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Review Article

Perimetry- Recent Advances

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Abstract

Despite innumerable developments in the field of glaucoma, it is one of the most undiagnosed disease, causing irreversible blindness. Perimetry is investigation in glaucoma management as it narrates the amount of functional loss of visual field secondary to the disease. In this review article we will journey through some of the landmark developments and future prospects in perimetry. This will include the new algorithms and testing strategies, pre-perimetric tests, novel techniques such as microperimetry, binocular field testing etc which have not only decreased the testing time but improved reliability of the tests. With the newer advancement such as Guided Progression Analysis(GPA) and Visual field Index(VFI) the focus of glaucoma management has now shifted to the rate of visual field loss, leading to timely surgical or medical management of glaucoma.

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Introduction

Visual field is a measurable part of visual function. Interpretation of visual field is an integral part of evaluation of many ophthalmic conditions such as glaucoma, neuro-ophthalmology and retinal pathologies. Standard automated perimetry (SAP) is the most widely used method to assess visual field deficit in glaucoma.[1] Many articles have been published on perimetry interpretation, but none of them have covered about the recent advances in perimetry. In this article, we will learn about the recent advances and their significance in the current era of modern perimetry.

Algorithms- Evolution

Currently in perimetry, adaptive mode of threshold estimation is used in which the stimulus luminance varies in ascending or descending steps until the threshold is estimated. This process is also known as staircase or bracketing. Early algorithms initiate examination from four principal stimulus locations called anchor points (Octopus) or seed points (Humphrey Field Analyser) followed by 4-2-1 dB bracketing strategy which crosses the threshold twice. Second generation algorithms include Dynamic strategy, wherein the step size increases from 2dB to 10dB in Octopus, when the visual field defect increases. FASTPAC algorithm of Humphrey applied 3dB steps either in ascending or descending fashion,but the threshold is crossed only once. Current algorithms used are Swedish Interactive Thresholding Algorithm(SITA), Zippy Adaptive Threshold Algorithm(ZATA), Tendency Oriented Perimetry(TOP), German Adaptive Thresholding Estimation(GATE-i/GATE), Adaptive Staircase Thresholding Algorithm (ASTA), Continuous Light Increment Perimetry(CLIP), SPARK Precision and SPARK Quick.

ZATA was introduced for Henson 8000 perimeter with two versions, Standard and Fast. It makes use of retinal sensitivity if available from previous tests to set the starting intensity for each test location thus saving considerable time. TOP was first introduced in 1996 for Octopus perimeters, it uses linear interpolation between test locations. TOP uses the response of subject at a specified point to estimate the sensitivity at that point and also modify sensitivity approximation of surrounding points, thus decreasing the slope of the boundary around visual field deficits.[2] GATE-i/GATE is similar to Full Threshold staircase and the SITA Standard strategy it starts by determining the sensitivity at five predefined seed locations. The threshold is defined as the mean of the dimmest seen stimulus and the brightest not seen stimulus. The ASTA Standard algorithm for baseline examinations uses a 4-2-2 staircase approach as well as neighbouring test target information and a quick termination methodology to reduce test time. ASTA Fast is a short test protocol advised for patients expected to be "within normal limits" or those who have previously shown unusual levels of fatigue while ASTA Follow-Up further reduces the test time during follow-up examinations. ASTA alogorithms are used in Heidelberg edge perimetry. CLIP is a fast threshold strategy, using stimuli with constantly rising luminance, offered for use with the Oculus Easyfield perimeter. In this algorithm stimulus luminance is continuously increased in smaller steps(usually 1dB), from an infrathreshold level according to the patient's reaction time until it is seen. The CLIP algorithm has been found suitable for the examination of children above the age of 8 years. SPARK strategy was first introduced on Oculus Easyfield perimeter. The SPARK Quick strategy is good for follow-ups and for screening examinations, it also offers a separate training strategy to reduce the curve of the learning effects in standard perimetry. SITA standard is analogous to Full Threshold algorithm, while SITA fast is analogous to FASTPAC. In 2019 Heijl and associates introduced a new time saving threshold visual field testing strategy called SITA Faster which is intended to replace SITA Fast.[3]

Advances In Testing Strategies

SITA Faster: At least five threshold visual field testing is required to quantify how quickly the patient is losing visual field sensitivity and there is a need of much frequent visual field testing in a newly diagnosed glaucoma patient.[4] But in actual practice, perimetric testing is considerably lower than recommended due to lack of resources.[5] In order to achieve higher number of testing, SITA faster strategy was introduced which is 50% faster than SITA standard testing and uses the same SITA algorithm and normative data as

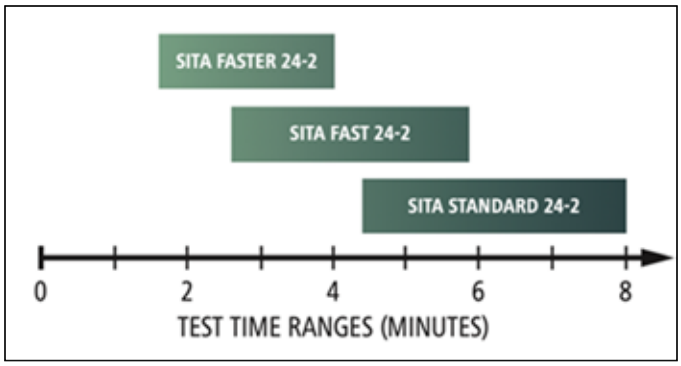

Figure 1: *Comparative testing duration of various SITA strategies*

SITA fast.(Figure 1)

SITA Faster starts much closer to the expected threshold in the principal points and necessitates only 1 reversal at prime test points as compared to two staircases in earlier SITA tests, also perimetrically blind points are not rechecked. Due to shorter duration of the test, patients with severe glaucoma appreciated SITA Faster the most. The testing time is also reduced by not using blind spot and false negatives detection in analysis; instead it uses gaze monitoring and false positives for test quality monitoring. SITA faster also has the advantage for GPA analysis and regression analysis wherein the software allows comparative interpretation of the three SITA thresholding strategies because of strong similarity between their visual field index findings.[6]

Pre-Perimetric Tests

As much as 35-50 % ganglion cells can be lost before a visual field defect is detected, thereby emphasing the importance of techniques to diagnose early glaucoma.[7] A brief of the genesis behind such tests is enumerated in Table 1.

Short wavelength automated perimetry (SWAP) also known as blue on yellow perimetry is a specialised technique in which a blue type V stimulus is used on a yellow background of 100 candela per square metre. Introduced in 1993, SWAP is based on the principle that yellow background light reduces the responsiveness of red and green cones by saturating them, so as to mainly test the blue cones, which are primarily affected in early glaucoma patients.[8] It helps to detect development of glaucoma in ocular hypertension (OHT) patients and progression of disease in early stages. In a study done by VK et al, SWAP was found to have a very high specificity compared with most of the Spectral Domain OCT(SD-OCT) parameters in differentiating glaucomatous optic neuropathy from non-glaucomatous eyes.[9] However SWAP has high test-retest variability and is highly affected by cataract and media opacities, thus it is not solely used for glaucoma management.

Table 1: Types of ganglion cells and their role in pre-perimetric testing

Ganglion Cell	Midget cells	Parasol cells	Bistratified cells
Distribution	70%	8-10%	6-10%
Size	Small	Large	Small
LGN Prjections	Parvocellular layer	Magnocellular layer	Interlaminar zones of Parvocellular layer
Other Name	P cells	M cells	
Function	•High resolution •Colour •Flicker	•Motion •Flicker	•Short wavelength blue stimuli

Frequency Doubling Technology (FDT)

FDT presents an achromatic sinusoidal grating stimulus of low spatial frequency undergoing counterphased flickering at a high temporal frequency, leading to apparent doubling of the spatial frequency of the grating, known as frequency doubling illusion.[10] FDT offers many advantages such as high sensitivity and specificity for diagnosing early glaucomatous damage[11], not greatly affected by refractive error and cataract.

FDT stimulus predominaths stimulates magnocellular ganglion cell pathway(My cells) involved in motion and flicker detection (Table 1). FDT has two presentation patterns, C-20 which represents the central 20 degree with 17 stimulus locations and N-30 which has two additional points in the nasal field. There are screening and threshold tests both of which compare individual test results with the normative database of more than 700 eyes of 450 subjects.[12] The C-20-1 has got higher specificity, while the N-30-5 has got higher sensitivity for detecting glaucomatous field damage. The second generation matrix FDT has improved spatial resolution of visual field defects and can detect small localized defects due to smaller target size and increased number of testing locations. Matrix threshold tests use Zippy Estimation of Sequential Thresholds(ZEST) algorithm which is based on Bayesian Statistics.[13] Matrix FDT has many advantages over the first generation as it has a video eye monitor for patient alignment tracking with an option to pause the test in between, patient display screen is larger thus preventing any movements to change fixation for seeing nasal points, data storage option and enhanced statistical analysis for better evaluation and interpretation of test results (Figure 2).

High Pass Resolution Perimetry (HRP)

HRP assesses the function of "P ganglion cells" which are concentrated in the central retina. The stimulus consists of a range of ring targets with dark borders and lighter centres stimuli(14 sizes) (Figure 3) used at 50 locations, the sensitivity is verified by varying the size and not the luminance of the stimulus. The stimulus distribution of the HRP corresponds with the arrangement of the ganglion cells, therefore it could be superior to SAP in detection of visual field defects.[14] The HRP demonstrates less variability at visual field locations with reduced sensitivity than SAP, however studies comparing HRP with SAP shows variable results.[15,16]

Rarebit perimetry (RBP)

This type of perimetry uses stimulus nearer in size to an individual ganglion cell (rarebits, microdots)[17] to identify abnormal function of any one fixed retinal ganglion cell.

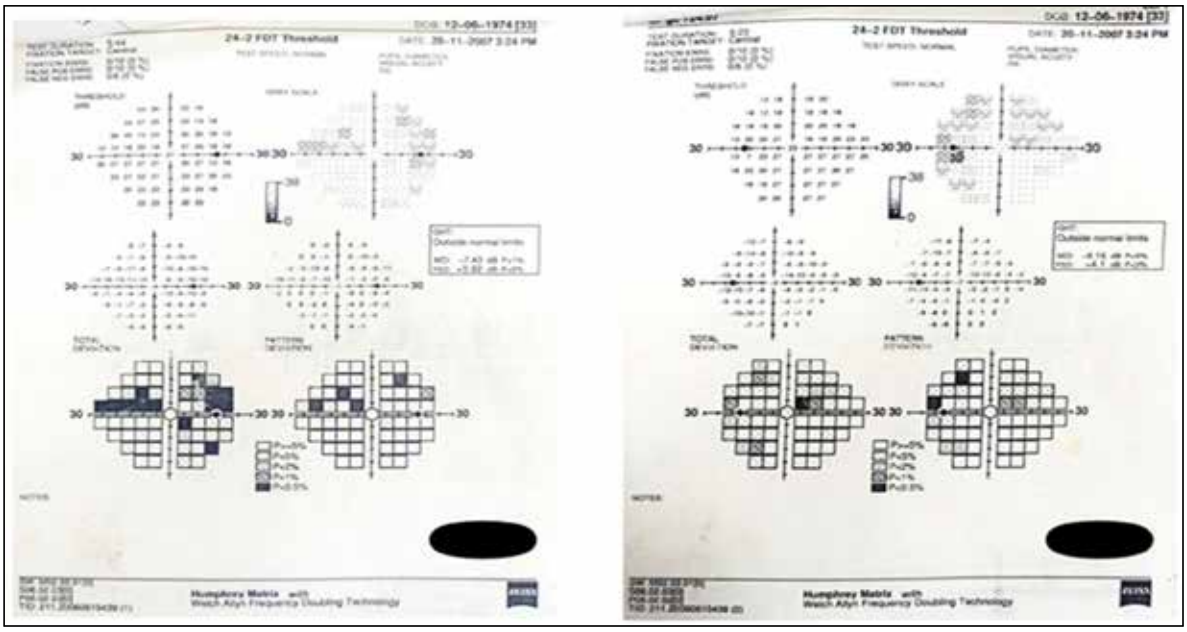

Figure 2: *24-2 Matrix FDT reliable fields revealing early scotomas in a 33 year old patient*

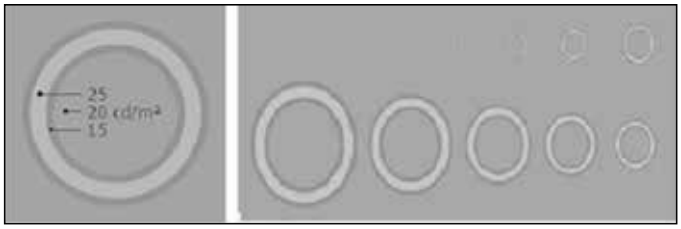

Figure 3: *High-pass resolution perimetry (HRP) stimulus consisting of variable size, fixed luminance. (Source: www.neuro-o.se)*

(Figure 4) The test uses 0,1 and 2 suprathreshold dots at 24 rectangular test areas and checks for the patient response. By evaluating a number of combinations of dots in small localized regions, it determines visual performance (detection or "hit" rate) in these areas. Nearly all rarebits are seen with a normal retina (close to 100% "hit rate"), while disorders of the visual system result in losses from missing or dysfunctional receptive fields which appear as gaps in the receptive field matrix. The outcome of the algorithm was adversely affected by optical defocus and by cataract.[18] RBP has been used as a screening method to detect central vision defects such as macular lesions, optic neuropathies and chiasmal lesions.

Motion Perimetry

Motion detection is largely detected by large ganglion cells via magnocellular pathway[19] and a damage to this pathway is associated with loss of motion perception.[20] Glaucoma patients who have been tested with full-field motion stimuli demonstrate deficits in motion perception.[21] The test background consists of randomly arranged white dots on a grey background, while the motion targets are circle random dot cinematograms randomly placed in order to reduce the effect of positional cues.[22] (Figure 5) These stimuli are of 17 different sizes with a diameter step factor of 100.1(1.259) and a 2-1 staircase is used to estimate threshold. The test evaluates 44 locations and progresses until the smallest circle is seen at each test point, making it time- consuming.

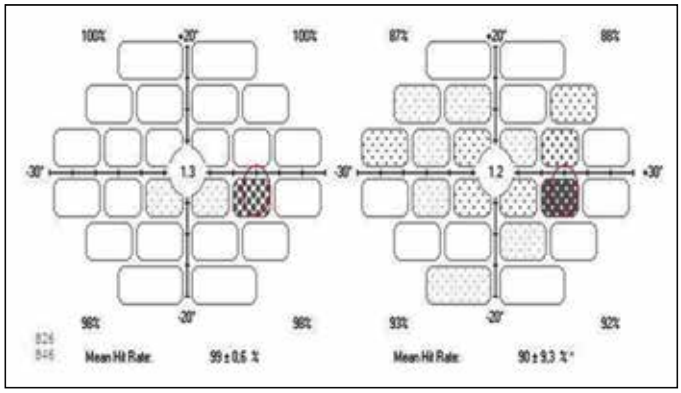

Figure 4: *Rarebit perimetry with rarebits stimulus (source:www.neuro-o.se)*

Flicker defined form (FDF)

This test consists of flickering random black and white dots on a background of 50 cdm^2 of mean luminance, creating an imaginary edge outline due to phase differences between the stimulus and the background (stimulates the magnocellular pathway)[23] (Figure 6) The Heidelberg edge perimeter (HEP)

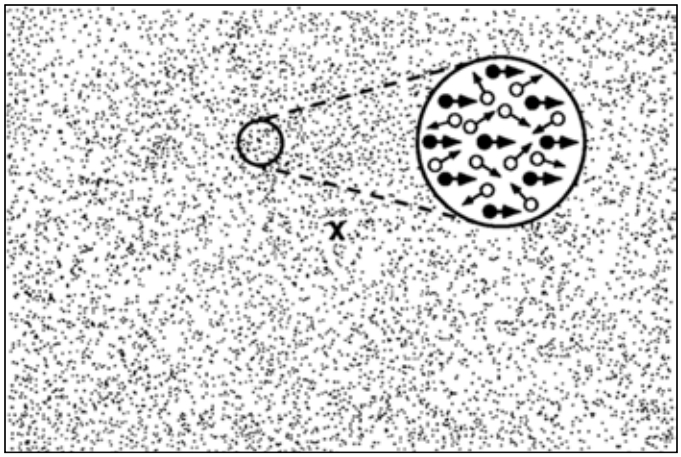

Figure 5: *Motion Perimetry video display. X represents the fixation target, small dots represent the motion targets.(Source: www.webeye.opth.uiowa.edu)*

is a monitor-based perimeter that uses the FDF stimulus to test central and peripheral visual fields. It offers a full set of standard tests for central 10°, 24° and 30° visual field as well as an extension to the periphery up to 60° (100 points) and uses the Adaptive Staircase Thresholding Algorithm (ASTA) for visual sensitivity estimation. There is a considerable learning effect over three visits for the Edge stimulus, therefore there is a lack of agreement between the HFA and FDF.

Pulsar Perimetry

This technique can evaluate both parvocellular and the magnocellular visual pathway.[24] It consists of two images the phase and counterphase image that alternate with a frequency of 10 Hz over 500 ms and merge with the background luminance of 32 cd/m^2 at the edges to avoid stimulating direction-selective ganglion cells. The Pulsar examination method of the Octopus 600 exclusively uses the Tendency Oriented Perimetry in which correlation of the threshold values in neighbouring locations is taken into account thereby reducing the examination time by nearly 80 %. The variability was lower for Pulsar, compared to both SAP and FDT.[25] Pulsar perimetry seems able to detect more cases of clear progressive glaucomatous damage than either confocal scanning laser ophthalmoscopy or nerve fibre polarimetry.[26]

Flicker Perimetry

This perimetry stimulates M ganglion cells. It consists of three different techniques: Temporal Modulation perimetry(TMP), Luminance Pedestal Flicker perimetry(LPF) and Critical Fusion Frequency perimetry(CFF). TMP reveals greater defects in early glaucoma at all temporal frequencies and thus identifies cases of ocular hypertension that are likely to develop glaucoma.[27] LPF perimetry is commercially available in Medmont M600 perimeter and demonstrates a flickering stimulus, superimposed on a base of a steady luminance and specifies the temporal frequency required to separate the stimulus from the base.[28] CFF perimetry determines the highest temporal frequency at which a flickering stimulus of constant luminance is originally perceived as a continuous(non-flickering) stimulus.[29] A few studies have reported flicker perimetry superior to SAP, in the investigation of glaucomatous field loss.[30]

Microperimetry/ Fundus Perimetry

It is a novel functional method which assesses retinal sensitivity while directly examining ocular fundus, thus correlating the pathology(nerve fibre layer loss, macular pathology etc.) and the corresponding functional loss.[31] The fundus is imaged in real-time and the visual field is directly mapped on it, thereby providing a direct structural and functional correlation. An eye tracker detects eye movements during stimulus projection, allowing accurate matching between expected and projected stimulus on the retina. Currently, there are three popular models: NIDEK MP3, Optos OCT/SLO, MAIA microperimeter(Centervue).

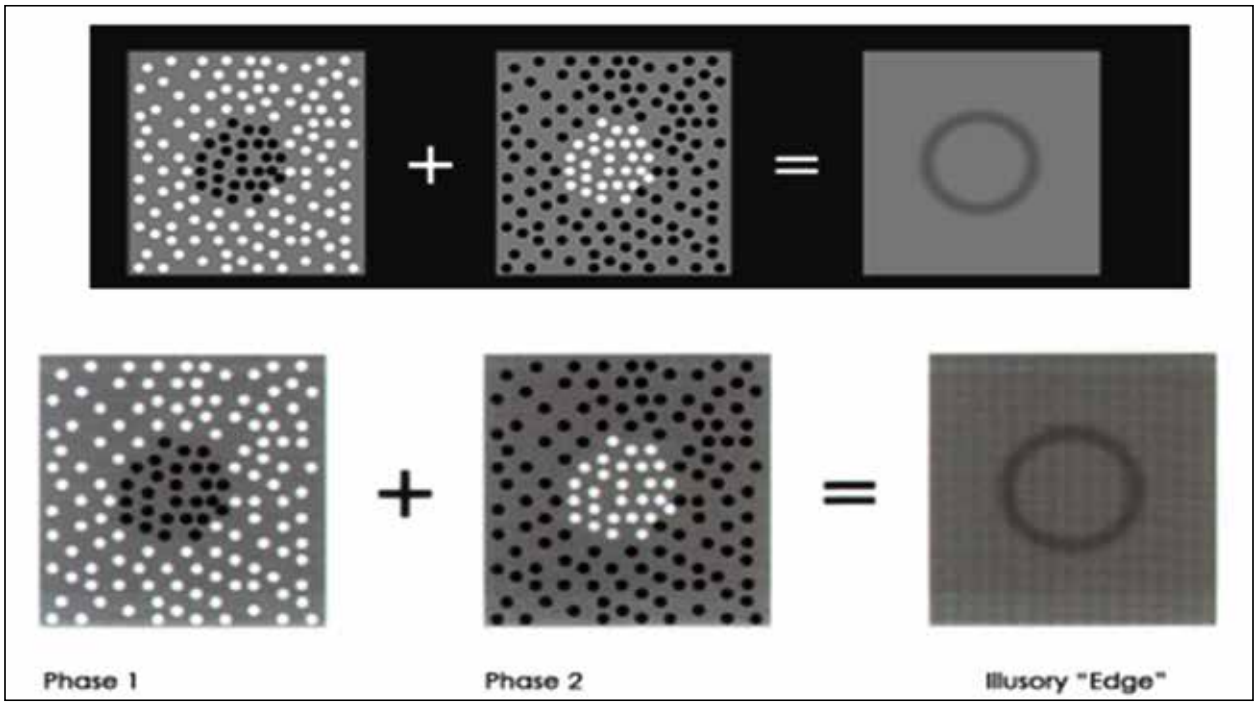

Figure 6: *Fliker defind from perimetry (Reference: www.oftis-opta.cz)*

The Compass perimeter(Centervue Padova, Italy) is a combination of scanning ophthalmoscope and automated perimeter, providing confocal images of the retina with retinal threshold sensitivity under non-mydriatic conditions. It has strategies similar to 24-2 and 10-2 programmes of SAP, along with recent addition of ZEST algorithm. There are three different testing modes namely Fast test, Expert test and Follow up test. The Fast test is done for uncooperative patients requiring only 3 minutes per eye. Microperimeter can be used for diagnosis and progression in early glaucoma cases, and evaluation of retinal sensitivity in localized areas of retinal nerve fibre layer defects (pre-perimteric glaucoma analysis)(Figure 7).

Advances in testing patterns 24-2c

The standard 24-2 algorithm of perimetry is known to miss the early macular damage which has been identified on 10-2 and OCT parameters.[32] The Humphrey 24-2C visual field test is a modified 24-2 visual field test that incorporates 10 additional test points in the central 10° of vision to aid in the detection of this missed damage. It was introduced on the Humphrey platform (HFA3) in 2019. The additional 10 points in the center are asymmetric in the two hemifields and are chosen as per studies indicating the more susceptible areas for early ganglion cell damage (Figure 8). It is available in the SITA faster testing mode by default, which helps keep the testing time comparable to 24-2 despite the addition of 10 extra points. This novel testing pattern helps to study the structure-function concordance in early glaucoma and suspects. Comparative studies have been done evaluating its role in glaucoma as well as neuro-ophthalmology.[33] 24-2c testing pattern has been compared with the standard 24-2 and 10-2 patterns. The results of comparative studies so far have been variable, citing no additional benefit to detection of extra field defect areas, although structural-functional concordance was not accurate.[34] The 24-2C exhibits the potential to be used as a hybrid between the 24-2 and 10-2 to better evaluate visual field defects.[35]

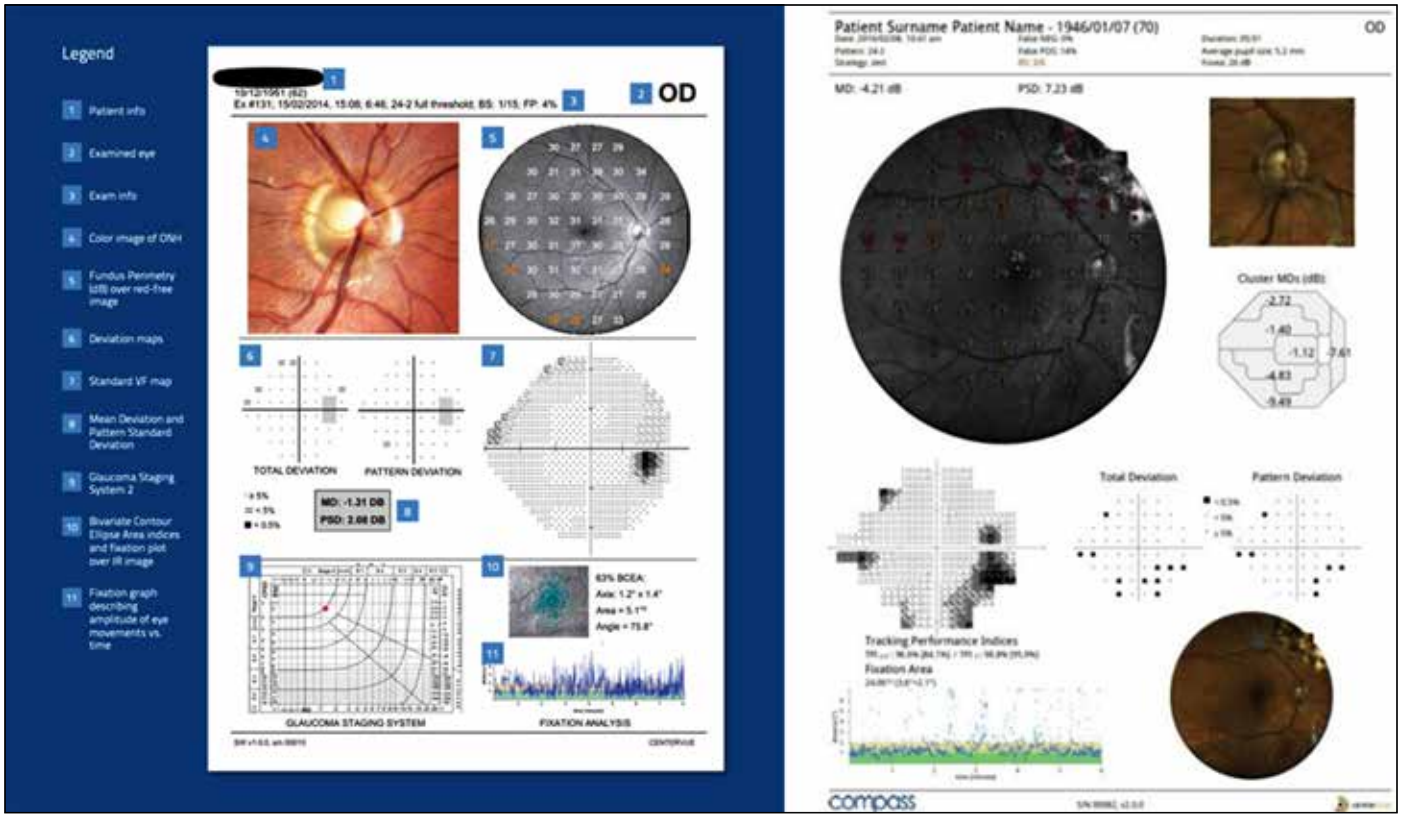

Figure 7: *Microperimetry print out (Reference: www.oftis-opta.cz)*

Advances in Analytical indices

Glaucoma Hemifield Test (GHT)

GHT is an artificial intelligence-based analysis that provides plain language classifications of 24-2 and 30-2 test results (points common to both) and is based upon patterns of loss specific to glaucoma (not neurological disorders).[36] Pattern Deviation scores in each of the five zones in the upper hemifield are compared to findings in mirror-imaged zones in the inferior visual field and compared to normative significance limits specific to each zone pair (Figure 9).

GHT findings are divided into the following categories:

i. Outside Normal Limits- One zone pair differs by an amount found in fewer than 1 % of normal subjects.
ii. Borderline- At least one zone pair differs by an amount found in 1% to 3% of normal subjects.
iii. General Depression Best test point locations have low sensitivity to the level seen in fewer than half a percent of normal subjects.
iv. Abnormally High Sensitivity- Best test points are so high as to be at levels seen in fewer than half a percent of normal subjects.
v. Within Normal Limits.

The GHT has been reported to have high sensitivity and specificity[37], with easy interpretation, especially by novice users. The method was designed to have an overall specificity between 84% to 90% depending on whether the Borderline findings are considered Outside Normal Limits or Within Normal Limits.

Visual Field Index (VFI)

Introduced by Bengtsson and Heijl in 2008, the Visual Field Index is an improved version of the older mean deriation (MD) index, that is less affected by cataract than MD, except in fields having MDs worse than -20dB. As opposed to MD, VFI is expressed in the percentage of normal age-

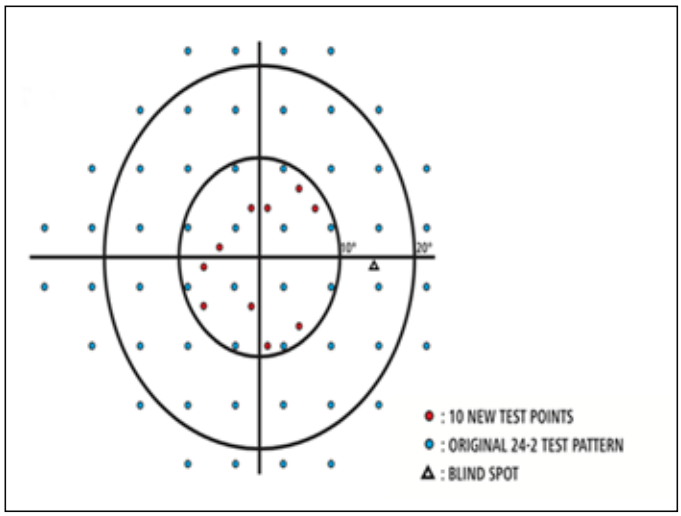

Figure 8: *Extra points covered during 24-2c examination in comparison to 24-2 examination.*

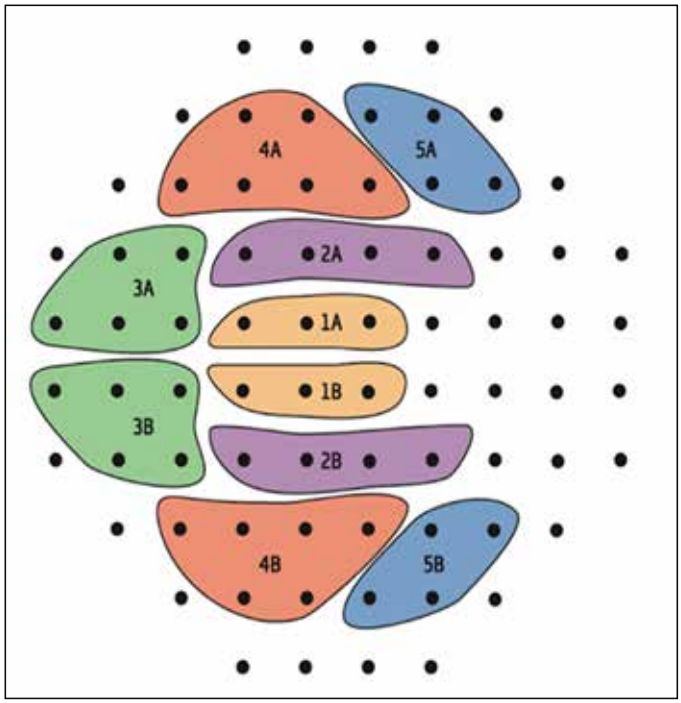

Figure 9: *GHT mirror-imaged zones (Source: www.keogt.com)*

corrected visual function, and is intended for use in assessing glaucoma progression and staging glaucomatous functional damage on a scale from normal function (100%) to perimetric blindness(0%). MD value associated with blind fields depends upon age and testing strategy, while VFI in a perimetrically blind field is always 0%, regardless of age or strategy and 100% in normal fields. VFI gives more weightage to the central test points as compared to the peripheral ones to account for the higher density of ganglion cells found in the central retina.[38]

Guided Progression Analysis (GPA)

Over the past decade, a paradigm shift has occurred in glaucoma management from monitoring progressive perimetric glaucomatous damage on serial field testing to current focus on the patient's rate of disease progression, relying heavily on the quantification and velocity of visual field loss over time. Defining a baseline test is important, as it could be the beginning of glaucoma therapy or a significant modification in the glaucoma treatment plan. GPA has been programmed to choose by default the earliest two fields as baseline tests.

GPA can be event based (Glaucoma Change Probability Maps) and trend based (VFI), both of which are reflected in the standardized GPA reports (Figure 10). The event based analysis determines visual field progression to be either present or absent, based on a predefined change in the parameters, and gives a point wise glaucoma change probability analysis. The progression analysis shows a numerical plot and a plot using intuitive symbols indicating progression of the disease. A solid triangle represents a point changing by an amount that is significant ($P<0.05$) and is repeated in three consecutive follow-up exams; half filed triangle identifies a point changing by an amount that is significant ($P<0.05$) and is repeated in two consecutive follow-up exams; small open triangle symbol is used when the change was not seen on the previous follow up test. A significant deterioration in the probability maps at same three or more points on two subsequent field tests predict a possible progression, whereas that on three subsequent tests determine a likely progression. The trend-based analysis is computed by the visual field index which provides the actual rate of change of visual field parameters and is based on linear regression analysis. The 'p' value of VFI slope determines the change of VFI with time and a negative slope represents disease progression. The VFI Bar histogram graphically represents the patient's current VFI value along with a 3-5 year projection of the VFI regression line, considering the same rate of progression is maintained. Mixed GPA program now allows intermixing of different strategies such as SITA Faster, Fast, Standard, 24-2, 30-2, and 24-2C in progression analysis due to their clinical equivalence.

Advances in Data Integration

Data synchronization and review is now available in recent models which keeps all perimeters connected through a local network, thereby decreasing patient waiting time, as fields may be performed on any one of the connected perimeters, with constant synchronisation of patient's fields over all connected perimeters.

Integrated Glaucoma Workplace has also been introduced in the advance models of Humphrey perimeters to enable digital synchronisation and integration of various glaucoma imaging modalities such as Humphrey visual field perimeter, OCT-RNFL, Ganglion cell analysis and macular GCC. This will enable an elaborate structural-functional correlation of the disease pathology and progression.

Advances in patient alignment and fixation monitoring

The initial perimeters utilised manual assessment of patient alignment by an extrenal examiner during the duration of the test., however this type of assessment was gross and had a lot of demerits including inter-examiner variability.

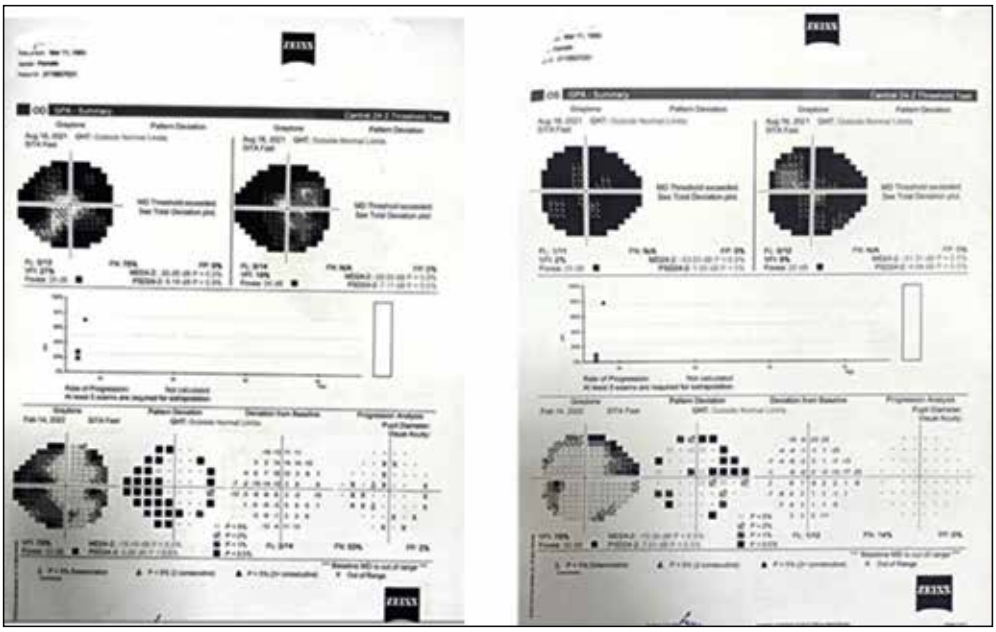

Figure 10: *GPA analysis showing signs of progression in the right eye.*

In 1974, Heijl-Krakau method was first described in which moderately bright stimuli are presented at the expected location of the physiological blind spot of the tested eye and any positive response to the stimuli suggested a loss of fixation.[39] The method though still widely used in many automated perimeters, has a few shortcomings because the patient's blind spot is not always situated in the location assumed, thus making the fixation loss stimuli a positive response during the examination. Also, the amount of gaze data provided by this method is quite limited, because only a few blind spot check stimuli can be presented during a visual field test.

The corneal view in the machine screen provides useful data regarding patient's pupil and lens centration using a green star, red star and green plus coding (Figure 11).

The Gaze tracker is a novel patient alignment monitoring system present in Humphrey perimeters and measures gaze direction every time a stimulus is presented. The patient's alignment is displayed in the form of lines, marks with a precision of approximately +/- 2 degrees and is presented at the bottom of the HFA printout. A line with full-scale marking extending upward indicates an off fixation i.e gaze error of 10 degrees, a small downward mark indicates that the gaze tracker was unable to measure gaze direction, while

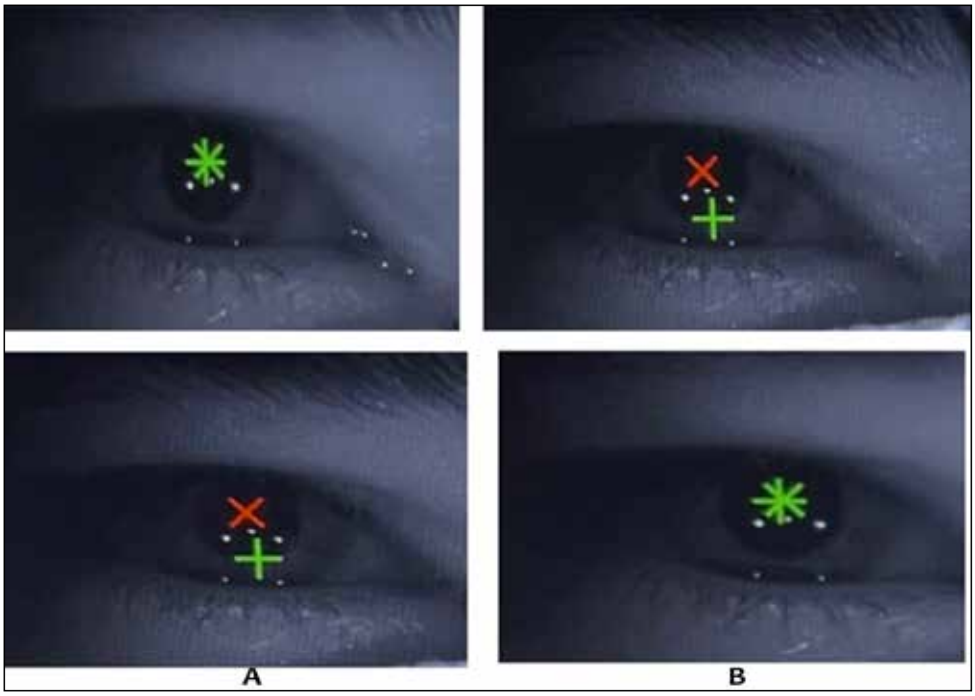

Figure 11: *Perimeter screen view showing- A: Misalignment; B: Proper alignment*

larger downward mark indicate eyelid interference with the device's view of the eye such as in blinking or squinting (Figure 12).

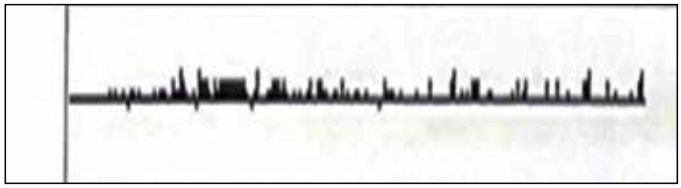

Figure 12: *Gaze tracker indicating off fixation*

The HFA gaze tracker uses image analysis to separately locate the centre of the pupil and the reflection of the light-emitting diode from the corneal surface. The spacing between these two points strongly depends upon gaze direction while being largely independent of the head position. Separate calculations provide head position information and are used to automatically keep the eye aligned at the centre of the trial lens.

Binocular Testing Strategy

Esterman Binocular Field Testing

This binocular field testing method available on the HFA utilises size III white stimuli of 10dB intensity to test 120 points in the central and peripheral visual field and records the visualisation response at each point. Esterman test can be used for driver's license screening and is as effective as HVF in detection of central defects in case of advanced glaucoma.[40] Binocular testing allows for naturally-occuring binocular enhancement wherein either eye compensates for the defects in the fellow eye, thereby making it more functional and relevant for the patient. However, it is difficult to judge whether the defect is absolute or relative, and there is no way to control fixation stability since the binocular testing conditions eliminate naturally occurring blind spots which are used for fixation control in other tests.

Crabb et al in 1998 described another new method known as Integrated Visual Field (IVF) which simulates a binocular visual field from the data of monocular visual fields of either eye.[41] The study revealed a substantial agreement between the simulated binocular results and the binocular Esterman test in classifying glaucomatous patients.

Advances in Refractive Error Correction

Liquid Trial Lens

Refractive error correction prior to initiating visual field testing is crucial for obtaining optimal test results. One diopter of spherical refractive blur in an undilated pupil will produce approximately one decibel of depression of the hill of vision when testing with a Goldmann size III stimulus. This can be avoided by performing perimetry with the patient wearing his refractive correction in the form of glasses or contact lenses (along with near add in presbyopic age group) or by manually placing the corrective trial lenses in the perimeter holder. A newly introduced liquid trial lens technology has proven to be equally effective, convenient and time saving technology for refractive correction. It automatically adjusts to the spherical and presbyopic power of the patient by changing the fluid pressure within the lens which changes its shape from concave to convex (Figure13). The power adjustment can be made between +8.0 D to -8.0 D range. It is recommended to use spherical equivalent corrections for astigmatism upto 2.0 D. The user interface contains + and – buttons to change the liquid trial lens power in 0.25 D steps, while the patient is asked whether the target is perceived as blurred or focussed before the procedure.

Advances in Perimetric Unit

Portable Perimeters

The idea of portable visual field testing was borne in order to facilitate monitoring of presumed stable or controlled glaucoma patients or suspects reducing the overall number of office visits for the patient. Although the portable perimeters have a low resolution and are not as accurate as compared to the in-office gold standard method, aggregating more data over a longer period of time may be more predictive than the smaller amount of higher quality data that's acquired only during annual or semi-annual office visits. Portable perimeters can be used in the office setup as well as for home screening and follow-up. Three most popular

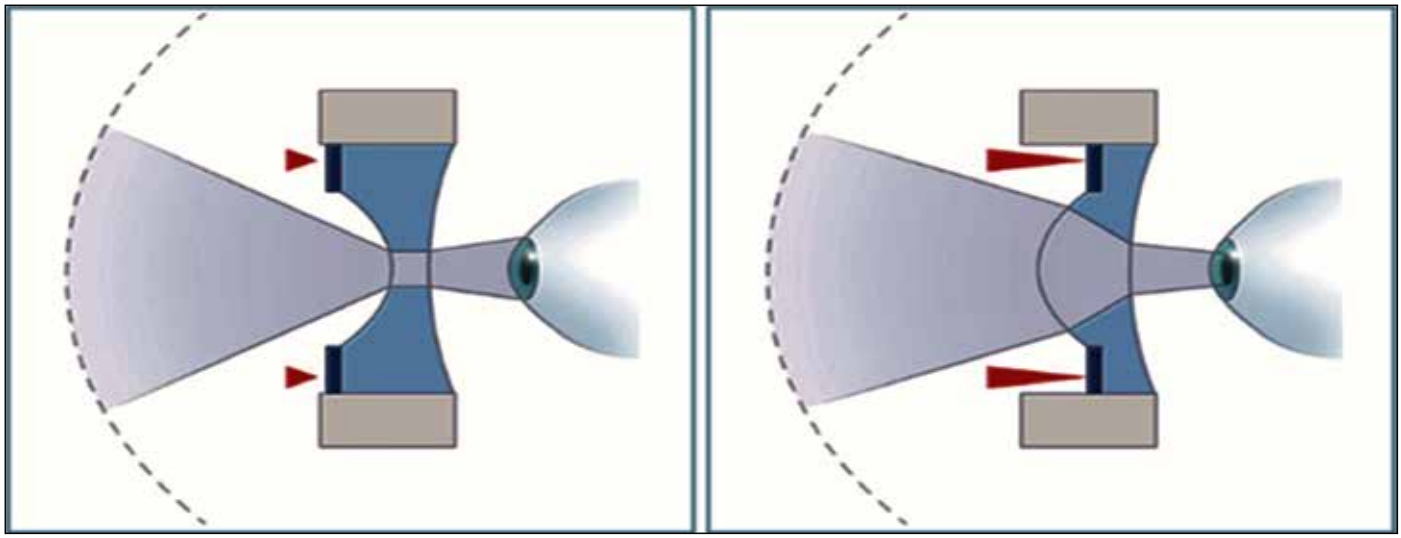

Figure 13: *The liquid tial lens changes power with a change in its shape which is due to an increase or decrease in fluid pressure within the lens.*

portable perimeter designs at present are Moorfields Motion Displacement Test(MDT), Melbourne Rapid Fields Test and Virtual Reality Peripheral Vision testing. MDT was one of the early portable visual field test in which 32 white lines on a gray background was used while fixating in the centre and any wiggling movement was documented by the patient with a button click. However, MDT is no longer in use and not available. Melbourne Rapid Field Test uses a free Ipad software and takes advantage of a moving fixation target in order to effectively increase the tablet surface area to test up to 30 degrees of field. Several published studies have validated the device as a screening tool similar to a tangent perimeter.[42] Virtual Reality peripheral Vision testing overcomes one of the major limitations of portable devices i.e. inability to control fixation and the screen to eye distance. With the virtual reality, no matter where the patient looks, the stimuli can be shown relative to fixation at that moment. Gyroscopes can account for head movement, and immersive environment can improve user engagement. Various inexpensive, light weight, mobile VR applications and software platforms are now available. Tsapakis et al showed a high correlation between the realibility of VF testing using a VR testing system and Humphrey test.[43] However, further long term studies are needed to validate portable perimeters.

Conclusion

Perimetry has come a long way from the era of kinetic perimeters consisting of heavy equipments to modern automated static perimeters consisting of faster and portable computers. The future of perimetry is now moving towards artificial intelligence for automated analysis of visual fields for the detection of glaucoma and predicting future progression. Another aspect of research and development is a portable brain-computer interface that detects visual function through recorded electric responses directly from the visual cortex thereby eliminating the subjective aspect of clicking to indicate when a visual stimulus is seen.[44]

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