CLINICAL STUDY

Comparison between relative dispersion analysis of high-pass resolution perimetry and standard threshold perimetry

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Abstract

Purpose **To evaluate the correlation of the dispersion index (DI) of relative dispersion analysis (RDA), a new high-pass resolution perimetry (HRP) index, with other HRP indices and those of the Humphrey standard threshold perimeter (STP) parameters.**
Methods **Sixty-eight eyes were randomly recruited. Thirty-one eyes were classified as glaucomatous (high intraocular pressure, abnormal visual field and/or optic disc) and 37 as ocular hypertensives (high intraocular pressure, normal visual field, normal optic disc). All the subjects were examined with Humphrey Perimeter, program 30–2, and HRP. The HRP data were also analysed with the RDA program. Statistical analysis was performed with Student's *t*-test, Pearson's *r* correlation coefficient, Mann–Whitney non-parametric test and Spearman correlation coefficient when appropriate.**
Results **Within the entire sample significant correlations were found between the RDA index (DI) and all the HRP indices ($p < 0.001$) and corrected pattern standard deviation ($p < 0.01$), pattern standard deviation (PSD) ($p < 0.01$), mean deviation ($p < 0.05$) and short-term fluctuation ($p < 0.05$) of STP. A stronger correlation was found in glaucomatous patients. In subjects with ocular hypertension DI was only weakly correlated with PSD, local deviation and form index. No difference in DI was found between glaucoma and ocular hypertension.**
Conclusion **The DI of HRP has the theoretical capacity to detect localised inhomogeneity of retinal sensitivity, but at present our data do not support this hypothesis. Before any clinical applications of this index further studies are needed.**

Key words Dispersion index, High-pass resolution perimetry, Relative dispersion analysis, Visual field – indices

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Differential light threshold perimetry is based on the subjective detection of a localised light increment relative to a uniform background. To detect early visual field defects high-pass resolution perimetry (HRP) or ring perimetry has been proposed as an alternative test to the standard threshold perimetry.[1-4]

Recently a new index has been introduced by Frisèn and Rossitti:[5] the dispersion index (DI) or the relative dispersion analysis index, which should be able to detect early visual field inhomogeneities. Frisèn and Rossitti[5] showed that this index detected abnormal visual field from 1.3 to 2.4 times more often than pattern standard deviation with a specificity of 96%.

The aim of this study was to evaluate the correlation of DI with HRP indices and Humphrey standard threshold perimetry (STP) indices.

Patients and methods

Sixty-eight subjects were randomly recruited and classified according to the European Glaucoma Society terminology.[6] All the patients had a visual acuity better than 6/12. Glaucomatous patients were defined as having primary open angle glaucoma (POAG) when they had an abnormal visual field and/or an abnormal optic nerve head (ONH)/retinal nerve fibre layer (RNFL) typical of glaucoma, open angle at gonioscopy and no clinically apparent secondary cause for their glaucoma. Visual fields were considered abnormal if they had at least: (a) three adjacent points depressed by 5 dB with one of the points being depressed by at least 10 dB; (b) two adjacent points depressed by 10 dB; or (c) a 10 dB difference across the nasal horizontal meridian in two adjacent points. None of the points could be edge points except immediately above or below the nasal horizontal meridian.[7,8] In addition visual field testing was considered reliable only

	26	26.25	24.7		
	24.9	22.95		23.07	
	23.3				
	22.6	22.2			
	22.5		21.45		
	21.9	20.7			20.98
	21.1				
	20.3	19.9			
	20.1		19.57		
	19.5	19.25			
	19.3			18.88	
	19.2	18.65			
	19		18.2		
	18.3	17.75			
	17.8				
	17.7	16.7			
	16.8		16.6		
	16.6	16.5			
	16.5				
	16.5	16.4		16.47	
	16.5		16.32		
	16.3	16.25			15.69
	16.3				
	16.2	15.95			
	16		15.57		
	15.9	15.2			
	15.3			14.9	
	15.1	14.35			
	14.6		14.22		
	14.1	14.1			
	14.1				
	14.1	13.45			
	13.7		13.17		
	13.2	12.9			
	13			12.83	
	12.8	12.75			
	12.7		12.5		
	12.6	12.25			
	12.3				12.19
	12.2	12.1			
	12.1		11.92		
	12.1	11.75			
	11.9			11.55	
	11.6	11.35			
	11.4		11.17		
	11.3	11			
	11.2				
	10.8				
MEAN	16.28	16.28	16.28	16.28	16.28
SD	3.99	3.98	3.93	3.85	3.61
COV	24.6%	24.4%	24.2%	23.7%	22.2%

Fig. 1. *Dispersion index (DI) calculation. All the HRP raw threshold data are ordered in a fixed sequence of ascending normal values in minutes of arc. All the data are ordered in a column with a fixed sequence. Thresholds are averaged pairwise in the following manner: the first with the second, the third with the fourth, and so on until the 47th with the 48th. With this recursive pairing, the series is contracted from 48 to 24 values, then to 12, 6 and to 3 units at five intervals. For each column five identical means and five different coefficient of variation (COV) are thus obtained. The DI is obtained from the least square linear regression between each coefficient of variation and interval length in logarithmic scale.*

when false negative and false positive responses were less than 30% and fixation losses were less than 20%.

Ocular hypertension subjects were defined as having high intraocular pressure > 22 mmHg on no treatment, normal visual field, normal ONH and RNFL. Subjects with unreliable visual field examinations were excluded.

All the subjects had previous perimetry experience and all were examined with both the Humphrey Field Analyzer (HFA) 640, program central 30–2 (Humphrey Instruments, San Leandro, CA, USA), and with high-pass resolution perimetry (HRP) (Nikon-High Tech Vision, Malmö, Sweden).

For HFA STP, mean deviation (MD), pattern standard deviation (PSD), short-term fluctuation (SF) and corrected pattern standard deviation (CPSD) were calculated and used for correlation. For Ophthimus 2.4 HRP, global deviation (GD), local deviation (LD), form index and neural capacity were calculated and used for correlation. The form index (FI) assesses the shape of the threshold surface on the basis of an extended isopter concept.[5] Neural capacity (NC) is defined as the functional fraction of the retinal-cortical neural channels.[5]

To calculate the DI, the relative dispersion analysis (RDA) program based on fractal analysis was used. Since the HRP measures thresholds at 50 locations in the central visual field (30°) and for this analysis 48 data points are needed, two points in the superior sector and two in the inferior sector are averaged pairwise. All the HRP raw threshold data are ordered in a fixed sequence of ascending normal values in minutes of arc. All the data are ordered in a column with a fixed sequence. Thresholds are averaged pairwise in the following manner: the first with the second, the third with the fourth, and so on until the 47th with the 48th. With this recursive pairing, the series is contracted from 48 to 24 values, then to 12, 6 and to 3 units at five intervals (Fig. 1). For each column five identical means and five different coefficient of variation (COV) are thus obtained. The DI is obtained from the least square linear regression between each coefficient of variation and interval length in logarithmic scale.[5]

For each patient only one eye was randomly chosen. All the data were analysed by descriptive analysis. When the distribution of the data was normal, Student's *t*-test and Pearson's *r* correlation coefficient were used to

Table 1. *Descriptive analysis*

	Glaucoma (n = 31)	Ocular hypertension (n = 37)	p value
Age (years)	62.9 (14.57)	63.2 (8.42)	NS
Refractive error	0.16 (4.69)	1.74 (2.97)	NS
HFS			
MD	−11.21 (7.53)	0.37 (1.89)	<0.001
PSD	7.20 (4.8)	2.46 (1.44)	<0.001
CPSD	6.03 (4.29)	1.42 (1.02)	<0.001
SF	2.37 (1.1)	1.56 (0.74)	<0.01
HRP			
GD	2.50 (1.7)	0.32 (1.58)	<0.001
LD	1.20 (0.53)	0.94 (0.27)	<0.05
NC	48.58 (25.11)	87.37 (25.2)	<0.01
FI	0.44 (0.24)	0.60 (0.21)	<0.01
DI	1.30 (0.3)	1.20 (0.2)	NS

n, number of eyes; HFA, Humphrey Field Analyzer; MD, mean deviation; PSD, pattern standard deviation; CPSD, corrected pattern standard deviation; SF, short-term fluctuation; HRP, high-pass resolution perimeter; GD, global deviation; LD, local deviation; NC, neural capacity; FI, form index; DI, dispersion index.

compare and correlate perimetric indices and RDA index between the glaucomatous group and ocular hypertension subjects. When the distribution of data was non-normal, the Mann–Whitney non-parametric test and Spearman correlation coefficient were used instead. A p value less than 0.05 was considered to be significant.

The glaucoma group was divided into three subgroups based on MD values to evaluate whether the DI performed better in patients with early glaucoma (MD > −6 dB), moderate glaucoma (−6 dB ≤ MD ≤ −12 dB) or advanced glaucoma (MD < − 12 dB).

To determine the capacity of DI to differentiate normal visual fields from glaucomatous fields, Frisèn and Rossitti's 95% percentile normal limit (1.14) was applied to all three subgroups.[5]

Results

Between the 31 cases of POAG and the 37 ocular hypertensives recruited there was no difference in terms of age and refractive error. A significant difference was found between glaucomatous patients and ocular hypertension subjects for MD, CPSD, PSD, GD, LD, NC and SF. No difference for DI was found between glaucoma and ocular hypertension (Table 1).

In the entire study population a significant correlation was found between DI and GD (r = 0.48, p < 0.001), LD (r = 0.36, p < 0.01), FI (r = −0.53, p < 0.001), NC (r = −0.55, p < 0.001), MD (r = −0.33, p < 0.05), CPSD (r = 0.38, p < 0.01), PSD (r = 0.35, p < 0.01) and SF (r = 0.33, p < 0.05) (Table 2).

When the correlation was calculated for the glaucomatous group only, similar results were found. In the ocular hypertensive group the DI was correlated with LD (r = 0.43, p < 0.01), FI (r = −0.4, p < 0.05) and PSD (r = 0.42, p < 0.05) (Table 2).

When the entire group was divided into three subgroups based on MD values, in the advanced glaucoma group (MD < −12 dB) the DI was 1.57 ± 0.36, in the moderate glaucoma group (−6 dB ≤ MD ≤ −12 dB) the DI was 1.2 ± 0.21 and in the early glaucoma group (MD > −6 dB) the DI was 1.12 ± 0.07.

When the 95% normal percentile was applied, the eyes classified by DI as glaucomatous were 9 of 16 in the advanced damage group, 4 of 9 in the moderate damage group and 5 of 11 in the early damage group.

Table 2. *Correlation between dispersion index and other visual field indices*

	All patients (n = 68)	Glaucoma (n = 31)	Ocular hypertension (n = 37)
HFA			
GD	0.48***	0.50**	NS
LD	0.36**	0.41*	0.43**
FI	−0.53***	−0.56**	−0.4*
NC	−0.55***	0.67***	NS
HRP			
HD	−0.33*	−0.5*	NS
CPSD	0.38**	0.6**	NS
PSD	0.35*	0.39*	0.42*
SF	0.33*	0.63***	NS

n, number of eyes; HFA, Humphrey Field Analyzer; MD, mean deviation; PSD, pattern standard deviation; CPSD, corrected pattern standard deviation; SF, short-term fluctuation; HRP, high-pass resolution perimeter; GD, global deviation; LD, local deviation; NC, neural capacity; FI, form index; DI, dispersion index.
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Discussion

HRP is a different technique to test the visual field that seems to be more sensitive than standard threshold perimetry.[2–4,9] With structured stimuli shaped as double-edge rings of different diameters, thresholds for detection and shape recognition are simultaneously measured. Wanger and Persson[10] found abnormal HRP results in a high percentage of eyes with suspected or early glaucoma when compared with results in normal eyes; however, their normal subjects were on average 10 years younger than their patients. Dannheim and co-workers,[11] comparing automatic standard threshold perimetry and HRP in glaucoma, found good agreement in the number of eyes detected as abnormal for each. In

contrast Lachenmayer and colleagues[12] found HRP to be less sensitive than automated light sense or flicker perimetry in detecting glaucoma.

Different techniques for examining visual function may provide the clinician with more information about the patient's status and are thus desirable. Automatic STP shows the values of each tested point, making it possible to differentiate normal from abnormal areas of the visual field. Several authors have introduced indices or algorithms to obtain clinically useful information. In order to quantify STP findings Flammer and co-workers[13] suggested the use of perimetric indices calculated from raw data provided by static computerised perimetry. Cumulative curves of the tested points ranked from the highest to the lowest sensitivity were proposed by Bebie and colleagues.[14]

HRP measures the thresholds at 50 locations in the central visual field. By analogy with standard threshold perimetry HRP measures the sensitivity of all the points tested. Visual field indices are also calculated. GD and LD are very similar to MD and CPSD or STP, and several authors found a strong correlation between them. FI and NC are calculated using different principles, yielding novel information on visual function.[5,15] As mentioned in Materials and Methods, the DI is obtained from the least square linear regression between the coefficient of variation of the five columns obtained by recursive pairing and interval length in logarithmic scale,[5] and should be able to detect early damage by fractal analysis.

The potential application of the DI should not be as an additional index to identify visual dysfunction, since it would be equally abnormal both in hemianopsia and localised paracentral scotoma, but rather the ability to detect early visual field defects. It should be applied to apparently normal visual fields in clinically suspicious cases such as patients with borderline clinical findings as glaucoma suspects or patients with ocular hypertension.

Generally, to read cumulative curves a standard threshold value map is necessary to avoid any misunderstanding in the results. In Bebie curves, a superior relative scotoma on an edge point due to the lens has the same representation as a nasal step. This is due to the fact that the Bebie curves may rank differently the data from each tested point each time the examination is repeated, regardless of their location. To overcome this difficulty, in RDA the raw data are ordered in a fixed sequence.

Although RDA uses a different method to evaluate the visual field based on fractal analysis, it uses a curve and an index to describe the visual field status. Although the concept on which this method is based makes it unusual for clinicians, the DI is theoretically able to capture mainly inhomogeneities in the distribution of threshold values across the tested points.

The strong correlation observed in our data between DI and all other HRP indices reflects the fact that the same raw values are entered and analysed with different algorithms. The weak correlation between DI and MD and the significant correlation with CPSD and PSD supports the use of this method for the detection of early localised defects or visual field inhomogeneity. However, in our sample this index did not identify precisely the abnormal visual fields and was not able to quantify the damage. Of 31 glaucomatous eyes, DI was abnormal in 18 and performed almost equally in each subgroup. Our selection of patients on the basis of a localised defect in the visual field could partially have biased some of these results.

DI showed good correlation both with HFA and with HRP indices of inhomogeneity, suggesting it had similar characteristics. Frisèn and Rossitti[5] reported that DI had a very high specificity. In our sample, the sensitivity was evaluated only in eyes with STP-evident glaucomatous damage, since in the ocular hypertension group an abnormal DI could be either a false positive of this new index or correctly indicate very early damage not yet detected by STP. The lack of any difference between the glaucomatous DI mean and the ocular hypertensive DI mean and the low sensitivity did not confirm previous results. One possible explanation was that in our sample all subjects classified as ocular hypertensives had, by definition, normal standard threshold perimetry results, thus making any correlation impossible within this subgroup and making it impossible to quantify the DI sensitivity. Another bias is possible due to the selection of our glaucomatous patients, based on STP and more localised defects.

The DI of HRP has the theoretical capacity to detect localised inhomogeneity of sensitivity. Our present results confirm that before its clinical application further studies on this HRP index are needed.

References

1. Frisèn L. High-pass resolution perimetry. Doc Ophthalmol 1993;83:1–25.
2. Lindblom B. High-pass resolution perimetry: a new method for the early detection of visual field. Chibret Int J Ophthalmol 1990;7:33–41.
3. Chauhan BC, House PH. Intratest variability in conventional and high-pass resolution perimetry. Ophthalmology 1991;98:79–83.
4. Douglas GR, Drance SM, Mikelberg FS, Schulzer M, Wijsman K. Variability of the Frisèn ring perimeter. In: Heijl A, editor. Perimetry update 1988/89. Amsterdam: Kugler and Ghedini, 1989:197–8.
5. Frisèn L, Rossitti S. Relative dispersion analysis enhances perimetric sensitivity. Vision Res 1996;31:491–7.
6. European Glaucoma Society. 1998 terminology and guidelines for glaucoma. Savona: Dogma, 1998:64–5.
7. Caprioli J. The contour of the juxtapapillary nerve fiber layer in glaucoma. Ophthalmology 1990;97:358–65.
8. Iester M, Swindale NV, Mikelberg FS. Sector based analysis of optic nerve head shape parameters and visual field indices in healthy and glaucomatous eyes. J Glaucoma 1997;6:371–6.
9. Birt CM, Shin DH, McCarty B, Kim C, Lee DT, Chung HS. Comparison between high-pass resolution perimetry and differential light sensitivity perimetry in patients with glaucoma. J Glaucoma 1998;7:111–6.
10. Wanger P, Persson HE. Pattern-reversal electroretinograms and high-pass resolution perimetry in suspected or early glaucoma. Ophthalmology 1987;94:1098–103.

11. Dannheim F, Abramo F, Verlohr D. Comparison of automated conventional and spatial resolution perimetry in glaucoma. In: Heijl A, editor. Perimetry update 1988/89. Amsterdam: Kugler and Ghedini, 1989:197–8.
12. Lachenmayer BJ, Drance SM, Douglas GR, Mikelberg FS. Light-sense, flicker and resolution perimetry in glaucoma: a comparative study. In: Mills RP, Heijl A, editors. Perimetry update 1990/91. Amsterdam: Kugler and Ghedini, 1991:351–6.
13. Flammer J, Jenni F, Bebie JH, Keller B. The Octopus glaucoma G-1 program. Glaucoma 1990;9:67–72.
14. Bebie H, Flammer J, Bebie TH. The cumulative defect curve: separation of local and diffuse components of visual field damage. Graefes Arch Clin Exp Ophthalmol 1989;227:9–12.
15. Frisèn L. Acuity perimetry: estimation of neural channels. Int Ophthalmol 1988;12:169–72.