

**Original Research Article**

**A Correlative Study of Automated Perimetry and Optical Coherence Tomography in Glaucoma**

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**ABSTRACT**

**Background**

To evaluate the correlation between visual field parameters and retinal nerve fiber thickness, optic nerve head changes in 50 cases of glaucoma. To evaluate correlation between structure and function of the visual field to aid in the early diagnosis of glaucoma and to prevent progression of glaucoma.

**Methods**

Informed consent was obtained from all the participants. The visual field function is established with octopus 301 and the structure of RNFL and ONH is done with SDOCT-SLO. Each participant underwent a complete ophthalmologic examination including visual acuity, refraction, Intraocular pressure by applanation tonometry, anterior segment evaluation by slit lamp biomicroscopy, gonioscopy by goldmann's single mirror indirect gonioscope, fundus examination, visual field by octopus perimetry, optical coherence tomography by SDOCT-SLO and the results are documented for correlative study.

**Results**

50 cases of primary open angle glaucoma and glaucoma suspects were included in the study. Pearson's correlation coefficient used to compare RNFL average thickness with mean deviation and loss variation of automated perimetry which strongly establishes the structure-function correlation.

**Conclusion**

The Pearson's correlation coefficient 'r' value in this study suggests a strong correlation of the functional measurements of standard automated perimetry with the structural elements of SDOCT-SLO in glaucoma suspects and in the primary open angle glaucoma group. It is also found out in this study that the <sup>1</sup>best parameter to compare the structure-function relationship in glaucoma is to compare the average retinal nerve fiber layer thickness with the mean defect and the loss variance.

It is also found that combining the structure-function data could potentially enhance the performance of early detection of glaucoma.

**Keywords:** Glaucoma, Automated Perimetry, Spectral Domain Optical Coherence Tomography, OCT RNFL thickness.

## INTRODUCTION

Glaucomatous disease is usually diagnosed and managed with<sup>[1]</sup> measurements of the structural and functional alterations associated with the loss of retinal ganglion cells and their axons. Although functional measures such as standard automated perimetry have been the gold standard for glaucomatous neuropathy, high resolution imaging has excellent accuracy & precision for assessment of structural defects caused by glaucoma. It appears that structural losses precedes functional losses. However there is an overall<sup>[2]</sup> correlation between structure and function in glaucomatous disease, because the underlying changes is both are caused by losses of retinal ganglion cells. Approximately<sup>[3]</sup> 25% RGC loss is required for an afferent pupillary defect, approximately 35% of RGC loss occurs before defects are detected with computerized threshold white on white perimetry & 40% RGC loss before acuity worsens.

## MATERIALS AND METHODS

Informed consent was obtained from all the participants. Each participant underwent a complete ophthalmologic examination including visual acuity, refraction, Intraocular pressure by Goldmann's Applanation tonometry, anterior segment evaluation by slit lamp biomicroscopy, gonioscopy by Goldmann's single mirror indirect gonioscope, fundus examination, visual field by octopus perimetry, optical coherence tomography by SD OCT-SLO and the results are documented for correlative study.

### Inclusion Criteria

Primary open angle glaucoma and glaucoma suspects

### Exclusion Criteria

- Patient with significant media opacity,
- Best corrected visual acuity worse than 6/24,
- A spherical correction  $> + / - 5.0D$ , cylinder correction  $> + / - 2.0D$ ,
- History of any retinal disease including diabetic or hypertensive retinopathy ,
- History of any eye trauma or surgery with the exemption of any uncomplicated cataract surgery,
- History of any surgical or neurologic field that affect the visual field,
- Unreliable visual field [false positive  $> 33\%$ , false negative  $> 33\%$ ]
- Poor quality OCT images.

### Assessment of Parameters

Visual field parameters by Standard Automated Perimetry are correlated with Retinal Nerve Fiber Layer thickness (RNFL thickness) and Optic Nerve Head (ONH) parameters by SD OCT-SLO in case of Primary Open Angle Glaucoma (POAG) and Glaucoma suspects.

**Measurements**

Using the Octopus Perimeter 301, observations of AP of 50 cases of glaucoma have been collected. SD-OCT was used for the recording of structural changes in RNFL, Macula and ONH. Variations noted between Glaucoma suspects and POAG group were analyzed including components such as age distribution, CCT, lens positions, BCVA, Fundus changes along with the ranges of IOPs, OCT RNFL thickness

**RESULTS**

Group	Cases	
	No	%
Glaucoma Suspect	28	56
POAG	22	44
<b>Total</b>	<b>50</b>	<b>100</b>

*Table 1: No. of eyes included in the study*

The clinical study consists of admixture of glaucoma suspects and primary open angle glaucoma group. 100 eyes of 50 subjects were taken for the study, of which 56 eyes of 28 patients were categorized into glaucoma suspect group and 44 eyes of 22 patients were categorized into primary open angle glaucoma group.

The age distribution of the subjects in the glaucoma suspect group was in the range of 22-65 years with the mean age of 44.9 years and standard deviation of 11.9 years.

The age distribution of the subjects in the primary open angle group was in the range of 21-83 years with the mean age of 54.9 years and standard deviation of 12.7 years.

The ratio of males to females in the glaucoma suspect group was 2.1:1 with the male predominance. The ratio of males to females in the primary open angle group was 0.83:1 with the slightly female predominance.

Intra Ocular Pressure	Right Eye		Left Eye	
	Glaucoma Suspect Group	POAG Group	Glaucoma Suspect Group	POAG Group
Range	10 - 30	16 - 28	12 - 28	14 - 34
Mean	18.4	20.6	18.2	20.8
SD	4.2	3.7	3.7	5.5
'p'	<b>0.0511 Not Significant</b>		<b>0.0516 Not Significant</b>	

*Table 2: Intraocular pressure among study groups*

The CCT corrected IOP in the right eye of the glaucoma suspect group was in the range of 10-30 with the mean IOP of 18.4 and standard deviation of 4.2.

The CCT corrected IOP in the left eye of the glaucoma suspect group was in the range of 12-28 with the mean IOP of 18.2 and standard deviation of 3.7.

The CCT corrected IOP in the right eye of the primary open angle glaucoma group was in the range of 16-28 with the mean IOP of 20.6 and standard deviation of 3.7.

The CCT corrected IOP in the left eye of the primary open angle glaucoma group was in the range of 14-34 with the mean IOP of 20.8 and standard deviation of 5.5.

Fundus	Right Eye		Left Eye	
	Glaucoma Suspect Group	POAG Group	Glaucoma Suspect Group	POAG Group
Range	0.3 – 0.8	0.3 – 0.9	0.3 – 0.9	0.3 – 0.9
Mean	0.6	0.67	.58	0.64
SD	0.16	0.15	0.17	0.18
‘p’	<b>0.1271 Not Significant</b>		<b>0.2673 Not Significant</b>	

*Table 3: Fundus (cup-disc ratio)*

The range of cup to disc ratio varies from 0.3-0.9 in glaucoma suspects and primary open angle glaucoma group.

The mean cup to disc ratio of the right and left eye of the glaucoma suspects were 0.6 and 0.58 respectively. The mean cup to disc ratio of the right and left eye of the primary open angle glaucoma group were 0.67 and 0.64 respectively.

The standard deviation of the right and left eye of the glaucoma suspects were 0.16 and 0.17 respectively. The standard deviation of the right and left eye of the primary open angle glaucoma group were 0.15 and 0.18 respectively.

**AUTOMATED PERIMETER**

Mean Sensitivity	Right Eye		Left Eye	
	Glaucoma Suspect Group	POAG Group	Glaucoma Suspect Group	POAG Group
Range	12.9 – 29.3	11.5 – 27	12.7 – 29.8	11.2 – 28.5
Mean	24.2	20.9	24.3	21.4
SD	4.5	5.1	4.6	4.8

*Table 4: Mean sensitivity in the study cases*

**Range of Mean Sensitivity:**

The range of mean sensitivity in the right and left eye of the glaucoma suspect group varies between 12.7-29.3 and that of the primary open angle glaucoma group varies between 11.2-28.5.

The mean in the right and left eye of the glaucoma suspects was 24.2 and 24.3 respectively and that of standard deviation was 4.5 and 4.6 respectively. The mean in the right and left eye of the primary open angle group was 20.9 and 21.4 respectively and that of standard deviation was 5.1 and 4.8 respectively.

Mean Deviation	Right Eye		Left Eye	
	Glaucoma Suspect Group	POAG Group	Glaucoma Suspect Group	POAG Group
Range	2.1 – 14.5	0.1 – 16.9	-0.4 – 14.4	-1.3 – 16
Mean	4.21	5.69	3.87	5.7
SD	4.38	5.26	4.48	4.66

*Table 5: Mean deviation among study cases*

**Range of Mean Deviation**

The range of mean deviation in the right and left eye of the glaucoma suspect group was 2.1 to 14.5 and -0.4 to 14.4 respectively and that of the primary open angle glaucoma group was 0.1 to 16.9 and -1.3 to 16 respectively.

The mean in the right and left eye of the glaucoma suspect group was 4.21 and 3.87 respectively and that of standard deviation was 5.69 and 5.7 respectively.

The mean in the right and left eye of the primary open angle glaucoma group was 5.69 and 5.7 respectively and that of standard deviation was 5.26 and 4.66 respectively.

Loss Variance	Right Eye		Left Eye	
	Glaucoma Suspect Group	POAG Group	Glaucoma Suspect Group	POAG Group
Range	1 – 94.5	1.9 – 89.5	0.7 - 137	2.9 – 80.1
Mean	22.62	29.51	23.01	27.15
SD	27.18	25.9	35.53	24.69

*Table 6: Loss variance among study group*

The range of loss variance in the right and left eye of the glaucoma suspect group was 1.0 to 94.5 and 0.7 to 137 respectively and that of primary open angle glaucoma group was 1.9 to 89.5 and 2.9 to 80.1 respectively.

**Range of Mean Loss Variance**

The mean of loss variance in the right and left eye of the glaucoma suspect group was 22.62 and 23.01 respectively and that of standard deviation was 27.18 and 35.53 respectively.

The mean of loss variance in the right and left eye of the primary open angle glaucoma group was 29.51 and 27.15 respectively and that of standard deviation was 25.9 and 24.69 respectively.

**OPTICAL COHERENCE TOMOGRAPHY**

RNFL Thickness	Right Eye			Left Eye		
	Glaucoma Suspect (Mean ± SD)	POAG (Mean ± SD)	‘p’	Glaucoma Suspect (Mean ± SD)	POAG (Mean ± SD)	‘p’
Inferior	119.3 ± 24.0	103.1 ± 25.9	<b>0.0262 Significant</b>	126.5 ± 18.3	106.5 ± 22.4	<b>0.0011 Significant</b>
Superior	120.6 ± 24.9	110.7 ± 22.9	0.1534 Not Significant	127.1 ± 22.5	111.0 ± 22.1	<b>0.0147 Significant</b>
Nasal	94.9 ± 17.6	90.0 ± 19.2	0.362 Not Significant	96.3 ± 17.4	88.2 ± 19.1	0.1235 Not Significant
Temporal	75.1 ± 12.6	69.2 ± 17.0	0.1602 Not Significant	71.7 ± 11.6	66.0 ± 18.4	0.19 Not Significant
Average	102.5 ± 15.9	93.3 ± 17.0	<b>0.0172 Significant</b>	105.4 ± 13.3	94.7 ± 17.2	<b>0.0164 Significant</b>

*Table 7: OCT RNFL Thickness*

The average retinal nerve fiber thickness in the right and left eye of the glaucoma suspect group was 102.5 and 105.4 respectively and that of standard deviation was 15.9 and 13.3 respectively which is significant.

The average retinal nerve fiber thickness in the right and left eye of the primary open angle glaucoma group was 93.3 and 94.7 respectively and that of standard deviation was 17 and 17.2 respectively which is significant.

**RNFL Thickness**

OCT ONH Topography	Right Eye		Left Eye	
	Glaucoma Suspect (Mean ± SD)	POAG (Mean ± SD)	Glaucoma Suspect (Mean ± SD)	POAG (Mean ± SD)
Disc area	3.62 ± 0.84	3.23 ± 0.76	3.64 ± 0.72	3.05 ± 0.84
Cup area	2.32 ± 1.03	2.06 ± 0.78	2.14 ± 1.02	1.77 ± 0.79
Rim Area	1.3 ± 0.49	1.08 ± 0.66	1.46 ± 0.66	1.23 ± 0.86
Cup Disc horizontal	0.82 ± 0.15	0.83 ± 0.11	0.82 ± 0.19	0.83 ± 0.13
Cup Disc Vertical	0.8 ± 0.16	0.85 ± 0.14	0.75 ± 0.17	0.81 ± 0.13
Cup Disc Area	0.64 ± 0.18	0.65 ± 0.19	0.56 ± 0.22	0.58 ± 0.21

*Table 8: OCT ONH Topography*

Correlation of OCT RNFL Thickness	Right Eye			Left Eye		
	Pearson's Corr. Coefficient with			Pearson's Corr. Coefficient with		
	Mean Sensitivity	Mean Deviation	Loss Variance	Mean Sensitivity	Mean Deviation	Loss Variance
Inferior	0.368	-0.3202	-0.4658	0.3715	-0.3628	-0.2575
Superior	0.2329	-0.2525	-0.3728	0.4575	-0.436	-0.4569
Nasal	0.3445	-0.3322	-0.3982	0.3497	-0.3282	-0.2399
Temporal	0.1982	-0.1522	-0.1729	0.3288	-0.3573	-0.3302
Average	0.3578	-0.3319	-0.458	0.3937	-0.3825	-0.3553

*Table 9: Correlation of Automated Perimetry and OCT*

Pearsons correlation coefficient of RNFL average with mean sensitivity is not significant, According to Hae young L.park et al, early in the stage of preperimetric glaucoma, RNFL thickness decreases without apparent decrease in retinal sensitivity by VF which explains the nonsignificant pearsons correlation coefficient, otherwise the pearsons correlation coefficient of RNFL average in mean sensitivity and loss variance is significant which explains the strong structure function correlation.

Optic Disc Parameter	Persons Correlation Coefficient of RNFL average in	
	Right Eye	Left Eye
Disc Area	0.2076	0.344
Cup Area	-0.1356	-0.0658
Rim Area	0.4295	0.4913
Cup Disc Horizontal	-0.3089	-0.2099

Cup Disc Vertical	-0.5985	-0.4355
Cup Disc Area	-0.3644	-0.3298
<i>Table 10: Correlation of RNFL average with optic disc parameters</i>		

The Pearson’s correlation coefficient of RNFL average in the right and left eye with the cup – disc area was -0.3644 and -0.3298 which explains significant correlation of RNFL thinning associated with increased cup disc area.

Global indices	Pearsons Correlation Coefficient of RNFL average in	
	Right Eye	Left Eye
Mean Sensitivity	0.3578	0.3937
Mean Deviation	-0.3319	-0.3825
Loss Variance	-0.458	-0.3553
<i>Table 11: Pearson's correlation coefficient of RNFL average with Global Indices</i>		

Pearsons correlation coefficient of RNFL average with mean sensitivity is not significant, According to Hae young L.park et al, early in the stage of preperimetric glaucoma, RNFL thickness decreases without apparent decrease in retinal sensitivity by VF which explains the nonsignificant pearsons correlation coefficient, otherwise the pearsons correlation coefficient of RNFL average in mean sensitivity and loss variance is significant which explains the strong structure function correlation.

**DISCUSSION**

<sup>[4,5]</sup>Function maps have been previously developed in order to understand the relationship between the optic disc morphology and the corresponding visual field defects.<sup>[6]</sup> The high variability of human RNFL distribution around the optic nerve head and the intratest variability of SAP limit the possibility of obtaining stronger correlations between these tests.<sup>[7]</sup> A study by Frédéric Pollet-Villard et tal shows that in advanced glaucoma (low visual field sensitivity and reduced RNFL or neuroretinal rim thickness), the relationship between neuroretinal rim thickness and retinal sensitivity seems to be much stronger than the relationship between RNFL thickness and visual field sensitivity. By contrast, earlier in the disease (MD > -15 dB: right), RNFL thickness seems to correlate with function better than the neuroretinal rim thickness does.<sup>[8]</sup> In our study Pearson's correlation coefficient of RNFL average with mean sensitivity is not significant.<sup>[9]</sup> According to giacinto triolo et tal In early in the stage of preperimetric glaucoma, RNFL thickness decreases without apparent decrease in retinal sensitivity by VF which explains the non significant Pearson's correlation coefficient, otherwise the Pearson's correlation coefficient of RNFL average in mean sensitivity and loss variance is significant which explains the strong structure function correlation. It is also found out in this study that the best parameter to compare<sup>[3]</sup> the structure-function relationship in glaucoma is to compare the average retinal nerve fiber layer thickness with the mean defect and the loss variance. It is also found that combining the structure-function data could potentially enhance the performance of early detection of glaucoma.

**CONCLUSION**

In conclusion, the Pearson’s correlation coefficient ‘r’ value in this study suggests a strong correlation of the functional measurements of standard automated perimetry with the structural elements of SD OCT-SLO in glaucoma suspects and in the primary open angle glaucoma group.

<sup>17</sup> OCT also aids in the early detection of structural loss before the evidence loss of visual field function in the standard automated perimetry.

**REFERENCES:**

- [1] Gupta V, Gupta A, Dogra. Atlas optical coherence tomography of macular diseases & Glucoma with DVD ROM. 3<sup>rd</sup> edn. Jaypee Brothers Medical Publishers 2010.
- [2] Damji KF, Freedman SF, Moroi SE, Rhee DJ, Shields MB. Shields textbook of glaucoma. 6<sup>th</sup> edn. Lippincott Williams and Wilkins 2010.
- [3] Tandon R, Sihota R. Parsons's diseases of the eye. 21<sup>st</sup> edn. Elsevier 2011.
- [4] Wu H, De Boer JF, Chen L, Chen TC. Correlation of localized glaucomatous visual field defects and spectral domain optical coherence tomography retinal nerve fiber layer thinning using a modified structure–function map for OCT. *Eye* 2015;29(4):525-33.
- [5] Lopez-Peña MJ, Ferreras A, Larrosa JM, Polo V, Pablo LE. Relationship between standard automated perimetry and retinal nerve fiber layer parameters obtained with optical coherence tomography. *Journal of Glaucoma* 2011;20(7):422-32.
- [6] Medeiros FA, Zangwill LM, Alencar LM, Bowd C, Sample PA, Susanna R, et al. Detection of glaucoma progression with stratus OCT retinal nerve fiber layer, optic nerve head, and macular thickness measurements. *Invest Ophthalmol Vis Sci* 2009;50(12):5741-8.
- [7] Structure-Function Relationships With Spectral-Domain Optical Coherence Tomography Retinal Nerve Fiber Layer and Optic Nerve Head Measurements Frédéric Pollet-Villard; Christophe Chiquet; Jean-Paul Romanet; Christian Noel; Florent Aptel
- [8] Hirneiß C, Reznicek L, Vogel M, Pesudovs K. The impact of structural and functional parameters in glaucoma patients on patient-reported visual functioning. *PLoS One* 2013;8(12):e80757.
- [9] Optical coherence tomography and optical coherence tomography angiography in glaucoma: diagnosis, progression, and correlation with functional tests

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