

A New Look at Selective Perimetry

What is its role in clinical practice?

BY MURRAY FINGERET, OD

Diagnosing open-angle glaucoma may be particularly challenging when damage is mild or early. Although most clinicians will not have difficulty detecting glaucomatous damage when both functional and structural defects are evident, patients presenting with a normal visual field combined with optic nerve and/or retinal nerve fiber layer (RNFL) damage may make practitioners stop and think. The physician must decide if the optic nerve's or RNFL's appearance is a result of glaucoma or represents a normal variation. Because this scenario arises so often, supplemental testing such as optic nerve/RNFL imaging or selective perimetry can play a useful role in everyday practice.

The definition of *glaucoma* has evolved such that optic nerve findings alone now may be considered a sufficient indication for a positive diagnosis.¹⁻³ Explanations for frequently seen disparities between standardized automated perimetry (SAP) findings and optic nerve/RNFL evaluations are complex. Often, these disparities are associated with factors ranging from redundancy in the visual system to the use of log scales in one automated measurement versus linear scales in another.

A series of instruments has been developed to help clinicians recognize glaucomatous damage when obvious loss is not apparent. Automated imaging devices evaluate the optic nerve, RNFL, and macula. They either compare results to age-corrected normative databases or plot results over time to detect threatening rates of change. Specialized perimetric tests have been developed to selectively assess visual function, with the goal of detecting visual field loss not found by SAP. This article describes these selective perimetric tests and their role in the diagnosis of glaucoma.

SHORT-WAVELENGTH AUTOMATED PERIMETRY

Short-wavelength automated perimetry (SWAP) or blue-yellow perimetry was commercially introduced more than 15 years ago. SWAP is available on the

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Humphrey perimeter (Carl Zeiss Meditec, Inc., Dublin, CA) and on Octopus perimeters (Haag-Streit USA Inc., Mason, OH). Both instruments also perform SAP, which can be useful when the clinician suspects glaucoma and the standard field is within normal limits.

With SWAP, a large Goldmann size V blue target is projected against a bright yellow background. The background reduces the sensitivities of the green and red cones, thus isolating the short-wavelength-sensitive blue cones and their associated small, bistratified retinal ganglion cells. Because only about 10% of retinal ganglion cells are of the bistratified variety, SWAP tests only a small fraction of the visual system. Early theories suggesting that SWAP works because bistratified cells are the first ones damaged in glaucoma are no longer widely accepted. Instead, the most popular theory is that SWAP owes its success to the fact that fewer cells are tested, and a reduced amount of overlap in tested ganglion cell-receptive fields exposes defects early. Defects found with SWAP often appear larger and deeper than with SAP, and many studies have suggested that SWAP can detect visual field loss earlier than SAP (Figure 1).⁴⁻⁸

Of course, all techniques have attendant difficulties. The original SWAP test was normally performed using a tedious full-threshold algorithm. Several years ago, Swedish interactive testing algorithm (SITA) SWAP was introduced, which reduced testing time by half while retaining similar sensitivity and reproducibility. SITA SWAP also possesses an improved dynamic range. Nonetheless, many patients still find the test difficult,

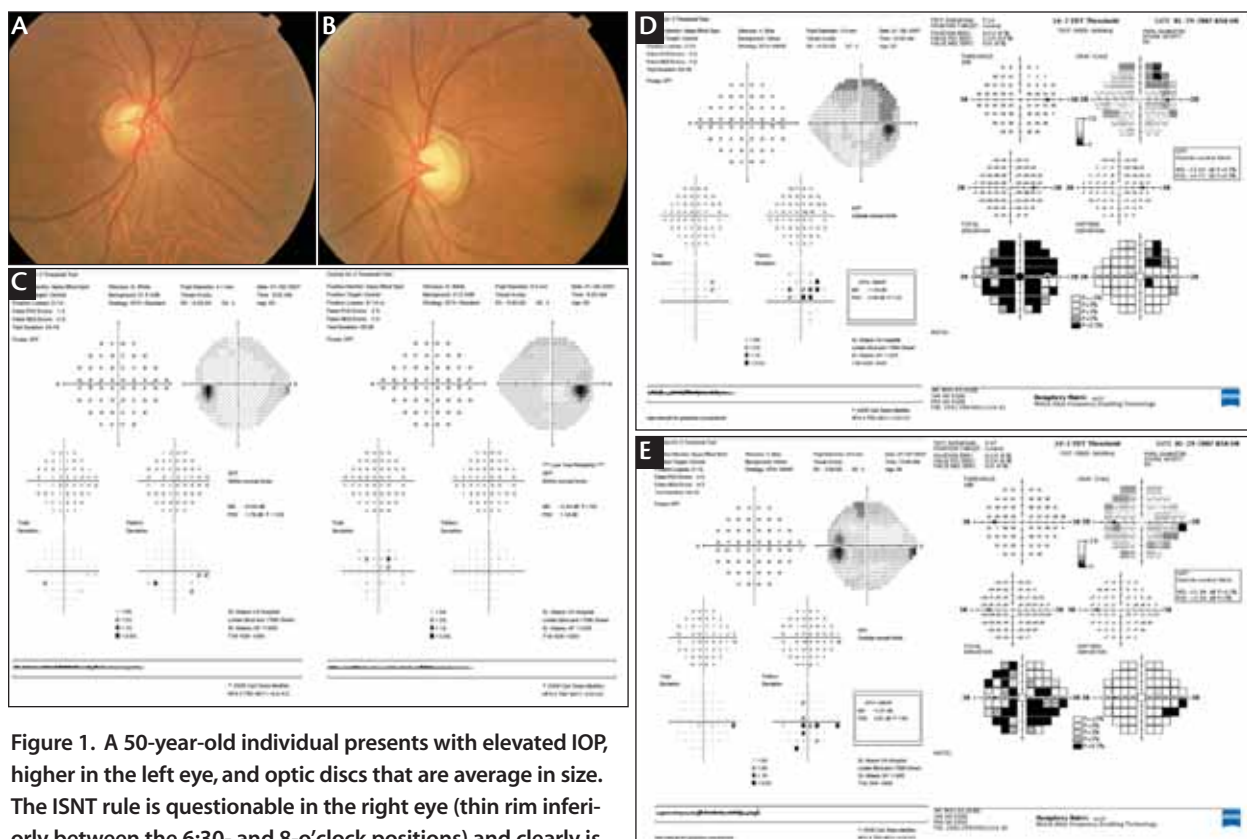


Figure 1. A 50-year-old individual presents with elevated IOP, higher in the left eye, and optic discs that are average in size. The ISNT rule is questionable in the right eye (thin rim inferiorly between the 6:30- and 8-o'clock positions) and clearly is not obeyed in the left eye, which has a thin rim superiorly. Peripapillary atrophy is greater in the left eye, with no signs of RNFL loss or disc hemorrhage (A, B). The Humphrey Field Analyzer 24-2 SITA standard visual field for the right eye is full. The glaucoma hemifield test is within normal limits in both eyes, with several points flagged in the inferior portion of the field for the left eye. The points are at the mildest level of significance. A person comfortable with analyzing field printouts would note the suspicious nature of this cluster of flagged points, even though the pattern may not be consistent with more popular definitions of *glaucomatous field loss* (C). SITA SWAP (left) and FDT threshold fields for the right eye show a superior partial arcuate scotoma. This finding may suggest glaucomatous damage, given the optic nerve's suspicious appearance (D). SITA SWAP (left) and FDT threshold fields for the left eye reveal an inferior partial arcuate scotoma (E). The scotoma noted on both tests is more marked than that found with SITA standard (Figure 1C).

perhaps because the visual system tested by SWAP has low resolution and responds slowly. Even with optimal refractive correction, the stimulus usually seems blurry and is not seen to turn on and off crisply. Because patients are unaccustomed to seeing under these conditions, it is hardly surprising that there is often a learning effect when they are introduced to SWAP testing, even among individuals who have long experience with SAP testing. Moreover, testing the blue cone system leads to higher intra- and intertest variability compared with white testing.^{9,10}

SWAP tests require a somewhat different interpretative strategy compared with standard white testing. SWAP's blue stimulus is highly attenuated by yellowed

crystalline lenses. In addition, because yellowing of the crystalline lens varies greatly among patients, simple age corrections are not sufficient. Thus, the analysis of SWAP results relies mostly on metrics that self-correct for media effects (the familiar pattern deviation probability plots, the glaucoma hemifield test, and the pattern standard deviation index) and ignores raw threshold sensitivities and metrics that simply apply an age correction (eg, the grayscale, mean deviation, and the total deviation probability plots). In patients who have excessively yellow lenses, lenticular attenuation of the stimulus may be so strong that there is not enough brightness range to fully determine the depth of very deep scotomata, further complicating the evaluation of tests.

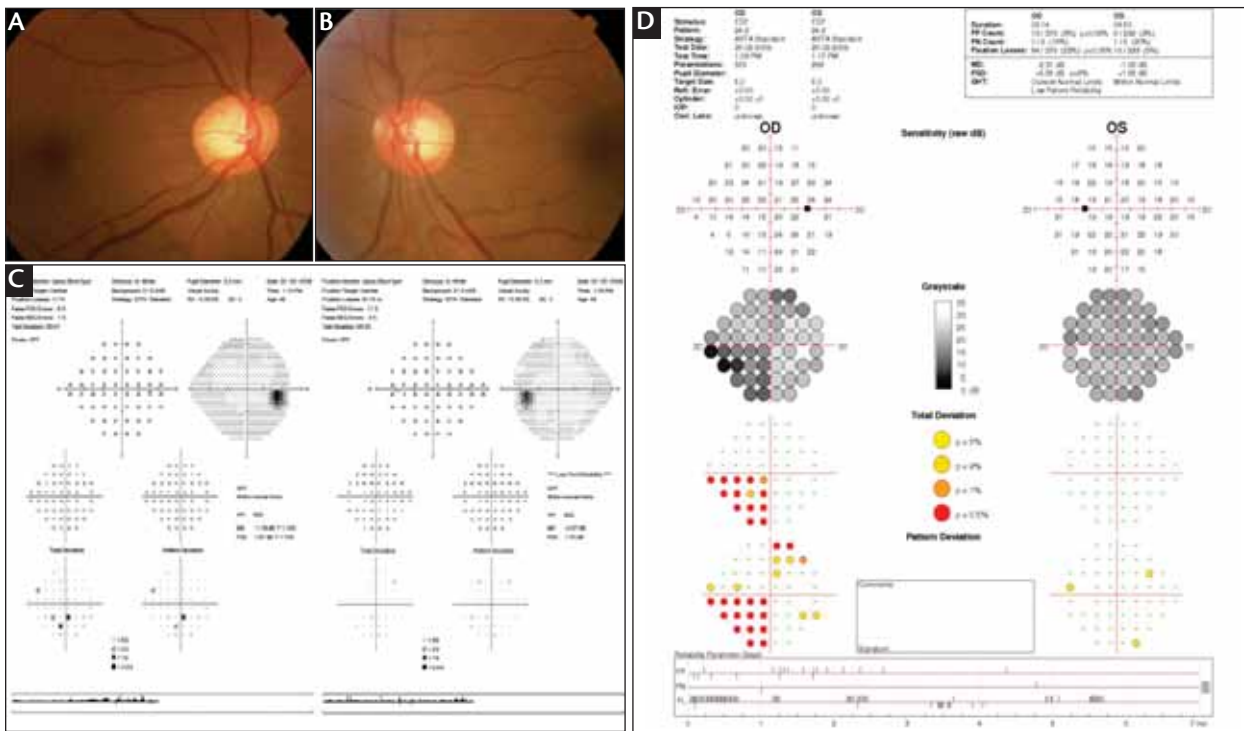


Figure 2. A 48-year-old patient presents with elevated IOP, higher in the right eye. The optic nerves are average in size. The neuroretinal rim is thin superiorly in the right eye, whereas the left eye's rim appears to be healthy (A, B). SITA standard visual field testing shows scattered points flagged for the right eye in no apparent pattern, whereas the left eye's field is full (C). On HEP threshold fields using adaptive staircase thresholding algorithm standard, an inferior partial arcuate scotoma is present for the right eye, but the left eye's field is full. The field loss correlates with the optic nerve findings in the right eye (D).

Given patients' frequently disquieting experience, increased testing variability, reduced testing range, and the need for a somewhat different strategy for interpreting the test, most practitioners seldom use SWAP. Overall, these problems do not appear to be correctable, and it is doubtful that, after all these years, SWAP will become a widely used clinical test.

FREQUENCY DOUBLING TECHNOLOGY

Frequency doubling technology (FDT) perimetry was commercially introduced in 1997, a few years after SWAP. FDT has been reported to selectively test the sensitivity of the magnocellular portion of the visual system, which serves a different subset of visual functions than SWAP. One difference between FDT and SWAP is that the former can only be performed on a stand-alone instrument. A significant paradigm shift would be needed for it to be replaced by FDT, because SAP is the primary perimetric test for most clinicians. FDT has been marketed primarily to the optometric community, where it is broadly used in clinical case detection.

FDT perimetry uses a low-spatial-frequency sinusoidal grating target that undergoes high-temporal-frequency counter-phase flicker. FDT is a flicker-type test in which patients are asked to respond when they notice a shimmering or flickering stimulus. The test measures the central 30° of the field of vision, with the original instrument presenting large, 10° X 10° peripheral stimuli and a 5° X 5° macular stimulus. Only 17 to 19 test point locations are evaluated with the original FDT perimeter, depending upon the testing pattern used.

The Humphrey Matrix FDT perimeter (Carl Zeiss Meditec, Inc.) is the most recent FDT tester and presents 50 grating stimuli throughout the central field. In addition to the original FDT suprathreshold tests, the Humphrey Matrix also offers 10-2, 24-2, and 30-2 threshold testing. Thus, the instrument is intended for use both in clinical case detection and in glaucoma diagnosis.

Like SWAP, SAP, and all other testing modalities, Humphrey Matrix testing is not without its challenges. Patients frequently report that the testing screen seems

EyeSuite Visual Field Analysis Software: a Clinician's Experience

BY JONATHAN MYERS, MD

A year ago, my practice installed EyeSuite software (Haag-Streit USA Inc., Mason, OH) on all of our computers in our electronic medical records office. The EyeSuite software is a visual field management and analysis system. Before, we had either viewed visual fields as PDF images on the screen or as traditional paper printouts with printed series analysis.

EyeSuite has been a great step forward for me in the daily care of patients. It allows me to access any patient's visual fields from any computer on my office network. Additionally, the software has analysis algorithms that simplify and expedite my interpretation of a single field or a series of fields. For the first time, I actually prefer viewing fields on the computer than on paper. I use the software to view patients' recent Octopus field tests (Haag-Streit USA Inc.) and also prior Humphrey visual field tests (Carl Zeiss Meditec, Inc., Dublin, CA).

HOW IT WORKS

The EyeSuite software interface starts with a simple screen where the user selects a patient. Once a patient has been selected, all of his or her visual fields are shown as grayscale "thumbnail" pictures across the bottom of the screen, each with a caption showing the date of the field and its reliability indices. With a single click, the most recent field is displayed in a customizable view that shows a user's preferred four-item view. For example, a doctor might choose to show the raw numbers (sensitivities), the grayscale, total deviation plot, and corrected box plot of probabilities (Figure 1).

A second click shifts the analysis from a single field to a series of fields. The software defaults to analyze the last six fields, but with a click, additional past fields can be added. The graphical analysis will then show the trends for the mean deviation, diffuse defect, and local defect for each eye, along with icons to flag statistically significant trends for progression in any of these areas (Figure 2). This setup is similar to that of the Humphrey system's Visual Field Index, which shows the global trend for change of entire fields and extends that trend into a predicted future. EyeSuite's analysis does not make any predictions for the future, but it does show the diffuse versus local defect trends by linear regression analysis and makes it easy to choose which fields to include in the analysis.

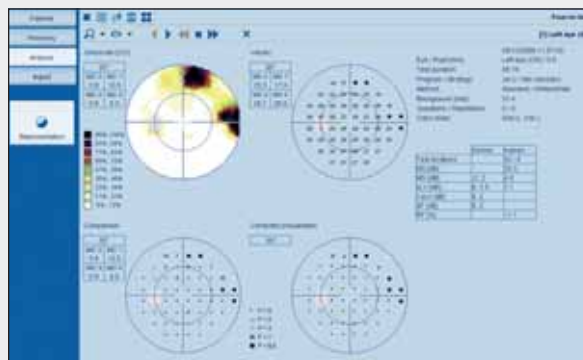


Figure 1. Four-in-one view. Color grayscale, values, comparison, and corrected probabilities are shown. Other options can be chosen as the default view according to the physician's preference.

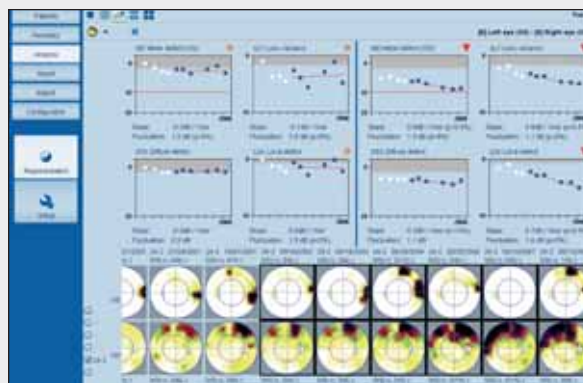


Figure 2. EyeSuite shows thumbnails of each field in a series at the bottom of the screen. The shaded box outlines are the fields included in the trend analysis (red lines) above. At top right are the last six fields analyzed for the right eye. The red downward triangles signify statistically significant worsening by linear regression analysis for the mean defect, local defect, and square root of loss variance.

EyeSuite allows further analysis of progression in two additional views that may be novel to many clinicians. The first is a Cluster Trend Analysis. It breaks the field into several "clusters"—groups of points covering areas with a shared distribution of

(Continued on page 30)

to fade during the test (Troxler phenomenon), requiring them to blink to bring it back. Also, the threshold testing points often seem to be sporadically flagged as being outside normal limits. The latter problem may relate to the limited number of steps in stimulus strength that are used during threshold testing. On the Humphrey perimeter, stimulus strength is varied in 1-dB steps over the full range of vision from 0 dB to about 40 dB. Thus, each decibel level is possible such that threshold scores may be, for example, 32, 31, 30, 29, 28, etc. With the Humphrey Matrix, 13 available stimulus contrasts are arranged in uneven intervals across the full testing range. Because steps are generally larger in the normal sensitivity range and smaller in scotomata, it is not uncommon for normal or nearly normal testing locations to be variably flagged as outside normal limits simply because of normal testing variability. The algorithm used is called *zest*, and it is conceptually similar to SITA in that it is quick and uses forecasting principles. As with SWAP, a number of articles have suggested that FDT field defects often precede SAP defects (Figure 1).^{11,12}

THE HEIDELBERG EDGE PERIMETER

The new Heidelberg Edge Perimeter (HEP; Heidelberg Engineering GmbH, Heidelberg, Germany) also selectively tests retinal ganglion cells, in this case, the magnocellular system. The HEP is available in many countries, and US regulatory clearance is pending. The technology is based on the concept of flicker-defined form, in which a high-temporal-frequency stimulus undergoes counter-phase flicker leading to a phantom contour illusion. The objective is to recognize early glaucomatous damage, and the instrument is similar to perimeters with SWAP in that it can also perform SAP testing (Figure 2). With the HEP, a flickering black-and-white patch creates an illusory edge due to differences in flicker phase between the stimulus and the background; patients perceive a circular stimulus. An adaptive staircase thresholding algorithm makes testing times comparable to those with other algorithms. Further studies are needed to understand the HEP's ability to recognize early loss, but the introduction of a new perimeter is exciting.

CONCLUSION

When a patient presents with findings that may indicate early glaucomatous damage but full SAP fields (and not a complete burden of proof), confirming damage with a selective perimetric test may be useful. SWAP has been clinically disappointing, and FDT is often confusing. HEP is the latest test to emerge and

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(Continued from page 28)

nerve fiber layer bundles. Examples include the nasal step area and the arcuate region. The values at these points are grouped together, and the software analyzes the average values for each region over time by linear regression. Grouping these points reduces variation from small shifts in fixation. Linear regression allows the identification of significant trends for change, while controlling for the patient's own variability over time in that region. The result is the average change for each region, in decibels per year, with the displayed icons indicating a high statistical probability of progression in a given area (Figure 3). This approach differs from STATPAK (Carl Zeiss Meditec, Inc.), which shows a change from average baseline data at every point in the field and alerts the user (with shaded triangles) to possible change from baseline values at any given point.

An additional view in EyeSuite is the Polar Trend Analysis, which traces each point in the field back to its likely origin at the disc. A radial line represents each field-testing point's initial and final defect values for a series of fields. For example, a point within a superior nasal step that progressed from -5 dB to -15 dB would be shown as an inferotemporal radial line extending from a circle representing 5 dB of loss out to a larger circle representing a 15-dB loss.

CONCLUSION

It is exciting to see innovation in visual field analysis aimed at helping clinicians to "separate the wheat from the chaff." These tools allow physicians to quickly identify areas of concern and then to drill down as deeply into the details as they desire. After a couple of weeks, this approach made my interpretation of

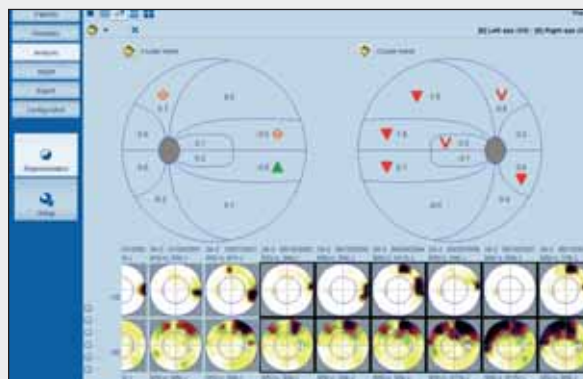


Figure 3. EyeSuite Cluster Trend analysis shows groups of points sharing similar nerve fiber layer bundles such as a nasal step. In this example, the right eye (on the right side of the figure) shows progression in the superior and inferior nasal steps, the superior arcuate, and the inferior temporal wedge regions, as highlighted by red downward triangles indicating significant change by linear regression in each of these areas. The numbers in the areas are the average loss per year in decibels for each point in that area.

fields more efficient and less cumbersome than a traditional review of printouts of individual fields and series of fields.

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shows potential. It will take time, however, to understand if this test will be a useful addition to clinicians' armamentaria. □

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