ORIGINAL ARTICLE

QUADRANT WISE ANALYSIS OF RNFL THICKNESS MEASURED BY OPTICAL COHERENCE TOMOGRAPHY (OCT) IN PRIMARY OPEN ANGLE GLAUCOMA (POAG) AND ITS ABILITY TO DETECT GLAUCOMA

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ABSTRACT: PURPOSE: To study the RNFL thickness measured by stratus optical coherence tomography (OCT) patients with primary open angle glaucoma (POAG) and normal subjects, analyse the quadrant which is most efficient parameter for detecting glaucomatous damage and its correlation with visual fields. **MATERIAL AND METHODS:** This is a cross-sectional study of 50 glaucomatous eyes and 50 normal subjects. RNFL thickness was measured in different quadrants using stratus optical coherence tomography. **RESULTS:** The RNFL thickness measured by OCT in 50 glaucomatous and 50 normal eyes showed that the Inferior RNFL thickness in POAG is 77.54±31.11 compared to normal subjects where Inferior RNFL thickness is 124.96±16.74 (P<0.001). The Superior RNFL thickness in POAG is 78.32±34.81 compared to normal subjects where Superior RNFL thickness is 113.86±15.07 (P<0.001). The Nasal RNFL thickness in POAG is 53.52±13.88 compared to normal subjects where Nasal RNFL thickness is 78.103±17.87 (P<0.001). The Temporal RNFL thickness in POAG is 49.72±18.01 compared to normal subjects where Temporal RNFL thickness is 60.17±12.15 (P<0.001). The Average RNFL thickness in POAG is 63.94±18.01 compared to normal subjects where Average RNFL thickness is 97.97±9.59 (P<0.001). Both mean deviation (MD) and pattern standard deviation (PSD) showed a significant correlation with all the RNFL thickness parameters in eyes with glaucoma (pearson correlation coefficient >0.4). **CONCLUSION:** RNFL thickness measured on OCT may serve as useful adjunct in accurately detecting glaucoma. Average and inferior RNFL thicknesses are among the most efficient parameters for detecting glaucoma correlating with the visual field changes.
KEYWORDS: RNFL Thickness, OCT, glaucoma.

INTRODUCTION: Optical coherence tomography (OCT) is a relatively new diagnostic modality that provides high resolution, cross-sectional imaging of ocular tissue in vivo. To measure RNFL thickness, retinal and macular thickness. Based on principle of low coherence-interferometry which generates retinal tomographs with <10 µm axial and approximately 20 µm transverse resolution. It measures the RNFL thickness in four quadrants.[1] OCT-determined RNFL thickness has been shown to be significantly reduced in patients with glaucoma, although with interindividual variability.[2,3,4,5,6] Time domain OCT (Stratus OCT 3, Carl Zeiss Meditec Inc, Dublin, California) can image both the ONH and the RNFL thickness. Recent results from the Advanced Imaging for Glaucoma Study (AGIS) showed that the best RNFL parameters to diagnose "perimetric glaucoma" (i.e., glaucoma based on abnormal visual field testing and glaucomatous ONH abnormalities) were the overall, superior quadrant or inferior quadrant RNFL thickness

values, with sensitivities around 72.9% and specificities of 93.7%.Optical Coherence Tomography may prove to be sensitive in the early detection of glaucoma before the appearance of alterations through a conventional Automated Perimeter.[7]

MATERIALS AND METHODS: Patients attending Glaucoma clinic and Out Patient Department in Minto Ophthalmic Hospital, Bangalore from January 2013 to April 2014. All patients underwent anterior segment slit-lamp examination, Goldman applanation tonometry, gonioscopy, and stereoscopic fundus examination by a 90D lens to exclude any anterior or posterior segment pathology, Stratus Optical Coherence Tomography, Humphrey visual field analyser.

50 patients between age group 30-70 years was included in the study having 38(76%) male and 12(24%) female. RNFL thickness was assessed using Stratus optical coherence tomography version 4.0.7(0132), scan protocols used were Fast RNFL Thickness scan.

INCLUSION CRITERIA:

1. Patient who have given written informed consent in their language.
2. Control group with age range of 30-70 years, best corrected visual acuity 6/9, IOP equal or less than 21mmHg, C/D ratio less than 0.5 or its difference between two eyes less than 0.2.
3. POAG group having age range 30-70 years, IOP of more than 21mmHg, with evidence of glaucomatous nerve head damage and retinal nerve fibre layer defect and anterior chamber angles open with glaucomatous visual field defect.

OCT TECHNIQUE: All participants including normal subjects had undergone RNFL scanning with STRATUS OCT VERSION 4.0.7(0132).The test was conducted by a single operator after pupillary dilation with 1% tropicamide eye drop. A circular scan with a circle diameter of 3.4 mm centered around optic disc was acquired by asking the subjects we to focus at internal fixation target. The location of scan was observed on the SLO image to ensure proper positioning of scan in relation to the ONH and average of three consecutive OCT images of the RNFL were obtained. The RNFL analysis uses an automated OCT software algorithm to identify anterior and posterior margins of RNFL. Images obtained having signal strength higher than 7 were considered.

The following RNFL parameters were evaluated: average peripapillary RNFLT (360˚), the four quadrant average RNFLT (superior, nasal, inferior and temporal) and 12 o'clock-hours RNFLT. The sectors were defined in clockwise order for the right eye and counter clockwise order for the left eye.

STATISTICAL ANALYSIS: Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. Student unpaired t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups Inter group analysis) on metric parameters. Pearson correlation of OPD and RNFL parameters in POAG and RNFL thickness is performed to assess the relationship Classification of Correlation Co-efficient (r).

Up to 0.1 Trivial Correlations.
0.1-0.3 Small Correlation.
0.3-0.5 Moderate Correlation.
0.5-0.7 Large Correlation.
0.7-0.9 V. Large Correlation.
0.9- 1.0 Nearly Perfect correlation.
1 Perfect correlation.

RESULTS: The mean age of the 50 POAG subjects was 54.08±12.27 and of normal subject is 45.76±11.57. Of the 50 POAG patients 38 were male (76%) and 12(24%) were female. Of the 50 normal subjects 32 were male (64%) and 18(36%) female.

Age in years	POAG		Normal subjects	
	No	%	No	%
30-39	6	12%	14	28%
40-49	13	26%	18	36%
50-59	9	18%	10	20%
60-70	22	44%	8	16%
TOTAL	50	100	50	100
MEAN±SD	54.08±12.27		45.76±11.57	

Table 1: Distribution of POAG patients and normal subjects based on age

Gender	POAG		Normal	
	No	%	No	%
Male	38	76	32	64
Female	12	24	18	36
Total	**50**	**100**	**50**	**100**

Table 2: Distribution of POAG patients and normal subjects based on gender

Samples are gender matched with P=0.275.

RNFL thickness	Poag	Normal	P value
Inferior rim	77.54±31.11	124.96±16.74	9.4, s, p <0.001
Superior rim	78.32±34.81	113.86±15.07	7.3, s, p <0.001
Nasal rim	53.52±19.54	78.103±17.87	6.4, s, p <0.001
Temporal rim	49.72±113.88	60.17±12.15	4.7, s, p <0.001
Average	63.94±18.01	94.97±9.59	10.6, s, p <0.001

Table 3: Quadrant wise comparison of RNFL thickness of POAG and normal subjects

CDR	POAG	
	No	%
0.5	1	2
0.6	16	32
0.7	15	30
0.8	14	28
0.9	4	8
Total	**50**	**100**

Table 4: CD ratio of POAG patients

RNFL thickness	Visual field md	Visual field PSD
Inferior	0.5214	-0.4086
Superior	0.418	-0.1825
Nasal	0.181	-0.0081
Temporal	0.3587	-0.2118
Average	0.5266	-0.319

Table 5: Showing correlation between visual fields and RNFL thickness

VALUES ARE PEARSON CORRELATION COEFFICIENT R VALUES: The above table shows correlation of RNFL thickness and visual field indices of POAG patients. The inferior, superior and average RNFL thickness and mean deviation of visual fields show positive moderately significant correlation (pearson correlation coefficient >0.4) while the nasal, temporal RNFL thickness and mean deviation of visual field show a weakly positive correlation.

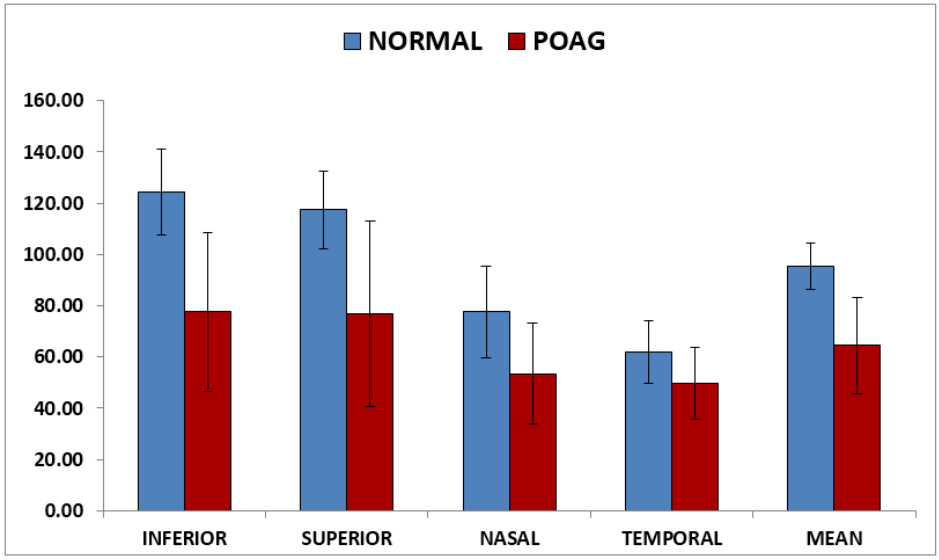

Chart 1: Chart depicting the RNFL thickness of POAG and normal subjects

The above chart and table depicts the RNFL thickness in POAG and NORMAL subjects.

The Inferior RNFL thickness in POAG is 77.54±31.11 compared to normal subjects where Inferior RNFL thickness is 124.96±16.74. This was shown to be statistically significant (P<0.001).

The Superior RNFL thickness in POAG is 78.32±34.81 compared to normal subjects where Superior RNFL thickness is 113.86±15.07. This was shown to be statistically significant (P<0.001).

The Nasal RNFL thickness in POAG is 53.52±13.88 compared to normal subjects where Nasal RNFL thickness is 78.103±17.87. This was shown to be statistically significant (P<0.001).

The Temporal RNFL thickness in POAG is 49.72±18.01 compared to normal subjects where Temporal RNFL thickness is 60.17±12.15. This was shown to be statistically significant (P<0.001).

The Average RNFL thickness in POAG is 63.94±18.01 compared to normal subjects where Average RNFL thickness is 97.97±9.59. This was shown to be statistically significant (P<0.001).

The cup disc ratio (CD ratio) of glaucomatous subjects have strong negative correlation with the RNFL thickness. Inferior RNFL has maximum correlation with CD Ratio, followed by superior, temporal, nasal.

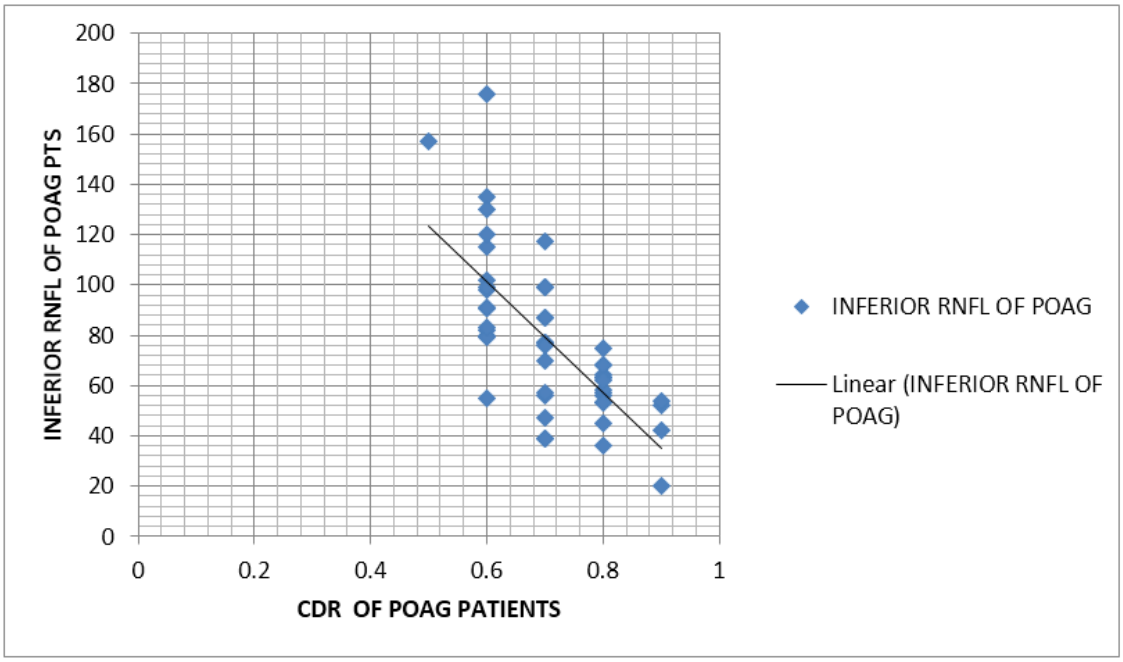

Chart 2: Showing correlation of inferior RNFL thickness with CDR in POAG patients

Pearsons correlation coefficient r between inferior rnfl thickness and CD ratio -0.958.

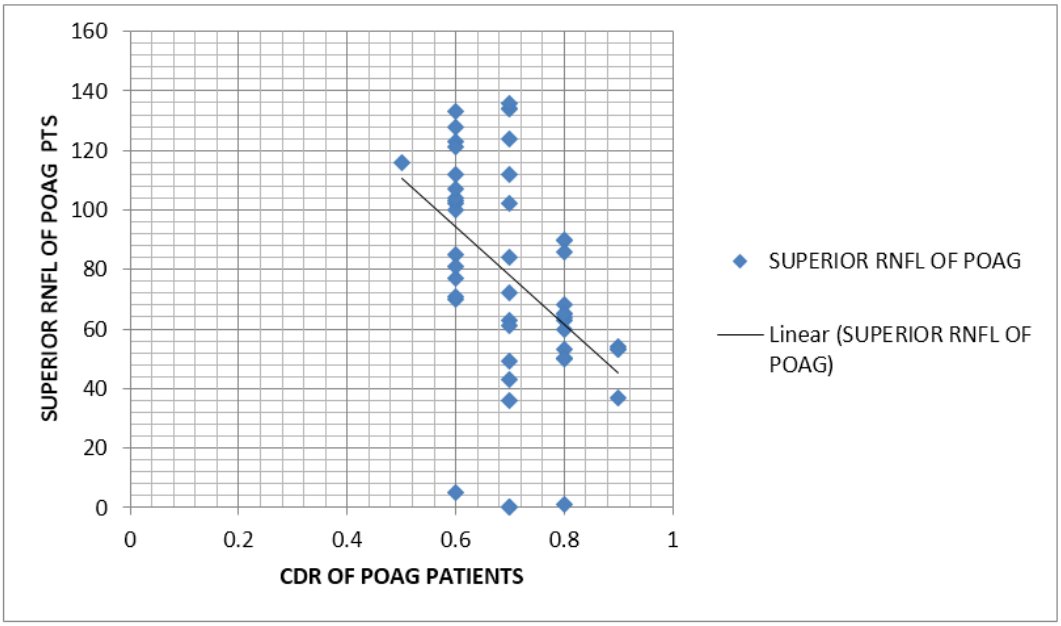

Chart 3: Showing relation of superior RNFL thickness of POAG with cd ratio

Pearsons correlation coefficient r between superior rnfl thickness and CD ratio -0.941

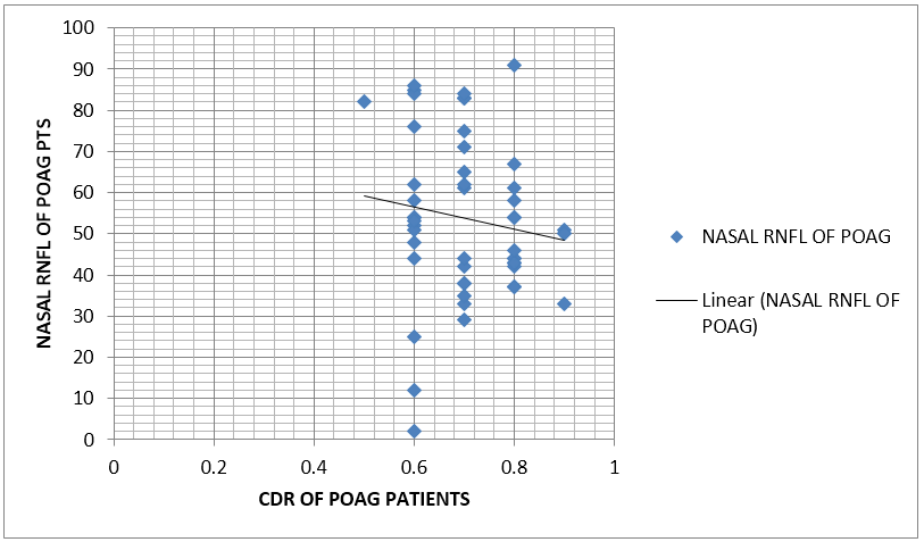

Chart 4: Showing relation of nasal RNFL thickness of POAG with cd ratio

Pearsons correlation coefficient r between nasal rnfl thickness and CD ratio -0.824.

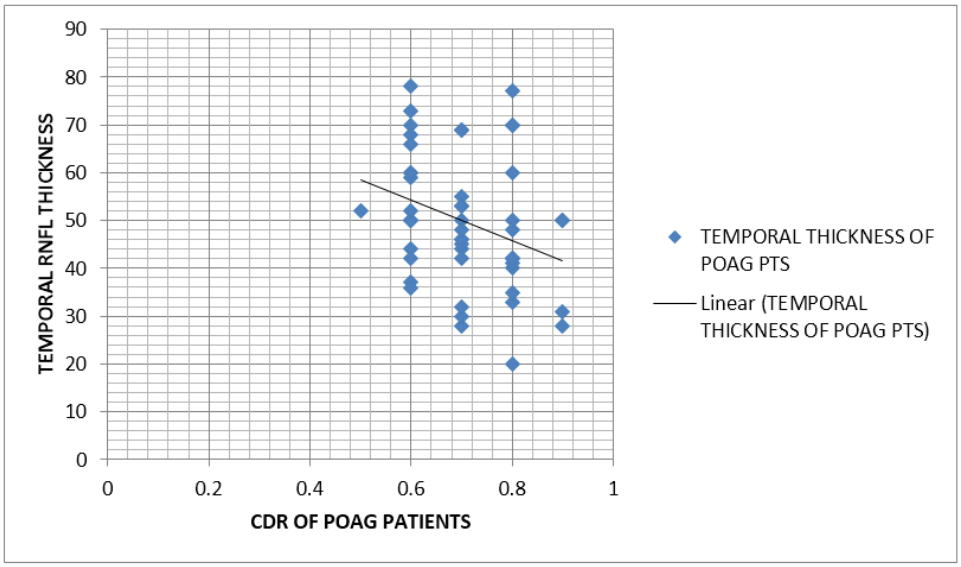

Chart 5: Showing relation of temporal RNFL thickness of POAG with cd ratio

Pearsons correlation coefficient r between temporal rnfl thickness and CD ratio -0.853.

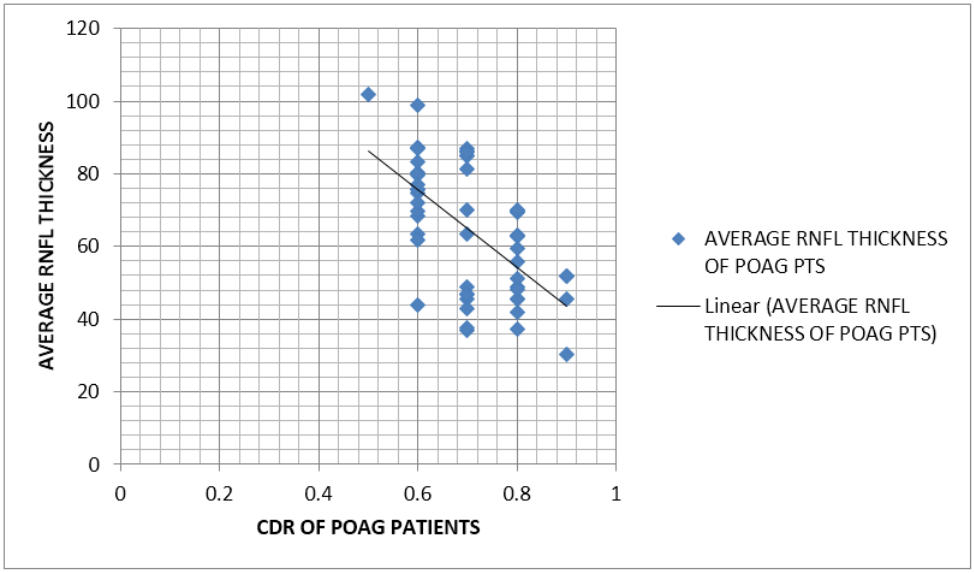

Chart 6: Showing relation of average thickness of POAG with cd ratio

Pearsons correlation coefficient r between average rnfl thickness and CD ratio -0.853.

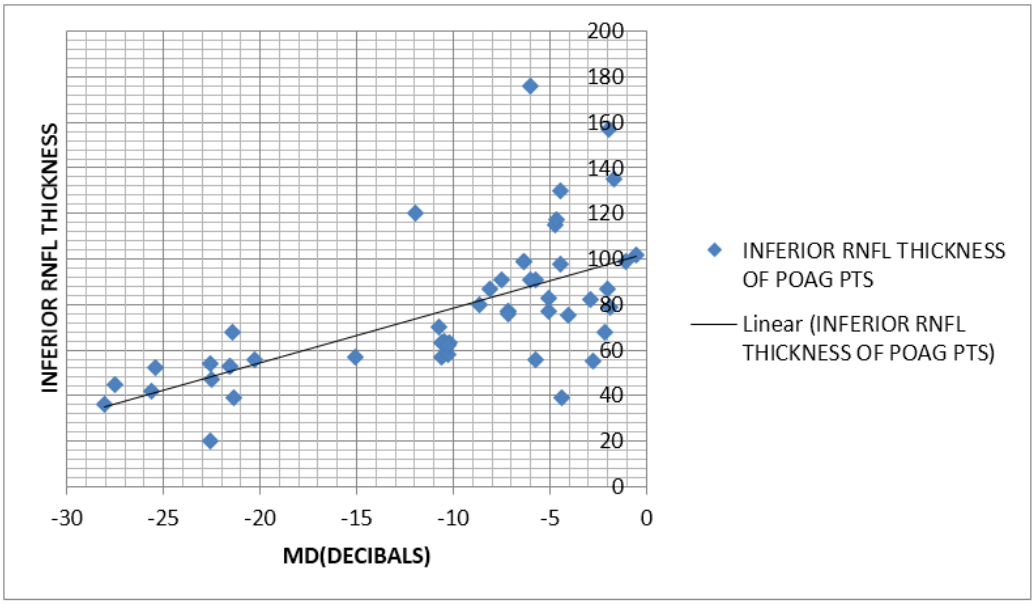

Chart 7: Depicting correlation of visual fields indices with inferior RNFL thickness of POAG

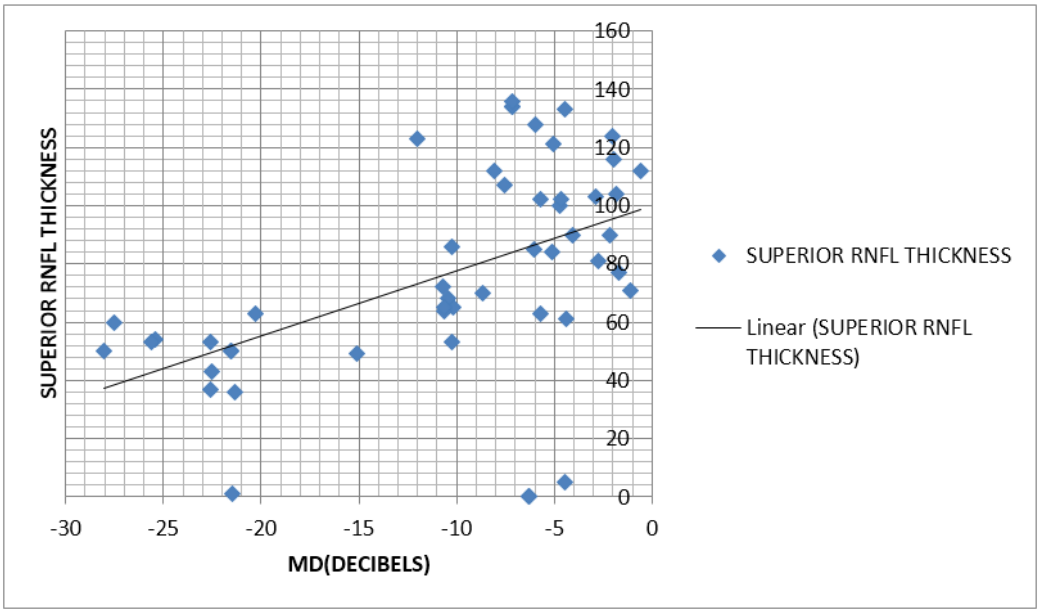

Chart 8: Depicting correlation of visual field indices and superior RNFL thickness

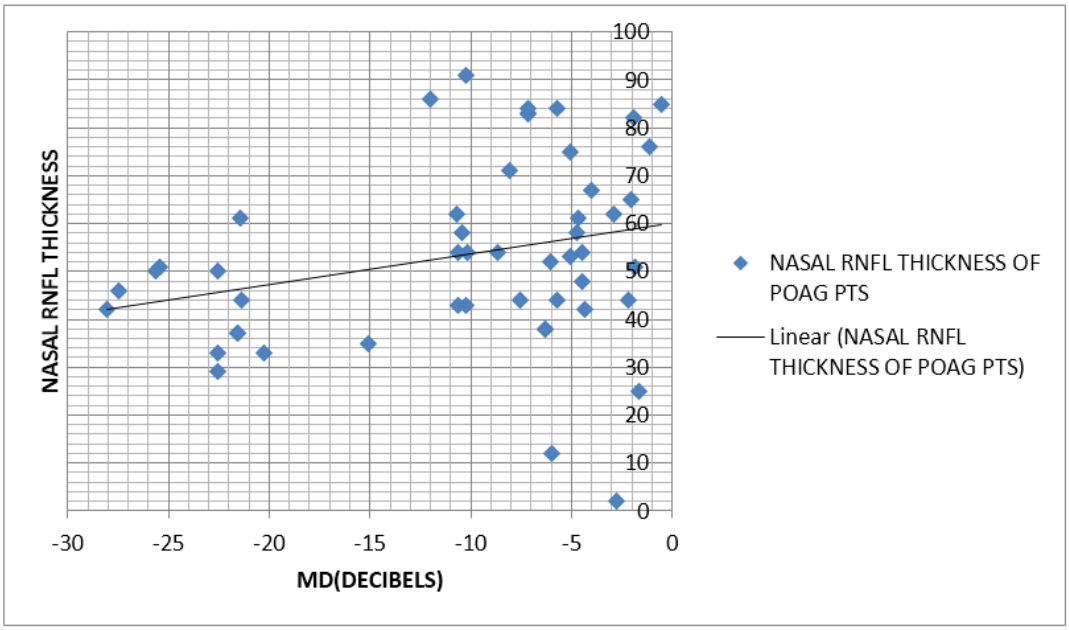

Chart 9: Depicting correlation of visual field indices with nasal RNFL thickness

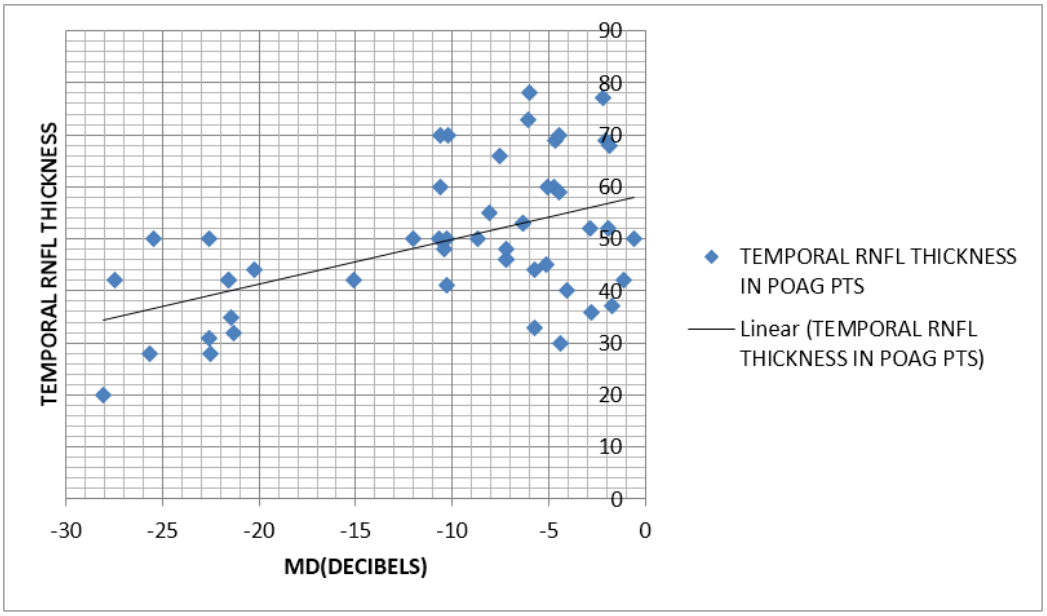

Chart 10: Depicting correlation of visual field indices and temporal RNFL thickness in POAG

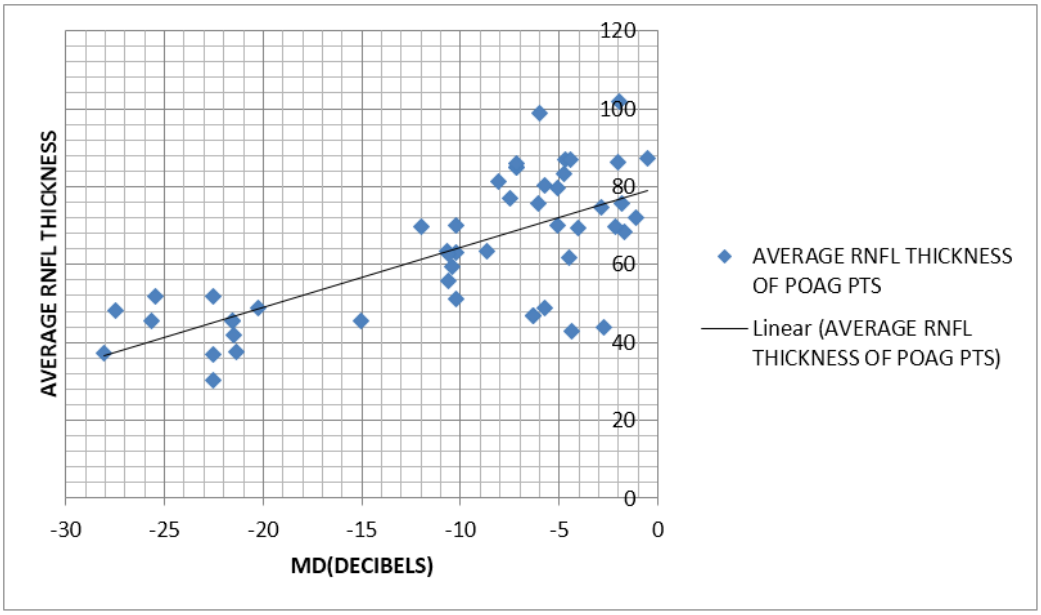

Chart 11: Depicting correlation of visual field indices and average RNFL thickness in POAG patients

DISCUSSION: Optical coherence tomography, is the imaging modality with sufficiently fine depth resolution to measure the RNFL thickness directly. Measurements of the circumpapillary RNFL are reproducible and useful in the early diagnosis of glaucoma. Stratus OCT measures the RNFL thickness profile along a 3.4-mm-diameter circle around the optic disc. Based on the profile, the averages of overall, quadrant, and clock-hour RNFL thickness are computed and displayed.[8]

In this study we have analysed the quadrant wise RNFL thickness of 50 POAG patients which showed that inferior and average RNFL thickness showed the maximuim negative correlation with the cup disc ratio compared to the other quadrants and positive correlation with mean deviation of the visual fields. This observation is in agreement with previous studies[9,10,11,12]

Study by Kanamori A et al, 237 glaucomatous eyes of 140 glaucoma patients were enrolled in the study. A significant relationship existed between the mean deviation and RNFL thickness in all parameters excluding the 3-o'clock area. The average RNFL thickness had the strongest correlation in all parameters ($r = -0.729$, $P < .001$).[13]

Study by Subbaih S et al, analysed the results of 30 normal, 30 ocular hypertensives and 30 glaucoma patients. Of the 90 eyes enrolled (mean age of patients 52.32±10.11 years), the mean RNFL thickness was significantly less in ocular hypertensive (82.87±17.21 mm; $P = 0.008$ and glaucomatous eyes (52.95±31.10 microm; $P < 0.001$), than in normals (94.26±12.36 microm). The RNFL was significantly thinner inferiorly in glaucomatous eyes (64.41±43.68 microm; $P<0.001$) than in normals (120.15±14.32 microm).[14]

Study by Sergios Taliantzis et al, 73 eyes with chronic open angle glaucoma were studied. All of them underwent OCT exam (Stratus 3000) for retinal nerve fibre layer (RNFL) thickness measurement with fast RNFL thickness protocol and visual fields (VF) examination. A moderate correlation between RNFL thickness and indices mean sensitivity (MS), mean defect (MD) and

loss variance (LV) of VF (0.547, −0.582, −0.527, respectively; P <0.001) was observed for all patients. The correlations became more important and strong when deep structural glaucomatous defects in OCT were detected, even when VF was still considered normal. Especially, MD was an index of an increased importance in our groups following progression of RNFL thickening. In clinical practice, mean defect seems to be the most valuable and representative parameter of the glaucomatous damage progression.[15]

Study by Yalvac et al, analysed 28 eyes of 28 glaucoma patients with various stages of Glaucoma were compared with 38 eyes of 38 normal age matched controls. Average RNFL thickness was 62.90±16.56 μm in the glaucoma group and 111±6.00μm in the control group (P<0.05). PSD and MD VF Zones and corresponding OCT RNFL thickness sectors were significantly correlated at specific sectors in the glaucoma group (P<0.01).[16]

From this study following findings were evolved: RNFL thickness was significantly reduced in POAG patients compared to normal subjects, the thinning in inferior and average RNFL was most significant in POAG patients compared to the normal subjects. The degree of glaucomatous visual field defects visual fields correlated with the severity of the RNFL thinning in POAG patients therefore correlating with the severity of glaucoma, which implies that glaucoma progression can be assessed by RNFL thickness analysis by OCT. The RNFL thickness decreases with the severity of glaucoma thus can be used in prognostication of glaucoma

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