



IJMIRD 2015; 2(2): 247-251
www.allsubjectjournal.com
Received: 20-01-2015
Accepted: 12-02-2015
E-ISSN: 2349-4182
P-ISSN: 2349-5979
Impact factor: 3.762

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Retinal nerve fiber layer thickness in glaucomatous and normal patients using spectral domain optical coherence tomography and standard automated perimetry-a comparative analysis

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Abstract

Glaucoma is characterized by a combination of structural changes in the retina and optic nerve head and functional perimetric damage. Examination and documentation of the retinal nerve fiber layer are essential for the diagnosis and monitoring of glaucoma. Spectral domain Optical coherence tomography (OCT) is a high resolution imaging device capable of obtaining reproducible retinal nerve fiber layer thickness measurements. **Aim:** The purpose of this study is to compare the efficacy of optical coherence tomography (OCT) and standard automated perimetry (SAP) in glaucoma versus normal patients. **Materials and methods:** It was a case control study. Patients diagnosed of primary open angle glaucoma were taken as cases in this study. They underwent visual field analysis using Humphrey SITA standard threshold 30-2 program and optical coherence tomography of the optic nerve head. **Data analysis:** The mean deviation of the visual field analysis and average RNFL thickness were compared in cases and controls. **Results:** A total of 19 patients of primary open angle glaucoma and 8 normal patients were included in this study. In our study, a significant difference was found among mean deviation, pattern standard deviation, average retinal nerve fiber thickness and temporal retinal nerve fiber thickness between cases and controls. Also, area under the receiver operating characteristics (ROC) curve showed that both mean deviation and average retinal nerve fiber thickness have very sensitivity in detecting glaucoma (0.992 and 0.930) and correlation was found between the mean deviation on visual field analysis and average retinal nerve fiber thickness by OCT. **Conclusion:** Our study concludes that there is a correlation between the structural and functional tests.

Keywords: Automated perimetry, primary open angle glaucoma, optical coherence tomography.

1. Introduction

Glaucoma is characterized by a combination of structural changes in the retina and optic nerve head and functional damage recognized on perimetry.^[1] Examination and documentation of the retinal nerve fiber layer are essential for the diagnosis and monitoring of glaucoma. Optical coherence tomography (OCT) is a high resolution imaging device capable of obtaining reproducible retinal nerve fiber layer thickness measurements.^[2] Spectral domain OCT provides a significantly increased scanning speed and resolution.^[3] Changes in the appearance of the RNFL often can be detected that precede optic disc damage and glaucomatous visual field loss.^[4-6] The purpose of this study is to compare the efficacy of optical coherence tomography (OCT) and standard automated perimetry (SAP) in glaucoma versus normal patients.

2. Material and methods

This was a prospective case control study conducted at a tertiary care centre in Mangalore. The glaucoma group had glaucomatous optic nerve damage with corresponding SAP abnormalities which met Anderson's criteria and a PSD outside 95% normal limits with a confirmatory result on a second visual field examination.

Controls had normal SAP results, defined as glaucoma hemifield results within normal limits, mean and pattern standard deviation (PSD) probability greater than 5%.

All subjects underwent a thorough ophthalmological examination including visual acuity, anterior segment examination using slit lamp biomicroscopy, intraocular pressure (IOP)

recording using Goldman’s applanation tonometry, posterior segment examination by direct and indirect ophthalmoscopy, gonioscopy and standard automated perimetry (full threshold 30-2). All patients with reliable SAP results with fixation losses less than 20%, false positive and false negative less than 33% were included. All subjects underwent imaging using SD-OCT (Carl Zeiss Meditec Inc. software A1.0) for measurement of RNFL thickness. OCT performs cross sectional imaging, three 3.4 mm diameter circular scans centered on the disc. An average thickness was calculated by taking the arithmetic mean of the 100 data points. The peripapillary RNFL thickness was divided into four quadrants defined as superior, inferior, nasal and temporal. Individuals in the normal group had an IOP of less than or equal to 21mm of Hg and had a normal optic disc appearance visualized by stereoscopic examinations. Patients with history of intraocular diseases, other diseases affecting visual field (pituitary lesions, demyelinating diseases), and coexisting retinal disease were excluded. Data analysis: Statistical analysis was performed using Receiver operating curves which were calculated using the mean values obtained. Means comparison analysis of paired parameters between the groups were evaluated by one-way ANOVA.

Data were reported as the mean +/- SD. Pearson correlation coefficients with absolute values equal to or greater than 0.5 suggesting a strong association with P +/- 0.01 were accepted as statistically significant.

3. Results

A total of 19 patients (38 eyes) with glaucoma and 8 normal patients (18 eyes) were examined. Average RNFL thickness by OCT was 91.75 +/- 7.91 and 68.52 +/- 18.70 in normal and glaucoma eyes. Difference between the two were significant (p<0.03). Pattern standard deviation by SAP was 2.36 +/-0.43 and 6.978 +/- 3.08 for normal and glaucoma patients. Mean deviation by SAP was -0.49 +/-1.14 and -9.12 +/-7.18 for normal and glaucoma patients as shown in Table [1]. Receiver operating characteristic (ROC) curves were used to describe the ability of each VF parameter and the average RNFL thickness to differentiate normal eyes from eyes with POAG as shown in Figure [1] and Figure [2]. The area under the curve calculated by ROC was as follows: RNFL average was 0.93, RNFL inferior and superior was 0.66 and 0.633 respectively. The area under the curve for mean and pattern standard deviation was 0.99 and 0.07 respectively.

Table 1: The group statistics of both the cases and normal are listed in the above table. MD - mean deviation, PSD - pattern standard deviation, RNFLAVG - Average retinal nerve fiber layer thickness. RNFLINF SUP NAS TEMP - Retinal nerve fiber layer thickness in inferior, superior, nasal and temporal quadrant respectively. P value: VHS - very high significance. MD - Standard Automated Perimetry (SAP) reading and RNFL average thickness as measured by Optical coherence tomography concludes the correlation between structural and functional test.

Group Statistics

	GROUP	N	Mean	Std. Deviation	z
MD	Cases	38	-9.2485	7.41216	5.66400
	Normals	16	-.4750	1.15576	p<0.001 VHS
PSD	Cases	38	6.9579	3.01509	5.68300
	Normals	16	2.2100	.52448	p<0.001 VHS
RNFLAVG	Cases	38	67.8684	17.44206	4.95900
	Normals	16	90.9375	6.32949	p<0.001 VHS
RNFLINF	Cases	38	40.0789	47.16984	1.91400
	Normals	16	59.7500	60.34733	P=.056 NS
RNFLSUP	Cases	38	42.8158	45.95230	1.58300
	Normals	16	55.8750	56.46813	P=.113 NS
RNFLNAS	Cases	38	29.8684	30.37795	.97700
	Normals	16	37.0625	37.50994	P=.329NS
RNFLTEMP	Cases	38	52.0789	13.41315	3.17800
	Normals	16	62.6875	7.52524	p<0.001 VHS

4. Discussion

Assessing the amount of glaucomatous damage is the first step towards 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. [7] The correlation of RNFL with VF abnormalities has already been reported in the literature. [8] In our study, we compared structural and functional parameters

of glaucoma patients with and without VF abnormalities. Our study is in accordance with previous OCT imaging studies[9] of normal patients’ shows that the superior and inferior quadrants of RNFL are the thickest in normal patients, but RNFL average has the highest discriminating power.[10] Our study found a correlation between MD and RNFL average, but PSD had no correlation. This could be due to the effect of the logarithmic scale which minimizes sensitivity changes at

high dB levels but maximizes changes at low dB. A cross sectional study can identify structural parameters that are associated with visual functions, but cannot address the temporal relationship between structure and function.^[6]

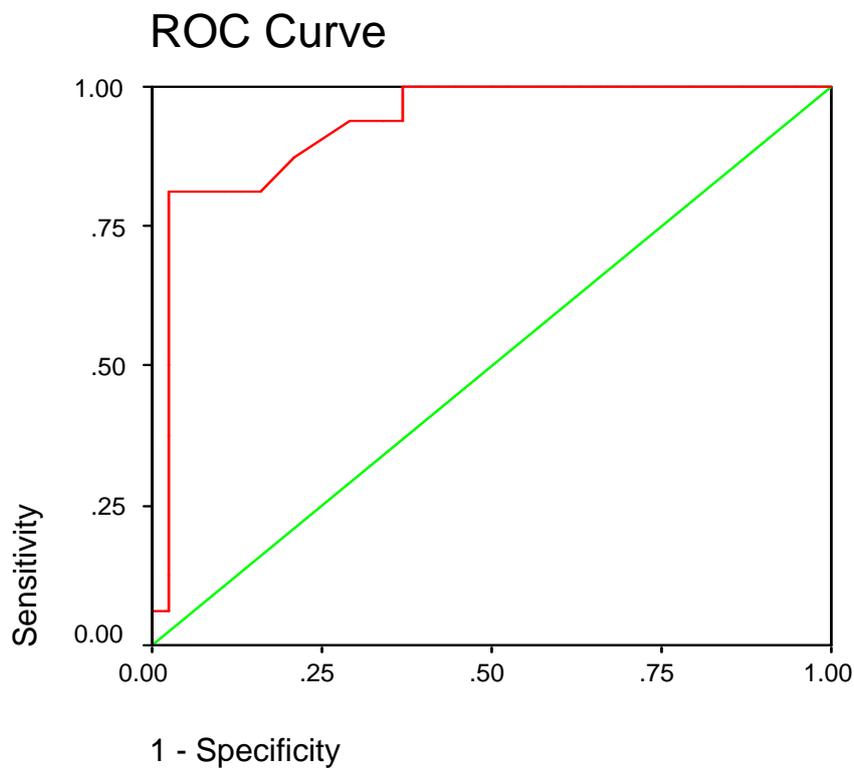
The definition of glaucoma becomes problematic when comparing the diagnostic accuracy of structural and functional tests, as in our study, as the definition used will either be biased toward on test or other.^[11] The other drawback of our study is that the glaucoma patients included are at different stages of the disease. More longitudinal data are needed to clarify the structural change with its

corresponding functional decline during the progression of glaucoma.

5. Conclusion

Our study concludes that there is a correlation between the structural and functional tests. There is a correlation between MD-SAP and RNFL average thickness as inferred by our study. It shows RNFL average to have the best discriminating power with the highest area under the ROC (0.93)

figures



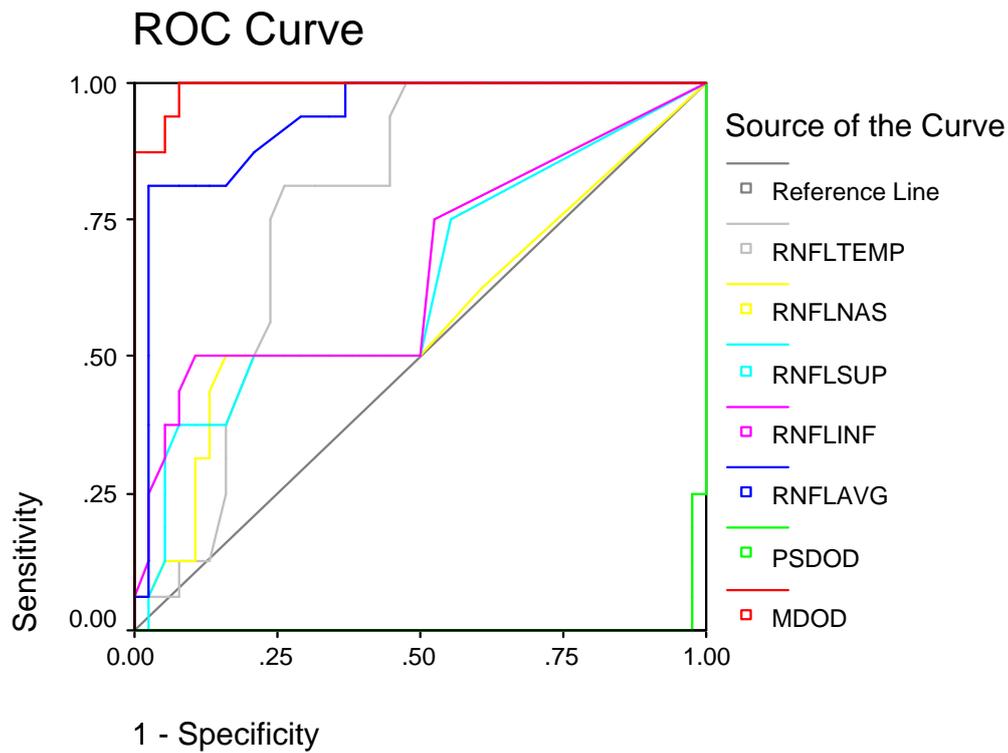
Diagonal segments are produced by ties.

Area Under the Curve

Test Result Variable(s): RNFLAVG

Area
.930

Fig 1: receiver operating characteristics curve showing high sensitivity of aberage retinal nerve fibre thickness in detecting glaucoma



Area Under the Curve

Test Result Variable(s)	Area
MDOD	.992
PSDOD	.007
RNFLAVG	.930
RNFLIN	.660
RNFLSUP	.633
RNFLNAS	.582
RNFLTEMP	.775

Fig 2: ROC curves of various components: mean deviation (MD), pattern standard deviation (PSD), Retinal nerve fibre thickness average (RNFLAVG), Retinal nerve fibre thickness inferior (RNFLIN), Retinal nerve fibre thickness superior (RNFLSUP), Retinal nerve fibre thickness nasal (RNFLNAS), Retinal nerve fibre thickness temporal (RNFLTEMP)

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