Research Article

Correlation between Retinal Nerve Fiber Layer Thickness Measured with Spectral Domain Optical Coherence Tomography and Visual Field in Patients of Primary Open Angle Glaucoma

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Abstract

Aim: To study the correlation between retinal nerve fiber layer (RNFL) thickness measured with spectral domain optical coherence tomography (SD-OCT) and visual field (VF) in patients of primary open angle glaucoma (POAG).

Materials and Methods: A total of 60 patients of POAG and 60 controls were studied for a period of one year from July, 2011 to June, 2012 in the Department of Ophthalmology, Institute of Medical Sciences, BHU. All the patients and controls underwent visual field analysis by standard automated perimetry using SITA standard 30-2 program and optic disc imaging by Cirrus SD-OCT. The relationship between RNFL thickness and VF sensitivity, expressed as mean deviation (MD) and pattern standard deviation (PSD) were evaluated. The association between RNFL/VF was described by Spearman's rho correlation coefficients.

Results: The correlation of RNFL and the VF parameters MD and PSD in normal eyes was not significant. In POAG eyes, RNFL and both MD (R=0.925) and PSD (R=-0.879) correlated significantly.

Conclusion: The study demonstrated that the correlation between RNFL and visual field parameters MD and PSD in normal eyes was not significant. In POAG eyes, RNFL and both MD and PSD correlated significantly with P <0.001.

Keywords: Retinal nerve fibre layer (RNFL) thickness, Mean deviation (MD), Pattern standard deviation (PSD), Primary open angle glaucoma (POAG).

Introduction

Glaucoma is a chronic progressive optic neuropathy characterized by a specific and progressive injury to the optic nerve and retinal nerve fiber layer (RNFL).[1] The loss of retinal ganglion cells (RGCs) axons may be apparent structurally as a local and/or a diffuse thinning of the retinal nerve fiber layer (RNFL)[3-6] and of the neuroretinal rim.[9] Functionally, RGC atrophy leads to characteristic visual field defects.[7] In clinical practice, as well as in clinical trials, both structural and functional losses are assessed for the diagnosis and monitoring of glaucoma.[2,8,9] Because injury due to glaucoma is largely irreversible, early detection and prevention of glaucomatous damage is of vital importance. Examination of the optic nerve head and its surrounding RNFL is considered essential in both detecting and monitoring glaucoma.[6] Damage to the RNFL and the optic disc has been shown to precede visual field loss. Quigley et al.[3] reported that up to 40 to 50% of the RNFL could be lost before visual field defects are detected by conventional perimetry. Thus, RNFL assessment has emerged as an important parameter for preperimetric diagnosis of glaucoma and may aid ophthalmologists in making an accurate and early diagnosis.

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Functional losses by glaucoma are traditionally evaluated with standard automated perimetry (SAP). Structural losses of RNFL can be evaluated by various imaging techniques. Recent advances in ocular imaging technology utilizing the optical properties of RNFL provide a potential means of obtaining quantitative RNFL thickness measurements. Furthermore, these techniques offer objectivity, rapidity, and reproducibility of measurements.
Currently available imaging techniques used for examining the RNFL and optic disc in glaucoma include confocal scanning laser ophthalmoscopy (CSLO), optical coherence tomography (OCT), and scanning laser polarimetry (SLP). Each of these techniques uses different technologies and light sources to characterize the distribution of RNFL and/or optic disc topography.

The purpose of this study was to study the correlation between retinal nerve fiber layer (RNFL) thickness measured with spectral domain optical coherence tomography (SD-OCT) and visual field (VF) in patients of primary open angle glaucoma (POAG).

Materials and Methods

A total of 60 patients of POAG and 60 controls were studied for a period of one year from July, 2011 to June, 2012 in the Department of Ophthalmology, Sir Sunderlal Hospital, Institute of Medical Sciences, Banaras Hindu University, Varanasi.

All subjects underwent full clinical ophthalmic evaluation, including medical, ocular, and family history; visual acuity testing; intraocular pressure measurement (IOP); assessment and grading of anterior chamber angle; slit lamp biomicroscopy; and indirect ophthalmoscopy.

We included the patients who fulfilled the following criteria:

1. Optic disc changes characteristic for glaucoma
    - C:D >0.6
    - Asymmetry of C:D between fellow eyes >0.2
    - Notching, thinning of neuroretinal rim, peripapillary hemorrhages.
2. An open anterior chamber angle (Grade 3 and above by Shaffer's classification).

Following patients were excluded from our study:

1. Age <40 years.
2. Other ocular disorders like uveitis, retinal detachment, retinal vascular disorders, etc.
3. Patients with diabetes, hypertension or with any other chronic disorders
4. Other forms of glaucoma like pigmentary glaucoma, pseudo-exfoliation syndrome, steroid induced glaucoma, etc. (all forms of secondary glaucoma)
5. Refractive error $\geq \pm$ 5.0 D.
6. Unreliable visual field test.

Achromatic automated perimetry was performed with Humphrey Field Analyzer (HFA; Humphrey-Zeiss) using Swedish Interactive Threshold Algorithm (SITA) Standard Central 30-2 program. The stimulus size used was Goldmann size III. Visual field reliability criteria was fixation losses <25%, false positive and false negative <20%. Visual field loss denotes functional loss and is a qualitative data. Hence, mean deviation [MD (dB)] and pattern standard deviation [PSD (dB)] was used as age-matched normative data.

Optic disc imaging was done using Cirrus HD Spectral Domain Optical Coherence Tomography (SD-OCT). The Cirrus HD-OCT uses spectral domain technology of an optic disc cube obtained from a 3-dimensional data set composed of 200 A-scans from each of 200 B-scans that cover a 6-mm^2 area centred on the optic disc. After creating an RNFL thickness map from the cube data set, the software automatically determined the center of the disc and then extracted a circumpapillary circle (1.73-mm radius) from this data set. We excluded all poor-quality scans with signal strength of <6. The average retinal nerve fiber layer (RNFL) thickness was noted for all the patients. It denotes the structural loss and is a quantitative data.

Statistical analysis was performed on computer (SPSS ver 16.0 software). The correlation between RNFL and visual field parameters (MD and PSD) was studied using Spearman's rho (ρ) as correlation coefficient. Spearman's rho is used as correlation coefficient when standard deviation is too high as compared to sample mean value or the sample size is too small. In our study, the sample size was adequate but standard deviation was too high as compared to sample mean. When sample mean is too high then skewed deviation is suspected and hence, non-parametric correlation coefficient like Spearman's rho is applied.

Results

60 patients with glaucoma and 60 healthy controls fulfilled our inclusion and exclusion criteria.

Table 1.Mean Values of RNFL, MD and PSD in Cases and Controls

	POAG Cases (N = 60)	Controls (N = 60)
Mean age (in years)	55.27 ± 10.29	53.98 ± 10.66
Average RNFL (μm)	81.20 ± 14.81	93.67 ± 4.58
MD (dB)	-7.24 ± 5.64	-1.02 ± 0.35
PSD (dB)	5.70 ± 4.81	2.34 ± 0.55

Table 2.Age-Wise Distribution

S. No.	Age Group (in years)	Cases		Controls	
		No.	Percentage (%)	No.	Percentage (%)
1.	40-44	7	11.7	8	13.3
2.	45-49	8	13.3	10	16.7
3.	50-54	8	13.3	10	16.7
4.	55-59	6	10	8	13.3
5.	60-64	7	11.7	5	8.3
6.	65-69	10	16.7	5	8.3
7.	70 and above	14	23.3	14	23.3
		60	100	60	100

The maximum number of POAG patients were in age group 70 years and above (23.3%).

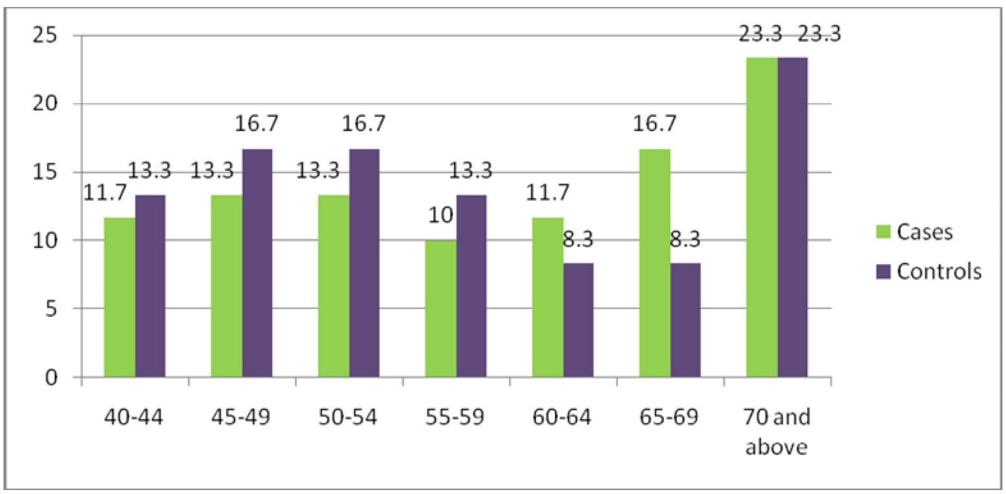

Figure 1.Number of POAG patients as per age group

Table 3.Sex-Wise Distribution

S. No.		Cases		Controls	
		No.	Percentage (%)	No.	Percentage (%)
1	Males	45	75.00	43	71.67
2	Females	15	25.00	17	28.33
	Total	60	100.00	60	100.00

Inference

Sex-wise analysis of the POAG patients showed that 75% of cases were males and 25% were females. The male to female ratio was 3:1.

Table 4.Correlation between RNFL and MD

	Cases			Controls		
	Mean ± SD	Spearman's ρ	P value	Mean ± SD	Spearman's ρ	P value
Average RNFL(μm)	81.20 ± 14.81	0.925	<0.001	93.67 ± 4.58	0.023	0.119
MD (dB)	-7.24 ± 5.64			-1.02 ± 0.35		

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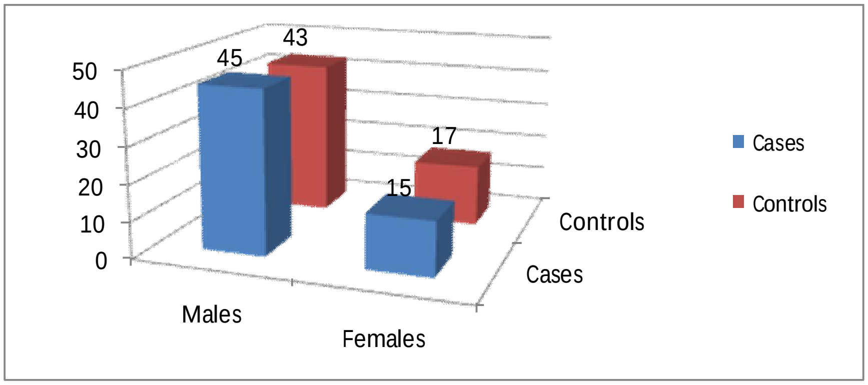

Figure 2.Gender-wise analysis of the POAG patients

The correlation between RNFL and MD in POAG cases is 0.925 with P <0.001 which is statistically significant.

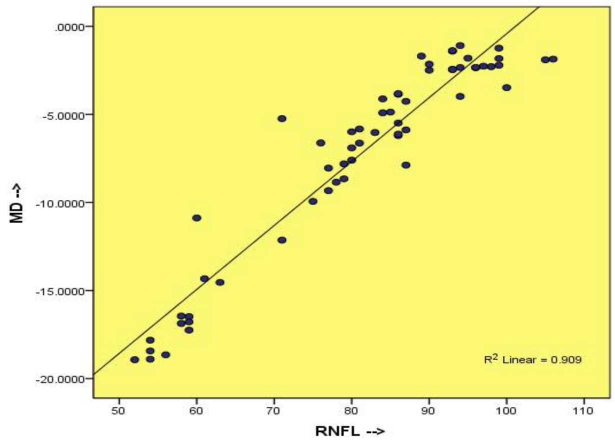

Figure 3.Correlation between RNFL and MD in POAG cases

Table 5.Correlation between RNFL and PSD

	Cases			Controls		
	Mean ± SD	Spearman's ρ	P value	Mean ± SD	Spearman's ρ	P value
Average RNFL(μm)	81.20 ± 14.81	-0.879	<0.001	93.67 ± 4.58	-0.188	0.150
PSD (dB)	5.70 ± 4.81			2.34 ± 0.55		

The correlation between RNFL and PSD in POAG cases is-0.879 with P <0.001 which is statistically significant.

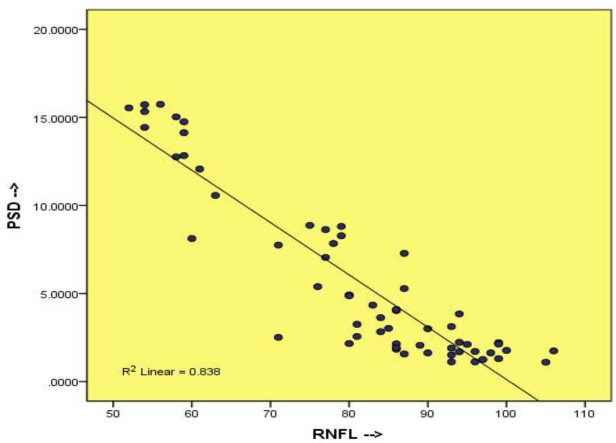

Figure 4.Correlation between RNFL and PSD in POAG cases

Discussion

Assessing the amount of glaucomatous damage is the first step toward the correct management of glaucoma. The damage is usually estimated by observation of structures affected by glaucoma (RNFL and optic disc) and by testing visual function by perimetry. It is of great importance to know the way the damage to specific structures affects visual function.

In this study, an objective quantitative measurement of RNFL thickness, as measured by SD-OCT was correlated with a quantitative measurement of VF as expressed in VF MD and with PSD.

The present study demonstrated that the OCT has the ability to detect early glaucomatous change by measuring RNFL thickness. This study, as in previous ones assessing RNFL thickness using monitoring tools such as SLP and HRT, were all cross-sectional due to the short history of these innovations.

A prospective study monitoring individuals for long term is desirable in evaluating the relationship between RNFL thickness and visual field. A prospective long-term study would give a better gauge as to the percentage of glaucoma-suspect eyes eventually developing into glaucoma. When a cross-sectional study is done, it is necessary that a large number of subjects be used.

There are various reports about correlations between visual field and RNFL thickness measured by OCT.

Table 6.Correlation coefficient between RNFL and MD

Study	Correlation Coefficient between RNFL and MD
Zangwill et al. 2000[10]	0.660 (*P*<0.001)
Parisi et al. 2001[11]	0.393 (*P*=0.031)
Soliman et al. 2002[12]	0.557 (*P*<0.0001)
Kanamori et al. 2003[13]	0.729 (*P*<0.001)
Sihota R et al. 2006[14]	0.626 (*P*<0.001)
Ajtony C et al. 2007[15]	0.718 (*P*=0.01)
Horn FK et al. 2009[16]	0.75 (*P*<0.001)
Cvenkel et al. 2011[17]	0.549 (*P*<0.001)
Kaushik S et al. 2011[18]	0.560 (P=0.005)

Compared with these studies, our results show a stronger relationship between visual field and RNFL thickness measured by OCT. In our study, the correlation between average RNFL thickness and mean deviation was 0.925 (P <0.001). The difference in results may be attributed to subject characteristics such as a homogenetics, differences in severity of glaucoma, and other methodological differences.

Our findings confirm previous observations of significant correlations between functional and structural changes in glaucoma patients and their absence in normal individuals.

The limitations of our study were small sample studied over short span of time. A cross-sectional study can identify structural parameters that are associated with visual function, but cannot address the temporal relationship between structure and function. More longitudinal data are needed to clarify structural change with its corresponding functional decline during the progression of glaucoma. Regression analysis of the structure-function relationship may give important information in assessing the pattern of progression.

Conclusion

In our study comprising of 60 cases and 60 controls, we established a strong correlation between average RNFL thickness and mean deviation which was 0.925 (P <0.001). The correlation between average RNFL thickness and PSD was-0.879 (P <0.001) which was also significant.

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. The correlation is significant in POAG eyes, but no correlation was detected between VF and RNFL parameters in normal eyes.

The results of this study demonstrate that functional loss in glaucoma relates well with OCT measurements of parapapillary RNFL. Our knowledge concerning the function/ structure relationships in glaucoma is progressively increasing, and consistency in reporting statistically significant and study population: clinically meaningful correlation coefficients, particularly in the most frequently involved topographically corresponding sectors of VF (superonasal and inferonasal) and parapapillary RNFL (inferotemporal and superotemporal), may represent common ground for future investigations aimed at exploring the diagnostic ability of the combination of functional and structural tests, which have already proved to be highly promising for more accurate detection of early glaucoma[19,20].

Conflict of Interest: None

References

1. Sommer A, Miller NR, Pollack I et al. The nerve fiber layer in the diagnosis of glaucoma. *Arch Ophthalmol* 1977; 95: 2149-56.

2. American Academy of Ophthalmology. Preferred Practice Pattern. Primary Open Angle Glaucoma. San Francisco, CA: *American Academy of Ophthalmology*, 2000.
3. Quigley HA, Addicks EM, Green WR. Optic nerve damage in human glaucoma. III. Quantitative correlation of nerve fiber loss and visual field defect in glaucoma, ischemic neuropathy, papilledema, and toxic neuropathy. *Arch Ophthalmol* 1982; 100: 135-46.
4. Jonas JB, Schiro D. Localised wedge shaped defects of the retinal nerve fibre layer in glaucoma. *Br J Ophthalmol* 1994; 78: 285-90.
5. Tuulonen A, Airaksinen PJ. Initial glaucomatous optic disk and retinal nerve fiber layer abnormalities and their progression. *Am J Ophthalmol* 1991; 111: 485-90.
6. Quigley HA, Miller NR, George T. Clinical evaluation of nerve fiber layer atrophy as an indicator of glaucomatous optic nerve damage. *Arch Ophthalmol* 1980; 98: 1564-71.
7. Keltner JL, Johnson CA, Cello KE et al. Classification of visual field abnormalities in the ocular hypertension treatment study. *Arch Ophthalmol* 2003; 121: 643-50.
8. Heijl A, Leske MC, Bengtsson B et al. Reduction of intraocular pressure and glaucoma progression: results from the early manifest glaucoma trial. *Arch Ophthalmol* 2002; 120: 1268-79.
9. Gordon MO, Kass MA. The ocular hypertension treatment study: Design and baseline description of the participants. *Arch Ophthalmol* 1999; 117: 573-83.
10. Zangwill LM, Williams J, Berry CC et al. A comparison of optical coherence tomography and retinal nerve fiber layer photography for detection of nerve fiber layer damage in glaucoma. *Ophthalmology* 2000; 107: 1309-15.
11. Parisi V, Manni G, Centofanti M et al. Correlation between optical coherence tomography, pattern electroretinogram, and visual evoked potentials in open angle glaucoma patients. *Ophthalmology* 2001; 108: 905-12.
12. Soliman MA, Van Den Berg TJ, Ismaeil AA et al. Retinal nerve fiber layer analysis: relationship between optical coherence tomography and red-free photography. *Am J Ophthalmol* 2002; 133: 187-95.
13. Kanamori A, Nakamura M, Escano MFT et al. Evaluation of the glaucomatous damage on retinal nerve fiber layer thickness measured by optical coherence tomography. *Am J Ophthalmol* 2003; 135: 513-20.
14. Sihota R, Sony P, Gupta V et al. Diagnostic capability of optical coherence tomography in evaluating the degree of glaucomatous retinal nerve fiber damage. *Invest Ophthalmol Vis Sci* 2006; 47: 2006-10.
15. Ajtony C, Balla Z, Somoskeoy S et al. Relationship between visual field sensitivity and nerve fiber layer thickness as measured by optical coherence tomography. *Invest Ophthalmol Vis Sci* 2007; 48: 258-63.
16. Horn FK, Mardin CY, Laemmer R et al. Correlation between local glaucomatous visual field defects and loss of nerve fiber layer thickness measured with polarimetry and spectral domain OCT. *Invest Ophthalmol Vis Sci* 2009; 50: 1971-77.
17. Cvenkel B, Kontestabile AS. Correlation between nerve fibre layer thickness measured with spectral domain OCT and visual field in patients with different stages of glaucoma. *Graefes Arch Clin Exp Ophthalmol* Apr 2011; 249(4): 575-84.
18. Kaushik S, Singh PS, Ichhpujani P et al. Retinal nerve fiber layer measurement and diagnostic capability of spectral-domain versus time-domain optical coherence tomography. *Eur J Ophthalmol* Sep-Oct 2011; 21(5): 566-72.
19. Stroutidis NG, Vinciotti V, Tucker AJ et al. Structure and function in glaucoma: the relationship between a functional visual field map and an anatomic retinal map. *Invest Ophthalmol Vis Sci* 2006; 47: 5356-62.
20. Shah NN, Bowd C, Medeiros FA et al. Combining structural and functional testing for detection of glaucoma. *Ophthalmology* 2006; 113: 1593-602.

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