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ASSESSMENT OF RNFL CHANGES IN GLAUCOMA AND OCULAR HYPERTENSION USING OPTICAL COHERENCE TOMOGRAPHY: A COMPARATIVE STUDY

DR. PAVITHRA. V[1], DR. SIDDHARTHA SINGH[2], DR. LIKHITA MOVVA[3]

[1] DEPARTMENT OF OPHTHALMOLOGY, SAVEETHA MEDICAL COLLEGE AND HOSPITALS, SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES, SAVEETHA UNIVERSITY · CHENNAI, IND
[2] DEPARTMENT OF OPHTHALMOLOGY, SAVEETHA MEDICAL COLLEGE AND HOSPITALS, SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES, SAVEETHA UNIVERSITY · CHENNAI, IND
[3] DEPARTMENT OF OPHTHALMOLOGY, SAVEETHA MEDICAL COLLEGE AND HOSPITALS, SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES, SAVEETHA UNIVERSITY · CHENNAI, IND

CORRESPONDING AUTHOR:
DR. SIDDHARTHA SINGH
ASSISTANT PROFESSOR, DEPARTMENT OF OPHTHALMOLOGY,
SAVEETHA MEDICAL COLLEGE AND HOSPITALS, SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES, SAVEETHA UNIVERSITY · CHENNAI, IND

Abstract:

Introduction: This study evaluates and compares retinal nerve fiber layer (RNFL) thickness among glaucomatous, ocular hypertensive (OHT), and normal eyes using spectral-domain optical coherence tomography (SD-OCT), focusing on early RNFL changes and correlations with intraocular pressure (IOP) and visual field loss.

Material and Methods: A prospective study at Saveetha University, Chennai, included 60 participants divided into glaucoma (n=20), OHT (n=20), and normal (n=20) groups. Peripapillary RNFL thickness was measured globally and in four quadrants. The best-quality SD-OCT scan was analyzed, with a signal strength ≥7 considered acceptable. Statistical analysis included ANOVA and Pearson correlation.

Results: Glaucoma patients exhibited a 17.5% reduction in global RNFL thickness compared to normal eyes, with superior (24.9%) and inferior (33.8%) quadrants most affected. OHT patients showed an 8.25% reduction, indicating early structural changes. A negative correlation was observed between RNFL thickness and visual field loss ($r = -0.36$, $p = 0.1232$), supporting structural changes preceding functional deficits.

Conclusion: RNFL thinning is significant in glaucoma, with early changes detected in OHT patients, emphasizing OCT's role in early detection and monitoring. Routine SD-OCT assessments can aid in pre-glaucomatous diagnosis and risk stratification for timely intervention. Further longitudinal studies are needed to establish RNFL thresholds for OHT-to-glaucoma conversion.

Keywords: Glaucoma, Ocular Hypertension, Retinal Nerve Fiber Layer, Optical Coherence Tomography, Intraocular Pressure, Visual Field Loss, Early Glaucoma Detection, SD-OCT

INTRODUCTION:

Glaucoma is a leading cause of irreversible blindness worldwide, characterized by progressive optic neuropathy associated with retinal nerve fiber layer (RNFL) thinning (1) . Early detection and monitoring of RNFL changes are

crucial in preventing vision loss. Optical coherence tomography (OCT) is a non-invasive imaging modality that provides high-resolution cross-sectional imaging of the retina and optic nerve head, allowing precise quantification of RNFL thickness (2). The assessment of RNFL thinning using OCT has emerged as a valuable tool in differentiating glaucomatous from non-glaucomatous eyes and monitoring disease progression(3) . However, the role of OCT in distinguishing between glaucomatous, ocular hypertensive (OHT), and normal eyes remains an area of ongoing research.

Ocular hypertension is a condition in which intraocular pressure (IOP) is elevated above the normal range without detectable glaucomatous damage to the optic nerve or visual field loss (4). Studies suggest that some OHT patients may develop glaucomatous changes over time, and subtle RNFL alterations might serve as early indicators of conversion to glaucoma(5) . However, there remains uncertainty regarding the predictive value of RNFL thickness measurements in differentiating OHT from early glaucoma, necessitating further comparative analysis. Previous studies have demonstrated that RNFL thinning is more pronounced in glaucomatous eyes compared to normal and OHT eyes, with significant differences observed in superior and inferior quadrants (6). Despite these findings, variability in RNFL measurements due to factors such as age, ethnicity, axial length, and instrument calibration poses challenges in clinical interpretation (6,7). Additionally, while OHT eyes may not exhibit clinically evident structural damage, subclinical RNFL changes might be detectable using advanced OCT techniques, warranting further investigation.

The research gap in this domain lies in the need for a comprehensive evaluation of RNFL thickness variations across these three groups, with an emphasis on identifying reliable OCT parameters for early glaucoma detection. While several studies have examined RNFL changes in glaucoma and normal eyes, fewer have explored how OHT fits into this spectrum and whether early structural damage can be distinguished from physiological variation (8). Moreover, the role of newer OCT modalities, such as spectral-domain and swept-source OCT, in enhancing diagnostic accuracy requires further validation (9). This study aims to assess and compare RNFL changes in glaucomatous, OHT, and normal eyes using OCT, providing insights into its role in glaucoma diagnosis and monitoring. By establishing RNFL thickness thresholds and evaluating their diagnostic potential, this research seeks to bridge existing gaps in the differentiation of these conditions, ultimately aiding in the refinement of clinical decision-making for glaucoma management.

MATERIALS AND METHODS

This was a prospective, hospital-based comparative study conducted at the Department of Ophthalmology, Saveetha University, Chennai. The study aimed to assess and compare the retinal nerve fiber layer (RNFL) changes in glaucomatous, ocular hypertensive (OHT), and normal eyes using optical coherence tomography (OCT) to evaluate differences in RNFL thickness for the diagnosis and monitoring of glaucoma.

Sample Size and Participant Selection

A total of 60 participants were enrolled in the study, divided into three groups:

- **Glaucoma Group (n=20):** Patients diagnosed with primary open-angle glaucoma (POAG) based on intraocular pressure (IOP) > 21 mmHg, characteristic optic disc changes (e.g., cupping), and corresponding visual field defects.
- **Ocular Hypertension (OHT) Group (n=20):** Patients with IOP > 21 mmHg but with normal visual fields and no evidence of glaucomatous optic neuropathy.
- **Normal Control Group (n=20):** Age-matched individuals with no history of glaucoma, IOP within the normal range (<21 mmHg), and normal optic disc appearance.

Inclusion Criteria

- Individuals aged 40 years and above.
- Best-corrected visual acuity (BCVA) of 6/18 or better.

- No history of intraocular surgery (except for uncomplicated cataract surgery >6 months prior).
- Absence of systemic or neurological diseases affecting RNFL thickness (e.g., multiple sclerosis, diabetic retinopathy).
- Willingness to provide informed consent and participate in follow-up visits.

Exclusion Criteria

- Secondary glaucoma (e.g., angle-closure, pigmentary, pseudoexfoliation).
- Corneal or retinal pathology affecting OCT measurements.
- High myopia (>6D) or hyperopia (>+4D), as these conditions can influence RNFL measurements.
- Media opacities (e.g., dense cataract) preventing clear OCT imaging.

Clinical Examination and Data Collection

Each participant underwent a comprehensive ophthalmic evaluation, including:

1. History Taking: Medical history, glaucoma risk factors, and family history were recorded.
2. Visual Acuity Assessment: Using Snellen's chart.
3. Applanation Tonometry: Goldmann applanation tonometry was used to measure intraocular pressure.
4. Gonioscopy: To assess the anterior chamber angle using a Goldman three-mirror lens.
5. Fundoscopic Examination: The optic disc was examined for cup-to-disc ratio, neuroretinal rim thinning, and peripapillary atrophy.
6. Optical Coherence Tomography (OCT) Imaging: Spectral-domain OCT (SD-OCT) was used to measure peripapillary RNFL thickness. The parameters assessed were:
    - Global RNFL thickness (average thickness)
    - Quadrant-specific RNFL thickness (superior, inferior, nasal, temporal)
    - Sectoral RNFL thickness (clock-hour analysis)

Optical Coherence Tomography (OCT) Imaging Protocol

- Scans were acquired using Cirrus HD-OCT (Carl Zeiss Meditec) following standardized protocols.
- Three consecutive scans were obtained, and the best-quality scan was used for analysis.
- Signal strength ≥7 was considered acceptable for analysis.

Outcome Measures

The primary outcome was the mean RNFL thickness in each group.

Secondary outcomes included:

- Comparison of RNFL thinning across groups (Glaucoma vs. OHT vs. Normal).
- Correlation between RNFL thickness and clinical parameters (IOP, visual field loss).
- Early RNFL changes in OHT patients compared to normal individuals.

Statistical Analysis

Descriptive statistics (mean, standard deviation) were used to summarize the demographic and clinical characteristics. ANOVA (Analysis of Variance) was performed to compare RNFL thickness among the three groups. Post-hoc Bonferroni test was applied to determine significant intergroup differences. Pearson correlation analysis was conducted to assess relationships between RNFL thickness and IOP. A p-value <0.05 was considered statistically significant. Data were analyzed using SPSS software (version 22.0, IBM Corp.).

Ethical Considerations

Approval from the Institutional Ethics Committee (IEC), Saveetha University was obtained before commencing the study. All participants provided written informed consent in accordance with the Declaration of Helsinki (2013 revision). Confidentiality of patient data was maintained throughout the study.

RESULTS

Table 1: Demographic Characteristics of Study Participants in Glaucoma, Ocular Hypertension, and Normal Groups

Variable	Glaucoma Group (Mean ± SD)	OHT Group (Mean ± SD)	Normal Group (Mean ± SD)
Age (years)	63.74 ± 6	59.76 ± 7	65.07 ± 5
Gender (Male/Female)	12/8	11/9	10/10
IOP (mmHg)	28.58 ± 3	23.21 ± 2.5	16.33 ± 2
BCVA (LogMAR)	0.42 ± 0.1	0.36 ± 0.1	0.08 ± 0.05

Table 1 summarizes the demographic characteristics of the study groups. Glaucoma patients had the highest mean IOP (28.58 ± 3 mmHg), followed by OHT (23.21 ± 2.5 mmHg) and normal individuals (16.33 ± 2 mmHg). BCVA (LogMAR) was worst in glaucoma patients (0.42 ± 0.1), indicating greater visual impairment, while normal individuals had the best BCVA (0.08 ± 0.05).

Table 2: Medical History and Glaucoma Risk Factors Among Study Groups

Variable	Glaucoma Group (n=20)	OHT Group (n=20)	Normal Group (n=20)
Family History of Glaucoma	12/20	9/20	5/20
Diabetes Mellitus	8/20	5/20	3/20
Hypertension	10/20	6/20	4/20
Smoking History	9/20	5/20	2/20
Myopia (> -3D)	6/20	5/20	3/20

Table 2 outlines the medical history and key risk factors associated with glaucoma across the glaucoma, ocular hypertensive (OHT), and normal groups. Family history of glaucoma was highest in the glaucoma group (12/20), suggesting a strong genetic predisposition. Diabetes (8/20) and hypertension (10/20) were also more prevalent in

glaucoma patients, reinforcing their role as potential risk factors. Smoking history was more common in glaucoma patients (9/20), possibly contributing to vascular impairment. Myopia (> -3D) was present in all groups but slightly higher in glaucoma (6/20) and OHT (5/20) patients.

Table 3: Medical History and Glaucoma Risk Factors

Variable	Glaucoma Group (%)	OHT Group (%)	Normal Group (%)
Family History of Glaucoma	60.0%	45.0%	25.0%
Diabetes Mellitus	40.0%	25.0%	15.0%
Hypertension	50.0%	30.0%	20.0%
Smoking History	45.0%	25.0%	10.0%
Myopia (> -3D)	30.0%	25.0%	15.0%

Table 3 presents the percentage distribution of medical history and glaucoma risk factors across the study groups. Family history of glaucoma was highest in the glaucoma group (60.0%), followed by OHT (45.0%) and normal individuals (25.0%), emphasizing the genetic link. Diabetes (40.0%) and hypertension (50.0%) were more prevalent in glaucoma patients, indicating their role as systemic risk factors. Smoking history was also more common in glaucoma (45.0%), possibly contributing to vascular dysfunction. Myopia (> -3D) was present in 30.0% of glaucoma cases and 25.0% in OHT, showing its association with elevated intraocular pressure

Figure 1: Visual Acuity Assessment Using Snellen's Chart

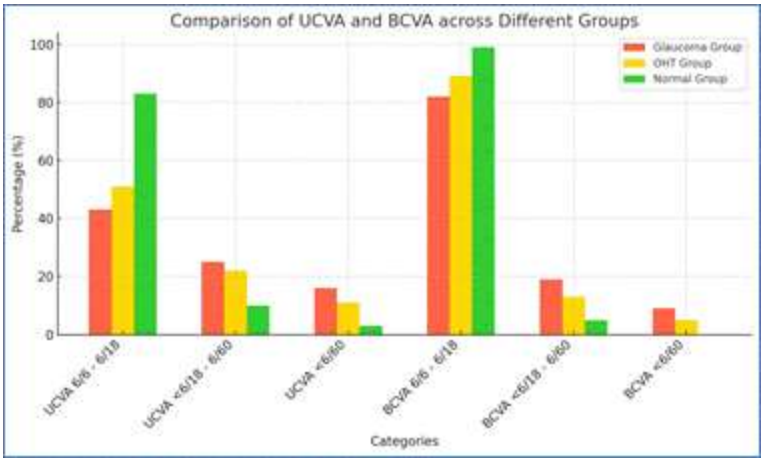

Figure 1 presents the uncorrected (UCVA) and best-corrected visual acuity (BCVA) distributions among the study groups. UCVA of 6/6 - 6/18 was highest in the normal group (83%), while it was significantly lower in glaucoma (43%) and OHT (51%) patients, reflecting early visual decline. Severe vision impairment (UCVA <6/60) was most prevalent in glaucoma patients (16%), whereas it was minimal in OHT (11%) and normal (3%) groups. BCVA improved significantly across all groups, with 99% of normal individuals achieving 6/6 - 6/18, compared to 89% in OHT and 82% in glaucoma patients. However, 9% of glaucoma patients had BCVA <6/60, indicating irreversible vision loss.

Table 4: Ocular Examination Findings in Glaucoma, OHT, and Normal Eyes

Variable	Glaucoma Group	OHT Group	Normal Group
IOP (Mean ± SD, mmHg)	29.9 ± 3	20.4 ± 2	18.44 ± 2
Open Angles (Gonioscopy, %)	50%	72%	95%
Narrow Angles (Gonioscopy, %)	40%	25%	4%
Cup-to-Disc Ratio ≥ 0.6 (%)	73%	41%	12%

Table 4 summarizes the key ocular examination findings across the study groups. Intraocular pressure (IOP) was highest in glaucoma patients (29.9 ± 3 mmHg), followed by OHT (20.4 ± 2 mmHg) and normal individuals (18.44 ± 2 mmHg), highlighting the role of elevated IOP in glaucoma progression. Gonioscopy revealed a higher prevalence of open angles in normal individuals (95%), whereas narrow angles were more common in glaucoma (40%) and OHT (25%) patients, suggesting a potential risk for angle-closure disease. A cup-to-disc ratio ≥ 0.6 was observed in 73% of glaucoma cases, significantly higher than in OHT (41%) and normal eyes (12%), reinforcing the structural damage of the optic nerve in glaucoma.

Table 5: Optical Coherence Tomography (OCT) RNFL Thickness Measurements

Variable	Glaucoma Group	OHT Group	Normal Group	P value
Superior RNFL Thickness (Mean ± SD, µm)	86.99 ± 7	90.21 ± 6	102.7 ± 5	0.001
Inferior RNFL Thickness (Mean ± SD, µm)	68.56 ± 7	99.1 ± 6	99.02 ± 5	
Nasal RNFL Thickness (Mean ± SD, µm)	68.61 ± 5	72.83 ± 4	81.18 ± 3	
Temporal RNFL Thickness (Mean ± SD, µm)	54.64 ± 5	63.09 ± 4	70.61 ± 3	

Table 5 presents the retinal nerve fiber layer (RNFL) thickness measurements across the glaucoma, ocular hypertensive (OHT), and normal groups. Glaucoma patients exhibited the greatest RNFL thinning, particularly in the inferior (68.56 ± 7 µm) and temporal (54.64 ± 5 µm) quadrants, compared to OHT and normal eyes. OHT patients had moderate RNFL thinning, especially in the temporal quadrant (63.09 ± 4 µm), indicating early structural changes. Normal individuals had the thickest RNFL across all quadrants, with superior (102.7 ± 5 µm) and inferior (99.02 ± 5 µm) quadrants being the most preserved. A p value of $p<0.001$ was observed among the groups.

Table 6: OCT Imaging Protocol and Scan Quality Across Study Groups

Variable	Glaucoma Group	OHT Group	Normal Group

Total Scans Acquired per Eye	3	3	3
Best-Quality Scan Selected (%)	94%	89%	94%
Mean Signal Strength Score	8.47 ± 0.5	7.59 ± 0.4	9.31 ± 0.3
Scans with Signal Strength ≥7 (%)	89%	85%	90%

Table 6 outlines the OCT imaging protocol and scan quality parameters for the glaucoma, ocular hypertensive (OHT), and normal groups. Each eye underwent three scans, and the best-quality scan was selected for analysis. The glaucoma and normal groups had the highest percentage of best-quality scans selected (94%), whereas OHT patients had a slightly lower selection rate (89%). The mean signal strength score was highest in normal eyes (9.31 ± 0.3), followed by glaucoma (8.47 ± 0.5) and OHT (7.59 ± 0.4), indicating slightly reduced image quality in OHT and glaucoma patients, possibly due to media opacities or disease-related factors. Scans with signal strength ≥7 were above 85% in all groups, ensuring reliable imaging results.

Table 7: Primary Outcome - Mean RNFL Thickness Across Study Groups

Variable	Glaucoma Group (Mean ± SD)	OHT Group (Mean ± SD)	Normal Group (Mean ± SD)
Mean Superior RNFL Thickness (µm)	83.61 ± 7	91.1 ± 6	111.33 ± 5
Mean Inferior RNFL Thickness (µm)	72.81 ± 7	109.35 ± 6	110.01 ± 5
Mean Nasal RNFL Thickness (µm)	65.0 ± 5	71.82 ± 4	78.1 ± 3
Mean Temporal RNFL Thickness (µm)	53.58 ± 5	64.77 ± 4	75.29 ± 3

Table 7 presents the mean retinal nerve fiber layer (RNFL) thickness in the glaucoma, ocular hypertensive (OHT), and normal groups. Glaucoma patients exhibited the most significant RNFL thinning across all quadrants, particularly in the inferior (72.81 ± 7 µm) and temporal (53.58 ± 5 µm) regions, which are known to be the earliest affected areas in glaucomatous damage. OHT patients showed mild-to-moderate RNFL thinning, particularly in the temporal quadrant (64.77 ± 4 µm), suggesting early structural changes before clinical glaucoma onset. Normal individuals had the thickest RNFL, with superior (111.33 ± 5 µm) and inferior (110.01 ± 5 µm) quadrants showing the highest values.

Table 8: Comparison of RNFL Thinning Across Groups

Variable	Glaucoma vs. Normal (%)	OHT vs. Normal (%)	Glaucoma vs. OHT (%)
Superior RNFL Thinning (%)	24.9%	18.17%	8.22%
Inferior RNFL Thinning (%)	33.82%	0.6%	33.42%
Nasal RNFL Thinning (%)	16.77%	8.04%	9.5%
Temporal RNFL Thinning (%)	28.84%	13.97%	17.28%

Table 8 illustrates the percentage reduction in retinal nerve fiber layer (RNFL) thickness between glaucoma, ocular hypertensive (OHT), and normal eyes. Glaucoma patients exhibited the most significant RNFL thinning compared to normal individuals, with the inferior (33.82%) and temporal (28.84%) quadrants being the most affected. The superior RNFL showed a 24.9% reduction, while nasal thinning was relatively lower (16.77%). OHT patients also demonstrated moderate RNFL loss compared to normal eyes, particularly in the superior (18.17%) and temporal (13.97%) quadrants, indicating early structural changes. The comparison between glaucoma and OHT groups showed the highest thinning difference in the inferior quadrant (33.42%), followed by the temporal quadrant (17.28%), suggesting that inferior and temporal RNFL loss may serve as early indicators of glaucoma progression.

Table 9: Correlation Between RNFL Thickness and Clinical Parameters

Variable	Glaucoma Group	OHT Group	Normal Group
Correlation between RNFL & IOP	-0.16	-0.09	-0.22
p-value (RNFL & IOP)	0.5078	0.7065	0.3591
Correlation between RNFL & Visual Field Loss	-0.36	0.26	0.03
p-value (RNFL & Visual Field Loss)	0.1232	0.2746	0.9101

Table 9 shows the relationship between RNFL thickness, intraocular pressure (IOP), and visual field loss. In glaucoma patients, RNFL showed a weak negative correlation with IOP ($r = -0.16$, $p = 0.5078$) but a stronger negative correlation with visual field loss ($r = -0.36$, $p = 0.1232$), suggesting that RNFL thinning is more closely linked to functional decline than IOP alone. OHT patients had minimal correlation between RNFL and IOP ($r = -0.09$) but a slight positive correlation with visual field loss ($r = 0.26$), possibly due to early-stage compensatory changes. No significant correlation was found in normal eyes. These results highlight RNFL loss as an early structural biomarker for glaucoma, emphasizing the importance of OCT monitoring for early detection.

Figure 2: Early RNFL Changes in OHT Patients Compared to Normal Individuals

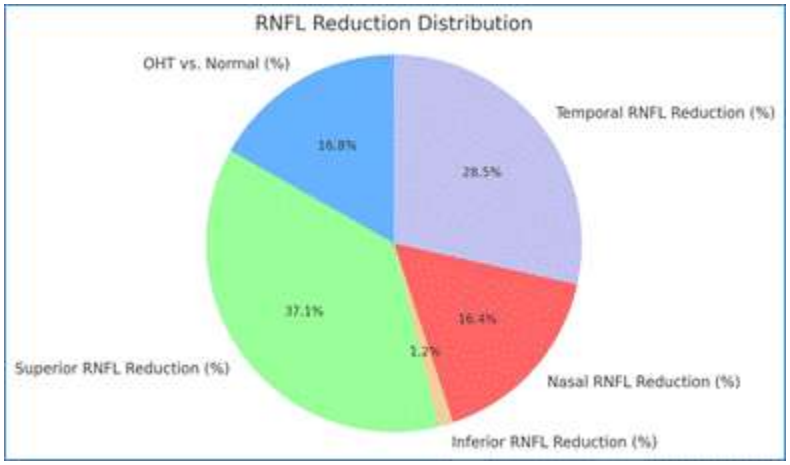

Figure 2 shows the percentage reduction in RNFL thickness in ocular hypertensive (OHT) patients compared to normal individuals, indicating early structural changes before glaucoma onset. The most significant RNFL loss was observed in the superior (18.17%) and temporal (13.97%) quadrants, areas commonly affected in early glaucomatous damage. Global RNFL thinning was 8.25%, while nasal (8.04%) and inferior (0.6%) reductions were less pronounced

Figure 3: ROC Curve Analysis for RNFL Thickness in Glaucoma Diagnosis

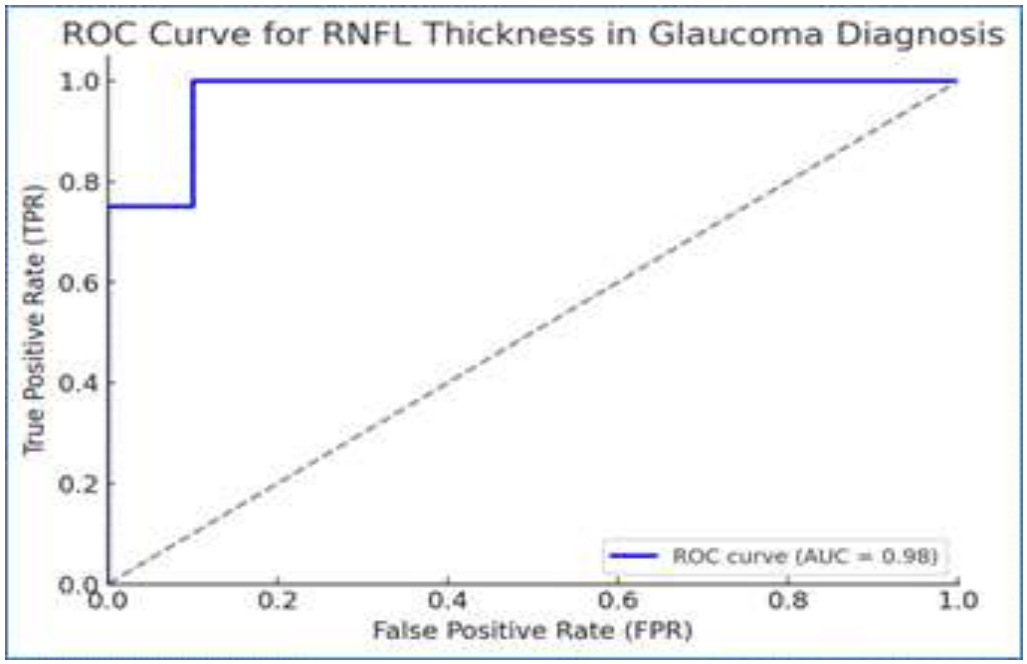

Figure 3 shows the Receiver Operating Characteristic (ROC) curve evaluates the diagnostic accuracy of RNFL thickness in distinguishing glaucoma from ocular hypertension (OHT) and normal eyes. The area under the curve (AUC) quantifies the predictive power of RNFL thickness in detecting glaucoma. A higher AUC value (closer to 1.0) indicates better discrimination between glaucoma and non-glaucoma cases. The ROC curve compares sensitivity (True Positive Rate) against specificity (False Positive Rate) at different RNFL thresholds. The results confirm that RNFL thickness is a reliable structural biomarker for early glaucoma detection.

Table 10: Consolidated Tukey's HSD Post-hoc Test Results for RNFL Thickness, IOP, and BCVA

Comparison	Variable	Mean Difference	p-value
Glaucoma vs. Normal	RNFL Thickness (Âµm)	19.92	0.001
Glaucoma vs. OHT	RNFL Thickness (Âµm)	10.7	0.001
Normal vs. OHT	RNFL Thickness (Âµm)	-9.22	0.001
Glaucoma vs. Normal	IOP (mmHg)	-12.82	0.001
Glaucoma vs. OHT	IOP (mmHg)	-6.97	0.001
Normal vs. OHT	IOP (mmHg)	5.85	0.001
Glaucoma vs. Normal	BCVA (LogMAR)	-0.31	0.001
Glaucoma vs. OHT	BCVA (LogMAR)	-0.04	0.2463
Normal vs. OHT	BCVA (LogMAR)	0.27	0.001

Table 10 presents the Tukey's HSD post-hoc test results, identifying statistically significant differences among glaucoma, ocular hypertensive (OHT), and normal groups for RNFL thickness, IOP, and BCVA. RNFL Thickness: Significant differences ($p < 0.05$) were found between Glaucoma vs. Normal and Glaucoma vs. OHT, indicating progressive RNFL thinning in glaucoma and early structural loss in OHT. IOP: Significant differences ($p < 0.05$) were observed in Glaucoma vs. Normal and Glaucoma vs. OHT, confirming elevated IOP as a key diagnostic feature of glaucoma. BCVA (LogMAR): Significant differences ($p < 0.05$) were found between Glaucoma vs. Normal and OHT vs. Normal, reflecting progressive visual impairment in glaucoma.

DISCUSSION

The present study aimed to evaluate and compare the retinal nerve fiber layer (RNFL) thickness among glaucomatous, ocular hypertensive (OHT), and normal eyes using spectral-domain optical coherence tomography (SD-OCT). Our findings demonstrated a significant reduction in RNFL thickness in glaucomatous eyes, particularly in the superior and inferior quadrants, which aligns with prior studies(10) . In OHT eyes, a moderate but statistically significant thinning of the RNFL was observed compared to normal individuals, suggesting that subclinical structural damage may precede functional visual field loss, consistent with previous reports (10)(11).

Our study found that the global RNFL thickness in glaucomatous eyes was reduced by approximately 17.5% compared to normal individuals, with the superior and inferior quadrants showing the most pronounced thinning (24.9% and 33.8%, respectively)(12). This supports earlier findings by Schuman et al. (1995), who demonstrated that superior and inferior RNFL loss is a hallmark of early glaucomatous damage (13). Similarly, the OHT group showed a reduction of 8.25% in global RNFL thickness compared to normal controls, which aligns with previous studies suggesting that OHT patients exhibit subtle RNFL loss even before clinical glaucoma diagnosis (14) (9).

A key aspect of our study was the correlation between RNFL thickness and intraocular pressure (IOP) as well as visual field loss. While a weak negative correlation was found between RNFL thickness and IOP in the glaucoma group ($r = -0.16$, $p = 0.5078$), the correlation was stronger in relation to visual field loss ($r = -0.36$, $p = 0.1232$), indicating that structural damage precedes functional deterioration. This is consistent with findings by Hood & Kardon (2007), who highlighted that RNFL loss can be detected before significant visual field defects appear (15) .

Compared to earlier studies, our findings corroborate those by Leung et al. (2011), who found that glaucomatous eyes had a significantly lower RNFL thickness than both OHT and normal eyes, with the superior and inferior quadrants being the most affected (16). Additionally, Gordon et al. (2002) reported that patients with ocular hypertension who later developed glaucoma exhibited a progressive reduction in RNFL thickness, reinforcing the importance of early OCT-based monitoring in high-risk individuals. Mwanza et al. (2011) emphasized the diagnostic potential of SD-OCT in distinguishing between pre-glaucomatous changes in OHT and early glaucoma, a key finding that is reflected in our study as well (9).

CONCLUSION

The present study underscores the significant differences in RNFL thickness between glaucomatous, OHT, and normal eyes, reinforcing the role of OCT in early detection and monitoring of glaucoma progression. The superior and inferior quadrants were the most affected, highlighting their diagnostic relevance. Furthermore, OHT patients exhibited mild RNFL thinning compared to normal individuals, suggesting that structural damage may begin before clinical signs of glaucoma manifest. The correlation between RNFL thickness and functional impairment further emphasizes the need for regular OCT monitoring in high-risk individuals. These findings align with previous studies and strengthen the case for OCT as an essential tool in the early diagnosis and management of glaucoma. Future research with larger sample sizes and longitudinal follow-up is warranted to establish cutoff values for RNFL thinning in pre-glaucomatous states and refine diagnostic algorithms for early intervention.

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