Evaluation of Macular Thickness Measurements for Detection of Band Atrophy of the Optic Nerve Using Optical Coherence Tomography

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Purpose: To evaluate the ability of optical coherence tomography (OCT) macular thickness parameters to differentiate between eyes with band atrophy (BA) of the optic nerve and healthy eyes.

Design: Cross-sectional study.

Participants: The study included 1 eye of each of 40 consecutive patients with BA of the optic nerve and permanent temporal hemianopic visual field (VF) defects owing to chiasmal compression and 31 age- and gender-matched healthy subjects.

Methods: All patients underwent VF assessment with kinetic Goldmann perimetry and Humphrey 24-2 full-threshold standard automated perimetry (SAP). Macular and retinal nerve fiber layer (RNFL) thickness scans were obtained using the commercially available Stratus OCT. The severity of VF defect in patients with BA was evaluated by the temporal mean defect (TMD), calculated as the average of the 22 values of the temporal total deviation plot of the SAP 24-2 test, excluding the 2 points immediately above and below the blind spot.

Main Outcome Measures: Receiver operating characteristic (ROC) curves and sensitivities at fixed specificities were calculated for each parameter. Spearman's rank correlation coefficients were used to evaluate the relationship between RNFL and macular thickness parameters and severity of VF loss as measured by the TMD.

Results: The macular thickness parameters related to the nasal hemiretina had the best performance to detect damage in BA eyes. No statistically significant difference ($P = 0.19$) was found between the ROC curve areas (AUCs) for the best macular thickness parameter (temporal/nasal macular thickness, AUC = 0.96) and the best RNFL parameter (average thickness, AUC = 0.99). Lower values of TMD, indicating more severe VF loss, were associated with lower macular thickness measurements. The highest correlation was observed for the parameter nasal average macular thickness ($\rho = 0.693$, $R^2 = 48\%$, $P<0.001$).

Conclusion: Eyes with BA of the optic nerve show significant thinning of the retinal thickness on the nasal macular area, which is associated with the severity of VF damage in these eyes. Macular thickness measurements could potentially be used to evaluate the amount of ganglion cell loss in patients with BA of the optic nerve and could prove clinically useful for detection of damage and for monitoring these patients. *Ophthalmology 2007;114:175–181 © 2007 by the American Academy of Ophthalmology.*

Optical coherence tomography (OCT) is a recently developed technology that uses near infrared light to produce cross-sectional images of the retinal structures from which estimates of thickness of the retinal layers can be made.[1] The ability of OCT to provide quantitative and reproducible measurements of the retinal nerve fiber layer (RNFL) has been evaluated in experimental and clinical studies.[2–7] We recently demonstrated that OCT is able to detect RNFL loss in patients with lesions of the optic chiasm.[8,9] In these patients, the crossed nerve fibers originating in the nasal hemiretina are lost, with preservation of the uncrossed fibers, which originate in the temporal hemiretina and penetrate the optic nerve through the superior and inferior arcuate fiber bundles. Therefore, RNFL loss occurs predominantly on the nasal and temporal sides of the optic disc, a pattern that can be identified on ophthalmoscopy as band atrophy (BA) of the optic nerve. This characteristic pattern of RNFL and ganglion cell loss in patients with optic chiasm compression may serve as a model to evaluate the ability of any instrument to accurately measure these structures.

Although OCT has been used, for the most part, to evaluate RNFL thickness, recent software improvements have made it possible to measure macular thickness as well.

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As the ganglion cell layer accounts for up to 40% of the thickness in the macular area, estimates of macular thickness could be used to investigate possible ganglion cell loss. In fact, previous studies have shown that OCT macular thickness measurements are significantly smaller in glaucomatous compared with healthy eyes.[10–13] However, no study has yet evaluated the role of macular thickness measurements in other conditions associated with ganglion cell loss, such as BA of the optic nerve.

The purpose of this study was to evaluate the ability of OCT macular thickness measurements to differentiate eyes with BA of the optic nerve from normal eyes. We also evaluated the relationship between macular thickness and severity of VF damage in patients with BA. Finally, the ability of macular thickness parameters to detect patients with BA was compared to that of RNFL thickness parameters using the same sample of subjects.

Materials and Methods

Design

This was an observational prospective cross-sectional study. Participants were recruited for examination at the Department of Ophthalmology of the University of São Paulo Medical School between May 2003 and October 2005. Approval from the Institutional Review Board Ethics Committee was obtained for the study. The study followed the principles of the Declaration of Helsinki and informed consent was obtained from all participants.

Subjects

A total of 40 eyes from 40 patients (22 male) with temporal hemianopia from chiasmal compression and 31 eyes from 31 normal (20 male) age- and gender-matched controls were studied. All patients with history of chiasmal lesions had already undergone previous treatment of the suprasellar lesion and had stable visual field (VF) defects and visual acuity (VA) for at least 1 year prior to study entry.

All subjects underwent a complete ophthalmologic examination including VF evaluation. Visual field testing was performed using the Goldmann perimeter (Haag-Streit AG, Bern, Switzerland). The V-4-e, I-4-e, I-3-e, I-2-e, and I-1-e stimuli were used to draw the isopters. Kinetic determinations were followed by static presentation of the stimuli, particularly in the central 30-degree area, to search for localized defects. All patients also underwent standard automated perimetry (SAP) using the 24-2 Full-threshold strategy (Humphrey Field Analyzer, Carl Zeiss Meditec, Dublin, CA). Visual field and OCT examinations were performed on the same day or within a maximum period of 2 weeks.

Inclusion criteria for the study included best corrected VA $\geq$ 20/30 in the study eye; age between 18 and 72 years; spherical refraction within $\pm$5 diopters and cylinder refraction within $\pm$4 diopters; intraocular pressure $<$ 22 mmHg; and reliable VF. A reliable Humphrey VF test was defined as one with $<$25% fixation losses, false-positive responses, or false-negative responses. Patients with a history of intraocular pressure elevation, clinical signs of glaucomatous optic neuropathy, or optic disc anomaly were excluded.

Patients with BA were required to have complete or partial temporal hemianopia on Humphrey and Goldmann perimetry and a nasal hemifield within normal limits on both tests. A normal nasal hemifield on Goldmann perimetry was defined by the presence of normal I-4-e, I-2-e, and I-1-e isopters. On SAP, a normal hemifield was defined as the absence of any cluster of at least 3 points with $P<5\%$ on the pattern deviation plot. Only 1 eye from each patient was selected for analysis. In 34 patients, only 1 eye met the inclusion criteria. For the 6 patients in whom both eyes fulfilled the inclusion criteria, 1 eye was randomly selected for analysis. The severity of VF defect in patients with BA was evaluated by calculating the temporal mean defect (TMD). This was performed by averaging the values of the total deviation plot for the 22 temporal points of the SAP 24-2 test, excluding the 2 points immediately above and below the blind spot.

The control group consisted of normal healthy volunteers recruited from among the hospital staff. All normal subjects had normal ophthalmic examination and normal SAP VF. A normal SAP VF was defined as a pattern standard deviation within the 95% confidence limits and a Glaucoma Hemifield Test result within normal limits. Healthy control eyes also had a healthy appearance of the optic disc and RNFL. One eye from each healthy subject was included for analysis, and the selection between right or left eye was performed to match the selection in patients with BA.

Optical Coherence Tomography Scanning

Subjects underwent ocular imaging with dilated pupils using a commercially available OCT (Stratus OCT, Carl Zeiss Meditec). All patients had RNFL thickness and macular thickness scans obtained during the same visit. Optical coherence tomography employs the principles of low-coherence interferometry and is analogous to ultrasound B-mode imaging but uses light instead of sound to acquire images of ocular structures. The basic principles and technical characteristics have been described.[14] Quality assessment of Stratus OCT scans was evaluated by an experienced examiner. Quality scans had to have focused images and signal strength $\geq$ 7, and presence of a centered circular ring around the optic disc for RNFL scans. For macula scans, the radial scans had to be centered on the fovea.

The fast macular thickness protocol was used to obtain macular thickness measurements with Stratus OCT. Optical coherence tomography measurements of the macula were generated from six 6-mm linear scans in a spokelike radial configuration with each line 30 degrees apart. Macular thickness parameters were automatically calculated by the Stratus OCT software (version 4.0.1) as the distance between the inner limiting membrane and retinal pigment epithelium. Macular thickness parameters evaluated in this study were foveal thickness, superior outer macular thickness, inferior outer macular thickness, temporal outer macular thickness, nasal outer macular thickness, superior inner macular thickness, inferior inner macular thickness, temporal inner macular thickness, nasal inner macular thickness, and average macular thickness. Average macular thickness was calculated as the weighted average of the sectoral macular thickness measurements excluding the fovea. The superior outer/inferior outer, temporal inner/nasal inner, and temporal outer/nasal outer relationships were also evaluated. To evaluate the relationship between the overall temporal and nasal macular thicknesses, the weighted average of values from the outer and inner segments was calculated for each hemiretina and the temporal/nasal ratio was obtained.

The fast RNFL algorithm was used to obtain RNFL thickness measurements with Stratus OCT. Three images were acquired from each subject, with each image consisting of 256 A-scans along a 3.4-mm-diameter ring around the optic disc. Peripapillary RNFL thickness parameters automatically calculated by existing Stratus OCT software (version 4.0.1) and evaluated in this study were average thickness (360-degree measure), temporal quadrant thickness (316–45 degrees), superior quadrant thickness (46–135

degrees), nasal quadrant thickness (136–225 degrees), inferior quadrant thickness (226–315 degrees), and thickness for each of 12 clock-hour positions with the 3 o'clock position as nasal, 6 o'clock position as inferior, 9 o'clock position as temporal, and 12 o'clock position as superior.

Statistical Analysis

Descriptive statistics included mean values ± standard deviation for normally distributed variables and median, first quartile, and third quartile for nonnormally distributed variables. Analysis of histograms and the Shapiro–Wilk test were used to evaluate the normality assumption.

Macular parameters and RNFL thickness values of eyes with BA and normal controls were compared using Student's *t* tests. Receiver operating characteristic (ROC) curves were used to describe the ability of Stratus OCT parameters to discriminate BA from healthy eyes. The method of DeLong et al[15] was used to compare areas under the ROC curves (AUCs). For each parameter, sensitivities at fixed specificities of 80% and 95% were calculated. Spearman's rank correlation coefficient (ρ) was used to evaluate the relationship between RNFL and macular thickness parameters and severity of VF loss as measured by the TMD.

$P<0.05$ was considered statistically significant. Results of statistical significance were provided after the Bonferroni correction based on the number of comparisons within each analysis. Statistical analyses were performed using SPSS v.13.0 (SPSS Inc., Chicago, IL).

Results

A total of 40 eyes with temporal hemianopia and 31 control eyes were studied. Thirty-four patients had pituitary adenoma, 3 had craniopharyngioma, and 3 had suprasellar meningioma. The mean ± standard deviation age was 45.1±12.7 years (range, 18–72) in BA patients and 43.7±12.1 years (range, 18–71) in normal subjects ($P = 0.66$, Student's *t* test). On Goldmann perimetry, 7 eyes had complete temporal hemianopia; 4 eyes had almost complete hemianopia with only a small inferior temporal remnant of field with V/4e target; 9 eyes had a temporal remnant of field with V/4e and I/4e targets (complete defect up to the I/3e stimulus); and 20 had milder defects in the upper temporal field involving I/3e, I/2e, and I/1e targets. On SAP, 17 eyes had complete temporal hemianopia; 7 had a defect of approximately 1 quadrant, and 16 eyes had a defect involving less than one quadrant of VF. Medians (first quartile, third quartile) of SAP mean deviation and SAP TMD were −7.7 decibels (dB) (−14.2 dB, −3.8 dB) and −18.8 dB (−29.6 dB, −9.2 dB). Funduscopic examination revealed signs of BA of the optic disc and RNFL in all 40 eyes with temporal hemianopic field defect (Fig 1).

Table 1 shows macular thickness measurements in eyes with BA and control eyes. After the Bonferroni correction ($\alpha = 0.003$; 16 comparisons), all macular thickness parameters were significantly lower in eyes with BA compared to normal eyes, except for foveal thickness, temporal outer, temporal inner, temporal average, and superior outer/inferior outer macula thickness. Receiver operating characteristic curve areas and sensitivities at fixed specificities are shown in Table 1. The macular thickness parameters temporal/nasal (AUC = 0.96), temporal outer/nasal outer (AUC = 0.94), and nasal outer thickness (AUC = 0.94) had the largest areas under the ROC curves. Figure 2 shows ROC curves for the 3 macular parameters with largest AUCs. There were no statistically significant differences in the ROC curve areas for these parameters ($P>0.05$ for all comparisons).

Table 2 shows RNFL thickness measurements in eyes with BA and healthy eyes. After the Bonferroni correction ($\alpha = 0.003$; 17 comparisons), all RNFL thickness parameters were significantly

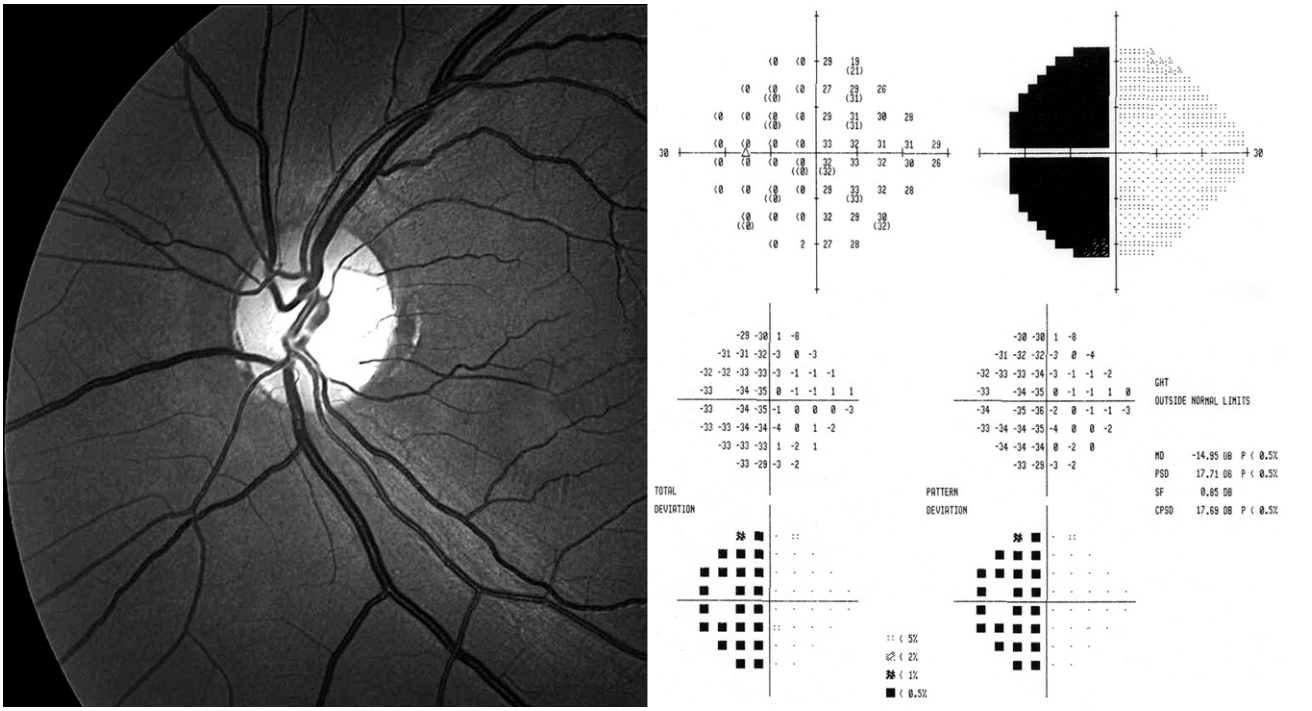

Figure 1. Left, Fundus photograph of the left eye of a patient with severe band atrophy. Note retinal nerve fiber layer loss in the temporal and nasal portions of the optic disc with relative preservation of the arcuate fibers from the temporal retina. **Right**, Visual field of the same patient showing complete temporal hemianopia.

Table 1. Mean Values (± Standard Deviation) of Stratus Optical Coherence Tomography Macular Thickness Parameters (in μm) with Areas under the Receiver Operating Characteristic Curves (AUC) and Sensitivities at Fixed Specificities

Parameter	Band Atrophy (n = 40)	Controls (n = 31)	P	AUC (SE)	Sensitivity/Specificity	
					Specificity≥95%	*Specificity≥80%*
Macular thickness	228.55 ± 12.18	247.54 ± 13.43	**<0.001**	0.85 (0.05)	50/97	70/81
Fovea	193.92 ± 17.05	196.48 ± 23.58	0.60	0.58 (0.07)	0/97	15/81
Temporal inner	254.52 ± 15.11	266.00 ± 19.16	0.006	0.68 (0.06)	3/97	50/84
Superior inner	248.67 ± 15.64	277.22 ± 17.85	**<0.001**	0.89 (0.04)	58/97	77/81
Nasal inner	239.95 ± 18.14	274.35 ± 17.30	**<0.001**	0.92 (0.03)	73/97	85/81
Inferior inner	253.52 ± 15.57	276.64 ± 16.86	**<0.001**	0.84 (0.05)	30/97	70/81
Temporal outer	220.40 ± 13.41	225.45 ± 13.76	0.124	0.61 (0.07)	8/97	33/84
Superior outer	225.52 ± 12.60	243.70 ± 14.42	**<0.001**	0.84 (0.05)	40/97	68/81
Nasal outer	224.90 ± 14.28	257.77 ± 16.08	**<0.001**	0.94 (0.03)	70/97	93/81
Inferior outer	218.95 ± 11.93	232.41 ± 16.11	**<0.001**	0.74 (0.06)	28/97	55/81
Superior/inferior outer	1.031 ± 0.038	1.050 ± 0.050	0.066	0.62 (0.07)	15/97	38/81
Temporal/nasal inner	1.062 ± 0.067	0.9633 ± 0.030	**<0.001**	0.93 (0.03)	48/95	97/80
Temporal/nasal outer	0.981 ± 0.046	0.873 ± 0.045	**<0.001**	0.94 (0.03)	68/95	97/80
Temporal average	228.20 ± 13.17	234.71 ± 13.79	0.047	0.63 (0.07)	10/97	40/81
Nasal average	236.51 ± 16.62	270.56 ± 15.49	**<0.001**	0.93 (0.03)	70/97	90/81
Temporal/nasal	0.967 ± 0.048	0.868 ± 0.035	**<0.001**	0.96 (0.03)	85/95	94/80

SE = standard error.
*Student's *t* test. Significant values are in bold.

lower in eyes with BA compared with normal eyes. Receiver operating characteristic curve areas and sensitivities at fixed specificities are also shown in Table 2. The Stratus OCT RNFL parameters with largest areas under the ROC curves were average thickness (0.99), temporal thickness (0.98), and nasal thickness (0.97). There was no statistically significant difference in the ROC curve areas for these parameters ($P>0.05$ for all comparisons). Figure 3 shows ROC curves for the 3 RNFL thickness parameters with the largest AUCs.

No statistically significant difference ($P = 0.19$) was found between the AUCs for the best macular thickness parameter (temporal/nasal, AUC = 0.96) and the best RNFL parameter (average thickness, AUC = 0.99).

Table 3 shows the associations between macular thickness parameters and TMD values. The highest correlation was observed for the parameter nasal average macular thickness ($\rho = 0.693$, $R^2 = 48\%$, $P<0.001$), with lower values of thickness associated with lower TMD values. Figure 4 shows a scatterplot of nasal average macular thickness measurements versus TMD values.

Table 3 shows the correlations between RNFL thickness parameters and the degree of severity of VF loss as assessed by TMD. Statistically significant correlations were found for most parameters. The parameter average thickness showed the highest correlation with severity of VF loss ($r = 0.569$, $R^2 = 32\%$, $P<0.001$). Figure 5 shows a scatterplot of total average versus TMD values.

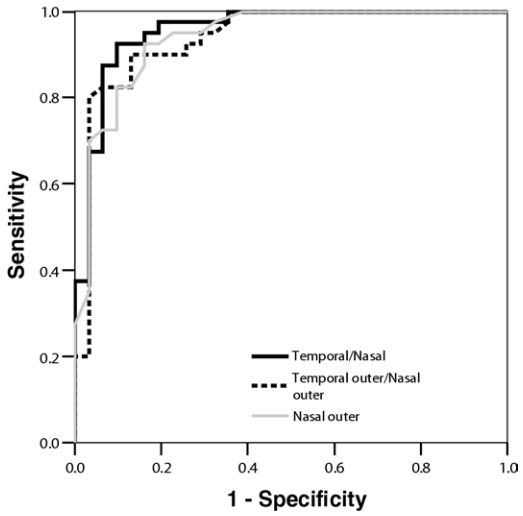

Figure 2. Receiver operating characteristic (ROC) curves of the 3 macular thickness parameters with largest areas under the ROC curves for the discrimination between eyes with band atrophy of the optic nerve and healthy eyes.

Discussion

In the present study, we demonstrated that macular thickness measurements in eyes with BA of the optic nerve were significantly lower than those in healthy control eyes. The macular thickness parameters related to the nasal area and those measuring relationships between the temporal and nasal hemiretinas had the best ability to detect damage in eyes with BA. The nasal outer macular thickness parameter had an AUC of 0.94, compared with only 0.61 for the parameter temporal outer thickness. These findings correspond to the expected pattern of damage in BA. Because the crossed fibers are damaged from chiasmal compression, the loss of ganglion cells affects predominantly the nasal hemiretina, resulting in a decrease of nasal macular thickness. This specific pattern of OCT macular damage in eyes with BA may be helpful in differentiating this condition from other diseases with a different pattern of ganglion cell loss, such as glaucoma.

Several authors have suggested a potential role for macular thickness parameters in the assessment of ganglion cell loss in glaucoma.[11–13] Although recent studies have shown that OCT optic nerve head and RNFL parameters provide superior discrimination between glaucomatous and healthy eyes when compared with macular parameters,[13,16] no study had previously addressed the ability of macular thickness

Table 2. Mean Values (± Standard Deviation) of Stratus Optical Coherence Tomography Retinal Nerve Fiber Layer Thickness Parameters (in μm) with Areas under the Receiver Operating Characteristic Curves (AUC) and Sensitivities at Fixed Specificities

Parameter	Band Atrophy (n = 40)	Normal (n = 31)	P*	AUC (SE)	Sensitivity/Specificity	
					Specificity≥95%	*Specificity*≥80%
Average thickness	68.65 ± 10.46	105.53 ± 11.08	**<0.001**	0.99 (0.08)	97/95	100/80
Superior thickness	88.77 ± 16.64	129.90 ± 17.62	**<0.001**	0.95 (0.03)	61/95	100/85
Temporal thickness	44.67 ± 9.30	73.48 ± 10.74	**<0.001**	0.98 (0.01)	84/97	97/82
Inferior thickness	95.02 ± 16.77	136.16 ± 16.92	**<0.001**	0.96 (0.02)	87/95	94/80
Nasal thickness	45.90 ± 8.73	82.25 ± 17.03	**<0.001**	0.97 (0.02)	77/95	97/80
Thickness at 12 o'clock	95.82 ± 29.26	135.32 ± 26.31	**<0.001**	0.84 (0.05)	32/95	77/80
Thickness at 11 o'clock	104.57 ± 30.58	138.80 ± 17.76	**<0.001**	0.82 (0.05)	19/95	61/80
Thickness at 10 o'clock	56.25 ± 22.12	88.32 ± 14.44	**<0.001**	0.89 (0.04)	58/95	84/80
Thickness at 9 o'clock	35.57 ± 9.54	58.16 ± 9.40	**<0.001**	0.95 (0.03)	87/95	94/82
Thickness at 8 o'clock	44.62 ± 13.27	74.16 ± 15.97	**<0.001**	0.93 (0.03)	81/95	94/80
Thickness at 7 o'clock	107.70 ± 28.52	140.77 ± 22.95	**<0.001**	0.82 (0.05)	32/95	61/82
Thickness at 6 o'clock	111.55 ± 25.22	151.22 ± 23.18	**<0.001**	0.88 (0.04)	48/95	87/80
Thickness at 5 o'clock	67.55 ± 25.68	115.74 ± 22.01	**<0.001**	0.91 (0.03)	61/95	87/80
Thickness at 4 o'clock	45.17 ± 11.51	76.77 ± 18.50	**<0.001**	0.92 (0.04)	61/97	94/80
Thickness at 3 o'clock	40.90 ± 8.63	70.67 ± 17.50	**<0.001**	0.94 (0.03)	77/95	87/80
Thickness at 2 o'clock	52.75 ± 14.53	101.48 ± 22.82	**<0.001**	0.97 (0.02)	81/95	94/80
Thickness at 1 o'clock	67.87 ± 26.65	117.42 ± 23.84	**<0.001**	0.92 (0.03)	52/95	90/80

SE = standard error.
*Student's *t* test. Significant values are in bold.

measurements to detect damage in eyes with BA. Medeiros et al[13] found a maximum ROC curve area of 0.81 for macular thickness parameters in the discrimination between glaucomatous and normal subjects, whereas peripapillary RNFL thickness parameters had a maximum ROC curve area of 0.91 in the same situation. In our study, we found similar diagnostic performances for macular and RNFL thickness measurements for detection of eyes with BA. Differences between these studies could be related to the different severity of damage in the included patients or to the different patterns of ganglion cell loss in these diseases. It is possible that the specific pattern of ganglion cell loss in eyes with BA favors detection of damage by macular thickness analysis. Also, in our study, as well as in previous ones, only the current macular thickness parameters provided by the standard Stratus OCT printout were investigated. It is possible that advances in the software designed to extract data from the macular area would improve detection of retinal ganglion cell loss in the posterior pole, both in patients with BA of the optic nerve as well as in other conditions.

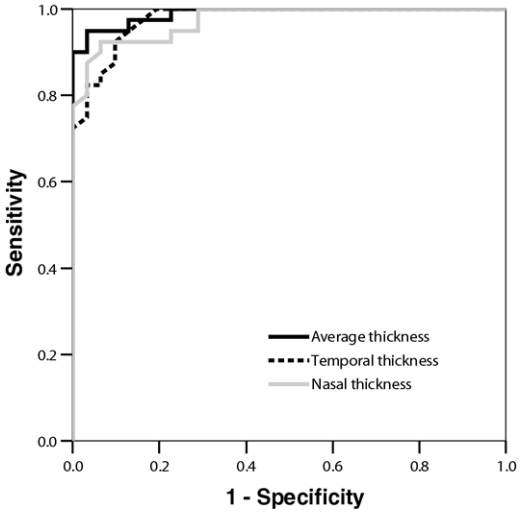

Figure 3. Receiver operating characteristic (ROC) curves of the 3 retinal nerve fiber layer thickness parameters with largest areas under the ROC curves for the discrimination between eyes with band atrophy of the optic nerve and healthy eyes.

The evaluation of BA cases also provides a potential model to investigate the ability of imaging instruments to accurately assess RNFL thickness in the temporal and nasal areas of the optic disc. The ability to assess RNFL loss in these areas is important for the study of several neuro-ophthalmologic conditions with a predilection for RNFL damage in these sectors, such as chiasmal and optic tract compression, heredodegenerative diseases, and toxic, nutritional, compressive, and even inflammatory optic neuropathies. In our study, we found that Stratus OCT RNFL parameters related to the temporal and nasal sectors were significantly different between BA patients and control subjects. Also, Stratus OCT RNFL parameters had an excellent performance in discriminating between the 2 groups, suggesting that this instrument can successfully assess RNFL loss in the temporal and nasal areas. These findings are in agreement with previous studies using earlier versions of the optical coherence tomograph (OCT-1),[9,17] and with a quantitative histologic analysis performed by Mikelberg and Yidegiligne[18] evidencing an almost complete loss of nerve fibers in the nasal and temporal quadrants of the optic disc in a patient with BA.

The patients included in our study had already undergone chiasmal decompression and retained severe and long-standing hemianopic VF defects, with corresponding structural damage observed on ophthalmoscopy as BA of the

Table 3. Associations between Macular and Retinal Nerve Fiber Layer (RNFL) Thickness Parameters and Temporal Mean Defect of the Visual Field

Macular Thickness Parameters	ρ*	*P*	RNFL Thickness Parameters	ρ*	*P*
Macular thickness	0.565	<0.001	Average thickness	0.569	<0.001
Fovea	0.012	0.940	Superior thickness	0.458	0.003
Temporal inner	0.308	0.053	Temporal thickness	0.423	0.007
Superior inner	0.499	0.001	Inferior thickness	0.543	<0.001
Nasal inner	0.653	<0.001	Nasal thickness	0.320	0.044
Inferior inner	0.476	0.002	Thickness at 12 o'clock	0.235	0.144
Temporal outer	0.416	0.008	Thickness at 11 o'clock	0.268	0.094
Superior outer	0.491	0.001	Thickness at 10 o'clock	0.323	0.042
Nasal outer	0.628	<0.001	Thickness at 9 o'clock	0.398	0.011
Inferior outer	0.542	<0.001	Thickness at 8 o'clock	0.309	0.053
Superior/inferior outer	−0.017	0.918	Thickness at 7 o'clock	0.317	0.047
Temporal/nasal inner	−0.442	0.004	Thickness at 6 o'clock	0.446	0.004
Temporal/nasal outer	−0.258	0.108	Thickness at 5 o'clock	0.450	0.004
Temporal average	0.388	0.013	Thickness at 4 o'clock	0.150	0.355
Nasal average	0.693	<0.001	Thickness at 3 o'clock	0.065	0.690
Temporal/nasal	−0.443	0.004	Thickness at 2 o'clock	0.413	0.008
			Thickness at 1 o'clock	0.460	0.003

*Spearman's rank correlation coefficient.

optic nerve. Therefore, VF defects in our cases were likely to be permanent. Significant correlations were found between RNFL and macular thickness measurements and the severity of VF loss in patients with BA of the optic nerve. These correlations were generally similar to previously reported structure–function relationships between Stratus OCT parameters and severity of VF loss in patients with glaucoma. Greenfield et al[10] reported R^2 of 0.47 and 0.45 for the associations between average macular thickness and RNFL average thickness, respectively, and VF mean defect in a group of 30 glaucomatous patients. In our study, the parameter nasal average macular thickness had the best association with the degree of field loss, with an R^2 of 0.48. For the RNFL thickness parameters, the best association was observed for the parameter average thickness, with an R^2 of 0.32. The significant relationships found between Stratus OCT parameters and measures of visual function in eyes with BA suggest that this instrument could potentially be used to evaluate the severity of disease in these patients. Future studies should be directed at studying the potential use of these measurements to monitor patients with this disease.

Our study provided an initial exploratory evaluation of the ability of macular thickness measurements to detect ganglion cell loss in patients with BA of the optic nerve. Although our results showed that Stratus OCT macular thickness measurements can distinguish between BA patients and healthy subjects, further studies are necessary to evaluate the role of macular thickness measures in distinguishing patients with BA from other clinical entities that could mimic the clinical picture of BA, such as other types of compressive and noncompressive optic neuropathies and glaucoma.

In conclusion, macular thickness measurements could potentially be used to evaluate ganglion cell loss in patients

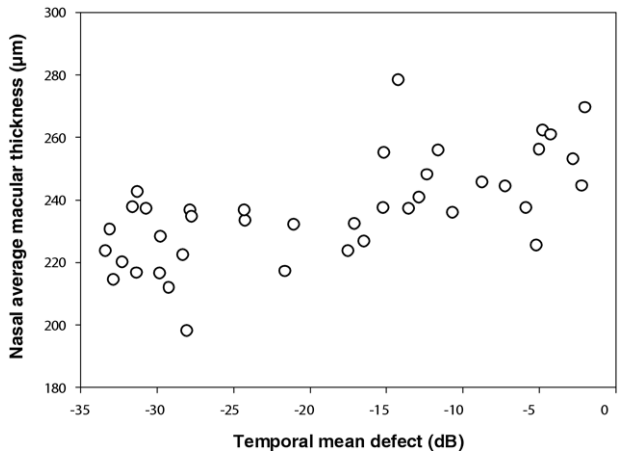

Figure 4. Scatterplot of nasal average macular thickness measurements versus temporal mean defect values in the 40 eyes with band atrophy of the optic nerve. dB = decibels.

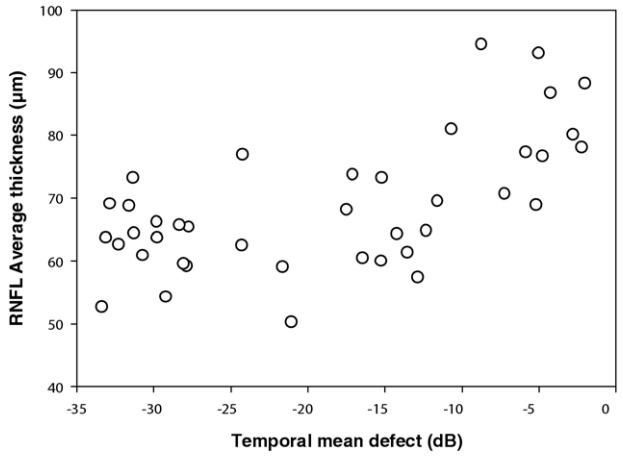

Figure 5. Scatterplot of retinal nerve fiber layer (RNFL) average thickness measurements versus temporal mean defect values in the 40 eyes with band atrophy of the optic nerve. dB = decibels.

with BA of the optic nerve and could prove to have clinical value for detection of damage and for monitoring these patients.

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