



**INTERNATIONAL  
PERIMETRIC  
SOCIETY**

**IPS 2004: 16th Perimetry & Imaging  
Symposium**

**Barcelona, Spain**

**June 29-July 2, 2004**

**Preliminary Programme and Abstracts**

## Wednesday 30.6.04

8.00 - 8.45 [Breakfast with our sponsors](#)

8.45 - 9.00 Opening ceremony

9.00 - 10.15	<b>Scientific Session 1</b>	Title of the session: <b>Detecting Progression</b>		
	Moderators: Balwantray David	Chauhan Crabb		
9.00 - 9.02			Introduction	
9.02 - 9.15	Andrew	Turpin	Improving GCP Limits Using Patient and Procedure Knowledge	paper
9.15 - 9.28	Nomdo	Jansonius	Bayes' Theorem Applied to Perimetric Progression Detection in Glaucoma	paper
9.28 - 9.41	David	Crabb	A New Approach to Detecting Change in Series of Retinal Images Acquired from Scanning Laser Tomography	paper
9.41 - 9.54	Balwantray	Chauhan	Criteria for change with the Heidelberg Retina Tomograph in healthy subjects and patients with glaucoma	paper
9.54 - 10.07	Chris	Johnson	A Glaucoma Change Probability (GCP) Analysis Procedure for Frequency Doubling Technology (FDT) Perimetry	paper
10.07 - 10.15			Discussion	

10.15 - 10.45 Coffee

10.45 - 11.45	<b>Scientific Session 2</b>	Title of the session: Psychophysics/Electrophysiol		
	Moderators: Chris	Johnson TBA		
10.45 - 10.47			Introduction	
10.47 - 11.01	Marta	Gonzalez-Hernandez	Spatial Summation Estimation in the Central Visual Field	paper
11.01 - 11.15	Allison	McKendrick	Psychophysical assessment of Contrast Gain Abnormalities in Magnocellular and Parvocellular Pathways in Glaucoma	paper
11.15 - 11.20	Marie-Josée	Fredette	The Influence of Light Scattering on FDT2 Measurements	poster
11.20 - 11.34	Roman	Blanco	Analysis of Local Damage to the Optic Nerve in Glaucoma with the Multifocal Electroretinogram Compared to the Multifocal Visual Evoked Potential Technique	paper
11.34 - 11.45			Discussion	

11.45 - 12.15 **3rd IPS Lecture** Douglas Anderson

12.15 - 13.00 [Aperitif with our sponsors](#)

13.00 - 14.00 Lunch

14.00 - 15.30	<b>Scientific Session 3</b>	Title of the session: Clinical perimetry		
	Moderators: TBA	TBA		
14.00 - 14.02			Introduction	
14.02 - 14.16	Aljoscha Steffen	Neubauer	Effect of Retinal Thickness on Central Visual Fields in Diabetic Retinopathy	paper
14.16 - 14.30	Bettina	Wabbels	Automated Static and Kinetic Visual Field Testing in Children	paper
14.30 - 14.35	Francesco	Morescalchi	Central visual field in patients affected by diffuse macular edema, after intraocular injection of triamcinolone acetonide	poster
14.35 - 14.40	Francesco	Morescalchi	Predicting reading speed from central visual field results	poster
14.40 - 14.54	Hiroyuki	Iijima	Automated static perimetry in eyes with central serous chorioretinopathy	paper
14.54 - 14.59	Mohamed	Saad	Visual Field Before and After Vitrectomy and Laser Photocoagulation for the Treatment of Diffuse Diabetic Macular Edema	poster
14.59 - 15.04	Eiko	Arimura	Quantification of Metamorphopsia in Patients with Macular Hole Using M-Charts	poster
15.04 - 15.09	Elena	Sorli	Transitory Functional Defects Showed by Tendency Oriented Perimetry (TOP) in Patients with Mild Brain Trauma	poster
15.09 - 15.14	Fritz	Dannheim	Rehabilitation of the Visual Field in Cerebral Lesions	poster
15.14 - 15.28	Ulrich	Schiefer	Kin-Train - a computer-based interactive teaching and scoring tool for practicing kinetic perimetry	paper
15.28 - 15.30			Discussion	

15.30 - 16.00 Coffee

16.00 - 17.15	<b>Scientific Session 4</b>	Title of the session: Fundus perimetry		
	Moderators: Ulrich Linda	Schiefer Zangwill		
16.00 - 16.02			Introduction	
16.02 - 16.16	Christina	Springer	Fundus perimetry with the MP 1 in normals - comparison to conventional threshold perimetry	paper
16.16 - 16.30	Klaus	Rohrschneider	Fundus perimetry in the long-term follow-up of Stargardt's disease	paper
16.30 - 16.35	Christina	Springer	Choice of stimulus duration and fixation object in fundus perimetry	poster
16.35 - 16.40	Tomoko	Sawada	An experimental automatic perimeter displaying fundus images and using very small targets	poster
16.40 - 16.50			Discussion	
16.50-17.00	Tribute to Professor Haratuke Matsuo by Professor Aiko Iwase			
17.00-17.10	Tribute to Professor Dr. Heinrich Harms by Professor Dr. Ulrich Schiefer			

## Thursday 1.7.04

8.00 - 8.45 [Breakfast with our sponsors](#)

9.00 - 10.30	<b>Scientific Session 5</b>	Title of the session: New perimetric Techniques		
	Moderators: Paul Mike	Spry Wall		
9.00 - 9.02			Introduction	
9.02 - 9.16	Chota	Matsumoto	Automated Flicker Perimetry Using Octopus 311	Paper
9.16 - 9.30	Paolo	Brusini	Rarebit Perimetry: A New Non-Conventional Visual Field Testing Method for Early Glaucomatous Functional Damage Detection	Paper
9.30 - 9.35	Steven	Newman	RAREbit: a novel perimetric strategy for detection of subtle optic nerve dysfunction	Poster
9.35 - 9.40	Sean	Ianchulev	Virtual Perimetry for glaucoma screening in the population	Poster
9.40 - 9.54	Andrew	Patterson	Testing a New Approach to Detecting Change in Series of Retinal Images Acquired from Scanning Laser Tomography	Paper
9.54 - 10.08	Paul	Spry	Clinical Evaluation of the Humphrey Matrix	Paper
10.08 - 10.13	Michele	Altieri	A computerised psychophysical test for the early detection of M-Cell and P-Cell dysfunction in ocular hypertension and glaucoma	Poster
10.13 - 10.18	Taketoshi	Suzuki	Usefulness of Eye Check Chart in Glaucomatous and Neuro-Ophthalmological Diseases	Poster
10.18 - 10.30			Discussion	

10.30 -11.00 Coffee

11.00 - 12.15	<b>Scientific Session 6</b>	Title of the session: Comparison of tests 1		
	Moderators: Paolo	TBA Brusini		
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11.02 - 11.16	Paolo	Capris	Test-Retest and Inter-Test Variability of SITA Fast and Clip Threshold Estimation	paper
11.16 - 11.30	T	Agawa	Comparison of Detectability of Early Glaucoma Using Scanning Laser Polarimetry and Frequency Doubling Technology	paper
11.30 - 11.44	Katarzyna	Nowomiejska	Semi-Automated Kinetic Perimetry (SKP) and Manual Kinetic Goldmann Perimetry in Patients with Advanced Visual Field Loss	paper
11.44 - 11.49	Carmen	Mendez Hernandez	Laser Polarimetry and White-White, Pulsar, FDT and Flicker Perimetries in Ocular Hypertension	poster
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11.59 - 12.10			Discussion	

12.10 - 13.00 [Aperitif with our sponsors](#)

13.00 - 19.00 [Lunch - Gaudi & Modernistic Barcelona / Ciutat Vella Tour](#)

## Friday 2.7.04

8.00 - 8.45 Breakfast with our sponsors

9.00 - 10.30	<b>Scientific Session 7</b>	Title of the session: Perimetric analysis	
	Moderators: David Aiko	Garway-Heath Iwase	
9.00 - 9.02		Introduction	
9.02 - 9.16	Yoshio	Yamazaki	Unilateral progression of visual field defects in normal-tension glaucoma paper
9.16 - 9.30	Andrea	Perdicchi	Analysis of visual field damage in glaucomatous paper
9.30 - 9.35	Yoko	Ishii	Frequency of nasal step and Bjerrum scotoma in early stage of glaucoma poster
9.35 - 9.40	G F	Pelliccioli	Modelling Visual Field Sensitivity Decay Over Time poster
9.40 - 9.56	Agnes	Hermann	Age-dependent normative values of differential luminance sensitivity in automated static perimetry - a formula converting threshold data obtained with TCC (Tuebingen Computer Campimeter) and Octopus 101 paper
9.56 - 10.10	Jens	Paetzold	Age-dependent reference values of semi-automated kinetic perimetry (SKP) with consideration of individual reaction times using the Octopus 101 paper
10.10 - 10.15	Sachiko	Okuyama	The Unility of Reliability Indices in Automated Perimetry: Forced Wrong Response Tests in Normal poster
10.15 - 10.20	Aiko	Iwase	A new quantitative analytical software for the HFA gaze tracking system poster
10.20 - 10.30			Discussion

10.30 - 11.00 Coffee

11.00 - 12.15	<b>Scientific Session 8</b>	Title of the session: Comparison of tests 2	
	Moderators: Paul	TBA Artes	
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11.02 - 11.16	Manuel	Gonzalez de la Ro	TOP-WW, Pulsar, FDT and HRT-II Diagnosis Reproducibility in Glaucoma Suspects paper
11.16 - 11.30	Lene	Martin	FDT and Rarebit Perimetry in Paediatric Glaucoma and Normal Controls paper
11.30 - 11.44	Ronald	Schuchard	Comparison of SLO Macular Perimetry, Binocular Perimetry, and Functional Visual Field Perimetry paper
11.44 - 11.58	Paul	Artes	The relationship between event-type change analyses with conventional perimetry (SAP), Frisen Ring perimetry (HRP), and Heidelberg Retina Tomography (HRT) in patients with glaucoma paper
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12.10 - 13.00 Aperitif with our sponsors

13.00 - 14.00 Lunch

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	Moderators: Ronald David	Harwerth Henson	
14.00 - 14.02		Introduction	
14.02 - 14.16	Ronald	Harwerth	Scaling the structure-function relationship for clinical GDx VCC and white on white perimetry in glaucoma paper
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14.40 - 14.54	Michele	Iester	Longitudinal change in optic disc topography and Sectorial Correlation Between Frequency Doubling Technology Sensitivity and Heidelberg Retina Tomograph Rim Area and Cup Shape Measure poster
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15.50 - 15.55	Lidia	Kria	Assessment of Inter-eye Differences of Optic Nerve Head Topographic Measurements by Heidelberg Retina Tomograph in Normal, Open-Angle Glaucoma and Ocular Hypertension Eyes - a study on Tunisian poster
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## IMPROVING GCP LIMITS USING PATIENT AND PROCEDURE KNOWLEDGE

A Turpin<sup>1</sup>, AM McKendrick<sup>2</sup>, BC Chauhan<sup>3</sup>. Curtin University of Technology, Perth, Australia<sup>1</sup>, University of Western Australia, Perth, Australia<sup>2</sup>, Dalhousie University, Halifax, Canada<sup>3</sup>.

**Purpose:** To show how the accuracy of the Glaucoma Change Probability (GCP) can be improved if individual patient variability and the characteristics of the visual field testing algorithm are taken into account.

**Methods:** Exhaustive computer-based analysis of all possible response sequences was used to derive 95% confidence intervals (CI) for end-point sensitivity measures using the Full Threshold algorithm under a variety of patient variability models. The models consisted of all combinations of frequency-of-seeing curve slopes following a Cumulative Gaussian curve with standard deviations of 1 through 5 dB and false positive and negative rates of 0%, 3%, 15% and 30%. For each model, the starting point of the Full Threshold algorithm (FT) was also varied to be  $\pm 4$  dB away from the patient's assumed "true" sensitivity.

**Results:** The table shows 95% CIs for end-points of FT starting at the value in the leftmost column for a patient with a true sensitivity of 20 dB under selected slopes (s) and false response rates.

Start	fp = 0% fn =		fp = 3% fn =		fp = 15% fn =		fp = 3% fn =	
	0%		3%		15%		15%	
Value	s = 1	s = 5	s = 1	s = 5	s = 1	s = 5	s = 1	s = 5
15 dB	15, 21	11, 23	16, 22	12, 24	12, 22	10, 22	14, 22	10, 24
20 dB	16, 20	14, 22	16, 20	12, 24	14, 20	10, 22	14, 22	12, 24
23 dB	17, 21	13, 25	18, 22	14, 26	14, 22	12, 26	16, 24	14, 26

**Conclusions:** Currently the limits used for determining whether a point has progressed or not using GCP is based solely on population values related to age-corrected baseline defect. This study demonstrates that individual patient variability and test procedure specific factors dramatically affect the 95% CIs of sensitivity measures, and should be considered when using GCP.

## **BAYES' THEOREM APPLIED TO PERIMETRIC PROGRESSION DETECTION IN GLAUCOMA**

NM Jansonius. Department of Ophthalmology, University Hospital Groningen,  
Groningen, The Netherlands.

**Purpose:** To calculate the posterior probability (positive predictive value) of progression for various established perimetric progression detection algorithms and for clinical assessment of series of visual fields.

**Methods:** Prior probability of progression was estimated from various published studies to be 5%, 10%, and 20% per year for well controlled, poorly controlled, and uncontrolled glaucoma respectively. Specificity of several established algorithms for progression detection (AGIS, CIGTS, GCP, PLRA) was estimated from literature to range from 0.80 to 0.99. Specificity of clinical assessment of series of visual fields was calculated to be 0.80 for 4 fields (2 baseline fields, 1 follow-up field after 1 year, and 1 confirmation of the suspected progression), 0.95 for 6 fields, and 0.99 for 10 fields. Calculations were performed for three different sensitivity values: 0.50, 0.80, and 1.00.

**Results:** Positive predictive value ranged from 12% to 96%. Positive predictive value was 64% for a prior probability of 10%, a sensitivity of 0.80, and a specificity of 0.95.

**Conclusions:** Realistic series of visual fields that are apparently progressive do have a positive predictive value of typically 50%, i.e. half of them is actually stable. In case of a high prior probability (uncontrolled glaucoma), 4 fields may be acceptable. If the suspicion is low, on the contrary, then even the generally accepted number of 6 visual fields is hardly sufficient

## A NEW APPROACH TO DETECTING CHANGE IN SERIES OF RETINAL IMAGES ACQUIRED FROM SCANNING LASER TOMOGRAPHY

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**Purpose:** To describe and apply a collection of new statistical technique for detecting topographic changes in the optic disc and peripapillary retina measured with the Heidelberg Retinal Tomograph (HRT)

**Methods:** Quantitative techniques, collectively referred to as Statistic Image Mapping, are widely used to measure activity and change in fMRI (functional magnetic resonance imaging) and PET (positron emission tomography) images of the brain. These techniques are adapted and applied to HRT images. In particular, we generate a test statistic at each pixel in series of aligned, pre-processed images, formed from linear regression of the topographic height against time of follow up. The standard error for this univariate statistic is corrected by a linear combination of the error at neighbouring pixels. Further, we compare the observed test statistic at each pixel against a distribution of all possible statistics by creating a permutation distribution of the images. This non-parametric approach relies wholly on the patient's own data and allows for meaningful results even if the data is sparse in time (short follow-up). Furthermore, use of the maximum test statistic permutation distribution solves the problem of multiple testing of pixels across the whole image, and thresholding discrete areas of changing pixels takes account of the spatial correlation that exists in the images. The techniques were developed from those used in fMRI brain activity experiments and implemented via purpose written software in C.

**Results:** The results from the analyses are summarised by an image superimposed on the HRT topography which, on a pixel by pixel basis, indicates areas that are changing beyond what would be expected by chance given the patient's follow up data alone. The permutation methods are computationally intensive, but a typical analysis takes approximately 2 minutes on a Pentium IV 2GHz processor.

**Conclusion:** Statistic Image Mapping appears to be an appropriate analysis for detecting change in digital images acquired by scanning laser tomography.

## **CRITERIA FOR CHANGE WITH THE HEIDELBERG RETINA TOMOGRAPH IN HEALTHY SUBJECTS AND PATIENTS WITH GLAUCOMA.**

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**Purpose:** To investigate criteria for change with the Heidelberg Retina Tomograph in healthy subjects and patients with glaucoma.

**Methods:** Ninety-five patients with glaucoma and 60 healthy controls were followed with 6-monthly Heidelberg Retina Tomograph 1 imaging for a mean of 6.3 years. Optic disk change was evaluated using the probability maps of the Heidelberg Eye Explorer (v 3.0.4.6) which show superpixels with statistically significant surface height change from baseline ( $p < 0.05$ ) in 3 consecutive mean topographies. The criteria for change were based on the size of the largest cluster of red (progressing) and green (improving) superpixels within the contour line, expressed as a percentage of disk area. Kaplan-Meier survival curves were derived with 3 criteria (2%, 5%, 10%), corresponding to cluster sizes of approximately 20, 50, and 100 superpixels within a typical disk area of  $2\text{mm}^2$ , respectively.

**Results:** Clusters of both red and green superpixels occurred more often in glaucoma patients than in healthy controls ( $p < 0.01$  with all criteria). In the controls, rates of progression and improvement were similar with any of the three criteria ( $p > 0.1$ , log-rank test). In contrast, the progression rates in the glaucoma group were, on average, twice as large as the rates of improvement. After 6 yrs of follow-up, the progression rate in glaucoma patients varied from 67% (largest cluster of red superpixels  $\geq 2\%$  of disk area) to 25% (largest cluster  $\geq 10\%$  of disk area); a criterion of 7.5% (largest cluster  $\geq 75$  superpixels in an average disk) gave an improvement rate just below 10% and a progression rate of 32% (95% CI; 24%, 40%).

**Conclusions:** The separation between survival curves for progression and improvement observed in the glaucoma patients, but not the healthy controls, confirms the validity of the change probability approach for analysing longitudinal HRT data. While clinicians looking for change should take into account the image quality, the quality of alignment as well as the amount of absolute height change, the criterion of ["largest cluster  $\geq 7.5\%$  of disk size"] appears to offer reasonable specificity for following glaucoma patients with the present implementation of the change probability software.

## A GLAUCOMA CHANGE PROBABILITY (GCP) ANALYSIS PROCEDURE FOR FREQUENCY DOUBLING TECHNOLOGY (FDT) PERIMETRY

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**Purpose:** Frequency Doubling Technology (FDT) perimetry has been reported to be sensitive for detecting glaucomatous, retinal and neuro-ophthalmologic visual field loss. However, the ability of FDT perimetry to determine progression has not been adequately determined to date. The purpose of this investigation was to evaluate the clinical efficacy of a Glaucoma Change Probability (GCP) analysis procedure for FDT perimetry to determine glaucomatous visual field progression. **Methods:** The Glaucoma Change Probability (GCP) and Glaucoma Progression Analysis (GPA) procedures are evaluations that permit examination of glaucomatous visual field progression for standard automated perimetry using the Humphrey Field Analyzer. To produce a similar visual field change probability procedure for FDT, we performed repeated testing in 64 patients with glaucomatous visual field loss and 47 normal control subjects. Standard automated perimetry and FDT perimetry (C-20 threshold test) were performed five times over a 4 week period of time. Empirical 5<sup>th</sup> and 95<sup>th</sup> percentiles were derived for each mean FDT sensitivity value to establish visual field locations on followup testing that were significantly better (+), worse (-) or within (o) the limits of variability in comparison to the baseline FDT visual field. The change probability analysis procedure is highly similar to the original methods employed by the Humphrey Field Analyzer for standard automated perimetry.

**Results:** Our findings indicate that it is possible to use this FDT GCP analysis procedure to monitor the visual field status of glaucoma patients and glaucoma suspects over extended time periods. Examples of glaucomatous visual field progression and stability will be presented for the FDT GCP analysis procedure.

**Conclusions:** The FDTGCP analysis procedure may be a useful clinical tool for the determination of glaucomatous visual field progression for the FDT perimeter. Further work at multiple centers will be needed to establish the overall clinical performance of this type of FDT visual field evaluation over time.

## **SPATIAL SUMMATION ESTIMATION IN THE CENTRAL VISUAL FIELD**

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**Introduction:** Classic kinetic perimetry based the equivalences between luminance (L) and stimulus area (A) in the equation  $L \times A^k = \text{constant}$ . Goldmann equivalences assume a value of  $k=0.83$ . Fankhauser estimated a difference between sizes Goldmann I and III of 3-4dB in the fovea (which is equivalent to  $k=0.291$ ) and 12dB at  $50^\circ$  of eccentricity ( $k=0.998$ ). Gramer estimated a change between sizes I and III and between III and V of 6-10dB (equivalent to a value of  $k=0.499-0.832$ ). We have evaluated the k value in 66 positions of the central visual field.

**Material and Methods:** A USB photometer was designed for automatically controlling the luminance scale of a video screen. 10 eyes of 10 healthy subjects (mean age 38.5 years, s.d.= 16.6) were examined for luminous thresholds in 66 locations of the central visual field (horizontal=  $-30^\circ$  to  $+30^\circ$ ) x (vertical=  $+24^\circ$  to  $-24^\circ$ ) with the TOP strategy, using stimuli of five different sizes (Goldmann 4, 3.5, 3, 2.5 and 1.9). The k value was calculated estimating the average of threshold equivalences for the five sizes.

**Results:** In relation to the threshold value obtained for size 4, sensitivity decreased 1.5, 2.9, 5.4 and 7.8 dB for the following sizes respectively. Therefore, a mean value of  $k=0.607$  was calculated for the whole visual field. The value of k increased in a lineal manner from the centre towards the periphery of the visual field, with a slope of 0.01 per degree ( $r=0.98$ ,  $p<0.01$ ). It was slightly higher in the inferior hemi-fields ( $k=0.657$ ) than in the superior hemi-fields ( $k=0.574$ ).

**Conclusions:** Spatial summation in the central visual field has specific values for every position, with slight variations depending on the eccentricity of the stimulus.

## PSYCHOPHYSICAL ASSESSMENT OF CONTRAST GAIN ABNORMALITIES IN MAGNOCELLULAR AND PARVOCELLULAR PATHWAYS IN GLAUCOMA

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**Purpose:** It is established that contrast sensitivity loss occurs in glaucoma. Contrast sensitivity is only one aspect of contrast processing. Another aspect is contrast gain control which enables adjustment of neuronal sensitivity to enable optimal response to the prevailing contrast conditions. This study compared the contribution of abnormalities of contrast sensitivity and contrast gain control to contrast processing abnormalities in early glaucoma.

**Methods:** Seventeen patients with primary open angle glaucoma and 17 approximately age-matched controls participated. Subjects were assessed foveally and mid-peripherally (12.5°). Glaucoma subjects were tested in a mid-peripheral region of normal visual field (neighbouring locations required to be within the normal 95% confidence limit on the Total Deviation plot of their most recent SITA/Full Threshold Humphrey Field Analyzer assessment). Control subjects were tested in matched locations. Contrast discrimination was assessed using the steady-pedestal (Magnocellular [M] pathway) and pulsed-pedestal (Parvocellular [P] pathway) stimuli of Pokorny and Smith (1997) for seven pedestal luminances between 15 and 75 cd/m<sup>2</sup>, presented on a background of 30 cd/m<sup>2</sup>.

**Results:** Glaucoma group thresholds were significantly elevated compared to controls foveally and peripherally on both the pulsed-pedestal (P) and steady-pedestal (M) tasks ( $p < 0.01$ ). Effect size statistics revealed a similar magnitude of deficits on M and P tasks. Foveal deficits were of a magnitude that could be explained by reduced contrast sensitivity, however the peripheral deficits were greater than predicted by reduced contrast sensitivity alone, consistent with an abnormality of contrast gain control.

**Conclusions:** Foveal and mid-peripheral dysfunction of M and P pathway contrast processing was identified in people with glaucoma, in areas of normal visual field performance. These findings are supportive of non-pathway-selective neural adaptation abnormalities in early glaucoma. This study suggests that contrast gain assessment may prove useful in detecting early glaucomatous functional loss.

Pokorny & Smith (1997) *J Opt Soc Am A*. 14: 2477-86.



## THE INFLUENCE OF LIGHT SCATTERING ON FDT2 MEASUREMENTS

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**Purpose:** To investigate the impact of light scattering, an optical property of certain type of cataracts, on the new frequency -doubling technology perimetry (FDT2: Humphrey Matrix with Welch Allyn FDT).

**Method:** 10 normal subjects (10 eyes) underwent 5 FDT2 measurements with 5 randomly ordered ground-glass diffusers including one clear glass. The effective optical densities of the diffusers were 0.06 (clear glass), 0.36, 0.78, 1.22, 1.67 log unit. The glare effect produced by these diffusers, measured by contrast sensitivity with a glare source (Miller-Nadler glare test), range from perception of the 5% contrast target to non-perception of the 75% contrast target. FDT2 MD, PSD and threshold values (dB) at 0 degree, 4.3 deg, 8.6 deg, 12.9 deg, 17.2 deg and 21.5 deg nasally along the 180 degree supero-central meridian were analyzed.

**Results:** The mean decrease in FDT2 MD were 6 dB, 15 dB, 23 dB and 28 dB respectively with 0.36, 0.78, 1.22 and 1.67 diffusers (statistically significant with  $p < 0.01$  for each diffuser compared to the clear glass). On PSD, no statistically significant change were recorded with each diffuser ( $p > 0.05$ ). Threshold value decrease was similar at every eccentricity (0 to 21.5 degree). Using the same diffusers, standard automated perimetry with Humphrey Visual Field were previously shown to decrease the mean threshold value by 3.3 dB, 8.1 dB, 12.6 dB and 18.3 dB respectively for the same diffusers.

**Conclusion:** Even minimal light scattering, such as might be caused by a mild cataract, may influence the threshold values measured by frequency-doubling technology; just as was previously shown for standard automated perimetric measurements. The difference in the magnitude of the impact may be explained by the different definition and conversion factor used to transform perceived contrast/light to a decibel scale. Studies on eyes with cataracts that have scattering properties are needed. Might abnormal optical properties of the ocular media help explain cases when decibel values of SAP and FDT2 Matrix fail to match?

# **ANALYSIS OF LOCAL DAMAGE TO THE OPTIC NERVE IN GLAUCOMA WITH THE MULTIFOCAL ELECTRORETINOGRAM COMPARED TO THE MULTIFOCAL VISUAL EVOKED POTENTIAL TECHNIQUE**

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**Purpose:** 1. To evaluate the electrophysiologic function in glaucoma by using a new protocol of the multifocal electroretinogram (mf-ERG) that emphasizes response contributions from ganglion cell fibers (optic nerve head component (ONHC)). 2. To compare glaucomatous losses in the ONHC with those estimated through inter-ocular comparison of the multifocal visual evoked potentials (mf-VEP).

**Methods:** mfERGs and mfVEPs of 26 individuals with glaucoma and 26 normal subjects were recorded and analysed with the VERIS 5.1 multifocal recording system.

**Stimulation:** The special, ganglion cell response enhancing protocol consisted of multifocal flash stimuli interleaved with two global flashes presented 13.3 ms and 40 ms after each multifocal frame. The intensity of both multifocal and global flashes was 2.7 cd•s/m<sup>2</sup>. The stimulus array consisted of 103 scaled hexagons. The recording time was 9 minutes per each eye. Pupils were dilated. The mfVEP stimulus consisted of a 60-sector dartboard grid, with each sector containing a contrast reversing check pattern. The mean stimulus luminance was 200 cd/m<sup>2</sup> viewed through a natural pupil. All multifocal stimulus arrays subtended ca. 45 degrees. The net recording time was 14 minutes per eye. **Analysis:** The effect induced by the focal flashes on the second one of the following global flashes contains the most prominent ONHC and was thus used for the evaluation of the mfERG data. Inter-ocular differences in focal VEP amplitude ratios were evaluated against those due to the noise contamination in each record.

**Results:** In advanced glaucoma the ONHC was mostly extinct. In early glaucoma areas with a visibly reduced ONHC generally matched but exceeded areas with local sensitivity changes seen in visual field by standard automatic achromatic perimetry. This suggests a far more undetected advanced damage to the ganglion cells in glaucoma. While large local inter-ocular differences were easily detected with the mfVEP technique, homonomous bilateral damage could not easily be distinguished from local signal reduction due to the convoluted cortical anatomy.

**Conclusions:** Our data suggest that in glaucoma, where the presentation is commonly bilateral, the ONHC protocol of the mfERG provides a better topographic evaluation than the inter-ocular mfVEP analysis. While a larger scale evaluation is needed, the study suggests that the ONHC analysis may outperform standard achromatic perimetry in sensitivity and reproducibility.

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## EFFECT OF RETINAL THICKNESS ON CENTRAL VISUAL FIELDS IN DIABETIC RETINOPATHY

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**Purpose:** While central retinal thickness is known to correlate well with visual acuity, little is known about the effect of posterior pole thickening on the central visual field. This study therefore investigates the correlation of central visual field and retinal thickness in diabetic patients.

**Methods:** On 39 eyes from 39 patients with systemic diabetes besides a complete clinical examination a 10-2 HFA perimetry and objective measurements of retinal thickness were performed by optical coherence tomography (OCT) and retinal thickness analyzer (RTA). Twenty-six patients had previously received focal laser therapy, while the remaining 13 did never receive any laser treatment.

**Results:** A good correlation of visual acuity and central retinal thickness was found with both instruments, OCT and RTA, which correlated highly with each other ( $r=0.82$ ,  $p<0.000$ ). Visual acuity also correlated strongly with the mean defect (MD) on visual fields (VF;  $r=0.50$ ,  $p=0.001$ ) but not with the pattern standard deviation (PSD). Subgroup analysis was performed on three groups: 1) clinically no diabetic retinopathy, 2) clinically significant macular edema and 3) macular edema after focal laser treatment. Although group 1 had a tendency towards a lower MD and PSD on ANOVA no significant difference was found between the groups. Retinal thickness in group 1 without retinopathy was significantly lower than the other groups. The eyes after laser treatment (group 3) showed a tendency towards lower retinal thickness and better visual acuity than group 2 but the same MD and PSD on VF. A good topographic correlation of VF defects and retinal thickening could be shown.

**Conclusions:** Central macular retinal thickness is vital for visual acuity. Thickened retina corresponds topographic to scotomas in visual fields. Focal laser treatment seems not to cause significant field defects.

## AUTOMATED STATIC AND KINETIC VISUAL FIELD TESTING IN CHILDREN

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**Purpose:** Visual field testing in children is always a challenge. Testing is hampered by fatigue effects, rapid boredom, lack of comprehension and easy distraction. The few studies concerning automated static visual field testing in children mainly agree that interindividual variability is high. We now tested feasibility and outcome of visual field testing in a standard clinical setting, comparing fast threshold strategy with the new CLIP (continuous light increment perimetry) strategy and using automated kinetic perimetry.

**Methods:** We examined 28 children aged 5-14 years at the Twinfield-perimeter. Included were healthy children, children with unilateral pathologies (normal eye tested) and children with strabismus. Automated kinetic perimetry was performed according to the Goldmann-standard with a test velocity of 2°/s with stimuli III/4, I/4, I/2 and I/1. Static perimetry was done with fast threshold strategy and CLIP-strategy in randomised order. One eye per subject was examined, each test was performed twice.

**Results:** Interindividual variability was high, even at the same age. Not all children were able to complete the entire procedure. Starting from age 7, reliable results were obtained in many children, starting from age 12, in most cases adult testing strategies were possible with good reproducibility for static and kinetic testing. CLIP seemed easier to perform than fast threshold, and found higher mean sensitivities. There was no significant difference between the children with strabismus and the other children.

**Conclusion:** Formal visual field testing in children is time consuming, but can be successfully performed in many children. Test performance was more dependent on the child's maturity and ability to concentrate than on age. If visual field testing is planned, desired accuracy and feasibility should be balanced. It is likely that children with visual disturbances might experience greater difficulty in undergoing such examinations than otherwise healthy children. Automated kinetic perimetry could be used to reliably monitor children under Vigabatrin therapy.

## **CENTRAL VISUAL FIELD IN PATIENTS AFFECTED BY DIFFUSE MACULAR EDEMA, AFTER INTRAOCULAR INJECTION OF TRIAMCINOLONE ACETONIDE.**

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**Purpose:** To investigate the effects on visual performance of intravitreal triamcinolone acetonide for the treatment of refractory diabetic macular edema.

**Methods:** Prospective case series study including eyes with significant diffuse or cystoid diabetic macular edema unresponsive to previous sessions of grid or focal laser treatment. In all patients included in the study group, 20 mg of triamcinolone acetonide were injected into the vitreous cavity. The visual and the anatomic responses were observed as well as complication related to the procedure. Visual acuity (using the ETDRS chart), reading speed, contrast sensitivity, visual field test (program 10-2, HFA II) and fluoroangiographic examination were assessed.

**Results:** Thirty eyes of 27 patients completed 6 or more months of follow-up. The mean ETDRS visual acuity improved from 20/80 to 20/40 at the 6<sup>th</sup> month follow-up visit. A dramatic improvement of contrast sensitivity and reading speed was registered in most of patients. This result was more consistent than the visual acuity improvement. The final reading speed value (mean: 98 words/minutes) was significantly better than the preoperative one (mean: 59 words/minutes). The central visual field improved in 22 patients. The central 4° showed the most significant improvement of mean sensitivity. There was a complete resolution of diabetic macular edema, documented by fluoroangiography in all eyes within 30 days after injection and in 24 eyes at the 6<sup>th</sup> month follow-up. All patients were treated with topical ocular antihypertensive therapy; 2 patients experienced IOP elevation of 28 mmHg in spite of the maximal topical antiglaucomatous therapy. After ALT, the IOP levels returned to normality in both cases.

**Conclusions:** Intravitreal triamcinolone is a promising therapeutic method that improves the quality of vision of patients affected by diabetic macular edema that fails to respond to conventional laser treatments. No vitreo-retinal complications (retinal detachment, vitreous haemorrhage or endophthalmitis) were experienced in the current study group. The major ocular side effect was IOP elevation but, in this series, the IOP of all patients was normal without any therapy after 6 months.

The improvement in reading speed and contrast sensitivity was correlated to the improvement of the central retinal sensitivity assessed with standard automatic perimetry. Further studies are necessary to assess the long-term efficacy of this therapy.

## PREDICTING READING SPEED FROM CENTRAL VISUAL FIELD RESULTS.

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**Purpose.** To investigate the correlation between reading speed and mean sensitivity of different areas of the central visual field in patients with relative central scotomas caused by diffuse macular edema.

**Methods :** 90 visual fields were obtained in patients with varying degree of diffuse macular edema, using the Humphrey 10-2 sita standard procedure. All patients underwent at least two previous perimetric examinations and those with a history of poor fixation were excluded from the study. The average sensitivity of nine areas of the central visual field were examined: central 2°, 4°, 6°, 8°, 10° and four quadrants (upper-right and left, lower-right and left) of the central 4°.

All patients underwent a complete evaluation of macular functions including high and low contrast distance visual acuity, near reading acuity and oral reading speed. Differences in correlation between each functional parameter and oral reading speed were evaluated.

**Results:** The central 2° and 4° ( $r = 0.78$  and  $r = 0.79$ ,  $P = 0.000$ ) and the 4° ( $r = 0.82$ ,  $P = 0.000$ ) upper-right quadrant provided better prediction of oral reading speed than the other parameters including MD ( $r = 0.62$ ,  $P = 0.001$ ) and distance visual acuity ( $r = -0.51$ ,  $P = 0.013$ ). Patients with a scotoma in the upper-right quadrant were significantly slower in reading performance. This finding was confirmed by the positive correlation between reading speed and PSD in this area ( $r = 0.43$ ,  $P = 0.01$ ). A significant correlation was also found between MS and reading speed with low contrast visual acuity.

**Conclusion:** The capacity to read has a major impact on the quality of life. Patients with relative scotomas in their central 10° often have visual performance difficulties far exceeding what would be expected from reduced visual acuity alone. On the other hand, patients with the same low visual acuity may complain different disability in reading, task performance and daily activities. Standard automatic perimetry may help to quantify their visual disability. The mean sensitivity of the central 4° and, in particular, of the upper-right quadrant mean sensitivity may provide good estimates of functional visual performance and related quality of life.

## **AUTOMATED STATIC PERIMETRY IN EYES WITH CENTRAL SEROUS CHORIORETINOPATHY**

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**Purpose:** To study the central visual field abnormality seen in eyes with central serous chorioretinopathy (CSC), which has rarely been evaluated quantitatively using automated static perimetry in a clinical study. The author claims that the severity of the disease should be assessed by the mean deviation (MD) of the central 10-degree automated static perimetry, which is independent of the visual acuity.

**Methods:** We reviewed the results of Humphrey perimetry, central 10-2 program taken for 121 eyes of 118 patients (22 female and 96 male) with CSC seen in our hospital between 1993 and 2003. A total of 132 episodes of serous retinal detachment (98 initial and 34 recurrent) was studied. In order to study the effects of active serous retinal detachment on the central visual field, eyes with obvious RPE atrophy evidenced by the angiographic window defects were excluded.

**Results:** Central visual field abnormality in eyes with CSC varied from no defects to severe and large central scotoma. Mean deviation (MD) ranged from -21.1 dB to 2.6 dB with the mean of -3.8 dB. Thirty seven of 132 perimetric results (28%) showed MD lower than -5 dB. The best corrected visual acuity ranged between 0.07 and 1.5 with the median of 0.7. The correlation between MD and logarithm of minimum angle of resolution (logMAR) was not significant ( $r = -0.116$ ,  $P = .186$ ) implying that the severity of central field defects could not be predicted from the visual acuity.

**Conclusion:** Eyes with CSC show various degrees of central visual field loss. Poor correlation between MD and corrected visual acuity implies that many eyes with CSC showing near normal visual acuity may suffer from severe central visual field abnormality. Automated static perimetry measuring the central 10-degree visual field in an eye with CSC provides additional information for assessing visual disability that could not be predicted by visual acuity testing.

## **VISUAL FIELD BEFORE AND AFTER VITRECTOMY AND LASER PHOTOCOAGULATION FOR THE TREATMENT OF DIFFUSE DIABETIC MACULAR EDEMA**

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**Purpose:** To determine the effect of vitrectomy and laser photocoagulation used for the treatment of diffuse diabetic macular edema on central visual field.

**Methods:** 40 eyes of 36 patients with diffuse diabetic macular edema (clinically significant) were classified into two groups: Group I included 20 eyes treated by vitrectomy, Group II included 20 eyes treated by laser photocoagulation. Patients were subjected to detailed history taking, clinical ophthalmic examination with slit lamp biomicroscopy with fundus contact lens, fluorescein angiography and automated perimetry using Octopus 301 (macular and 32 programs).

**Results:** Significant visual acuity improvement was recorded in group I while the improvement was not significant in group II. Eyes in group I showed mild improvement in the visual field in most cases, while eyes in group II showed some deterioration in the visual field parameters. In 9 patients of group II new paracentral scotomata were observed post-laser treatment.

**Conclusion:** Paracentral scotomata might be caused by laser burns after treatment by photocoagulation.



## QUANTIFICATION OF METAMORPHOSIA IN PATIENTS WITH MACULAR HOLE USING M-CHARTS™

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**Purpose:** In case of macular hole, metamorphosis is one of the most important symptoms as well as the visual loss and the central scotoma. We investigated the relationship between the degree of the metamorphosis and the morphological changes of macular hole.

**Subjects and Methods:** Using M-CHARTS™ developed by us, we quantified the metamorphosis scores of 35 eyes of 35 patients with idiopathic macular hole. We also evaluated the corrected visual acuity and the central 10° differential light sensitivity using Octopus 101 program M2. The size of the macular hole and the fluid cuff were measured using scanning laser ophthalmoscope (SLO) and OCT3 images. In 22 patients, we also evaluated improvement of the metamorphosis scores after vitrectomy.

**Results:** The metamorphosis of macular hole patients were characterized by the straight lines bending toward the central scotoma. There was a significant correlation between the metamorphosis score and the fluid cuff size. After vitrectomy, the visual acuity improved in 14 patients and the metamorphosis scores improved in 16 patients.

**Conclusion:** M-CHARTS™ is a simple and useful method for the quantification and the follow-up of metamorphosis in patients with macular hole.

## **TRANSITORY FUNCTIONAL DEFECTS SHOWED BY TENDENCY ORIENTED PERIMETRY (TOP) IN PATIENTS WITH MILD BRAIN TRAUMA**

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**Purpose:** To analyze the results of the TOP perimetric strategy in patients with mild brain trauma.

**Methods:** Both eyes of 36 patients, without previous ocular, vascular or neurological pathology; affected of mild brain trauma, (GCS among 13-15, without pathological findings in Computer Tomography examination, with loss of consciousness for less than 30 minutes and episode of amnesia for less than 24 hours), were examined using the TOP strategy and the Octopus 1-2-3 three times (twice a week after the traumatism and once a month later). The obtained data was compared with a control group of 36 subjects examined twice.

**Results:** The MD and LV square root (sLV) were significantly higher in the first two examinations (MD = 3.1 and 4.0dB, sLV = 2.8 and 2.9dB) than in the third one (MD = 1.0dB, sLV = 1.9dB) ( $p < 0.01$ ). There were not differences between the MD and sLV of the third exam of the pathological group and the two examinations of the control group (MD = 0.6 and 0.7dB, sLV = 1.9 and 1.8dB) ( $p > 0.05$ ), indicating a complete recovery. The test-retest threshold fluctuation of the pathological group (3.2 +/- 2.9dB) showed a highly significant difference with regard to the control group (1.2 +/- 1.2dB) ( $p < 0.01$ ). 28.9% of the examined points in the first two examinations of the pathological group showed relative scotomas. Among them, 52.1% were reproduced in the same position in both examinations and 48.2% coincided in homonymous points of both eyes.

**Conclusions:** It seems that a transitory neurological defect occurs in these patients; it can be evidenced as a diffuse deterioration of the retinal sensibility, with increased threshold fluctuation. The analysis of the focal visual field loss disposition indicates that there is a neurological suffering with some certain topographical preferences, which is specific in each case.

## **REHABILITATION OF THE VISUAL FIELD IN CEREBRAL LESIONS**

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**Purpose:** 20 - 30% of patients in rehabilitation centres for neurological disorders suffer from visual field deficits, most often as homonymous defects. Training programs for restitution of function by repeated stimulation of the defective field under steady fixation are of limited value. A diagnostic program is presented for the evaluation and monitoring of field defects during compensational training of search saccades.

**Method:** A computer program was developed projecting a scenic screen on which a central fixation icon is superimposed alternating with a search icon in 11 positions within the 45° field in random order. The time required to detect the search icon is recorded for each presentation. 2 consecutive series allow an estimation of short term fluctuation or short term training effects.

**Results:** In a pilot study, this program has been applied to a group of 10 patients suffering mainly from hemianopic field defects of different origin. A follow up after training of search saccades was possible in some of them. The time lag for the search in the affected hemifield was reduced. This effect corresponded to the normalization of a computer assisted line division test.

**Conclusion:** A diagnostic test for the evaluation of practical performance in the visual environment allows to monitor training effects of compensational visual rehabilitation in cerebral lesions.

## ***KIN-TRAIN* – A COMPUTER-BASED INTERACTIVE TEACHING AND SCORING TOOL FOR PRACTICING KINETIC PERIMETRY**

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**Purpose:** To create an interactive computer-based teaching software for kinetic perimetry with an implemented evaluation system for scoring examination technique.

**Methods:** This software is based on the original user interface of the new semi-automated kinetic perimetry (SKP) feature of the OCTOPUS 101 perimeter (HAAG-STREIT, Koeniz, CH).

The *trainer* creates a (pseudo-) 3D individual “hill of vision” with a specific pathology. Response characteristics can be modified by altering the individual frequency of seeing curve, reaction time, fixation quality, ocular alignment, and pupil size of the virtual patient. The trainer may also enter relevant findings and images regarding patient’s history, current complaints etc. into a comprehensive electronic medical chart.

The *trainee* can individually select target characteristics (angular velocity, stimulus size and luminance). He also independently defines origin, end and thereby direction of each kinetic stimulus with the help of so-called vectors. As soon as the kinetic stimulus, moving along a given vector, is perceived by the virtual patient according to the previously defined conditions, this position is marked as “local kinetic threshold”. Quality of the perimetric examination can be quantitatively assessed by the ratio of intersection area and union area of the individual trainee’s result and the related trainer-defined original isopter. These ratio values and other parameters, such as detection of the blind spot, classification of the assessed scotoma, examination duration etc., determine a score. Weight of the parameters can be adjusted. The score allows for certification of the trainee, based on predefined standards.

**Results:** Meanwhile representative scotoma patterns (e.g. hemianopic field loss, nerve fiber related defects, concentric constrictions, central scotoma), together with related patients’ charts have been entered into the actual training software version, which has already been successfully used in several perimetric courses.

**Conclusion:** *KIN-TRAIN* is a computer-based interactive learning tool, which allows for certifiable education in kinetic perimetry.

## **FUNDUS PERIMETRY WITH THE MP 1 IN NORMALS – COMPARISON TO CONVENTIONAL THRESHOLD PERIMETRY**

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**Purpose:** The Micro Perimeter 1 permits an automated full threshold static fundus perimetry. For the evaluation of the perimetric results normal values are essential, but do not exist up to now. Aim of this study was to determine light sensitivity threshold values obtained with the MP1 in healthy volunteers and to correlate them with conventional automated static perimetry using the Octopus 101 Perimeter.

**Methods:** In 25 healthy eyes of 25 healthy volunteers static threshold perimetry was performed with the Octopus 101 (Haag-Streit AG, Switzerland), program CT1, and the MP1 Micro Perimeter (Nidek Inc., Italy) in random order. Light increment threshold sensitivity values were compared for 21 matching points in a rectangular test grid using similar examination settings (Goldmann III stimuli, presentation time 100 ms, white background illumination of 1.27 cd/m<sup>2</sup>). The Octopus 101 CT1 program tested 77 locations in a rectangular 6degree grid in an area of 28 x 28 degrees while the MP1 tested 70 stimulus locations in a rectangular 3-degree grid covering an area of 27 x 18 degrees.

**Results:** For the 21 matching locations mean light sensitivity was 15.5 dB (range 13.0-17.1 dB) with the MP 1 and 30.3 dB (range 27.7-33.9 dB) with the Octopus. On the average the Octopus showed higher threshold values for all test locations than the MP1 did. The mean difference between both examinations was  $14.8 \pm 1.3$  dB comprising all locations and  $15 \pm 1.2$  dB excluding the test locations at the blind spot. The difference between the two devices varied from 12.3 to 17.5 dB showing nearly the same difference for each location except in the surrounding of the blind spot.

**Conclusion:** The results display that there exists a systemic difference between both devices of about 15 dB. The stimulus location did not influence this difference significantly. Light sensitivity values in microperimetry with the MP1 are comparable to the threshold values obtained with the Octopus 101 using a correction factor of about 15 dB.

## FUNDUS PERIMETRY IN THE LONG-TERM FOLLOW-UP OF STARGARDT'S DISEASE

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**Purpose:** To assess and evaluate functional changes in fundus perimetry during the long-term follow-up of patients with Stargardt's disease and fundus flavimaculatus.

**Methods:** Fundus perimetry with the Scanning Laser Ophthalmoscope was performed in 35 eyes of 18 patients with stargardt's macular dystrophy or fundus flavimaculatus over a mean follow-up period of 4 years (1 to 9 years). Static threshold perimetry with a 4-2-1 staircase strategy and Goldmann III stimuli was carried out with an average number of 60 stimuli. The depth and size of the scotomata as well as the stability and location of fixation (preferred retinal locus, PRL) during perimetry were analyzed for each examination. The results were compared intraindividually in relation to the first exam and correlated with best corrected visual acuity.

**Results:** Fundus perimetry lasted for  $521 \pm 194$  sec. During the baseline perimetric exam 31 eyes (89%) showed an absolute central scotoma measuring  $4.5 \text{ cm}^2$  in average. During follow-up this central scotoma increased by  $3.2 \text{ cm}^2$  in average while there was no significant change in scotoma depth.

Regarding the area and stability of fixation the mean number of patients already used an extrafoveal retinal locus for fixation at the beginning of the follow-up, the mean deviation around the mean fixation point was 0.84 degrees. During follow-up stability of fixation did not change significantly while the PRL remained at the upper border of the scotoma and moved upwards according to the increasing scotoma size. Visual acuity remained stable over the follow-up (mean progression 0,06 lines) at an average of 20/100.

**Conclusions:** Fundus perimetry represents an effective device to evaluate functional changes in the follow-up of patients with Stargardt's disease. Although visual acuity showed only minor changes, an enlargement of the central scotoma and a movement of the PRL were observed during fundus perimetry explaining the increasing problems during reading and visual performance over time.

## INFLUENCE OF STIMULUS DURATION AND FIXATION OBJECT IN FUNDUS PERIMETRY

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**Purpose:** Fundus perimetry is useful in the assessment of the macular function. Aim of this study was to determine and quantify the influence of different parameter settings on perimetric results in fundus-controlled perimetry obtained with the MP1 Microperimeter.

**Methods:** In 66 healthy eyes of 33 volunteers microperimetry was performed with the MP1 Micro Perimeter (Nidek Inc., Italy) using two different settings for stimulus duration and fixation object in random order. Stimulus presentation time was set to 100 ms in one eye and to 200 ms in the other eye. Either a black or a red cross served as fixation object. A rectangular 3-degree grid with 70 stimulus locations covering an area of 27 x 18 degrees and a 4-2-1-staircase strategy was used in both settings. For each test point location light sensitivity threshold values were analyzed and compared intraindividually between both eyes. Fixation stability was assessed by evaluating the deviation from the mean fixation point during microperimetry.

**Results:** Light sensitivity threshold values between the two settings varied according to the chosen stimulus presentation time. For a stimulus duration of 200 ms the mean light sensitivity ( $18.0 \pm 0.7$  dB) was significantly higher than for the 100 ms stimulus duration ( $16.0 \pm 0.6$  dB). Fixation stability employing a red cross as fixation object was superior to the use of a black cross. While the eyes fixating a red cross showed a stable fixation in 93.7 %, only 78.8 % of the eyes looking at a black cross had a stable fixation.

**Conclusion:** Light sensitivity values in microperimetry with the MP1 depend highly on the choice of parameter settings. Reduction of the stimulus presentation time from 200 ms to 100 ms leads to a decrease of light sensitivity threshold values of about 2 dB. A red and well visible fixation object can augment the fixation stability in comparison to a black fixation object. The choice of parameter settings can influence microperimetric results and should therefore be carefully selected prior to examination.

## **AN EXPERIMENTAL AUTOMATIC PERIMETER THAT DISPLAYS THE FUNDUS IMAGE ON A LIQUID CRYSTAL DISPLAY AND CAN DETECT VISUAL LOSS USING VERY SMALL TARGETS**

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**Purpose:** We have developed an experimental automatic perimeter that displays the fundus image on a monitor, for measuring the visual field disturbance in cases of nerve fiber bundle defect (NFB), using very small targets.

**Methods:** The system of our perimeter was developed on Visual Basic.net. Two liquid crystal displays (LCD) were used. One was used as the campimeter and the other as the monitor for examination. The position of the macula and the center of the optic disc were marked after testing the blind spot. The examiner could decide measuring points while observing the fundus image on the LCD screen. The test target was white, 2.9 min in diameter, and 100 ms in duration.

**Results:** Ten cases were examined. Scotomata were detected in cases in which no changes could be detected with the conventional automatic perimeter.

**Conclusions:** These results suggested that using very small targets was useful in detecting visual losses in NFB when the receptive fields were sparse.



## AUTOMATED FLICKER PERIMETRY USING OCTOPUS 311

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**Purpose:** Using a new automated perimeter Octopus 311, we evaluated the clinical usefulness of the flicker perimetry in glaucoma and glaucoma suspect patients.

**Subjects and Methods:** Forty five eyes of 45 normal subjects, 62 eyes of 62 glaucoma patients, 28 eyes of 28 glaucoma suspect patients were examined by light-sense perimetry, flicker perimetry and frequency doubling perimetry. Flicker perimetry was performed using the Octopus 311 and its remote software package. The suprathreshold 4-zone 'probability' strategy was used for classify the CFF probability level. The classified levels were set at 5%, 1% of probability of normality and 5 Hz. Frequency doubling perimetry was performed using C-24-5, C-24-1, N-30-5, N-30-1 screening program using the Matrix. Light-sense perimetry was performed using HFAII full threshold program 24-2. The OCT3 was used for evaluating the RNFL thickness in all glaucoma and glaucoma suspect patients.

**Results:** In the early stage of glaucoma, the area under ROC curves were about 0.94 in both flicker and Matrix N-30-1, and 0.89 in C-24-1. In the moderate and advanced stages of glaucoma, the areas under ROC curves were almost 1.0 in all tests. In glaucoma suspect and normal hemifields of glaucoma patients, abnormal CFF values were detected by flicker perimetry corresponding with the fundus changes by OCT3. The average test duration of flicker perimetry was about 3 minutes in normal eyes and about 5.5 minutes in glaucoma patients.

**Conclusion:** The 4-zone 'probability' strategy in Octopus 311 is a useful method for evaluating the flicker field in glaucoma and glaucoma suspect patients.

## **RAREBIT PERIMETRY: A NEW NON-CONVENTIONAL VISUAL FIELD TESTING METHOD FOR EARLY GLAUCOMATOUS FUNCTIONAL DAMAGE DETECTION.**

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**Purpose:** To evaluate the use of Frisén's Rarebit Perimetry (RBP), a new non-conventional visual field testing method, in detecting early glaucomatous visual field damage, and to compare it with standard automated perimetry (SAP)

**Methods:** 43 patients with ocular hypertension (OHT), 39 patients with early primary open-angle glaucoma (POAG) and 41 normal controls were considered. All patients underwent testing with both the Humphrey Field Analyzer (HFA) SITA 30-2 program, and with RBP. In the analysis of the results, the following items were taken into consideration: the HFA-MD and HFA-PSD; the RBP mean hit rate (MHR); and, the number and pattern of non-hit-rate areas.

Sensitivity (Se), specificity (Sp) and the area under the receiver operating characteristic curve (AROC) for RBP, were all calculated using different algorithms.

**Results:** The RBP-MHR was  $88.6\% \pm 14.8$  in the control group,  $79.1\% \pm 10.9$  in the OHT group and  $64.3\% \pm 13.8$  in POAG group (differences statistically significant). The Number and the magnitude of the RBP-non-hit-rate areas were significantly higher in the POAG group. The largest AROC (0.95), giving rise to a Se of 97.4% and a Sp of 92.7%, was obtained when an abnormal RBP test was defined as having at least one of the following conditions: 1) MHR  $<80\%$ ; 2)  $>15$  areas having a non-hit-rate of  $>10\%$ ; 3)  $=2$  areas with a non-hit-rate of  $>50\%$ ; or, 4) at least 1 area with a non-hit-rate of  $=70\%$ . Abnormal RBP results were observed in 44.2% -65.1% of the patients in the OHT group.

**Conclusions:** The RBP is a quick, comfortable and inexpensive non-conventional perimetric test. It is easily available (only a PC device is required), and is quite effective in detecting early glaucomatous functional defects.

## **RAREBIT: A NOVEL PERIMETRIC STRATEGY FOR DETECTION OF SUBTLE OPTIC NERVE DYSFUNCTION.**

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**Purpose:** Because of visual system redundancy, subtle visual field defects may not be obvious on standard automated perimetry (SAP). A recently developed program (by Dr. Lars Frisen) that uses tiny points of light, RAREbit, purportedly better detects subtle defects. We undertook a study of patients with known asymmetric optic nerve function, yet normal fields using a Humphrey 24-2 SITA-fast program (size III test object) to determine the ability of RAREbit perimetry to accurately detect subtle field defects missed by SAP.

**Methods:** 7 patients (5 women, 2 men) with equal acuity but asymmetric optic nerve function (based on the presence of an afferent papillary defect) agreed to participate in the study. All 7 with normal (symmetric with the uninvolved eye) Humphrey 24-2 SITA-fast fields using a size III test object were retested using the 24-2 full-threshold program utilizing a size I test object. This was followed by the RAREbit “rabbit” test utilizing the protocol outlined by Lars Frisen. The three results for each eye were then compared side by side for asymmetry that would corroborate the presence of asymmetric optic nerve function.

**Results:** The RAREbit perimetry “rabbit” test invariably (7 of 7) detected the eye with the afferent pupil defect. This was corroborated by the size I FT Humphrey 24-2 in all but one case. The “rabbit” test took slightly more than half of the time required of the Humphrey 24-2 FT size I test (average “rabbit” time 6 minutes 34 seconds compared to average 24-2 FT size I time of 11 minutes 26 seconds.)

**Conclusions:** RAREbit perimetry can detect subtle field defects that are not seen on Humphrey 24-2 SF size III testing. The test is faster and easy to perform than the 24-2 I size.

## VIRTUAL PERIMETRY FOR GLAUCOMA SCREENING IN THE POPULATION

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**Purpose:** Peristat is a virtual perimetry system that allows self-testing on any standard computer monitor via Internet connection. Sensitivity and specificity of Peristat to detect visual field defects were compared to standard Humphrey Visual Field Analyzer data.

**Design:** Prospective, comparative observational case series

**Participants:** 58 eyes of 33 patients.

**Main Outcome Measures/Testing:** Semi-quantitative analyses comparing Peristat and Humphrey visual field scores. The study evaluated patients with an established glaucoma diagnosis and glaucoma suspects who had undergone comprehensive ophthalmologic examinations including prior office perimetry evaluation (Humphrey Field Analyzer). Inclusion criteria were: diagnosis or suspicion of glaucoma, best corrected visual acuity better than 20/200 and reliable performance on prior standardized office perimetry. Computer literacy was not required and over 40% of the patients tested were computer illiterate, with no previous computer or Internet experience. All of the glaucoma suspects had cup-to-disc ratios greater than 0.5. A total of 58 eyes [of 33 patients] were interrogated with the Humphrey and the Peristat systems – 10 eyes of 5 patients without documented glaucomatous field loss and 48 eyes with mild-to-severe scotomas by standard 24-2 office perimetry. Severe glaucomatous field damage was defined as MD>10; mild-moderate visual field defects were defined as MD <10; and normal visual fields had no deviation from age-matched controls as defined by the Humphrey system. A standard computer set-up was used with a 17" monitor, keyboard and mouse. The program was delivered through a remote connection with a server and the patients interacted unassisted, after a brief instruction on the browser-enabled program interface.

**Results:** All patients completed the Peristat test without difficulty. Testing time varied between 3 and 9 minutes, tending to be longer with more severe visual field defects. Test results were reviewed, masked, by 2 glaucoma specialists and 1 general ophthalmologist. Each quadrant for every eye tested was graded for visual field defects for both the Humphrey and the Peristat. The density of the scotomas was graded on a scale from 0-3 (0 = none/artifact/nonspecific; 1 = minimal; 2 = moderate; 3 = severe scotomas). The Peristat demonstrated a high degree of correlation with the Humphrey instrument. Among the three reviewers, sensitivity ranged from 80-83%. Similarly, test specificity was between 94% and 96% for all three reviewers. The inter-observer variability was negligible. In a second sub-analysis in which cases with mild defects were excluded, the Peristat's efficacy was further optimized – sensitivity between 84%-86% and specificity between 94% and 97%. Patients performed the Peristat test with similar facility to their Humphrey test. Fixation losses and test reliability were comparable for both.

**Conclusion:** Peristat is a reliable self-test which demonstrates high clinical utility for the detection of visual field defects at a fraction of the cost of standard office perimetry. In selected populations, the Peristat could be a valuable tool for cost-effective self-screening for visual field loss and detection of glaucoma.

## TESTING A NEW APPROACH TO DETECTING CHANGE IN SERIES OF RETINAL IMAGES ACQUIRED FROM SCANNING LASER TOMOGRAPHY

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**Purpose:** To evaluate a new Statistic Image Mapping technique for detecting topographic changes in Heidelberg Retinal Tomograph (HRT) images in comparison with 'Topographic Change Analysis' (TCA super-pixel analysis; Chauhan et al 2001 *Arch Ophthalmol* 119:1492-99) available on the HRTII.

**Methods:** Fifty series of HRT images were generated using a novel computer simulation. For each series the same single HRT image was replicated 3 times to represent a baseline visit and then replicated 3 times again at 5 follow-up 'visits'. Two types of noise were then added to these identical images; first, noise that would be attributed to movement during image acquisition was mimicked using a re-alignment algorithm acting in 3 translations and 3 rotations; next, Gaussian noise was added to each pixel by sampling from a Normal distribution with a mean set at the topographic height at that pixel. Another 50 series were generated in the same way but the topographic height of a small, discrete part of the image was fixed to deteriorate over the follow up period. We then replicated the TCA super-pixel analysis and applied the published criteria for change to the two sets of data. Next we then applied the new Statistic Image Mapping methods to the same series of images.

**Results:** With the 50 stable virtual 'patients', the TCA super-pixel method falsely flagged 12% as 'changing' whilst the new Statistic Image Mapping technique did not flag any as falsely 'changing'. TCA super-pixel correctly identified 88% of the 'changing' patients but the new Statistic Image Mapping technique identified nearly all of the 'changing' patients (98% sensitivity).

**Conclusion:** This computer simulation experiment indicates that the Statistic Image Mapping techniques have better diagnostic precision in detecting change in series of HRT images as compared to a commercially available algorithm (TCA super-pixel). The new techniques are the subject of further computer experiments, and may prove to be clinically useful in detecting changes in the optic disc in glaucoma.

## CLINICAL EVALUATION OF THE HUMPHREY MATRIX

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**Purpose:** The Humphrey Matrix is able to examine the central visual field using Frequency Doubling Technology with a 24-2 stimulus pattern and fast-thresholding algorithm. The aim of this investigation was to evaluate performance of the Matrix Program 24-2 within a routine hospital glaucoma service environment.

**Methods:** A prospective series of randomly selected referrals to a glaucoma service were evaluated with the Matrix Program 24-2 Threshold in addition to standardised clinical assessment, including optic nerve head (ONH) evaluation by a glaucoma specialist and standard automated perimetry (Humphrey Field Analyzer (HFA) Program 24-2 SITA Fast). The discriminatory power of both visual field tests to identify individuals with ONH features consistent with glaucomatous optic neuropathy (GON) was quantified. Visual field test results were considered abnormal if the glaucoma hemifield test was outside normal limits or if pattern standard deviation was below the 5<sup>th</sup> percentile of the age-matched normal range.

**Results:** Of the 48 individuals referred for suspected glaucoma, 15 had chronic glaucoma, 21 required monitoring as glaucoma suspects and 12 were normal. For all individuals, average Matrix test duration per eye was 5mins 23seconds (range 4.49 to 6.39). The number of individuals producing reliable test results (fixation losses  $\leq$ 25%, false positives and negatives  $\leq$ 33%) in both eyes with the Matrix (36/48) exceeded that of the HFA (30/48). The sensitivity and specificity of the Matrix to GON was 100% and 26% respectively, compared with 80% and 52% for the HFA. In the sample studied, the positive predictive value of the Matrix (31%) was marginally higher than the HFA (25%). The amount of visual field loss, by mean deviation, identified by HFA and Matrix was found to be significantly associated ( $R^2$  0.65,  $p < 0.001$ ).

**Conclusions:** The Humphrey Matrix exhibited similar performance levels to the HFA when used in a clinical glaucoma service setting. The discriminatory power characteristics and positive predictive value suggest that the Matrix has potential for use in 'enriched' patients populations typical of those newly referred for suspected glaucoma.

## **A NEW PSYCHOPHYSICAL TEST FOR THE EARLY DETECTION OF M-CELL AND P-CELL DYSFUNCTION IN OCULAR HYPERTENSION AND GLAUCOMA.**

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**Purpose:** To demonstrate how a new computerised version of a psychophysical test can assess the early M-Cell and P-Cell dysfunction in Ocular Hypertension (OHT) and Primary Open Angle Glaucoma (POAG).

**Methods:** 162 eyes of 162 patients were included in the study: 59 eyes with OHT, 51 eyes with POAG and 52 normal controls eyes. Each eye was tested with a stimulation program designed for use with a laptop computer connected to a monitor screen. This test was directed at the so-called ST1 and ST2 responses which have similar characteristics to those found respectively in the parvo-cellular (P-Cell) and magno-cellular (M -Cell) pathway. The measurement of spatial and temporal responses relies upon the measurement of a target which moves across a spatially (gratings) and temporally (flicker) modulated background. The ST1 responses assessed threshold values at 0.36 Hz, 0.72 Hz and 8.24 Hz, the ST2 responses assessed threshold values at 5.00 Hz, 7.50 Hz and 10.00 Hz. All subjects were also assessed by standard threshold perimetry: Humphrey Field Analyzer (HFA) 640, Program 24-2. Perimetric indices such as Mean Deviation (MD) and Pattern Standard Deviation (PSD) were also calculated.

**Results:** Comparison of the OHT with the normal-control group showed a statistically significant difference ( $p < 0.05$ ) in the ST1 threshold value at 0.36 Hz and in the ST2 threshold value at 7.50 Hz. Comparing the POAG group with the normal control group we found a statistically significant difference ( $p < 0.05$ ) in the ST1 threshold value at 0.36 Hz and 0.72 Hz and in the ST2 threshold value at 5.00 Hz and at 7.50 Hz. In the POAG group compared with the OHT there was a statistically significant difference ( $p < 0.05$ ) in the ST1 threshold value at 0.36 Hz and in the ST2 threshold value at 5.00 Hz. On comparing the computerised psychophysical test with the HFA, the only statistically significant correlations found was between MD and ST1 at 0.36 Hz ( $r = 0.0432$ ;  $p < 0.05$ ) and between MD and ST2 at 10.00 Hz ( $r = 0.0389$ ;  $p < 0.05$ ) in the POAG group.

**Conclusions:** The studied computerised test appears to detect glaucomatous changes, with both ST1 and ST2 responses, and may prove useful in the screening for early glaucoma.

## USEFULNESS OF EYE CHECK CHART IN GLAUCOMATOUS AND NEURO-OPHTHALMOLOGICAL DISEASES

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**Purpose:** To investigate the feasibility and reliability of a new “Eye Check Chart” (ECC, Optworld Co., Japan) for the bedside evaluation of the visual fields in patients with glaucoma and neuro-ophthalmological diseases.

**Materials and Methods:** There were 271 eyes of 136 patients with POAG and 65 eyes of 35 patients with visual pathway abnormalities studied. The ECC was presented 40 cm in front of the eye, and special questions were asked to determine whether a field defect was present. Humphrey perimetry (HP) with the 30-2 SITA program was also performed. The results of the ECC and HP were compared to see if they agreed or disagreed. The results were analyzed for each group using the Graves’ modification of Aulhorn’s classification in glaucomatous eyes. Patients with pre- and post-geniculate lesions were analyzed. Two-hundred and twenty-four eyes of 112 consecutively patients in one general ophthalmological outpatient clinic were screened.

**Results:** The sensitivity of ECC to detect visual field changes was 57% in Grade I POAG, and 84-100% in grade II to V POAG. The sensitivities of ECC to detect visual field changes were 87% and 80% in eyes with pre- and post-geniculate lesions, respectively. Acquired abnormal color vision in cases of optic neuritis was detected, but a complete hemianopia was missed in a patient with a postgeniculate lesion due to hemispatial neglect. Forty of 244 eyes showed some positive response, and 20 (50%) of these probably had field abnormalities. False positives were observed in cataract patients, and false negatives were observed in 12 eyes (6.5%).

**Conclusions:** The ECC was useful for detecting visual field defect in patients with glaucoma, lesions in the visual pathways, and other ocular diseases that cause visual field defects. The ECC is a simple and has highly reliable chart to detect visual field defects.



## **TEST-RETEST AND INTER-TEST VARIABILITY OF SITAFast AND CLIP THRESHOLD ESTIMATION**

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**Purpose:** The reproducibility (inter-test variability) and the inter-algorithm differences of the Fast Swedish Interactive Thresholding Algorithm (SITAFast) of the Humphrey Field Analyzer (HFA) and the Continuous Light Increment Perimetry (CLIP) strategy of the Oculus perimeter were evaluated in damaged visual fields.

**Methods:** Twentyone eyes of twentyone glaucomatous patients (mean age 68 years) with damaged visual fields ( Mean Defect (MD) >8 dB) were examined in two sessions.

In the first session, each patient was tested first either with Oculus Full Threshold (FT) strategy or with Humphrey FT strategy and with SITAFast and CLIP strategies, in random order.

Second session was performed at least 3 days later, with the same procedure.

**Results:**The average point-wise sensitivity difference between SITAFast and HFA FT strategy (0,84 dB) was significantly lower (  $p < 0,0001$ ) than between CLIP and Oculus FT strategy (1,71 dB). No significant difference was found in the test-retest variability between the two fast strategies. The CLIP mean sensitivity was lower than SITAFast (1,98 dB). The mean test time duration for CLIP (450 +100 sec.) and for SITAFast (366±72 sec.) were significantly shorter than the corresponding FT strategies. A point-wise analysis for the total deviation map values was carried out.

**Conclusions:**This two fast strategies based on very different algorithms showed a good threshold estimation and good reproducibility with a great time saving in severe damaged visual fields.

## COMPARISON OF DETECTABILITY OF EARLY GLAUCOMA USING SCANNING LASER POLARIMETRY AND FREQUENCY DOUBLING TECHNOLOGY

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**Purpose:** Previously we reported that the detectability of early glaucoma by scanning laser polarimetry (GDx) was improved when used with a variable corneal compensator (GDx-VCC, Laser diagnostic Technologies) than when used with a fixed corneal compensator (GDx-FCC) (ARVO 2004). In this study, we evaluated the detectability of early glaucoma using GDx-VCC, GDx-FCC, and frequency doubling technology (FDT). **Methods:** Thirty-six eyes of 36 patients (mean age, 61.3±13.2 years) with early glaucomatous visual field changes and 41 eyes of 41 normal persons (mean age, 57.8±11.0 years) were studied. The classification of glaucoma was primary open-angle glaucoma in 15 eyes and normal-tension glaucoma in 21 eyes. The mean deviations (MD) for Program 24-2 of the Humphrey Field Analyzer (HFA) were greater than -6.0 dB in all eyes. Average MD for the HFA were -2.4±1.9 dB in glaucoma group and 0.8±1.3 dB in normal group. Each eye was tested using GDx-VCC and GDx-FCC, and the Full Threshold C-20 Program of FDT was performed on all subjects. Evaluation was performed using GDx parameters such as TSNIT Average (TA), Superior Average (SA), Inferior Average (IA), TSNIT Standard Deviation (TSD), and Nerve Fiber Indicator (NFI). A case with any parameter below the 95% confidence interval was defined as abnormal (for NFI, greater than 50 in GDx-VCC or greater than 60 in GDx-FCC was abnormal). **Results:** The sensitivity and specificity were 94.4% and 85.4%, respectively, for GDx-VCC, and 52.8% and 80.5% for GDx-FCC, when abnormality was defined as mentioned above. For the FDT, the sensitivity and specificity were 83.3% and 75.6%, respectively, when abnormality was defined as having one of the global indices (MD, PSD) below the 95% confidence interval, and 86.1% and 75.6% when abnormality was defined as having more than one probability symbol below the 99% confidence interval. Although only two parameters (TSD and NFI) of GDx-FCC correlated significantly with MD of the HFA, all parameters of GDx VCC showed significant correlation with MD (Pearson correlation,  $p < 0.0001$ ). **Conclusion:** GDx-VCC detected early glaucoma better than FDT and GDx-FCC, and shows good correlation with visual field.

## SEMI-AUTOMATED KINETIC PERIMETRY (SKP) AND MANUAL KINETIC GOLDMANN PERIMETRY IN PATIENTS WITH ADVANCED VISUAL FIELD LOSS

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**Purpose:** To compare visual field results obtained using a new technique of kinetic visual field examination semi-automated kinetic perimetry (SKP) with those obtained using conventional manual Goldmann kinetic perimetry in patients with advanced visual field loss.

**Method:** Seventy-seven patients with retinal nerve fiber layer (RNFL) loss (36 patients), concentric constriction of the visual field (20 patients) and hemianopia (21 patients) were enrolled into the study. Examinations were performed with Goldmann kinetic perimeter and SKP implemented in Octopus 101 instrument (Haag-Streit, Koeniz, Switzerland). One eye of each patient was tested with both methods using three stimuli according to the Goldmann classification. Stimulus angular velocity was 3°/s in SKP. The area of each isopter in SKP was measured in square degrees (deg<sup>2</sup>) without reaction time correction. Goldmann visual field results were digitised and the area of isopters was quantified. In order to compare the location of the corresponding isopters *intersection areas* of superimposed isopters were expressed as percentage of *union areas*. The area and position of isopters for a defined stimulus condition obtained with both methods were compared.

**Results:** Isopters obtained by Goldmann perimetry were smaller by 20% (C.I. 12% to 27%). The mean area of 231 obtained isopters was 4610 deg<sup>2</sup> for Goldmann and 5091 deg<sup>2</sup> for SKP. The *intersection area* of Goldmann and SKP results amounted to 73% (C.I. 69% to 77%) of the *union* for stimulus III4e over all groups of patients. Examination durations did not differ between two methods (median 15 minutes).

**Conclusion:** Visual field results obtained using SKP seem to be very well comparable to those obtained by traditional manual Goldmann perimetry. SKP may be used in clinical practice in diagnosing and monitoring advanced visual field loss as an examiner-independent and standardised method alternative to Goldmann perimetry.

## LASER POLARIMETRY AND WHITE-WHITE, PULSAR, FDT AND FLICKER PERIMETRIES IN OCULAR HYPERTENSION.

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**Purpose:** To evaluate the diagnostic yield of White-White (TOP G1-WW), Pulsar, FDT and TOP-Flicker perimetries and of laser polarimetry in patients with ocular hypertension (OHT).

**Method:** Each test was performed by five homogeneous groups for age and sex of OHT (selected based on a normal papilla and to the loss variance square root or sLV-TOP-WW <2.45) and normal (controls) patients for the analysis of the following parameters: the 36 parameters of the laser polarimetry (NFA II-GDx version 1.0.04) (GDx), mean defect (MD) for Octopus topG1 (tG1), MD and sLV for Pulsar and Flicker, and MD and pattern standard deviation (PSD) for FDT. Only one eye per patient was analyzed.

- Group 1 (tG1): 63 OHT patients and 62 controls.
- Group 2 (Pulsar): 56 OHT patients and 47 controls.
- Group 3 (FDT): 49 OHT patients and 44 controls.
- Group 4 (Flicker): 53 OHT patients and 59 controls.
- Group 5 (GDx): 58 OHT patients and 46 controls.

**Results:** Best ROC areas ( $p < 0.05$ ) corresponded to the quotients Ratio Mean Superior/Inferior (RMSI) (63.7) and Ratio Integral Superior/Inferior (RISI) (62.8) of GDx and Pulsar's MD (60.4). With a 95% of specificity, the parameters with best sensitivities corresponded to RMSI (22.4%), RISI (19%) and Pulsar's MD (17.9%).

**Conclusions:** Pulsar's MD, RMSI and RISI of GDx were the only ones that showed capacity to differ between controls and OHT. Other indexes of GDx like RIIT, RMIN, EM and RMIT also presented significant differences, but contrarily to what expected they were more normal in OHT than in controls. None of the FDT, Flicker and Octopus indexes reached significant differences between OHT and controls. Demanding a high specificity (95%), the most sensitive parameters corresponded to those of the GDx which analyze the relationship between the superior and inferior quadrants of the nerve fibre layer, and to Pulsar's MD.

## **VISUAL FIELD TESTING WITH THE NEW HUMPHREY MATRIX: A COMPARISON BETWEEN FDT N-30 AND MATRIX N-30F TESTS.**

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**Purpose:** The aim of our study was to determine if the N-30-F FDT full threshold test of the new Carl Zeiss Humphrey Matrix Visual Field Instrument was comparable to the traditional Humphrey FDT N-30 program.

**Methods:** 30 eyes from 30 patients chosen randomly, with a diagnosis ranging from normal, ocular hypertension and different stages of glaucoma, were included in this study. All patients underwent visual field testing with Standard Automated Perimetry, FDT N-30 program, and with the N30-F program found in the new Matrix Visual Field Instrument, using the full threshold strategy in both cases. The N-30 F FDT test is essentially the same 19-point test performed on the prior Humphrey FDT, utilizing the same data base, however, moving fixation is not required, not to mention that the threshold algorithm has been enhanced in order to reduce testing time. The plots and global indices, along with the defect location for each patient, were analyzed in the comparison of FDT with Matrix.

**Results:** Tests performed with the N-30 F FDT program in the new Matrix Visual Field Instrument were comparable with those performed with N-30 program of FDT, with the exception of the number of points with probability level of  $p < 5\%$  in the central area on both the total and pattern deviation maps, which were significantly lower in the Matrix test (Wilcoxon's test,  $p < 0.05$ ). High correlation was found between correspondent parameters of the two tests.

**Conclusion:** The Matrix N-30-F full threshold program is comparable to the FDT N-30 test. Matrix provides a similar FDT testing method, but in addition, has new testing programs incorporated, that may prove to offer a greater sensitivity, seeing that the number of visual field locations is much greater. The new instrument also has a video eye-monitoring device useful in verifying that the eye alignment and fixation are maintained during the testing period.

## **RAREBIT PERIMETRY AND FREQUENCY DOUBLING TECHNOLOGY IN SUBJECTS WITH OCULAR HYPERTENSION.**

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**Purpose:** To compare the “Rarebit Perimetry” and Frequency Doubling Technology (FDT) perimetry in detecting early visual field damage in subjects with ocular hypertension.

**Methods:** 20 subjects with ocular hypertension (intraocular pressure > 21mmHg on no treatment, normal white-on-white automated perimetry recorded by a Humphrey 750 II VFA, program 30-2, normal optic nerve head and normal retinal nerve fiber layer) underwent Rarebit Perimetry and FDT. Only one eye of each subject was randomly selected. All subjects had at least two standard threshold visual field tests. Rarebit Perimetry and FDT were performed twice and only the second record was considered for analysis. The abnormality of Rarebit and FDT findings was stated according to predefined criteria.

**Results:** The mean FDT MD was  $0.2 \pm 2.5$  and the mean FDT PSD was  $4.5 \pm 1.8$ . The “mean hit rate” of Rarebit Perimetry was  $88.6 \pm 6.9$ . According to the abnormality criteria we adopted, pathological findings were recorded in 12 eyes: 4 eyes had pathological Rarebit Perimetry only; 5 eyes had pathological FDT only; 3 eyes had both Rarebit and FDT altered.

**Conclusions:** Both Rarebit Perimetry and FDT proved to be able to detect early visual field damage in some eyes. However, the lack of agreement between these techniques in identifying pathological eyes is questionable. It could be explained by the different functions they explore: Rabbit Perimetry tests the integrity of the neural network by means of microdots of high contrast, so reducing or even eliminating the redundancy effect, while FDT utilizes large stimuli that seem to be processed by M<sub>y</sub> ganglion cells. Both techniques are very fast and easy to be performed. Rarebit Perimetry has the advantage of not requiring any expensive device, as it simply runs on a personal computer and needs only a liquid crystal display, representing the perimeter’s screen. Further, larger and longitudinal studies, however, are needed before considering its implication in early glaucoma diagnosis.

## UNILATERAL PROGRESSION OF VISUAL FIELD DEFECTS IN NORMAL-TENSION GLAUCOMA

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**Purpose:** To investigate the clinical factors influenced the progression of visual field defects in patients with NTG.

**Methods:** We evaluated the relationship between the difference in the right and left eyes of 52 NTG patients who were followed-up for more than 4 years regarding refractive error, values for peak, trough, and mean, during the 24-hour IOP diurnal variation, mean IOP during the follow-up period with anti-glaucomatous medication, pattern of visual field defects, optic disc appearance, and the frequency of disc haemorrhage. Enrolled subjects were classified into unilateral progression, progression of both side, and non-progression in either side according to the progression of visual field defect during the follow-up period. The progression of visual field defect was determined using with Glaucoma change Probability Analysis in Humphrey Field Analyzer STATPAC 2.

**Results:** In 11 cases with unilateral progression of visual field defects, the visual field at the initial visit was significantly more damaged in the progressive eye than in the non-progressive eye ( $p < 0.05$ ). There was no significant side difference in other clinical factors. 12 cases with progression in both side, and 29 cases with non-progression in either side showed no difference in clinical factors.

**Conclusions:** NTG patients with advanced visual field defect have the possibility of deterioration of visual field defects. These cases should be observed carefully.

## ANALYSIS OF VISUAL FIELD DAMAGE IN GLAUCOMATOUS MYOPIC EYES

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**Purpose:** An analysis was carried out on a computerized perimetry of a group of patients affected by open angle chronic glaucoma. The following was analyzed: 1) The varying sensibility of the central 30° of visual field. 2) The statistical significance and its clinical interest related to different refractive conditions. **Methods:** 110 patients (208 eyes), with an average age of 56.7 years ( $\pm 14.8$ ) were tested at least three times, once every six months. The total sum of visual fields was 837. All the patients were divided into 4 subgroups relating to refraction. At the first visual field the disease had been in evidence for an average of 4.7 years ( $\pm 3.7$ ) and in all the patients the intraocular pressure under therapy remained stable for the whole period of the study (Av. 16.9 mmHg  $\pm 2.3$ ). A central 30° visual field (OCTOPUS 123 Prog.G1) was carried out at each control. The resulting data was analyzed by PERIDATA Trend function. These results in turn were processed using Macintosh computer Statview II program. **Results:** At the first exam 82% of eyes showed a global decrease of relative differential light (MD > 2 dB) and in 67% of the eyes examined the distribution of the defect was inhomogeneous (LV > 6 dB). The analysis of variance for subgroups showed a major significant decrease of MD in high myopic patients (ANOVA test). A linear regression analysis (PERIDATA) highlighted a statistically significant change of MD value in 36% and of LV value in 34% of the eyes studied. An analysis for subgroups showed that the high myopic patients had the highest percentage of change of MD and LV (respectively 46% and 42%). Among the groups, there was no significance in the different progression of MD decrease (ANOVA test) **Conclusions:** Despite good intraocular pressure a deterioration of visual field is more frequent in high myopic patients ( $> -8.50$  D), although its progression does not show any significant difference between myopic and emmetropic or hypermetropic eyes. Vascular factors should be hypothesized in high myopic eyes as responsible of deterioration as supplementary cause of progression of visual field damage in presence of a good tonometric balance.



## FREQUENCY OF NASAL STEP AND BJERRUM SCOTOMA IN EARLY STAGE OF GLAUCOMA

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**Purpose:** Both nasal step and Bjerrum scotoma are well-known as the first deterioration of visual field in early stage of glaucoma. We investigated the frequency of nasal step and Bjerrum scotoma in early stage of glaucoma in Japan.

**Subject and Method:** Thirty eight Visual field data from 38 subjects (male 17, female 21, from 21 to 82 year old) were selected from eyes with small depression change from normal range of Bebie curve in G2 program of Octopus visual field analyzer, while the contralateral eyes were within normal range. Subjects were required to have had at least two tests. The trough of sensitivities at each point; upper nasal, lower nasal,  $<10^\circ$ , from  $10^\circ$  to  $20^\circ$  was defined as the beginning of the glaucoma depression.

**Results:** Mean MS was 26.92 dB. Fifteen eyes showed Bjerrum scotoma first, and thirteen showed nasal step first. Ten showed both nasal step and Bjerrum scotoma at once.

**Conclusion:** This investigation demonstrated that no difference of frequencies as the first change of early stage of glaucoma between nasal step and Bjerrum scotoma.

## MODELLING VISUAL FIELD SENSITIVITY DECAY OVER TIME

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**Purpose:** Recent models have suggested a linear relationship between linear (1/Lambert) visual field (VF) sensitivity and underlying ganglion cell (GC) numbers and a curvilinear relationship between logarithmic (dB,  $10 \cdot \log(1/\text{Lambert})$ ) VF sensitivity and GC numbers. This study compared the predictive power of linear regression analysis of 1/Lambert and dB VF sensitivity over time in predicting future VF sensitivity.

**Methods:** The Moorfields Eye Hospital Ocular Hypertension database was searched for eyes that had converted from Ocular Hypertension to Glaucoma, on the basis of repeatable visual field defects, and had in excess of 15 Humphrey VF. Eleven eyes fitted the selection criteria (mean follow-up 5.1 years). VF locations with a sensitivity more than 10 dB below the age-matched normal threshold, and greater than 0 dB, in the last VF in the series were selected for analysis. Seventy-seven locations from 8 eyes satisfied the criteria and were analysed. The first VF in the series was excluded. Linear regression analysis of VF sensitivity (dependent variable) against time was performed on the next 5, or the next 10, VFs and the resulting equations for each point were used to predict the sensitivity value at that point in the last VF in the series. Linear regression was performed with VF sensitivity scaled in dB and 1/Lambert. The predicted sensitivity values (in dB) were then compared to the actual thresholds at last field in order to calculate the prediction error.

**Results:** Using the first five fields, the mean prediction error was 5.6 dB, standard deviation (SD) 18.7 dB, and -7.7 dB, SD 32 dB, for dB and 1/Lambert sensitivity, respectively. When using the first ten fields, the mean prediction error was 3.8 dB, SD 6.7 dB, and -13.9 dB, SD 21.6 dB, for dB and 1/Lambert sensitivity, respectively.

**Conclusions:** The prediction using VF sensitivity scaled in dB resulted in smaller errors than the scaling in 1/Lambert. Basing the prediction on more fields resulted in smaller prediction errors when using the dB scale.

# AGE-DEPENDENT NORMATIVE VALUES OF DIFFERENTIAL LUMINANCE SENSITIVITY IN AUTOMATED STATIC PERIMETRY – A FORMULA CONVERTING THRESHOLD DATA OBTAINED WITH TCC (TUEBINGEN COMPUTER CAMPIMETER) AND OCTOPUS 101.

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**Purpose:** To implement age-dependent normative threshold data with TCC (monitor / prototype) and Octopus 101 (cupola / commercially available) and to find the conversion of differential luminance sensitivity (dls) between these two instruments.

**Methods:** We examined 83 eyes of 83 ophthalmologically healthy subjects, 12 per decade, on each of the two instruments, using an identical thresholding strategy (4-2-1 dB, 3 reversals) and the same grid of test points. Stimuli were arranged in circular order with centripetal test point condensation. Threshold estimation was performed with the maximum-likelihood method. To describe the reference values, smooth mathematical models were estimated for TCC and Octopus, which fit a “hill of vision” to the data.

**Results:** The model fit was satisfactory ( $R^2 = 0.62$  for TCC and  $R^2 = 0.49$  for Octopus). Covariables defining the model were: age, eccentricity and angle. As identical grids were used on both perimeters, threshold differences per location and per subject were analyzed. Mean Octopus – TCC difference was 1.1 dB. The threshold differences depended on eccentricity. The minimal difference occurred at an eccentricity of  $15^\circ$  (0.62 dB). Dls differences increased towards the centre (2.1 dB) and towards the periphery (2.2 dB at  $30^\circ$ ). The conversion formula was estimated to:

$$dls_{\text{Octopus}} = dls_{\text{TCC}} + 2.1 \text{ dB} - 0.20 \text{ dB/deg.} \times \text{ecc.} + 0.0068 \text{ dB/deg.}^2 \times \text{ecc.}^2$$

The effects of age and angle were negligible. Standard deviations of both, reference values and differences, were 2.4 dB.

**Conclusions:** Dls differences between the TCC and Octopus instruments are small and introduce little scatter. The formula presented allows grid-independent conversion of threshold data for follow-up studies, when switching from the prototype campimeter to a commercially available perimeter which can be used for multicenter studies. Our age-dependent reference values make the Octopus 101 a valuable diagnostic instrument.

**AGE-DEPENDENT REFERENCE VALUES  
OF SEMI-AUTOMATED KINETIC PERIMETRY (SKP)  
WITH CONSIDERATION OF INDIVIDUAL REACTION TIMES  
USING THE OCTOPUS 101 INSTRUMENT**

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**Purpose:** To estimate a smooth model for normative values of local kinetic threshold, corrected for individual reaction times (RTs), regarding the factors age and stimulus condition (luminance, size and angular velocity).

**Methods:** 84 eyes of 84 normal subjects (12 per decade), aged from 10 to 79 years, were examined. OD/OS was randomized. SKP was carried out with the Octopus 101 perimeter (Haag-Streit, Koeniz, CH). Targets were presented along 8 meridians in random order with constant angular velocity. Four stimulus conditions III4e 25°/s, II4e 5°/s, I3e 5°/s and I2e 2°/s were applied, basically to assess the dependence on velocity and age. Additionally 9 subjects (3 of the 2<sup>nd</sup>, 5<sup>th</sup> and 8<sup>th</sup> decade) were examined along 24 meridians with the following Goldmann stimulus condition V4e, V2e, V1e, IV2e, III4e, III3e, III1e, II2e, I4e, I3e, I1e, I1a with 3°/s, mainly to rate the shape of the isopters in detail.

**Results:** All data were used to fit a smooth model for local kinetic threshold, depending on the covariables age, stimulus size, luminance and meridian ( $R^2 = 0.86$ ): Intense and large stimuli are almost independent of age, whereas small and dim stimuli show a distinct dependence on age with approximately 1° decline per decade. Doubling the diameter of the target and at the same time reducing the luminance by 5 dB gives roughly the same isopter (“Goldmann’s rule”). The eccentricities of isopters are independent of target velocity if “response locations” are corrected for individual RTs. The correction is approximately 3° for velocities of 5°/s and 15° for 25°/s.

**Conclusions:** This model allows the relation of individual (kinetic) perimetric results to age-dependent reference values. Individual RTs should be considered in order to adjust threshold location independently of target velocity and response characteristics of the patient.

## **THE UTILITY OF RELIABILITY INDICES IN AUTOMATED PERIMETRY: FORCED WRONG RESPONSE TESTS IN NORMAL SUBJECTS.**

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**Purpose:** To assess the utility of reliability indices in standard and time consuming automated perimetric threshold tests in normal subjects who were forced to make wrong responses in fixed ratios.

**Methods:** Seven normal experienced subjects who understood the strategies of automated perimetry were tested in one eye using program 30-2 on the Humphrey Visual Field Analyzer 750 (HFA II) with three strategies, which were full threshold (FT), SITA standard (SITA-S) and SITA fast (SITA-F), and program 32 on the Octopus 101 with three strategies, which were normal (NS), dynamic (DS) and TOP. In each test, they were forced to make correct answers as usual or to make either false-positive (FP) or false-negative (FN) responses in a fixed ratio of 33% or 20%. We analyzed the reliability indices and the perimetric assessments including the global indices.

**Results:** In the results of the forced FN response tests, the ratios of FN responses were underestimated and were less than 20% with SITA-S and SITA-F in all subjects. In the results of the forced FP response tests using the HFA II, fixation losses were counted high under the Heijl-Krakau method and the ratios of FP responses were estimated variously among the subjects. In the results of the tests with TOP, the ratios of FP and FN responses were ranged 0 to 50 % because of small numbers of catch trials, which were four in each test. The reliability indices of the tests with DS were similar to those with NS.

**Conclusion:** The reliability indices in the results of tests with time consuming strategies should not be assessed in the same way as the standard threshold strategies, NS or FT.

# A NEW QUANTITATIVE ANALYTICAL SOFTWARE FOR THE HFA GAZE TRACKING SYSTEM

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**Purpose:** To develop a new software to qualitatively analyze the Gaze tracking results of the Humphrey Field Analyzer (HFA).

**Materials & Methods:** The Software, named Eye Chart™, collects the information of the Gaze tracking system of the HFA II , counts the spikes, and analyzes the data statistically. To estimate the validity of this software, we employed 1,000 HFA single fields from 1,000 eyes of 1,000 glaucoma patients with various stages. The results of the new Eye Chart Software were compared with the fixation loss index with the Heijl-Krakau method obtained at the same perimetric examination. **Results:** The statistically analyzed results of the new software were significantly correlated with the fixation loss index.

**Conclusion:** The new software can analyze the HFA Gaze tracking results in an appropriate manner.

## TOP-WW, PULSAR, FDT AND HRT-II DIAGNOSIS REPRODUCIBILITY IN GLAUCOMA SUSPECTS

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**Purpose:** To determine the diagnosis ability and reproducibility of the main indices provided by TOP-32-WW, PULSAR-T30W, FDT-Threshold-N30 and HRT-II.

**Method:** 47 eyes from 47 subjects referred as glaucoma suspects (GS) were examined twice. Cases with TOP-WW-MD>6dB were excluded. Results were compared with those obtained from 70 normal control subjects (C).

**Results:** The mean MD value using TOP-32-WW in the GS group (0.8. sd=1.8dB) was not significantly different than in C(0.96. s.d.=07dB) ( $p>0.05$ ). Fluctuation values were: TOP -WW-MD: 1.55dB, LV squared root (TOP-WW-sLV)=1.17dB, PULSAR-MD:1.40src, PULSAR-sLV=0.79src, FDT-MD=1.60dB, FDT-PSD=1.79dB. Sensitivity for 95% specificity was in each case 4.3, 26.6, 14.9, 30.9, 11.7 and 9.6%. Disc area in GS (mean=2.12. s.d.=0.34 mm<sup>2</sup>) was significantly higher than in C (mean=1.97. sd=0.45mm<sup>2</sup>) ( $p<0.01$ ). 15 of the 21 HRT II indices were significantly correlated with the disk area. The best HRT II sensitivity was given by the Maximum Contour Depression (35.1%), but once corrected with the disk area (formula similar to that from Garway -Heath and Jonas) was reduced to 17.0%. The most sensitive HRT indices without relation with the disk area were the Average Variability (21.3%), Height Variation Contour (16.0%) and FSM Discriminant Function Value (11.7%). Diagnosis reproducibility of the 5 perimetry indices and 3 HRT II was: 91.5, 70.2, 87.2, 72.3, 89.4, 89.4, 78.7, 89.4 and 97.9%. The diagnosis ability was estimated by multiplying sensitivity by reproducibility resulting on: 3.9, 19.4, 13.0, 22.3, 10.5, 8.6, 16.7, 14.3 and 11.5%.

**Conclusions:** Many GS actually correspond to normal big optic nerves. The best sensitivity and diagnosis efficacy corresponded to PULSAR-MD, followed by TOP-WW-sLV, PULSAR-sLV and Average Variability-HRT II. The best coincidence between perimetry indices and HRT II was also found with PULSAR-MD.

## **FDT AND RAREBIT PERIMETRY IN PAEDIATRIC GLAUCOMA AND NORMAL CONTROLS**

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**Purpose:** To evaluate the sensitivity and specificity of frequency doubling technology (FDT) and Rarebit microdot perimetry (RB) in paediatric glaucoma.

**Methods:** Thirteen young patients (age 7-15 years) with paediatric glaucoma and twenty age-matched healthy controls were examined with both the FDT and the RB perimetry.

**Results:** Twenty-nine subjects could perform the FDT and 31 the RB perimetry. Twenty-seven of the FDT and twenty-eight of the RB fields were regarded as reliable. Two glaucoma patients could not perform any of the examinations, in one patient because of low visual acuity and in one patient because of lack of co-operation. Another patient, also with low vision could perform the RB, but did not perceive the FDT stimuli. One of the healthy subjects could perform the RB but not the FDT examination. The RB examination was preferred by 94% of the examined subject and patients. According to the program's standard classifications seven of the 20 healthy controls were normal in FDT and 14 of 20 in RB. Among the glaucoma patients, six of 10 were abnormal in FDT and 7 of 11 in RB. Thus the sensitivity and specificity were 60% and 35% for the FDT and 64% and 70% for RB.

**Conclusions:** In the studied age group (7-15 years) the Rarebit perimetric method showed higher sensitivity for detection of optic nerve damage in paediatric glaucoma and was preferred by most of the examined children. Definition of normal limits in young subjects is needed to improve specificity in both methods.



## **COMPARISON OF SLO MACULAR PERIMETRY, BINOCULAR PERIMETRY, AND FUNCTIONAL VISUAL FIELD PERIMETRY**

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**Purpose:** A study to compare perimetry protocols was done on 24 people with bilateral macular scotomas including: 1) Monocular macular perimetry with the SLO; 2) Monocular and binocular macular perimetry with a projector and a pupil eye tracker monitoring fixation; and 3) Functional Visual Field perimetry with a projector and free eye movement.

**Methods:** SLO and Projection Macular Perimetry was performed on each subject's dominant eye to validate the projection perimetry protocol. The binocular SLO Perimetry results were then overlapped (with the PRL for fixation as the overlap point) to produce a binocular scotoma model. Projection Perimetry was repeated with a binocular presentation. Functional Visual Fields were found by randomly presenting targets while subjects scanned the visual field to find the targets. The targets were left on until the subject indicated the direction of the target (relative to the center). The scotomatous areas as found by each method were compared (matched pair t-test, two-tailed) along with false positives, false negatives, and Kappa values for the results at each perimetry pattern location.

**Results:** Three of the 24 subjects (13%) had significantly (0.01; Fisher's Exact Test) different SLO Perimetry and Projection Perimetry areas and pattern locations for their dominant eyes. Seven of the 24 subjects (29%) had significantly (0.01; Fisher's Exact Test) different Projection Perimetry binocular results compared to the model of SLO results. The pattern locations that had longer-than-normal times for the Functional Visual Fields were not comparable to the binocular Projection Perimetry pattern results.

**Conclusions:** Accurate and reliable control of fixation while doing Projection Perimetry gives scotoma results similar to SLO Perimetry. Combining monocular visual fields to model the binocular visual field (volume scotoma) does not produce reliable results. Functional Visual Fields are sometimes related to the location of the scotoma but are not related to the size of the scotomatous area. Functional Visual Fields may be a better outcome measure of the effect of scotomas on everyday function than standard perimetry.

## **THE RELATIONSHIP BETWEEN PROGRESSION WITH CONVENTIONAL PERIMETRY (SAP), FRISEN RING PERIMETRY (HRP), AND HEIDELBERG RETINA TOMOGRAPHY (HRT) IN PATIENTS WITH GLAUCOMA**

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**Purpose:** To investigate the agreement between event-type visual field change probability analyses of static automated perimetry (SAP) and High-Pass Resolution perimetry (HRP), and the change probability maps of the Heidelberg Retina Tomograph (HRT).

**Methods:** 85 glaucoma patients and 41 controls were followed with 6-monthly SAP, HRP and the HRT1 tests for 6.3 years (mean). SAP and HRP were evaluated for change using Pattern-Deviation change probability analyses, the criteria for progression being based on the number of test locations with deterioration ( $p < 0.05$ ) from baseline (average of 2 exams) on 3 consecutive follow-up tests. Optic disk change was evaluated using the HRT probability maps which indicate statistically significant topographical change from baseline ( $p < 0.05$ ) in 3 consecutive images. HRT change criteria were based on the size of the largest cluster of red superpixels within the contour line, relative to disk size. To assess the agreement between the 3 techniques, we derived 3 sets of progression criteria (least, moderately, and most conservative) that resulted in similar numbers of progressing glaucoma eyes (35, 20 and 15, respectively) with each of the 3 techniques.

**Results:** The agreement between HFA and HRP was higher than that between either of the field test and the HRT analyses. Agreement statistics varied substantially with the progression rates; with the most conservative criteria (3 locations with SAP and HRP, 17.5% of red superpixels within the disk), kappa was highest between the visual field tests (SAP and HRP,  $\kappa = 0.71$ ), but least between the field tests and the HRT ( $\kappa < 0.12$ , NS). The moderately conservative criterion (2 test locations with SAP and HRP, 10% of red superpixels) classified progression in 22, 20, and 20 eyes with SAP, HRP, and HRT respectively, yet only 5 eyes were classified as progressing with all of the 3 techniques.

**Conclusions:** Event-analyses confirm the poor agreement between structural and functional tests of progression previously observed with other analyses. While the prognostic value of optic disk progression is not as yet clear, disk imaging and visual field tests should be regarded as contributing independent information in the clinical care of glaucoma patients.

## SCALING THE STRUCTURE-FUNCTION RELATIONSHIP FOR CLINICAL PERIMETRY

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**Purpose:** The full ranges for glaucomatous visual field defects and retinal ganglion cell losses can cover several orders of magnitude and, therefore, an interpretation of the structure-function relationship for clinical perimetry requires scaling of both variables. However, the most appropriate scale has not been determined and the present study was undertaken was to compare linear and logarithmic transformations, which have been proposed for correlating the perimetric defects and neural losses from glaucoma. **Methods:** Perimetry, by behavioural testing, and retinal histology data were obtained from rhesus monkeys with significant unilateral visual field defects caused by experimental glaucoma. Ganglion cell densities were measured in sections of retina that corresponded to specific perimetry test locations for the treated and control eyes. The linear (percentage) and logarithmic (decibel) relationships for sensitivity loss as a function of ganglion cell loss were analyzed.

**Results:** With decibel scaling, visual sensitivity losses and ganglion cell densities were linearly correlated with high r-values and low mean deviations, although the parameters of the functions varied with eccentricity. The structure-function relationships expressed as percentage-loss functions were less systematic in two respects. First, the relationship exhibited considerable scatter in the data for small losses in visual sensitivity and, second, visual sensitivity losses became saturated with larger losses in ganglion cell density. The parameters of the percentage-loss functions also varied with eccentricity, but the variation was less than for the decibel-loss functions. **Conclusions:** In log-log coordinates the structure-function for clinical perimetry is relatively precise and accurate, especially for cell losses of greater than about 3 dB. Linear relations between perimetric defects and ganglion cell losses could improve the structure-function relationship for visual losses associated with small amounts of cell loss, but the high variability limits the usefulness in that range of the function. The comparatively greater precision and accuracy of decibel-loss functions are a likely consequence of the logarithmic scale of stimulus intensity for perimetry measurements and the relationship between visual sensitivity and the number of neural detectors is a probability summation function.

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## GDx VCC AND WHITE ON WHITE PERIMETRY IN GLAUCOMA PATIENTS

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**Aim:** To evaluate which GDx VCC parameter is more correlated to visual field indices. **Methods:** Eighty consecutive glaucomatous patients were recruited in this study. Glaucomatous patients were classified when an abnormal visual field and/or an abnormal optic disc was present. One eye was chosen randomly from all the subjects. All ONHs were examined with the GDx VCC (Laser Diagnostic Technologies, Inc, San Diego, CA, USA) and visual fields were assessed by Humphrey Perimeter, program 24-2 (Humphrey Instrument, Inc, San Leandro, CA, USA). GDx parameters and visual field indices were considered. Pearson's r correlation coefficient were used to compare the two set of data. A linear regression model was also calculated to evaluate the independent contribution of each GDx VCC parameters.

**Results:** The mean age (+/- standard deviation) was 62.4 +/- 10.4, the average of the mean deviation (MD) was -2.36 +/- 2.8 and the mean pattern standard deviation (PSD) was 3.32 +/- 2.6. Significant correlation was found between MD and the number ( $r=0.26$ ) and between MD and the superior average ( $r=-0.34$ ). The linear regression model found the number to be the predictor variable of MD (Beta 0.41,  $p=0.026$ ). Significant correlation was also found between PSD and the number ( $r=0.39$ ) and between PSD and the superior average ( $r=-0.32$ ). The linear regression model found the number to be the predictor variable of PSD (Beta 0.45,  $p=0.014$ ).

**Conclusion:** GDx VCC was significantly correlated to visual field indices even in early glaucomatous patients. The number is still the best indicator of visual field damage.

## SITA-STANDARD, HRT-II AND GDx-VCC IN GLAUCOMA DIAGNOSIS

DR GIOVANNI MILANO

**Purpose:** the aim of the study is to compare HRT -II and GDx-VCC outcomes in different classes of patients classified with the help of automated perimetry (HFA-II:24-2, SITA-Standard).

**Methods:** The study is still in progress. At the moment the authors have selected 34 outcomes patients referring to the Glaucoma service of the University Eye Clinic of Pavia, Italy. All subjects have been submitted to a complete ophthalmic examination and classified as Normals (IOP<21 mmHg, normal VF), Ocular Hypertensives (IOP>21mmHg, normal VF), Early Glaucoma (IOP>21mmHg, VF: early glaucomatous loss according to Hodapp classification), Advanced Glaucoma (IOP>21 mmHg, VF: moderate or advanced glaucomatous loss according to Hodapp classification). They were also submitted to the analysis of the optic disk with Heidelberg Retina Tomograph-II (HRT-II) and of the nerve fiber layer with Glaucoma Diagnosis-Variable Corneal Compensation (GDx-VCC). At the moment only one index (regression analysis for HRT-II and NFI for GDx-VCC) has been taken into account but a more accurate statistical analysis has been planned when a larger number of subjects will be available.

### **Results:**

Clinical Classification	Patients number	HRT-II	GDx-VCC
Normals	7	5 normal, 1 borderline, 1 pathological	5 normal, 0 borderline, 2 pathological
Ocular Hypertensives	14	7 normal, 6 borderline, 1 pathological	10 normal,4 borderline, 0 pathological
Early Glaucoma	3	2 normal, 0 borderline, 1 pathological	3 normal, 0 borderline, 0 pathological
Advanced Glaucoma	10	3 normal,1 borderline, 6 pathological	2 normal, 3 borderline, 5 pathological

**Conclusions:** the agreement among clinical data, mainly based on VF outcomes, and morphological analysis of the optic disk and the fibres layer is not perfect with a slight better correlation in the N and OH groups. The concordance between HRT -II and GDx-VCC seems rather good.

## LONGITUDINAL CHANGE IN OPTIC DISC TOPOGRAPHY AND VISUAL FIELDS

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**Purpose:** To investigate the relationship between serial variation in optic disc topography and visual fields.

**Subjects and methods:** Fifty-one eyes with risk factors for glaucoma but no standard automated perimetry (SAP) or optic disc abnormalities (Suspect Group), and 38 eyes with glaucomatous optic neuropathy (GON) but no SAP abnormalities (GON Group) were enrolled in a prospective, longitudinal study. The optic disc and visual fields were assessed annually using the Heidelberg Retina Tomograph (HRT) and Humphrey visual field analyzer respectively. A baseline and 3 follow-up visits were completed. HRT image sequences were subjected to superpixel change analysis. Change at  $\geq 20$  contiguous superpixels was considered “progressed” or “improved” depending on the direction of change.

An eye was deemed to have ‘converted’ if the SAP glaucoma hemifield test became ‘outside normal limits’, the pattern standard deviation probability fell outside the lower 5<sup>th</sup> normal percentile, or a cluster of  $\geq 3$  points outside the 5<sup>th</sup> normal percentile were present on the pattern deviation plot.

**Results:** Three eyes (7.9%) in the GON Group, and 2 eyes (3.9%) in the Suspect Group converted. In the GON Group, progression anywhere on the image was observed accompanying visual field conversion in 2 eyes (5.3%). However this progression was not within the optic disc. In the Suspect Group, progression was observed anywhere on the image accompanying visual field conversion in 1 eye (2.0%). This progression was within the optic disc. Progression was observed anywhere on the image with no visual field conversion in 20 eyes (52.9%) in the GON Group, and 30 eyes (58.8%) in the Suspect Group. Of these, progression was within the optic disc in 11 eyes (28.9%) in the GON Group, and 16 eyes (31.4%) in the Suspect Group.

**Conclusions:** In the GON Group, the rate of visual field conversion was higher when progression was observed anywhere than when progression was required to occur within the disc. Progression was more prevalent with HRT than visual fields.

## **SECTORIAL CORRELATION BETWEEN FREQUENCY DOUBLING TECHNOLOGY SENSITIVITY AND HEIDELBERG RETINA TOMOGRAPH RIM AREA AND CUP SHAPE MEASURE**

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**Purpose:** To evaluate the sectorial correlation between Heidelberg Retina Tomograph (HRT) parameters and the Frequency Doubling Technology (FDT) indices.

**Methods:** One eye was randomly chosen from 100 patients with primary open angle glaucoma (abnormal visual field and/or abnormal optic nerve and untreated IOP above 21 mmHg) and ocular hypertension (normal visual field and normal optic nerve and untreated IOP above 21mmHg). All the patients were examined with Humphrey Perimeter program 30-2, full threshold, FDT program C 20-5 and HRT. Findings were analysed using Pearson's correlation coefficient and linear regression.

**Results:** Significant ( $P<0.001$ ) correlation was found between FDT Mean Deviation and HRT rim area (RA) and cup shape measure (CSM). Significant ( $P<0.001$ ) sectorial correlation was found between FDT sensitivity and RA and CSM. When a linear regression model was applied, RA was significantly ( $P<0.001$ ) correlated to all FDT sector sensitivity.

**Conclusion:** In this glaucomatous group cup shape measure and rim area showed significant correlation. Rim area showed to be more predictive of FDT sensitivity than CSM.

## THE RELATIONSHIP BETWEEN A FUNCTIONAL VISUAL FIELD MAP AND AN ANATOMICAL RETINAL MAP

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**Purpose:** To examine the relationship between an anatomical map relating the retinal nerve fibre layer (RNFL) distribution to the optic nerve head (Garway-Heath et al. *Ophthalmology* 2000 Oct;107(10):1809-15.) and a ‘functional map’ derived from the inter-point correlation of raw sensitivity values (Gardiner et al. *Vision Res* 2004 Apr;44(8):839-48).

**Methods:** Inter-point correlation values were generated for all possible pairs of visual field (VF) test points in a data-set of 98,000 Humphrey VF tests taken from the Moorfields Eye Hospital archive. The relationship between these correlation values and the physical distance between the VF test point pairs was evaluated by Pearson’s correlation coefficient and multiple regression analysis. The distance between the pairs of VF test points was calculated in two ways. Firstly, the anatomical map was used to estimate the angular distance at the optic nerve head, between the RNFL bundles corresponding to the VF test points in each pair (ONHd). Secondly, the retinal distance between pairs of test points was calculated from the Humphrey VF template (RETd).

**Results:** All scatter plots showed a negative association between inter-point retinal sensitivity correlation values and distance between points: ONHd ( $r = -0.78$ ) and RETd ( $r = -0.57$ ). The raw sensitivity correlation values could be predicted from a multiple regression model using ONHd, RETd, and combined interaction of ONHd and RETd ( $R^2 = 0.74$ )

**Conclusions:** An encouraging level of association was observed between correlated points in the visual field and the relative location of those test points in the peripheral retina and at the optic nerve head. These results help to validate the relationship between structure and function and may be of use in the further refinement of physiologically derived visual field filters.

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## COMPARISON SUBJECTIVE AND OBJECTIVE FINDINGS IN GLAUCOMA PATIENTS

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**PURPOSE:** To compare changes of the visual field (VF) with objective findings on HRT II.

**MATERIAL and METHODS:** 65 eyes were divided due to changes in the VF (Aulhorn's scale FV). 13 eyes were normal, they served as a control group. VF was tested by HFA perimeter (Full threshold test 30-2). Typical glaucoma changes, global indices MD and PSD were evaluated. Stereometric analysis of the optic nerve head (ONH) was evaluated by HRT II. Results (Cup/Disc Area Ratio, Rim Area, Rim Volume, Mean RNFL Thickness, Height Variation Contour and Cup Shape Measure-CSM) were compared with VF changes.

**RESULTS:** Early glaucoma changes were preferably demonstrated on the ONH by CSM, optionally by C/D Ratio. Advanced glaucoma changes are better monitored on VF changes by MD coefficient.

By coefficient CSM on HRT II (evaluating cup shape and volume together) we can observe evolution of glaucoma changes as in initial phase, as in terminal phase.

**CONCLUSIONS:** The best correlation exists between coefficient CSM on HRT II and VF changes.

## **STRUCTURAL AND FUNCTIONAL RELATIONSHIP IN PATIENTS WITH VIGABATRIN-ATTRIBUTED VISUAL FIELD LOSS**

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**Purpose:** to determine the relationship between visual field loss and retinal nerve fibre layer (RNFL) thickness in patients who have been exposed to the anti-epileptic drug vigabatrin.

**Methods:** the right eye of 16 patients exposed to vigabatrin (mean age 42.5, SD 9.6 years), of 13 age-matched epilepsy patients never exposed to vigabatrin (mean age 40.0, SD 7.49 years) and of 16 age-matched normal subjects (mean age 38.0, SD 12.53) underwent optical coherence tomography (OCT) using the OCT -3. Three separate 360° scans around the optic disc were taken using the Proportional Circle scan to account for differences in disc size (the vertical radius of the disc was measured using the Fast Optic Disc scan). Perimetry was undertaken utilising Three-Zone Age-Corrected suprathreshold perimetry with the Full Field 135 Point Screening Program and threshold perimetry with Program 30-2 and the FASTPAC algorithm of the Humphrey Visual Field Analyzer 750.

**Results:** twelve of the 16 patients in the vigabatrin exposed cohort exhibited vigabatrin-attributed visual field loss. No cases of field loss were found in the two control groups. The group mean RNFL thickness was attenuated in those patients exposed to vigabatrin with visual field loss (mean 65.4µm, SD 10.5) compared to that of the epilepsy control group (mean 99.1µm, SD 16.1) ( $p < 0.001$ ) and compared to that of the normal control group (mean 111.0µm, SD 13.4) ( $p < 0.001$ ). The mean RNFL thickness in the epilepsy control group and the normal control group was not significantly different ( $p = 0.132$ ).

**Conclusions:** patients with vigabatrin-attributed visual field loss exhibit a reduction in the RNFL as designated by OCT. This suggests that OCT can be used for the assessment of vigabatrin-attributed damage in those patients unable to perform perimetry.

## **EARLY DETECTION OF RETINAL NERVE FIBER LAYER (RNFL) INJURY USING POLARIMETRY**

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**Purpose:** To assess the RNFL in glaucomatous eyes with achromatic field defects limited to one hemifield.

**Methods:** 26 eyes of 26 individuals with open angle glaucoma (OAG) with glaucomatous optic neuropathy and an abnormal achromatic automated perimetry (AAP) defect limited to one hemifield consistent with glaucoma were enrolled in this multicenter study. Eligible fields had a glaucoma hemifield test (GHT) outside normal limits associated with a cluster of 3 contiguous abnormal points (at least 1 point at the  $p < 0.5\%$  level) in the involved field. There was no cluster of points (more than 2 points) or point(s) at the  $p < 0.5\%$  level in the “normal” hemifield. Eyes with any other ocular abnormality or unreliable visual field were excluded. Polarimetry was performed using a variable corneal compensator GDx (GDx-VCC<sup>TM</sup>, Laser Diagnostic Technologies, Inc., San Diego, CA). GDx-VCC data were considered abnormal when a TSNIT (RNFL map) parameter was at the  $p < 2\%$  significance level or if the deviation map showed at least 3 contiguous points at the  $p < 0.5\%$  significance level. The GDx-VCC normative database was used to determine abnormality.

**Results:** 26 eyes (26 OAG patients) were included. Mean pattern standard deviation was  $8.29 \pm 5.05$  dB. A corresponding GDx-VCC RNFL defect was associated with 22/26 (84.6%) abnormal hemifields and in 13/26 (50%) regions associated with normal achromatic hemifields.

**Conclusions:** In OAG, GDx-VCC RNFL injury often involves the superior and inferior optic nerve even when achromatic field defects are limited to one hemifield.

## RETINA AND OPTIC DISC MEASURES IN AGED NORMALS

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**Purpose:** To evaluate retinal posterior pole and optic disc parameters by the Retinal Thickness Analyzer (RTA) in aged probands tested normal by clinical examination and visual field analysis.

**Methods:** Probands over 40 years of age without any prior history of eye diseases were recruited. Only probands with a completely normal ophthalmologic examination and visual field testing on Humphrey Field Analyzer (HFA) using the SITA 24-2 program were included. A total of 74 eyes from 74 patients were enrolled and underwent topographic measurements of the posterior pole and the optic disc with the RTA. The “glaucoma full” program in software version 4.11B was applied. This program gives for the posterior pole the minimum and perfoveal minimum retinal thickness, the posterior pole and perfoveal superior to inferior (S/I) asymmetry, the posterior pole and perfoveal abnormally thin areas, the number of thin clusters at the posterior pole and the posterior pole pattern deviation. Optic disc measurements consist of disc and cup area, cup/disc area ratio, rim area, cup and rim volume, mean and maximum cup depth, cup shape measure, height variation contour, mean retinal nerve fibre layer (RNFL) thickness and RNFL cross section area. Analysis consisted of extensive graphical, ANOVA and correlation analysis.

**Results:** Mean patients age was 59.9±10.3 years. The rim area of the optic nerve head showed a significant correlation with the posterior pole and perfoveal minimum thickness. There was also a good correlation between the spherical equivalent and the rim area and rim volume of the optic disc and the mean RNFL thickness. There was no relevant correlation between the IOP and all parameters of the optic disc and posterior pole except for the posterior pole asymmetry (S/I), which showed a highly significant correlation (p=0.02). Mean defect and pattern standard deviation of the HFA did not correlate significantly with any of the retina or optic disc measures in this normal population. Increasing age did not influence the visual field results but correlated significantly with several morphologic measures.

**Conclusions:** Topographic normocollective measurements of the posterior pole and optic disc by RTA imaging were obtained. Some interesting correlations could be shown which support the theory that automatic quantitative topographic analysis can provide additional information about pathogenesis, earlier diagnosis, progression and management of major eye diseases such as glaucoma.

## OPTIC NERVE HEAD ANALYSIS IN A NORMAL INDIAN POPULATION USING THE HEIDELBERG RETINAL TOMOGRAPH II

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**Purpose:** To define values for various parameters with regard to the optic nerve head using a scanning laser ophthalmoscope, the Heidelberg Retina Tomograph II, in a normal Indian population.

**Methods:** 85 eyes of 85 normals were randomly selected for evaluation of the optic disc with the Heidelberg Retinal Tomograph (HRT II, version 1.5.0). All subjects were examined with the Humphrey perimeter program 24-2 and the HRT II. All HRT parameters were analyzed using Pearson's coefficient of correlation. The 2-tailed t-test was used to determine if there was any significant difference in HRT parameters with regard to age, refractive error and disc areas. Linear regression analysis was done to predict the correlation between disc area and cup-disc area ratio.

**Results:** Average disc size in the population under study was  $2.33 \pm 0.44 \text{mm}^2$  (95% CI; 2.23-2.43). The specificity of the MRA varied from 88.2% to 96.1% depending upon the criteria used to define an abnormal disc. The RB (R Burk) and FSM (F S Mickelberg) discriminant values had a specificity of 94.1% and 84.7% respectively. A significant correlation ( $r^2 = 0.256$ ) was observed between disc area and cup-disc area ratio.

**Conclusions:** The MRA, FSM and RB discriminant functions have a reasonably high specificity in the normal Indian population. Establishment of a normative database will aid in identifying and analyzing glaucoma suspects and diseased patients.

**ASSESSMENT OF INTER-EYE DIFFERENCES OF OPTIC NERVE HEAD  
TOPOGRAPHIC MEASUREMENTS BY HEIDELBERG RETINA  
TOMOGRAPH IN NORMAL, OPEN-ANGLE GLAUCOMA AND OCULAR  
HYPERTENSION EYES  
– A STUDY ON TUNISIAN PATIENTS –**

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**Purpose:** Asymmetry of mean defect and/or cup -disc is one important factor well-known in the diagnosis of glaucoma. We sought important to evaluate the inter-eye differences of optic nerve head (ONH) topographic parameters with Heidelberg retina tomograph (HRT) in normal eyes in comparison with big cup, ocular hypertension (OHT) and primary open-angle glaucoma (OAG) eyes.

**Methods:** 274 eyes of 137 Tunisian patients were studied at the department of ophthalmology at Charles Nicolle University Hospital. ONH topographic measurements of both eyes were evaluated by confocal scanning laser ophthalmoscope type HRT in 40 normal patients (80 eyes), 22 big cup (44 eyes), 24 OHT (48 eyes) and 51 OAG (102 eyes). Disc and cup area, cup/disc area ratio, rim area, height variation contour, cup and rim volume, mean and maximum cup depth cup shape measure, mean RNFL thickness and RNFL cross section area were evaluated. RNFL measurements were correlated with VF indices.

**Results:** RNFL measurements particularly RNFL cross section area with a mean of  $0,235\text{mm}^2 (\pm 0,153\text{mm}^2)$  was found to be the normal variation between both eyes in normal eyes. No statistically significant differences were found between normal, OHT and big cup eyes whereas an asymmetry of more than  $0,400\text{mm}^2 (\pm 0,300\text{mm}^2)$  was found in OAG. RNFL measures were correlated with VF indices asymmetry.

**Conclusion:** The assessment of asymmetry in normal eyes seems to be an important parameter in the analysis of RNFL measurements to distinguish suspected and/or pathological asymmetry thus may help in the diagnosis of RNFL damage.