



EFFECT OF MYOPIA ON THE THICKNESS OF THE RETINAL NERVE FIBRE LAYER MEASURED BY OPTICAL COHERENCE TOMOGRAPHY

Dr. Younis Ahmad Dar¹, Dr. Sheikh Sajjad², Dr. Sadiya Aijaz^{3*}, Dr. Ashaq⁴

¹Postgraduate scholar, Department of Ophthalmology, SKIMS Medical College, Bemina Srinagar, Jammu and Kashmir, India

²Professor and Head, Department of Ophthalmology, SKIMS Medical College, Bemina Srinagar, Jammu and Kashmir, India

^{3*}Postgraduate scholar, Department of Ophthalmology, SKIMS Medical College, Bemina Srinagar, Jammu and Kashmir, India

⁴Postgraduate scholar, Department of Ophthalmology, SKIMS Medical College, Bemina Srinagar, Jammu and Kashmir, India

***Corresponding Author:** Dr. Sadiya Aijaz

*Postgraduate scholar, Department of Ophthalmology, SKIMS Medical College, Bemina Srinagar, Jammu and Kashmir, IndiaMail id: sadiya_aijaz@yahoo.com

ABSTRACT

Background: Myopia is a refractive error where light rays focus in front of the retina. Studies using Optical Coherence Tomography (OCT) have shown temporal displacement and thinning of the retinal nerve fibre layer (RNFL) in myopia. **Objectives:** To evaluate the effect of myopia on the RNFL thickness measured by Optical Coherence Tomography (OCT). **Methods:** This observational study included 300 patients, aged 19-37 years, randomly selected from the OPD of the Department of Ophthalmology at SKIMS Medical College, Srinagar. Spectral domain OCT (Cirrus HD-OCT) was used to measure RNFL thickness in four quadrants (superior, inferior, temporal, and nasal). RNFL thickness was compared among groups with low, moderate, and high myopia. **Results:** The mean RNFL thickness in the temporal quadrant was correlated with the severity of myopia, showing a decrease in high myopic patients compared to moderate and low myopia. In the superior quadrant, RNFL thickness was also significantly reduced in high myopia. The average RNFL thickness showed minimal variation with age ($p = 0.873$). Axial length increased with the severity of myopia, with mean values of 22.7 ± 1.59 mm in Group 1 (low myopia), 23.8 ± 1.62 mm in Group 2 (moderate myopia), and 26.2 ± 2.23 mm in Group 3 (high myopia), with a statistically significant association. **Conclusion:** RNFL thickness decreases with increasing myopia, particularly in the superior, inferior, and nasal quadrants. Increased axial length is associated with greater myopia severity.

Keywords: Myopia, Retinal Nerve Fibre Layer (RNFL), Optical Coherence Tomography (OCT), Axial Length

INTRODUCTION

Myopia, also known as near-sightedness, is a refractive condition where incoming light focuses in front of the retina, usually due to an elongated eyeball or increased refractive power. This causes distant objects to appear blurry and shifts the eye's far point to a finite distance^{1,2}. Myopia can be classified based on its cause into axial, curvature-related, or lenticular types. Clinically, it is also divided into simple myopia—which typically stabilizes after childhood—and pathological myopia, which is characterized by progressive, degenerative changes in the posterior eye and may result in significant refractive errors and reduced visual acuity³.

The severity of myopia is commonly categorized by corrective lens power: low (≤ -3.00 D), moderate (-3.00 D to -6.00 D), and high (> -6.00 D). High myopia is frequently associated with retinal complications such as posterior staphyloma and posterior vitreous detachment (PVD)⁴. Additional forms of myopia include pseudomyopia, often linked to excessive accommodative effort; induced myopia, which may arise from certain drugs or systemic factors like altered blood glucose; and night myopia, which occurs in low-light environments⁵.

Globally, myopia represents a major cause of visual impairment. Structural changes in the eye—such as thinning of the retinal nerve fiber layer and formation of posterior staphylomas—are especially prevalent in high myopia^{6,7}. These alterations can be effectively assessed using advanced imaging modalities like Optical Coherence Tomography (OCT), which offers detailed cross-sectional views of the retina^{8,9}.

Currently, there is no definitive method to prevent the onset of myopia. However, several corrective options are available, including prescription eyeglasses, contact lenses, orthokeratology (Ortho-K), and refractive surgical procedures such as photorefractive keratectomy (PRK) and laser-assisted in situ keratomileusis (LASIK)^{10,11,12}. Additional interventions like phakic intraocular lenses and Ortho-K have shown promise, with the latter demonstrating effectiveness in slowing the progression of myopia^{13–16}.

The retinal nerve fiber layer (RNFL), made up of the axons of retinal ganglion cells, plays a vital role in visual processing and is particularly vulnerable to damage from conditions such as glaucoma. Its integrity can be assessed using Optical Coherence Tomography (OCT), a high-resolution, non-invasive imaging technology¹⁷. OCT allows for detailed visualization of retinal layers, making it an essential tool for identifying and monitoring structural changes related to myopia^{18–21}.

AIMS AND OBJECTIVES

1. To study the effect of myopia on the thickness of the retinal nerve fibre layer (RNFL) measured by Optical Coherence Tomography.
2. Evaluate the pattern of RNFL changes in different sectors of retina among myopes.
3. Evaluate the correlation of RNFL thickness with severity of myopia (low, moderate and high).

MATERIAL AND METHODS

This observational study was conducted at the Postgraduate Department of Ophthalmology, SKIMS Medical College Bemina, Srinagar, over a period of 1.5 years, from April 2019 to October 2021. Prior to enrollment, informed consent was obtained from each participant, and only those meeting the inclusion criteria were enrolled.

Inclusion Criteria

- Patients of either sex
- Age between 19 and 37 years
- Different degrees of myopia
- Intraocular pressure (IOP) < 21 mm Hg
- No glaucomatous changes (e.g., disc hemorrhages or glaucomatous cupping with vertical cup-disc ratio > 0.7)

Exclusion Criteria

- History of severe ocular trauma
- Previous intraocular or refractive surgery
- Diagnosed glaucoma or IOP > 21 mm Hg
- Neurologic diseases
- Diabetes
- Hypertension
- Media opacity

METHODS

The study included patients aged 19 to 37 years who were randomly selected from the outpatient department (OPD) of the Department of Ophthalmology at SKIMS Medical College Srinagar. Based on refractive error, subjects were divided into three groups:

- Group 1: Patients with low myopia (< 3D)
- Group 2: Patients with moderate myopia (3D to 6D)
- Group 3: Patients with high myopia (> 6D)

A thorough medical history was taken, followed by a systemic examination. Ocular assessment included:

- Visual Acuity: Measured using Snellen's chart
- Retinoscopy: Performed to determine refractive error
- Slit Lamp Biomicroscopy: For anterior segment examination
- Intraocular Pressure Measurement: Using a Goldmann's applanation tonometer
- Refraction: Determined using an automatic refractometer, with confirmation by a designated optometrist/ophthalmologist
- Axial Length Measurement: Performed using A-scan ultrasound

All participants underwent imaging with spectral domain optical coherence tomography (SD-OCT) using the Cirrus HD-OCT system. A 360-degree peripapillary scan was performed to evaluate the retinal nerve fiber layer (RNFL) thickness, segmented into four quadrants: superior, inferior, temporal, and nasal. RNFL measurements from each quadrant were then compared among the groups based on varying degrees of myopia severity.

Collected data were organized in Microsoft Excel and subsequently analyzed using SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were described using frequencies and percentages. Visual data representation included bar graphs and pie charts. To explore the relationship between RNFL thickness and myopia severity, a one-way analysis of variance (ANOVA) was conducted. A p-value below 0.05 was considered to indicate statistical significance, with all tests being two-tailed.

RESULTS

In this study, the age of patients ranged from 20 to 37 years, with a mean age of 27.1 ± 4.62 years. The majority of patients, 54 (36%), were in the age group of 25-29 years, followed by 47 (31.3%) patients in the age group of 20-24 years, 39 (26%) patients aged 30-34 years, and 10 (6.7%) patients aged above 35 years. The sample had a slight female predominance, with 51.3% (n=77) females and 48.7% (n=73) males. Patients were classified into three groups based on the severity of myopia: Group 1 (low myopia, n=150), Group 2 (moderate myopia, n=88), and Group 3 (high myopia, n=62).

The mean axial length in Group 1 (low myopia) was 22.7 ± 1.59 mm (95% CI: 22.7–23.2), in Group 2 (moderate myopia) was 23.8 ± 1.62 mm (95% CI: 23.4–24.1), and in Group 3 (high myopia) was 26.2 ± 2.23 mm (95% CI: 25.7–26.8). A statistically significant association was found between axial length and the severity of myopia ($p < 0.001$).

Table 1: Axial Length Distribution in Different Myopia Groups

Group	No. of Patients	Mean Axial	Mean Axial
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	(n)	Length (mm)	Length (mm)
Low Myopia (Group 1)	150	22.7 ± 1.59	22.7–23.2
Moderate Myopia (Group 2)	88	23.8 ± 1.62	23.4–24.1
High Myopia (Group 3)	62	26.2 ± 2.23	25.7–26.8

The peripapillary retinal nerve fibre layer (RNFL) thickness in the temporal, inferior, nasal, and superior quadrants showed significant differences between the three groups. The average RNFL thickness was significantly lower in the high myopia group (Group 3, $82.3 \pm 9.48 \mu\text{m}$) compared with the low (Group 1, $91.3 \pm 8.45 \mu\text{m}$) and moderate (Group 2, $87.5 \pm 9.61 \mu\text{m}$) myopic groups.

Table 2: RNFL Thickness in Different Myopia Groups (μm)				
Quadrant	Group 1 (Low Myopia)	Group 2 (Moderate Myopia)	Group 3 (High Myopia)	p-value
Temporal	65.86 ± 9.69	93.34 ± 11.81	62.68 ± 13.70	0.095
Superior	115.30 ± 13.34	109.93 ± 14.64	96.24 ± 19.94	< 0.001
Nasal	68.38 ± 8.43	63.91 ± 6.83	59.76 ± 12.97	0.003
Inferior	120.23 ± 14.19	113.89 ± 14.05	94.21 ± 15.71	< 0.001

When comparing RNFL thickness in each quadrant, we found a significant reduction in thickness in the high myopia group (Group 3) across all quadrants. In the temporal quadrant, the difference between groups was statistically insignificant ($p = 0.095$). However, in the superior ($p < 0.001$), nasal ($p = 0.003$), and inferior ($p < 0.001$) quadrants, RNFL thickness was significantly lower in the high myopia group compared to the low and moderate myopia groups.

In terms of overall RNFL thickness, Group 1 (low myopia) had a mean thickness of $91.3 \pm 8.45 \mu\text{m}$ (95% CI: 89.9–92.7), Group 2 (moderate myopia) had a mean of $87.5 \pm 9.61 \mu\text{m}$ (95% CI: 85.4–89.5), and Group 3 (high myopia) had a mean of $82.3 \pm 9.48 \mu\text{m}$ (95% CI: 79.8–84.7). The difference between these groups was statistically significant ($p < 0.001$).

Additionally, when analyzing the correlation of RNFL thickness with age, no significant difference was found. Patients aged 20–24 years had a mean RNFL of $88.61 \mu\text{m}$, followed by $88.41 \mu\text{m}$ in patients aged 25–29 years, $87.65 \mu\text{m}$ in patients aged 30–34 years, and $89.35 \mu\text{m}$ in patients aged above 35 years. The observed difference was statistically insignificant with a p-value of 0.873.

DISCUSSION

The evaluation of retinal nerve fiber layer (RNFL) thickness in individuals with myopia through Optical Coherence Tomography (OCT) offers important insights into the structural retinal changes associated with varying myopia severity. OCT, a highly sensitive and non-invasive imaging modality, has significantly enhanced the understanding of retinal pathologies by enabling precise measurement of RNFL thickness. Numerous studies have reported that myopia is linked with RNFL thinning, particularly in the temporal, superior, and inferior quadrants—findings that are consistent with the results observed in this study.

In the present analysis, the average age of participants was 27.1 ± 4.62 years, with most subjects aged between 25 and 29. These results are in line with earlier studies by Ahmad JL et al. (2017)²², Awasthi (1996)²³, and Porwal S et al. (2020)²⁴, which noted a higher prevalence of myopia in younger adults, typically in the 20–30-year age group. Additionally, no significant differences in RNFL thickness were observed between genders, corroborating findings by Biswas A et al. (2015)²⁵, who also reported no gender-related variations in RNFL measurements.

Our findings further demonstrated that axial length increases proportionally with the degree of myopia. Specifically, the mean axial length was $22.7 \pm 1.59 \text{ mm}$ in Group 1 (low myopia), $23.8 \pm 1.62 \text{ mm}$ in Group 2 (moderate myopia), and $26.2 \pm 2.23 \text{ mm}$ in Group 3 (high myopia). This progressive elongation of the eyeball with increasing myopic severity mirrors observations made in studies by Ahmad JI et al. (2017)²² and Das P et al. (2016)²⁶. The statistically significant correlation between axial length and myopia severity emphasizes the critical role of axial elongation in the development and progression of myopia.

In terms of retinal nerve fiber layer (RNFL) thickness, our study revealed a significant reduction in RNFL measurements among participants with high myopia (Group 3) when compared to those with low (Group 1) and moderate (Group 2) myopia. This thinning was most evident in the superior, nasal, and inferior quadrants. These observations are consistent with prior findings, such as those by Biswas A et al. (2015)²⁵, who noted thinning predominantly in the temporal quadrant in cases of low to moderate myopia, and by Mohammad Salih PA (2012)²⁷, who reported overall RNFL thinning in highly myopic eyes, excluding the temporal quadrant. Similarly, our study found no statistically significant difference in the temporal quadrant across groups, aligning with results from Said-Ahmed KEG et al. (2017)²⁸, who observed that this region tends to be less influenced by the degree of myopia.

Quantitatively, the superior quadrant demonstrated a marked decrease in RNFL thickness in the high myopia group, with an average of $96.24 \pm 19.94 \mu\text{m}$, compared to $109.93 \pm 14.64 \mu\text{m}$ in the moderate group and $115.30 \pm 13.34 \mu\text{m}$ in the low myopia group ($p < 0.001$). Significant thinning was also evident in the nasal ($p = 0.003$) and inferior ($p < 0.001$) quadrants. These results are in line with those of Kamath AR and Dudeja L (2014)²⁹ and Rauscher FM et al. (2009)³⁰, who identified similar patterns of RNFL reduction associated with increased axial length and higher myopia severity.

The underlying causes of RNFL thinning in myopic eyes are believed to involve multiple mechanisms. Elongation of the eyeball in myopia can exert mechanical tension on the retina, resulting in structural thinning. In addition, degenerative changes in the retina and enlargement of the optic disc in myopic eyes may lead to a redistribution of ganglion cell axons, further reducing RNFL thickness. Developmental factors, such as early-life regression of retinal ganglion cells, may also contribute. Our findings support the theory that these structural and developmental changes play a significant role in RNFL thinning, particularly in individuals with high myopia, where increased axial length and retinal degeneration are commonly observed.

Numerous studies have utilized Optical Coherence Tomography (OCT) to investigate changes in the retinal nerve fiber layer (RNFL) in myopic eyes. Research by Leung AK et al. (2006)³¹ and Rauscher FM et al. (2009)³⁰ identified a significant inverse relationship between axial length and RNFL thickness across most quadrants, with the exception of the temporal quadrant. These results align with the findings of our study, which also demonstrated marked RNFL thinning in the superior, nasal, and inferior quadrants as the severity of myopia increased.

CONCLUSION

This study demonstrated that individuals with high myopia show distinct patterns in retinal nerve fiber layer (RNFL) distribution, characterized by a notable reduction in thickness as myopia severity increases—especially in the superior, inferior, and nasal quadrants. The average RNFL thickness was found to decline with increasing myopia, with the thinnest measurements recorded in the high myopia group. Additionally, axial length showed a proportional increase with higher degrees of myopia, suggesting a mechanical stretching of the eye structure. These results underscore a strong association between RNFL thinning and the severity of myopia, highlighting the value of regular RNFL assessment in myopic patients—particularly those with high myopia—as an indicator of disease progression and retinal integrity.

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