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# Retinal Nerve Fiber layer (RNFL) Thickness Measurement with Optical Coherence Tomography (OCT) in Normal Children

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## Abstract

**Background and Objectives:** To assess retinal nerve fiber layer thickness in normal children using spectral-domain optical coherence tomography.

**Methods:** This cross-sectional study of 120 healthy participants collected data over six months (September 2022 to March 2023) in Shahid Aso Eye Hospital in the Sulaimany province. Parents provided demographic information (age, sex, residency), and general and ocular history was recorded. The Snellen E chart was used to record patient's visual acuity and spherical equivalent was calculated. Cycloplegic refraction, dilated fundus examination, and non-contact air puff tonometry were performed.

**Results:** Optical coherence tomography data was obtained from 120 participants (61.7% females, 38.3% males), mean age 12.2 ± 2.8, mean spherical equivalent of right eye -0.47 ± 1.3, mean spherical equivalent of left eye -0.39 ± 1.25. The mean retinal nerve fiber layer thickness was 101.12 ± 10 for the right eye and 100.2 ± 10.1 for the left eye, respectively. Age did not affect retinal nerve fiber layer thickness in either gender. Gender had statistically significant effect on retinal nerve fiber layer thickness in right eye's superior quadrant (P=0.02) and nasal quadrant (P=0.04). Right eye spherical equivalent had statistically significant impact on retinal nerve fiber layer thickness in right eye’s inferior and temporal quadrants (P=0.03).

**Conclusion:** This study's data can help create a standard pediatric database. Retinal nerve fiber layer thickness in children was mainly affected by gender and spherical equivalent, with no significant impact from age.

**Keywords:** Intraocular pressure, Retinal nerve fiber layer, Spectral domain optical coherence tomography, Spherical equivalent

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## Introduction

Optical coherence tomography (OCT) is a non-contact imaging technique that uses reflected light to generate detailed cross-sectional eye images. It provides non-invasive, reproducible, high-resolution, in vivo assessments of the retina and retinal nerve fiber layer (RNFL) for both adults and children.[1] Optical coherence tomography (OCT) is the optical equivalent of ultrasound imaging. In ultrasound, a sound pulse generates a cross-sectional image from detected echoes. Similarly, OCT emits a light pulse, but measures interference between light waves from the reference and sample arms instead of directly measuring reflection delays.[2,3] Optical coherence tomography (OCT) has become crucial for diagnosing and tracking glaucoma, detecting damage earlier than visual field tests.[4] Initially, 2.85 million optic nerve fibers are present, but 35% are lost by the third trimester, and the peripapillary retinal nerve fiber layer (RNFL) continues to thin with age. As people age, their refractive condition often shifts from hyperopia to myopia. This RNFL thinning can result from natural ganglion cell loss or axial elongation associated with myopia.[5] Time-domain OCT (TD-OCT) is a medical imaging technique that produces high-resolution images of body tissues using near-infrared light. This two-dimensional imaging method captures light wave reflections from various depths within the tissue.[6] Currently, the majority of commercial ophthalmic OCT systems are SD-OCT systems, which offer volumetric images of the human retina covering a field of view of at least 6 mm × 6 mm × 2 mm. These systems achieve a lateral resolution better than 20 µm and an axial resolution of around 5 µm in tissue.[7] The retinal nerve fiber layer (RNFL) consists of ganglion cell axons that traverse the inner retina and form the optic nerve, extending to the brain's lateral geniculate nucleus.[8] After passing through the lamina cribrosa sclerae, the retinal nerve fiber layer (RNFL) forms the optic nerve. Measuring RNFL thickness is a common in vivo method to assess optic nerve function. [9] The aim of this study is to assess the thickness of the RNFL using OCT in normal children aged 7 to 17 years old and determine impact of age, sex and spherical equivalent on RNFL thickness.

## Patients and methods

This is a cross-sectional study of 120 participants aged between 7 and 17 years. Data acquisition spanned duration of six months, commencing from September 2022 through March 2023, in Shahid Aso Eye Hospital in the Sulaimany province. Guardians provided informed consent, including procedure details and potential adverse effects. Patients' demographic data, including age, gender, and residency, were documented. A comprehensive medical and ocular history, including past systemic or ocular diseases, was obtained for each child. The study included children aged 7 to 17 with normal optic nerve heads and intraocular pressure (IOP) ≤ 21 mmHg. Children who exhibited elevated levels of hypermetropia ≥ +4.0, myopia ≥ -5.0, astigmatism ≥ -4.0 and conditions such as amblyopia, glaucoma, and various vascular, metabolic, neurological, and other related disorders, were ineligible for inclusion in the study. Each participant underwent a comprehensive ocular assessment, including evaluation of uncorrected and best corrected visual acuity using the Snellen E chart by a proficient optometrist with a trial frame adjusted on the participant's face. Refractive status was assessed pre- and post-cycloplegia using the Nidek ARK-1 auto-refractor for each child, with two rounds of 1% cyclopentolate and 1% tropicamide eye drops administered 10 minutes apart. After 30 minutes, a third round of cyclopentolate and tropicamide drops was given. Cycloplegic refraction, performed post 1% cyclopentolate administration, determined the spherical equivalent.



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Following that, slit-lamp biomicroscopy examined the anterior segment, a dilated fundus exam utilized a 90D Volk lens, and non-contact tonometry assessed intraocular pressure (IOP). After pupil dilatation, optical coherence tomography (OCT) examinations were conducted using the iVue (Version 2018.0.0.41) ©2004-2023 Optovue, Inc., a spectral domain (SD-OCT) device, to assess peripapillary retinal nerve fiber layer (RNFL) parameters for all participants. The instrument uses a scanning laser diode emitting a scan beam with an average wavelength of 840±10 nm, capturing high-resolution images of ocular microstructures. Participants were selected using simple random sampling. Data analysis utilized SPSS-24 software, employing Student's t-test and chi-square test to delineate relationships among factors at a significance level of 0.05. Throughout data collection and research, ethical considerations were followed under the management of both the Ministry of Higher Education and the Ministry of Health. and ethical approval was obtained from the Kurdistan Higher Council of Medical Specialties (KHCMS) Research Protocol Ethics Committee on November 26, 2023, under issue number 9.

## Results

This study involved one hundred and twenty participants, with 61.7% being females (74 children) and 38.3% being males (46 children). All participants were examined in Shahid Aso Eye Hospital in Sulaimany. The mean age was 12.2 ±2.8. The mean vision of the right eye was 0.69 ± 0.29 and the mean vision of the left eye was 0.71 ± 0.29. The mean SE of the right eye was -0.47 ± 1.3 and the mean SE of the left eye was -0.39 ± 1.25, as illustrated in Table (1).

**Table (1):** This table describes the mean of different variables

| Variable of interest | Mean | SD |
|---|---|---|
| Age | 12.2 | 2.8 |
| Right eye vision | 0.69 | 0.29 |
| Left eye vision | 0.71 | 0.29 |
| Right eye SE | -0.48 | 1.3 |
| Left eye SE | -0.4 | 1.25 |

Detailed demographic information regarding the retinal nerve fiber layer (RNFL) thickness for both the right and left eyes is displayed below in Table (2).

**Table (2):** This table describes RNFL thickness in different quadrants of the right and left eyes

| Quadrants | Mean | SD |
|---|---|---|
| Right eye average RNFL | 101.12 | 10 |
| Right eye superior RNFL | 122.22 | 13.59 |
| Right eye inferior RNFL | 123.42 | 16.29 |
| Right eye nasal RNFL | 81.55 | 13.71 |
| Right eye temporal RNFL | 75.66 | 11.55 |
| Left eye average RNFL | 100.2 | 10.1 |
| Left eye superior RNFL | 120.65 | 15.72 |
| Left eye inferior RNFL | 123.57 | 17.77 |
| Left eye nasal RNFL | 80.94 | 16.44 |
| Left eye temporal RNFL | 73.18 | 10.39 |

The thickest quadrants of the RNFL were in the following sequence: inferior, superior, nasal, and temporal quadrants. Applying simple regression analysis, age difference did not demonstrate statistically significant impact on the thickness of the retinal RNFL across all quadrants, with “P values” of 0.1 for the right eye and 0.58 for the left eye, as shown in Table (3).


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**Table (3):** This table describes the significance of age to RNFL in each quadrant

| Ageα RNFL | P value |
|---|---|
| Right eye | 0.1 |
| Left eye | 0.58 |
| Superior Right | 0.28 |
| Inferior Right | 0.33 |
| Nasal Right | 0.25 |
| Temporal Right | 0.17 |
| Superior Left | 0.7 |
| Inferior Left | 0.45 |
| Nasal Left | 0.19 |
| Temporal Left | 0.2 |

Using regression analysis, no significant differences in the RNFL thickness between the left and right eyes based on gender were observed, with “P values” of 0.1 and 0.58, respectively. However, gender did have an impact on the superior quadrant (P = 0.02) and nasal quadrant (P = 0.04) of the right eye as demonstrated in Table (4).

**Table (4):** This table describes the significance of sex to RNFL in each quadrant

| Sexα RNFL | P value |
|---|---|
| Right | 0.11 |
| Left | 0.34 |
| Right Superior | 0.02* |
| Right Inferior | 0.12 |
| Right Nasal | 0.04* |
| Right Temporal | 0.63 |
| Left Superior | 0.13 |
| Left Inferior | 0.11 |
| Left Nasal | 0.39 |
| Left Temporal | 0.28 |

*Significant P value

Simple regression analysis revealed no significant impact of SE on RNFL in either eye, except for the right eye, where SE significantly affected its inferior and temporal quadrants (P = 0.03). The regression analysis depicting the relationship between the spherical equivalent (SE) of both right and left eyes and the retinal nerve fiber layer (RNFL) of both right and left eyes is shown in Figures (1) and (2) below.

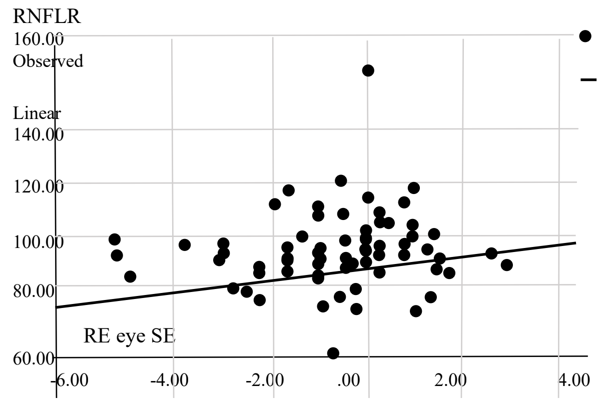


**Figure (1):** This figure shows regression analysis between right eye SE and right eye RNFL

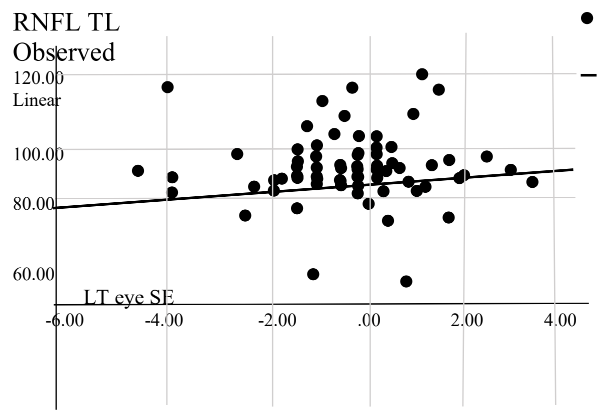


**Figure (2):** This figure illustrates regression analysis between left eye SE and left eye RNFL

## Discussion

Accurate measurement of the peripapillary retinal nerve fiber layer (pRNFL) has become an essential factor in the diagnosis and monitoring of glaucoma in adults and children.[10] In early disease stages, when visual fields seem normal, evaluating the optic nerve head (ONH) and RNFL is


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essential for diagnosis and management.[11] Optical coherence tomography serves as a non-invasive supplementary diagnostic tool for glaucoma, allowing quantitative assessment of RNFL thickness and optic disc parameters.[12] Analysis revealed average RNFL thicknesses: 101.1 ± 10 for the right eye and 100.2 ± 10.1 for the left eye, closely matching earlier studies' findings. Wang et al.'s Gobi Desert Children Eye Study reported similar measurements: 101.3 ± 9.2 µm in right eyes and 101.2 ± 9.3 µm in left eyes.[13] Similarly, Söhnel et al. reported a mean global RNFL thickness of 102.88 ± 8.79 µm.[14] RNFL exhibited greatest thickness in inferior, superior, nasal, and temporal regions, consistent with ISNT rule observed in previous studies, aligning with a study conducted by Pawar et al.[15] In our study, age did not show a statistically significant effect on RNFL, aligning with the findings presented by Kang et al, Wang et al while Söhnel et al and Zhang et a showed significant age-associated changes in various macular layers and peripapillary retinal nerve fiber layer thickness. [11,13,14,16] In this study, no statistically significant variance between males and females in RNFL thickness was observed, except in the right superior and right nasal quadrants (P values 0.02 and 0.04, respectively). Other studies by Al-Haddad et al and Cubuk et al discovered that gender had no impact on the thickness of RNFL. Li et aland Zhao et al observed a thicker RNFL in females. In this study, RNFL thickness was unaffected by SE, except in the right inferior and right temporal quadrants (P value 0.03 for both).[17-20] Unlike studies by Eslami et al and Ayala et al, notable correlation between SE and RNFL thickness was found. While Larsson et al and Jeong et al reported a negative correlation between RNFL thickness and SE.[21-24] Awareness of limitations is crucial, notably the relatively small sample size for statistical analysis. Minor inconsistencies in scan acquisition may have occurred, potentially misrepresenting distances from the optic disc in some RNFL measurements, despite excluding scans with noticeable discontinuities. Limited availability of prior research on this subject is another restriction.

## Conclusion

Retinal nerve fiber layer thickness in children was primarily influenced by gender and spherical equivalent, with age having no significant effect. This study's data can aid in establishing a reference database for pediatrics.

## Conflict of Interest

The authors declare no conflicts of interest. All authors approved the manuscript, disclosing no financial interests. This submission is original and not under review elsewhere.

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