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THE CHANGES IN THE THICKNESS OF RETINAL NERVE FIBRE LAYER AND GANGLIONIC CELL LAYER AS A PRECURSOR OF GLAUCOMATOUS DAMAGE IN VARIOUS TYPES OF GLAUCOMA

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ABSTRAC

Background: Glaucoma is a progressive optic neuropathy characterised by the loss of retinal ganglion cells (RGC)and their axons, which leads to distinctive irreversible changes in the optic nerve head (ONH) and corresponding visual field defects. Aim is to evaluate and compare the changes in thickness of the Retinal nerve fibre layer (RNFL) and Ganglionic cell layer (GCL) in patients with primary open angle glaucoma, primary angle closure glaucoma, glaucoma suspects and controls using optical coherence tomography.

Materials and Methods: A cross-sectional observational study was conducted among 80 patients, with 20 having primary open-angle glaucoma, 20 with primary angle closure glaucoma, 20 suspects, 10 having open angle and 10 having narrow angle and 20 controls. OCT was done to evaluate the thickness of the Retinal nerve fibre layer and Ganglion cell layer.

Results: Significant thinning in the average RNFL and GCC thickness was observed in POAG and PACG groups, with a P value = 0.001 in both eyes, correlating strongly with functional visual field impairment.

Conclusion: The study highlights the crucial role of OCT-based imaging in modern glaucoma management, emphasizing its value in both diagnosis and monitoring of disease progression.

Keywords: Retinal nerve fibre layer, Ganglion cell layer, Optical coherence tomography, primary open angle glaucoma, primary angle closure glaucoma, glaucoma suspects.

INTRODUCTION

Glaucoma is a progressive optic neuropathy characterised by the loss of retinal ganglion cells (RGC)and their axons, which leads to distinctive irreversible changes in the optic nerve head (ONH) and corresponding visual field defects. (Wu CW, Chang YC et al, in 2023).[1]

The World Health Organisation (WHO) has identified glaucoma as the second leading cause of vision loss after cataracts. However, unlike cataracts, the damage caused by glaucoma is permanent and cannot be reversed. (Pascolini D, Mariotti SP in 2012).[2]

The global socioeconomic impact of glaucoma is steadily increasing, with an age-standardised prevalence of about 3–5% among individuals over 40 years old. This number is expected to grow, reaching 112 million affected individuals by 2040. (Bhartiya S, Ichhpujani P in 2025).[3]

Diagnostic technologies aim to detect glaucoma in its earliest stages to slow disease progression and minimise vision loss and its impact on quality of life (Tang Y, Pan X, Cao K, 2021).[4] Structural changes in the optic nerve head (ONH), the circumpapillary retinal nerve fibre layer (cpRNFL), and the macula often occur before any visual field defects become detectable. (Wu CW, Chang YC in 2023).[1]

The primary pathological hallmark of glaucoma is the loss of retinal ganglion cells (RGCs), which leads to atrophy of the associated inner retinal layers. These include the retinal nerve fibre layer (RNFL), composed of ganglion cell axons; the ganglion cell layer (GCL), which contains the cell bodies; and the inner plexiform layer (IPL), where the dendrites reside. The macula houses the highest concentration of RGCs, approximately 50% of the total (Quigley HA, Dunkelberger GR, 1989,[5] Quigley HA, Miller NR, 1980).[6] Since RGC death occurs before RNFL thinning, measuring RNFL thickness has proven valuable for early detection and timely management of glaucoma. Given the macula's dense population of RGCs, evaluating macular GCL thickness is also considered an effective method for assessing ganglion cell loss. (Kaushik S, Kataria P, in 2018).[7] Spectral-domain optical coherence tomography (SD-OCT) is a non-invasive imaging technology that provides high-resolution, cross-sectional images of ocular tissues with excellent reproducibility. In recent years, SD-OCT has enabled advanced macular imaging and has become a valuable tool for the clinical diagnosis and monitoring of glaucoma (Kotowski J, Folio LS, 2012 and Tan O, Li G, 2008).[8]

MATERIALS AND METHODS

A Cross-sectional observational study was conducted to evaluate changes in the thickness of retinal nerve fibre layer and ganglion cell layer in 80 patients attending the glaucoma clinic of the ophthalmology outpatient department in a tertiary health care hospital in northern India from July 2023 to February 2025.

The patients were divided into 5 groups -

Group A: Patients with Primary Open Angle Glaucoma

Group B: Patients with Primary Angle Closure glaucoma

Group C: Glaucoma suspects with Open angle

Group D: Glaucoma suspects with Narrow angle

Group E: Controls

The ethical clearance was taken by the ethical committee of Subharti Medical College.

Informed written consent was obtained from all the participants before enrolment.

Inclusion Criteria

The diagnostic criteria for primary open-angle glaucoma (POAG) were as follows

1. Initial IOP >21 mm Hg on 2 separate occasions
2. Visual acuity >20/40
3. Detection of an open angle on gonioscopy
4. Diagnosis of typical GON on stereoscopic fundus examination and a reproducible glaucomatous visual field defect

Glaucomatous optic neuropathy (GON) is defined as an interocular cup-disk ratio asymmetry of >0.2, optic disk rim thinning (NRR- neuro retinal rim) or notching, any disc haemorrhage, any RNFL defect, or a cup-to-disk ratio of ≥0.6. Glaucomatous visual field defects were detected based on the following criteria: ≥2 contiguous points with P<0.01, or ≥3 contiguous points with P<0.05 in the superior or inferior arcuate areas on the pattern deviation plot or a 10-dB difference across the nasal horizontal midline at ≥2 adjacent locations and an outside normal limit on the glaucoma hemifield test. A visual field defect was considered reliable if the fixation loss was <20% and the rate of false- positive and false-negative errors was <25%.

The diagnostic criteria for Primary angle closure glaucoma (PACG) were as follows:

1. IOP> 21 mm Hg on 2 separate occasions
2. Visual acuity >20/40
3. Von Herring grading of <II
4. Anterior chamber angle of <2 on indirect gonioscopy according to Shaffer grading
5. At least 1 clock hour of peripheral anterior synechiae and/or the pigment deposition on trabecular meshwork in any quadrant on gonioscopic examination
6. Diagnosis of typical GON on stereoscopic fundus examination and a reproducible glaucomatous visual field defect

The diagnostic criteria for Glaucoma suspects were as follows:

1. IOP </>21 mm Hg on 2 separate occasions
2. Visual acuity >20/40
3. Appearance of the optic disk consistent with glaucoma on stereoscopic fundus examination
4. Gonioscopy and Perimetry findings within normal limits

Controls fulfilled the following criteria:

1. IOP of 10-21 mm Hg
2. Visual acuity > 20/40
3. No history of elevated IOP
4. No family history of glaucoma
5. Normal appearance of the optic disk head on fundoscopy and normal visual fields

Exclusion criteria:

Exclusion criteria were as follows:

1. Patients with any anterior segment pathology leading to considerable opacity of the ocular media
2. Concomitant retinal disease,
3. A history of refractive or vitreoretinal surgery
4. Patients with marked peripapillary atrophy.
5. Patients with any possible neurological field loss

Study design: All participants underwent complete preliminary ophthalmic examinations, including

1. Visual acuity testing using the Snellen chart
2. Intraocular pressure (IOP) measured using Goldman's applanation tonometer
3. Gonioscopy to visualise angle of anterior chamber
4. Stereoscopic fundus examination for evaluation of the optic disc
5. Standard full-threshold automated perimetry (30-2 mode, Humphrey Field Analyser, model 740; Carl Zeiss Meditec, Inc.).
6. Central corneal thickness by pachymetry

The detection of changes in the thickness of the circum-peripapillary retinal nerve fibre layer (RNFL) using the traditional optic nerve head (ONH) scan and the macular layers using the ganglion cell complex (GCC) scan was performed using optical coherence tomography. (Mocean 4000 Plus, Shenzhen Moptim Imaging Technique Co. Ltd., China)

Statistical Analysis: The software SYSTAT 13.2 version was used for data analysis. The mean and standard deviation of quantitative data were used as representations. P value <0.05 was considered significant in our analysis.

RESULTS

The present cross-sectional observational study was conducted at a Tertiary health care hospital of Northern India during July 2023 to February 2025 among 80 patients. Out of 80 patients, 20 were having primary open-angle glaucoma, 20 were having primary angle closure glaucoma, 20 were glaucoma suspects, and 20 were controls. The study aimed to evaluate the changes in the thickness of RNFL and GCC using OCT among the above-mentioned groups and to detect and prevent glaucoma-associated blindness.

Table 1: Comparison of retinal nerve fibre layer (RNFL) thickness measurements across five groups (both eyes).

RNFL	Site	Open Angle Glaucoma Mean (SD)	Angle Closure Glaucoma Mean (SD)	Suspects Open Angle Mean (SD)	Suspects Narrow Angle Mean (SD)	Control Mean (SD)	p-value
Average Thickness	OD	71.39(23.19)	95.05(10.62)	105.49(3.35)	107.06(3.93)	105.56(3.04)	0.001*
	OS	73.41(24.27)	97.35(10.64)	105.50(2.30)	107.08(2.52)	106.06(2.46)	0.001*
Superior	OD	87.30(30.50)	113.86(12.21)	138.60(23.57)	134.80(6.71)	131.60(6.12)	0.001*
	OS	88.70(31.38)	116.71(13.23)	131.10(27.60)	131.10(12.31)	129.45(8.83)	0.001*
Inferior	OD	93.40(36.62)	92.81(15.23)	133.0(22.42)	149.30(13.72)	130.95(19.90)	0.001*
	OS	90.70(33.11)	101.10(10.78)	128.0(23.55)	146.40(3.10)	143.05(12.45)	0.001*
Nasal	OD	65.80(20.17)	80.62(16.90)	84.60(25.23)	86.40(10.11)	89.80(7.51)	0.001*
	OS	67.90(22.61)	79.10(16.88)	75.0(12.17)	81.40(6.19)	90.50(9.29)	0.001*
Temporal	OD	60.80(19.12)	72.14(19.22)	71(8.94)	77.22(11.99)	88.85(13.26)	0.001*
	OS	60.25(21.02)	73.52(17.99)	72.0(12.51)	74.0(8.76)	85.2(11.77)	0.001*

The [Table 1] presents average retinal nerve fibre layer (RNFL) thickness measurements and retinal nerve fibre layer thickness across different quadrants (Superior, Inferior, Nasal, and Temporal) in both eyes (OD – right eye and OS – left eye) among five groups: Primary Open Angle Glaucoma, Primary Angle Closure Glaucoma, Suspects Open Angle, Suspects Narrow Angle, and Controls. Individuals with open-angle glaucoma consistently exhibit significantly lower mean RNFL thickness than other groups in both eyes, indicating more advanced nerve fibre loss. The open angle suspects, narrow angle suspects and Angle Closure groups generally display slightly less thickness than controls. Statistically significant differences (p = 0.001*) are present across all comparisons.

Table 2: Comparison of Ganglion Cell Complex (GCC) thickness measurements across various retinal regions in five groups (both eyes).

GCC		Open Angle Glaucoma Mean (SD)	Angle Closure Glaucoma Mean (SD)	Suspects Open Angle Mean (SD)	Suspect Narrow Angle Mean (SD)	Control Mean (SD)	p-value
Average Thickness	OD	85.85(13.15)	87.95(5.15)	94.70(3.37)	91.70(2.58)	97.38(320)	0.001*
	OS	84.55(13.97)	86.61(6.25)	96.20(2.39)	95.70(3.16)	97.03(3.21)	0.001*
Superior	OD	90.0(18.31)	96.38(6.13)	110.80(9.96)	103.40(16.15)	113.35(7.51)	0.001*
	OS	93.75(18.88)	102.0(5.12)	114.30(10.44)	101.0(12.94)	116.55(12.03)	0.001*
Inferior	OD	94.4(19.88)	94.33(15.10)	116.40(8.72)	110.90(12.14)	115.05(9.06)	0.001*
	OS	96.20(23.21)	95.14(17.93)	116.10(10.49)	94.30(19.80)	109.10(7.68)	0.003*
Nasal	OD	93.05(21.17)	93.62(5.52)	111.30(12.17)	107.40(13.10)	113.45(5.51)	0.001*
	OS	88.35(22.51)	95.52(8.93)	109.90(14.28)	97.60(9.95)	106.45(10.11)	0.001*
Temporal	OD	85.35(17.16)	86.0(12.48)	90.40(4.77)	101.10(16.39)	106.10(10.54)	0.001*
	OS	86.20(19.12)	83.90(10.42)	99.30(14.09)	92.0(5.72)	102.75(9.86)	0.001*
SN	OD	92.45(19.15)	99.86(7.50)	113.60(11.23)	102.50(19.57)	100.35(9.40)	0.005*
	OS	92.25(19.85)	99.90(7.22)	114.30(12.30)	112.60(15.06)	100.15(12.11)	0.001*
IN	OD	93.0(23.46)	96.76(8.80)	113.0(8.96)	113(13.14)	101.25(10.61)	0.001*
	OS	95.75(20.90)	97.14(10.96)	116.80(14.01)	81.90(16.52)	101.35(7.11)	0.001*
ST	OD	89.55(15.59)	92.19(6.0)	100.60(7.82)	98.20(11.85)	104.40(6.69)	0.001*
	OS	88.40(17.21)	99.95(8.55)	104.60(9.96)	100.80(2.66)	105.15(6.75)	0.001*
IT	OD	92.25(18.25)	88.05(13.99)	108.50(8.26)	105.30(15.88)	109.15(8.20)	0.001*
	OS	93.6(20.15)	91.52(17.72)	110.60(12.40)	98.10(12.09)	103.55(4.16)	0.006*

The [Table 2] displays average Ganglion Cell Complex (GCC) thickness measurements and Ganglion Cell Complex (GCC) thickness across various quadrants (Superior, Inferior, Nasal, Temporal, Superonasal, Inferonasal, Superotemporal, Inferotemporal) in both eyes for

five subject groups: Primary Open Angle Glaucoma, Primary Angle Closure Glaucoma, Open Angle Suspects, Narrow Angle Suspects, and Controls. Open-angle glaucoma patients consistently exhibit the lowest GCC thickness, indicating significant ganglion cell loss. Open-angle suspects and narrow-angle suspect groups, and Angle Closure Glaucoma patients show slight thinning of GCC values as compared to controls, suggesting varying degrees of retinal ganglion cell compromise. All regions demonstrate statistically significant differences ($p < 0.005$).

Table 3: Comparison of retinal nerve fibre layer (RNFL) thickness between various glaucoma groups and healthy controls across both eyes.

Group	Group	OD		OS	
RNFL		**MD**	**p-value**	**MD**	**p-value**
Open Angle Glaucoma	Control	-34.17	0.001*	-32.65	0.001*
Angle Closure Glaucoma	Control	-10.48	0.119	-8.71	0.410
Suspects Open Angle	Control	-0.075	1.000	-0.562	1.000
Suspects Narrow Angle	Control	1.495	1.000	1.014	1.000
Superior					
Open Angle Glaucoma	Control	-44.3	0.001*	-40.75	0.001*
Angle Closure Glaucoma	Control	-17.74	0.003*	-12.74	0.050
Suspects Open Angle	Control	7.00	0.339	1.65	0.836
Suspects Narrow Angle	Control	3.2	0.661	1.65	0.836
Inferior					
Open Angle Glaucoma	Control	-37.55	0.001*	-52.35	0.001*
Angle Closure Glaucoma	Control	-38.14	0.001*	-41.95	0.001*
Suspects Open Angle	Control	2.05	0.826	-15.05	0.059
Suspects Narrow Angle	Control	18.35	0.052	3.35	0.671
Nasal					
Open Angle Glaucoma	Control	-24	0.001*	-22.6	0.001*
Angle Closure Glaucoma	Control	-9.18	0.082	-11.4	0.023*
Suspects Open Angle	Control	-5.2	0.424	-15.5	0.013*
Suspects Narrow Angle	Control	-3.4	0.600	-9.1	0.139
Temporal					
Open Angle Glaucoma	Control	-28.05	0.001*	-24.95	0.001*
Angle Closure Glaucoma	Control	-16.71	0.001*	-11.68	0.023*
Suspects Open Angle	Control	-17.85	0.005*	-13.2	0.037*
Suspects Narrow Angle	Control	-11.65	0.066	-11.2	0.076

[Table 3] presents the mean differences (MD) in retinal nerve fibre layer (RNFL) thickness between all four groups and healthy controls, for both eyes (OD & OS). Patients with Primary Open Angle Glaucoma consistently show the most pronounced RNFL thinning across all regions in both eyes, with highly significant p-values ($p = 0.001$*), indicating substantial nerve fibre loss. Primary Angle Closure Glaucoma also shows significant thinning, particularly in the Inferior and Temporal regions in both eyes, though the results are less consistent compared to Primary Open Angle Glaucoma. Suspects for Open Angle Glaucoma demonstrate mild but statistically significant thinning mainly in the Temporal and Nasal quadrants in the left eye and the temporal quadrants in the right eye, while Suspects for Angle Closure do not show significant differences from controls.

Table 4: Ganglion cell complex (GCC) thickness across glaucoma types and controls, with comparisons for overall Mean difference and specific regions in both eyes.

Group	Group	OD		OS	
GCC		**MD**	**p-value**	**MD**	**p-value**
Open Angle Glaucoma	Control	-11.53	0.001*	-12.48	0.001*
Angle Closure Glaucoma	Control	-9.43	0.001*	-10.41	0.001*
Suspects Open Angle	Control	-2.68	1.00	-0.830	1.00
Suspects Narrow Angle	Control	-5.68	0.515	-1.33	1.00
Superior					
Open Angle Glaucoma	Control	-23.35	0.001*	-22.8	0.001*
Angle Closure Glaucoma	Control	-16.97	0.001*	-14.55	0.001*
Suspects Open Angle	Control	-2.55	0.593	-2.25	0.652
Suspects Narrow Angle	Control	-9.95	0.040*	-15.5	0.003*
Inferior					
Open Angle Glaucoma	Control	-20.65	0.001*	-12.9	0.020*
Angle Closure Glaucoma	Control	-20.72	0.001*	-13.96	0.011*
Suspects Open Angle	Control	1.35	0.809	7.00	0.295
Suspects Narrow Angle	Control	-4.15	0.457	-14.8	0.029*
Nasal					
Open Angle Glaucoma	Control	-20.4	0.001*	-18.1	0.001*
Angle Closure Glaucoma	Control	-19.83	0.001*	-10.93	0.018*
Suspects Open Angle	Control	-2.15	0.667	3.45	0.540
Suspects Narrow Angle	Control	-6.05	0.228	-8.85	0.118

Temporal					
Open Angle Glaucoma	Control	-20.75	0.001*	-16.55	0.001*
Angle Closure Glaucoma	Control	-20.1	0.001*	-18.84	0.001*
Suspects Open Angle	Control	-15.7	0.003	-3.45	0.499
Suspects Narrow Angle	Control	-5	0.335	-10.75	0.037*
SN					
Open Angle Glaucoma	Control	-7.9	0.073	-7.9	0.077
Angle Closure Glaucoma	Control	-0.49	0.909	-0.24	0.955
Suspects Open Angle	Control	13.25	0.015*	14.15	0.010*
Suspects Narrow Angle	Control	2.15	0.687	12.45	0.024*
IN					
Open Angle Glaucoma	Control	-8.25	0.080	-5.6	0.224
Angle Closure Glaucoma	Control	-4.49	0.332	-4.21	0.355
Suspects Open Angle	Control	11.75	0.042*	15.45	0.007*
Suspects Narrow Angle	Control	11.75	0.042*	-19.45	0.001*
ST					
Open Angle Glaucoma	Control	-14.85	0.001*	16.75	0.001*
Angle Closure Glaucoma	Control	-12.2	0.001*	-5.2	0.129
Suspects Open Angle	Control	-3.8	0.342	-0.55	0.896
Suspects Narrow Angle	Control	-6.2	0.123	-4.35	0.303
IT					
Open Angle Glaucoma	Control	-16.9	0.001*	-9.95	0.039*
Angle Closure Glaucoma	Control	-21.1	0.001*	-12.02	0.012*
Suspects Open Angle	Control	-0.65	0.903	7.05	0.228
Suspects Narrow Angle	Control	-3.85	0.473	-5.45	0.350

[Table 4] presents mean differences (MD) in Ganglion Cell Complex (GCC) thickness between various groups and healthy controls in both eyes (OD & OS). Primary Open Angle Glaucoma patients consistently show the greatest GCC thinning across all quadrants with statistically significant p-values ($p < 0.001$), indicating severe ganglion cell loss. Primary Angle Closure Glaucoma also demonstrates significant thinning in most areas, though slightly less pronounced. Open-angle suspects and narrow-angle suspects generally show smaller and less consistent changes, with a few regions, such as SN and IN, showing statistically significant increases, possibly reflecting early structural changes. Notably, the Temporal and Inferior sectors in Primary Open-angle Glaucoma and Primary Angle Closure Glaucoma exhibit marked thinning, reinforcing these areas' sensitivity to glaucomatous damage.

DISCUSSION

Retinal Nerve Fibre Layer (RNFL) Thickness

In the present study, a significant reduction in Retinal Nerve Fibre Layer (RNFL) thickness was observed among glaucomatous eyes when compared to healthy controls.

In this study, we observed that Primary Open Angle Glaucoma (POAG) eyes showed the most pronounced thinning. POAG eyes had an average RNFL thickness of 71.39 ± 23.19 µm (OD) and 73.41 ± 24.27 µm (OS), while controls had an average RNFL thickness of 105.57 ± 3.04 µm (OD) and 106.06 ± 2.46 µm (OS). Ahmed E.Abd El-Nabya et al [9] similarly reported average RNFL thicknesses of 67.2 ± 12.8 µm in primary open-angle glaucoma patients and 102.8 ± 10.4 µm in normal eyes. Similarly, Kanamori et al,[10] reported significant average RNFL thinning of 72.7 ± 8.4 in primary open-angle glaucoma eyes.

We observed the mean RNFL difference in POAG compared to controls was -34.17 µm (OD) and -32.65 µm (OS), closely matching findings by Ahmed E.Abd El-Nabya et al,[9] who reported a mean RNFL thickness of approximately 32–35 µm in moderate to advanced primary open-angle glaucomatous eyes.

In the present study, we observed the average RNFL thickness of PACG in (OD) 95.05 ± 10.62 and (OS) 97.35 ± 10.64, which is slightly thinner than controls. Similar findings were seen in the study of Rao HL et al,[11] with average RNFL thickness of 93.90 ±13.69.

In this study, Primary Angle Closure Glaucoma (PACG) eyes demonstrated a less decrease in mean RNFL thickness as compared to controls, with differences of -21.43 µm (OD) and -18.88 µm (OS). This agrees with Rao HL et al,[11] observations of 20–23 µm of mean RNFL thickness in PACG patients.

According to this study, open-angle suspect group exhibited average RNFL thickness of (OD) - 105.6 ± 3.35, (OS)- 105.4 ± 2.30 and of narrow-angle suspects (OD)- 107.6 ± 3.39, (OS) - 107.6 ± 2.52, showing minimal thinning as compared to controls. It contrasts with the findings in the study of Kaushik S et al,[7] having an average RNFL thickness of 87.9 ± 12.12 µm in open-angle suspects and 95.9 ± 11.12 µm in angle closure suspects, showing marked thinning.

This study showed open-angle suspects showed mean RNFL thickness differences of -7.90 µm (OD) and -8.12 µm (OS), and narrow-angle suspects showed mean RNFL thickness differences of (OD) -5.68 and (OS) -1.33 which did not reach statistical significance, highlighting the early or preclinical stage of disease.

In this study, the sectoral analysis revealed that the superior and inferior quadrants were predominantly affected in glaucoma, Superior RNFL being the most affected (POAG OD: 87.30 ± 30.50 µm vs. Controls OD: 131.60 ± 6.12 µm). Corroborating similar findings, Hood et al,[12] identified these regions as

particularly vulnerable to early glaucomatous damage due to their dense axonal arrangement. Similar findings were observed by Geevarghese A et al,[13] who noted these quadrants are most vulnerable due to their higher axonal density and susceptibility to intraocular pressure (IOP)-related stress. The temporal and nasal quadrants showed comparatively less thinning, which is typical in earlier stages of glaucomatous damage. Significant RNFL thinning, particularly in the superior and inferior quadrants, was evident among glaucoma patients, consistent with global patterns of glaucomatous structural damage.

Ganglion Cell Complex (GCC) Thickness

GCC Thickness Differences Between Groups and Controls

Ganglion Cell Complex (GCC) analysis in the current study revealed significant thinning among glaucomatous eyes (being more pronounced in Primary Open Angle Glaucoma patients than Primary Angle Closure Glaucoma patients) when compared to controls.

In this study, we found that POAG patients had reduced average GCC thickness (OD: 85.85 ± 13.15 µm; OS: 84.55 ± 13.97 µm), while controls maintained higher values (OD: 97.38 ± 3.20 µm; OS: 97.03 ± 3.21 µm). These findings are comparable to NA JH et al,[14] who documented an average GCC thickness value of 86.1 ± 8.3 µm in POAG eyes versus 98.7 ± 7.5 µm in normal eyes. Another study by Nouri-Mahdavi K et al,[15] reported average GCC values of 83.4 ± 6.4 µm in primary open-angle glaucoma eyes, supporting our findings.

In this study, the mean GCC reduction in Primary Open Angle Glaucoma (POAG) eyes is of -11.53 µm (OD) and -12.48 µm (OS), findings closely paralleling the study by Leung CK et al,[16] where mean GCC thinning in POAG eyes ranged between 10–12 µm.

As demonstrated by this study in PACG patients, the average value of GCC was observed as 87.95 ± 5.15 in the right eye and 86.61 ± 6.25 in the left eye, showing thinning of GCC as compared to controls. Similarly, Harsha L Rao et al,[17] observed avg. GCC thickness in PACG patients was 77.9 ± 11.9, supporting our findings.

We observed that Primary Angle Closure Glaucoma (PACG) eyes exhibited a slightly lesser mean GCC reduction (-9.43 µm OD, -10.41 µm OS), aligning with Na JH et al,[13] who noted mean GCC thinning of approximately 8–10 µm in PACG patients.

In this study, the open-angle suspects had an average GCC thickness of (OD) 94.70 ± 3.37 (OS)96.20 ± 2.39, showing mild thinning in comparison to controls. A similar finding was demonstrated by Goktug Firatli et al,[18] having 104.67 µm as average GCC thickness in open-angle suspects. In narrow angle suspects, we observed an average GCC thickness of (OD) 91.7 ± 2.58 and (OS) 95.70 ± 3.16, showing minimal thinning, which was the same as 95.63 (90.73–100.53) in narrow angle suspects as seen by Yizhen Tanga et al.[19]

In contrast, in this study, glaucoma suspects displayed minimal GCC loss, with open-angle suspects showing a negligible mean GCC difference of -2.68 µm (OD) and -0.83 µm (OS), which was statistically nonsignificant. In Narrow angle suspects, mean GCC values also remained relatively stable, further affirming the value of GCC analysis in distinguishing early from advanced disease.

Sectoral analysis further highlighted that the superior and inferior macular regions were the most affected in glaucomatous eyes, showing marked thinning, with a superior average GCC thickness in POAG measured as 90.0 ± 18.31 µm in the right eye compared to 113.35 ± 7.51 µm in the right eye in controls. Tan et al [20] similarly found superior average GCC thinning of ~92.87 ± 7.20 µm in POAG eyes. Whereas, in contrast to Kim et al,[21] findings, superior average GCC thickness remained within normal limits in POAG patients. This was also supported by the previous findings by Hood et al,[11] that demonstrated early macular involvement correlating with peripapillary RNFL loss. These observations emphasise that GCC thinning reflects early retinal ganglion cell body loss, thereby reinforcing the clinical utility of GCC measurements in the early detection and monitoring of glaucoma progression.

This study showed that there may be a diagnostic accuracy and clinical utility of OCT-derived RNFL and GCC measurements in glaucoma management. Both parameters may offer critical insights into early structural changes that precede detectable functional loss, particularly in POAG and PACG. Sectoral analysis underscores the susceptibility of the superior and inferior retinal quadrants. Using OCT in routine ophthalmic evaluations may enhance the ability to detect glaucomatous damage in its incipient stages, facilitating timely intervention.

Limitation: Further studies with larger sample sizes and of longer duration are recommended to confirm the predictive diagnostic accuracy and clinical utility of OCT-derived RNFL and GCC measurements in glaucoma management and disease progression.

CONCLUSION

The findings of this study clearly establish that:

1. Significant reductions in RNFL and GCC thickness were observed in POAG and PACG eyes, correlating strongly with functional visual field impairment.
2. Superior and inferior sectors were particularly vulnerable to glaucomatous damage.
3. Optical Coherence Tomography (OCT) may be a sensitive and objective tool for diagnosis and monitoring glaucoma patients .

By confirming the correlation between structural and functional damage, and aligning them numerically with global research findings, this study tells about the important role of OCT-based imaging in the contemporary clinical management of glaucoma,

emphasising that OCT may be used for diagnosis and for monitoring disease progression.

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