Abstracts Frequency-doubling perimetry
(Stand Juni 2000)

Trible JR, Schultz RO, Robinson JC, Rothe TL
Accuracy of glaucoma detection with frequency-doubling perimetry
Eye Institute, Medical College of Wisconsin, Milwaukee, Wisconsin, USA

PURPOSE: To determine the accuracy of glaucoma detection by frequency-doubling perimetry. METHODS: Stereoview optic nerve photographs, visual field examination, intraocular pressure measurements, medical and ocular history, and a screening and full threshold frequency-doubling perimetry examination were performed in a prospective study of consecutive subjects. Inclusion criteria included age of 45 years or older, absence of ocular disease other than glaucoma, cataract, or mild drusen, and Snellen visual acuity of 20/60 or better. A total of 125 eyes in 102 glaucoma subjects and 95 eyes of 95 normal subjects were included. Each eye was classified as "normal," "glaucoma," or "uncertain" by each of three ophthalmologists on the basis of all available clinical information with the exception of frequency-doubling perimetry results. Those in the glaucoma group were subclassified as having early (n = 51), moderate (n = 42), or severe (n = 32) glaucoma on the basis of automated Humphrey visual field criteria. In the glaucoma group, two eyes from a subject were allowed to be included (23 of 102 subjects) if they differed in level of damage because they were never analyzed within the same statistical analysis.

RESULTS: Several diagnostic algorithms were evaluated. Algorithms based on the most depressed single point, pair of adjacent points, and cluster of three points performed nearly identically. For the screening test, if any abnormality was identified, specificity was 95%, whereas sensitivity was 39%, 86%, and 100% for early, moderate, and severe glaucoma, respectively. For the full threshold test, with at least one point depressed to the P < 0.5% level, specificity measured 91%, whereas sensitivity was 35%, 88%, and 100% for early, moderate, and severe glaucoma, respectively. The two global indices, mean deviation and pattern standard deviation, were also evaluated and were generally less accurate.

CONCLUSION: Frequency-doubling perimetry, which is rapid and easily administered, is effective at detecting moderate and severe disease and appears well suited for glaucoma screening.

Sample PA, Bosworth CF, Blumenthal EZ, Girkin C, Weinreb RN
Visual function-specific perimetry for indirect comparison of different ganglion cell populations in glaucoma.

PURPOSE: To compare short-wavelength automated perimetry, frequency-doubling technology perimetry, and motion-automated perimetry, each of which assesses different aspects of visual function, in eyes with glaucomatous optic neuropathy and ocular hypertension. METHODS: One hundred thirty-six eyes from 136 subjects were evaluated with all three tests as well as with standard automated perimetry. Fields were not used in the classification of study groups to prevent bias, because the major purpose of the study was to evaluate each field type relative to the others. Seventy-one of the 136 eyes had glaucomatous optic neuropathy, 37 had ocular hypertension, and 28 served as age-matched normal control eyes. Glaucomatous optic neuropathy was defined by assessment of stereophotographs.
Criteria were asymmetrical cupping, the presence of rim thinning, notching, excavation, or nerve fiber layer defect. Ocular hypertensive eyes had intraocular pressure of 23 mm Hg or more on at least two occasions and normal-appearing optic disc stereophotographs. Criteria for abnormality on each visual field test were selected to approximate a specificity of 90% in the normal eyes. Thresholds for each of the four tests were compared, to determine the percentage that were abnormal within each patient group and to assess the agreement among test results for abnormality, location, and extent of visual field deficit. Results: Each test identified a subset of the eyes with glaucomatous optic neuropathy as abnormal: 46% with standard perimetry, 61% with short-wavelength automated perimetry, 70% with frequency-doubling perimetry, and 52% with motion-automated perimetry. In the ocular hypertensive eyes, standard perimetry was abnormal in 5%, short wavelength in 22%, frequency doubling in 46%, and motion in 30%. Fifty-four percent (38/71) of eyes with glaucomatous optic neuropathy were normal on standard fields. However, 90% were identified by at least one of the specific visual function tests. Combining tests improved sensitivity with slight reductions in specificity. The agreement in at least one quadrant, when a defect was present with more than one test, was very high at 92% to 97%. More extensive deficits were shown by frequency-doubling perimetry followed by short-wavelength automated perimetry, then motion-automated perimetry, and last, standard perimetry. However, there were significant individual differences in which test of any given pairing was more extensively affected. Only 30% (11/37) of the ocular hypertensive eyes showed no deficits at all compared with 71% (20/28) of the control eyes (P < 0.001). Conclusions: For detection of functional loss standard visual field testing is not optimum; a combination of two or more tests may improve detection of functional loss in these eyes; in an individual, the same retinal location is damaged, regardless of visual function under test; glaucomatous optic neuropathy identified on stereophotographs may precede currently measurable function loss in some eyes; conversely, function loss with specific tests may precede detection of abnormality by stereophotograph review; and short-wavelength automated perimetry, frequency-doubling perimetry, and motion-automated perimetry continue to show promise as early indicators of function loss in glaucoma.

Trible JR, Schultz RO, Robinson JC, Rothe TL
Accuracy of glaucoma detection with frequency-doubling perimetry.
Eye Institute, Medical College of Wisconsin, Milwaukee, Wisconsin, USA

Purpose: To determine the accuracy of glaucoma detection by frequency-doubling perimetry. Methods: Stereoview optic nerve photographs, visual field examination, intraocular pressure measurements, medical and ocular history, and a screening and full threshold frequency-doubling perimetry examination were performed in a prospective study of consecutive subjects. Inclusion criteria included age of 45 years or older, absence of ocular disease other than glaucoma, cataract, or mild drusen, and Snellen visual acuity of 20/60 or better. A total of 125 eyes in 102 glaucoma subjects and 95 eyes of 95 normal subjects were included. Each eye was classified as "normal," "glaucoma," or "uncertain" by each of three ophthalmologists on the basis of all available clinical information with the exception of frequency-doubling perimetry results. Those in the glaucoma group were subclassified as having early (n = 51), moderate (n = 42), or severe (n = 32) glaucoma on the basis of automated Humphrey visual field criteria. In the glaucoma group, two eyes from a subject were allowed to be included (23 of 102 subjects) if they differed in level of damage because they were never analyzed within the same statistical analysis. Results: Several diagnostic algorithms were evaluated. Algorithms based on the most depressed single point, pair of
adjacent points, and cluster of three points performed nearly identically. For the screening test, if any abnormality was identified, specificity was 95%, whereas sensitivity was 39%, 86%, and 100% for early, moderate, and severe glaucoma, respectively. For the full threshold test, with at least one point depressed to the P < 0.5% level, specificity measured 91%, whereas sensitivity was 35%, 88%, and 100% for early, moderate, and severe glaucoma, respectively. The two global indices, mean deviation and pattern standard deviation, were also evaluated and were generally less accurate. CONCLUSION: Frequency-doubling perimetry, which is rapid and easily administered, is effective at detecting moderate and severe disease and appears well suited for glaucoma screening.

Burnstein Y, Ellish NJ, Magbalon M, Higginbotham EJ
Comparison of frequency doubling perimetry with Humphrey visual field analysis in a glaucoma practice.

PURPOSE: To determine the sensitivity and specificity of frequency doubling perimetry with Humphrey visual field testing used as the gold standard. METHODS: Frequency doubling perimetry and Humphrey visual field testing (24-2) were performed on 29 consecutive patients in a glaucoma practice. Data for the right eye were used to calculate sensitivity, specificity, and receiver operating characteristic curves. RESULTS: For the frequency doubling perimetry in screening mode, and with an abnormal glaucoma hemifield test used as the gold standard, the area under the receiver operating characteristic curve was 89.3%, 81.5%, or 75.0% for the presence of mild, moderate, or severe relative defects, respectively. Similar results were found with the use of mean deviation (P <.05) to define Humphrey visual field defects. For frequency doubling perimetry in threshold mode, the area under the receiver operating characteristic curve was 93.4% with the presence of any defect (P <.05) used as the criterion for an abnormal case, and an abnormal glaucoma hemifield test as the gold standard. In all cases, the threshold mode detected defects better than the screening mode.

Patel SC, Friedman DS, Varadkar P, Robin AL
Algorithm for interpreting the results of frequency doubling perimetry.
Department of Ophthalmology, Greater Baltimore Medical Center, Baltimore, MD, USA.

PURPOSE: To evaluate an algorithm for the identification of glaucomatous visual field defects with the screening mode of frequency doubling technology. METHODS: Screening-mode frequency doubling technology and Swedish interactive threshold algorithm perimetry were performed on 137 of 150 consecutive patients referred to a glaucoma specialist. We created an algorithm for the frequency doubling technology that gave increased importance to both more severe defects and defects closer to fixation. These values were then compared with the results of the Swedish interactive threshold algorithm visual fields evaluated by the glaucoma hemifield test, two masked glaucoma specialists, and a published definition of glaucomatous damage to determine sensitivity and specificity of the frequency doubling technology screening mode for detecting glaucoma.
Cello KE, Nelson-Quigg JM, Johnson CA
Frequency doubling technology perimetry for detection of glaucomatous visual field loss.

PURPOSE: To evaluate the ability of frequency doubling technology perimetry to detect early, moderate, and advanced glaucomatous visual field loss.

METHODS: In a prospective study, frequency doubling technology perimetry (C-20 full threshold) was performed in the right eye of 254 normal control subjects and 230 patients with early (n = 85), moderate (n = 114), or advanced (n = 31) glaucomatous visual field loss. Previous Humphrey Field Analyzer test results were used to classify glaucomatous visual field loss as early (mean deviation no worse than -6 dB), moderate (mean deviation between -6 and -12 dB) or advanced (mean deviation between -12 and -22 dB). RESULTS: Receiver operating characteristic curves showed 100% sensitivity and specificity (area under the curve, 1.0) for detecting advanced glaucomatous visual field loss, approximately 96% sensitivity and 96% specificity (area under the curve, 0.9751) for detecting moderate glaucomatous visual field loss, and approximately 85% sensitivity and 90% specificity (area under the curve, 0.9261) for early glaucomatous visual field loss. CONCLUSIONS: Frequency doubling technology perimetry demonstrates high sensitivity and specificity for detection of early, moderate, and advanced glaucomatous visual field loss.

Alward WL
Frequency doubling technology perimetry for the detection of glaucomatous field loss
Editorial, no abstract available

Iester M, Mermoud A, Schnyder C
Frequency doubling technique in patients with ocular hypertension and glaucoma: correlation with octopus perimeter indices.

PURPOSE: To ascertain whether frequency doubling technique (FDT) (Welch-Allyn, Skaneateles, NY; Zeiss-Humphrey, San Leandro, CA) indices provide results comparable with those of standard Octopus threshold perimeters (Interzeag AG, CH-8952 Schlieren, CH) in patients with glaucoma and in patients suspected of having ocular hypertension, glaucoma, or both.

METHODS: A comparative, consecutive, case series. PARTICIPANTS: Thirty-nine glaucomatous patients and 41 patients with ocular hypertension or suspected glaucoma were recruited consecutively. METHODS: The visual field of the study participants were assessed by FDT program C-20 full threshold and Octopus program dG1X. Only one eye of each participant was selected randomly. Pearson's r correlation coefficient was calculated among the FDT and Octopus indices. MAIN OUTCOME MEASURES: Using Octopus perimeter, mean defect (MD), mean sensitivity (MS), loss variance (LV), and corrected loss variance (CLV) were calculated and used for correlation. For the FDT, mean deviation (FDT-MD) and pattern standard deviation (FDT-PSD) were calculated and used for correlation. Also, the time required to perform the visual field test was considered. RESULTS: In the entire population, a statistically significant correlation (Pearson's r, P<0.001) was found between FDT-MD and both MS (0.77) and MD (-0.80) and between FDT-PSD and both LV (0.50) and CLV (0.45). When the glaucoma group was considered alone, similar significant correlation was found between the indices. In the suspected ocular hypertension and glaucoma suspect group, no
significant correlation was found. A significant (P<0.001) difference was found between FDT and Octopus for the time needed to perform the visual field test. CONCLUSIONS: This new technique could be used both to screen populations and to observe glaucomatous visual field progression in early and moderate stages. The FDT is a faster way to analyze the visual field and captures threshold values for each point, but it is important to remember that this is a new technique and its limits are still unknown.

Fabre K, Michiels I, Zeyen T
The sensitivity and specificity of TOP, FDP and GDX in screening for early glaucoma.

The purpose of this study was to evaluate the efficacy of three screening tests in detecting glaucoma in its early stage: the Tendency Oriented Perimetry (TOP) and Frequency Doubling Perimetry (FDP) visual field tests, and the Glaucoma Diagnostic (GDX) nerve fibre layer analyser. Eighteen patients with glaucoma who showed an early defect on HFA c 24-2 and twenty normals underwent the three tests. TOP showed a sensitivity of 94.4% and a specificity of 75%, FDP showed a sensitivity of 72.2% and a specificity of 100%, and GDX a sensitivity of 77.7% and a specificity of 60%.

Yamada N, Chen PP, Mills RP, Leen MM, Lieberman MF, Stamper RL, Stanford DC
Screening for glaucoma with frequency-doubling technology and Damato campimetry.
Arch Ophthalmol 1999 Nov;117(11):1479-84

OBJECTIVE: To assess frequency-doubling technology (FDT) perimetry (Humphrey Systems, San Leandro, Calif) and Damato campimetry (Precision Vision, Villa Park, Ill) for detecting glaucoma in a public glaucoma screening. METHODS: A 2-day public glaucoma screening was held at 2 different institutions. Each subject underwent 2 visual field screening tests (Damato campimetry and FDT perimetry in screening mode), an ophthalmologic examination, and Humphrey perimetry (24-2 FASTPAC) for each eye. Eyes were divided into 4 categories: normal, ocular hypertensive, glaucoma suspect, and definite glaucoma. The sensitivity and specificity of FDT perimetry and Damato campimetry for detecting glaucoma were estimated with receiver operating characteristic curves. RESULTS: Among 240 subjects who underwent FDT, the number identified as normal, ocular hypertensive, glaucoma suspect, and definite glaucoma was 151, 28, 35, and 26, respectively; among 175 subjects who underwent Damato campimetry, the numbers for the same groups were 118, 19, 19, and 19, respectively. The areas under the receiver operating characteristic curve for FDT perimetry and Damato campimetry were 0.925 and 0.883, respectively. The optimal sensitivity and specificity for FDT perimetry were 92% and 93%, while those for Damato campimetry were 53% and 90%, respectively. The average test time was 1 minute and 3 minutes per eye for FDT perimetry and Damato campimetry, respectively. CONCLUSION: Frequency-doubling technology perimetry was superior to Damato campimetry in this screening for glaucoma.

Adams CW, Bullimore MA, Wall M, Fingeret M, Johnson CA
Normal aging effects for frequency doubling technology perimetry.
Optom Vis Sci 1999 Aug;76(8):582-7

PURPOSE: To determine the influence of normal aging on contrast sensitivity for frequency doubling technology (FDT) perimetry. METHODS: Contrast sensitivity measures were
obtained for frequency-doubled stimuli (0.25 cycles per degree sinusoidal gratings undergoing 25 Hz counterphase flicker) at 17 target locations (4 per quadrant plus the central 5 degrees) using a prototype of the Welch Allyn (Skaneateles, NY)/Humphrey Systems FDT perimeter (Humphrey Systems, Dublin, CA). A total of 407 normal subjects (761 eyes) between the ages of 15 and 85 years were tested. RESULTS: Between the ages of 15 and 60 years there was an approximately linear decrease in contrast sensitivity of 0.6 dB per decade. After the age of 70, there was a slightly greater sensitivity loss with age. There were no meaningful differences in sensitivity loss as a function of age for different visual field locations. A small but consistent reduction in contrast sensitivity (approximately 0.7 dB) was found at all visual field locations for the second eye tested that may be due to a central adaptation process. CONCLUSIONS: Normal aging effects for FDT perimetry are similar to those obtained for conventional automated perimetry, except that the FDT perimetry aging effects do not appear to be eccentricity dependent. These normative data provide a basis for establishing a statistical analysis procedure and probability plots for FDT perimetry.

Johnson CA, Cioffi GA, Van Buskirk EM
Frequency doubling technology perimetry using a 24--2 stimulus presentation pattern.
Optom Vis Sci 1999 Aug;76(8):571-81

PURPOSE: To assess whether smaller targets and a 24-2 stimulus presentation pattern would improve the ability of frequency doubling technology (FDT) perimetry to detect and characterize early glaucomatous visual field loss. METHODS: One hundred normal subjects between the ages of 20 and 85 participated in this study. In addition, 53 patients who either had early glaucomatous visual field loss (n = 23) or were high-risk glaucoma suspects with normal conventional visual fields (n = 30) were evaluated with the commercial version of FDT perimetry (full threshold test) with 17 stimuli (four 10 degrees diameter square targets per quadrant and a central 5 degrees circular target) and a custom version of FDT perimetry using 54 stimuli (4 degrees targets with 6 degrees grid spacing) arranged in a 24-2 stimulus presentation pattern. RESULTS: The custom FDT test using a 24-2 stimulus presentation pattern had a similar dynamic range, and demonstrated normal aging characteristics and test-retest reliability that were similar to the commercial version of FDT perimetry using 17 larger stimuli. Both FDT tests showed an age-related sensitivity reduction of approximately 0.6 dB per decade, and exhibited an average test-retest reliability of 1 to 1.5 dB. The custom 24-2 FDT perimetry test had a greater variation of sensitivity with eccentricity than the commercial version of FDT perimetry that was probably related to the difference in stimulus size. The custom 24-2 FDT perimetry test had a greater percentage of abnormal test locations than the commercial FDT test for both early glaucomas and high-risk glaucoma suspects. CONCLUSIONS: FDT perimetry can be performed with smaller targets using a presentation pattern that is similar to conventional automated perimetry. In comparison to the commercially available 17 target display, the 24-2 stimulus pattern appears to have modestly higher sensitivity for detection of early glaucomatous loss and provides better characterization of the pattern of visual field loss, but the test takes approximately twice as long.

Phipps JA, Guymer RH, Vingrys AJ
Temporal sensitivity deficits in patients with high-risk drusen.

PURPOSE: Data is reported from an ongoing trial considering functional losses in patients with high-risk drusen. We evaluate the temporal processing in 12 subjects: four patients with
high-risk drusen, four age-matched controls and four young observers aged 22-30.

METHODS: Subjects were tested using frequency-doubling technology, macula static and flicker fields on a Medmont perimeter and foveal temporal contrast sensitivity at 2, 5, 10 and 24 Hz. RESULTS: Eyes with high-risk drusen had good visual acuity (6/9.5(-2) or better). All control eyes had normal fields for static, flicker and frequency-doubling perimetry. All high-risk drusen eyes had normal static perimetry in the presence of abnormal flicker and frequency-doubling perimetry. High-risk drusen eyes showed a generalized loss of temporal sensitivity across all frequencies. CONCLUSIONS: We conclude that eyes with high-risk drusen show losses to temporal stimuli in the presence of near-normal acuity and static thresholds. We suggest that flickering stimuli might be useful for detecting and monitoring such patients.

Chauhan BC; Johnson CA
Test-retest variability of frequency-doubling perimetry and conventional perimetry in glaucoma patients and normal subjects.
Invest Ophthalmol Vis Sci, 1999 Mar, 40:3, 648-56

PURPOSE: To compare the test-retest variability characteristics of frequency-doubling perimetry, a new perimetric test, with those of conventional perimetry in glaucoma patients and normal control subjects. METHODS: The study sample contained 64 patients and 47 normal subjects aged 66.16±11.86 and 64.26±7.99 years (mean ± SD), respectively. All subjects underwent frequency-doubling perimetry (using the threshold mode) and conventional perimetry (using program 30-2 of the Humphrey Field Analyzer; Humphrey Instruments, San Leandro, CA) in one randomly selected eye. Each test was repeated at 1-week intervals for five tests with each technique over 4 weeks. Empirical 5th and 95th percentiles of the distribution of threshold deviations at retest were determined for all combinations of single tests and mean of two tests, stratified by threshold deviation. The influence of visual field eccentricity and overall visual field loss on variability also were examined. RESULTS: Mean test time with frequency-doubling perimetry in patients and normal control subjects was 5.90 and 5.25 minutes, respectively, and with conventional perimetry was 17.20 and 14.01 minutes, respectively. In patients, there was a significant correlation between the results of the two techniques, in the full field and in quadrants, whereas in normal subjects there was no such correlation. In patients, the retest variability of conventional perimetry in locations with 20-dB loss was 120% (single tests) and 127% (mean tests) higher compared with that in locations with 0-dB loss. Comparative figures for frequency-doubling perimetry were 40% and 47%, respectively. Variability also increased more with threshold deviation in normal subjects tested with conventional perimetry. In both patients and normal subjects, variability increased with visual field eccentricity in conventional perimetry, but not in frequency-doubling perimetry. Both techniques showed an increase in variability with overall visual field damage. CONCLUSIONS: Frequency-doubling perimetry has different test-retest variability characteristics than conventional perimetry and may have potential for monitoring glaucomatous field damage.

Kondo Y; Yamamoto T; Sato Y; Matsubara M; Kitazawa Y
A frequency-doubling perimetric study in normal-tension glaucoma with hemifield defect.
PURPOSE: The authors prospectively compare perimetric results obtained by conventional differential light sensitivity (DLS) perimetry and frequency-doubling perimetry (FDP) in normal-tension glaucoma (NTG) with a hemifield visual field defect, assuming that some of these eyes already have early glaucomatous changes in the “intact” hemifield. METHODS: Eleven eyes of 11 patients with NTG who met the enrollment criteria were studied. Seven eyes had an upper hemifield defect and four had a lower defect, determined by DLS with a Humphrey Field Analyzer (Zeiss-Humphrey, Inc., San Leandro, CA, U.S.A.). Frequency-doubling perimetry and DLS perimetry were conducted less than 7 days apart. To quantitatively detect nerve fiber layer defect (NFLD), scanning laser ophthalmoscopy was also performed. RESULTS: Of the 11 intact hemifields, seven showed NFLD. Of the seven, six also showed visual field defects by FDP. Of the four eyes without NFLD, two showed no defects in the intact hemifield by FDP. The threshold values of FDP and DLS perimetry did not significantly correlate in either the intact or the defective hemifields, or in the total field. The average test time of FDP was approximately 6 minutes. CONCLUSIONS: Frequency-doubling perimetry may detect early glaucomatous visual field defects.

Quigley HA
Identification of glaucoma-related visual field abnormality with the screening protocol of frequency doubling technology.

PURPOSE: To evaluate the predictive power of frequency doubling technology to distinguish glaucoma suspects from persons with glaucoma visual field loss. METHODS: A consecutive series of 76 subjects referred to a glaucoma service underwent perimetry in one eye with frequency doubling technology in a screening mode and Humphrey 24-2 threshold testing in random order, and had optic disk and clinical nerve fiber layer grading. RESULTS: All subjects performed perimetry with both instruments satisfactorily, with an average test time of 1.8 +/- 0.7 minutes per eye for the frequency doubling technology (instrument time). Of 33 eyes classified as abnormal by glaucoma hemifield test, 91% (30/33) were abnormal on frequency doubling technology (two or more abnormal locations of 17), whereas 94% (31/33) of glaucoma suspects with normal Humphrey fields had normal results with frequency doubling technology. Frequency doubling technology results were highly correlated with Humphrey mean deviation by linear regression (r² = .74, P = .047) and with corrected pattern standard deviation probability value. A frequency doubling technology error score for each quadrant of the field was highly correlated with the number of severely abnormal points per quadrant in Humphrey threshold tests (r² = .63, P = .034). There was close agreement between clinical examination of the optic disk and nerve fiber layer and frequency doubling technology results. Three-level quantification of abnormality in frequency doubling technology results did not add to diagnostic accuracy. CONCLUSION: Frequency doubling technology testing shows promise as a screening method in glaucoma.

Sponsel WE; Arango S; Trigo Y; Mensah J
Clinical classification of glaucomatous visual field loss by frequency doubling perimetry.

PURPOSE: To determine whether the frequency doubling perimeter (FDP) can grade glaucomatous visual function loss in a clinically relevant manner. Sinusoidal gratings < 1 cpd that undergo counterphase flicker > 15 Hz appear to have twice as many bands of light, a phenomenon referred to as the "frequency doubling illusion." Evidence suggests that this
psychophysical effect is mediated in part by large-diameter ganglion cells, which are reported to be lost early in the glaucomatous disease process. A portable, commercially available FDP has already demonstrated high diagnostic potential for glaucoma screening. METHODS: Sixty-four eyes of 42 glaucomatous patients and 22 eyes of 14 normal subjects were evaluated by means of both frequency doubling perimetry and Humphrey perimetry. A clinical scoring algorithm modeled after the Hodapp-Parrish-Anderson criteria for scoring Humphrey visual field defects was derived for the FDP at the halfway point of the study, and all participants were reassessed with this algorithm upon its completion. RESULTS: FDP mean and pattern deviation showed strong linear correlations with Humphrey 30-2 mean deviation ($R = 0.75; P < .0001$) and corrected pattern standard deviation values ($R = 0.64; P < .0001$). Despite this, neither global index could consistently categorize the graded glaucomatous visual fields in a manner consistent with the Hodapp-Parrish-Anderson criteria. The new FDP scoring algorithm did provide good segregation (73% precise parity, 93% parity within one Humphrey grade). CONCLUSIONS: Sixteen-zone frequency doubling perimetry can segregate glaucomatous visual field loss into pathologic categories approximating those obtained with Humphrey 30-2 perimetry by means of a formula modeled after the Hodapp-Parrish-Anderson criteria.

Johnson CA; Samuels SJ
Screening for glaucomatous visual field loss with frequency-doubling perimetry.
Invest Ophthalmol Vis Sci, 1997 Feb, 38:2, 413-25

PURPOSE: To conduct a preliminary evaluation of the efficacy of the frequency-doubling contrast test as a means of screening for glaucomatous visual field loss. METHODS: Contrast thresholds for frequency-doubled stimuli were obtained under four test conditions: superior hemifield, inferior hemifield, and central (5 degrees radius) targets using a method of adjustment (MOA); superior hemifield, inferior hemifield, and central targets using a modified binary search (MOBS); four quadrant stimuli and the central target using MOBS; and 16 stimuli (four per quadrant) and the central target using MOBS. One eye each of 36 patients with early (12), moderate (12), and advanced (12) glaucomatous visual field loss was tested, as was one eye each of 36 age-matched normal control subjects. RESULTS: For hemifield stimuli, the MOBS test procedure had better test-retest reliability, lower individual variation, and greater separation of the normal population and the population with glaucoma than did the MOA procedure. The use of progressively smaller, more localized stimuli produced successively better separation of glaucomatous and age-matched normal control eyes. Area under the Receiver Operating Characteristic curve was 0.81 for hemifield stimuli (sensitivity and specificity, 70% to 75%), 0.91 for quadrant stimuli (sensitivity and specificity, 83% to 85%), and 0.965 for the 16 stimuli (sensitivity 93%, specificity 100%). Test time was approximately 1.3 minutes for hemifields, 1.5 minutes for quadrants, and 5 minutes for the 16 targets. CONCLUSIONS: Preliminary results indicate that the frequency-doubled contrast test provides a quick, efficient means of screening for glaucomatous visual field loss. Test time is relatively short, test-retest reliability is good, and sensitivity and specificity for detection of glaucomatous visual field loss is very good. The use of the MOBS staircase procedure and small, localized stimuli result in the best performance for screening purposes. An expanded normative database and the use of more rapid suprathreshold screening strategies should enhance further the efficacy of this test.
Brusini P; Busatto P

**Frequency doubling perimetry in glaucoma early diagnosis.**

Frequency-doubling perimetry (FDP) is a new, out-of-the-ordinary, visual field testing method. Its sensitivity and reliability was tested in 16 patients (32 eyes) with ocular hypertension and 21 patients (37 eyes) with early chronic glaucoma. Significant defects were found in almost 10% of hypertensive eyes and in 67.7% of glaucomatous eyes. FDP is an effective and sensitive technique for glaucoma functional loss assessment.
Abstracts High-pass-resolution perimetry
(Stand Juni 2000)

Martínez Belló C; Chauhan BC; Nicolela MT; McCormick TA; LeBlanc RP
Intraocular pressure and progression of glaucomatous visual field loss.
Departments of Ophthalmology, Dalhousie University, Halifax, Nova Scotia, Canada.

PURPOSE: To evaluate the relationship between intraocular pressure and visual field progression in patients with primary open-angle glaucoma.

METHODS: We prospectively followed 113 patients with early to moderate glaucomatous field damage. Conventional automated static perimetry, high-pass resolution perimetry, and intraocular pressure measurements were carried out at 6-month intervals. The mean and the highest intraocular pressure in the follow-up were compared in stable and progressing patients with each perimetric technique.

RESULTS: The mean (+/- SD) follow-up was 4.5 +/- 0.9 years. The mean (+/- SD) intraocular pressure in patients remaining stable with conventional perimetry [18.2 +/- 3.3 mm Hg, n = 81 (71.7%)] was not significantly different (P =.65) from those in whom it progressed (17.9 +/- 3.3 mm Hg, n = 32 [28.3%]). The mean intraocular pressure in patients remaining stable with high-pass resolution perimetry (17. 9 +/- 3.5 mm Hg, n = 63 [55.8%]) was not significantly different (P =.33) from those in whom it progressed (18.5 +/- 3.0 mm Hg, n = 50 [44.2%]). The mean (+/- SD) of the highest (single or three highest) pressure during follow-up for stable and progressing patients with conventional perimetry was not significantly different (22.6 +/- 5.0 and 23.0 +/- 4.6 mm Hg, respectively, P =.76). However, for high-pass resolution perimetry, the difference was highly significant (21.6 +/- 4.5 and 24.1 +/- 4.9 mm Hg, respectively, P < .01). Furthermore, patients who progressed with high-pass resolution perimetry had more damaged baseline fields compared with those who remained stable (P <.01).

CONCLUSIONS: The mean level of intraocular pressure does not differentiate glaucoma patients with progressive visual field loss from ones who remained stable. Baseline visual field status and peak intraocular pressure of patients who progress with high-pass resolution perimetry are significantly different from those who remain stable.

Martin LM; Lindblom B; Gedda UK
Concordance between results of optic disc tomography and high-pass resolution perimetry in glaucoma.
J Glaucoma, 2000 Feb, 9:1, 28-33
Department of Clinical Science, Karolinska Institutet, Stockholm, Sweden.

PURPOSE: To evaluate concordance between results obtained with the Heidelberg Retina Tomograph (HRT) (Heidelberg Engineering GmbH, Heidelberg, Germany) and those obtained with the high-pass resolution perimeter (HRP) in glaucoma diagnosis.

METHODS: A total of 217 patients from the glaucoma services at St. Erik Eye Hospital, Stockholm, Sweden (n = 107) and Sahlgrenska University Hospital, Göteborg, Sweden (n = 110) were included in the study. All patients were examined because of known or suspected glaucoma in at least one eye. The conventional indices presented by the instruments were used, i.e., glaucoma index from the HRT (negative values = abnormal, positive = normal) and combined deviation (upper normal limit 2.1 dB) from the HRP. RESULTS: The concordance regarding the classification of normal or glaucomatous by the two instruments was 71% (153/217 eyes).
The HRT indicated glaucoma but HRP findings were normal in 47 patients, and the reverse occurred in 17 patients. There was a significant difference in optic disc area between patients with abnormal HRT findings and normal HRP findings and in patients with normal HRT findings and abnormal HRP findings. The concordance could not be improved by adjusting for disc size. The correlation between combined deviation on HRP and the HRT glaucoma index was $r = -0.53$. **CONCLUSION:** A significant correlation was found between the combined index given by HRP and the HRT glaucoma index in 217 patients examined for known or suspected glaucoma. Discordant findings were observed in 64 patients; in 22 this discordance was explained by the influence of disc size. No other reasons for differences in examination results could be detected.

**Popovic V; Sjöstrand J**  
**Course of exfoliation and simplex glaucoma after primary trabeculectomy.**  
Br J Ophthalmol, 1999 Mar, 83:3, 305-10  
Sahlgrenska University Hospital, Department of Ophthalmology, Mölndal, Sweden.

**AIM:** To study the course of exfoliation and simplex glaucoma with respect to intraocular pressure (IOP) regulation and visual field survival after primary trabeculectomy. **METHODS:** Postoperative IOP regulation and complications were analysed prospectively in 95 patients. Mean follow up was 46 months. Visual field survival was studied by high pass resolution perimetry (HRP) in a subsample of 28 patients. **RESULTS:** Medical treatment was reinstated in 42% of exfoliation and in 36% of simplex glaucoma. In these patients, mean medicine free survival time, last untreated IOP, and mean IOP at the end of follow up were similar for both glaucoma types. Among patients with controlled postoperative IOP without added medication, mean IOP at the end of follow up was significantly lower in exfoliation glaucoma. Visual field deterioration and the pattern of complications were similar for both glaucoma types. **CONCLUSION:** The effect of trabeculectomy on IOP regulation was good in both types of glaucoma, and somewhat better in exfoliation glaucoma. The magnitude of IOP lowering could not separate patients with continued visual field deterioration from those in whom visual fields remained stable. Visual field preservation was similar for both glaucoma types.

**Shirakashi M; Funaki S; Funaki H; Yaoeda K; Abe H**  
**Measurement of retinal nerve fibre layer by scanning laser polarimetry and high pass resolution perimetry in normal tension glaucoma with relatively high or low intraocular pressure.**  
Br J Ophthalmol, 1999 Mar, 83:3, 353-7  
Department of Ophthalmology, Niigata University School of Medicine, Japan.

**AIMS:** To determine whether any differences may exist in the relation between the neural capacity as determined by high pass resolution perimetry and the thickness of the retinal nerve fibre layer (RNFL) in patients having normal tension glaucoma (NTG) with a relatively high intraocular pressure (IOP) between 16 and 21 mm Hg (HNTG) v those with a lower IOP below 15 mm Hg (LNTG). **METHODS:** Scanning laser polarimetry and high pass resolution perimetry were performed in 20 eyes of 20 patients with HNTG and 21 eyes of 21 patients with LNTG. The correlation between total and regional thickness of the peripapillary RNFL and the corresponding total and regional neural capacity with linear regression analysis were evaluated. **RESULTS:** Overall, although the total RNFL thickness was not significantly correlated with the total neural capacity, the RNFL thickness in each of the superior and
inferior quadrants was significantly correlated with the corresponding regional neural capacity (r = 0.44, p = 0.0045; r = 0.39, p = 0.0126 for each). The RNFL thickness in each of the superior and inferior quadrants in the HNTG group was significantly correlated with the corresponding regional neural capacity (r = 0.52, p = 0.0196; r = 0.49, p = 0.0286 for each). No significant correlation between neural capacity and the RNFL thickness was observed either globally or regionally in the LNTG group. CONCLUSION: The degree of the correlation between neural capacity as determined by high pass resolution perimetry and thickness of the RNFL as measured by scanning laser polarimetry appeared to differ in NTG patients with an IOP higher than 15 mm Hg v those with a lower IOP.

Chauhan BC; House PH; McCormick TA; LeBlanc RP
Comparison of conventional and high-pass resolution perimetry in a prospective study of patients with glaucoma and healthy controls.
Arch Ophthalmol, 1999 Jan, 117:1, 24-33
Department of Ophthalmology, Dalhousie University, Halifax, Nova Scotia

OBJECTIVE: To determine whether high-pass resolution perimetry detected glaucomatous visual field progression earlier than conventional perimetry. METHODS: In a prospective longitudinal study, we observed 113 patients with open-angle glaucoma and with early to moderate visual field damage and 119 healthy control subjects. Each subject underwent testing at 6-month intervals using conventional and high-pass resolution perimetry (program 30-2 of the Humphrey Field Analyzer [Humphrey Instruments, Inc, San Leandro, Calif] and the Ring program of the Ophthimus perimeter [Hi-Tech Vision, Göteborg, Sweden], respectively). Our predetermined criterion for progression with conventional perimetry was the presence of at least 4 overlapping nonedge locations outside the fifth percentile for test-retest variability of threshold deviations (defined by the Glaucoma Change Probability Analysis of the Statpac 2 program) in 2 of 3 consecutive visual fields. We employed the identical criterion for progression with high-pass resolution perimetry using our own test-retest variability data. We repeated this procedure in the controls to measure the false-positive rate of progression. RESULTS: Patients were observed for a median of 4.5 years and 11 examinations with each technique. Fifty-seven patients (50.4%) did not show progression with either technique. Twenty-four patients (21.2%) showed progression with high-pass resolution perimetry alone, whereas 6 (5.3%) showed progression with conventional perimetry alone. Of the remaining 26 patients (23.0%) who showed progression with both techniques, 14 (54%) showed progression with high-pass resolution perimetry first (median, 12 months earlier); 5 (19%), with conventional perimetry first (median, 6 months earlier); and 7 (27%), with both techniques at the same time. Controls were observed for a median of 5 years and 11 examinations with each technique. One control (0.8%) showed progression with high-pass resolution perimetry. CONCLUSIONS: Our results suggest that high-pass resolution perimetry detects glaucomatous visual field progression earlier than conventional perimetry in most patients with progression.

Birt CM; Shin DH; McCarty B; Kim C; Lee DT; Chung HS
Comparison between high-pass resolution perimetry and differential light sensitivity perimetry in patients with glaucoma.
J Glaucoma, 1998 Apr, 7:2, 111-6
Sunnybrook Health Science Centre, University of Toronto, Canada.
PURPOSE: High-pass resolution perimeters such as the Ophthimus (High of the visual field than conventional perimeters such as the Humphrey (Humphrey Instruments Inc., San Leandro, CA, U.S.A.), which is based on differential light sensitivity. The Ophthimus provides global indices and statistical analyses conceptually similar to those produced by the Humphrey. In addition, the Ophthimus provides, as a unique parameter, the estimated neural capacity. PATIENTS AND METHODS: Twenty-one patients with chronic open-angle glaucoma and reliable fields on both Humphrey and Ophthimus testing were evaluated. The results from the two different techniques were compared. RESULTS: The estimated neural capacity was correlated to global deviation and mean deviation at a statistically significant level. There were also correlations between mean deviation and global deviation and between pattern standard deviation and local deviation, but not between retest standard deviation and short-term fluctuation. CONCLUSION: It is not clear at this point if the neural capacity of the Ophthimus provides any clinically useful information over and above global deviation. Mean test time was shorter with the Ophthimus system than the Humphrey. Performance on the reliability indices was better for the Ophthimus. The Ophthimus may prove useful in following patients with glaucoma.

Donahue SP; Wall M; Stanek KE

Motion perimetry in anisometropic amblyopia: elevated size thresholds extend into the midperiphery.
J AAPOS, 1998 Apr, 2:2, 94-101
Dept. of Ophthalmol. and Vis. Sci., Vanderbilt University School of Medicine, Nashville, USA.

PURPOSE: Our purpose was to determine whether motion detection abnormalities in patients with anisometropic amblyopia exist and to determine the extent of these abnormalities in the central and midperipheral visual field. METHODS: We used of motion perimetry to evaluated 10 anisometropic subjects with no manifest strabismus. Each of 44 locations in the visual field corresponding to the test sites of the Humphrey 24-2 program was tested with circular patches of motion (random dot cinematograms) displayed on a computer screen. Stimulus patch size was reduced in a 2/1 staircase manner to determine the smallest patch of motion detectable at each test location (threshold). Data from 15 age-matched normal subjects were used as controls. RESULTS: Vision in the amblyopic eye ranged from 20/25 to count fingers. The overall mean size threshold for amblyopic eyes was elevated (61% +/- 73%) compared with fellow eyes and age-matched normal eyes (p < 0.03) (i.e., the moving patch of dots in the field had to be larger for it to be detected when viewing with the amblyopic eye). The increase in size threshold was consistent across the visual field and was not greater for central locations. CONCLUSION: The amblyopia caused by anisometropia is associated with an abnormality in motion detection that extends into the midperiphery of the visual field.

Martin L; Wanger P

Five-year follow-up of treated patients with glaucoma using high-pass resolution perimetry.
J Glaucoma, 1998 Feb, 7:1, 22-6
Stockholm University College of Health Sciences, Sweden.

PURPOSE: The authors describe high-pass resolution perimetry findings during the first five years of antiglaucoma treatment. PATIENTS AND METHODS: Thirty-seven patients were examined six times, once a year for five years, with best corrected visual acuity, applanation
tonometry, slitlamp examination, funduscopy, and high-pass resolution perimetry. Twenty-nine of these were treated for glaucoma and eight followed for ocular hypertension without treatment. RESULTS: The resolution thresholds in the treated group improved during the first two years and deteriorated after that back to baseline level. Regarding individual patients, the visual fields were improved in 4, unchanged in 16, and deteriorated in 13 of the 29 treated glaucoma patients at the end of the study period. CONCLUSIONS: Resolution visual fields showed initial improvement and subsequent deterioration in treated patients with early glaucoma. The conventional therapy, aiming at reducing intraocular pressure, appeared to postpone visual field decay for at least five years in about 50% of the patients.

Ravalico G; Parentin F; Pastori G; Baccara F
Spatial resolution threshold in pseudophakic patients with monofocal and multifocal intraocular lenses.
J Cataract Refract Surg, 1998 Feb, 24:2, 244-8
Istituto di Clinica Oculistica, Trieste, Italy.

PURPOSE: To compare the spatial resolution threshold in the central visual field of pseudophakic patients with monofocal and multifocal intraocular lenses (IOLs). SETTING: Eye Clinic, University of Trieste, Italy. METHODS: Twenty phakic normal subjects and four groups of 20 pseudophakic patients each, implanted with refractive and diffractive multifocal IOLs (Domilens Progress 1, AMO Array MPC25NB, or Pharmacia 811X) or with monofocal IOLs (Allergan PC43NB), were studied. The spatial resolution threshold in the central visual field was assessed using high-pass resolution perimetry. Measurements were performed adding spherical correction to test the different foci of the IOL. RESULTS: No significant differences between phakic subjects and pseudophakic patients with monofocal IOLs were found. In distance vision, no significant differences between patients with refractive multifocal IOLs and those with monofocal IOLs were found. The group with the diffractive multifocal IOL showed a significantly higher spatial resolution threshold (P = .003). In intermediate vision, the AMO Array group showed a significantly lower spatial resolution threshold than the other groups (P < .01). The best performance at near distance was in the diffractive group, which was statistically significantly different from the other groups (P < .001). CONCLUSION: In the diffractive group, the high spatial resolution threshold in distance vision could be explained by the lower brightness of the principal focus, related to a different light energy division between the foci. In the Domilens group, the high spatial resolution threshold in near vision could be related to the light energy scattered in a large number of foci.

Shirakashi M; Abe H; Sawaguchi S; Funaki S
Measurement of thickness of retinal nerve fiber layer by scanning laser polarimetry and high-pass resolution perimetry in patients with primary open-angle or normal-tension glaucoma.
Department of Ophthalmology, Niigata University School of Medicine, Japan.

PURPOSE: To evaluate the correlation between neural capacity, determined by high-pass resolution perimetry, and thickness of the retinal nerve fiber layer, evaluated by scanning laser polarimetry, in patients with primary open-angle glaucoma or normal-tension glaucoma.
METHODS: Thickness of the peripapillary retinal nerve fiber layer was measured by scanning laser polarimetry in 19 eyes of 19 patients with primary open-angle glaucoma and in 23 eyes of 23 patients with normal-tension glaucoma. There were no significant differences between the two groups in mean age, sex ratio, or mean neural capacity. RESULTS: Neural capacity was significantly correlated with thickness of the retinal nerve fiber layer in all 42 eyes (r = 0.31, P = 0.0429). Neural capacity was significantly correlated with thickness of the retinal nerve fiber layer in the eyes of patients with primary open-angle glaucoma (r = 0.60, P = 0.0061), but not in the eyes of patients with normal-tension glaucoma (r = 0.04; P = 0.8522). CONCLUSION: The degree of correlation between neural capacity determined by high-pass resolution perimetry and thickness of the retinal nerve fiber layer measured by scanning laser polarimetry appeared to differ in patients with primary open-angle glaucoma vs those with normal-tension glaucoma.

Kono Y; Yamamoto T; Kitazawa Y

A new scoring system for comparing the results of high-pass resolution perimetry and differential light sensitivity perimetry in glaucoma patients.
Department of Ophthalmology, Gifu University School of Medicine, Japan.

Using a new standard, we compared the visual field defects detected by high-pass resolution perimetry (HRP) and differential light sensitivity (DLS) perimetry in 61 eyes of 61 open-angle glaucoma patients. Abnormal test points were determined using probability plot analysis of HRP and total deviation probability maps of the Humphrey Field Analyzer. To evaluate the agreement between the two tests, we developed a new scoring system. Thirty-three eyes, 23 eyes, and 5 eyes had good, fair, and poor agreement, respectively. In relation to Aulhorn's stage classification, the more advanced the glaucomatous stage, the more increased the percentages of good agreement. These results suggest that the distribution and severity of visual field defects demonstrated by HRP agree closely with those found using DLS perimetry in glaucomatous eyes, especially those with advanced visual field changes.

Kono Y; Chi QM; Tomita G; Yamamoto T; Kitazawa Y

High-pass resolution perimetry and a Humphrey Field Analyzer as indicators of glaucomatous optic disc abnormalities. A comparative study.
Ophthalmology, 1997 Sep, 104:9, 1496-502
Department of Ophthalmology, Gifu University School of Medicine, Japan.

BACKGROUND: The "neural capacity (NC)" of high-pass resolution perimetry (HRP) may be correlated to the neuroretinal rim area of the optic disc. The authors compared HRP with conventional differential light sensitivity (DLS) perimetry in terms of correlation with glaucomatous optic disc changes. METHODS: Thirty-seven eyes of 37 normal-tension glaucoma (NTG) patients were examined. The authors used an Ophthimus system for HRP and a Humphrey Field Analyzer (HFA) for DLS perimetry. The total rim area and the area of temporal, superior, nasal, and inferior quadrants were determined using a confocal laser tomographic scanner. Quadrant NC (QNC) was calculated using the resolution thresholds corresponding to a given quadrant. Quadrant mean deviation (QMD) was calculated from the total deviations of HFA. RESULTS: In all eyes, NC and MD showed significant correlations with total rim area (Spearman rank correlation coefficient [rs] = 0.375, P < 0.05 for NC; rs = 0.336, P < 0.05 for MD). A significant correlation was observed in 21 eyes with early visual
field changes ($rs = 0.469, P < 0.05$), but not in 16 eyes with advanced visual field changes. Both QNC and QMD showed significant correlations with inferior rim area ($rs = 0.575, P < 0.01$ for QNC; $rs = 0.431, P < 0.01$ for QMD). However, no significant correlations were found between QNC or QMD and superior rim area. CONCLUSIONS: The NC may relate to glaucomatous optic disc changes better than does MD in NTG, especially in eyes with early-stage visual field changes.

Martin L
Cataract and high-pass resolution perimetry.
Stockholm University College of Health Sciences, Solna, Sweden.

The present study describes the influence of cataract on high-pass resolution perimetry results. Twenty-five otherwise healthy patients were examined before and after cataract surgery. Their preoperative visual acuities ranged from 0.1 to 0.8 and their mean resolution thresholds from 3.9 to 12.3 dB. Both elevated mean thresholds and local visual fields defects were observed. In patients with low-grade cataract, i.e. preoperative visual acuity 0.3 to 0.65, the mean improvement in perimetric results after operation was approximately 1 dB. In patients with higher degrees of lens opacity, visual acuity 0.1 to 0.25, the difference between pre- and postoperative perimetry results showed a wide range, 1.4-6.2 dB. In conclusion, cataract induced different types of visual field defects. The general threshold increase due to low-grade cataract ($VA \geq 0.3$) could be compensated for by subtracting 1 dB from the measured value.

Kitazawa Y; Yamamoto T
Glaucomatous visual field defects: their characteristics and how to detect them.
Clin Neurosci, 1997, 4:5, 279-83
Department of Ophthalmology, Gifu University School of Medicine, Japan.

Functional defects of glaucomatous optic neuropathy are reviewed and summarized. Glaucomatous visual field defects are basically comprised of four major patterns: an isolated scotoma, an arcuate scotoma, a nasal step, and generalized depression. The field loss progresses conforming to the optic nerve head and retinal nerve fiber changes. Interpretation of the visual field and some tips of the interpretation are outlined in addition to describing differential diagnosis. Lastly, blue-on-yellow perimetry and high-pass resolution perimetry, both of which are promising tools for early detection of glaucoma, are introduced.

Graham SL; Drance SM; Chauhan BC; Swindale NV; Hnik P; Mikelberg FS; Douglas GR
Comparison of psychophysical and electrophysiological testing in early glaucoma.
University of British Columbia, Vancouver, Canada.

PURPOSE: To compare the sensitivity and specificity of a wide range of psychophysical and electrophysiological tests in the detection of early glaucomatous damage. METHODS: Forty-three normals and 43 patients with early glaucoma, some still without field defects, were tested with differential light threshold perimetry, short-wavelength automated perimetry, high-pass resolution perimetry, motion detection, flicker contrast sensitivity, flickering and isoluminantly matched letter tests, and pattern and flash electroretinography, including
photopic, scotopic, oscillatory potentials, and 30 Hz flicker. Receiver operating characteristic analysis was applied to continuous variables derived from each of the tests. RESULTS: Most parameters reflected glaucomatous loss to some degree, even though only single variables were analyzed separately in the receiver operating characteristic analysis. The pattern electroretinogram and some of the letter acuity tests had the best sensitivity and specificity, followed by short-wavelength automated perimetry and high-pass resolution-perimetry. Motion detection, flicker contrast, and flash electroretinogram parameters scored poorly. Six patients with normal results on the Humphrey field test had abnormal results on many of the other tests. CONCLUSIONS: Applying different psychophysical and electrophysiological tests may add to our ability to detect early glaucomatous damage.

Yu M; Zhou W; Ye T
A study of high-pass resolution perimetry in the early diagnosis of primary open-angle glaucoma
Chung Hua Yen Ko Tsa Chih, 1996 Jul, 32:4, 267-71
Zhongshan Ophthalmic Center, Sun Yat-sen University of Medical Sciences, Guangzhou.

OBJECTIVE: To evaluate the application of high-pass resolution perimetry (HRP) in detecting the early visual field loss of glaucoma. METHOD: According to the method described by Frisén, we developed HRP in a personal computer. The HRP was used to examine the visual field of 22 normal subjects (44 eyes), 27 cases (41 eyes) of primary open-angle glaucoma (POAG) with abnormal automated visual fields and 10 cases (13 eyes) of early POAG or suspected POAG with normal automated visual fields. RESULTS: The mean resolution threshold in the normal subjects was 3.96±0.55db in the right eyes and 3.98±0.55dB in the left eyes. It is demonstrated that HRP was more sensitive than automated perimetry in detecting the glaucomatous visual field defects, its sensitivity was 93.75% and specificity was 97.7%. The early visual field loss of glaucoma might present increment of the retinal resolution threshold. CONCLUSION: HRP is a relatively sensitive method for the detection of the early visual field loss in POAG, and it can be used extensively.

Kono Y; Chi Q; Tomita G; Yamamoto T
"Neural capacity" index correlates with neuroretinal rim area of glaucomatous eyes better than light sensitivity
Nippon Ganka Gakkai Zasshi, 1996 Mar, 100:3, 223-9
Department of Ophthalmology, Gifu University School of Medicine, Japan.

We compared the relationship between the neuroretinal rim area and the neural capacity (NC) index of high-pass resolution perimetry (HRP) and the differential light sensitivity (DLS) of a Humphrey Field Analyzer (HFA). Subjects were 40 eyes of 27 normal-tension glaucoma (NTG) patients. The total rim area and the area of its temporal, superior, nasal, and inferior quadrants were determined with a confocal laser tomographic scanner. Mean local NC (MLNC) was calculated using the resolution thresholds corresponding to the quadrant. Mean local DLS (MLDLS) was calculated using the data of program 30-2 of HFA. In a total of 40 eyes, NC and mean deviation were significantly correlated with the total rim area (rs = 0.422, p < 0.01; rs = 0.360, p < 0.05, respectively). NC was also significantly correlated with the total rim area in 19 eyes with early visual field changes, but not in 21 eyes with advanced changes. MLNC was significantly correlated with the superior and inferior rim areas, and MLDLS was significantly correlated with the inferior rim area. These results indicate that
indices of HRP may relate to glaucomatous optic disc changes better than those of HFA in NTG, especially in patients with early visual field defects.

Frisén L; Rossitti S
**Relative dispersion analysis enhances perimetric sensitivity.**
Vision Res, 1996 Feb, 36:3, 491-7
Department of Ophthalmology, University of Göteborg, Sweden.

Objective identification of minor visual field defects is problematic. A possible solution is to examine spatial correlations by means of relative dispersion analysis, a tool of fractal analysis. We studied patients with glaucoma, previous optic neuritis, chiasmal compression and lesions of the brain hemispheres, using high-pass resolution perimetry. One-hundred visual field records were drawn consecutively for each category and ranked according to severity of defects. Records with scores ranking below the 35th percentile, i.e. those with the smallest field defects, were analysed. Relative dispersion analysis recognized 1.3-2.4 times more abnormal subjects than did pattern standard deviation. A previously described form index was intermediate in sensitivity. Specificity was 96%. Relative dispersion analysis appears to capture a novel aspect of visual field abnormality, with good sensitivity and specificity. The analysis is easily performed.

Meyer JH; Funk J
**High-pass resolution perimetry and light-sense perimetry in open-angle glaucoma.**
Ger J Ophthalmol, 1995 Jul, 4:4, 222-7
Universitäts-Augenklinik, Freiburg, Germany.

To determine the correlation between the results obtained with light-sense and ring perimetry in glaucoma, we examined 201 eyes of 107 patients with ocular hypertension or different stages of glaucoma using Octopus 1-2-3 and the Ophthimus ring perimeter. Statistical parameters describing the mean visual field defect ["global defect, GD," or "neural capacity, NC" (Ophthimus)] were significantly correlated (P < 0.0001). Statistical parameters describing the local deviations were significantly correlated as well ["loss of variance, LV" (Octopus) and "local defect, LD" (Ophthimus), P < 0.0001]. Correlation between the MD and the LV or LD was somewhat less significant. As compared with the MD or LV (Octopus) the Ophthimus parameters GD, NC, and LD were less often pathological. We conclude from our data that due to the good correlation between light-sense and resolution perimetry results, both perimeters are equally suited for the follow-up of glaucoma patients. Sensitivity to early glaucomatous damage seems to be higher in light-sense perimetry (Octopus 1-2-3).

Graham SL; Drance SM
**Interpretation of high-pass resolution perimetry with a probability plot.**
Department of Ophthalmology, University of British Columbia, Vancouver, Canada.

BACKGROUND: The interpretation of high-pass resolution perimetry (HRP) fields can be difficult. An age-related probability plot was derived from a known data base to determine whether this improved specificity and sensitivity in early glaucoma detection. METHODS: Forty glaucoma patients with minor field loss and 40 normals of equivalent age and sex underwent HRP. All had previous Humphrey field data available for comparison. The detection of previously confirmed field defects by HRP was examined using different
parameters. RESULTS: Using the age-corrected 95% confidence levels gave the best results, with sensitivity of 82.5% (33/40) and specificity of 85% (34/40). Using the contour plot yielded lower sensitivity (67.5%), while subjectively "eyeballing" the ring printout gave higher sensitivity (90%), but led to poor specificity (72.5%). CONCLUSION: The use of a probability plot enhances the performance of HRP. A certain proportion of cases may be missed using one criterion alone, but combining the information with other indices can increase the yield.

Martinez GA; Sample PA; Weinreb RN
Comparison of high-pass resolution perimetry and standard automated perimetry in glaucoma.
Glaucoma Center, University of California at San Diego, La Jolla, USA

PURPOSE: We sought to ascertain whether high-pass resolution perimetry would provide results comparable to those of standard perimetry. METHODS: Thirty-four eyes with primary open-angle glaucoma, 37 eyes suspected of having glaucoma, and 36 normal control eyes were matched for age and lens density. We controlled for refraction, pupil size, and learning effects. Standard and ring visual fields were obtained with the Humphrey perimeter and the Frisén ring perimeter, respectively. Each test was judged according to the Glaucoma Hemifield Test (a statistical visual field analysis method) to be outside normal limits (abnormal) or not outside normal limits (normal or borderline). RESULTS: Under these conditions, both tests identified 19 of 34 (56%) glaucoma eyes as outside normal limits. High-pass resolution perimetry determined that 34 of 36 (94%) normal eyes were not outside normal limits; standard perimetry determined that all 36 normal eyes were not outside normal limits. High-pass resolution perimetry determined 12 of 37 (32%) eyes that were glaucoma suspects were outside normal limits; standard perimetry determined three of the 37 (8%) glaucoma suspect eyes were outside normal limits. Overall agreement between the two tests was 65%. CONCLUSION: With the Glaucoma Hemifield Test, high-pass resolution perimetry was comparable to standard perimetry in sensitivity and specificity, and identified a slightly higher percentage of patients at risk for glaucoma as abnormal. These results suggest that high-pass resolution perimetry should continue to be explored as an alternative to standard perimetry for the diagnosis and treatment of glaucoma.

Frisén L
High-pass resolution perimetry: central-field neuroretinal correlates.
Vision Res, 1995 Jan, 35:2, 293-301
Department of Clinical Neuroscience, University of Göteborg, Sahlgren's Hospital, Sweden.

Minimum angles of resolution (MAR) were measured at 0-10 deg horizontal eccentricity in three normal subjects, using high-pass spatial frequency filtered targets, at four different contrast levels. Results were correlated with recent data on human cone and ganglion cell separations in corresponding retinal locations. MARs and cone separations showed a close proportionality through the origin for all contrast levels. Ganglion cell correlates were more difficult to elucidate as the cell bodies are displaced from their input cones. Taking a functional estimate of the displacement into account, the number of ganglion cells appeared to be large enough to uphold an "effective" distribution that obeys the same proportional relationship to MAR that previously has been demonstrated outside 10 deg. Analysis of the nature of age effects provided support for this model.
Fifteen children aged less than 11 years, affected by congenital glaucoma, underwent visual field testing using two different methods: conventional computerized perimetry (24-2 Humphrey program) and High Pass Resolution perimetry (Ring test). The aim of the study was to discover which of the two perimetric techniques was more suitable for younger patient. Results showed that HPR perimetry is more suitable to children. Reasons include the short duration of the test (5 min), and the appearance like a pleasant game to 80% of the subjects tested. In addition it proved to be better than Humphrey test because of the minimal possibilities of memorisation with a reproducibility factor of 68% in our sample and because of the reliable results and satisfactory evaluation in 76% of the eyes examined.

In order to find out to which extent high-pass resolution perimetry would detect any changes in patients treated for glaucoma, resolution perimetry results were evaluated from 56 glaucoma patients and 15 untreated ocular hypertensive patients followed for 2 to 3 years. Fifty-nine of the 71 examined patients showed lower resolution thresholds, i.e. increased sensitivity, after 2 years, compared to initial values. The threshold decrease was significantly larger in the treated glaucoma patients (median 1.22 dB) than in the untreated ocular hypertensive patients (0.48 dB). The threshold decrease in the untreated ocular hypertensive group corresponds to the previously described learning effect. In 35 of the 56 treated glaucoma patients the thresholds improved more than 0.84 dB, the upper confidence imit in the untreated group, which may indicate a beneficial effect of antiglaucoma therapy in these patients. The threshold change was unrelated to initial resolution threshold and cannot be explained by a sorting effect. The observations in the current study using resolution perimetry indicate that improved visual function can be demonstrated in many patients treated for early glaucoma, at least during the first 2 years of treatment.

In der vorliegenden Studie wurden vergleichend der Einfluss künstlicher Medientrübungen (Mattfolien) auf den Visus und die Schwellenwerte der Lichtsinn- und Ringperimtrie untersucht. Verwendet wurden das G1-Programm am Octopus 1-2-3 und der „Ring-Test“ am Ringperimeter nach Frisén (Fa. High-Tech-Vision). Es wurden 10 Augen von 10 gesunden Probanden mit einem Visus von 1,25 oder besser, jeweils bei 6 verschiedenen Trübungsstärken, untersucht. Im Bereich der Visusstufen oberhalb 1,2 zeigten sich konstante
Empfindlichkeiten. Mit zunehmender künstlicher Medientrübung nahmen die Werte bei beiden Verfahren ab, am Ringperimeter ausgeprägter als am Lichtsinnperimeter. Auf der Visusstufe Handbewegungen erfolgte am Ringperimeter keine Reaktion mehr, am Lichtsinnperimeter war dagegen noch die Wahrnehmung mehrerer Reizstärken möglich. Es bestand eine lineare Korrelation zwischen dem Logarithmus des Visus und den Empfindlichkeiten am Octopus 1-2-3 (r=0,99, p<0,001) und am Ringperimeter (r=0,98, p<0,001). Der Empfindlichkeitsabfall pro log-Stufe Visusminderung beträgt am Octopus 1-2-3 9,43dB, am Ringperimeter 5,19dB. Nach unseren Ergebnissen ist das Ringperimeter in der kommerziell erhältlichen Form gegenüber Medientrübungen empfindlicher als das Lichtsinnperimeter. Dies ist bei der klinischen Anwendung zu berücksichtigen.

Chauhan BC; LeBlanc RP; McCormick TA; Mohandas RN; Wijsman K
Correlation between the optic disc and results obtained with conventional, high-pass resolution and pattern discrimination perimetry in glaucoma.
Department of ophthalmology, Dalhousie University, Halifax.

The purpose of this study was to determine whether results obtained with two new techniques, high-pass resolution perimetry and pattern discrimination perimetry, correlated better to the appearance of the optic disc than results obtained with conventional automated perimetry in patients with open-angle glaucoma. Our sample consisted of 28 eyes of 28 patients with early glaucomatous field damage who are part of a prospective follow-up study. We used the second of two sets of baseline perimetric examinations separated by 1 week in the analysis. Neuroretinal rim area was calculated by planimetry of stereophotographs of the disc and was correlated to the visual field sensitivity measured with each of the techniques. We found a poor correlation between the disc and field measurements (correlation coefficients; -0.048 for conventional perimetry, 0.111 for high-pass resolution perimetry and -0.315 for pattern discrimination perimetry). Although the correlation appeared to be higher with the newer techniques, the differences were not statistically significant.

Chauhan BC; LeBlanc RP; McCormick TA; Rogers JB
Comparison of high-pass resolution perimetry and pattern discrimination perimetry to conventional perimetry in glaucoma.
Department of Ophthalmology, Dalhousie University, Halifax.

We compared two new perimetric techniques, high-pass resolution perimetry and pattern discrimination perimetry, to conventional automated static perimetry in an ongoing prospective study. Forty-eight patients with open-angle glaucoma whose median age was 63.4 (range 15.6 to 89.7) years were included in the study. There was a significant correlation between the results obtained with high-pass resolution perimetry and conventional perimetry for both the whole field and the four quadrants (p < 0.001). However, the correlation between pattern discrimination perimetry and conventional perimetry was poor. The differences between the correlations of the newer techniques with conventional perimetry were statistically significant for the whole field and the superior quadrants (p < 0.01) and were borderline significant for the inferior quadrants. Although the three techniques showed very good concordance in both the extent and location of damage of the visual field in some patients, in others it was poor. Our results show that high-pass resolution perimetry and
pattern discrimination perimetry may be measuring different components of the visual response.

Chauhan BC; Mohandas RN; Whelan JH; McCormick TA

**Comparison of reliability indices in conventional and high-pass resolution perimetry.**
Ophthalmology, 1993 Jul, 100:7, 1089-94
Department of Ophthalmology, Dalhousie University, Halifax, Nova Scotia, Canada.

PURPOSE: The purpose of this study is to compare reliability indices in conventional (Humphrey) and high-pass resolution (Ring) perimetry in healthy subjects followed prospectively at 6-month intervals. METHODS: Of the 146 healthy subjects (mean age, 50.24 years; range, 30-84 years) enrolled in the study, 102 have been tested twice and 71 three times. The authors compared the reliability indices, fixation losses, false-positive rate, and false-negative rate between the two techniques, both cross-sectionally and serially. RESULTS: Fixation losses were slightly higher with high-pass resolution perimetry, whereas false-positive errors were higher with conventional perimetry. False-negative errors were uncommon with either technique. Of 319 fields, 30 (9.4%) conventional and 39 (12.2%) high-pass resolution perimetry fields were unreliable using the current suggested reliability criteria. Nearly all unreliable fields were due to high fixation errors. Using alternative criteria derived from baseline 95th percentile values, unreliable fields were attributed more equally to all three reliability parameters. In subjects tested three times, the reliability indices remained constant. CONCLUSION: The results of this study showed that healthy subjects have comparable reliability indices when tested with conventional and high-pass resolution perimetry.

Frisén L; Nikolajeff F

**Properties of high-pass resolution perimetry targets.**
Acta Ophthalmol (Copenh), 1993 Jun, 71:3, 320-6
Department of Ophthalmology, University of Göteborg, Sweden.

Relationships between high-pass resolution perimetry ring targets and conventional perimetry and acuity targets were explored by optical analytical techniques and by comparative measurements in normal humans. High-pass resolution and acuity targets produced closely proportional resolution measurements, showing that the critical ring detail is the width of the bright core. High-pass resolution and conventional perimetry thresholds were not equally well correlated. From a purely optical point of view, high-pass resolution targets appeared to lose somewhat more contrast on defocusing. On the other hand, high-pass resolution appears to show less variability in practical, clinical use.

Kono Y; Maeda M; Yamamoto T; Kitazawa Y

**Comparison of high-pass resolution perimetry and differential light sensitivity perimetry in glaucoma patients**
Nippon Ganka Gakkai Zasshi, 1993 May, 97:5, 644-8
Department of Ophthalmology, Gifu University School of Medicine, Japan.

High-pass resolution perimetry (HRP) enables one to estimate the number of functioning retinal ganglion-cells. We investigated the correlation between HRP and Humphrey Field Analyzer 630 in 35 eyes of 23 primary open-angle glaucoma and 75 eyes of 46 normal-tension glaucoma patients. In a total of 110 eyes, both functional channels and global
deviation of HRP were significantly correlated with MD (r = 0.74, p < 0.01; r = -0.71, p < 0.01, respectively). Local deviation of HRP was also significantly correlated with corrected pattern standard deviation (r = 0.77, p < 0.01). These correlations tended to be higher in eyes with more advanced field changes than in those with fewer changes. These results indicate that HRP may be useful for evaluation of glaucomatous visual field abnormalities. The observed discrepancies between the two different methods in early stage glaucoma may be attributable to differences in physiological factors tested in these methods.

Tuulonen A; Lehtola J; Airaksinen PJ
Nerve fiber layer defects with normal visual fields. Do normal optic disc and normal visual field indicate absence of glaucomatous abnormality?
Ophthalmology, 1993 May, 100:5, 587-97; discussion 597-8
Department of Ophthalmology, University of Oulu, Finland.

PURPOSE: When the optic disc has normal appearance with no abnormalities in routine automated perimetry, the subject is not considered to have glaucoma. The purpose of this study is to show how such patients may have localized retinal nerve fiber layer defects with corresponding functional abnormality. METHODS: The authors selected eight eyes of eight patients who had a localized retinal nerve fiber layer defect extending within a few degrees from fovea but in whom the optic disc appearance and Humphrey 30-2 visual fields were normal. Of the eight patients, three had positive family history of glaucoma, two had suspected retinal nerve fiber layer abnormality in routine eye examination, two had increased intraocular pressure (IOP), and one had advanced low-tension glaucoma in one eye with a normal fellow eye. The authors examined the central 10 degrees visual field with 1 degree resolution using Humphrey perimeter and the Ring and Centring programs of the high-pass resolution perimeter. RESULTS: A central field defect corresponding to retinal nerve fiber layer defect was found in six of eight patients: in both 10 degrees Humphrey field and Centring programs (2 eyes), in Humphrey only (2 eyes), and in Centring only (2 eyes). CONCLUSION: The results indicate that retinal nerve fiber layer photographs are helpful in diagnosing glaucoma because early glaucomatous abnormalities cannot be excluded without nerve fiber layer photography. Currently available routine perimetric examination programs do not always detect very early functional damage.

Tomita G; Maeda M; Sogano S; Kitazawa Y
An analysis of the relationship between high-pass resolution perimetry and neuroretinal rim area in normal-tension glaucoma.
Acta Ophthalmol (Copenh), 1993 Apr, 71:2, 196-200
Department of Ophthalmology, Gifu University School of Medicine, Japan.

We evaluated the reproducibility of measurements of the visual function index, 'functional channels', of high-pass resolution perimetry and the correlation between functional channels and topographic changes of the optic nerve head, particularly on the neuroretinal rim area. The median coefficient of variation for the six intra-individual measurements of functional channels with high-pass resolution perimetry was 9.5%. In 26 eyes of 18 normal-tension glaucoma patients, functional channels showed statistically significant correlation with the neuroretinal rim area (rim area) of the optic disc measured by a Rodenstock Optic Nerve Head Analyzer. These results suggested that functional channels of high-pass resolution perimetry may be a useful new parameter for evaluating visual function of glaucoma patients.
Review of all available reports comparing high-pass resolution perimetry (HRP) and conventional perimetry in normals and in subjects with different visual disorders reveals closely comparable aspects of sensitivity, specificity, and reliability. HRP shows important advantages concerning variability, test duration, and subject preferences. Drawbacks seem largely limited to somewhat loose renditions of visual field defects of small area and large depth. Otherwise HRP's novel format of graphic result presentation may be better suited to visual evaluation than conventional gray-scale maps with their lumping of thresholds and extensive interpolations. Several examples are provided of visual field defects due to various lesions throughout the visual system.

Tokuhisa T; Oyama K; Tamaki R; Kitahara K
A dissociation of thresholds between Goldmann kinetic perimetry and high-pass resolution perimetry in retinitis pigmentosa
Department of Ophthalmology, Jikei University School of Medicine, Minato-ku, Japan.

The authors studied the differences between the automated static perimetry of high-pass resolution perimeter (HRP) and the kinetic perimetry of the Goldmann perimeter in 12 patients with retinitis pigmentosa. In a total of 10 eyes of 6 patients, we found 19 quadrants in which the patients were not able to recognize the largest ring target even when the target was within the isopter of the Goldmann perimetry. Also, there were 10 quadrants in which the largest target was not recognized in a total of 6 eyes of 4 patients even though their visual field showed symmetrical isopter in upper and lower or right and left quadrants in the Goldmann perimetry. As a result, it was suggested that the causes of the dissocation were a greater decrease in sensitivity for the low spatial frequency target than the high spatial frequency target and/or a greater decrease in resolution sensitivity than light sensitivity in retinitis pigmentosa.

Lindblom B; Hoyt WF
High-pass resolution perimetry in neuro-ophthalmology. Clinical impressions.
Department of Neurological Surgery, School of Medicine, University of California, San Francisco.

High-pass resolution perimetry is a new technique for visual field testing that determines extrafoveal resolution thresholds. The authors used this method in a neuro-ophthalmology clinic and compared it with other visual field tests. The main advantages of the technique were the short test time and the strong preference by patients for this technique over conventional automated perimetry. The sensitivity and specificity of the test seemed to be as good as or better than conventional perimetry. A minor disadvantage was its slightly less precise spatial definition of field defects. In this report, the authors present their experiences with this new perimetric technique.
Sample PA; Ahn DS; Lee PC; Weinreb RN

High-pass resolution perimetry in eyes with ocular hypertension and primary open-angle glaucoma.
Department of Ophthalmology, University of California, San Diego, La Jolla, USA

We analyzed the results of high-pass resolution perimetry on normal eyes, eyes with ocular hypertension, and eyes with primary open-angle glaucoma. The subjects were matched for age and lens density. We controlled for refraction, visual acuity, pupil size, miotic medications, and learning effects. Under these conditions the glaucomatous eyes showed a significant reduction in overall resolution threshold compared to both normal (P less than or equal to .01) and hypertensive eyes (P less than .01). The hypertensive eyes were not significantly different from normal. Standard increment threshold fields and high-pass resolution visual fields had an agreement of abnormality of 67%. Resolution perimetry showed a 92% agreement with standard perimetry in the location of the defect, when the defect was apparent on both tests. These results indicated that resolution perimetry may be useful for diagnosis and management of primary open-angle glaucoma.

Lindblom B

Effects of laser-induced retinal lesions on perimetric thresholds.
Department of Ophthalmology, University of Göteborg, Sweden.

Differential light sensitivity and high-pass resolution thresholds were studied before and after pan-retinal photocoagulation in subjects with proliferative diabetic retinopathy. The photocoagulated retinal area was measured and the relative change in ganglion cell separation was estimated. The change in differential light thresholds after treatment, when expressed in decibels, appeared to be linearly related to the calculated change in ganglion cell separation. At present, this empirical finding lacks a theoretical explanation. For high-pass resolution, theory predicts a direct proportionality between the change in ganglion cell separation and resolution threshold. This relationship was confirmed, supporting the claim that high-pass resolution directly reflects the number of functional retino-cortical neural channels.

Wall M; Conway MD; House PH; Allely R

Evaluation of sensitivity and specificity of spatial resolution and Humphrey automated perimetry in pseudotumor cerebri patients and normal subjects.
Department of Ophthalmology, Tulane University School of Medicine, New Orleans, Louisiana

To determine the sensitivity and specificity of high-pass resolution perimetry ("ring test"), 18 patients with pseudotumor cerebri (PTC) and 18 age-matched controls were examined with the Humphrey program 24-2 and the ring test. Goldmann perimetry also was done to determine if defects found with the ring test were present with another method. Testing with Humphrey perimetry revealed defects in 15 PTC patients and four control subjects; with the ring test, 13 PTC patients and two control subjects had abnormalities. The disturbed areas in
the control subjects with both automated tests were not reproducible. Humphrey perimetry had a sensitivity of 83% and the ring test, 72%. The specificities were Humphrey perimetry, 78% and the ring test, 89%. These differences were not statistically significant. Qualitative assessment of the presence and extent of damage using the pointwise probability plots and graphically displayed raw data showed good correlation of the tests in 11 of the 18 patients. The lack of correlation in four of the patients was caused by the presence of a generalized depression or a peripheral contraction on the Humphrey test; this defect, not present on retesting, may have been related to fatigue or poor motivation. The ring test is a sensitive and specific perimetric technique in patients with PTC.

Wall M; Lefante J; Conway M

Variability of high-pass resolution perimetry in normals and patients with idiopathic intracranial hypertension.
Department of Psychiatry and Neurology, Tulane University School of Medicine, New Orleans, Louisiana

High-pass resolution perimetry, or the "ring test," is a recently developed type of acuity perimetry. To determine its test-retest variability, we studied 10 normals and 10 patients with idiopathic intracranial hypertension (IIH) by testing both eyes four separate times. There was no increase in variability from the center out to 21 degrees of visual field eccentricity. However, there was a significant increase from 22 degrees to 29 degrees in both normals and IIH patients. Unlike light sensitivity threshold automated perimetry, with an increase in threshold level there was no significant increase in variability in either normals or patients. This may be because of the test's method, which thresholds by target size rather than intensity. As expected, there was a large intersubject variability in the patients, with the visual fields being significantly disturbed by analysis of total field, quadrants, concentric rings, and anatomic nerve fiber bundle regions. Surprisingly, there was no significant difference in the total within subject variability of normals and patients. Because with the ring test there is no increase in variability with an increase in threshold, this method of perimetry may have great utility for following patients with disturbed visual fields. The ring test appears to have advantages that promote low test-retest variability.

Wall M

High-pass resolution perimetry in optic neuritis.
Department of Psychiatry & Neurology, Tulane University School of Medicine, New Orleans, Louisiana

The topography of visual field defects resulting from optic neuritis as measured by spatial resolution perimetry is not known. Using high-pass resolution perimetry, the number and severity of visual field defects in the central visual field was determined in 18 patients with resolved optic neuritis and 18 age-matched controls. Comparisons were made between three groups of eyes: (1) the involved eyes of the patients, (2) the uninvolved eyes of the patients, and (3) the eyes of the controls. Concentric zone analysis showed the involved eyes to have depression of the visual field in all zones with slightly more loss centrally. The "uninvolved" eyes showed a mild equal depression in all zones. Spatial resolution acuity measurements (which correlate directly with the spatial separation of retinal ganglion cell receptive field centers) indicated that the percentage of functioning retinocortical channels for normal eyes,
uninvolved eyes, and involved eyes were 112%, 94%, and 58% of the reference normal values, respectively. These differences were all statistically significant. Resolution perimetry of the central visual field of eyes with resolved optic neuritis involves the cecocentral and Bjerrum areas. The loss was often patchy and a combination of cecocentral and arcuate defects. There was also a mild generalized depression of the uninvolved eye.

Martin Boglind L
High-pass resolution perimetry in uncomplicated myopia.
Stockholm College of Health and Caring Sciences, Sweden.

Fifteen subjects (28 eyes) with uncomplicated myopia (3-9 D) were examined using high-pass resolution and Goldmann perimetry. In the central 30 degree field a slight increase was observed in mean resolution threshold significantly correlated to the degree of myopia. In the Goldmann visual fields threshold increase was observed in the area around the blind spot in eight subjects (10 eyes). In the resolution fields only one subject (one eye) showed a corresponding abnormality.

Frisén L
High-pass resolution perimetry and age-related loss of visual pathway neurons.
Department of Ophthalmology, University of Göteborg, Sweden.

The normal, age-related decline of results of high-pass resolution perimetry (HRP) predicts a loss of approximately 9,000 retino-cortical neural channels per year of age, or about 1 channel each hour. Previously of approximately 5,000 neurons per year. The HRP results can be accounted for by postulating that neurons are lost at the same rate also in the geniculo-striate visual pathway.

Martin Boglind LM; Graves A; Wanger P
The effect of topical antiglaucoma drugs on the results of high-pass resolution perimetry.
Department of Ophthalmology, Sabbatsberg Hospital, Stockholm, Sweden.

We conducted a randomly assigned, double-masked, crossover study of the effects of betaxolol, epinephrine, pilocarpine, and timolol on the high-pass resolution perimetry results in normal subjects. The influence of topical administration of these intraocular pressure-reducing drugs was negligible, which confirmed the reliability of high-pass resolution perimetry results. The method seems appropriate for the diagnosis of glaucoma and the follow-up of patients with glaucoma.

Chauhan BC; House PH
Intratest variability in conventional and high-pass resolution perimetry.
Ophthalmology, 1991 Jan, 98:1, 79-83
Department of Ophthalmology, University of British Columbia, Vancouver, Canada.
The authors studied the effects of threshold, age, and visual field location on intratest variability in 11 normal subjects between the ages of 15 and 50 years (mean, 35.37 years). The subjects were tested with a conventional manual (Tübinger) perimeter and a high-pass resolution (Ring) perimeter at the following locations: (0 degrees, 30 degrees), (0 degrees, 15 degrees), (0 degrees, -15 degrees), and (0 degrees, -30 degrees). Frequency-of-seeing curves were constructed to obtain accurate estimates of threshold and intratest variability. Although location did not have a significant effect on intratest variability in conventional perimetry, intratest variability increased with threshold \( P = 0.031 \) and age \( P = 0.012 \). The results with resolution perimetry contrasted sharply and showed that neither threshold, age, nor location had a significant effect on intratest variability \( P \) greater than 0.225. Although the thresholds with the two types of perimetry were correlated, intratest variability was not. These results show that resolution perimetry may be able to bypass some of the limitations encountered in obtaining thresholds with conventional perimetry, thereby providing more reliable information.

Martin Boglind LM

**Influence of amblyopia on high-pass resolution perimetry.**

Stockholm College of Health and Caring Sciences, Sweden.

Seventeen subjects with amblyopia due to strabismus and anisometropia were examined using high-pass resolution perimetry. In addition to the standard technique, testing the 5-30 degrees visual field, an optional program testing the central 4 degrees visual field was used. Threshold elevation was confined to the central 4 degrees visual field and strongly correlated with visual acuity, expressed as minimum angle of resolution. Standard high-pass resolution perimetry did not reveal any significant abnormalities in the amblyopic subjects. In conclusion, the technique is useful for the diagnosis of ocular or neurologic disorders also in subjects with a high degree of amblyopia.

Airaksinen PJ; Tuulonen A; Välimäki J; Alanko HI

**Retinal nerve fiber layer abnormalities and high-pass resolution perimetry.**

Acta Ophthalmol (Copenh), 1990 Dec, 68:6, 687-9
Department of Ophthalmology, University of Oulu, Finland.

The purpose of this study was to compare high-pass resolution perimetry (HRP) test results with clinical optic disc measurements and semi-quantitative retinal nerve fiber layer (RNFL) estimates. HRP reflects the separation of functional ganglion cells in the retina, and estimates a 'Functional Channel Fraction (FCF)' index that expresses the number of functional ganglion cells relative to average normal. FCF was statistically highly significantly correlated both with the overall and diffuse RNFL score \( r = -0.63, P \) less than 0.0001 and with the neuroretinal rim area \( r = 0.44; P \) less than 0.001. This suggests that HRP is a useful psychophysical test to assess optic nerve integrity in glaucoma.

Frisén L

**Acuity perimetry: estimation of neural channels.**

Int Ophthalmol, 1988, 12:3, 169-74
Department of Ophthalmology, University of Göteborg, Sweden.
Measurements of peripheral visual acuity allow quantitative estimations of retino-cortical neural channels. Analysis of results from high-pass resolution perimetry revealed that about 2/3 of all channels are contained within 30 degrees of visual field eccentricity and that loss of 1/3 raises the average threshold level about 1 decibel. The analytical procedure can be applied to any type of visual field defect.

Frisén L
High-pass resolution targets in peripheral vision.
Ophthalmology, 1987 Sep, 94:9, 1104-8
Department of Ophthalmology, University of Göteborg, Sweden.

Visual acuity was measured at 10 degree intervals on the horizontal meridian in two normal subjects, using high-pass spatial frequency filtered test targets in a computer graphics display. The close similarity between detection and recognition thresholds resulted in quick and reliable measurements. Peripheral acuity was proportional to local retinal ganglion cell separation. High-pass targets appear to be nearly ideal for clinical perimetry because of the easy test task and the possibility of interpreting results in terms of numbers of functional neuroretinal channels. The major limitation appears to be a somewhat fuzzy definition of small, circumscribed defects.

Wanger P; Persson HE
Pattern-reversal electroretinograms and high-pass resolution perimetry in suspected or early glaucoma.
Ophthalmology, 1987 Sep, 94:9, 1098-103
Department of Ophthalmology, Sabbatsberg Hospital, Stockholm, Sweden.

Twenty-one patients, age 28 to 78 years, with elevated intraocular pressure (IOP) in one or both eyes, were examined with pattern-reversal electroretinograms (PERG), high-pass resolution perimetry (HRP), and conventional computer-assisted perimetry (CAP). Among the 42 eyes, 33 were hypertensive (IOP greater than or equal to 22 mmHg) and nine were normotensive (IOP less than or equal to 20 mmHg). The optic disc was judged abnormal in 14 of the hypertensive and one of the normotensive eyes. Fourteen abnormal PERGs and 19 abnormal HRPs were observed in the 33 hypertensive eyes. Conventional CAP gave abnormal results in three of the hypertensive eyes. Seven of the nine normotensive eyes were normal in all examinations. HRP was abnormal in one of the normotensive eyes and conventional CAP was abnormal in another. Thus, PERG and HRP showed a high incidence of optic nerve dysfunction in suspected or early glaucoma. These new methods should be clinically useful for diagnosis and management of conditions with increased IOP.
Abstracts Flicker-Perimetrie
(Stand August 2000)

Eisner A, Samples JR
Flicker Sensitivity and Cardiovascular Function in Healthy Middle-aged People.
Neurological Sciences Institute, Oregon Health Sciences University, OR 97209

OBJECTIVE: To establish normative relations between measures of visual function and cardiovascular variables that are important for age-related disease, including various forms of glaucoma. METHODS: Foveal flicker sensitivities, resting blood pressures and heart rates, and intraocular pressures were measured in 18 individuals aged 40 to 68 years. All subjects had 20/20 or better visual acuity in the test eye and no evidence of eye disease or glaucoma suspicion on clinical evaluation and medical history. No subjects were using medication to lower blood pressure. Flicker sensitivity was measured by increasing the illuminance of a fully modulated 20-Hz test stimulus until flicker was perceived. Two test-background stimulus combinations were used: a 570-nm ("yellow") test on a predominantly long-wavelength ("magenta") background and a 580-nm ("yellow") test on a 580-nm ("yellow") background. The illuminance of the yellow background was dimmer than that typically used for short-wavelength automated perimetry, whereas the illuminance of the magenta background was greater. RESULTS: The 2 flicker sensitivity measures were distinguished by the strong dependence of the magenta background measure on the ratio of mean arterial blood pressure to heart rate. Log flicker sensitivity on this background generally could be modeled as a linear combination of age, intraocular pressure, and ratio of mean arterial blood pressure to heart rate. The optimal model accounted for 84% of the variance (R = 0.92) from all but 2 outlying individuals. After age and intraocular pressure effects were partialled out, an increasing ratio of mean arterial blood pressure to heart rate was strongly associated with decreasing flicker sensitivity. CONCLUSIONS: Reduced cardiovascular function impacts the ability of the normal visual system to adapt and regulate flicker sensitivity. Elevated intraocular pressure and increased age reduce flicker sensitivity relatively uniformly across a range of stimulus conditions. Because the ratio of mean arterial blood pressure to heart rate equals total peripheral vascular resistance multiplied by cardiac stroke volume, and because total peripheral resistance is determined largely at the arterioles, it is likely that even modest changes in arteriolar function are associated with measurable alterations of visual function.

Jünemann AGM, Horn FK, Martus P, Korth M
The full-field temporal contrast sensitivity test for glaucoma: influence of cataract
J Glaucoma 2000, 238 (5): 427-432
Department of Ophthalmology, University of Erlangen-Nürnberg, Germany

To determine the influence of lens opacities on temporal contrast sensitivity, measured by the full-field flicker test ("Erlangen flicker test"). Methods: Thirty-six consecutive patients (mean age 71.1±11.6 years, 12 male, 24 female, refractive error -1.5±3.8 dpt) with cataract (visual acuity 0.21±0.16, retinal acuity 0.56±0.32, no glaucoma) were studied. Temporal contrast sensitivity (full-field flicker test, 37.1 Hz) and lens opacity (back scatter Lens Opacity Meter, Interzegag) were measured preoperatively and on the 3rd postoperative day. Statistics: nonparametric tests (Wilcoxon-test, Spearman correlation coefficient, Mann-Whitney U-test).
Results: No significant difference was seen in temporal contrast sensitivity pre- and postoperatively, but there was a significant difference in lens opacity measurements pre- and postoperatively. No significant correlation was found between temporal contrast sensitivity and lens opacity values preoperatively and postoperatively. Conclusion: The temporal contrast sensitivity, measured by the full-field flicker test, seems to be independent of lens opacity due to the range of cataract included in this study. The data indicate that the full-field flicker test is useful for early glaucoma detection even in patients with cataract formations.

Multivariate approach for quantification of morphologic and functional damage in glaucoma.
Dept. for Medical Informatics, Biometry, and Epidemiology, University of Erlangen-Germany.

PURPOSE: To determine the usefulness of confirmatory factor analysis in examination of morphometric, electrophysiological, and psychophysical quantitative methods that measure the extent of global glaucomatous damage without referring to a preselected gold standard.

METHODS: In a cross-sectional clinical study, 406 eyes of 203 glaucoma patients and 200 eyes of 100 normal control subjects 18 to 70 years old underwent optic disc morphometry, automated perimetry, measurement of temporal contrast sensitivity by a full-field flicker test, blue-on-yellow visually evoked potential (VEP), and black-and-white pattern-reversal electroretinogram (ERG). Diagnosis of glaucoma was based on a qualitative classification of the optic nerve head and retinal nerve fiber layer independent of intraocular pressure and visual field. Confirmatory factor analysis was performed in the patient group as a whole and in a subgroup showing moderate to advanced glaucomatous optic nerve head damage.

RESULTS: The confirmatory factor analysis models explained the data satisfactorily (P > 0.18, all patients; P > 0.34, subgroup). Global glaucomatous damage was quantified best by the mean defect of automated perimetry (r = 0.81; r = 0.87), followed by the area of the neuroretinal rim (r = 0.64; r = 0.73), the full-field flicker test (r = 0.59; r = 0.65), the pattern-reversal ERG amplitude (r = 0.54; r = 0.55), and the VEP peak time (r = 0.55; r = 0.54).

CONCLUSIONS: Confirmatory factor analysis allows quantification of the validity of established and new procedures that measure global glaucomatous damage using cross-sectional data. The results are not dependent on the preselection of a specific gold standard. Psychophysical testing and morphometry quantified glaucomatous damage best, compared with electrophysiological procedures.

Rota-Bartelink A
The diagnostic value of automated flicker threshold perimetry.
Curr Opin Ophthalmol 1999 Apr;10(2):135-9

Automated perimetry techniques have advanced from the standard white-on-white threshold perimetry to a myriad of perimetric models. These models include motion detection, frequency-doubling contrast sensitivity, and spatial contrast sensitivity perimetry. The research findings for the more popular of the automated perimetry models, in particular those of blue-on-yellow and critical fusion frequency perimetry, are discussed and compared with findings for flicker threshold perimetry. Flicker threshold perimetry demonstrates resistance to such factors as test variability and retinal image blur and has great promise in its ability to detect early visual field loss in the presence of primary open-angle glaucoma.
AIM: Flicker deficits have been reported in various maculopathies, including age-related macular degeneration. We test whether flicker losses exist in patients with central serous chorioretinopathy (CSC) and whether the size and flicker frequency of the target is important in detecting such losses. METHODS: We examined four CSC patients with temporal modulation (flicker perception) perimetry using the Medmont auto-flicker module (Medmont Pty Ltd, Melbourne, Vic. Australia), as well as static perimetry and colour vision. One case was examined using sophisticated laboratory equipment to precisely measure their temporal contrast sensitivity function (temporal CSF or de Lange curve) using larger targets to consider the effect of target frequency and size. Two patients were followed longitudinally and tested after resolution of the maculopathy. We compared our patients with an age-matched control group of 11 people. RESULTS: Temporal modulation perimetry detected larger and more localized defects in all cases of active CSC compared with static perimetry. There appeared to be size and frequency tuning to the deficit, with greatest loss being found at 16 Hz with small (0.5 degree) targets. The losses resolved in one case where the retina recovered in 4 weeks, but remained to a lesser degree in another case who suffered a 2 year long fluctuating course before the CSC subsided. CONCLUSIONS: Temporal modulation perimetry detects a loss of flicker sensitivity in patients with CSC. Deeper and more clearly defined scotomata are found with a flickering stimulus compared with a steady state one. The greatest losses of flicker sensitivity are found with 16 Hz modulation and with small targets located directly over the lesion. The duration of the disease may be important for recovery of flicker sensitivity. Temporal modulation perimetry appears to be a valuable tool for the confirmation of functional loss due to CSC.
blue-on-yellow pattern-onset VEP showed comparable sensitivity (85%, 84%, and 85%) with 80% specificity, and a pattern-reversal electroretinogram showed lower sensitivity (64%). The first three methods contributed independent information to a diagnostic score. This score improved sensitivity to 94%, with a specificity of 89%. All procedures moderately correlated with the neuroretinal rim area of the optic disc (r=0.32-0.46). The psychophysical tests showed a higher correlation with visual field defects (r > 0.5) than the electrophysiological tests (r < 0.3). CONCLUSIONS: The multivariate approach substantially increased the diagnostic validity compared with single procedures. This was probably because the diagnostic procedures under investigation tested different aspects of visual function.

Wall M; White WN 2nd
Asymmetric papilledema in idiopathic intracranial hypertension: prospective interocular comparison of sensory visual function.
Department of Ophthalmology, College of Medicine, University of Iowa, USA

PURPOSE: Visual loss is the main morbidity of idiopathic intracranial hypertension (IIH). The relationship between papilledema grade and visual loss is unclear. The goal of this study was to determine whether there is a relationship between papilledema grade and visual loss. METHODS: Fundus photographs of 478 patients with IIH were reviewed, and their degree of papilledema was graded using Frisén’s scheme. We identified 46 patients (10%) with IIH and highly asymmetric papilledema, as defined by an interocular difference of two or more grades. Nine of these patients with active asymmetry agreed to return for a series of visual tests. They underwent three visual field tests—Humphrey visual field analyzer 24-2, motion perimetry, and ring perimetry. The perimetry outcome measures were mean deviation, foveal threshold, and means for eccentric zones (3 degrees, 9 degrees, 15 degrees, and 21 degrees). The patients participated also in visual acuity, Farnsworth-Munsell 100-hue, Pelli-Robson contrast sensitivity, and foveal flicker fusion testing. Their relative afferent pupillary defect was graded using neutral density filters. RESULTS: The intereye comparisons showed vision to be worse in the eye with the high-grade papilledema for all outcome measures. The magnitude of the loss with the perimetry tests increased with eccentricity. The measures of central visual function, although in the normal range, were relatively depressed in the eye with high-grade papilledema. CONCLUSIONS: Visual loss in patients with asymmetric papilledema caused by IIH was most pronounced in the eye with the higher grade of papilledema. Foveal visual functions, although they remained in the normal range, were also decreased in patients with high-grade papilledema. In patients with high-grade papilledema, visual loss appeared to affect the entire visual field, and the peripheral field showed the most deficit. Our findings showed that high-grade papilledema was associated with visual dysfunction in patients with IIH.

Yoshiyama KK; Johnson CA
Which method of flicker perimetry is most effective for detection of glaucomatous visual field loss?
Optics and Visual Assessment Laboratory, Department of Ophthalmology, University of California, Davis, Sacramento, USA.

PURPOSE: The authors compared the efficacy of two different forms of flicker perimetry: temporal modulation perimetry (TMP), which measures contrast thresholds for a fixed
temporal frequency, and critical flicker frequency (CFF), which measures the highest frequency for which flicker is detected at a fixed contrast. METHODS: The authors compared 16 patients with early to moderate glaucomatous visual field loss with 16 age-matched normal controls. Flicker stimuli consisted of 2 degrees diameter targets of 2 seconds in duration, presented in 44 locations throughout the central 30 degrees visual field. Flicker was presented within a cosine envelope to avoid temporal transients. For TMP, contrast sensitivity thresholds were measured for 8-Hz sinusoidal flicker; CFF thresholds were measured for a stimulus of 100% contrast. RESULTS: The results indicate that TMP and CFF produced similar test-retest reliability in normals. CFF had slightly better reliability in glaucoma patients. Receiver operating characteristic analysis revealed that TMP could provide better separation of normals and glaucoma patients than did CFF. Similar findings were obtained when the thresholds for both procedures were converted to Z scores. CONCLUSIONS: Both methods of flicker perimetry testing provide acceptable test-retest reliability, and both can distinguish normal subjects from glaucoma patients. However, TMP is more effective in separating normal subjects from glaucoma patients than CFF, suggesting that TMP is the method of choice for detecting glaucomatous damage using flicker perimetry.

Lachenmayr BJ; Kojetinsky S; Ostermaier N; Angstwurm K; Vivell PM; Schaumberger M
The different effects of aging on normal sensitivity in flicker and light-sense perimetry
Invest Ophthalmol Vis Sci, 1994 May, 35:6, 2741-8
Section of Psychophysics and Physiological Optics, University Eye Hospital, Munich, Germany.

PURPOSE. To verify whether or not an accelerated loss at an older age for normal sensitivity in the central visual field is present when using the stimulus configuration of conventional white/white automated light-sense perimetry and the stimulus configuration of the automated flicker perimeter developed by one of the authors (BJL). METHODS. One hundred thirty eyes of 130 normal subjects aged 9 to 86 years were tested with the Humphrey-Field-Analyzer 640, program 30-2, and our automated flicker perimeter. In addition, short introductory learning programs were used for both techniques. All tests were performed in random order. RESULTS. Mean critical flicker fusion frequency shows a linear loss over the entire age range (r = -0.5546, P < 0.0001, slope a = -0.3820 dB/decade), whereas mean light difference sensitivity decreases only slightly up to 46 years of age (r = -0.0118, P = 0.9226, slope a = -0.0153 dB/decade), with a marked acceleration above 46 years of age (r = -0.7304, P < 0.0001, slope a = -2.0640 dB/decade). CONCLUSIONS. The absence of an accelerated loss at an older age for critical flicker fusion frequency (CFF) and the presence of such a loss for light-difference sensitivity (LDS) might be attributed to the independence of a flickering stimulus from distributing effects induced by the ocular media at an older age as proposed by one of the authors. The different age effects for CFF and LDS could also be explained by different age-related losses at different sites and for different neuronal populations throughout the visual pathways.

Lachenmayr BJ; Drance SM
The selective effects of elevated intraocular pressure on temporal resolution.
Ger J Ophthalmol, 1992, 1:1, 26-31
Department of Ophthalmology, University of British Columbia, Vancouver, Canada.
Twenty-seven eyes of 27 patients with normal tension glaucoma (NTG), 68 eyes of 68 patients with primary open-angle glaucoma (POAG), and 11 eyes of 11 patients with special forms of high-tension glaucoma (SHTG) including (pigmentary glaucoma, angle-closure glaucoma, secondary glaucoma, etc.), were examined by automated light-sense and temporal resolution perimetry. Light-sense perimetry was performed with the Humphrey Field Analyzer, using program 30-2. Temporal resolution perimetry was conducted with a system developed by Lachenmayr. Global field indices were calculated for all visual fields and modalities: mean defect (MD) for light-sense perimetry and mean flicker defect (FD) for flicker perimetry. For each of the three glaucoma groups there was a significant linear correlation of FD over MD. The slope of the regression line (regression coefficient a) increased with increasing maximal pressure level of the glaucomatous group: for NTG a = 0.6671, for POAG a = -1.2413, and for SHTG a = -2.235. The differences of the regression coefficients between NTG and POAG and between NTG and SHTG were statistically significant (P = 0.0366 and P = 0.0046, respectively). The results of the present study provide evidence that the relative amount of damage to flicker compared to light-sense perimetry increases with increasing maximal pressure level of a glaucomatous population. Thus, flicker perimetry may be a tool for the identification of eyes with pressure-produced damage.

Gleissner M; Lachenmayr BJ
Light perception and flicker perimetry. Effect of refractive error, artificial media opacities and pupillary size
Ophthalmologe, 1992 Apr, 89:2, 162-5
Augenklinik, Universität München.

The influence of defocus, artificial media opacities and pupil size on perimetric thresholds in automated light sense and flicker perimetry was investigated in 20 eyes of 20 normal subjects. Thresholds were determined at 13 locations in the central visual field. Blurring the retinal image by a small defocus or by slight artificial media opacities causes a measurable reduction in light-difference sensitivity. Flicker fusion frequency, however, is much more resistant to degradation of the retinal image. Artificial pupil size has a similar effect on both light-difference sensitivity and flicker fusion frequency. The present study shows that perimetric methods using temporal threshold criteria should be more suitable for the detection of neuronal damage in the presence of factors disturbing the quality of the retinal image than methods using static criteria.

Lachenmayr BJ; Drance SM; Douglas GR; Mikelberg FS
Light-sense, flicker and resolution perimetry in glaucoma: a comparative study.
Department of Ophthalmology, University of British Columbia, Vancouver, Canada.

A total of 106 eyes of 106 patients with different types of glaucoma were examined by automated light-sense, flicker and resolution perimetry (Humphrey Field Analyzer, program 30-2; flicker perimeter as described by Lachenmayr [16, 18]; resolution perimeter as devised by Frisén [4, 6, 8-11]). The fields were classified in a masked fashion as being normal or as having purely diffuse loss, purely localized loss or diffuse as well as localized loss. As compared with light-sense perimetry, resolution perimetry had a markedly lower sensitivity in the detection of glaucomatous damage (77%) but a high specificity (93%); the comparison of resolution perimetry with flicker perimetry showed similar results (sensitivity, 75%; specificity, 85%). When flicker perimetry was compared with light-sense perimetry and vice versa, the sensitivity was high (95% and 94%, respectively), but the specificity was low (57%
and 62%, respectively). The prevalence of detection of diffuse loss by both light-sense and resolution perimetry was related to visual acuity, whereas flicker perimetry did not show such a relationship.

Lachenmayr B; Gleissner M; Rothbächer H
**Automated flicker perimetry**
Fortschr Ophthalmol, 1989, 86:6, 695-701

Flicker fusion frequency (FFF), the threshold criterion of flicker perimetry, is a functional parameter of the temporal transfer properties of the visual system. An automated flicker perimeter suitable for clinical routine purposes is presented that allows perimetric examination of the central visual field with high spatial resolution. The intent of the present study was to investigate the outcome of flicker perimetry in comparison to static light-sense perimetry. In the majority of cases of ocular hypertension and suspected glaucoma (n = 31), chronic open-angle glaucoma (n = 36) and acute neuritis/papillitis (n = 10) defects are indicated by flicker perimetry in areas of the visual field with normal light sensitivity according to static light-sense perimetry (Octopus 201, program G 1). In many cases of preproliferative diabetic retinopathy (n = 10), however, flicker perimetry indicates fewer defects than static perimetry (Octopus 201, program 32). The results collected up to now suggest that automated flicker perimetry might represent a specific functional test of the retinal Y-ganglion cells.
Abstracts Motion perimetry
(Stand Juni 2000)

Sample PA; Bosworth CF; Blumenthal EZ; Girkin C; Weinreb RN
Visual function-specific perimetry for indirect comparison of different ganglion cell populations in glaucoma.
Invest Ophthalmol Vis Sci, 2000 Jun, 41:7, 1783-90
Department of Ophthalmology, University of California at San Diego, La Jolla, USA

PURPOSE: To compare short-wavelength automated perimetry, frequency-doubling technology perimetry, and motion-automated perimetry, each of which assesses different aspects of visual function, in eyes with glaucomatous optic neuropathy and ocular hypertension. METHODS: One hundred thirty-six eyes from 136 subjects were evaluated with all three tests as well as with standard automated perimetry. Fields were not used in the classification of study groups to prevent bias, because the major purpose of the study was to evaluate each field type relative to the others. Seventy-one of the 136 eyes had glaucomatous optic neuropathy, 37 had ocular hypertension, and 28 served as age-matched normal control eyes. Glaucomatous optic neuropathy was defined by assessment of stereophotographs. Criteria were asymmetrical cupping, the presence of rim thinning, notching, excavation, or nerve fiber layer defect. Ocular hypertensive eyes had intraocular pressure of 23 mm Hg or more on at least two occasions and normal-appearing optic disc stereophotographs. Criteria for abnormality on each visual field test were selected to approximate a specificity of 90% in the normal eyes. Thresholds for each of the four tests were compared, to determine the percentage that were abnormal within each patient group and to assess the agreement among test results for abnormality, location, and extent of visual field deficit. RESULTS: Each test identified a subset of the eyes with glaucomatous optic neuropathy as abnormal: 46% with standard perimetry, 61% with short-wavelength automated perimetry, 70% with frequency-doubling perimetry, and 52% with motion-automated perimetry. In the ocular hypertensive eyes, standard perimetry was abnormal in 5%, short wavelength in 22%, frequency doubling in 46%, and motion in 30%. Fifty-four percent (38/71) of eyes with glaucomatous optic neuropathy were normal on standard fields. However, 90% were identified by at least one of the specific visual function tests. Combining tests improved sensitivity with slight reductions in specificity. The agreement in at least one quadrant, when a defect was present with more than one test, was very high at 92% to 97%. More extensive deficits were shown by frequency-doubling perimetry followed by short-wavelength automated perimetry, then motion-automated perimetry, and last, standard perimetry. However, there were significant individual differences in which test of any given pairing was more extensively affected. Only 30% (11/37) of the ocular hypertensive eyes showed no deficits at all compared with 71% (20/28) of the control eyes (P < 0.001). CONCLUSIONS: For detection of functional loss standard visual field testing is not optimum; a combination of two or more tests may improve detection of functional loss in these eyes; in an individual, the same retinal location is damaged, regardless of visual function under test; glaucomatous optic neuropathy identified on stereophotographs may precede currently measurable function loss in some eyes; conversely, function loss with specific tests may precede detection of abnormality by stereophotograph review; and short-wavelength automated perimetry, frequency-doubling perimetry, and motion-automated perimetry continue to show promise as early indicators of function loss in glaucoma.
Bosworth CF; Sample PA; Williams JM; Zangwill L; Lee B; Weinreb RN

Spatial relationship of motion automated perimetry and optic disc topography in patients with glaucomatous optic neuropathy.

J Glaucoma, 1999 Oct, 8:5, 281-9
Glaucoma Center, University of California, San Diego, La Jolla, USA.

PURPOSE: To compare the spatial relationship of focal motion automated perimetry (MAP) visual field defect with focal defect in optic disc topography. METHODS: Patients (n = 12) with focal MAP visual field loss and focal change in optic disc topography were studied. The MAP visual field was divided into 12 field zones representing retinal nerve fiber layer arcuate bundles. Zones of MAP loss were related to rim area ratio (RAR), which was obtained by dividing the rim area, measured by the Heidelberg Retina Tomograph (HRT; Heidelberg Engineering, Heidelberg, Germany), into 36 10 degrees sectors and then dividing the area of each sector by the total rim area for each subject. Rim area ratio was compared to a normative database (n = 76) to quantify change in optic disc topography. In these same patients, the spatial relationship between standard automated perimetry (SAP) and short-wavelength perimetry (SWAP) and optic disc topography was also assessed. RESULTS: Motion automated perimetry superior visual field zones 14 through 19 were most often associated with a reduction in RAR for inferior sectors 24 through 29, and inferior visual field zones 4 through 7 were most often associated with a reduction in RAR for superior temporal sectors 11 through 16. Similar spatial relationships were found between SWAP and SAP and the RAR. CONCLUSION: Focal MAP visual field loss and focal changes in optic disc topography are spatially related. This relationship is similar to that found between SWAP and SAP with optic disc topography. Focal thinning or notching detected by RAR analysis might be independent of the specific functional test employed.

Wall M; Jennisch CS

Random dot motion stimuli are more sensitive than light stimuli for detection of visual field loss in ocular hypertension patients.

Optom Vis Sci, 1999 Aug, 76:8, 550-7
Department of Neurology, University of Iowa, Iowa City, USA

PURPOSE: To determine whether motion detection perimetry or luminance size threshold perimetry (a test using the motion perimetry method with luminance stimuli) is more sensitive in detecting visual loss in ocular hypertension patients. METHODS: Motion perimetry uses a customized computer graphics program to detect a subject's ability to identify a coherent shift in position of moving dots in a defined circular area against a background of fixed dots. Motion size threshold is defined as the smallest circular area within which dot motion is detected. Patients respond by touching the area of the computer monitor where they perceive the stimulus with a light pen. The localization errors are measured as the number of pixels from target center for each trial. Luminance size threshold perimetry uses the same technique except the background is dark gray and the stimuli are filled lighter gray circles. We tested one eye in each of 27 ocular hypertension patients and 27 age-matched normal subjects with both tests. Our main outcome measures were motion and luminance size thresholds, total deviation probability plot data, and spatial localization errors. RESULTS: With the total deviation probability plot analysis, the ocular hypertension patients had a greater number of abnormal test locations with motion perimetry stimuli than with luminance stimuli. The abnormal test points were located most often in the superior and inferior nasal regions. Six subjects had nerve fiber bundle-like defects to motion stimuli whereas three patients had
defects with luminance size threshold perimetry. The ocular hypertension patients had significantly greater localization errors than the controls with both tests. CONCLUSIONS: Using a size thresholding technique in ocular hypertension patients, random dot motion stimuli appear to be more sensitive than luminance stimuli. Errors in stimulus localization are significantly increased in ocular hypertension patients, independent of the stimulus (motion or luminance) used.

Westcott MC; Fitzke FW; Hitchings RA
Abnormal motion displacement thresholds are associated with fine scale luminance sensitivity loss in glaucoma.

This study tests the hypothesis that abnormal motion displacement thresholds coexist with scotomas on a finer spatial scale than is measurable by conventional Humphrey perimetry. Eighteen patients with primary open angle glaucoma in one eye, and 18 age matched normal controls underwent motion displacement threshold testing and high spatial resolution perimetry. The motion displacement thresholds were significantly elevated in the glaucoma eyes, in 73% this exceeded normal limits. Ten glaucoma eyes had normal Humphrey 24-2 field nearest the motion test site: of these seven had abnormally elevated motion displacement thresholds and six had fine scale threshold depressions detected with high spatial resolution perimetry. This result suggests that glaucomatous elevations of motion displacement threshold may be present in areas of normal Humphrey 24-2 field, and this may coexist with measurable scotomas beyond the resolution of conventional Humphrey perimetry in some, but not all patients.

Bosworth CF; Sample PA; Gupta N; Bathija R; Weinreb RN
Motion automated perimetry identifies early glaucomatous field defects.
Arch Ophthalmol, 1998 Sep, 116:9, 1153-8
Glaucoma Center and Dept. of Ophthalmology, University of California, San Diego, La Jolla, USA.

OBJECTIVE: To determine if motion automated perimetry can identify early glaucomatous visual field defects in patients with suspected glaucoma (by disc), those with ocular hypertension, and those with primary open-angle glaucoma. METHODS: Motion automated perimetry, a foveally centered motion test, and standard visual field tests were conducted on one randomly selected eye of normal patients (n = 38), patients with suspected glaucoma (by disc) (n = 28), patients with ocular hypertension (n = 18), and patients with primary open-angle glaucoma (n = 21). Subjects performance on both motion tests were compared with their performance on standard perimetry. RESULTS: Perimetric motion thresholds significantly distinguished the groups (P< or =.001), while the foveally centered motion test was unable to separate them (P< or =.32). Of the total patients, 90.5% of those with glaucoma, 39.3% of those with suspected glaucoma, 27.8% of those with ocular hypertension, and 5.3% of the normal subjects had abnormal results on motion automated perimetry testing. Perimetric motion thresholds were significantly correlated with standard visual field thresholds (P< or =.001). CONCLUSION: Motion automated perimetry identifies visual field defects in patients who already show standard visual field loss as well as in a moderate percentage of those with suspected glaucoma and ocular hypertension, indicating that the testing of discrete locations might be necessary for increased diagnostic utility.
Wu J; Coffey M; Reidy A; Wormald R
Impaired motion sensitivity as a predictor of subsequent field loss in glaucoma suspects: the Roscommon Glaucoma Study.
Southampton University, Ophthalmic Epidemiology Unit.

AIM: To determine if impaired motion sensitivity is a significant predictor of subsequent field loss in glaucoma suspects. METHOD: A population based prospective study; a 5 year follow up of all glaucoma suspects who had been identified from a population based random sample survey in the west of Ireland. 78 glaucoma suspects whose visual field function was annually measured by Henson CFS 2000 and for whom data on family history of glaucoma, ocular status, and motion impairment had been recorded. Visual field loss was defined as Henson visual field survival score of 94 or less. RESULTS: 18 people developed visual field loss in at least one eye. Motion impairment at baseline was associated with a 2-18 times greater risk of development of the visual field loss (p < 0.001). This association was independent of sex, family history of glaucoma, intraocular pressure, and C/D ratio at baseline. The Cox's proportional hazards regression analysis confirmed the above results after adjustment for age and the C/D ratio. CONCLUSION: Motion impairment is an independent predictor of visual field loss in glaucoma suspects, although it is not clear how long motion impairment precedes visual field loss.

Donahue SP; Wall M; Stanek KE
Motion perimetry in anisometropic amblyopia: elevated size thresholds extend into the midperiphery.
J AAPOS, 1998 Apr, 2:2, 94-101
Dept. of Ophthalmol. and Vis. Sci., Vanderbilt University School of Medicine, Nashville, USA.

PURPOSE: Our purpose was to determine whether motion detection abnormalities in patients with anisometropic amblyopia exist and to determine the extent of these abnormalities in the central and midperipheral visual field. METHODS: We used of motion perimetry to evaluated 10 anisometropic subjects with no manifest strabismus. Each of 44 locations in the visual field corresponding to the test sites of the Humphrey 24-2 program was tested with circular patches of motion (random dot cinematograms) displayed on a computer screen. Stimulus patch size was reduced in a 2/1 staircase manner to determine the smallest patch of motion detectable at each test location (threshold). Data from 15 age-matched normal subjects were used as controls. RESULTS: Vision in the amblyopic eye ranged from 20/25 to count fingers. The overall mean size threshold for amblyopic eyes was elevated (61% +/- 73%) compared with fellow eyes and age-matched normal eyes (p < 0.03) (i.e., the moving patch of dots in the field had to be larger for it to be detected when viewing with the amblyopic eye). The increase in size threshold was consistent across the visual field and was not greater for central locations. CONCLUSION: The amblyopia caused by anisometropia is associated with an abnormality in motion detection that extends into the midperiphery of the visual field.

Wall M; White WN 2nd
Asymmetric papilledema in idiopathic intracranial hypertension: prospective interocular comparison of sensory visual function.
PURPOSE: Visual loss is the main morbidity of idiopathic intracranial hypertension (IIH). The relationship between papilledema grade and visual loss is unclear. The goal of this study was to determine whether there is a relationship between papilledema grade and visual loss.

METHODS: Fundus photographs of 478 patients with IIH were reviewed, and their degree of papilledema was graded using Frisén's scheme. We identified 46 patients (10%) with IIH and highly asymmetric papilledema, as defined by an interocular difference of two or more grades. Nine of these patients with active asymmetry agreed to return for a series of visual tests. They underwent three visual field tests—Humphrey visual field analyzer 24-2, motion perimetry, and ring perimetry. The perimetry outcome measures were mean deviation, foveal threshold, and means for eccentric zones (3 degrees, 9 degrees, 15 degrees, and 21 degrees). The patients participated also in visual acuity, Farnsworth-Munsell 100-hue, Pelli-Robson contrast sensitivity, and foveal flicker fusion testing. Their relative afferent pupillary defect was graded using neutral density filters.

RESULTS: The intereye comparisons showed vision to be worse in the eye with the high-grade papilledema for all outcome measures. The magnitude of the loss with the perimetry tests increased with eccentricity. The measures of central visual function, although in the normal range, were relatively depressed in the eye with high-grade papilledema.

CONCLUSIONS: Visual loss in patients with asymmetric papilledema caused by IIH was most pronounced in the eye with the higher grade of papilledema. Foveal visual functions, although they remained in the normal range, were also decreased in patients with high-grade papilledema. In patients with high-grade papilledema, visual loss appeared to affect the entire visual field, and the peripheral field showed the most deficit. Our findings showed that high-grade papilledema was associated with visual dysfunction in patients with IIH.

Sample PA; Bosworth CF; Weinreb RN

Short-wavelength automated perimetry and motion automated perimetry in patients with glaucoma
Arch Ophthalmol, 1997 Sep, 115:9, 1129-33
Glaucoma Center, University of California, San Diego, La Jolla, USA.

OBJECTIVE: To compare short-wavelength automated perimetry (SWAP), a test favoring the detection of the target by the parvocellular pathways of vision, with motion automated perimetry (MAP), a test favoring detection by the magnocellular pathways, in the same eyes.

PARTICIPANT: Thirty-three individuals in whom glaucoma was suspected (glaucoma suspects) and 17 patients with primary open-angle glaucoma were compared with 30 age-matched normal control subjects.

INTERVENTIONS: Short-wavelength automated perimetry was done with the usual protocol (program 24-2). Motion coherence thresholds were measured with 14 random dot targets that covered the 24-2 field area. Short-wavelength automated perimetry test locations corresponding to each of the 14 motion automated perimetry locations were averaged to compare 14 locations for each text.

RESULTS: Short-wavelength automated perimetry and motion automated perimetry were correlated by visual field location (whole field r = -0.40, P < .001), especially in the superior field (r = -0.45, P < .001). Overlap for defective locations was present in 16 (94%) of the 17 eyes with glaucoma, although in the glaucoma suspect eyes each test showed the earliest deficit in a percentage of individuals with overlap in only 3 (21%) of the 14 eyes. An analysis of variance showed a significant effect of diagnosis for both tests (SWAP and MAP, P < .001); the eyes of patients with glaucoma were significantly different from those of the normal controls. The results for glaucoma suspects were significantly different on SWAP only in the superior temporal field (Tukey-Kramer test).

CONCLUSIONS: Both tests successfully identified eyes with glaucoma
and a percentage of the glaucoma suspect eyes; both were correlated by field location. These results suggest that damage due to glaucoma is nonselective for either the parvocellular or the magnocellular ganglion cell axons, that there may be individual differences in which type of ganglion cell shows damage first, and that when standard visual field loss is present the results of SWAP and MAP are defective.

Bosworth CF; Sample PA; Weinreb RN
Perimetric motion thresholds are elevated in glaucoma suspects and glaucoma patients.
Department of Ophthalmology, University of California at San Diego, La Jolla, USA.

The purpose of this study was to determine if a clinically feasible perimetric motion test utilizing random-dot kinematograms could identify glaucomatous visual field defects. Using a staircase procedure, an automated perimetric motion test and a larger foveally presented target were given to normal (n = 30), glaucoma suspects (n = 31) and primary open-angle glaucoma patients (n = 19). Motion thresholds at specific locations throughout the whole visual field were significantly elevated in glaucoma patients (P < or = 0.001). Perimetric motion testing identified 84.2% of the primary open-angle glaucoma patients and 25.8% of the glaucoma suspects as abnormal. A larger foveal stimulus was unable to distinguish between the different subject groups (P < or = 0.185). Perimetric motion thresholds were significantly correlated with Humphrey standard visual field thresholds in the glaucoma and glaucoma-suspect patients (P < or = 0.0002).

Joffe KM; Raymond JE; Chrichton A
Motion coherence perimetry in glaucoma and suspected glaucoma.
Faculty of Medicine, University of Alberta, Edmonton, Canada.

Motion direction sensitivity in glaucoma patients, glaucoma suspects and controls was assessed perimetrically at 22 visual field locations using small random dot kinematograms and a motion coherence task. For foveal stimulus presentations, mean motion coherence sensitivity was normal in both patient groups. However, nearly all glaucoma patients and about half of glaucoma suspects (all with normal visual fields as assessed with static perimetry) had some deficit of motion sensitivity. These were most pronounced and most prevalent in the superior field at 15 and 21 deg eccentricity. Glaucoma appears to produce a reduction in the normal integrative visual function necessary for the perception of global motion in textured displays and this disruption is non-uniformly distributed across the visual field.

Wall M; Jennisch CS; Munden PM
Motion perimetry identifies nerve fiber bundlelike defects in ocular hypertension
Arch Ophthalmol, 1997 Jan, 115:1, 26-33
Department of Neurology, College of Medicine, University of Iowa, Iowa City, USA.

OBJECTIVE: To determine whether patients with ocular hypertension (OHT) have elevated motion perimetry thresholds. DESIGN: Motion perimetry uses a customized computer graphics program to detect the ability to identify a coherent shift in position of 50% of dots in a defined circular area against a background of fixed dots. Motion size threshold is defined as
the smallest circular area in which dot motion is detected. Subjects respond by touching the area of the computer monitor with a light pen where motion stimuli are perceived. Reaction times (milliseconds) to stimuli and localization error (number of pixels from target center) are also obtained for each trial. SETTING: University hospital ophthalmology clinic. PATIENTS OR OTHER PARTICIPANTS: Twenty-seven patients with OHT and 27 age-matched normal subjects. One eye was tested in each subject. MAIN OUTCOME MEASURES: Random dot motion stimuli size thresholds and total deviation probability plot data, reaction times, and spatial localization errors. RESULTS: The patients with OHT had more abnormal test points in the total deviation probability plot analysis compared with the controls (P < .001, chi 2). The abnormal test points were concentrated in the superior and inferior nasal regions. Six subjects had nerve fiber bundlelike defects to motion stimuli. Six subjects (5 overlapping with the probability plot analysis) had abnormal glaucoma hemifield test results. The patients with OHT also had significantly greater localization errors. CONCLUSION: Motion threshold perimetry may be a more sensitive method to detect visual field abnormalities in OHT than conventional automated perimetry.

Graham SL; Drance SM; Chauhan BC; Swindale NV; Hnik P; Mikelberg FS; Douglas GR
Comparison of psychophysical and electrophysiological testing in early glaucoma.
University of British Columbia, Vancouver, Canada.

PURPOSE: To compare the sensitivity and specificity of a wide range of psychophysical and electrophysiological tests in the detection of early glaucomatous damage. METHODS: Forty-three normals and 43 patients with early glaucoma, some still without field defects, were tested with differential light threshold perimetry, short-wavelength automated perimetry, high-pass resolution perimetry, motion detection, flicker contrast sensitivity, flickering and isoluminantly matched letter tests, and pattern and flash electroretinography, including photopic, scotopic, oscillatory potentials, and 30 Hz flicker. Receiver operating characteristic analysis was applied to continuous variables derived from each of the tests. RESULTS: Most parameters reflected glaucomatous loss to some degree, even though only single variables were analyzed separately in the receiver operating characteristic analysis. The pattern electroretinogram and some of the letter acuity tests had the best sensitivity and specificity, followed by short-wavelength automated perimetry and high-pass resolution-perimetry. Motion detection, flicker contrast, and flash electroretinogram parameters scored poorly. Six patients with normal results on the Humphrey field test had abnormal results on many of the other tests. CONCLUSIONS: Applying different psychophysical and electrophysiological tests may add to our ability to detect early glaucomatous damage.

Lachenmayr B
Informative value of psychophysical examinations aside from conventional white-white perimetry
Ophthalmologe, 1996 Aug, 93:4, 389-95

In addition to routine light-sense perimetry testing, elementary visual function, i.e., light difference sensitivity, numerous methods and procedures were developed to test more complex psychophysical threshold criteria in glaucoma patients in order to detect functional glaucomatous loss earlier. The various methods differ with respect to the area of the visual field tested (central, perimetric, global or Ganzfeld stimulation) and the psychophysical threshold criteria (spatial and/or temporal transfer, color, complex criteria including form
perception, etc.). Two domains proved to be of special interest: examination of the temporal transfer properties (flicker stimulation, motion perception, "motion-defined-form") and testing of the short-wave-length cone system (blue/yellow perimetry). The blue cone system is part of the parvocellular pathway, criteria in the field of temporal transfer may be allocated to the magnocellular pathway. There is histopathological evidence that ganglion cell axons of the magnocellular system are prone to glaucomatous damage in an earlier stage of the disease. There may even be some kind of specific damage. The role of various psychophysical procedures are discussed with reference to data in the literature and own experience with special emphasis on the practical applicability for early diagnosis of functional glaucomatous damage.

Plummer DJ; Arevalo JF; Fram N; Quiceno JI; Sample PA; Freeman WR
Effectiveness of entoptic perimetry for locating peripheral scotomas caused by cytomegalovirus retinitis.
Shiley Eye Center, Dept. of Ophthalmology, University of California, La Jolla, USA.

OBJECTIVE: To determine the effectiveness of random particle motion, presented on a computer monitor, as a noninvasive test for detecting cytomegalovirus retinitis. DESIGN: A prospective masked study in which patients were asked to trace out any disturbances on a transparency placed over a computer monitor that displayed continuous random particle motion, while the patient fixated on a central spot (entoptic perimetry). SETTING: The Acquired Immunodeficiency Syndrome Ocular Research Unit at the University of California, San Diego, in La Jolla. PATIENTS: Twenty-two men with cytomegalovirus retinitis who were positive for human immunodeficiency virus, 11 men without cytomegalovirus retinitis who were positive for human immunodeficiency virus, and eight men who were negative for human immunodeficiency virus. INTERVENTION: None. MEASUREMENTS: Sensitivities and specificities were used to compare the results of entoptic perimetry with fundus photographs. RESULTS: Entoptic perimetry demonstrated a 95% sensitivity and a 95% specificity in detection of cytomegalovirus retinitis. CONCLUSION: Entoptic perimetry may be an effective and inexpensive screening test for cytomegalovirus retinitis in hospitals and community clinics.

Wall M; Ketoff KM
Random dot motion perimetry in patients with glaucoma and in normal subjects.
Department of Neurology, University of Iowa, College of Medicine, Iowa City, USA.

PURPOSE: To determine whether patients with primary open-angle glaucoma have an increase in size thresholds, prolongation of reaction times, and greater localization errors to random dot motion stimuli than normal subjects. METHODS: Motion perimetry, a computer graphics method of visual field testing, quantitates a subject's ability to detect a correlated shift in position of dots within a defined circular area against a background of fixed dots. We measured motion thresholds, the smallest detectable circular dot motion target, at the Humphrey 24-2 test loci. By using the subject's light-pen responses to the location of the targets, we computed motion size threshold, reaction times, and localization errors (number of pixels from where the subject touched the monitor to the target center). With motion perimetry and conventional automated perimetry, we tested one eye in each of 25 patients with primary open-angle glaucoma and 25 age-matched control subjects. We then generated
total deviation pointwise probability plots for the patients with primary open-angle glaucoma. RESULTS: Patients with primary open-angle glaucoma had increased mean motion size threshold (P < .001) and increased localization errors (P < .002), compared with the control subjects. With the probability plot analysis, there was good correlation of the visual field defects between the two perimetry tests. Additionally, motion perimetry identified nerve fiber bundle-like defects in 12 patients that were not detected with conventional automated perimetry. CONCLUSIONS: Patients with primary open-angle glaucoma had abnormal motion perception with an increase in spatial localization error.

Wall M; Montgomery EB
Using motion perimetry to detect visual field defects in patients with idiopathic intracranial hypertension: a comparison with conventional automated perimetry.
Neurology, 1995 Jun, 45:6, 1169-75
Department of Neurology, University of Iowa, College of Medicine, Iowa City, USA.

Motion perimetry, a method of visual field testing that uses computer graphics to measure motion perception, quantitates a subject's ability to detect a coherent shift in position of dots in a defined circular area against a background of fixed dots. Motion size threshold is defined as the smallest detectable circular target in which dot motion is detected. Subjects respond by touching a computer monitor screen with a light pen, first when they see a target (reaction time) and a second time where motion targets are detected (localization). Reaction time (msec) to the stimulus and localization error (number of pixels from target center) are then calculated and stored. We tested on eye in each of 20 idiopathic intracranial hypertension (IIH) patients and 40 age-matched normal subjects by conventional automated perimetry (Humphrey visual field analyzer, program 24-2) and motion perimetry. Pointwise probability plots of individual abnormal test points for size threshold responses were generated for the IIH patients based on the 95% confidence limits of the normal subject responses. An analysis of the subjects' visual field pairs (motion versus conventional automated perimetry) was performed based on these probability plots. The IIH patients had an elevated mean motion threshold (p < 0.001) and reaction time (p < 0.001) compared with the normal subjects. There were no significant differences for the localization errors. Based on the probability plot analysis, there was good correlation of the visual field defects between the two perimetry tests. In addition, motion perimetry identified nerve fiber bundle-shaped defects in nine patients in whom they were not detected with conventional automated perimetry.

Wojciechowski R; Trick GL; Steinman SB
Topography of the age-related decline in motion sensitivity.
Optom Vis Sci, 1995 Feb, 72:2, 67-74
School of Optometry, University of Montreal, Quebec, Canada.

PURPOSE. We examined whether the decline in motion sensitivity in the elderly is equivalent for different visual field locations. METHODS. High velocity (28 degrees/s) random dot kinematograms (RDK's) were used to measure direction discrimination thresholds for 5 locations in the visual field (1 position centered on fixation and 4 locations each centered 18 degrees from fixation in the nasal, temporal, superior, and inferior quadrants). Differential luminance sensitivity was assessed by automated perimetry. Younger (N = 15, mean age = 22.9 +/- 1.3 years) and older (N = 13, mean age = 66.6 +/- 4.5 years) subjects were studied. RESULTS. Motion sensitivity varied with test location for both younger and older subjects, but sensitivity was significantly lower in older individuals. The largest age-
related reduction in sensitivity was in the central location, whereas the smallest decline was in the superior position. No significant correlations between motion and differential luminance sensitivity were evident. CONCLUSIONS. There is a significant age-related deterioration in visual sensitivity to motion which is more pronounced in the central visual field than in some regions of the more peripheral field. Although both motion and differential luminance sensitivity decrease with age, the rate and the magnitude of the loss differ for these two visual functions.

Baez KA; McNaught AI; Dowler JG; Poinoosawmy D; Fitzke FW; Hitchings RA
Motion detection threshold and field progression in normal tension glaucoma.
Br J Ophthalmol, 1995 Feb, 79:2, 125-8
Moorfields Eye Hospital, London.

Psychophysical tests may demonstrate abnormalities of visual function before the appearance of conventional visual field loss in glaucoma. Motion detection thresholds (MDT) were measured in the normal fellow eye of 51 patients with confirmed normal tension glaucoma and initially unilateral field loss. Humphrey visual fields from the initially normal eye covering a mean follow up of 3.4 years were assessed using pointwise linear regression analysis. In 22 of the 51 eyes with normal visual fields at presentation, field deterioration occurred at one or more Humphrey locations within a mean of 1.7 (SD 1.6) years. An initially abnormal MDT test showed a sensitivity of 73% and a specificity of 90% in predicting field deterioration within the cluster of four Humphrey locations closest to the original MDT test site. Sensitivity was lower (40%) in predicting progression at retinal locations distant from the MDT test site, though specificity remained high (90%).

Lachenmayr B; Lund OE
15 years automated perimetry--where does the path lead?
Klin Monatsbl Augenheilkd, 1994 Dec, 205:6, 325-8
Augenklinik, Universität München.

15 years ago the first fully automated perimeter became available, the Octopus 201, developed by Fankhauser in Bern. Some of the objections which were raised in those days against automated perimeters have turned out true, many, however, not. From todays perspective automated perimetry has brought tremendous advantages for clinical routine diagnosis. The essential power of automated perimetry is its ability to obtain quantitative data which can be processed statistically. The examination of the central visual field may be performed in a much more sophisticated way than by manual kinetic testing. Automated perimetry, however, also has its draw-backs, which are mostly due to mistakes or errors by the examiner, not so much to the method itself. For routine light-sense perimetry the upcoming years will give us faster and optimized testing strategies. Procedures for automated interpretation of visual field data will be developed. The interest in more complex perimetric test criteria goes on one hand into the direction of independence of disturbancies of the optical media (e.g. temporal criteria), on the other hand into the differentiation of various cell populations in the visual system (Blue/Yellow-Perimetry; Motion-Defined-Form etc.). For objective perimetry a powerful system for pattern-ERG and pattern-VECP with a spatial resolution comparable to standard perimetric tests is available. Also in these fields of perimetry the coming years will bring interesting and revolutionary new developments which will open new diagnostic dimensions.
A total of 173 eyes (visual field defect stages O-V) of 99 glaucoma patients were investigated by means of conventional threshold-oriented suprathreshold automated test point perimetry using the Tübingen Automatic Perimeter (TAP) and by means of white-noise-field campimetry (flickering random dot pattern) using the Tübingen Electronic Campimeter (TEC). Most eyes were affected by primary open-angle glaucoma (119) or low tension glaucoma (35). The concordance between the two methods was good in 65 eyes (37.6%). Sufficient in 32 (18.5%) eyes, poor in 32 cases (18.5%) and inadequate in 44 eyes (25.4%). Among the last group of 44 eyes, 32 perceived a scotoma in the noise field (NF) but did not show any pathologic defect in conventional automated test point perimetry: the opposite constellation was found in only 12 eyes. In most cases, scotoma in the NF showed a change in both brightness and motion (noise) perception. No clear relationship between the type of glaucoma and a certain constellation of the aforementioned NF specifications could be found. Complete lack of noise perception in the scotoma occurred more frequently in advanced glaucoma (stage > or = IV). In 110 eyes of 63 of the glaucoma patients, white-noise-field campimetry was carried out during artificial IOP elevation achieved by suction-cup oculopression: during steplike increases of the negative pressure in the suction-cup up to maximum of 375 mmHg the following stages could be seen (the percentage of eyes that perceived each phenomena over the negative pressure range is shown in brackets): change in NF perception compared with initial findings (96.4%); impairment of central noise-field perception (78.2%); concentric constriction of NF (61.8%); complete breakdown of noise (field) perception (42.7%). A further, quantitative classification of these eyes was possible by evaluation of the negative pressure in the suction-cup that led to any one of these NF phenomena. The results demonstrate the usefulness of white-noise-field campimetry as a very fast screening method for detecting glaucomatous visual field defects. It can also be performed as a pressure tolerance test and thus be used to classify glaucomatous risk stages.

In a total of 121 patients scotomata, detected by white-noise campimetry, were presented graphically in a standardized manner. The intensity of brightness and strength of motion (“noise”) perception within the scotoma, as well as the reliability of the patients' statements, were taken into consideration. The results of white-noise campimetry were compared with conventional raster perimetry using the Tübingen automatic perimeter. In each case the examiner was naive with respect to the result of the other method. In 77% of all comparisons, the correspondence between the results obtained with white-noise campimetry, on the one hand, and automatic perimetry on the other was sufficiently close, so that one method confirmed the other. However, when white-noise campimetry was used alone congenital...
visual field defects, long-standing retinal scotomata, and old suprageniculate lesions mostly could not be detected. When these defects were excluded from the analysis, the correspondence between the two methods increased to 85% (in the 89 remaining patients). Special applications of white-noise campimetry as a screening method or for the purpose of patient self-examination are discussed. Furthermore, it is suggested that this method could be used as a tolerance test for revealing expansion of the scotoma under short-term artificial elevation of the intraocular pressure.