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"Comparative Study of Retinal Nerve Fibre Layer Thickness And Optic Nerve Head Changes In Glaucoma Patients Using Optical Coherence Tomography

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Abstract:
Background:*Glaucoma is a group of progressive optic neuropathies characterized by degeneration of retinal ganglion cells and retinal nerve fibre layers that result in changes in the optical nerve head.It is associated with intraocular pressure related damage to the optic nerve, resulting in the loss of retinal ganglion cells.Worldwide prevalence of glaucoma is 3.54%. The number of people with glaucoma across the globe was estimated to be 64.3 million in 2013 which will increase to76.0 million in 2020 and 111.8 million in 2040 among the age group of 40 to 80 years.Glaucomatous optic neuropathy causes progressive death of retinal ganglion cells and their axons.Clinically, visual field loss often correlates with nerve fiber layer loss and optic nerve damage.Since RNFL thinning and ONH changes are irreversible, early diagnosis is essential.Optical coherence tomography(OCT), a well-accepted tool for the diagnosis of glaucoma, enables to objectively measure parameters like optic nerve head (ONH), retinal nerve fibre layer(RNFL) thickness and macular thickness.The present study is carried out to assess retinal nerve fiber layer thickness and optic nerve head damage in glaucomatous patients using OCT.*
Aim*: To compare the retinal nerve fibre layer thickness and optic nerve head changes in glaucoma patients using OCT.*
Materials and methods*: This is a hospital based cross-sectional study done among 100 patients of glaucoma between 18-70 years among both males and females.After written and informed consent taken from the patients, a detailed history was taken regarding chief complaints with duration of illness. Clinical examination of the patient included a detailed general physical and systemic examination, followed by an ophthalmological examination which includes best corrected visual acuity, anterior segment evaluation using slit lamp, IOP measure using Goldman's applanationtonometry, fundus examination using 90D slit lamp, ONH parameters and RNFL thickness measurements were obtained by OCT. Results obtained were subjected to statistical analysis.*
Results*: In this study it was found that the mean age was 49.19±3.9 of which 59% were males, 41% were females, the correlation of C: D ratio vertical with inferior RNFL thickness was -0.509 with superior RNFL of -0.49.The optic disc parameters were strongly correlated with retinal nerve fibre layer thickness.*
Conclusion*: based on the results and methodology employed it can be concluded that RNFL thickness is well correlated to optic disc parameters for which OCT was found to be accurate in obtaining Retinal thickness measurements, Hence OCT is shown to have greater diagnostic accuracy in RNFL measurements.*
Key words*: Glaucoma, Retinal nerve fibre layer thickness (RNFL), optic nerve head (ONH), Optical coherence tomography (OCT.*

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I.INTRODUCTION

Glaucoma is a group of progressive optic neuropathies characterized by a degeneration of retinal ganglion cells and retinal nerve fiber layers that result in changes in the optical nerve head [(1)].It is associated with intraocular pressure related damage to the optic nerve, resulting in the loss of retinal ganglion cells [(2)].As a leading cause of irreversible blindness worldwide, Glaucoma poses a significant public health problem and is associated with a reduced quality of life [(3)].

Worldwide prevalence of glaucoma is 3.54%. The number of people with glaucoma across the globe was estimated to be 64.3 million in 2013 which will increase to76.0 million in 2020 and 111.8 million in 2040 among the age group of 40 to 80 years. [(4)] The prevalence of POAG is highest in Africa and the prevalence of PACG is highest in Asia. [(4)] As per the data from World Health Organization, India has a 1% prevalence of blindness. There are about 8.9 million blind in India and 12.8% are due to glaucoma. Vellore Eye Survey (VES) is the first comprehensive study of the prevalence for eye diseases including glaucoma of an Indian population.

Glaucomatous optic neuropathy causes progressive death of retinal ganglion cells and their axons. These structural changes precede visual field defects as measured by standard automated perimetry. Clinically, visual field loss often correlates with nerve fiber layer loss and optic nerve damage. It is well established that significant amount of ganglion cell death (40%) occurs before any visual field defect is produced. Early detection of glaucoma has focused on evaluation of the ONH and the RNFL thickness, because both the RNFL and the ONH can be imaged and have been shown to undergo structural changes prior to clinically detectable visual field loss. Nerve fiber layer thinning is seen in glaucoma, because it is directly correlated with loss of ganglion cells, which is assumed to be a primary event in glaucomatous damage. Since RNFL thinning and ONH changes are irreversible, early diagnosis is essential. Optical coherence tomography(OCT), a well-accepted tool for the diagnosis of glaucoma, enables to objectively measure parameters like optic nerve head (ONH), retinal nerve fibre layer(RNFL) thickness and macular thickness. Spectral domain OCT (SD-OCT) is a recent technique that is used in the imaging of ocular structures with higher resolution and faster scan rate compared with previous version of this technology

II.MATERIAL AND METHODS:

Study area: the present study was conducted in outpatient department of ophthalmology, PES institute of medical sciences, Kuppam. Andhra Pradesh, India

Study period: A total duration of 25 months from October 2020 to November 2022.

Study design: A hospital based observational cross-sectional study

Study sample: 100 patients diagnosed with Primary open angle glaucoma were included in the study

INCLUSION CRITERIA:

1. Diagnosed cases of primary open angle glaucoma.
2. Age 18 to 70 years.

EXCLUSION CRITERIA: 1. Secondary glaucoma. 2. Angle closure glaucoma. 3. Advanced glaucoma. 4. Media opacities like significant cataract, corneal opacities etc. 5. Congenital developmental glaucoma Congenital anomalies of anterior chamber 7. Concurrent active eye disease in the study eye that may affect the IOP 8. Eyes with proliferative or severe non proliferative retinopathy 9. Eye with field loss attributed to a non-glaucoma condition.

III.METHODOLOGY

After obtaining the approval of the institutional ethical committee a written and informed consent was taken from the patients in his/her vernacular language. A detailed history was taken regarding chief complaints and duration of illness. Clinical examination of the patient included a detailed general physical examination and systemic examination was done followed by detailed ophthalmological examination which included

- Recording of distant and near visual acuity by Snellen's chart and BCVA
- Anterior segment evaluation using slit lamp Bio microscopy
- IOP measurement using Goldman's applanation tonometry
- Visual field testing using Humphrey visual field
- Fundus examination using 90D slit lamp for viewing the stereoscopic view of the optic disc
- ONH parameters and RNFL thickness measurements were obtained by OCT

The pupils were dilated using tropicamide eye drops. The patient is seated comfortably in front of the OCT machine with chin positioned on chin rest. The patient is asked to fixate on the fixation target (green color light). Serial scans were done. Signal strength of more than or equal to 6 was considered for analysis.

DATA ENTRY AND ANALYSIS:

Data entry was done using Microsoft Excel version 2013. At a later stage all the data was transferred to SPSS version 20.0 for statistical analysis. Descriptive summary using frequencies, proportions, graphs and cross tabs were used to display study results. Data was tabulated in 2×2 contingency tables and statistical tests were applied. Probability (p) was calculated to test for statistical significance at 5% level of significance. Association between various factors was determined using Chi Square test. The analysis of ONH and RNFL parameters was done by calculating the mean and standard deviation using 95% confidence interval. The correlation between the ONH and RNFL parameters was done using Pearson's correlation.

IV. RESULTS

Table No 1: Age distribution

Age (years)	Frequency	Percentage
<40	8	8%
41-50	40	40%
51-60	44	44%
>60	8	8%
Total	100	100%

Out of the total 100 cases, majority 82% of them belonged to the age group of 41-60 years. The mean age was 49.1972, Standard deviation (SD) ± 3.976 among cases. The mean IOP was 24.25 ±3.53mm Hg.

Table No 2: Gender distribution

Gender	Frequency	Percentage
Males	59	**59%**
Females	41	41%
Total	100	100%

Among the study population, 59% were males and 41% were females

Table No 3: Analysis of ONH parameters

Parameter	Mean	Standard Deviation	95%CI
Disc area(mm^3)	3.292	1.15	3.126 to 3.457
Cup area(mm^3)	3.388	1.05	2.238 to 2.538
Rim Area(mm^3)	1.002	0.8857	0.876 to 1.129
C: D Vertical	0.852	0.1337	0.833 to 0.871
C: D Area ratio	0.715	0.2315	0.681 to 0.748

OCT was performed and parameters were analyzed. ONH parameters include disc area, cup area, rim area, vertical C: D, C: D area ratio, Table showing the analysis of the ONH parameters with 95% confidence interval

Table No 4: RNFL Analysis by OCT

Parameter	Mean	Standard Deviation	95%CI
INF	106.43	27.90	102.45 to 110.41
TEM	61.15	13.48	59.22 to 63.07
SUP	102.696	25.80	99.01 to 106.38
NAS	76.38	23.70	73.0 to 79.77
AVG RNGL	86.66	19.33	83.90 to 89.42

Most of the patients had thinning in the superior and inferior quadrants.

Table no 5: correlation of optic nerve head parameter and RNFL Thickness:

Disc parameters		RNFL thickness				
		Inferior RNFL	Temporal RNFL	Superio RNFL	Nasal RNFL	Average RNFL
Disc area($mm^{3)}$	Pearson correlation	0.378	0.466	0.436	0.433	0.496
	P-Value	0.000	0.000	0.000	0.000	0.000
Cup area($mm^{3)}$	Pearson correlation	0.05	0.30	0.06	0.08	0.119
	P-Value	0.433	0.000	0.413	0.259	0.100
RIM Area($mm^{3)}$	Pearson correlation	0.43	0.187	0.548	0.502	0.527
	P-Value	0.000	0.010	0.000	0.000	0.000
C/D area ratio($mm^{3)}$	Pearson correlation	-0.342	-0.149	-0.450	-0.397	-0.421
	P-Value	0.000	0.039	0.000	0.000	0.000
C: D Vertical	Pearson correlation	-0.509	-0.149	-0.493	-0.441	-0.509
	P-Value	0.000	0.040	0.000	0.000	0.000

It can be said that there is a good correlation between the C: D Vertical with the Inferior RNFL.

Table No 6: Correlation between the vertical C: D and the respective RNFL

RNFL	C: D VERTICAL
INF	-0.509
SUP	-0.493

From the above table it can be said that there is a good correlation of C: D ratio Vertical with superior RNFL Thickness

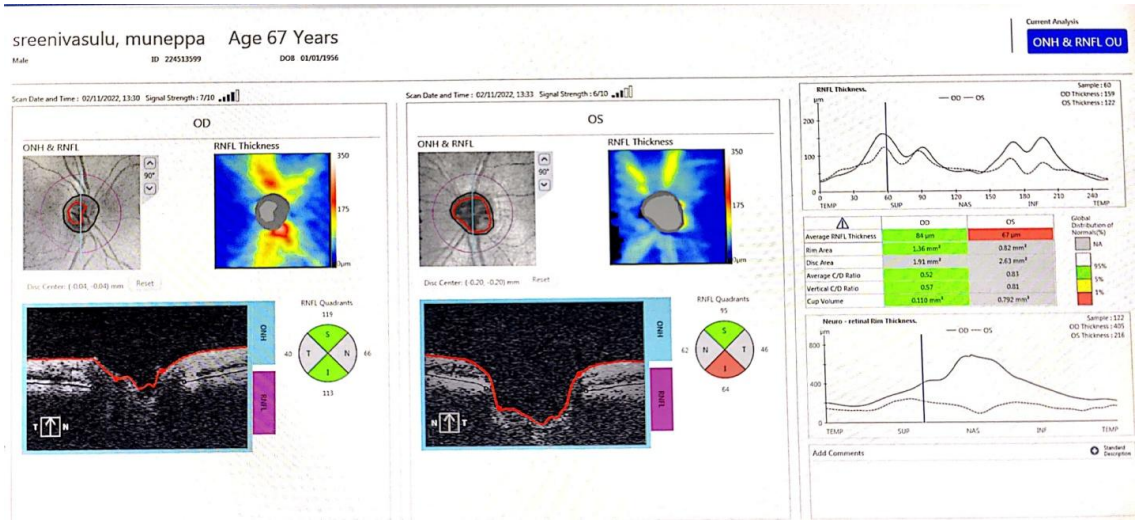

Figure 1 :OCT findings of case

V. DISCUSSION

Glaucoma is a disease primarily associated with damage to the Retinal Ganglion Cell (RGC) bodies and axons, which causes characteristic patterns of Visual Field (VF) defects and changes in the appearance of the Optic Nerve Head (ONH). It is well established that significant amount of ganglion cell death (25 to 30%) occurs prior to any visual field defect is observed, thus giving rise to the concept of pre- perimetric glaucoma analysis. OCT provides an objective and quantitative measurement of RNFL thickness by measuring echo time delay and intensity of backscattered light from different retinal layers using a low coherence interferometry. Third-generation time-domain optical coherence tomography (TD-OCT) machines achieve axial resolution of 10–15 mm, whereas newer spectral-domain or fourier domain optical coherence tomography (SD-OCT) can delineate structures more clearly with an axial resolution of 5–7 mm.

When the results are compared with other studies it was found that in this study out of the total 100 cases, majority 82% of them belonged to the age group of 41-60 years. The mean age was 49.1972, Standard deviation (SD) ± 3.976 among cases and 59% were males and only 41% were females. **Jain R et al [(5)]**have reported that the mean age of the study population was 57.98±2.14 years. **Batool A et al [(6)]**have reported that the mean age of the study population was 55.54±15.58.**Jain R et al[(5)]** have reported that 33 (66%) were males and 17 (34%) were females which was similar to this study .In the present study the mean IOP was 24.25 ±3.53 mm Hg.**Batool A et al[(6)]**have reported that the mean IOP in the right eye was 16.46±8.06 mm Hg and mean IOP in the left eye was 16.75 ±9.82 mm Hg.**Cronemberger S et al[(7)]**have reported that the mean IOP was similar between GS and POAG groups (15.6 ± 3.47 vs 15.6 ± 2.83 mmHg, p = 0.90) as was IOP peak at 6 AM (21.7 ± 3.85 vs 21.3 ± 3.80 mmHg, p = 0.68).Among the Optic disc parameters the mean disc area was 3.292±1.1599mm^2, mean cup area was found to be 2.388±1.0504mm^2. The mean rim area was 1.002±0.8857mm^2. The mean C: D area ratio was 0.715±0.2316. The mean C: D vertical was found to be 0.852±0.1337.Regarding RNFL thickness Inferior RNFL thickness was found to be 106.43±27.904µm. Superior RNFL thickness was found to be 102.696±25.809 µm. Temporal RNFL thickness was 61.152±13.482 µm and nasal RNFL thickness was found to be 76.387 ±23.703µm. Average RNFL thickness in POAG was 86.668 ±19.330µm.Hence it was found that most of the patients had more thinning in the superior and inferior quadrants. **Nouri - MahdaviK et al[(8)]**, have reported that RNFL thickness in inferior quadrant and RNFL average thickness have best discriminated healthy eyes from glaucomatous eyes which is in correlation to our study. There was a study done by **Mansoori et al [(9)]** which shows no correlation between the ONH and RNFL parameters.**Shruti Nitin et al[(10)]** have reported that average and inferior RNFL thickness were decreased in pre-perimetric glaucomatous eyes compared to normal eyes (p 0.01).**Mwanza et al[(11)]** showed that Cirrus OCT had an excellent intravisit and intervisit reproducibility of RNFL thickness and ONH parameters. They found out that the focal RNFL thickness loss was present in inferior area of mild POAG patients. RNFL defects were

found in sectors 1, 6 and 7 in the moderately advanced disease subgroups and in all sectors of severely advanced disease subgroup.**Naithani et al [(12)]** proved that the average RNFL thickness was the best parameter in differentiating early and moderate glaucoma from normal controls.**Badala et al[(13)]**, analyzed the benefits between the abilities of the four methods - Stratus OCT, scanning laser polarimetry, VCC, HRT III, and disc photograph, used for imaging of optic disc and RNFL. By using the combination of stratus OCT, HRT III they found that average RNFL thickness and cup-disc area ratio was shown to deliver a high diagnostic precision.Li et al suggested that the best parameters of SD-OCT technique for discriminating normal from early glaucoma were average thickness for RNFL

VI. CONCLUSION

Based on the results and the methodology employed it is concluded that the RNFL thickness were well correlated to optic disc parameters. OCT has been shown to obtain accurate and reproducible RNFL and retinal thickness measurement. OCT has shown to have greater diagnostic accuracy in RNFL measurements.

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