Original Article

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Early Detection of Glaucoma Prevents Visual Impairment : A Clinical Study

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Abstract

Introduction: Of the irreversible causes of blindness, glaucoma ranks second which can be treated by early identification of disease and to slow its progression and preserve vision. *Aim:* The purpose of our study was to calculate the RNFL and ONH parameters using OCT in primary open angle glaucoma (POAG) patients and to determine if any correlation exists between the two. *Materials and methods:* The study included 95 eyes of 50 patients above 40 years of age with POAG. Central corneal thickness was calculated using optic pachymetry, IOP measurement using applanation tonometry. SD-OCT was used to calculate the RNFL and ONH parameters. *Results:* The ONH parameters and the RNFL thickness were tabulated and correlation between them was analysed. Superior and inferior quadrants thinning of RNFL was evident in most of the patients. Superior RNFL and the vertical ONH parameters showed best correlation (-0.442, p-value 0.005). *Conclusion:* The RNFL thickness were well correlated to optic disc parameters. OCT helps in acquiring high resolution accurate images, reproducible RNFL and retinal thickness measurement. OCT has shown to have greater diagnostic accuracy in RNFL measurements, there by helping the ophthalmologists to identify subtle changes of the normal RNFL pattern, ONH parameters before visual field defects develop.

Keywords: RNFL; ONH; POAG; SD-OCT

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Introduction

Visual morbidity have an adverse impact on physical and mental health [1]. Visual instability leads to accidents, emotional distress, social withdrawal, and depression when compared to healthy population [2]. Visual disturbances progresses as a person gets old and its progression depends on his systemic and ocular condition. Causes of visual impairment most commonly being cataract, glaucoma, age-related macular degeneration, and diabetic retinopathy are more prevalent among the elderly age group [3].

Glaucoma is identified by death of ganglion cells in spread over a period of years resulting in optic nerve damage leading to visual field loss and irreversible blindness [4]. Glaucoma is regarded as the second leading cause of irreversible blindness. 64.3 million people are affected with glaucoma between the age group 40-80 years, when study was done in 2013 and the prevalence increasing to 76.0 million in the year 2020 and 111.8 million in 2040 worldwide [4]. The estimated prevalence of glaucoma in India is 12 million around the age group of 40 years and older [5]. 6.48 million people are diagnosed withprimary open angle glaucoma (POAG) making it the most common variant [6]. Among 2.6% prevalence of glaucoma, POAG marks at 1.7%, PACG at 0.5% and 0.3% of secondary glaucoma after excluding pseudoexfoliation [7].

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Early Timed intervention can stop the progression of the disease and preserve. Retinal function can be measured with techniques such as SAP, SWAP and FDT [8]. However, more than 40% of the optic nerve axons can be damaged before glaucomatous changes are detectable by perimetry [9].

Optical coherence tomography (OCT), a well-accepted recent modality identifies early glaucomatous damage, Using glaucoma profile scan pattern measuring parameters like optic nerve head (ONH), retinal nerve fibre layer (RNFL) thickness and macular scan pattern. Highest resolution and faster scan rate are the peculiarities of spectral domain OCT (SD-OCT) which helps in acquiring ocular structures when compared with previous Time domain version of this technology [10]. It is based on Michelson Interferometry principle.

Assessment of posterior segment ocular structures is therefore a crucial step in early diagnosis of glaucoma along with progression analysis by using OCT.

Aims and Objectives

To study the optic nerve head (ONH) and retinal nerve fibre layer (RNFL) changes using optical coherence tomography (OCT) and to access the correlation between the parameters in primary open angle glaucoma patients (POAG).

Materials and Methods

A cross-sectional study, conducted in the department of ophthalmology at a tertiary care hospital, in South India

Institutional ethical committee approval was obtained for this study.

The study was conducted from January 2017 to June 2018. 95 eyes of 50 patients were included in the study.

A written informed consent was obtained from the patients.

Inclusion Criteria

- Patients above 40 yrs of age.
- Patients already diagnosed as glaucoma and on treatment
- Patients with the risk factors of glaucoma like
  (a) Raised intra ocular pressure
  (b) Family history of primary open angle glaucoma
  (c) Diabetes mellitus
  (d) Systemic hypertension

Exclusion Criteria

- High myopia
- Retinal pathologies
- Non-compliant patients
- Media opacity
- Uveitic glaucoma
- Secondary glaucoma

Brief Explanation of the Procedure

All cases of POAG who attended ophthalmology OPD were included.

- Detailed history regarding the ocular complaints, systemic diseases, family history and previous medical and surgical history was taken.
- A thorough ophthalmic examination was done which included

Recording of distant and near visual acuity by Snellen's chart and BCVA. Intra ocular pressure measurement by Goldman's Applanation Tonometry.

Anterior segment examination by slit lamp biomicroscopy.

Posterior pole examination by 78 D / 90 D lens for viewing the stereoscopic view of the optic disc and macula. Measurement of central corneal thickness was done by using DGH ultrasonic pachymetry.

ONH parameters and RNFL thickness measurements were obtained by SD-OCT. The patients were informed regarding the procedure that, it is an entirely non- invasive procedure and would need his utmost cooperation for a few minutes only. The pupils were dilated using tropicamide. 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 colour light). Serial scans were done. Signal strength of more than 6 was considered for analysis.

Visual field testing was done using Humphrey visual field.

All the above parameters were taken into consideration and were analysed.

Data Collection

All data was entered into a Data Collection Proforma Sheet (Annexure) and were entered into MS Excel 2013.

Statistical Methods

The study subjects were categorized according to age, gender in terms of percentages and standard deviation. The analysis of ONH and RNFL parameters was done. The correlation between the ONH and RNFL parameters was done using Pearsons correlation. The above statistical procedures were performed by the statistical package namely IBM SPSS statistics-20.

Results

Demographics

Out of 50 patients, 5 patients were one-eyed patients. The mean age of the patients was 61.58 ± 9.89 years. Among 50 patients there were 30 (60%) males and 20 (40%) females. The mean IOP was 24.18 ±3.504 mm Hg.

Among the patients, 26 were already on treatment and 24 were newly diagnosed cases. Figure 1 shows the risk factors among the patients. The mean CCT was 466 ± 2.1 microns. 33 patients had risk factors out of which 25 were diabetics, 5 had a family history of POAG and three patients were hypertensives.

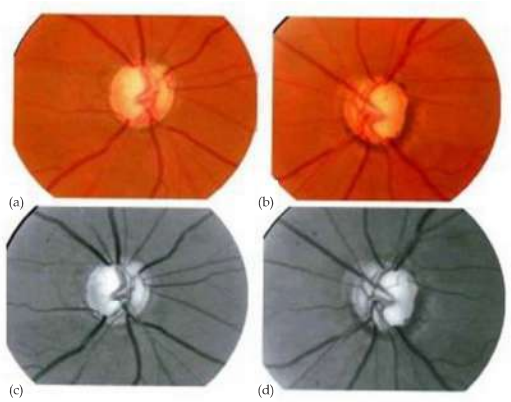

Fig. 1:

Optic Nerve Head Analysis

OCT was performed and parameters were evaluated. The mean disc area was 3.31 ± 1.161 mm^2; mean cup area was found to be 2.39 ± 1.09 mm^2. The mean rim area was 1.006 ± 0.872 mm^2. The mean CD area ratio was 0.708 ± 0.239. The mean cup depth was found to be 0.290 ± 0.134 mm and the max cup depth was 0.654 ± 0.206 mm. The mean C:D horizontal was 0.893 ± 0.152 and the mean C:D vertical was found to be 0.849 ± 0.142. (Table 1). (Figs 2- 5).

RNFL Analysis

RNFL thickness was measured by OCT in all four quadrants. RNFL thickness of all the patients were

Table 1: Analysis of ONH parameters

Parameter	Mean ± S.D	95% CI	
		Lower	Upper
DISC AREA (mm^2)	3.31 ± 1.161	3.08	3.55
CUP AREA (mm^2)	2.39 ± 1.09	2.17	2.62
RIM AREA (mm^2)	1.006 ± 0.877	0.83	1.18
C: D HORIZONTAL	0.893 ± 0.152	0.86	0.93
C: D VERTICAL	0.849 ± 0.142	0.82	0.88
C: D AREA RATIO	0.708 ± 0.239	0.66	0.76
MEAN CUP DEPTH (mm)	0.290 ± 0.134	0.26	0.32
MAX CUP DEPTH (mm)	0.654 ± 0.200	0.61	0.69

Table 2: RNFL Analysis

Parameter	Mean ± S.D	95% CI	
	(µm)	Lower	Upper
SUP	105.28 ± 26.556	99.87	110.69
TEM	61.43 ± 13.789	58.62	64.24
INF	102.09 ± 25.593	96.88	107.31
NAS	75.28 ± 22.350	70.73	79.84

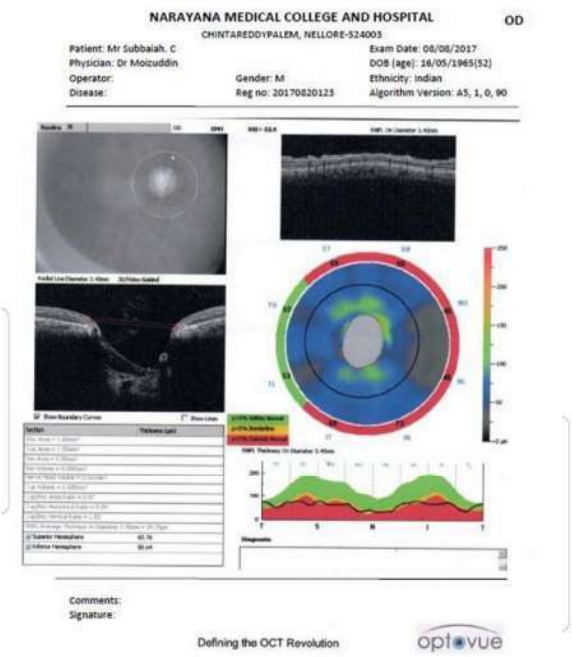

Fig. 2:

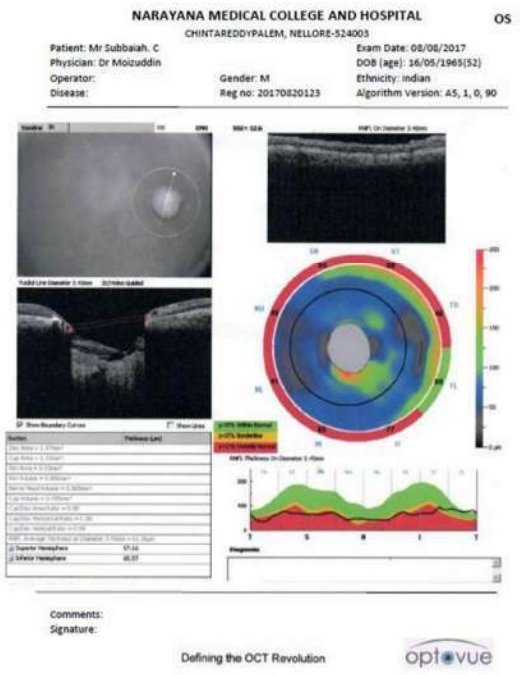

Fig. 3:

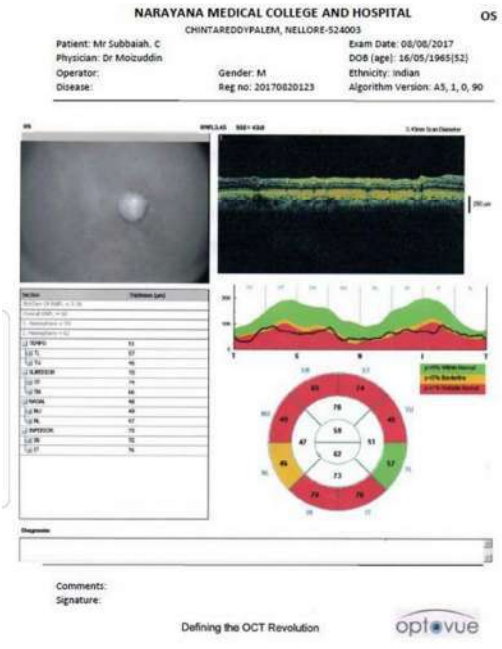

Fig. 4:

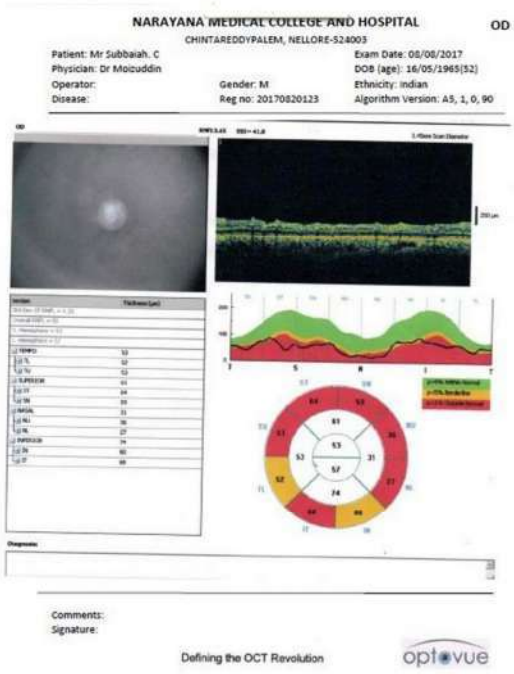

Fig. 5:

Table 3: Correlation between optic nerve head parameters and RNFL thickness

Disc Parameters	RNFL Thickness				
	Superior RNFL	Inferior RNFL	TemporalRNFL	Nasal RNFL	Average RNFL
DA (mm^2)	0.328**	0.387**	0.474**	0.341**	0.441**
CA (mm2)	0.044	0.060	0.296**	0.070	0.112
RA (mm^2)	0.404**	0.486**	0.151	0.436**	0.471**
C/D Ratio	-0.279**	-0.369**	-0.113	-0.295**	-0.336**
C:D Horizontal	-0.292**	-0.214*	-0.160	-0.366**	-0.317**
C:D Vertical	-0.442**	-0.416*	-0.76	-0.340**	-0.418**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

analysed by each quadrant separately. Superior and Inferior thinning was found in most of the patients. Superior RNFL thickness was found to be 105.28 ± 26.55 µm. Inferior RNFL thickness was found to be 102.09 ± 25.593 µm. Temporal RNFL thickness was 61.43±13.789 µm and nasal RNFL thickness was found to be 75.28 ± 22.35 µm. Average RNFL thickness in POAG was 86.02 ± 22.07 µm. (Table 2)

Parameters and RNFLThickness

The disc area was moderately correlated with superior RNFL thickness (r = 0.328), inferior RNFL thickness (r = 0.387), nasal RNFL thickness (r = 0.341) and highly correlated with temporal RNFL thickness (r = 0.474), average RNFL thickness (r = 0.441). The cup area moderately correlates with temporal RNFL thickness (r = 0296). The rim area was moderately correlated with superior RNFL thickness (r = 0.404), nasal RNFL thickness (r = 0.436) and highly correlated with inferior RNFL thickness (r = 0.486), average RNFL thickness (r = 0.471). The CD ratio was moderately correlated with superior RNFL thickness (r = 0.279), nasal RNFL thickness (r = 0.295) and highly correlated with inferior RNFL thickness (r = 0.369), average RNFL thickness (r = 0.336) (Table 3).

Correlation between horizontal C:D, with nasal RNFL, temporal RNFL and vertical C:D with superior RNFL and inferior RNFL was done and found good correlation between vertical C:D with superior RNFL (Table 4,5)

Table 4: Correlation between the vertical C:D and the respective RNFL

RNFL	C:D-V
SUP	-0.442
INF	-0.416

Table 5: Correlation between the horizontal C:D with the respective RNFL

RNFL	C:D-H
NAS	-0.366
TEM	-0.160

Discussion

Glaucoma can impact on the performance of many daily activities like pedestrian walk, car driving, performing house hold activities, reading, assessment of distances and seeing objects coming from sideways there by affecting the productivity of life [11]. Since glaucoma is a disease found most commonly in elderly, it leads to increased risk of road traffic accidents and falls from height [12].

Long follow ups with ophthalmologists, ocular surface discomfort, one of the side effects of glaucoma medication contributes to overall burden [13]. Fear of becoming blind, emotional distress, financial constraints and other health issues make a person feel depressed leading to psychological burden [14]. Other weakening medical, psychological and social constraints may influence patients' visual morbidity. These complex interactions reduce the quality of life. Hence, early detection of glaucoma is very important in clinical management so that visual function and quality of life are preserved [15].

RNFL defects are the earliest detectable parameters in patients of glaucoma and may precede visual field changes by months or years. RNFL thinning is a sensitive indicator for detecting the extent of glaucomatous damage and that RNFL loss precedes measurable optic nerve head (ONH) and visual field (VF) damage approximately six years before any detectable VF defects [16]. Thus, the possibility of detecting these defects in areas

of physiological decreased visibility is enhanced, when Optical Coherence Tomography (OCT) is used. Optic disc and RNFL abnormalities, and their progression, require accurate and objective methods which would facilitate the diagnosis and monitoring of glaucomatous optic neuropathy [16].

In this study , there is direct correlation between the RNFL thickness and the ONH parameters similar to a few studies done previously by Savini G *et al*., Kasumovic S *et al*., [17,18]. There was a study done by Mansoori *et al*., which shows no correlation between the ONH and RNFL parameters [19].

Analysis of the pattern of RNFL defects with SD-OCT imaging have shown that most frequently RNFL defects have been at the infero-temporal meridian followed by the supero-temporal meridian [20] which is in correlation to this study.

RNFL progression analysis can also be performed using OCT. Glaucoma progression algorithms are of two types: event-based and trend-based approaches, similar to visual field progression detection methods. Event-based analysis compares both scans, the present and the previous and shows the difference between them. Trend-based approach using regression analysis data, defines the progression by monitoring the change over time to provide a rate of progression and corresponding significance level [21].

SD-OCT imaging technology is one of the most rapidly evolving and unparalleled new feature which is becoming possible with the help of 3D rendering. Sophisticated techniques and approaches for macular and optic disc evaluation are being investigated. It is most probable that SD-OCT will continue to integrate more accurate and feasible diagnostic strategies which are not currently available. Newer technologies such as swept source OCT, SD-OCT integrated with adaptive optics and polarisation-sensitive SD-OCT are currently under development. We however are hoping to gain a better understanding of the structural status of glaucoma through future use of state-of-the-art technologies [22].

Ongoing improvements in the hardware platforms and software algorithms will help in enhancing our understanding of the structural pathogenesis of glaucoma and offer more objective and accurate detection of structural damage and longitudinal change because of progression. A study done by Medeiros *et al*., demonstrated that algorithms that combine structural and functional measurements will improve the detection of glaucoma progression compared with either method used alone [23].

The limitations of this study being a cross sectional study and progression analysis could not be performed. Progression analysis provides an algorithm in the management that serves to be very helpful for patient education, leading to a good compliance.

Conclusion

Based on the results and the methodology employed, we have concluded that:

The RNFL thickness were well correlated to optic disc parameters.

OCT has been shown to obtain high resolution images and reproducible RNFL retinal thickness measurement.

OCT has shown to have greater diagnostic accuracy in RNFL measurements.

SD-OCT is a substantial objective and structural assessment instrument of recent times becoming a wonder technology that can help ophthalmologists in diagnosing and managing glaucomatous diseases (especially early stages), if used along with serial clinical scans.

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