The Relationship between Optical Coherence Tomography and Scanning Laser Polarimetry Measurements in Glaucoma

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Purpose: To investigate the relationship between optical coherence tomography (OCT) and scanning laser polarimetry (SLP) in measuring peripapillary retinal nerve fiber layer (RNFL) thickness in glaucomatous eyes.
Methods: Fifty glaucomatous eyes were evaluated in this study. Evaluations were analyzed two ways. First, parameters of the Stratus OCT (average thickness, superior/ inferior average) and GDx VCC (TSNIT average, nerve fiber indicator (NFI), superior/ inferior average) were correlated using the Pearson's correlation coefficient (r). Secondly, comparison (r) of these parameters was completed using the mean deviation (MD) of visual field defect.
Results: The following parameters were found to be significantly correlated (P<0.005). TSNIT average / average thickness (r=0.673), NFI/average thickness (r=-0.742), superior average (r=0.841), and inferior average (r=0.736). In the correlation analysis using the severity of visual field defect, all these parameters had statistically meaningful correlations (P<0.005).
Conclusions: GDx VCC and Stratus OCT are highly correlated in glaucomatous eyes. Therefore, peripapillary RNFL thickness measured by Stratus OCT and GDx VCC may be equally helpful in the diagnosis of glaucoma. *Korean Journal of Ophthalmology 20(4):225-229, 2006*

Key Words: GDx VCC, Glaucoma, OCT, Retinal nerve fiber layer thickness

Glaucoma is optic neuropathy with the loss of retinal ganglion cells (RGC) and their axons.[1,2] The loss of RGC axons may be structurally apparent as a localized and/or diffused thinning of the retinal nerve fiber layer (RNFL).[2-5] Optical coherence tomography (OCT) and scanning laser polarimetry (SLP) are two imaging technologies designed to measure peripapillary RNFL thickness. With OCT (Stratus OCT; Carl Zeiss Meditec, Dublin, California, USA), scanning interferometry is used to obtain a cross section of the retina based on the reflectivity of the different layers of the retina.[6-8] A high reflectance layer located just under the inner surface of the retina corresponding to the RNFL is measured with a computer algorithm to determine RNFL thickness.[8] The GDx VCC (Laser Diagnostic Technology, San Diego, California, USA) , the latest version of SLP, is equipped with a variable corneal compensator and estimates the thickness of the RNFL by measuring the summed retardation of a polarized scanning laser beam, induced by form-birefringent microtubules supporting the RGC axons.[9-11] Despite previous studies' demonstration of relatively high diagnostic accuracy in detection of glaucoma with OCT and GDx VCC,[12-18] it is not known whether the measurements of Stratus OCT and GDx VCC have any correlation at all.

The purpose of this study was to investigate the relationship between Stratus OCT and GDx VCC peripapillary RNFL measurements in glaucoma. According to the severity of visual field defect, the relationship of these measurements will be evaluated.

Materials and Methods

Glaucomatous eyes of 50 different patients meeting the eligibility criteria were included in this prospective study. Eligibility criteria included reproducible glaucomatous visual field defect,[19] and glaucomatous appearance of the optic disc regardless of intraocular pressure. A glaucomatous optic disc was defined as cup:disc asymmetry between the eyes that was greater than or equal to 0.2, rim thinning, notching, excavation, or RNFL defect. Informed consent was obtained from each subject. All patients underwent complete ophthalmic examination, including slit-lamp biomicroscopy (stereoscopic

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examination of optic disc), gonioscopy, Goldmann applanation tonometry, achromatic automated perimetry (Humphrey field analyzer [HFA]II, central 24-2 Full-Threshold strategy; Carl Zeiss Meditec, Dublin, CA, USA), GDx VCC imaging, and Stratus OCT imaging. One eye of each subject was used for the study. If both of the patient's eyes met the eligibility criteria, one eye was randomly selected. According to the mean deviation (MD) of HFA, three arbitrary criteria of visual field defect were classified as early 「no worse than -6 decibel (dB)」, moderate (worse than -6 dB but no worse than -12 dB), and severe (worse than -12 dB).[20] All subjects had visual acuity of 20/40 or better. Patients with any significant coexisting ocular disease, including posterior segment eye disease and corneal disease, or systemic diseases with possible ocular involvement, such as diabetes mellitus, were excluded.

OCT imaging (Stratus OCT, software 3.0; Carl Zeiss Meditec, Dublin, California, USA) of the peripapillary RNFL was performed using three 360-degree circular high resolution scans with a diameter of 3.4 mm centered on the optic disc (Fast RNFL scan). The mean of the three RNFL thickness measurements was used for the study. The thickness of average and superior/inferior quadrants was obtained.

GDx VCC imaging (Laser Diagnostic Technology, San Diego, California, USA) was performed using a scan circle of 3.2 mm diameter centered on the optic disc, and the mean of three measurements was used. TSNIT average, nerve fiber indicator (NFI), and superior/inferior averages were obtained. For statistical analysis, Pearson's correlation coefficient (r) was calculated for each set of parameters, and P value of less than or equal to 0.005 were considered statistically significant.

Results

Fifty glaucomatous eyes of 50 patients were enrolled in this study (27 males, 23 females). Patient age range was 22± 84 years of age with a mean age of 54.70±14.68 years. The study included 31 cases of normal tension glaucoma (NTG), 11 primary open angle glaucoma (POAG), 5 secondary open-angle glaucoma (SOAG) and 3 primary angle -closure glaucoma (PACG). All glaucomatous eyes had visual field loss of -10.04±6.66 dB mean deviation and 7.49±3.19 corrected pattern standard deviation (Table 1).

Table 1. Subject characteristics (n=50)

Age (yrs) (range)	54.70±14.68 (22-84)
Gender (Male : Female)	27 : 23
Refraction (D)	-0.35±2.35
Type of glaucoma	
POAG	11
NTG	31
SOAG	5
PACG	3
Visual field (HFA)	
MD (dB)	-10.04±6.66
CPSD	7.49±3.19

POAG: primary open angle glaucoma, NTG: normal tension glaucoma, SOAG: secondary open angle glaucoma, PACG: primary angle closure glaucoma, HFA: humphrey field analyzer, MD: mean deviation, CPSD: corrected pattern standard deviation.

Measured parameters of peripapillary RNFL using GDX VCC were 42.37±5.62 μm TSNIT average, 50.72±18.66 nerve fiber indicator (NFI), 50.62±9.53 μm superior average, and 45.41±8.51 μm inferior average. Using the Stratus OCT, measured parameters were 74.18±13.32 μm average thickness, 89.50±20.10 μm superior average, and 82.50±22.56 μm inferior average (Table 2).

The relationships between GDx VCC and Stratus OCT parameters are graphically represented in Figs. 1, 2, 3, and 4. Statistically significant correlations were observed in each parameter (P<0.005). Pearson coefficients were as follows: 0.673 for TSNIT average/average thickness (Fig. 1), -0.742 for NFI/average thickness (Fig. 2), 0.841 for superior average (Fig. 3), and 0.736 for inferior average (Fig. 4). All parameters had positive correlations except for the NFI because NFI has a higher positive value in glaucoma.

Patients were divided into early, moderate, and severe glaucoma according to the severity of the visual field defect (Table 3). Early glaucoma (15 eyes) had -3.82±1.38 dB for MD whereas moderate glaucoma (20 eyes) had -8.81±1.96 dB and severe glaucoma (15 eyes) had -17.90±6.21 dB.

Table 2. Parameter measurements of GDx VCC and Stratus OCT

	Parameter	Value (mean±SD)
GDx VCC	TSNIT Average (μm)	42.37±5.62
	NFI	50.72±18.66
	Superior Average (μm)	50.62±9.53
	Inferior Average (μm)	45.41±8.51
Stratus OCT	Average Thickness (μm)	74.18±13.32
	Superior Average (μm)	89.50±20.10
	Inferior Average (μm)	82.50±22.56

NFI: nerve fiber indicator.

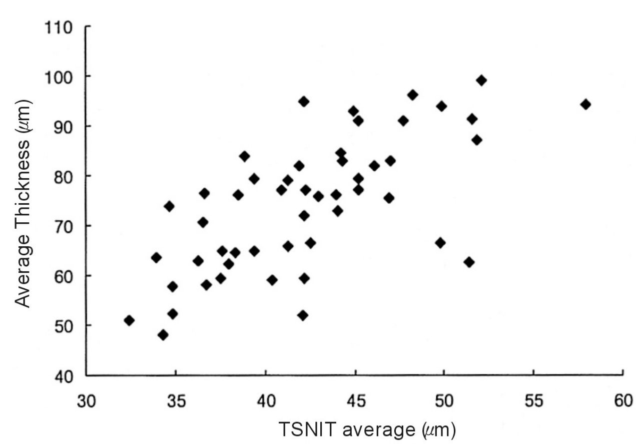

Fig. 1. Scatterplot of TSNIT average versus average thickness.

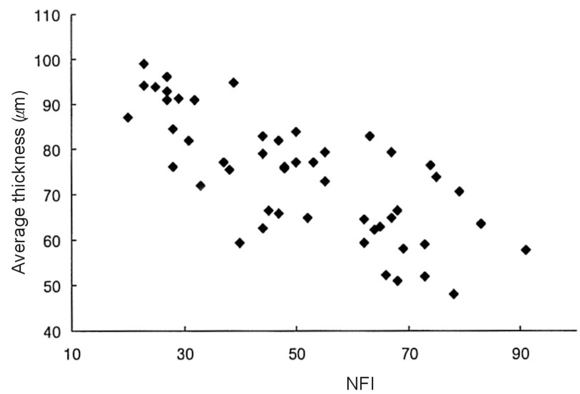

Fig. 2. Scatterplot of NFI (Nerve fiber indicator) versus average thickness.

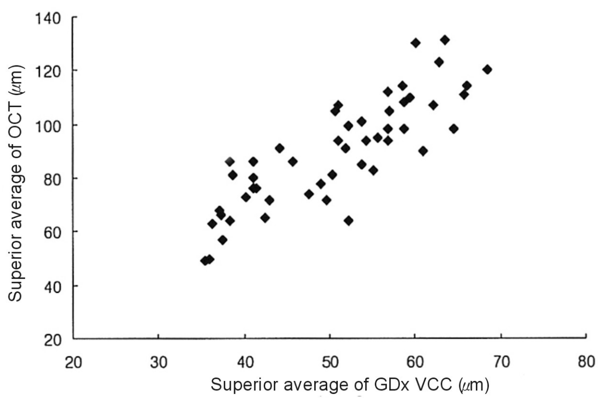

Fig. 3. Scatterplot of superior averages.

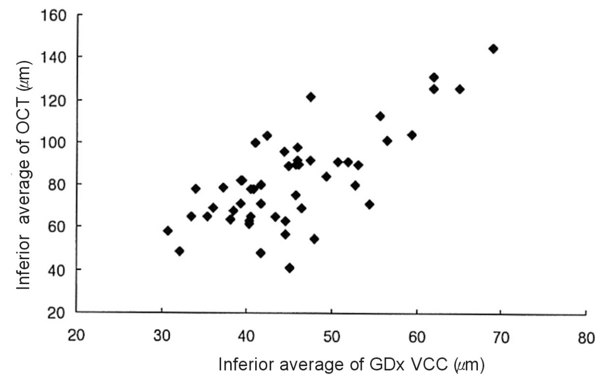

Fig. 4. Scatterplot of inferior averages.

Table 3. Subcriteria of patients according to the visual field defect

	No.	Value (mean±SD)*
Early (-6 dB ≤MD)	15	-3.82±1.38
Moderate (-12 dB≤MD<-6 dB)	20	-8.81±1.96
Severe (MD<-12 MD)	15	-17.90±6.21

*ANOVA test, P<0.05.
MD: mean deviation.

Table 4. Relationship of GDx VCC and OCT in early glaucoma

	TSNIT Average / Average Thickness	NFI / Average Thickness	Superior Average	Inferior Average
r	0.778*	-0.658*	0.855*	0.870*

*P<0.005
r: Pearson's correlation coefficient.

Table 5. Relationship of GDx VCC and OCT in moderate glaucoma

	TSNIT Average / Average Thickness	NFI / Average Thickness	Superior Average	Inferior Average
r	0.759*	-0.741*	0.778*	0.742*

*P<0.005
r: Pearson's correlation coefficient.

Table 6. Relationship of GDx VCC and OCT in severe glaucoma

	TSNIT Average / Average Thickness	NFI / Average Thickness	Superior Average	Inferior Average
R	0.526*	-0.829*	0.902*	0.850*

*P<0.005
r: Pearson's correlation coefficient.

Results of the relationship between GDx VCC and Stratus OCT in all three groups are presented in Tables 4, 5, and 6. GDx VCC and Stratus OCT remained significantly correlated with each other in each glaucoma group (P<0.005).

Discussion

Previous histomorphometric assessments of peripapillary RNFL thickness in human eyes give mean thicknesses of 215 and 367 μm.[21,22] There are currently two different imaging modalities designed to analyze peripapillary RNFL thickness, and the Stratus OCT and GDx VCC are the two latest commercially available models. Many studies have found relatively high diagnostic accuracy in glaucoma detection with GDx VCC and OCT.[12-18] The use of these devices has been especially helpful in the documentation of glaucomatous changes and could potentially aid in the clinical management of glaucoma.

Previously, most studies concentrated on either GDx VCC or OCT, and only a few studies actually compared GDx VCC versus OCT in glaucoma. Greaney et al.[23] compared OCT1 with the GDx fixed corneal compensator (earlier version of SLP) for the discrimination of glaucoma. The study found that OCT1 measurements of RNFL thickness were significantly inferior to GDx RNFL thickness in the discrimination of glaucoma, whereas a combination of these imaging methods significantly improved discriminability. Bagga et al.[24] demonstrated that GDx VCC had a high correlation with visual function and RNFL thickness as assessed by OCT1. Recently, Leung et al.[25] reported that the total average RNFL thickness measured with Stratus OCT and GDx VCC were highly correlated (r=0.852) and that measurements of Stratus OCT and GDx VCC RNFL were significantly correlated.

Our study showed that parameters of GDx VCC and Stratus OCT were significantly correlated with each other. Correlation coefficients (r) were 0.673 for TSNIT average /average thickness, -0.742 for NFI/average thickness, 0.841 for superior average, and 0.736 for inferior average. Notably, higher correlations were observed in NFI/average thickness and superior average. The NFI, which is a global measure of focal and diffused retinal nerve fiber layer loss using neural networks, discriminated well between normal and glaucoma among parameters.[26] Kanamori et al.[27] found that the average thickness in OCT parameters had the strongest correlation with the visual field defect. The strongest correlation was between NFI and average thickness, which might be meaningful. Because the nasal and temporal quadrants have been reported to have higher variability in the OCT and SLP RNFL measurements,[28-31] we exclude them in this study.

Sixty percent of patients with ocular hypertension had evidence of retinal nerve fiber layer loss occurring up to six years before a detectable change in standard automated perimetry.[32] Reus and Lemij[33] reported patients with mild to moderate visual field loss in glaucoma may be better monitored with GDx VCC and patients who have severe visual field loss in glaucoma with standard automated perimetry. We wanted to examine the relationship between GDx VCC and Stratus OCT in eyes with early, moderate, and severe glaucomatous visual field defects. In this study, the correlation between GDx VCC and Stratus OCT was statistically significant in all three visual field defect groups. However, we could not find well-ordered relationships with respect to the amount of visual field defect. In the NFI/ average thickness comparison, correlations were strongest in eyes with severe field defects (r=-0.829) rather than early (r =-0.658) or moderate (r=-0.741) field defects. Superior and inferior comparisons had very high correlations (r=0.855, 0.870 respectively) in early glaucomatous field defect.

In conclusion, our results demonstrate that the measurements of GDx VCC and Stratus OCT are strongly correlated with each other in perimetric glaucoma, and that this relationship remains, regardless of the degree of glaucomatous visual field defect. In further study, correlations should be examined in preperimetric glaucoma.

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