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TO STUDY THE ROLE OF OPTICAL COHERENCE TOMOGRAPHY (OCT) FOR GLAUCOMA SCREENING, DIAGNOSIS AND DETECTION OF GLAUCOMA PROGRESSION

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ABSTRACT **Purpose:** This study aims to evaluate the role of Optical Coherence Tomography (OCT) in the screening, diagnosis, and monitoring of glaucoma progression. Specifically, it assesses the effectiveness of OCT and its various modalities in detecting glaucoma and tracking its progression over time in department of ophthalmology at M.L.B Medical College Jhansi. **Materials and Methods:** A prospective observational clinical study on 112 was conducted over 20 months at the Department of Ophthalmology, Maharani Laxmi Bai Medical College and Hospital, Jhansi, Uttar Pradesh. The study included patients attending the Ophthalmology OPD and from the periphery who met the inclusion criteria. Detailed ocular examinations, including visual acuity tests, intraocular pressure (IOP) measurements, fundus examinations, and OCT scans, were performed at baseline and regular follow-up visits. Data were collected and analyzed to compare the diagnostic accuracy of OCT against traditional methods and to monitor changes in the retinal nerve fiber layer (RNFL). **Results:** The findings indicate that OCT is a highly reliable tool for early detection of glaucoma, showing high sensitivity and specificity in diagnosing glaucomatous changes. Longitudinal OCT scans proved valuable in tracking RNFL changes over time, aiding in timely adjustments to treatment plans. The combined use of OCT and fundus photography significantly improved diagnostic accuracy, particularly in early glaucoma cases. **Conclusion:** OCT is an effective non-invasive imaging technique for glaucoma screening, diagnosis, and progression monitoring. Implementing OCT in clinical practice can enhance early detection and management of glaucoma, leading to better patient outcomes. Future research should continue to explore advanced OCT technologies to further improve diagnostic accuracy and patient care.

KEYWORDS : Optical Coherence Tomography, Glaucoma, Retinal Nerve Fiber Layer, Screening, Diagnosis, Disease Progression

INTRODUCTION

Glaucoma is a group of diseases marked by progressive optic neuropathy, rather than being a single illness. This condition causes a distinctive optic disc appearance and a specific pattern of irreversible visual field abnormalities. While increased intraocular pressure (IOP) is often linked to these abnormalities, it is not always present. High IOP is the most common risk factor for glaucoma, but there are several other risk factors as well. When IOP is consistently high without glaucomatous damage, it is known as "ocular hypertension." Conversely, "normal or low tension glaucoma" (NTG/LTG) occurs when optic disc cupping and/or visual field abnormalities are present even with normal or low IOP[1-3].

Several Optical Coherence Tomography (OCT) devices function based on similar principles but exhibit differences in diagnostic capabilities, acquisition speeds, and resolutions. This section examines three popular Spectral-Domain OCTs (SD-OCTs): the Spectralis (Heidelberg Engineering, Dossenheim, Germany), the Cirrus (Carl Zeiss Meditec, Dublin, CA), and the RTVue (Optovue Inc., Fremont, CA), highlighting their distinctive features. Numerous studies have assessed the diagnostic accuracy of these SD-OCTs individually or in comparison with time-domain OCT technology.[4-8]. Given the importance of the Retinal Nerve Fiber Layer (RNFL) in ophthalmic research, this section will compare protocols based on RNFL measurements and examine their diagnostic accuracy.[9].

Principle Idea of OCT[10]:

The principle of low-coherence interferometry is fundamental to all OCT systems. Temporal coherence refers to the duration over which a light source emits a wave train that maintains a consistent phase relationship, measured at a specific point in space. Light sources with low temporal coherence maintain a fixed phase relation only for a short interval, corresponding to a limited travel range known as the coherence length or coherence gate. A light source with a broad spectral bandwidth includes various wavelengths, making it a broadband source with low coherence. Conversely, monochromatic laser light has a narrow spectral line and a coherence length of several meters.

An interferometer works by splitting the light from a source into two separate paths and then recombining the light returning from these paths at the output. Interference occurs under certain conditions: coherent waves superimpose, resulting in constructive interference (where the waves reinforce each other), destructive interference (where they cancel each other out), or any condition in between. The associated light intensity can be measured as an electrical signal using a photodetector. This signal depends on the difference in the optical path length between the two arms. For a low-coherent light source, such as a superluminescent diode (SLD) or a pulsed laser, interference is possible only if the optical paths are matched to be equal in length within the short coherence length of the source, typically in the micrometer range.

MATERIAL AND METHOD

Research Design:

This study was designed as a prospective observational clinical study focused on evaluating the effectiveness of Optical Coherence Tomography (OCT) in the screening, diagnosis, and monitoring of glaucoma progression. The study was conducted over a span of 20 months (from August 2022 to March 2024) in the Department of Ophthalmology at Maharani Laxmi Bai Medical College and Hospital,

Sample Selection

Inclusion Criteria:

1. **Age Range:** Patients aged 20 to 70 years to capture a broad adult population at risk for glaucoma.
2. **Consent:** Willingness and ability to provide written informed consent on a prescribed format and adherence to study protocols.
3. **Diagnosis:** Patients with a known or newly diagnosed unilateral or bilateral primary open-angle glaucoma, characterized by:
   - Elevated intraocular pressure (IOP) greater than 21 mmHg on at least two separate visits.
   - Characteristic glaucomatous optic disc changes (as present in fundus examination and/or in OCT).
   - Characteristic visual field changes suggestive of glaucoma.
4. **Gonioscopy:** Open or closed angles confirmed by Goldmann goniolens examination.
5. **Physical Fitness:** Patients physically capable of undergoing perimetry and Optical Coherence Tomography (OCT) evaluation.

Exclusion Criteria:

1. **Age Restrictions:** Patients younger than 20 years or older than 70 years to focus on the adult population most affected by primary

open-angle glaucoma.

2. **Other Ocular Conditions:** Exclusion of patients with ocular conditions that could confound the study results, including: Uveitis, retinal detachment, or retinal vascular disorders,High refractive errors (more than ±5.0D),Hazy media that interferes with OCT imaging.
3. **Systemic Conditions:** Exclusion of patients with chronic systemic diseases such as diabetes or hypertension that could affect ocular health.
4. **Other Forms of Glaucoma:** Patients with other forms of glaucoma (e.g., secondary angle-closure glaucoma) were excluded to maintain focus on primary glaucoma.
5. **Recent Ocular Surgery or Trauma:** Patients with a history of ocular trauma or surgery within the past six months.
6. **Unreliable Test Results:** Patients with unreliable visual field test results.
7. **Cognitive or Comprehension Issues:** Inability to understand and comply with test procedures.
8. **Pregnancy or Lactation:** To avoid potential risks to the mother and child.

Sample Including Sample Size Calculation:

The sample for this study comprised of the patients attending the Outpatient Department (OPD) of ophthalmology at Maharani Laxmi Bai Medical College and Hospital, Jhansi, Uttar Pradesh. The sample selection process was designed to ensure the inclusion of a representative cohort of patients at varying stages of glaucoma, as well as individuals at risk for the disease. A total of 112 patients (222 eyes, as 2 of the cases were uniocular) diagnosed with glaucoma were enrolled.

$$n = \frac{Z2xpx(1-P)}{d2}$$

Z^2=1.96x1.96=3.8416
1-P=1.0.026=0.9741
n= 39.1828992
Rounding up, the required sample size is approximately 41 participants.

Adjusting for the Design Effect:

In studies involving clustered sampling, the sample size must be adjusted for the design effect (DEFF). For our study, the design effect is 2.5. The adjusted sample size is calculated as:

- Design effect DEFF=2.5
- Adjusted sample size=nxDEFF=41x2.5=102.5
- Rounding up, the final adjusted sample size is approximately 103 participants.

To ensure robustness and account for potential dropouts or non-responses, we decided to include a total of 112 participants.

Data Collection and Procedure

Data collection followed a structured and systematic protocol to ensure consistency and reliability in the assessment of patients with potential or diagnosed glaucoma. This comprehensive approach incorporated multiple diagnostic tools and methodologies to obtain a detailed understanding of each patient's ocular health status.

Patient History:

Medical History: Detailed documentation of general health conditions, including systemic diseases like hypertension and diabetes that can influence ocular health.
Ocular History: Record of previous eye conditions, surgeries, treatments, and current medications.
Family History: Collection of information regarding familial incidence of glaucoma or other hereditary eye diseases.

Visual Acuity Tests: Conducted under standardized lighting conditions using both Snellen's and LogMAR Charts to ensure accuracy. Both distance and near visual acuity were assessed to determine the overall visual function of each eye.

Intraocular Pressure Measurement: Measurements were performed at consistent times of the day to control for diurnal variations, utilizing non-contact tonometry/Goldman applanation tonometry for IOP measurement.

Fundus Examination: Conducted with pupils dilated using mydriatic agents to allow thorough inspection of the retina and optic nerve head. Slit lamp biomicroscopy using 90D lens and Direct / indirect ophthalmo-scopy were used to evaluate the optic disc for signs of glaucomatous damage such as cupping and notching.

Slit Lamp Examination: A detailed assessment of the anterior segment of the eye was performed to detect abnormalities in the cornea, anterior chamber, iris, and lens.

Spectral Domain - Optical Coherence Tomography (SD-OCT) Scanning:

High-resolution imaging was utilized to measure the retinal nerve fiber layer (RNFL) thickness and other key parameters such as the macular ganglion cell complex (GCC)..

Gonioscopy: A detailed anterior chamber angle examination using a 3D mirror gonioscope to visualize the anterior chamber angle structures. This procedure was crucial in categorizing the type of glaucoma (open-angle vs. angle-closure).

Perimetry: For Visual field testing, Humphrey Visual Field Analyzer (HFA) was commonly used, employing the 24-2 or 30-2 test patterns for comprehensive coverage of the central visual field. Serial visual field tests were compared over time to track the progression of visual field defects.

RESULTS

1. We initially identified 120 patients who met the inclusion criteria for the study. However, 8 patients were excluded (dropout) due to various reasons such as loss to follow-up or incomplete data, resulting in a final study population of 112 patients.In total, 222 eyes of 112 patients were included in the study (since two subjects were uniocular).
2. **Age Wise Distribution:** 31 patients (27.68%)were between 21-40 years old, 49 patients (43.75%) were between 41-60 years old, and 23 patients (20.54%) were older than 60 years. This distribution indicates that a significant portion of our patients were in the age group more than 40 year.
3. **Sex Wise Distribution:**The gender distribution among the 112 patients showed a slight predominance of females, with 61 patients (54.46%) compared to 51 males (45.54%). This finding suggesting a higher prevalence of certain types of glaucoma in females.
4. **Distribution of Patients on the Basis of Gonioscopy:** Gonioscopic examination revealed that the majority of our patients, 80 (71.43%), had POAG, while 32 patients (28.57%) PACG. This distribution underscores the predominance of POAG in the studied population, which is consistent with global trends where POAG is the most common form of glaucoma.
5. **Distribution of Patients of Primary Open Angle Glaucoma (POAG) on the Basis of Onset and Progression of Glaucoma:**

POAG	Number of patients	Percentage
Late onset glaucoma(non progressive)	66	82.50%
Early onset glaucoma (progressive)	14	17.50%
Total	80	100.00%

6. **Table 6:Distribution of Patients of Primary Angle Closure Glaucoma (PACG) on the Basis of Onset and Progression of Glaucoma :**

PACG	Number of patients	Percentage
Late onset glaucoma (non progressive)	15	46.88%
Early onset glaucoma (progressive).	17	53.13%
Total	32	100.00%

7. **Mean IOP(mmHg) Follow up After 6 Month:**

Mean IOP		Day 1	6 months	p-value
Late onset glaucoma (non progressive)(n=80)	Right eye	27.05±4.01	23.26±2.40	0.001
	Left eye	25.32±3.25	22.05±2.20	0.001
Early onset glaucoma (progressive)(n=31)	Right eye	34.39±3.67	33.10±3.22	0.15
	Left eye	34.10±4.52	32.74±4.25	0.23

8. **Mean IOP (mmHg) Follow up After 20 Months:**

Mean IOP		Day 1	20 months	p-value
Late onset glaucoma (non progressive)(n=80)	Right eye	27.05±4.01	19.16±1.54	0.0001
	Left eye	25.32±3.25	18.74±2.98	0.0001
Early onset glaucoma (progressive)(n=31)	Right eye	34.39±3.67	31.71±2.95	0.003
	Left eye	34.10±4.52	31.35±4.16	0.015

9. **Mean RNFL (µm) at Day 1 and 12 Months**

			RNFL at Day 1	RNFL at 20 Months	p-value
Total	Late Onset Glaucoma (non-progressive)	RE	77.28±5.90	76.04±5.67	0.17
		LE	78.89±5.66	77.63±5.60	0.15
	Early Onset glaucoma (progressive)	RE	71.48±5.40	66.24±5.36	0.0003
		LE	71.68±5.39	66.58±5.62	0.0006
Superior	Late Onset glaucoma (non-progressive)	RE	91.26±13.28	89.89±12.99	0.51
		LE	93.05±13.65	91.74±13.88	0.54
	Early Onset glaucoma (progressive)	RE	83.16±10.27	77.65±10.04	0.04
		LE	84.74±10.69	79.06±11.05	0.04
Inferior	Late Onset glaucoma (non-progressive)	RE	89.63±10.10	88.47±9.82	0.46
		LE	89.63±10.34	88.37±10.13	0.44
	Early Onset glaucoma (progressive)	RE	78.32±11.07	72.65±11.07	0.05
		LE	77.94±10.43	72.32±11.42	0.05
Nasal	Late Onset glaucoma (non-progressive)	RE	62.74±6.28	61.37±6.25	0.48
		LE	62.00±7.48	61.00±7.51	0.35
	Early Onset glaucoma (progressive)	RE	61.81±8.70	57.26±8.17	0.04
		LE	61.87±8.74	57.45±8027	0.03
Temporal	Late Onset glaucoma (non-progressive)	RE	65.47±9.95	64.37±9.82	0.48
		LE	70.89±10.01	69.42±9.93	0.35
	Early Onset glaucoma (progressive)	RE	62.61±10.36	57.42±9.23	0.04
		LE	62.16±7.79	57.48±8.39	0.03

DISCUSSION

1. Age: In our study the age distribution indicates that a significant portion of our patients were in the age group more than 40 year. Glaucoma can occur at any age, it is most commonly diagnosed in older adults, with a significant increase in risk as people age.
2. Gender: In our study gender distribution showed a slight predominance of females.
3. In our study, gonioscopic examination revealed that 80 patients (71.43%) had POAG, while 32 patients (28.57%) had PACG. This distribution indicate the predominance of POAG, consistent with global trends.
4. In non-progressive cases, significant IOP reduction was observed over time, indicating effective management. However, in progressive cases, the reduction was less pronounced, highlighting the challenge in managing early onset progressive glaucoma. The significant difference in IOP reduction over time between non-progressive and progressive cases underscores the importance of early detection and aggressive management in progressive cases.
5. In our study, cases with non-progressive glaucoma showed thinning of RNFL over a span of 20 months as follows;

RNFL (NON PROGRESSIVE GLAUCOMA)	THINNING IN RNFL OVER 20MONTHS(µm)		RELATIVE THINNING IN RNFL (µm/year)
TOTAL	RE	1.24	0.74
	LE	1.26	0.75
SUPERIOR	RE	1.37	0.82
	LE	1.31	0.78
INFERIOR	RE	1.16	0.69
	LE	1.26	0.75
NASAL	RE	1.37	0.82
	LE	1.00	0.60
TEMPORAL	RE	1.1	0.66
	RE	1.47	0.88

6. In our study, cases with progressive glaucoma showed thinning of RNFL over a span of 20 months as follows;

RNFL (PROGRESSIVE GLAUCOMA)	THINNING IN RNFL OVER 20 MONTHS(µm)		THINNING IN RNFL (µm/year)
TOTAL	RE	5.24	3.14
	LE	5.10	3.06
SUPERIOR	RE	5.51	3.30
	LE	5.68	3.40
INFERIOR	RE	5.67	3.40
	LE	5.62	3.37
NASAL	RE	4.55	2.73
	LE	4.42	2.65
TEMPORAL	RE	5.16	3.09
	LE	4.16	2.49

CONCLUSION

1. Glaucoma predominantly affects individuals over the age of 40.
2. Our studies suggesting higher glaucoma prevalence in females.
3. The study identified a higher prevalence of Primary Open-Angle Glaucoma (POAG) compared to Primary Angle-Closure Glaucoma (PACG) among the patients.
4. Our study demonstrated that conservative treatment is effective in significantly reducing IOP in late onset glaucoma patients over both 6-month and 20-month follow-up periods. However, the effectiveness was less pronounced in early onset glaucoma patients, suggesting that these patients might benefit from more intensive treatment protocols to manage IOP and prevent further optic nerve damage.
5. In our study, measurements taken at Day 1 and 20 months showed stable RNFL thickness in non-progressive cases, whereas progressive cases exhibited significant RNFL thinning over time. This thinning is indicative of ongoing optic nerve damage in progressive glaucoma.

The substantial decrease in RNFL thickness in progressive cases after 20 months emphasizes the utility of OCT in monitoring disease progression and highlights the need for timely intervention.

In non-progressive cases, minimal changes were observed in all four quadrants over 20 months, suggesting stability. In contrast, progressive cases exhibited significant thinning, particularly notable after 20 months. This quadrant-specific analysis aids in understanding the pattern of optic nerve damage, which often starts in specific regions and progresses. The differences in RNFL thinning between non-progressive and progressive cases highlight OCT's ability to detect and monitor subtle changes in glaucoma patients.

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