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Original Article

Ophthalmology Section

Analysis of Retinal Nerve Fibre Layer and Optic Nerve Head by Optical Coherence Tomography in POAG

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ABSTRACT

Introduction: Glaucoma is the second leading cause of blindness. Early identification of disease is important, as treatment can slow the disease progression and preserve vision.

Aim: The purpose of our study was to evaluate the Retinal Nerve Fibre Layer (RNFL) and Optic nerve head (ONH) using Optical Coherence Tomography (OCT) in primary open angle glaucoma (POAG) and to determine if any correlation exists between the two.

Materials and Methods: In a Cross-sectional study including, 73 eyes of 39 patients with POAG, aged 40 years and above, we evaluated retinal nerve fiber layer (RNFL) and optic nerve head (ONH) changes using optical coherence tomography (OCT). The statistical analysis was done using Epi Info software.

Results: The mean age was 62.82±9.78 years and IOP was 24.25±3.685 mmHg. Mean thickness of RNFL was 101.67±25.8µm, 60.21±14.02µm, 98.67±25.10µm, 72.44±21.914µm of superior, temporal, inferior and nasal quadrants respectively. The ONH parameters and the RNFL thickness were quantified and analyzed. It was found that most of the patients had more thinning in the superior and inferior quadrants. Superior RNFL and the vertical ONH parameters showed best correlation (-0.439, p-value 0.005).

Conclusion: SD-OCT is a powerful objective and structural assessment tool in diagnosing and managing glaucoma and hence should be a part of routine glaucoma evaluation. Correlation of ONH topography with RNFL thickness may be of value in patients with suspicious disc picture. Superior quadrant of the RNFL was found to be the most reliable parameter in primary open angle glaucoma.

Keywords: Cup disc ratio, Disc area, Glaucoma, Peripapillary nerve fiber thickness

INTRODUCTION

Glaucoma is an optic neuropathy characterized by progressive loss of retinal ganglion cells and optic nerve damage resulting in visual field loss and eventual blindness [1]. It is the second leading cause of blindness worldwide. In India the burden is estimated about 11.2 million in adult population [2].

Early diagnosis and appropriate intervention can delay the natural history of the disease. Retinal function can be measured with psychophysical techniques such as standard automated perimetry, short-wavelength automated perimetry, and frequency-doubling technology, but more than 1/3rd of axonal damage would have already occurred before it is detected by perimetry [3].

A tool that detects axonal damage before functional deficit is manifested (i.e. pre-perimetric damage) is of immense value in glaucoma. Spectral Domain Optical Coherence Tomography (SD-OCT) based on Michaelson interferometry provides high-resolution images of the retinal nerve fiber layer (RNFL) [4]. The images of the RNFL and optic nerve head (ONH) obtained by OCT are proving to be invaluable in diagnosis and management of primary open angle glaucoma (POAG).

However, there is as yet no clear consensus on the correlation between ONH and RNFL, both of which are affected in the disease [5]. We have evaluated the RNFL and ONH parameters in known POAG patients to determine possible correlation between them.

MATERIALS AND METHODS

This cross-sectional study was conducted in Mahatma Gandhi Medical College and Research Institute, Pondicherry, from January 2014 to June 2015 for a period of 18 months. Institutional human ethical committee approval was obtained. All patients diagnosed as POAG, above the age of 40 years were included in the study. Patients with uveitis, secondary glaucoma, high myopia, retinal pathologies and media opacities causing difficulty in performing the OCT were excluded from the study. Following routine clinical examination, RNFL and ONH images were obtained on Optos® SD-OCT (Spectral Domain – Optical Coherence Tomography).

RNFL thickness was measured with a 3.4mm diameter rim placed around the optic nerve. The software tracks the position of the RNFL OCT scan and its position in relation to the optic nerve. The RNFL thickness map is displayed along with colour coding for easy understanding. For ONH analysis, optic nerve topography mode was used. A 3D tomographic image of the optic nerve was generated from a stack of sequential OCT and confocal SLO images. An in-built software analyzed the data in the machine and a report was created on: disc area, cup area, rim area, cup/disc area, mean cup depth and maximum cup depth. The measurements were compared to set parameters in the normative database. To be acceptable for inclusion the signal strength was taken into consideration. OCT scans, with signal strength (signal noise ratio – SNR) of >6 were included.The statistical analysis was done using Epi Info software. Mean and standard deviation (SD) values with 95% confidence intervals were calculated for all RNFL and ONH parameters. Pearson's correlation was applied to determine correlation between RNFL thickness and ONH parameters. p-value of <0.05 was considered statistically significant for the study.

RESULTS

73 eyes of 39 patients (23 males and 16 females) above 40 years of age with POAG were included in the study. The mean age was 62.82±9.78 years. The mean IOP was 24.25±3.69 mm of Hg and the mean CCT was 566±2.1µ and SNR was 6.8.

RNFL thickness of all the patients were analyzed for each quadrant separately. Most of the patients had more thinning in the superior and inferior quadrants [Table/Fig-1]. ONH parameters include disc area, cup area, rim area, horizontal C:D, vertical C:D, C:D area ratio, mean cup depth and maximum cup depth [Table/Fig-2]. The mean RNFL thickness of all the quadrants showed a statistically significant correlation with the ONH parameters of which superior quadrant showing the best correlation [Table/Fig-3 and 4].

Parameter	Mean±SD	95% CI
SUP	101.67±25.81 µ	95.65 – 107.69
TEM	60.21 ± 14.02 µ	56.93 – 63.48
INF	98.67 ± 25.10 µ	92.81 – 104.53
NAS	72.44 ± 21.91µ	67.33 – 77.55

[Table/Fig-1]: RNFL Analysis.
*SUP –Superior, TEM – Temporal, INF – Inferior, NAS- Nasal, CI – Confidence Interval.

Parameter	Mean±SD	95% CI
Disc Area (mm^2)	3.153 ± 1.171	2.872 – 3.421
Cup Area (mm^2)	2.312 ± 1.102	2.062 -2.573
Rim Area (mm^2)	0.890 ± 0.817	0.699 – 1.081
C:D Horizontal	0.892 ± 0.157	0.855 -0.929
C:D Vertical	0.857 ± 0.147	0.822 -0.890
C:D Area Ratio	0.724 ± 0.241	0.668 – 0.780
Mean Cup Depth (mm)	0.256 ± 0.142	0.263 – 0.329
Max Cup Depth (mm)	0.640 ± 0.201	0.593 – 0.687

[Table/Fig-2]: ONH analysis.
*SUP –Superior, TEM – Temporal, INF – Inferior, NAS- Nasal, CI – Confidence Interval.

RNFL	C : D VERTICAL
Superior	r = -0.43 p – value – 0.005
Inferior	r = -0.385 p – value – 0.001

[Table/Fig-3]: Correlation between the superior and inferior quadrants of RNFL with the vertical C:D.
* RNFL – Retinal nerve fiber layer, SUP – Superior, INF – Inferior, C:D – Cup Disc ratio.

RNFL	C:D HORIZONTAL
Nasal	r = -0.31 p – value =0.006
Temporal	r = -0.21 p- value – 0.036

[Table/Fig-4]: Correlation between the nasal and temporal quadrants of RNFL with the horizontal C:D.
* RNFL – Retinal nerve fiber layer, NAS – Nasal, TEM – Temporal, C:D – Cup Disc ratio.

DISCUSSION

OCT has now become almost a mandatory tool for diagnosis and follow-up of POAG. The instrument measures various parameters in the optic disc and also compares the patient's values with normative database available. Traditional description of increased cup disc ratio (C:D), vertically oval cup favors ONH topography as an important parameter. Ganglion cell loss, the primary event in glaucomatous damage is better reflected in RNFL thickness [6]. There is a wide normative variation in ONH topography [7]. This coupled with observations of RNFL thinning prior to perimetric defects argues in favor of RNFL thickness as the better suited parameter in glaucoma detection [8].

RNFL thickness is measured by a circular scan of 3.4mm diameter placed concentric to the disc. Because this is a fixed size ring, the distance from the disc where RNFL thickness is measured would vary with disc diameter [8]. Further studies revealed an increased optic nerve fiber count in larger size discs [9]. A smaller disc size would register a thinner RNFL either due to anatomically lesser optic nerve fiber count or due to greater distance of measurement from the disc, increases the chances of being falsely diagnosed as glaucoma. Similarly, in a larger disc, with thicker RNFL, early loss is likely to be missed as this would still be within the normal curve. Also age related thinning of RNFL in the presence of normal ONH morphology cautions against diagnosis of POAG based only on RNFL curve [5].

Disc area ranging from 1.8 to 5.3 mm^2; we used a fixed ring size in proven glaucomatous eyes. Mansoori et al., observed an inverse correlation between RNFL thickness and C:D in all quadrants in a study of normal eyes [10]. In this study of glaucomatous eyes we observed a similar relationship, which was most for superior RNFL thickness and vertical C:D, similar to a study done by Khanal et al., [11]. Few previous studies suggest that, thinning in the inferior quadrant being more sensitive measure in open angle glaucoma [12-14]. In our study both the inferior and superior quadrants correlated well with the vertical C:D, but superior being the most sensitive.

Though measuring the RNFL thickness provides information regarding the extent of glaucomatous damage, it has to be correlated clinically for deciding the best management. Hence, SD- OCT plays a key role in the management of open angle glaucoma.

LIMITATION

A larger sample size would have been of value in determining the role of age as a confounding factor in RNFL thickness.

CONCLUSION

SD-OCT is a powerful non-invasive objective and structural assessment tool in diagnosing and managing glaucoma hence should be a part of routine glaucoma evaluation. It is not prudent to diagnose glaucoma by RNFL thickness curve. It is inarguably an excellent tool in follow up of glaucoma progression. Correlation of ONH topography with superior RNFL thickness may be of value in patients with suspicious disc picture. Superior quadrant of the RNFL was found to be the most reliable parameter in primary open angle glaucoma.

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