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Original Research Article

Correlation of structural and functional changes in primary open angle glaucoma (POAG) patients based on visual field and optical coherence tomography

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Abstract

Background: Primary open-angle glaucoma (POAG) is characterized by an open anterior chamber angle, glaucomatous optic nerve head (ONH) changes, visual field (VF) defect, and an intraocular pressure (IOP) more than 21 mm Hg on more than one occasion.
Aim & Objectives: Comparison of subjective and objective diagnosis of structural abnormality of optic nerve head caused in glaucoma patients by 90D lens on slit lamp v/s SD OCT based disc and RNFL changes and functional abnormality by visual field changes using standard automated perimetry (SAP). The Objective is to assess clinical cup/disc ratio, RNFL loss using SD OCT and visual field by perimetry, and the correlation of intraocular pressure (IOP) with all these variables, thereby identifying risk factors and aiding proper management, early diagnosis, grading severity and halting progression of primary open angle glaucoma.
Materials and Methods: Cross-sectional study at a primary care centre on 102 primary open angle glaucoma patients (180 eyes) visiting ophthalmology department for a period of 2 years.
All patients underwent visual assessment, IOP measurement by Goldman applanation tonometer, gonioscopy, optic nerve head examination with slit lamp biomicroscopy using 90D lens, an optical coherence tomography (OCT) and visual field by perimetry.
Results: We observed a statistically significant correlation between clinical cup/disc ratio, increase in loss of RNFL thickness and probability of abnormal visual field.
CDR of 0.6 to 1.0 were observed, which statistically correlated with SD OCT CDR, (P=0.007). A statistically significant correlation between OCT and VF (P= 0.0183), of which inferior-temporal sector defect had a significant correlation with corresponding superonasal VF defect (P value=0.0048).
Conclusion: We observed that persistent higher levels of IOP were notably related to higher rates of progressive RNFL loss. The proportion and severity of scotoma increases as CD ratio increases along with an increase in loss of RNFL thickness.
Visual field analysis by automated perimeter is more specific as compared to SD-OCT, which is more sensitive.

Keywords: Glaucoma, Glaucomatous optic nerve head, Intraocular pressure, Visual field, Optical coherence tomography, Perimetry, Slit lamp biomicroscopy, CD ratio, Gonioscopy, RNFL, Goldman applanation tonometry.

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1. Introduction

Glaucoma is a multifactorial disease characterized by loss of retinal ganglion cells leading to degeneration of optic nerve.1 There are two major types of glaucoma: Primary and secondary glaucoma (open-angle and angle-closure) due to different anatomic and pathophysiological factors.[1] Primary open-angle glaucoma (POAG) is an adult-onset, bilateral disease, characterized by an open anterior chamber angle, glaucomatous optic disc changes, characteristic visual field (VF) defects, and an intraocular pressure (IOP) of >=21 mm Hg on more than one occasion.[2]

As both structural and functional variables deteriorate with progressive glaucoma, the relationship between structure and function measurements is remarkably important.[3]

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Structural damage can be assessed with 90D lens on slit lamp biomicroscope subjectively and OCT images of retinal nerve fiber layer (RNFL) objectively.[4]

Functional change in POAG is assessed by visual field changes using standard automated perimetry (SAP), which also helps in glaucoma follow-up and detecting disease progression. However, SAP is highly dependent on patient attention levels and also, it reveals functional defects only after significant structural damage has already taken place.[5] Hence, the present research is designed to study the correlation of structural and functional aspects in glaucoma patients based on optical coherence tomography and visual field perimetry.

An understanding of the structure-function relation in POAG is required for both grading the severity of disease and for halting its progression.

2. Research Gap

Assessment of structural changes using 90D lens is subjective to observer, leading to variation in glaucomatous disc evaluation, where OCT disc assessment could come to rescue and aid early diagnosis.

Moreover, SAP is also very subjective depending on patient cooperation, attention level and media clarity. Also, the first perimetry report is not very reliable and it needs to be repeated for proper analysis.

Several studies investigated the relation between structural and functional damage in primary open-angle glaucoma (POAG), but the results are still open to discussion.

3. Materials and Methods

A prospective cross-sectional study was carried out at a primary care centre, on 102 primary open angle glaucoma patients (180 eyes) visiting ophthalmology department from August 2020 to November 2022.

3.1. Inclusion criteria:

Patients with primary open angle glaucoma and on treatment.

3.2. Exclusion criteria

Patients having-

1. Angle closure glaucoma
2. Age related macular degeneration (ARMD)
3. Cataract > grade II NS
4. Optic neuritis
5. Visual acuity < 6/18
6. Neurological deficits

3.3. Methodology

All patients who had been diagnosed with primary open angle glaucoma whether on treatment or not underwent detailed ophthalmic evaluation which included thorough history taking, vision assessment using Snellen's distant vision chart, IOP by Goldman applanation tonometer, gonioscopy by four mirror gonioscope, optic nerve head examination with slit lamp biomicroscopy using 90D lens, an optical coherence tomography (OCT) and visual field by perimetry. All patients had VF testing using Humphrey Field Analyzer 750, SITA standard 24-2 programand OCT RNFL thickness measurements using Spectralis on the same day. VF defect at 52 test points in the total deviation plot were used and written in dB. These total deviation points were grouped into six sectors: superonasal, nasal, inferonasal, inferotemporal, temporal, and superotemporal. Normal volunteers were those without ocular disease except for early cataract, and with normal optic disc findings and VF tests. Normal VF test criteria was devised after the Ocular Hypertension Treatment Study (OHTS) 21 and was defined as pattern standard deviation (PSD) of 45% and glaucoma hemifield test (GHT) within normal limits. If both eyes were normal or had glaucoma, one eye was selected randomly by the investigator, who at the time of selection was masked to the OCT results. Circular scan pattern of SD-OCT was used for peri-papillary RNFL thickness assessment. The scan circle was 12 degrees in diameter, so in millimeters it varied depending on the axial length. For a typical eye length, the circle was B3.5–3.6 mm in diameter. 16-23 frames were acquired with real-time on. Scans were only included if there was a clear fundus image, and if there was a continuous scan pattern without missing or blank areas. The Spectralis OCT calculates the average RNFL thickness of overall globe (360 degrees), in four quadrants temporal (T), superior (S), nasal (N), inferior (I)). Correlation of glaucomatous VF defects and SD-OCT RNFL thinning in four sectors (i.e., superior-temporal (TS), superior-nasal (NS), inferior-nasal (NI), and inferior-temporal (TI)) was done. The RNFL thickness values for T, TS, NS, N, NI, and TI were used in the present study. The local RNFL thickness deviation was calculated by subtracting the RNFL thickness values of glaucoma patients from the mean RNFL thickness values of age-matched normal subjects (control group) in all six sectors.

3.4. Statistical analysis

The collected data was edited and coded in MS Excel and analysis was done with IBM SPSS Statistics software version 26 (Statistical Package for Social Scientist). Descriptive statistics in the form of frequencies and percentages were then calculated. Analysis of quantitative variables was done using parametric tests (independent t-test). To compare before and after values of same entity, paired t-test was used.

P-value of<0.05 showed statistical significance.

4. Results

102 glaucoma patients were included in the study and 180 eyes were evaluated. The majority of patients (35%) were between 51-60 years of age.

68.2% of the study subjects had IOP between 10-21 mmHg with a mean NFL thickness of 100.6 ± 10.7 while remaining 30.8% had IOP between 22-30 mmHg with mean NFL thickness of 60.5 ± 10.9. The difference in the mean NFL thickness in subjects with IOP between 10-21 and 22-30 mmHg is statistically significant (P<0.0001). Therefore, higher the IOP, lower the NFL thickness.

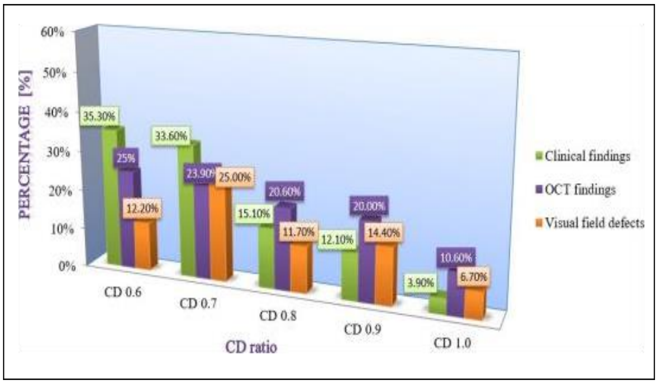

Figure 1: Correlation of clinical CD ratio with OCT CD ratio and VF defects

In my study clinical CD ratio vs OCT CD ratio (P=0.0007), OCT vs VF (P=0.018) and Clinical CD ratio vs visual field defect (P=0.00073) shows a positive correlation. As the CD ratio increases the amount of VF loss also increases.

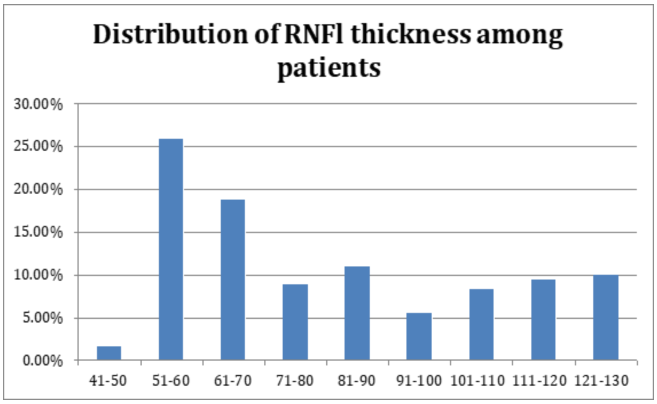

Figure 2: Distribution of RNFL thickness among study population

26.1% had NFL thickness between 51-60 µm followed by 18.9% with 61-70 µm, 11.1% had NFL thickness between 81-90 µm while 10% had NFL thickness between 121-130µm. (**Figure 2**)

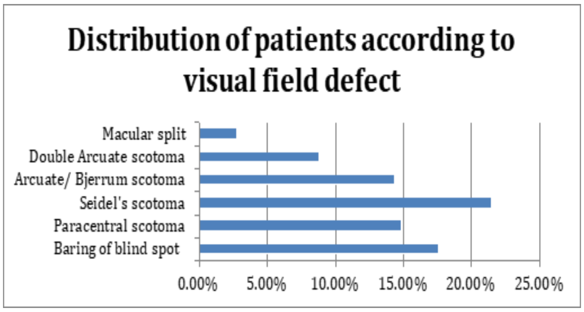

Figure 3: Correlation of Clinical CD ratio by 90D lens with visual field defect

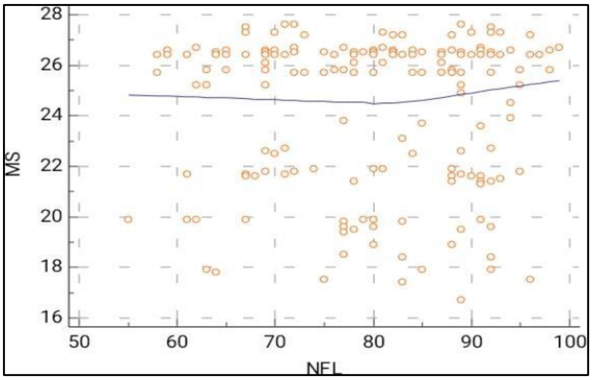

Figure 4: Correlation of Mean sensitivity of VF with OCT NFL thickness

In our study, OCT NFL thickness correlates with VF test as coefficient of variation is <1.

In our study, area in the ROC curve was 0.835 with P<0.0001 which is significant. (**Figure 5**) VF is more specific and OCT is more sensitive for diagnosis of glaucoma patients.

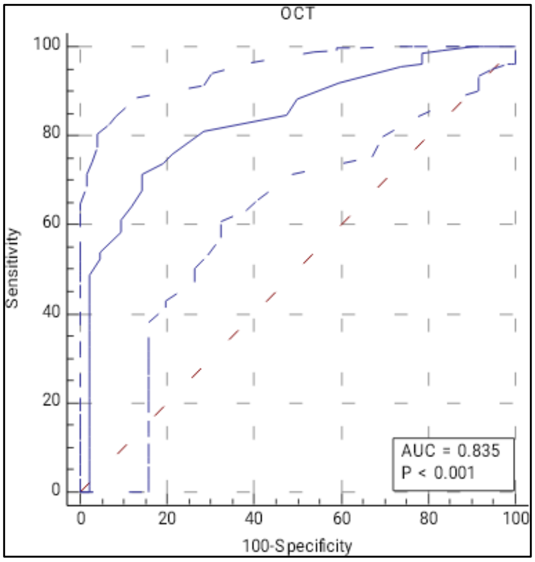

Figure 5: ROC curve of OCT vs. VF

Table 1: Correlation of OCT rim status with visual field defect

OCT			VF		
Rim status	No	%	Field defect	No	%
Inferior-nasal sector	34	18.70%	Superotemporal field defect	24	13.20%
Superior-temporal sector	35	19.25%	Inferonasal field defect	43	23.65%
Superior-nasal sector	44	24.20%	Inferotemporal field defect	19	10.45%
Inferior-temporal sector	85	46.75%	Superonasal field defect	98	53.90%
Significance: P value = 0.0048.					

Here,
Rim status on OCT RNFL is mentioned with corresponding visual field defect in percentage (%). (**Table 1**)
In my study, OCT sectoral defects had a significant correlation with corresponding VF defects with P value =0.0048.

5. Discussion

Primary open-angle glaucoma (POAG) is a chronic disease in which there is an open angle of anterior chamber, raised intraocular pressure with glaucomatous optic disc changes and VF abnormalities. In glaucoma, the structural changes related to retinal ganglion cell damage are supposed to be correlated with functional changes i.e. visual field [VF] damage based on the characteristic projection of the retinal nerve fibers. [6,7]

This was a cross-sectional study in which 102 patients with open-angle glaucoma were enrolled in the study. In our study, majority of the patients (35%) were in their 5th decade of life and minimum number of patients were in 7th decade of life (17%). Whereas, in the study done by Gupta et al.[8] majority of patients were in 3rd decade of life (40%). In the present study, male dominance was observed with a male: female ratio of 1.08:1. Similarly, Wong D et al.[9] and Rao HL et al.[10] reported male preponderance, and the ratio was found to be 2.4:1 and 1.9:1 respectively.

Intraocular pressure remains the most crucial risk factor for POAG and indeed the only modifiable risk factor. In our study of 102 glaucomatous patients mean IOP of POAG patients was 27.12±5.5 mm Hg while Jonas, J. B et al. in their study of 200 glaucomatous patients found that mean IOP of POAG patients was 30.0±5.0 mm Hg, which correlates with our study.[11]

The ONH in the form of cup disc ratio is the entity that is used to define POAG and is also considered important risk factor as many studies have reported large cup disc ratio in POAG patients. In the present study, CDR 0.6 to 1.0 was observed. While Wensor et al., study of prevalence of glaucoma in the Melbourne visual impairment project found that in 56 diagnosed POAG patients CDR was 0.4 to 1.0.[12]

In our study, CD 0.6 to 1.0 ratio was observed, which statistically correlated with SD OCT CD ratio, (P=0.007). While in the study of Mwanza et al., which also assessed the clinical CD ratio and SD-OCT CD ratio, it was found to be significant with (P< 0.01).[13]

In our study we observed statistical significance between OCT and VF (P= 0.0183). While the study of Zivkovic et al. also found significant correlation between OCT and VF, which correlates with our study (P<0.001).[14]

In our study, considering the distribution of the visual field defects, out of 180 eyes of 102 patients with POAG, majority of eyes had Seidel's scotoma (21.45%) and baring of blind spot (17.6%), while the visual field distribution of POAG eyes in E Ezinne et al.[15] showed that the most common visual field defect was Seidel's scotoma.[15]

In our study, OCT sectoral defects had a significant correlation with corresponding VF defects (P value=0.0048), of which inferior-temporal sector defect had a significant correlation with corresponding superonasal VF defect with (P value=0.0048) and it was found to be most common. This is in accordance with the study of Baniasadi, N. et al.[16] who compared detection of progressive RNFL thinning with visual field progression.

In our study, we observed weak to fair positive correlation (Pearson's coefficient value= 0.3498) by carrying out correlation of mean sensitivity of VF with NFL thickness obtained in SD-OCT. In some studies, structural and functional changes in advancement of glaucoma do not occur parallelly. On the other hand, some studies found moderate to strong structural and functional correlation. Similarly, according to Csilla et al.[17] RNFL thicknesses has a strong correlation with visual field changes.

6. Limitations

Sample size is little inadequate considering glaucoma being a common disease entity.

7. Conclusion

Primary open angle glaucoma is a significant cause of irreversible blindness. From this study, we observed that persistent higher levels of IOP were notably related to higher rates of progressive RNFL loss. The proportion and severity of scotoma increases as CD ratio increases along with an increase in loss of RNFL thickness. We noted a statistically important correlation between cup/disc ratio and possibility of abnormal visual field. In this way, the present study signifies the use of perimetry at regular intervals on follow-up visits in patients with primary open angle glaucoma. Similarly, it is intriguing to see that early ONH changes detected clinically, where the fields may be normal, show significant findings in an optical coherence tomography scan. Hence, the use of OCT in POAG prior to the appearance of visual field changes should be done for patient's benefit. As compared to visual field test by perimetry, OCT corresponds well with the actual Nerve fibre loss. Out of all 4 sectoral defects majority of the population in my study had Inferior-temporal sectoral defect (46.75%) by OCT and superonasal (53.90%) visual field defect by VF.

Like this, we can investigate the disease a step closer to "where the action is," at the level of the NFL. By direct evaluation of the NFL with OCT, earlier diagnosis and detection of glaucomatous progression is possible, even before typical signs such as visual field loss and cupping of the optic nerve head are evident. Nevertheless, the importance of visual field analysis by automated perimeter at regular intervals cannot be overlooked, as it is more specific as compared to SD-OCT, which is more sensitive, as concluded from my study.

8. Source of Funding

None

9. Conflict of Interest

None.

10. Ethical

Ethical No.: GCSMC/EC/Dissertation/Approve/2020.

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