Correlation Between Average Retinal Nerve Fiber Layer Thickness and Rim Area of the Spectral-Domain OCT with the Humphrey Visual Field Index in Eyes with Glaucoma

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ABSTRACT

Objective: To determine the correlation between the average retinal nerve fiber layer (RNFL) thickness and optic nerve head rim area (RA) measured with a spectral-domain optical coherence tomography (OCT) with the visual field index (VFI) using the Humphrey Visual Field Analyzer in glaucoma patients.

Methods: Eighty-five consecutive patients diagnosed with glaucoma underwent spectral-domain OCT of the optic disc and Humphrey perimetry. A glaucoma specialist confirmed the presence of glaucomatous optic neuropathy based on findings in the optic nerve head photographs, OCT measurements of the RNFL and optic disc, and standard automated perimetry. The correlation of the average RNFL thickness and rim area with the VFI was determined using the Spearman's correlation coefficient analysis.

Results: A total of 121 glaucomatous eyes of 85 patients were included in the study. There were 47 males and 38 females, ages ranging from 12 to 94 years. The average RNFL thickness, RA, and VFI were 67.9 ± 12.3 μm, 0.65 ± 0.3 mm^2, and 56 ± 32%, respectively. The average RNFL thickness ($r = 0.35$) showed a stronger positive correlation with VFI than RA ($r = 0.15$), but the difference was not statistically significant.

Conclusion: The average RNFL thickness and rim area of the spectral-domain OCT demonstrated a positive correlation with the VFI of the Humphrey Visual Field Analyzer. The OCT parameters, exemplified by average RNFL and RA, were not good indicators for VFI.

Keywords: Optical coherence tomography, Spectral-domain OCT, Cirrus OCT, Average peripapillary RNFL thickness, Rim area, Glaucoma, Visual field index

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Glaucoma is the leading cause of irreversible blindness worldwide. In 2010, there were 60.5 million people affected by glaucoma, and this will increase to 79.6 million by year 2020.[1] Glaucoma is a progressive disease characterized by optic nerve head damage, peripapillary retinal nerve fiber layer (RNFL) loss, and characteristic visual field defects.

Detection and monitoring of glaucoma patients is based on recognition of structural and functional changes.[2-4] The spectral-domain optical coherence tomography (OCT) is currently being used in the diagnosis and assessment of structural changes in glaucomatous eyes. It quantitatively measures the thickness of the peripapillary retinal nerve fiber layer and the optic nerve head (ONH) rim area (RA). The global indices for this examination are the average RNFL thickness and rim area.

The Humphrey Visual Field Index (VFI) is a relatively new global perimetric index that assesses the overall integrity of the visual field expressed as a percent of a normal age-adjusted visual field.[5-6] In patients with advanced glaucoma, functional tests may not be reliable, with some patients unable to do visual field testing. Hence, there is a need for other indices to monitor the disease.

In this study, we established the correlation of the OCT parameters; namely, average RNFL thickness and rim area value, with the visual field index of the Humphrey Visual Field Analyzer.

METHODOLOGY

This was a cross-sectional study involving patients who underwent spectral-domain OCT of the optic nerve and Humphrey perimetry from January 2011 to October 2012 at the International Eye Institute, St. Luke's Medical Center - Global City. Their medical records were retrieved and eyes diagnosed with glaucomatous optic neuropathy based on stereoscopic optic nerve head photographs, Cirrus spectral domain OCT RNFL and ONH measurements, and Humphrey standard automated perimetry were included in the study.

Eyes without glaucomatous optic neuropathy or with other types of optic neuropathy; inadequate signal strength of 5/10 or below on spectral domain OCT imaging; high false positive (>33%), high false negative responses (>33%), and high fixation loss (>33%) on Humphrey visual field test; and patients with visual acuity of <20/200 who were unable to undergo standard automated perimetry were excluded.

Each patient underwent eye examinations consisting of standard automated perimetry (Humphrey Field Analyzer, Carl Zeiss Meditec, Dublin CA) using the 30-2 SITA standard strategy, optical coherence tomography (Cirrus OCT, Carl Zeiss Meditec, Dublin, CA) using the RNFL and ONH:Optic Disc Cube 200x200 protocol, and optic nerve head photography using a Zeiss fundus camera and VISUPAC system. A glaucoma specialist independently interpreted all examination results based on glaucomatous optic nerve head changes and RNFL thinning on OCT, with corresponding functional changes in perimetry.

Statistical Analysis

The average peripapillary RNFL thickness, optic nerve head rim area, and visual field index (VFI) of each eye were collated. The relationship between the average RNFL thickness and VFI, and optic nerve head rim area and VFI were analyzed using Spearman's correlation coefficient, with a positive correlation being a value greater than 0. The Fisher r-to-z transformation was used to assess the significance of the difference between the two correlation coefficients. A value of $p \leq 0.05$ was considered statistically significant.

RESULTS

A total of 121 eyes of 85 glaucoma patients were included for analyses. The mean age of the patients was 63.7 ± 16.6 years, ranging from 12 to 94 years. 55.3% were male (n = 47) and 44.7% were female (n = 38).

The mean average peripapillary RNFL thickness was 85.6 ± 5.7μm, ranging from 46 to 111μm. The highest average peripapillary RNFL thickness (111μm) was observed in a 31-year-old male, and the thinnest (46μm) in a 58-year-old male. The mean average RNFL thickness was similar for males and females (67.4 ± 13.6μm vs 68.6 ± 10.4μm; p = 0.58). The optic nerve head rim area ranged from 0.18 to 1.94 mm^2 with a mean of 0.646 ± 0.3 mm^2. The mean rim area was similar for males and females (0.64 ± 0.29 mm^2 vs. 0.65 ± 0.25 mm^2, p = 0.92). The largest rim area

(1.94 mm^2) was observed in a 53-year-old male and the thinnest (0.18 mm^2) in a 74-year-old female. The visual field index ranged from 0 to 98% with a mean of 56 ± 32%. The mean VFI was significantly higher in females than in males (65 ± 30% vs 48 ± 32%; p = 0.03). The highest VFI (98%) was observed in a 58-year-old female and the lowest (0%) was observed in five different males.

Scatter plot showing the relationship between the average peripapillary RNFL thickness and VFI and the optic nerve head rim area with VFI are shown in Figures 1 and 2. A direct linear correlation was found for the average RNFL thickness and VFI (r = 0.35), and for the rim area and VFI (r = 0.15). The average RNFL thickness showed a greater correlation with the VFI than the rim area; however, this was not statistically significant (p = 0.10).

Of the 121 eyes tested, 30.5% (n = 37) had VFI between 0 and 33%, 22.3% (n = 27) between 34 and 66%, and 47.1% (n = 57) between 67 and 100%. Using Spearman's correlation coefficient, a positive correlation was established between RNFL thickness and VFI (r = 0.34), and between rim area and VFI (r = 0.02) in eyes with VFI values of 0-33% (Table 1). Although the RNFL thickness showed higher correlation coefficient with VFI than the rim area, the difference was not statistically significant (p = 0.16). A positive correlation was also established for the RNFL thickness and rim area with VFI in the 34-66% and 67-100% subgroups (Table 1). The difference between the 2 groups was also not statistically significant (p > 0.05).

Table 1. Spearman's correlation coefficient analyses of RNFL and rim area in the different VFI subgroups.

VFI (%)	RNFL Correlation Coefficient (r)	Rim Area Correlation Coefficient (r)
0-33 (n=37)	0.338	0.015
34-66 (n=27)	0.247	0.050
67-100 (n=57)	0.319	0.339

DISCUSSION

The results from this study showed that in patients with glaucoma, the average RNFL thickness and the optic nerve head rim area obtained from the spectral-domain OCT demonstrated weak positive correlations with the visual field index obtained from standard automated perimetry of the Humphrey Visual Field Analyzer (Figures 1 and 2), similar to the findings of Sehi et al.[7] This indicates a weak structure-function relationship. Nilforushan et al[8] reported a higher correlation of rim area with VF thresholds compared to the RNFL. Our study, however, showed that the average RNFL thickness had a greater correlation with VFI than optic nerve head rim area, but it was not statistically significant (p >0.05).

Though this study showed that, over-all, there was a correlation between the average RNFL thickness and rim area with the VFI, the correlation was not high. This was true especially for eyes with more significant visual field loss; in those with VFI of 0-33%, the Spearman's correlation coefficient was 0.34 and 0.02 for average RNFL thickness and rim area respectively. In earlier stages of glaucoma, the average RNFL thickness and rim area showed the highest correlation (r = 0.32 and 0.34 respectively), indicating that the OCT best predicts the VFI in earlier stages of the disease.

The limitation of this study was the relatively small sample that included glaucomatous eyes. Moreover,

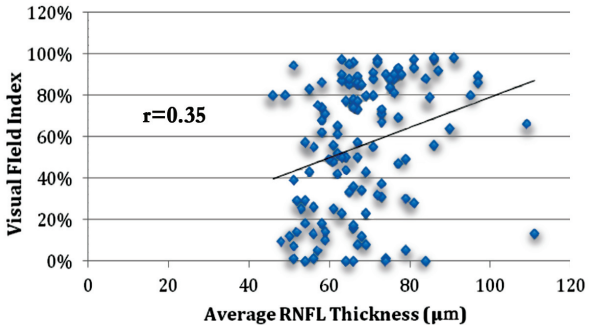

Figure 1. Scatterplot of the average RNFL thickness vs. visual field index in glaucomatous eyes.

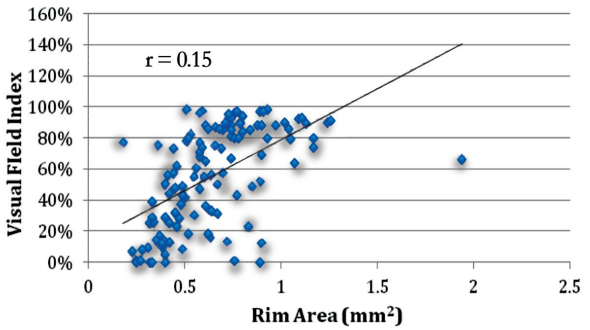

Figure 2. Scatterplot of the rim area vs. visual field index in glaucomatous eyes.

eyes with different co-morbidities that may decrease the VFI were also not excluded in this study. Further prospective studies involving non-glaucomatous and glaucoma suspects can be used as comparison groups. Other parameters, such as the cup-to-disc ratio and Hoddap classification, can be studied to further divide the eyes into subgroups.

In conclusion, the average peripapillary RNFL thickness and optic nerve head rim area measured by the spectral-domain OCT have positive correlations with the standard automated perimetry visual field index of the Humphrey Visual Field Analyzer. These OCT parameters are weak indicators for VFI, indicating weak structure-function relationships in many cases of glaucoma.

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