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A study on correlation between automated perimetry and optical coherence tomography findings in glaucoma suspects

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ABSTRACT

Aim and Objective: To evaluate the correlation between optic disc and retinal nerve fiber layer (RNFL) parameters of SD OCT scan of optic disc, and, visual field indices of Humphrey visual field analyzer.

Materials and Methods: This is a prospective, cross-sectional study of 47 patients who are glaucoma suspects. They have been screened for glaucoma by comprehensive ophthalmic examination including visual field testing by automated perimetry and optic nerve head and retinal nerve fiber layer thickness changes assessment by optical coherence tomography.

Results: Mean age of the glaucoma suspects was 54.35 ± 10.6 years. Women were having higher (58.7%) mean age as compared to men (41.3%). Mean IOP in glaucoma suspects was 17.97 mmHg. The mean CD ratio was measured as 0.66 ± 0.11 and with significant negative correlation between the mean MD and CD ratio values ($p < 0.05$) and similarly between MD and Vertical CDR. PSD showed significant positive correlation with CDR and also with Vertical CDR. Correlation is noted between MD and average RNFL, with significant positive correlation between MD and superior RNFL.

Conclusion: Spectral domain OCT, when used in combination with automated perimetry helps in early diagnosis of glaucoma. SD OCT of Optic disc alone can detect changes of RNFL in patients with normal discs and visual fields. Optic Disc OCT plays a vital role in diagnosing preperimetric glaucoma patients.

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1. Introduction

Blindness is defined as vision less than 3/60 or corresponding visual field loss in the better eye with the best possible correction. As per 2020, glaucoma is second among the most common causes for blindness, worldwide.¹ Unlike cataract, which is the most common cause of blindness worldwide, glaucoma causes irreversible visual impairment which is detected early and is even preventable unlike cataract which mostly is only treatable and not preventable.

Glaucoma is a chronic, progressive optic neuropathy caused by a group of ocular conditions, which lead to damage to the optic nerve with loss of visual function.

The most common risk factor known is a raised intraocular pressure.² The global prevalence of glaucoma among people aged between 40 and 80 years is 3.54%. Whereas, the prevalence of cataracts increases with age, ranging from 3.9% among 55-64 years to 92.6% among those 80 years and older.³ Glaucoma is classified into open angle or closed angle. Each further classified into primary and secondary.

Primary open angle glaucoma (POAG) is an adult onset progressive optic neuropathy, which is bilateral and nearly symmetrical with open angle on gonioscopy, glaucomatous optic nerve head changes with corresponding visual field defects and raised intraocular pressure of > 21 mm of HG.⁴

Prevalence of POAG in white individuals of age group 40-49 years is 0.9% and in people > 80 years is 2.2% while prevalence in black individuals ranged from 1.2% to

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11.3% in Baltimore eye study.⁵

Glaucoma affects nearly 11.2 million people of age group 40 or more with POAG affecting 6.48 million and Primary angle closure affecting 2.54 million.⁶ 12 million people are affected by glaucoma in India with prevalence ranging from 2% to 13%.⁷

Glaucoma suspects are the individuals with at least one of the following clinical features of the disease

1. Elevated Intraocular pressure
2. Suspicious optic nerve abnormalities
3. Repeatable visual field abnormality consistent with clinical optic nerve damage
4. Family history of glaucoma⁶

Visual field loss in glaucoma follows a characteristic pattern which can be detected by Perimetry, but for it to appear on perimetry there should be 30 percent loss of retinal ganglion cells. Hodapp, Parrish and Anderson gave criteria for glaucomatous damage on Standard automated perimetry (SAP),

Cluster of three or more non-edge points in a typical location for glaucoma which are depressed on PSD <5% of which one is depressed <1% on two consecutive fields

Corrected PSD <5% of normal individuals on two consecutive fields, GHT outside normal limits on two consecutive occasions.⁸

Spectral domain OCT, a novel non-invasive rapidly evolving, computer-based imaging tool provides quantitative information about the optic nerve head, retinal nerve fiber layer and ganglion cell layer through which the structural changes in optic nerve head, RNFL loss and Ganglion cell death can be detected way before appearance of visual field defects on perimetry.

Optical coherence tomography (OCT) — uses infrared 843-nm diode light source, using a beam splitter, is divided into two light sources of which one is projected into the patient's eye and the other into mirror; the reflected waves of light from both are captured by a photo detector and the difference in the amount of interference between them is used to generate cross-sectional images of the retina and the disc.⁹

Both Perimetry and OCT give test reports based on comparison to normative data. So alone they are not completely reliable for diagnosis, rather both the investigation reports need to be correlated with each other and with clinical findings for the diagnosis of Glaucoma. This correlation thus is of particular use in patients who are glaucoma suspects.

Kuang TM et al. in a longitudinal study estimating the diagnostic accuracy and lead time of OCT detection of glaucoma before the development of field defects, concluded that the use of OCT in glaucoma suspects helps in early detection of glaucoma before fields.¹⁰

Several clinical studies done on disc OCT and visual fields examination established a positive correlation in

glaucoma patients by which OCT helps in diagnosis and monitoring of glaucoma progression, but studies of correlation between SD-OCT and visual fields are lacking in glaucoma suspects and preperimetric glaucoma patients. This study correlates SD-OCT of optic disc with visual field parameters of Standard automated perimetry in glaucoma suspects, in population of north Karnataka which helps in early detection of glaucoma, as early detection and treatment is the Mainstay for glaucoma management and its progression.

2. Materials and Methods

This is a cross-sectional and time bound study that has been carried out on the patients attending the outpatient department of Ophthalmology, Shri B.M.Patil's BLDE Medical College, Hospital and Research Centre, Vijayapura.

The study includes total of 47 glaucoma suspects. They have been screened for glaucoma by complete ophthalmic examination including detailed history.

1. Visual acuity
2. Slit lamp examination
3. Direct and Indirect ophthalmoscopy
4. Gonioscopy, Applanation tonometry
5. Automated perimetry, Optical coherence tomography

2.1. Inclusion criteria

Glaucoma suspects above 40 years

2.2. Exclusion criteria

1. Patient with media opacity
2. Best corrected visual acuity worse than 6/24
3. A spherical correction > +1-6 OD, cylinder correction > +/-2 OD
4. History of any eye trauma or surgery with the exemption of any
5. Uncomplicated cataract surgery: Optic neuritis patients
6. Patients with macular or vitreoretinal disease
7. Unreliable visual field [false positive > 20%, false negative > 20%]
8. Poor quality OCT images.

2.3. Statistical analysis

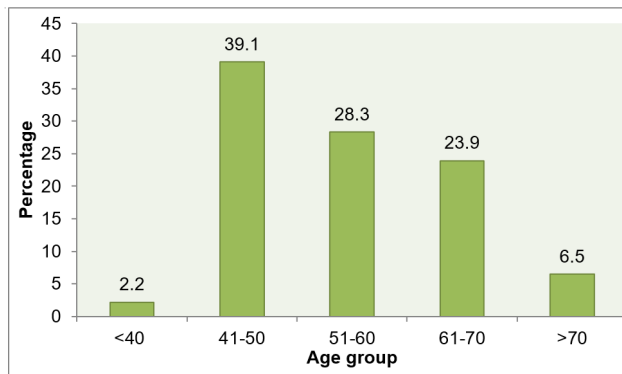
The data obtained is entered in a Microsoft excel sheet, and statistical analysis performed using statistical package for social sciences (version 20).

Results are presented as mean (median) +/- SD counts and percentages and diagrams. Normally distributed continuous variables in two groups are compared using Independent t test for not normally distributed variables Mann Whitney test has been used.

Relationship between the variables is analyzed using Pearson’s / spearman’s correlation. Categorical variables between two groups are compared using chi square test, $P < 0.05$ is considered statistically significant. All statistical tests performed are two tailed.

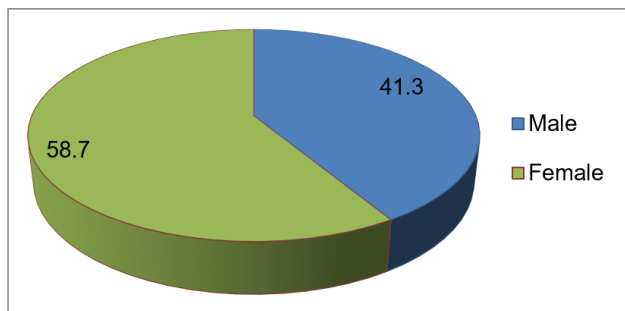
3. Results

In the present study respondents in the age group of 41-50 years are more (39.1%) followed by participants in 51-60 years of age (28.3%), 61-70 years of age (23.9%) and elder than 70 years (6.5%). Only 1 patient was found to be younger than 40 years (2.2%) (Graph 1). The mean age of the participants is 54.35 ± 10.6 years.



Graph 1: Frequency of age wise distribution (%)

The proportion of women is higher (58.7%) compared to men (41.3%) in the present study (Graph 2). Mean IOP recorded in glaucoma suspects is 17.97 mm of Hg and the maximum recorded IOP 26 mm of Hg.



Graph 2: Frequency of gender wise distribution (%)

The mean MD value was measured as -4.15 ± 3.44 and the mean rim area was measured as 1.21 ± 0.24 . There is no significant correlation between the MD and rim area ($p > 0.05$).

The mean disc area was measured as 2.69 ± 0.52 and there is significant positive correlation between the mean MD and disc area values ($p < 0.05$). The mean CD ratio was measured as 0.66 ± 0.11 and there is significant

Table 1: Correlation of different variables with mean deviation

Variable	Mean \pm SD	Correlation with MD (p value)
MD	-4.15 ± 3.44	
Rim area	1.21 ± 0.24	0.878
Disc area	2.69 ± 0.52	0.024*
CD Ratio	0.66 ± 0.11	0.003*
Vertical CD Ratio	0.69 ± 0.084	0.000*

Table 2: Correlation of different variables with pattern standard deviation

Variable	Mean \pm SD	Correlation with PSD (p value)
PSD	3.08 ± 2.20	
Rim area	1.21 ± 0.24	0.066
Disc area	2.69 ± 0.52	0.250
CD Ratio	0.66 ± 0.11	0.001*
Vertical CD Ratio	0.69 ± 0.084	0.000*

negative correlation between the mean MD and CD ratio values ($p < 0.05$), and similarly between MD and vertical CDR.(Table 1)

The mean PSD was measured as 3.08 ± 2.20 and when correlated with the mean rim area and disc area no significant correlation was observed ($p > 0.05$). The mean PSD showed Positive correlation with CD ratio and vertical CD ratio.($p > 0.05$).(Table 2)

The average RNFL was found to be 82.86 ± 6.16 , and the mean GHT values based on normal limits are measured as below.(Table 3)

Table 3: Correlation between GHT and RNFL thickness

GHT	Number	Mean \pm SD
Borderline	14	83.5 ± 2.20
Generalized reduction of sensitivity	1	93.0 ± 0.0
Outside normal limits	30	81.89 ± 6.47
Within normal limits	2	87.25 ± 0.35
Total	47	82.86 ± 6.16

The RNFL was measured as 82.86 ± 6.16 and there is significant positive correlation between the mean MD and RNFL values ($p < 0.05$). There is a positive correlation between MD and different RNFL values, but a significant positive correlation was seen between MD and S RNFL. (Table 4)

There is a positive correlation between Pattern Standard Deviation (PSD) and different RNFL values except N RNFL which has a negative correlation, but a significant positive correlation was seen between PSD and S RNFL, PSD and t RNFL. (Table 5)

There is a positive correlation between different parameters and RNFL values except for rim area which has

Table 4: Correlation between MD and different RNFL

MD	Pearson's Correlation	P-value
S RNFL	.309	0.037*
I RNFL	0.18	0.231
T RNFL	0.134	0.376
N RNFL	0.19	0.206

Table 5: Correlation between PSD and different RNFL

PSD	Pearson's Correlation	P-value
S RNFL	0.393	0.006*
I RNFL	0.011	0.941
T RNFL	0.445	0.002*
N RNFL	-0.244	0.102

a negative correlation. Significant positive correlation was seen between RNFL and disc area.(Table 6)

Table 6: Correlation between RNFL and disc parameters

RNFL	Pearson's Correlation	P-value
Rim area	-0.027	.856
Disc area	0.415	.004*
CD ratio	0.032	.831
Vertical CD ratio	0.086	.568

4. Discussion

Glaucoma is one of the leading causes of preventable blindness in INDIA with estimated prevalence of 12 million causing significant visual function disability which is irreversible, so early identification of glaucoma prevents the progression of glaucomatous field loss.

Lisa et al. conducted a study to compare the number of RGC topographically mapped with specific visual field threshold test data in same eyes of glaucoma patients concluded that at least 25% to 35% RGC loss is associated with statistical abnormalities in SAP and RGCs with larger diameter axons die preferentially in glaucoma.¹¹

H A Quigley correlated RGC atrophy with automated perimetry in human eyes with glaucoma and concluded that 20% loss of RGC in central 30 degrees of retina corresponds with 5-dB sensitivity loss and 40% loss corresponded with 10-dB loss.¹²

C A Girkin compared progression in Short wavelength automated perimetry(SWAP) and white on white standard automated perimetry in eyes with progressive glaucomatous disc damage and concluded that SWAP identified more patients than SAP for progressive Glaucomatous changes of optic disc.¹³

Alberto Diniz-Filho et al. studied the association between IOP and rates of RNFL loss measured with Spectral domain OCT by observational cohort study and concluded

that higher levels of IOP are associated with faster rates of RNFL loss and OCT RNFL thickness measurements can be used as bio markers to evaluate the efficacy of medical interventions to reduce the risk of disease progression.¹⁴

dimitrios Bizios et al. conducted a study in which combination of SAP and OCT data was used to diagnose glaucoma with complementary information from structural and functional measurements aided by Artificial Neural Networks(ANNs) and concluded that combination of fused OCT and SAP parameters improved the accuracy of ANNs compared to use of SAP parameters alone.¹⁵

Ake Tzu-Hui Lu et al conducted a study to identify the OCT RNFL parameters to optimize glaucoma diagnosis and concluded that overall RNFL thickness along with superior quadrant or inferior quadrant RNFL thickness average is used best for glaucoma diagnosis.¹⁶

In 2019 Nikhil RP, G Chandrasekhar, Vinod Potluri in their "Early Detection of Glaucoma Prevents Visual Impairment: A Clinical Study" concluded that The RNFL thickness were well correlated to optic disc parameters, with OCT obtaining high resolution images and reproducible RNFL thickness measurement.¹⁷

Kazuyuki hirooka et al in their study 'Use of the structure-function relationship in detecting glaucoma progression in early glaucoma' concluded that When mild Visual field defect is present, OCT RNFL thickness measurements can be helpful in discerning glaucoma progression,¹⁸

Mithra Sei et al in a prospective longitudinal clinical trial to compare detection of progressive RNFL atrophy by Time domain OCT with visual field progression by SAP in glaucoma suspects and preperimetric glaucoma and perimetric glaucoma concluded that structural progression is followed by functional progression in glaucoma suspects and glaucomatous eyes, with Average and superior RNFL thickness predicting subsequent SAP loss.¹⁹

In glaucoma, progression is the rule, not the exception as evident with EMGT trail, in which glaucomatous eyes showed some level of progression with long enough duration of follow up even with well controlled IOP.²⁰

Glaucoma suspects progress to primary open angle glaucoma at approximately 1% to 2% over 5 to 15 years, early detection of glaucomatous disc damage by SD OCT or by repeatable visual field loss in HVF single field examination confirms diagnosis of glaucoma and helps in early management of the disease which further helps in reduction of glaucoma progression.

In this study, correlation of optic disc parameters and RNFL thickness with visual field changes in 47 eyes of 47 patients with Glaucoma suspects are analyzed. The mean age in the suspect group is 54.35 ± 10.6 years, in the gender distribution 41.3% are males and 58.7% are females.

4.1. Optic disc parameters

Among the optic disc parameters, disc area is 2.69 ± 0.52 , Rim area 1.21 ± 0.24 , CD Ratio 0.66 ± 0.11 .

4.2. RNFL thickness

Superior RNFL thickness in suspects was found to be 105.63 ± 20.4 , Inferior RNFL thickness in suspects was found to be 99.19 ± 19.34 , Temporal RNFL thickness in suspects was found to be 62.38 ± 22.3 , Nasal RNFL thickness in suspects was found to be 68.61 ± 27.48 .

4.3. Visual field indices

The mean deviation in suspects -4.15 ± 3.44 , The pattern standard deviation in suspects 3.08 ± 2.20 .

4.4. Optic disc parameters and RNFL thickness

Significant positive correlation was seen between RNFL and disc area and a negative correlation with rim area. With no correlation between vertical CDR and RNFL thickness and overall CDR.

4.5. Optic disc parameters and visual field indices

There is significant positive correlation between the mean MD and disc area values (p value 0.024), with no significant correlation between the MD and rim area ($p > 0.05$).

A significant negative correlation between the mean MD and CD ratio and vertical CDR ratio (p value 0.003) No correlation was noted with PSD and rim area or disc area and a positive correlation with CDR.

4.6. Glaucoma hemifield test

Majority of the patients 63.8% (30 of 47) lie outside normal limits, 23.4% (14 of 47) are borderline with 1 patient had generalized reduction of sensitivity, and 2 patients with in normal limits.

4.7. RNFL thickness and visual field indices

A positive correlation noted between MD and average RNFL, with significant positive correlation between MD and superior RNFL. A negative correlation was noted between PSD and Nasal RNFL and positive correlation between Superior RNFL, temporal RNFL and PSD.

Goal of glaucoma management is to prevent loss of visual function which relates to quality of life as even moderate visual field loss can have profound implications, Imaging modalities doesn't quantify visual function hence should be used to supplement visual field testing with SAP rather than standalone testing modalities for follow up of glaucoma patients or for assessing glaucoma progression OCT alone is insufficient for glaucoma diagnosis and follow up and should always be in conjunction with SAP.²¹

The various imaging technologies have their own advantages and limitations, and their classification shows only partial agreement with clinical exam in diagnosing glaucoma. Agreement between classification with quantitative imaging and VF testing is only moderate. Diagnosis of glaucoma based only on OCT exam should be avoided

RNFL thickness measurement reaches a plateau at nearly 40-50 μ following which OCT will not detect further loss of RNFL loss even in advanced glaucomas with perimetric MD in the ranges of -10dB to -15dB called floor effect which makes OCT vulnerable to impossible to use for structural corroboration with perimetric findings in advanced cases of glaucoma as standalone device for follow-up.²²

Hyoung Won Bae et al conducted a study to identify the role of disc findings and VF tests with OCT images in which ophthalmologists were provided with disc and red free photographs followed by VF test and then with OCT images concluded that optic disc evaluation and VF findings are sufficient for glaucoma diagnosis which is further aided by OCT in ambiguous cases.²³

5. Limitations

1. Only glaucoma suspects were included in the study with no comparison with normal subjects.
2. Only 47 patients were included, larger sample size might represent the population well.
3. Study duration was not long enough to study glaucoma progression.
4. OCT Macula was not included in the study which helps in early diagnosis of glaucoma suspects.

6. Conclusion

In this study of glaucoma suspects RNFL thickness correlated with Rim area and Disc area of optic disc parameters. Patients with RNFL thinning had visual field loss, with Average RNFL and superior RNFL correlating with MD.SD OCT of Optic disc can detect changes of RNFL with normal discs and visual fields.

Disc OCT can produce accurate and reproducible RNFL and retinal thickness measurements with a diagnostic accuracy in RNFL measurements. Optic Disc OCT plays an important role in diagnosing preperimetric patients of glaucoma suspect. Spectral Domain Optical Coherence Tomography of optic disc measurements used with standard automated perimetry helps not only in early diagnosis but also in further management and in assessing glaucoma progression.

7. Sources of Funding

None.


8. Conflict of Interest

None.

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