ORIGINAL ARTICLE

Posterior Pole Retinal Thickness for Detection of Structural Damage in Anterior Ischaemic Optic Neuropathy

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ABSTRACT

This objectives of this study were to compare posterior pole retinal thickness (PPRT) and peripapillary retinal nerve fibre layer thickness (RNFLT) between the affected eyes of patients with previous nonarteritic anterior ischaemic optic neuropathy (NAION) and their unaffected eyes and to assess the structure-function relationship. Eighteen eyes with NAION and 14 contralateral unaffected eyes were included in this cross-sectional study. Humphrey visual field (VF) sensitivities were obtained. RNFLT (six sectors) and PPRT (four quadrants) were measured with spectral-domain optical coherence tomography (Spectralis; Heidelberg Engineering, Heidelberg, Germany). These parameters were compared between both eyes of patients with unilateral NAION. The correlation of RNFLT and PPRT with VF mean sensitivity (MS) values (linear units) was also analysed. The main outcome measure was the correlation of MS values with PPRT and RNFLT. A significant difference existed between the affected eyes and the unaffected fellow eyes in the MS values, all sectors of RNFLT, and all quadrants of PPRT. A significant linear correlation was observed between RNFLT and PPRT and corresponding MS values in global and regional measures. The strongest correlation was between inferior temporal VF and its corresponding superior nasal PPRT and RNFLT between the normal and affected eyes was 0.97 and 0.96, respectively. The results show that PPRT and RNFLT provide equivalent performance to detect structural damage in ischaemic optic neuropathy.

Keywords: ischaemic optic neuropathy, nerve fibre layer thickness, retinal thickness, spectral-domain optical coherence tomography

INTRODUCTION

Nonarteritic anterior ischaemic optic neuropathy (NAION) is the most common clinical presentation of acute ischaemic damage to the optic nerve and is characterised by a sudden painless visual loss, visual field defects, optic disc oedema, and peripapillary haemorrhages.¹ Histologic study on optic nerves affected with NAION has shown nerve fibre loss of the nerve.² Rodent model of NAION is associated with the isolated retinal ganglion cell (RGC) axonal ischaemia similar to those in human NAION.³ In this model, axonal damage causes RGC apoptosis, which

is manifested by loss of ganglion cells across the central retina.⁴

Spectral-domain optical coherence tomography (SD-OCT) is able to quantify macular thickness, ganglion cell complex thickness, and peripapillary retinal nerve fibre layer thickness (RNFLT).⁵ Defects in the RNFLT have been observed in NAION.^{6–10} The RGC layer is more than 1 cell layer thick at the macula (cell density up to 4–6 cell bodies thick); therefore, it was proposed that loss of retinal ganglion cells and nerve fibre layer can be reflected by a reduction in macular and central retinal thickness. NAION eyes were shown to have maculae that were thinner and

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smaller in volume than those of uninvolved eyes.¹⁰ Recently, in addition to macular thickness map, a posterior pole scan has been introduced in the Spectralis SD-OCT (Heidelberg Engineering, Heidelberg, Germany), which displays the retinal thickness over the entire posterior pole ($30^\circ \times 25^\circ$ OCT volume scan). Of particular interest, therefore, is whether posterior pole retinal thickness (PPRT) correlates well with visual field (VF) thresholds (differential light sensitivity). Such a finding would suggest structure-function correlation in NAION. We performed regional analyses to determine how PPRT and RNFLT relate to visual function in NAION patients and examined how these patterns differ from unaffected eyes.

METHODS

Seventeen patients with previous NAION who met the inclusion criteria between January 2011 and January 2013 at the Farabi Eye Hospital were included. The study was carried out with the approval of the research ethic committee. Informed consent was obtained from all patients, and the study was conducted in accordance with the Declaration of Helsinki. Initial evaluation included best-corrected visual acuity testing, applanation tonometry, slit-lamp biomicroscopy, and fundus examination. The best-corrected visual acuity was measured using a Snellen chart at 6 m and was converted into logarithm of the minimum angle of resolution (logMAR) scores for statistical analysis. Inclusion criteria for this cross-sectional study were (1) a history of unilateral sudden visual acuity and/or field loss; (2) a history of acute optic disc swelling and haemorrhage that had resolved; (3) clearly delineated disc borders at study commencement; and (4) an ophthalmologically healthy fellow eye (an eye without abnormal findings on complete ophthalmologic assessments, best-corrected visual acuity exceeding 20/25, and normal VF test results).^{11,12}

Exclusion criteria included any clinical and laboratory findings of arteritic AION^{11,12}; any history or clinical evidence of retinal disease; neurologic disease; glaucoma; intraocular pressure of more than 21 mm Hg; cup-to-disc ratio of more than 0.3; intraocular surgery or laser therapy; and refractive error beyond ± 5.00 dioptres.

VF Testing

Swedish Interactive Thresholding Algorithm standard 24-2 perimetry (Carl Zeiss Meditec, Dublin, California, USA) was performed in all subjects. Qualified tests had a false positive of $<12\%$ and fixation loss and false negative of $<30\%$. Light sensitivity in visual field was expressed in two

ways: decibel (dB) and nonlogarithmic 1/L scales (L; luminance measured in lamberts).⁶ Hood and Kardon mentioned the importance of taking the antilog (nonlogarithmic scales) before averaging the measures of the perimetry.¹³ Briefly, unlogged 1/L value at each tested location = $k \times 10^{\text{dB}/10}$, where k (constant number) = 31.6 asb/10000 asb, and dB is light sensitivity in decibel.⁶ k was ignored, because of being constant for all points. The 1/L sensitivity values were obtained in all 52 testing points, after excluding one above and below the blind spot. The individual values were grouped into the following regions: global field and six field sectors corresponding to six sectors pertinent to the nerve fibre layer anatomy.¹⁴ In addition, we obtained 1/L values of 34 central points of visual field (central 15° or 30° diameter), an area roughly equivalent to the area covered by Spectralis OCT posterior pole scan. The values were grouped into four quadrants: superior nasal (SN), superior temporal (ST), inferior nasal (IN), and inferior temporal (IT), and into superior and inferior hemifields.

These antilogged values averaged in each visual field region (global, six sectors, four quadrants, and hemifields) and mean sensitivity (MS) in each region was obtained to use for linear regression analysis.

Global and hemifield MS values were also log-transformed back to the decibel scale to compare affected and unaffected eyes. Mean deviation (MD) was also recorded.

OCT

All OCT scans were performed with the Spectralis SD-OCT (Heidelberg Engineering; software version 5.3.2). A real-time eye tracker couples the SD-OCT scanner to the eye position and stabilizes the OCT scan on the retina. All testing was carried out by the same operator (M.K.) on all subjects. A colour scale at the bottom of the scan indicated quality of scans, where it had to be in the green range to be considered a good-quality scan.

Posterior Pole Retinal Thickness Map

The PPRT map encompasses $30^\circ \times 25^\circ$ (approximately 17° radius) of retina. This map includes an 8×8 grid that is positioned along the fovea to disc axis and mean retinal thickness is given for each cell. The grid was divided into four quadrants and the average value of 16 locations in each quadrant was obtained (Figure 1). We also used mean hemisphere retinal thickness.

Nerve Fibre Layer Map. This map supplies the estimates of the ST, SN, IN, IT, nasal (N), and temporal (T) RNFLT in six sectors. According to the scheme in Figure 1, these sectors were roughly equivalent to

FIGURE 1 Visual field (24-2) (A) sensitivity and (B) grey scale plots from a patient with anterior ischaemic optic neuropathy of left eye with inferior nasal field loss. Division of the visual field test points and corresponding retinal nerve fibre optic nerve (RNFL) profile (C) into sectors. For example, sector 3 field region maps to the superior temporal RNFL sector from 41° to 80°. The 34 points (central 15°) contained in the central blue square (A, D) correspond to an area covered by posterior pole retinal thickness scan (E). Division of these points into four quadrants and mirror image of VF test points superimposed to the corresponding area of posterior pole (D). In this patient, inferior nasal VF quadrant maps to superior temporal posterior pole retinal thickness that shows marked retinal thinning. IT=inferior temporal; IN=inferior nasal; ST=superior temporal; SN=superior nasal; N=nasal; T=temporal; RNFL=retinal nerve fibre layer.

the sectors that Garway-Heath et al.¹⁴ mentioned. Average RNFL thickness was also used.

Comparing Local VF MS Values with Local PPRT and RNFLT

The corresponding regions of the VF, PPRT, and RNFLT profiles were specified. In other words, we related ST (sector 1), SN (sector 2), IN (sector 3), SN (sector 4), T (sector 5), and N (sector 6) regions of

the 24-2 field to IN, IT, ST, IT, N, and T sectors of the RNFLT, respectively. We also related SN, ST, IN, and IT quadrants of 24-2 field to IT, IN, ST, and SN quadrants of the PPRT profile, respectively (Figure 1).

Statistical Analysis

The *t* test was performed to evaluate the difference in the parameters between the affected and unaffected eyes. To measure the strength of the relationships of

TABLE 1 Global and hemifields visual field indexes, PPRT, and RNFLT between affected NAION eye and contralateral unaffected eye.

Visual parameters	Unaffected eye Mean $\pm$ SD ($n = 14$)	Affected NAION eye Mean $\pm$ SD ($n = 18$)	p Value
Visual acuity, logMAR	0.09 $\pm$ 0.14	0.44 $\pm$ 0.34	0.001*
Visual field MD, dB	-1.84 $\pm$ 1.69	-15.04 $\pm$ 5.47	0.000*
Global MS, dB	28.63 $\pm$ 1.66	22.97 $\pm$ 4.96	0.000*
Inferior hemifield MS, dB	29.66 $\pm$ 1.42	20.24 $\pm$ 7.21	0.000*
Superior hemifield MS, dB	29.03 $\pm$ 1.91	23.00 $\pm$ 8.48	0.014*
Inferior hemifield MS, 1/L	974.57 $\pm$ 331.02	228.40 $\pm$ 309.58	0.000*
Superior hemifield MS, 1/L	865.57 $\pm$ 309.58	493.46 $\pm$ 416.79	0.007*
Average PPRT, μ m	297.57 $\pm$ 12.82	271.86 $\pm$ 13.14	0.000*
Superior hemifield PPRT, μ m	293.96 $\pm$ 12.13	263.33 $\pm$ 16.07	0.000*
Inferior hemifield PPRT, μ m	295.05 $\pm$ 14.65	280.36 $\pm$ 19.72	0.02*
Average RNFLT, μ m	102.92 $\pm$ 10.77	61.69 $\pm$ 18.26	0.000*

logMAR=logarithm of the minimum angle of resolution; MD=mean deviation; MS=mean sensitivity; NAION=nonarteritic anterior ischaemic optic neuropathy; RNFLT=retinal nerve fibre layer thickness; PPRT=posterior pole retinal thickness; dB=decibel.

*Significant difference.

average PPRT and RNFLT with VF MS values, we calculated Pearson's correlation coefficients (r) for the global and sectoral measurements. VF MS was treated as the dependent variable and RNFLT and PPRT as the independent variables. For evaluating residual thickness, we used RNFLT as dependent variable in the regression analysis. The standardised residuals and Cook's distance were also examined for identifying outliers.

Receiver operating characteristic (ROC) curves were used to describe the ability of each parameter to differentiate NAION from unaffected eyes.

Data were presented as the mean $\pm$ SD. Most statistical analyses were performed by using SPSS version 17.0 (SPSS, Inc., Chicago, Illinois, USA). ROCKit software¹⁵ was used to compare areas under the ROC curve. A p value of <0.05 was considered statistically significant. We tested the significance of multiple correlation analyses using the conservative Bonferroni method. Therefore, with maximum of six different comparisons and mean r of 0.5, $p < 0.01$ was considered significant for multiple correlations.

RESULTS

Seventeen patients (9 men, 8 women) with NAION were evaluated. One patient had bilateral NAION and data from two unaffected eyes were not available; therefore, the data from 32 eyes (18 NAION eyes and 14 contralateral unaffected eyes) were included. The mean $\pm$ SD age was 55 ± 8 years (range, 45–75 years). The mean time between onset of NAION and study enrolment was 138 days, ranging from 90 to 240 days. Mean best-corrected visual acuity was 0.06 logMAR (approximately 20/25 Snellen equivalent) in the control eyes and 0.53 logMAR (20/70 Snellen equivalent) in the affected eyes ($p = 0.000$). Nine eyes had an

altitudinal inferior field defect,¹⁶ one had a superior field defect, and the remaining patients had superior and inferior hemifield defects. Visual field MD ranged from -26.11 to -8.59 dB (mean, -14.39 dB) in the affected eyes.

Global Parameters

Visual acuity, MD, global MS, hemifield MS values, average and hemifield PPRT, and average RNFLT were significantly different between the affected and unaffected eyes (Table 1). Because of collinearity associated with average RNFLT and PPRT (variance inflation factors of 2.4), we did separate linear regression for these variables. Regression analysis showed the relation of average PPRT with MS value (expressed on 1/L scale) ($r^2 = 0.44$, $p = 0.000$) and of average RNFLT with MS value ($r^2 = 0.49$, $p = 0.000$).

We calculated the differences in hemifield PPRT between the affected and unaffected eyes. Mean differences of superior and inferior hemifield thicknesses between two eyes were $29.46 \pm 16.62 \mu\text{m}$ and $15.05 \pm 15.37 \mu\text{m}$, respectively. There was a statistically significant difference between these two measures (one-sample t test, $p = 0.003$).

Regional Parameters

The visual field MS values in all regions of the affected eyes were significantly lower than the contralateral unaffected eyes (Table 2). All of the sectoral RNFLT values in the affected eyes were significantly different from unaffected eyes (all $p < 0.001$). In addition, all of the quadrant PPRT maps for the affected eyes were significantly different from unaffected eyes (all $p < 0.05$), with the borderline p value of the map

TABLE 2 OCT parameters (posterior pole and RNFL thickness) and corresponding visual field MS values (expressed on unlogged 1/L scale) from 18 nonarteritic anterior ischaemic optic neuropathy eyes compared with 14 normal unaffected eyes.

Retinal/optic disc area	OCT parameters (unaffected eye)	OCT parameters (NAION eye)	<i>p</i> Value	Corresponding visual field MS (unlogged), unaffected eye	Corresponding visual field MS (unlogged), NAION eye	<i>p</i> Value
Posterior pole (inferior nasal)	313.14 ± 19.38	291.79 ± 25.01	0.011*	864.47 ± 297.90	489.06 ± 400.56	0.010*
Posterior pole (superior nasal)	310.27 ± 13.14	271.91 ± 17.73	0.000*	953.27 ± 316.91	283.45 ± 263.25	0.000*
Posterior pole (inferior temporal)	277.72 ± 11.90	267.68 ± 14.42	0.039*	864.47 ± 297.90	489.06 ± 448.16	0.008*
Posterior pole (superior temporal)	277.72 ± 13.48	254.72 ± 16.44	0.001*	993.50 ± 397.83	179.47 ± 255.32	0.000*
RNFL (superior nasal)	118.07 ± 21.63	57.72 ± 24.56	0.000*	623.77 ± 305.26	110.01 ± 126.53	0.000*
RNFL (superior temporal)	137.57 ± 19.73	60.0 ± 25.93	0.000*	982.43 ± 371.0	192.67 ± 245.62	0.000*
RNFL (inferior nasal)	121.71 ± 25.87	79.72 ± 29.32	0.000*	537.52 ± 288.14	263.98 ± 242.77	0.009*
RNFL (inferior temporal)	133.50 ± 16.86	100.88 ± 38.60	0.000*	743.50 ± 277.144	400.31 ± 332.48	0.003*
RNFL (temporal)	68.92 ± 9.47	44.66 ± 13.25	0.000*	1231.07 ± 351.34	584.63 ± 330.81	0.000*
RNFL (nasal)	73.42 ± 14.32	46.05 ± 17.21	0.000*	608.58 ± 182.85	287.0 ± 199.22	0.000*

OCT=optical coherence tomography; MS=mean sensitivity; RNFL=retinal nerve fibre layer; NAION=nonarteritic anterior ischaemic optic neuropathy.

*Significant difference.

representing the inferior temporal retinal thickness (superior nasal field).

When linear regression analysis between structure and function was evaluated, we used the data from the affected and unaffected eyes.^{13,17} Also, in this model, MS values were expressed in 1/L scales. In summary, when the relation between the sectoral nerve fibre thicknesses with their corresponding visual field sectors was evaluated, only those representing the IN nerve fibre layer region did not show significant association with the corresponding superior temporal VF (Figure 2A). The relation of PPRT with corresponding VF MS values was also identifiable in all of the quadrants except IT retinal area (Table 3). In addition, Table 3 shows correlations of the regional OCT parameters with logMAR visual acuity.

Figure 2B, C show the fit with a linear regression mode for the relationship between IN and SN retinal thickness maps and 1/L scale MS values.

Hood et al.^{13,17} mentioned residual RNFLT remaining after extensive RGC damage and we used sector 3 data and corresponding ST RNFLT to calculate residual thickness. The resulting mean residual RNFLT after severe loss in MS (with losses of 29.6 – 18.2 dB = 11.4 dB) was 60.0 µ. The mean normal value in unaffected eyes was 137.57 µ. These values are the fits of a linear regression formula using RNFLT (ST) as the outcome variable and MS (1/L) as predictor (with some approximations) that showed that

$$\text{RNFLT} = 0.069 \times \text{MS (unlogged)} + 56.73 (r^2 = 0.57, p = 0.00) \text{ (Figure 2D)}.$$

We considered the differences in quadrant PPRT and MS values between the affected and unaffected eyes. The most severe losses of MS were found in IN (12.86 dB) and IT (8.55 dB) visual fields.

Correspondingly, ST and SN retinal quadrants had 22.6 ± 5.4 and 38.3 ± 5.6 µ reductions in thickness. However, IT quadrant had 10.0 ± 4.7 µ reduction in thickness and 6.25 dB loss of MS in corresponding SN field.

OCT parameters with the widest area under the ROC curve to discriminate NAION versus unaffected eyes were SN (0.97), ST (0.87) posterior pole retinal thickness areas, and SN (0.96), ST (0.96), temporal (0.92) RNFLT maps. There was not a significant difference between ROC curve area for SN PPRT thickness and SN RNFLT ($p=0.5$) and between ST PPRT thickness and ST RNFLT ($p=0.06$).

DISCUSSION

RNFLT has been used as a main structural test of optic nerve integrity in patients with optic neuropathy. However, this test does present some limitations.¹⁸ First, the correlation between RNFLT and visual threshold is limited. At least four published studies have shown different correlations in NAION. One study has not found a correlation between the superior RNFLT and the corresponding involved VF sector,⁹ whereas another study found a correlation only for IT optic disc sector with OCT.¹⁰ Alasil et al.¹⁹ found correlations between the peripapillary nerve fibre hemispheric averages and hemispheric VFs and Papchenko et al.¹⁰ found correlations of different quadrants of visual field with RNFLT with time-domain OCT. Although different ranges of damage levels in optic nerve ischaemia might cause a range of correlations in different studies, analyses in these studies were not optimal for testing correlations because dB values were averaged.⁷ Second, the contribution of non-neuronal elements to RNFLT measurements represents a possible

FIGURE 2 (A) The linear model shows change in retinal nerve fibre layer (RNFL) thickness of the inferior temporal disc with changes in mean sensitivity (MS) sector 2 region for 32 eyes of patients with anterior ischaemic optic neuropathy. (B) Scatterplot shows the correlation between inferior temporal quadrant mean sensitivity (MS) value and superior nasal posterior pole retinal thickness. (C) The correlation of superior temporal quadrant MS value with inferior nasal posterior pole retinal thickness. (D) The linear model shows change in retinal nerve fibre layer (RNFL) thickness of the superior temporal disc with changes in mean sensitivity (MS) of inferior temporal visual field region (sector 3) for calculating residual nerve fibre layer thickness.

source of confounding.¹⁸ Third, mapping of VF to corresponding nerve fibre layers is more complicated than with posterior pole retinal locations. Finally, the retinal nerve fibre layer is composed of the RGC axons, and therefore assessment of the RGC and macula may be a more direct method for measuring optic nerve damage than circumpapillary RNFLT.

Therefore, many studies have used macular OCT for evaluation of different types of optic neuropathies.^{20–22} Recently, Aggarwal *et al.*²³ measured macular ganglion cell complex thickness in NAION and showed correlation of hemispheric ganglion cell complex loss with altitudinal VF loss. Papchenko *et al.*¹⁰ found the correlations of macular thickness parameters (using Stratus time-domain OCT) with VF

TABLE 3 Correlations of regional visual field MS values and visual acuity with OCT parameters (32 eyes).

OCT parameter	VF region	<i>r</i> between VF and OCT	<i>p</i> Value	<i>r</i> between VA and OCT	<i>p</i> Value
Posterior pole OCT					
IN retinal thickness	ST quadrant	0.67	0.000*	−0.55	0.001*
SN retinal thickness	IT quadrant	0.79	0.000*	−0.49	0.004*
IT retinal thickness	SN quadrant	0.35	0.040	−0.43	0.012
ST retinal thickness	IN quadrant	0.54	0.001*	−0.33	0.058
Optic nerve OCT					
IN RNFL thickness	Sector 1	0.32	0.067	−0.37	0.032
IT RNFL thickness	Sector 2	0.79	0.000*	−0.54	0.001*
ST RNFL thickness	Sector 3	0.76	0.000*	−0.53	0.001*
SN RNFL thickness	Sector 4	0.57	0.001*	−0.43	0.012
T RNFL thickness	Sector 5	0.61	0.000*	−0.65	0.000*
N RNFL thickness	Sector 6	0.75	0.000*	−0.42	0.013

r = correlation coefficient; RNFL = retinal nerve fibre layer; OCT = optical coherence tomography; VF = visual field; SN = superior nasal; ST = superior temporal; IN = inferior nasal; IT = inferior temporal; T = temporal; N = nasal.

*Significant difference.

mean deviation (MD) in NAION, but they did not emphasise regional visual field analyses.

Our study demonstrates that, when examined with OCT, eyes affected with NAION show defects not only in RNFLT but also in PPRT. Because the photoreceptor layer is not believed to decrease in thickness in NAION, this loss of retinal thickness is attributed mainly to the ganglion cell and nerve fibre layer. All global OCT parameters were significantly different between affected and unaffected eyes. As Table 1 shows, superior hemifield MS value is depressed by a lesser amount than inferior hemifield in the affected eyes, which might explain mild loss of corresponding inferior hemifield PPRT. Defects were also identified with most regional parameters. Hayreh and Zimmerman²⁴ showed that absolute inferior nasal sector visual loss was the most common defect detected in NAION. We also found more loss of MS values in inferior nasal VF. Correspondingly, ST and SN posterior pole quadrants and ST and SN disc sectors had more reductions in thickness.

In this study, the relationship between a structural measure, PPRT and RNFLT values, and a functional measure, MS and VA values, was also observed. The average PPRT and RNFLT were correlated with global VF indexes. VF regions correlated with both corresponding RNFLT and PPRT. The strongest correlation was between IT visual field and SN retinal quadrant. The ST nerve fibre sector and its related field sector 3 had an extremely reduced MS and thickness and therefore were used to estimate residual RNFLT. We found residual RNFL thickness of 60 μ with regression analysis. Hood et al.¹⁷ found residual thickness of 45.5 μ in ST sector after AION with Stratus OCT.

There were other interesting findings in this study. IN and SN retinal thickness that had the highest coefficient of correlation with corresponding VF quadrants correlated well with logMAR visual

acuity. These areas also matched with the double peaks of the macular nerve fibre profile.²⁵ On the other hand, ST, IT, and T sectors of RNFLT that receive input from the papillomacular bundle area correlated with logMAR visual acuity. Correlations between the average RNFLT and logMAR VA from 6 months onwards in NAION and between the temporal RNFLT and the best-corrected VA in glaucoma patients have been reported.⁸

ROC analysis showed SN retinal thickness of less than 292 μ (as a cut-off value) has 94% sensitivity and 93% specificity for detecting NAION. Cut-off value of 85 μ for ST RNFLT had 88% sensitivity and 100% specificity. Suh et al.¹² found that rim-nerve fibre layer correlation in the 11-o'clock sector (ST sector) was able to distinguish 100% of NAION eyes. SN RNFLT of less than 81 μ also had 83% sensitivity and 93% specificity. There was not a significant difference between ROC curve area for SN PPRT thickness and SN RNFLT and between ST PPRT thickness and ST RNFLT in our study.

This study indicates that whereas RNFLT loss was significantly associated with NAION, PPRT showed at least equal diagnostic capability to detect structural damage. Similar to our study, visual function correlated with macular thickness in glaucoma.²⁶ Na et al.²⁷ reported the glaucoma progression detection capability of macular ganglion cell layer thickness. According to their results, ganglion cell layer thickness showed similar sensitivity to RNFL or total macular thickness in terms of agreement with progression determined by optic disc/RNFL photographic or VF assessment.

Given the caveats with RNFLT mentioned above, in particular the confounding contribution of non-neural tissue, a strong case can be made that PPRT should be preferred; but that case is not based on superior statistical performance of PPRT, as we did not find a significant difference between ROC curve areas of these parameters.

One limitation of our study is small sample size; in addition, PPRT represents total retinal thickness. Therefore, 65–70% PPRT unchanged in NAION and retinal structures other than RGC and nerve fibre may confound the data. Finally, RNFLT and PPRT cut-off values for detecting NAION were reached by statistics in a small sample size. We must proceed with caution in the clinic, as structure and function were not always correlated.

Clinical implication of PPRT in NAION includes the identification of treatments aimed at preserving axons without the confounding effect of oedema associated with RNFLT thickening in the acute state,¹⁸ evaluation of structural damage, and assessment of VA prognosis. In this direction, it will be important in the future to design a cohort study to determine thickness changes after NAION.

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Note: Figure 1 of this article is available in colour online at www.informahealthcare.com/oph

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