Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Evaluation of the Strength and Pattern of Relationship between Visual Field Sensitivity and Retinal Nerve Fiber Layer Thickness as Measured by Optical Coherence Tomography in Patients Having Primary Angle-Closure Glaucoma

Amrita Dey[1], Amrita Pal[2], Oishwarya Chakraborty[3]

[1]Senior Resident, Department of Ophthalmology, Medical College Kolkata, Kolkata,West Bengal, India, [2]Resident Medical Officer, Department of Ophthalmology, Medical College Kolkata, Kolkata, West Bengal, India, [3]Junior Resident, Department of Ophthalmology, Medical College Kolkata, Kolkata,West Bengal, India

Abstract

Objective: The objective of the study was to evaluate the strength and pattern of relationship between visual field (VF) sensitivity and retinal nerve fiber layer (RNFL) thickness as measured by optical coherence tomography (OCT) in patients having primary angle-closure glaucoma.

Materials and Methods: In this hospital-based cross-sectional study, a total of 50 patients visiting the outpatient department of a tertiary care eye center in Kolkata and satisfying the inclusion criteria were randomly selected. The patients into groups underwent complete ocular examination. Total study was for 18 months (January 1, 2019–June 30, 2020). Subjects underwent detailed ophthalmic examination including slit-lamp examination, intraocular pressure (IOP) measurement, gonioscopy, stereoscopic fundus examination, automated VF testing, and Heidelberg Spectralis OCT fast RNFL scan.

Results: Regression analysis was used to correlate the VF parameters on standard automated perimetry (SAP) with the average and sectoral RNFL thickness in OCT. Data were analyzed using Microsoft Excel 2007 and GraphPad Prism 8.0.0. The mean (±SD) age of the study group was 51.79 ± 10.32 years. The mean (±SD) IOP of the population was 20.04 ± 3. Regarding the VCDR, maximum patients (*n* = 27) had 0.7 cupping followed by 0.8 (*n* = 26) and 0.6 (*n* = 22) cupping, respectively. Mean MD (±SD) and PSD (±SD) of the population were −10.28 ± 5.88 and 8.12 ± 3.77, respectively. Mean (±SD) superior and inferior hemifield sensitivities were 18.45 ± 7.71 and 20.43 ± 6.54, respectively. Mean (±SD) values of superior, inferior, temporal, and nasal RNFL thickness were 87.29 (±29.41), 79.08 (±31.96), 61.2 (±15.19), and 64.62 (±17.41), respectively. Mean TSNIT average (±SD) was 72.96 (±17.72). Plotting TSNIT avg. RNFL thickness against age, the slope showed a 0.393 μm yearly decline in average RNFL thickness.

Conclusion: As per this study, it was concluded that there is a direct correlation between the VF loss in automated perimetry and the RNFL loss in OCT. Therefore, OCT can be considered for monitoring the progression of glaucoma.

Key words: Primary angle-closure glaucoma, Retinal nerve fiber layer, Sensitivity, Visual Field

Access this article online

www.ijss-sn.com

Month of Submission : 07-2022
Month of Peer Review : 08-2022
Month of Acceptance : 08-2022
Month of Publishing : 09-2022

INTRODUCTION

Glaucoma is a group of disorder characterized by progressive irreversible optic neuropathy consistent with excavation and undermining of the neural and connective tissue elements of the optic disk and specific pattern of visual field (VF) defects that are associated frequently

Corresponding Author: Dr. Amrita Dey, 8/16, A, Prabhuram Sarkar Lane, Tangra, Kolkata - 700 015, West Bengal, India.

but not invariably with raised intraocular pressure. It is associated with accelerated apoptosis of retinal ganglion cells (RGCs) that manifest as increased cupping of the optic disk and thinning of the retinal nerve fiber layer (RNFL).[1]

Glaucoma affects more than 67 million person worldwide, of whom about 10% or 6.6 million are estimated to be blinded by it. Glaucoma is the leading cause of irreversible blindness worldwide and is the second only to cataract as the most common cause of blindness overall. The incidence of primary angle glaucoma closure glaucoma was estimated at 2.4 million persons per year. In India, 12.8% of total blindness are reported to occur due to glaucoma. Asians represent 47% of those with glaucoma[2] and 7% of those with angle-closure disease. The prevalence of PACG in South India ranges from 0.5% to 4.30%,[3] whereas in East India, it was only 0.23%.[4]

Primary angle-closure glaucoma is defined as a progressive, chronic optic neuropathy in adults where intraocular pressure and other currently unknown factors contribute to damage and in which, in the absence of other identifiable causes, there is characteristic acquired atrophy of the optic nerve and loss of retinal ganglion cells and their axons. This is associated with an anterior chamber angle that is closed by gonioscopic appearance.

As the visual loss in primary angle-closure glaucoma can be silent, sustained, and often without symptoms it goes unnoticed, undetected, and undiagnosed in many cases. It is well known in clinical practice that RNFL defects are very early signs of glaucoma, since they present the first step in the glaucomatous morphological loss in the retina. RNFL changes precede the appearance of functional changes in the VF and thus have greater value as early indication of the disease.[5-7]

An accurate evaluation of RNFL and ONH damage thus seems to be crucial for an early diagnosis of glaucoma. Optical coherence tomography (OCT) represents an useful method for objective detection and quantification of glaucomatous RNFL atrophy.[8-10] It has been demonstrated to have high levels of reproducibility,[11] to incorporate age-matched normative data, and to allow non-invasive assessment of the peripapillary RNFL.

The Aim of this Study

The aim of the study was as follows:

1. To evaluate the strength and pattern of the relationship between VF sensitivity as measured by standard automated perimetry (SAP) and RNFL thickness as measured by SD-OCT in different stages of primary angle-closure glaucoma.
2. To determine the regional relationship between major areas of glaucomatous RNFL thinning identified by OCT and areas of decreased VF sensitivity identified by SAP in glaucomatous eyes.
3. To quantify the correlation between increasing age and RNFL thickness.
4. To find out the association between disc changes as measured by VCDR and average RNFL thickness.

MATERIALS AND METHODS

Population-based studies are important for the assessment of disease burden, health-care policy planning, and appropriate resource allocation. This is a hospital-based cross-sectional study which was conducted in patients visiting the outpatient department and glaucoma clinic of a tertiary eye care center in Kolkata. Fifty patients attending the outpatient department and glaucoma clinic were selected. The study commenced on January 2019 and concluded on June 2020.

The Institutional Ethics Review Board approved the study that adhered to the tenets of the Declaration of Helsinki.

Inclusion Criteria

All patients diagnosed as established cases of primary angle-closure glaucoma.

- Age between 18 and 70 years.
- IOP >21 mm of Hg at some stage

Glaucomatous optic neuropathy (GON) defined as vertical cup-disk asymmetry between fellow eyes of 0.2, a cup-disk ratio of 0.6, focal or diffuse neuroretinal rim narrowing with concentric enlargement of the optic cup, localized notching, or both as seen by stereoscopic ophthalmoscopy with +90 D lens.

- Glaucomatous VF defects in 24-2 SAP defined as those with
- On pattern deviation plot a cluster of ≥3 contiguous points with a sensitivity loss of $P < 5\%$ in the superior or inferior arcuate areas, at least one of which is depressed below the 1% level.
- Pattern standard deviation significant at $P < 5\%$
- An abnormal result in the glaucoma hemifield test.
- Closed angles obtained on gonioscopy
- Good quality scans obtained in peripapillary RNFL
- thickness evaluation by OCT, with a signal-to-noise ratio of>35;
- Good quality SAP
- performed at ±1 month from OCT imaging; with fixation losses below 20% and false positives and negatives below 20%
- Refractive error within a ±6 spherical diopter range, with less than ±3 cylinder diopters
- Informed written consent.

Exclusion Criteria

- Best-corrected visual acuity on the Snellen chart worse than 6/18.
- Corneal or lens opacity that interfered with clinical evaluation of the optic disk and posterior pole through an undilated pupil,
- Significant parapapillary atrophy that caused blind spot enlargement on the VF tests, interfered with VF readings, or causing false nerve fiber layer thickness data by OCT evaluation.
- Patients with tilted discs or any vitreal or retinal diseases were excluded, as well.
- Open-angle glaucoma,
- Secondary glaucomas,
- History of intraocular surgery, except uncomplicated cataract surgery
- Diabetes mellitus
- Diseases affecting VF, for example, pituitary lesions, demyelinating diseases, neurological causes, and AIDS.
- Patients on medications known to affect VF sensitivity (e.g., chloroquine).

On arrival at the examination center, the subjects were requested to sign an informed consent. In the case of illiterate subjects, the consent form was readout to them in their vernacular language in the presence of either a relative or a community volunteer. The left thumb impression was used as a signature for illiterate patients.

They then proceeded through various ophthalmic examinations and diagnostic procedures in the following order:

1. Ocular and medical history
2. Lensometry was performed where necessary
3. Refraction and recording of best-corrected visual acuity
4. Pupillary evaluation
5. Corneal pachymetry: The central corneal thickness was measured using the ultrasound pachymeter
6. Slit-lamp bio-microscopy, including van Herrick grading of the angle of the anterior chamber angle, was performed
7. Applanation tonometry: Intraocular pressure (IOP) recording with the Goldmann applanation tonometer was done. Calibration was done by trained senior glaucoma surgeons on a weekly basis
8. Gonioscopy: A Goldmann 3-mirror hand-held gonioscope was used, and the angle was graded according to the Shaffer system. Gonioscopy was performed in dim ambient illumination with a shortened slit that did not fall on the pupil. An angle was considered occludable if the pigmented trabecular meshwork was not visible in >270° of the angle in dim illumination. All subjects with occludable angles in one or both the eyes were deemed to have primary angle-closure disease (PACD). If the angle was occludable, indentation gonioscopy was performed, and the presence or absence of peripheral anterior synechiae was recorded. Laser iridotomy was performed in subjects with occludable angles after obtaining their consent. The rest of the examination was deferred to another convenient date following laser iridotomy
9. Grading of lens opacities (Lens Opacities Classification System II)
10. Fundus examination using +90 D lens
11. Optic disk evaluation was done using + 78D lens. The vertical cup-disk ratio was recorded, and a special note was made of peripapillary atrophy and optic disk/peripapillary hemorrhage, bayoneting sign, baring of circumlinear vessels, and laminar dot sign
12. Automated VF testing was done in all subjects using Humphrey field analyzer using central 24-2 SITA standard test
13. Heidelberg Spectralis OCT fast retinal nerve fiber layer (RNFL) scan was employed to determine RNFL analysis.

Statistical Analysis Plan

Regression analysis was used to correlate the VF parameters on SAP with the average and sectoral RNFL thickness in OCT. Data were analyzed using Microsoft Excel 2007 and GraphPad Prism 8.0.0.

$P < 0.05$ was considered to be statistically significant.

RESULTS

A total of 50 patients were enumerated who visited the outpatient department from January 2019 to June 2020.

Data from all the 50 subjects were analyzed.

The mean (±SD) age of the study group was 51.79 ± 10.32 years (Table 1). About 61% of the participants were male and 39% were female (Tables 2 and 3).

Table 1: Age distribution of patients

Age group (in years)	Number	Percentage
<20	0	0
20–30	4	4.45
30–40	4	4.45
40–50	29	32.22
50–60	31	34.45
60–70	22	24.45

Table 2: Gender distribution of the patients

Gender	Number	Percentage
Male	55	61
Female	35	39

The mean (±SD) IOP of the population was 20.04 ± 3.72 (Table 4).

About 60% of the patients had a visual acuity equal to or worse than 6/12 (Table 5).

Table 3: Laterality of the eye

Laterality of the eye	Number	Percentage
Right	43	48
Left	47	52

Table 4: Distribution of IOP in the study population

IOP (mmHg)	No. of patients
<10	0
10–15	4
15–20	38
20–25	40
25–30	7
30–35	1

IOP mean with SD: 20.04±3.72

Table 5: Distribution of BCVA in the study population

BCVA	No. of patients
6/6	15
6/9	15
6/12	30
6/18	30

Table 6: Distribution of vertical C/D ratio in the study population

Vertical C/D ratio	No. qof patients
0.4	1
0.5	8
0.6	22
0.7	27
0.8	26
0.9	6

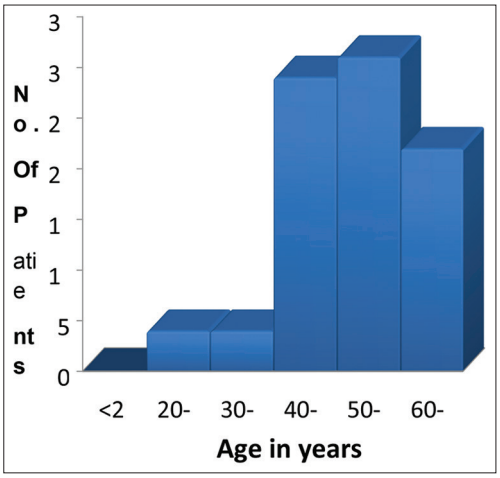

Figure 1: Bar chart showing age distribution of patients

Regarding the VCDR, maximum patients (n = 27) had 0.7 cupping followed by 0.8 (n = 26) and 0.6 (n = 22) cupping, respectively (Tables 6 and 7).

Mean MD (±SD) and PSD (±SD) of the population were −10.28 ± 5.88 (Figures 1 to 7) and 8.12 ± 3.77 (Figure 8), respectively.

Mean (±SD) superior and inferior hemifield sensitivities were 18.45 ± 7.71 and 20.43 ± 6.54, respectively (Figures 9 and 10).

Mean (±SD) values of superior, inferior, temporal, and nasal RNFL thickness were 87.29 (±29.41), 79.08 (±31.96), 61.2 (±15.19), and 64.62 (±17.41), respectively (Table 8).

Mean TSNIT average (±SD) was 72.96 (±17.72) (Figures 11 and 12).

Plotting TSNIT avg. RNFL thickness against age, the slope showed a 0.393 μm yearly decline in average RNFL thickness (Figures 13 and 14).

Plotting vertical cup-disk ratio against TSNIT average, we get a negative slope correlation with R^2 = 0.23 and $P < 0.0001$ (Figures 15 to 17).

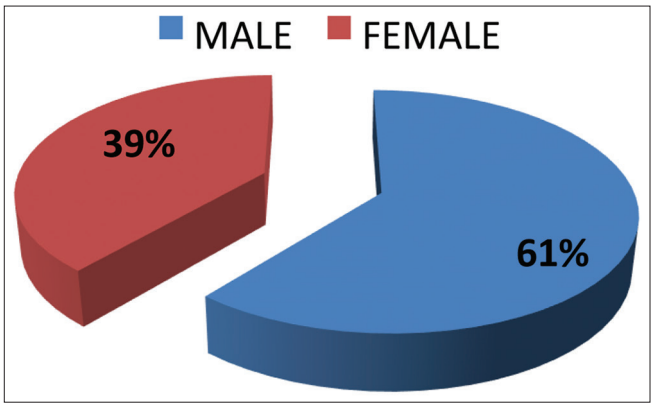

Figure 2: Pie chart showing gender distribution of the patients

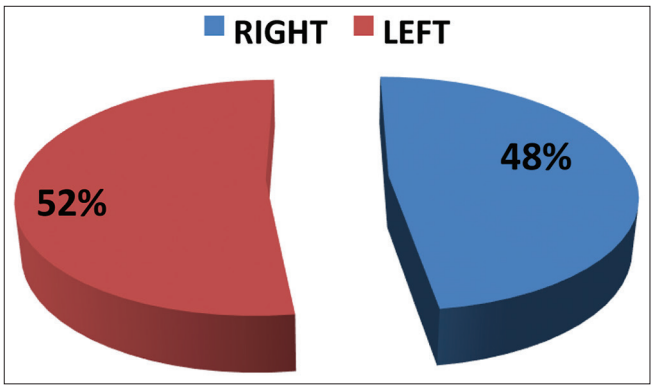

Figure 3: Pie chart showing laterality of the eyes

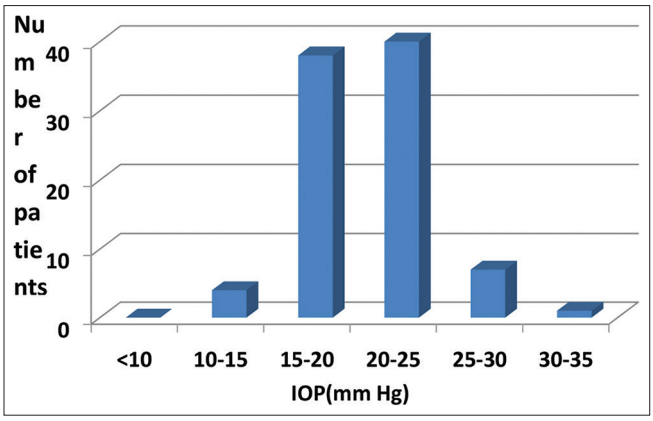

Figure 4: Bar chart showing distribution of IOP in the study population

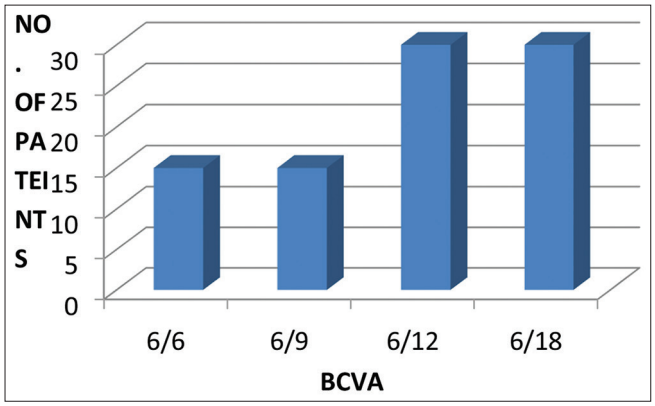

Figure 5: Bar chart showing distribution of BCVA in the study population

Table 7: Visual field parameters in the study population

Parameter	Mean	Standard deviation	Range
MD	−10.28	5.88	−26.82–[−1.35]
PSD	8.12	3.77	1.47–15.78
Superior hemifield sensitivity	18.45	7.72	0.24–29.28
Inferior hemifield sensitivity	20.43	6.54	1.33–29.9

Demographic Characteristics

No. of patients	50
No. of eyes	90
Minimum age	20 years
25% percentile	45 years
Median age	52 years
75% percentile	59.25 years
Maximum 70 years range	50 (20–70)
Mean	51.79 years
Standard deviation	10.32
Standard error of mean	1.088

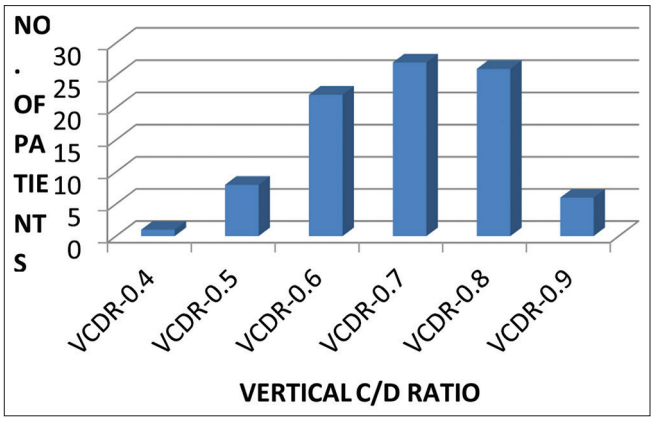

Figure 6: Bar chart showing distribution of vertical C/D ratio in the study population

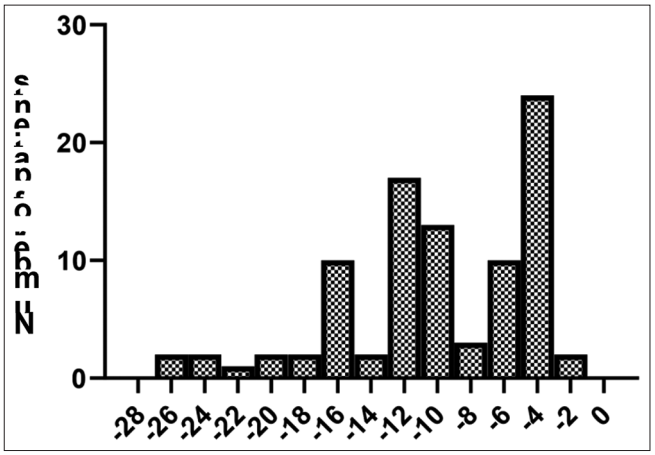

Figure 7: Histogram of frequency distribution of mean deviation

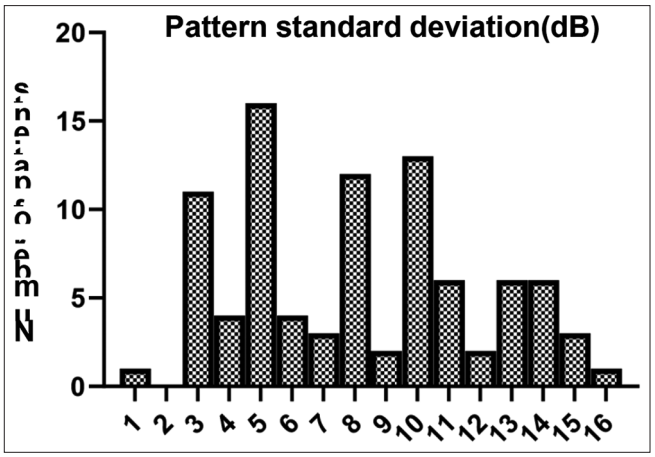

Figure 8: Histogram of frequency distribution of pattern standard deviation (dB)

DISCUSSION

Glaucoma is an optic neuropathy characterized by loss or retinal ganglion cells and their axons, the RNFL. Glaucoma is the leading cause of irreversible blindness worldwide and is the second only to cataract as the most common cause of blindness overall.[12] Primary angle-closure glaucoma is associated with or without raised intraocular pressure(IOP), but VF loss and specific

Goodness of fit	
R square	0.4187
Is slope significantly non-zero?	
F	63.39
DFn, DFd	1, 88
P value	<0.0001
Deviation from zero?	Significant

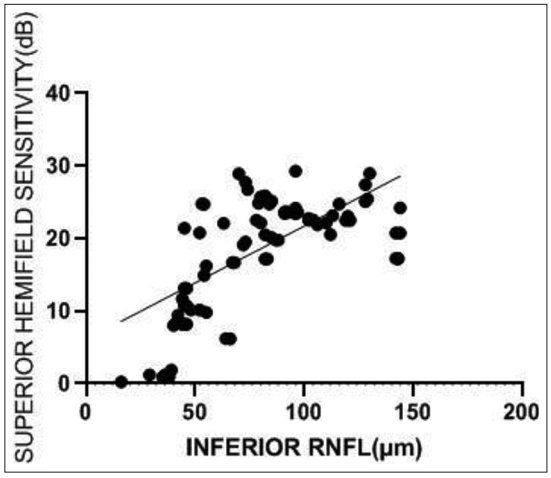

Figure 9: Inferior RNFL versus superior hemifield (scatter plot)

Goodness of fit	
R square	0.4252
Is slope significantly non-zero?	
F	65.11
DFn, DFd	1, 88
P value	<0.0001
Deviation from zero?	Significant

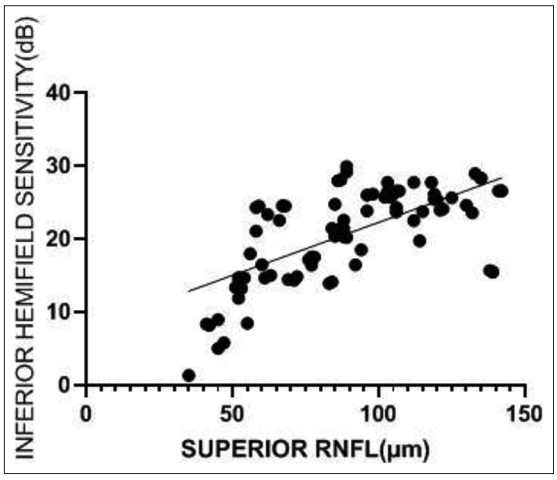

Figure 10: Superior RNFL versus inferior hemifield (scatter plot)

pattern of optic nerve damage are characteristic. As the disease progresses VF loss and optic nerve damage increases in a characteristic way. The major hurdle is in the diagnosis of PACG patients as these patients often present in the late stage when majority of the damage is already done. Therefore, both the parameters, that is,

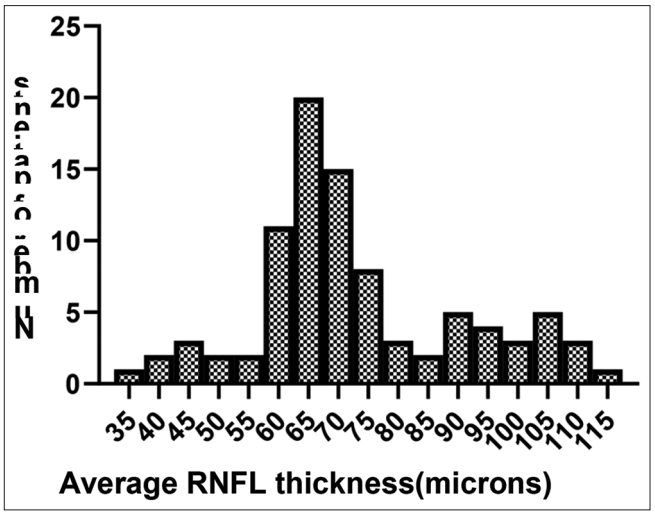

Figure 11: Histogram of frequency distribution of average RNFL

Goodness of Fit	
R square	0.05245
Is slope significantly non-zero?	
F	4.871
DFn, DFd	1, 88
P value	0.0299
Deviation from zero?	Significant

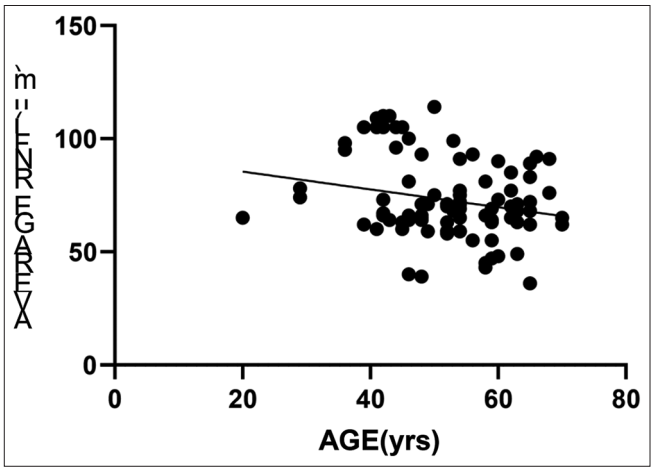

Figure 12: Age versus average RNFL (scatter plot)

VF loss and optic nerve damage, are essential for the detection of primary angle-closure glaucoma and also to detect its progression.

The mean (±SD) age of the study group was 51.79 ± 10.32 years. About 61% of the participants were male and 39% were female. It is to be noted that the mean age in this study was much lower than some other famous studies like Nilforushan *et al.*[13] in which was about 66.5 years or Ajtony *et al.*[14] in which it was 63.4 years. Hence, this study is looking at a much younger age group.

The mean (±SD) IOP of the population was 20.04 ± 3.72.

Goodness of fit	
R square	0.01185
Is slope significantly non-zero?	
F	1.055
DFn, DFd	1, 88
P value	0.3071
Deviation from zero?	Not significant

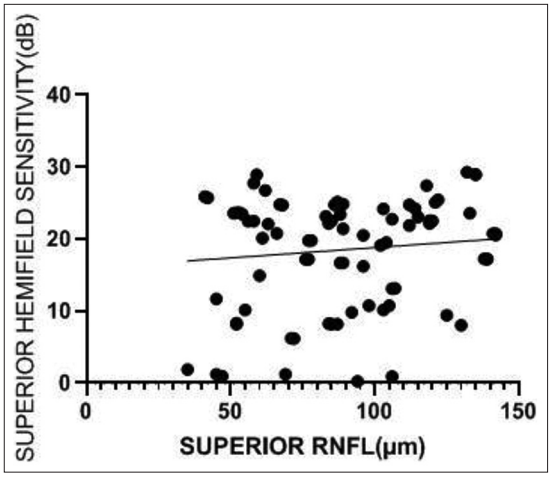

Figure 13: Superior RNFL versus superior hemifield (scatter plot)

Goodness of fit	
R square	0.02387
Is slope significantly non-zero?	
F	2.152
DFn, DFd	1, 88
P value	0.1459
Deviation from zero?	Not significant

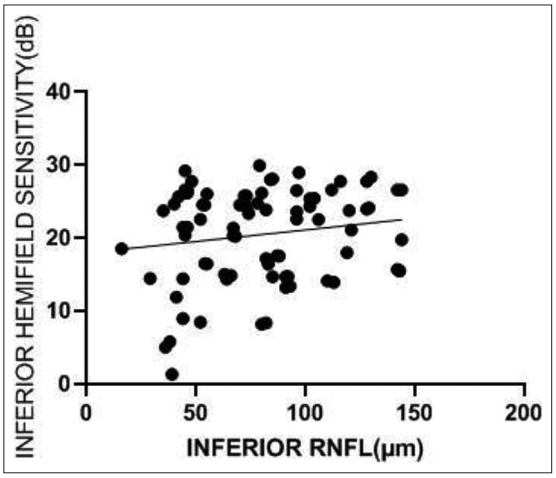

Figure 14: Inferior hemifield versus inferior RNFL (scatter plot)

Mean MD (±SD) and PSD (±SD) of the population were −10.28 ± 5.88 and 8.12 ± 3.77, respectively. In Nilforushan *et al.,* it was −1.3 ± 1.9 and 2.3 ± 1.2, respectively. In Ajtony *et al.*, it was about 4.33 ± 5.00 and 4.05 ± 3.31, respectively.[14]

Goodness of fit	
R square	0.2285
Is slope significantly non-zero?	
F	26.07
DFn, DFd	1, 88
P value	<0.0001
Deviation from zero?	Significant

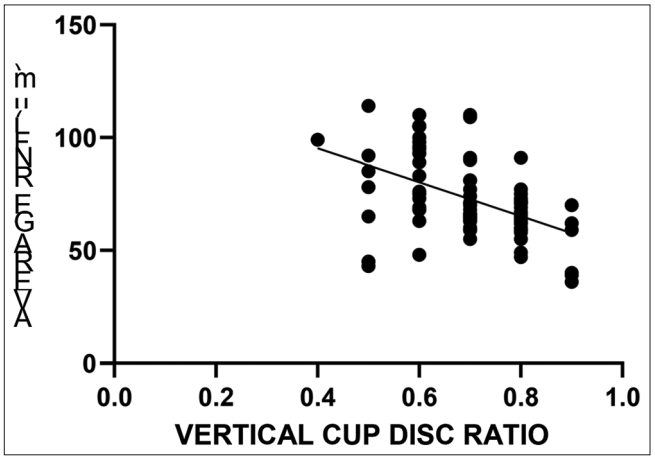

Figure 15: VCDR versus average RNFL (scatter plot)

Goodness of fit	
R squared	0.4205
Is slope significantly non-zero?	
F	63.86
DFn, DFd	1, 88
P value	<0.0001
Deviation from zero?	Significant

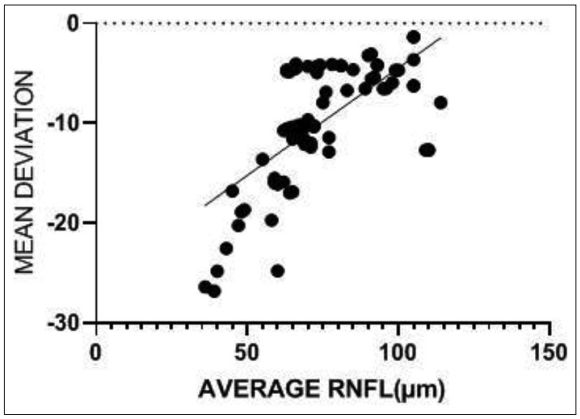

Figure 16A: Average RNFL versus mean deviation – linear regression (scatter plot)

Table 8: RNFL parameters in the study population

Parameter	Mean	Standard deviation	Range
Superior RNFL	87.29	29.41	35–142
Inferior RNFL	79.08	31.96	16–144
Temporal RNFL	61.20	15.19	26–90
Nasal RNFL	64.62	17.41	26–109
TSNIT average RNFL	72.96	17.72	36–114

Goodness of fit	
Degrees of freedom	87
R squared	0.6388
Sum of squares	1110
Sy.x	3.573

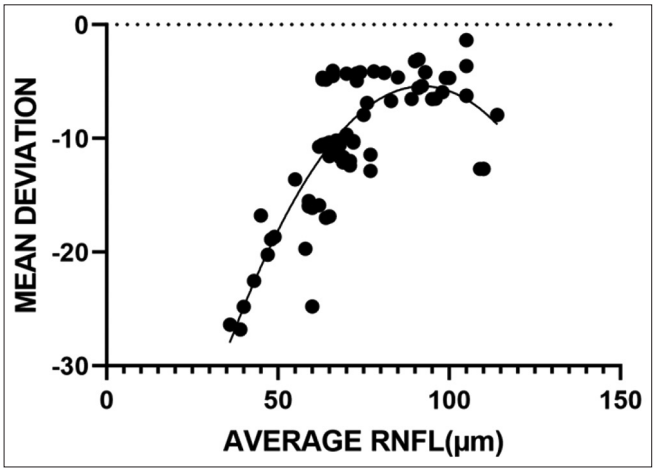

Figure 16B: Average RNFL thickness versus mean deviation: Non-linear regression (scatter plot)

Goodness of fit	
R square	0.2094
Is slope significantly non-zero?	
F	23.30
DFn, DFd	1, 88
P value	<0.0001
Deviation from zero?	Significant

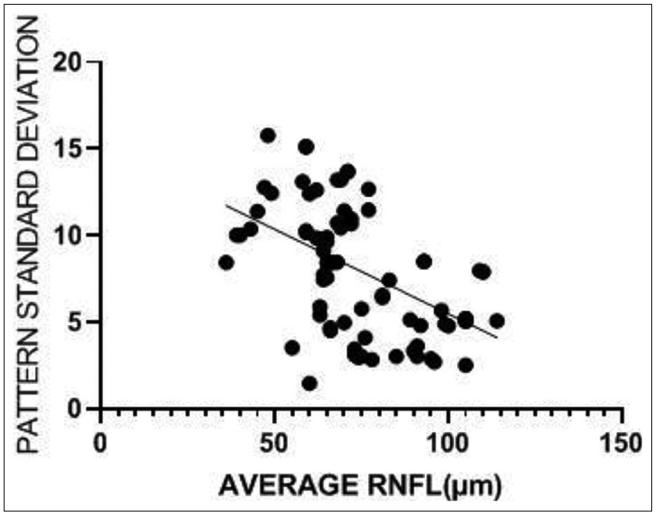

Figure 17: Average RNFL versus PSD (scatter plot)

Hence, this study is looking at subjects with advanced VF defects. It is to be mentioned here that both the above studies had pre-perimetric and glaucoma suspects in their consideration.

Mean (±SD) superior and inferior hemifield sensitivities were 18.45 ± 7.71 and 20.43 ± 6.54, respectively.

Mean (±SD) values of superior, inferior, temporal, and nasal RNFL thickness were 87.29 (±29.41), 79.08 (±31.96), 61.2 (±15.19), and 64.62 (±17.41), respectively.

Mean TSNIT average (±SD) was 72.96 (±17.72).

The mean RNFL thickness in Nilforushan *et al.* was 85.6 and 77.9 in Ajtony *et al.*, so this study is looking at patients with much more greater RNFL thinning (Table 8).

Regarding the VCDR, maximum patients (n = 27) had 0.7 cupping followed by 0.8 (n = 26) and 0.6 (n = 22) cupping, respectively.

About 60% of the patients had a visual acuity equal to or worse than 6/12.

Plotting TSNIT avg. RNFL thickness against age, we got a negative slope correlation with R^2 = 0.05 and P = 0.03 (<0.05), which was statistically significant.

The slope showed a 0.393 µm yearly decline in average RNFL thickness with increasing age. Other researchers like Ajtony *et al.* got a decrease of 0.36 µm/year.[14] Alamouti and Funk[15] reported a 0.44 µm yearly decline, whereas Kanamori *et al.*[16] calculated 0.22 µm per year using OCT II.

Plotting vertical cup-disk ratio against TSNIT avg., we get a negative slope correlation with R^2 = 0.23 and P < 0.0001, which was statistically significant. That is with increasing VCDR, the average RNFL decreases.

Plotting mean deviation against avg. RNFL thickness, we get a positive linear correlation slope with R^2 = 0.42 and P < 0.0001, which was statistically significant. That is, as the mean deviation became less negative, the average RNFL thickness increases.

When plotted using a non-linear regression method, the best-fit curve (quadratic) had a positive correlation with better fit (R^2 = 0.64).

Speaking of other authors, Ajtony *et al.*[14] got a positive correlation with R^2 = 0.723 with a non-linear (quadratic) regression method in the POAG group.

Arun *et al.*[17] got a negative correlation slope with R^2 =0.53 with linear regression analysis between absolute value of MD versus average RNFL thickness, with only POAG patients in the study group. Zangwill *et al.*[18] got a positive correlation with R^2 = 0.35–0.43 and in Nilforushan *et al.*[13] got a positive correlation with R^2 = 0.051. It is to be noted that both Zangwill *et al.* and Nilforushan *et al.* both had glaucoma suspects and ocular hypertensives in their study population hence the lower correlation. Ajtony *et al.*[14]

have clearly shown that in pre-perimetric glaucoma, the correlation was lower (R^2 = 0.015) than POAG group (R^2 = 0.723).

Plotting pattern standard deviation against average RNFL, we get a negative correlation slope with linear regression (R^2 = 0.21), $P < 0.0001$, which was significant statistically. This shows that with increase in PSD, the avg. RNFL thickness decreases. Ajtony *et al.* got a negative correlation with $R^2 = 0.474$.

Arun *et al.* got a negative correlation with $R^2 = 0.31$ with only POAG patients.[17]

Plotting superior hemifield sensitivity with inferior RNFL thickness, we get a positive correlation slope with $R^2 = 0.42$ and $P < 0.0001$, which was statistically significant. This shows that decrease of average superior hemifield retinal sensitivity was followed by a decrease in inferior RNFL thickness. Nilforushan *et al.* got a positive correlation slope with $R^2 = 0.107$, but it again had glaucoma suspects in its consideration. Arun *et al.* also got a positive correlation with $R^2 = 0.48$ with only POAG patients.[17]

Plotting inferior hemifield sensitivity with superior RNFL thickness, we get a positive correlation slope with $R^2 = 0.43$ and $P < 0.0001$, which was statistically significant. This shows that decrease of average inferior hemifield retinal sensitivity was followed by a decrease in superior RNFL thickness. Nilforushan *et al.* got a positive correlation slope with $R^2 = 0.068$, but it again had glaucoma suspects in its consideration. Arun *et al.* also got a positive correlation with $R^2 = 0.38$ with only POAG patients.[17]

To show that the reverse does not hold true, we plotted superior hemifield sensitivity with superior RNFL thickness and inferior hemifield sensitivity with inferior RNFL thickness. The first one had very low correlation with $R^2 = 0.012$ and $P = 0.3$, which was not statistically significant. Second one had a $R^2 = 0.023$ and $P = 0.14$, again not significant statistically.

CONCLUSION

In this study, the correlation of SD-OCT structural measures (RNFL thickness) with functional measures derived from SAP in a group of eyes with established primary angle-closure glaucoma was investigated.

A total of 90 eyes ($n = 90$) from 50 patients with established PACG were taken into consideration.

The mean (±SD) age of the study group was 51.79 ± 10.32 years; 61% of the participants were male and 39% were female.

The mean (±SD) IOP of the population was 20.04 ± 3.72.

Mean MD (±SD) and PSD (±SD) of the population were −10.28 ± 5.88 and 8.12 ± 3.77, respectively.

Mean (±SD) superior and inferior hemifield sensitivities were 18.45 ± 7.71 dB and 20.43 ± 6.54 dB, respectively.

Mean (±SD) TSNIT average RNFL thickness was 72.96 (± 17.72) μm.

Mean (±SD) values of superior, inferior, temporal, and nasal RNFL thickness were 87.29 (±29.41) μm, 79.08 (±31.96) μm, 61.2 (±15.19) μm, and 64.62 (±17.41) μm, respectively.

Regarding the VCDR, maximum patients ($n = 27$) had 0.7 cupping followed by 0.8 ($n = 26$) and 0.6 ($n = 22$) cupping, respectively.

About 60% of the patients had a visual acuity equal to or worse than 6/12.

Plotting TSNIT avg. RNFL thickness against age, we got a negative slope correlation which was statistically significant. The slope showed a 0.393 μm yearly decline in average RNFL thickness with increasing age.

Plotting vertical cup-disk ratio against TSNIT avg., we get a negative slope correlation with $R^2 = 0.23$ and $P < 0.0001$, which was statistically significant. That is with increasing VCDR, the average RNFL decreases.

Plotting mean deviation against avg. RNFL thickness, we get a positive linear correlation slope with $R^2 = 0.42$ and $P < 0.0001$, which was statistically significant. That is, as the mean deviation became less negative, the average RNFL thickness increases.

When plotted using a non-linear regression method, the best-fit curve (quadratic) had a positive correlation with better fit ($R^2 = 0.64$).

Plotting pattern standard deviation against avg. RNFL, we get a negative correlation slope with linear regression (R^2 = 0.21), $P < 0.0001$, which was significant statistically. This shows that with increase in PSD, the avg. RNFL thickness decreases.

We find good positive correlation between superior and inferior hemifield sensitivity with inferior ($R^2 = 0.42$) and superior RNFL thickness ($R^2 = 0.43$), respectively.

However, the vice-versa was not true.

In summary, the strength of the relationship between structure and function detected in our study is in good agreement with previous reports in the literature.

Based on the result of this study, there is a direct correlation between the VF loss in automated perimetry and the RNFL loss in OCT. Therefore, OCT can be considered for monitoring the progression of glaucoma.

ACKNOWLEDGMENT

We would like to acknowledge our director Professor Asim Kumar Ghosh, Regional Institute of Ophthalmology, Medical College Kolkata, Dr. Somnath Das, Professor and Head of department, Department of Ophthalmology, Rampurhat Government Medical College and Hospital, Dr. Chandan Bari, Medical Officer, Regional Institute of Ophthalmology, Medical College, Kolkata, who helped relentlessly in conducting this study.

REFERENCES

1. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol 2006;90:262-7.
2. Quigley HA. Number of people with glaucoma worldwide. Br J Ophthalmol 1996;80:389-93.
3. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: A systematic review and meta-analysis. Ophthalmology 2014;121:2081-90.
4. Ramachandran A, Snehalatha C, Dharmaraj D, Viswanathan M. Prevalence of glucose intolerance in Asian Indians. Urban-rural difference and significance of upper body adiposity. Diabetes Care 1992;15:1348-55.
5. Sommer A, Miller NR, Pollack I, Maumenee AE, George T. The nerve fiber layer in the diagnosis of glaucoma. Arch Ophthamol 1977;95:2149-56.
6. Quigley HA, Dunkelberger GR, Green WR. Retinal ganglion cell atrophy correlated with automated perimetry in human eyes with glaucoma. Am J Ophthalmol 1989;107:453-64.
7. Johnson CA, Cioffi GA, Liebmann JR, Sample PA, Zangwill LM, Weinreb RN. The relationship between structural and functional alterations in glaucoma. Semin Ophthalmol 2000;4:221-33.
8. Zangwill LM, Bowd C, Berry CC, Williams J, Blumenthal EZ, Sánchez-Galeana CA, *et al*. Discriminating between normal and glaucomatous eyes using the heidelberg retina tomograph, GDx nerve fiber analyzer, and optical coherence tomograph. Arch Ophthalmol 2001;119:985-93.
9. Reus NJ, Lemij HG. Diagnostic accuracy of the GDx-VCC for glaucoma. Ophthalmology 2004;111:1860-5.
10. Dada T, Gadia R, Aggarwal A, Dave V, Gupta V, Sihota R. Retinal nerve fiber layer thickness measurement by scanning laser polarimetry (GDx-VCC) at conventional and modified diameter scans in normals, glaucoma suspects, and early glaucoma patients. J Glaucoma 2009;18:448-52.
11. Budenz DL, Fredette MJ, Feuer WJ, Anderson DR. Reproducibility of peripapillary retinal nerve fiber thickness measurements with stratus OCT in glaucomatous eyes. Ophthalmology 2008;115:661-6.
12. Tiesch J. The epidemiology of primary open angle glaucoma. Ophthalmol Clin North Am 1991;4:649-57.
13. Nilforushan N, Nassiri N, Moghimi S, Law SK, Giaconi J, Coleman AL, *et al*. Structure-function relationships between spectral-domain OCT and standard achromatic perimetry. Invest Ophthalmol Vis Sci 2012;53:2740.
14. Ajtony C, Balla Z, Somoskeoy S, Kovacs B. Relationship between visual field sensitivity and retinal nerve fiber layer thickness as measured by optical coherence tomography. Invest Ophthalmol Vis Sci 2007;48:258-63.
15. Nouri-Mahdavi K, Hoffman D, Coleman A1, Liu G, Li G, Gaasterland D, *et al*. Predictive fators for glaucomatous visual field progression in the advanced glaucoma intervention study. Ophthalmology 2004;111: 1627-35.
16. Inatani M, Iwao K, Inoue T, Awai M, Muto T, Koga T, *et al*. Long-term relationship between intraocular pressure and visual field loss in primary open-angle glaucoma. J Glaucoma. 2008;17:275-9.
17. Narayanaswamy A, Su DH, Baskaran M, Tan AC, Nongpiur ME, Htoon HM, *et al*. Comparison of ocular response analyzer parameters in Chinese subjects with primary angle-closure and primary open-angle glaucoma. *Arch Ophthalmol* 2011;129:429-34.
18. Medeiros FA, Zangwill LM, Bowd C, Mansouri K, Weinreb RN. The structure and function relationship in glaucoma: Implications for detection of progression and measurement of rates of change. Invest Ophthalmol Vis Sci 2012;53:6939-46.

How to cite this article: Dey A, Pal A, Chakraborty O. Evaluation of the Strength and Pattern of Relationship between Visual Field Sensitivity and Retinal Nerve Fiber Layer Thickness as Measured by Optical Coherence Tomography in Patients Having Primary Angle-Closure Glaucoma. Int J Sci Stud 2022;10(6):16-25.

Source of Support: Nil, **Conflicts of Interest:** None declared.