measured by Stratus OCT found For every 1-mm-greater axial length, mean RNFL thickness measured thinner by approximately $2.2 \mu\text{m}$ ($p < 0.001$). [8]

But **Hoh et al.** (2006) found that mean average peripapillary RNFL thickness did not correlate with 3.40-mm ($r = -0.04$, $P = 0.62$), 4.50-mm ($r = -0.03$, $P = 0.75$), or $1.75 \times \text{VDD}$ ($r = -0.02$, $P = 0.78$) scan diameters. [8]

• We also found a significant negative correlation between Axial length and peripapillary RNFL thickness in myopia.

Savini et al. in 2012 evaluated influence of Axial length on RNFL thickness in healthy subjects. They found negative correlation between axial length and RNFL in average 360 degree ($r = -0.69$, $p < 0.0001$) and in all four quadrants namely superior ($r = -0.52$, $p = 0.0003$), inferior ($r = -0.72$, $p < 0.0001$), nasal ($r = -0.60$, $p < 0.0001$) and temporal ($r = -0.30$, $p = 0.0485$). [9]

Leung et al. in 2006 also showed significant negative correlation between Axial length and Average 360 RNFL thickness ($r = -0.314$, $P = 0.001$). They also concluded with, there is decrease in RNFL thickness with increase in Axial length of the eye. [6]

Rauscher et al. in 2009 also found RNFL thickness decreased with higher axial length in average 360 degree ($r = -0.70$, $p < 0.001$), Superior quadrant ($r = -0.60$, $p = 0.001$) and Inferior quadrant ($r = -0.60$, $P = 0.001$). Nasal and temporal

RNFL thickness showed no significant associations with myopia. So they also showed negative correlation between Axial length and RNFL thickness. [7]

The reduction of RNFL thickness with increasing axial length could be explained by the observation that there is increased scleral and retinal thinning in myopic eyes. In myopic eyes, the elongation of the globe leads to mechanical stretching and thinning of the retina. Therefore, it is conceivable that the extent of the elongation would be related to the degree of retinal thinning, although it is yet to be ascertained whether the RNFL thickness is decreased at the histologic level.

5. Conclusion

Myopia is the most common type of refractive error and Axial myopia is the most common and important type of myopia. Axial myopia results in stretching of the globe and stretching of all coats of the eye.

In our study we found a negative correlation between Axial length and peripapillary RNFL thickness in myopia.

Thinning of RNFL is a good indicator of glaucoma and it also occurs in myopic eyes. So, measurement of RNFL thickness without knowing the refractive status can lead to misdiagnosis of glaucoma.

To avoid such misdiagnosis, a new normative RNFL profile for myopic patients is needed, to improve the sensitivity and specificity of glaucoma detection, and the properties of the RNFL thickness profile in cases of high myopia should be considered.

References

- [1] Duke – Elder's Practice of Refraction, 10 th edition, chapter 5. Myopia, pg no. 53
- [2] American Academy of Ophthalmology (2014 – 2015), (Basic and clinical science course), Section 3, Clinical Optics, chapter – 5, Intraocular Lenses, pg no. 200
- [3] Schweitzer KD, Ehmman D, Garcia R. Nerve fibre layer changes in highly myopic eyes by optical coherence tomography. Canadian Journal of Ophthalmology/Journal Canadien d'Ophthalmologie. 2009 Jun 30;44(3):e13-6
- [4] Kamath AR, Dudeja L. Peri-papillary retinal nerve fiber layer thickness profile in subjects with myopia measured using optical coherence tomography. Journal of Clinical Ophthalmology and Research. 2014 Sep 1;2(3):131.
- [5] Kim MJ, Lee EJ, Kim TW. Peripapillary retinal nerve fibre layer thickness profile in subjects with myopia measured using the Stratus optical coherence tomography. British Journal of Ophthalmology. 2010 Jan 1;94(1):115-20.
- [6] Leung CK, Mohamed S, Leung KS, Cheung CY, Chan SL, Cheng DK, Lee AK, Leung GY, Rao SK, Lam DS. Retinal nerve fiber layer measurements in myopia: an optical coherence tomography study. Investigative

- ophthalmology & visual science. 2006 Dec 1;47(12):5171-6.
- [7] Rauscher FM, Sekhon N, Feuer WJ, Budenz DL. Myopia affects retinal nerve fiber layer measurements as determined by optical coherence tomography. *Journal of glaucoma*. 2009 Sep;18(7):501.
- [8] Budenz DL, Anderson DR, Varma R, Schuman J, Cantor L, Savell J, Greenfield DS, Patella VM, Quigley HA, Tielsch J. Determinants of normal retinal nerve fiber layer thickness measured by Stratus OCT. *Ophthalmology*. 2007 Jun 30;114(6):1046-52.
- [9] Savini G, Barboni P, Parisi V, Carbonelli M. The influence of axial length on retinal nerve fibre layer thickness and optic-disc size measurements by spectral-domain OCT. *British Journal of Ophthalmology*. 2012 Jan 1;96(1):57-61.

