Practical Perimetry

Practical Perimetry is a collective effort of clinicians and glaucomatologists from around the globe. It is a practical primer on perimetry for general ophthalmologists, glaucoma surgeons, neuro-ophthalmologists, and trainees as well. The book is extensively illustrated with examples of real-life clinical scenarios and aims to help the clinician choose the appropriate diagnostic protocol and achieve optimal results each time the visual field is performed, in terms of both reliability and interpretation. The book also elucidates the key points to look out for when using visual fields in the serial monitoring of patients.

It is also an attempt to keep the clinicians abreast of the latest developments in visual field charting, especially the novel platforms available for correlation of structure and function and its place in the serial monitoring of both glaucoma and neuro-ophthalmo-logical diseases.

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Shibal Bhartiya is currently working as a senior consultant glaucoma surgeon at Fortis Memorial Research Institute, Gurgaon, Haryana, India and Fortis BIL Rajiv Hospital, New Delhi, India. She was a Senior Clinical Research Fellow in the Glaucoma Services of the Department of Clinical Neurosciences, University of Geneva, Switzerland. Prior to that, she did her glaucoma training as Senior Research Associate in the Cornea and Glaucoma Services at Dr. Raj Centre for Ophthalmic Sciences, AIIMS, New Delhi.

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Shibal Bhartiya has lectured at and chaired various sessions in regional and international meetings. She serves as a reviewer for many ophthalmology journals and is the Executive Editor of the Journal of Current Glaucoma Practice, the Official Journal of the International Society of Glaucoma Surgery.

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Over time, perimetry has evolved from confrontation visual field evaluation to the current state-of-the-art automated perimeters which even offer structural and functional correlation. The wealth of information thus made available from visual field testing has revolutionized current glaucoma practice, and has provided new dimensions to the management of neurological disease as well. Numerous models with multiple software and testing-strategies has further deepened the knowledge of perimetry, making it one of the most important tools in the ophthalmologists’ armamentarium.

I take great pleasure and pride in introducing this remarkable book on Practical Perimetry edited by Shibal Bhartiya, Murali Ariga, George V Puthuran and Ronnie George. It is the collaborative effort of an esteemed panel of ophthalmologists under their able leadership and provides an in-depth illustration of the science and art of perimetry.

Not only does this book address visual field analysis in patients of glaucoma, it also focuses on perimetry in retinal diseases and neuro-ophthalmological disorders. The book covers the entire evolution of visual field analysis: from the history of perimetry to role of frequency doubling perimetry (FDP), short wavelength automated perimetry (SWAP) and the recent advances for structural-functional correlation. Each of the sections and chapters of the book is well illustrated with ample color pictures and visual field print-outs, explaining the concepts with meticulous detail. The editors and authors must be congratulated for highlighting the clinical relevance of each visual field, and progression analysis with well-illustrated examples from clinical situations.

I do believe that the book Practical Perimetry will prove invaluable to postgraduate students, fellows and practising ophthalmologists in learning and refining interpretation of visual fields, and in its clinical correlation, thereby, improving the standard of care provided to our patients.

I wish the editors and the book all the success.

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Medical technology in the recent years has evolved at a pace hitherto unimaginable. Despite, the cornerstones of glaucoma diagnosis and management remain intraocular pressure measurement and perimetry, that is the monitoring of visual fields. Not only that, perimetry remains an art form, the performance and interpretation of which continue to confound generations of ophthalmologists and optometrists alike.

The book that you hold in your hands, Practical Perimetry, is a distillation of the collective efforts of clinicians and glaucomatologists from around the globe. The book aims to help the clinician choose the appropriate diagnostic protocol, and achieve optimal results each time the visual field is performed in terms of both reliability and interpretation. The book also elucidates the key points to look out for when using visual fields in the serial monitoring of patients. It has also been our attempt to illustrate each of the complicated concepts with pertinent clinical cases, so as to elucidate the fallacies and pitfalls in interpretation.

This book is also an attempt to keep you abreast of the latest developments in visual field charting, especially the novel platforms available for correlation of structure and function, and its place in the serial monitoring of both, glaucoma and neuro-ophthalmological diseases.

It should suffice to say that it is our earnest endeavor to help you take care of your patients better, and we hope you find reading this book as enjoyable and fruitful as we found putting it together.

Shibal Bhartiya
Murali Ariga
George V Puthuran
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Visual field examination has been the gold standard to detect structural loss in glaucoma over decades now. The technique has undergone a paradigm shift from kinetic to static and now to automated perimetry. Automated perimeters make our work as glaucoma specialists much simpler but at the same time is not without its own limitations. Common pitfalls in perimetry at the time of testing as well as assessment can lead to misdiagnosis in many situations.

**Practical Pearls in Recording Fields**

Always inform the patient about the procedure before starting. The patient should be reassured that during the field recording, more than 50% of the light spots will not be seen. Give the patient an option to pause the test in between if he/she is tired. The patient should have taken enough rest, and ensure that he/she is attentive. Movements of the other eye can cause watering and discomfort, therefore close the other eye well. If the patient has a poor attention span, one can select faster tests like 24-2 SITA fast. If a test result is abnormal or shows progression, always repeat the test. Always record the visual fields on the same program which has been used earlier for better and meaningful comparisons.

**Data Entry**

Date entry is required as a preliminary step, under the tab “Main menu”. The following entries are included:

1. **Date, time**: These may be automatically entered by the computer.
2. **Patient name, identification number, and birth date**: If the examiner wishes to have the perimeter print out as a sequential analysis of several fields, done over time in the same patient, the name must be entered exactly the same on all fields. Numbers and birth dates help to differentiate patients with the same name.
3. **Visual acuity, pupil diameter (in clinic), and refractive correction used during perimetry**: Again, if comparisons over time are to be made, the examiner needs to know if any of these factors are changing. A decrease in pupil diameter from 4 to 2 mm will reduce sensitivity by about 0.7 dB. Refractive blur will also increase thresholds diffusely.
4. **The type of test and eye being tested**: Finally, on the next screen, the type of test to be performed is chosen, following which the eye being tested is indicated. After this a screen appears with a display of the locations that will be tested in the field, along with the reliability indices that will be completed. There is an option to display the eye position monitor, which is a video camera view of the patient’s eye for online monitoring of fixation. This option should be chosen. The screen remains visible during the test.

**Patient Placement**

The eye not being tested is occluded with a patch. The patch should be flush to the nose and not protruding to avoid obscuring the vision of the viewing eye. The buzzer is placed in the patient’s hand. Either the chair or the perimeter is adjusted for the patient’s height. Discomfort resulting from poor posture maintained over 10 minutes
Instructions to the Patient

Giving instructions to the patients is critical, particularly in those new to the test. A few minutes of counselling greatly increases the likelihood of obtaining useful data. The following key points must be stressed to all patients:

1. They should always look at the steady yellow light at the center, no matter how boring this is. If they are looking away, we have no idea of fixation, and if this happens too often the test becomes meaningless.

2. While they fix on the yellow light, the computer will flash small spots of light at random locations in their side vision. Their task is to press the button in their hand every time they are aware of something flashed.

3. If this is a threshold test, the perimeter is trying to determine at each location the boundary between the visible and the invisible. This has two consequences. The first is that there will always be some very faint lights that they do not see, no matter how good their vision is. The second is that lights very close to the boundary will be quite dim and they will feel uncertain of their presence. They should do their best but simply signal if they are aware that something has flashed, no matter how dim it is.

4. They should not feel afraid to blink from time-to-time. The best plan is to blink just after they see a target, since there is always a short interval between one target and the next.

5. A typical threshold test will take about 10 minutes for each eye.

6. It is best if a technician monitors the test, providing feedback on fixation via the eye monitor, but patients should not talk to the technician unless there is a problem. On the screen displayed during the test, the perimeter initially provides the option of a short demonstration. The lights should be dimmed and this demo should be shown so that (1) the patient can see examples of the flashes that are the targets, and (2) the examiner can see that the patient understands the concept of fixation. It is useful to remind the patient at this point to keep their eye on the yellow spot and press the button when they see the small white flashes. Once the operator is confident that the patient can comply with fixation and respond to flashes, the test can be started. After completion of the first eye’s test, the occluder is removed and the lights turned on so that the occluded eye recovers from its dark adaptation state.

Threshold Perimetry Analysis

The Single-Field Analysis

Always check a few simple things first. The name, to ensure that it is the right patient; the date; and the refraction used. The latter is important when comparing one field with another in follow-up. An apparent global decrease in sensitivity may merely reflect a difference in lenses used, with presumably improper refraction on one occasion.

Reliability Indices

Can you trust what you see or is it junk? These indices will help you:

1. **Fixation loss (FL):** The perimeter periodically flashes a target in the physiologic blind spot, which it maps early in the course of the test. If the patient is not looking at the yellow fixation light, he or she will see the flash and press the button. The denominator tells how many times the perimeter tested for this, and the numerator the number of times the patient fell for it. Frequent FLs cast doubt on the sensitivity of the test to find subtle defects. The location and margins of such defects will be degraded by a roving eye. On the other hand caution is required when interpreting seemingly low fixation loss indices in patients with blind spots that are enlarged or fall within larger field defects (such as a temporal hemianopia). These patients may still not see the target probing for FL even if they are making large movements with their eyes. This means of monitoring fixation is known as the Heijl-Krakau method. The disadvantage is that the results cannot be modified by fixation data.

Other automated devices monitor actual eye position with video or infrared technology and either halt testing or exclude trials with improper eye position. The newer Humphrey Field analyzers also monitor eye position with a video system but do not use the data to modify data on-line, except to exclude trials in the case of blinks. Rather, a small graph is made to provide one with a sense of eye stability during the test, to augment the FL index.

2. **False positives (FPs):** Occasionally there are intervals during which the machine makes a soft click but shows no target. An overly sensitive subject will have a high FP error rate, pressing the button during these intervals. This too will lead to underestimation of the severity and
extent of a defect. SITA strategy does not use these “catch trials” but, rather, counts the number of anticipatory responses, made too soon after a flash to be a considered as a response to the light.

3. False negatives (FNs): A fairly bright suprathreshold target is flashed in a region previously tested with fainter targets. If the patient fails to indicate its presence, this is a FN error. A high FN rate usually implies inattention or fatigue and will be accompanied by a field with scattered factitious elevations of threshold. For all these reliability indices, the Humphrey field analyzer suggests that more than 20% error rate is a warning of poor reliability. This will be indicated by an “XX” beside the aberrant value and a printed statement of “low patient reliability,” in the upper left corner.

4. Number of questions asked and time taken to do the test: These are not usually that important, but if the patient’s reliability is poor, it may be because the test took a long time and presented a lot of trials, leading to fatigue. The problem can also work in the other direction. An unreliable patient will confuse the machine’s algorithms and not allow it to use its statistical shortcuts, leading to longer test times. Patients with complex field defects generally take longer to test than those with normal fields.

Practical Pearls in Assessment of Fields

One should never comment on possible glaucoma based on fields, until the patient has been examined (Fig. 5.1). Old age, ailments, poor attention span, cataract surgery, presence of retinal or neurological disease may result in variation in fields and hence need a series of fields to assess progression. If the first field is abnormal, one should repeat it, as 85% of patients will lose the defect on first field. Two consistent visual fields are required before we comment on any visual field. When a diagnosis is questionable, then the course visual fields take over time is the only sure way to determine whether a visual field defect is due to glaucoma or not.

Fig. 5.1: Showing a typical glaucomatous field defect. Clinical examination shows a superior notch in the right disc (right up) with corresponding retinal nerve fiber layer wedge defect (arrow) and inferior field loss (left)
**Pitfalls in Automated Perimetry**

Despite automation and sophisticated statistical analysis, perimetry has several pitfalls. Experts have cautioned that fields should not be interpreted in isolation, but in the light of clinical findings. Non-glaucomatous retinal and optic disc pathologies cause visual field defects leading to the misinterpretation of glaucoma. We illustrate a few clinical situations with fallacious field changes which can lead to misdiagnosis.

**Retinal Defects**

Sometimes retinal lesions can cause changes in the visual field similar to glaucoma (Figs 5.2 and 5.3). A careful examination of retina and optic disc is necessary to rule out any such cause. Retinal pathologies generate deeper lesions in the visual field with absolute scotomas that have sharp borders and do not respect the horizontal meridian. This is in contrast to a glaucomatous visual field loss that has less clearly defined borders but at the same time respects the horizontal meridian.

**Neurological Causes**

Neurological disorders are also very important when correlating visual field and optic disc changes because ganglion cell loss in neurological disorders also causes field defects. The characteristic pattern of visual field loss in neurological disorders is different from the glaucomatous visual field loss. They do not respect the horizontal meridian and generally the defects are usually confined to one side of the vertical meridian (Fig. 5.4). Optic disc in such cases appears healthy or shows temporal pallor due to loss of papillomacular bundle and does not follow the ISNT rule. Sudden appearance of vertical visual field defect in the field should raise the suspicion of a neurological abnormality.

**Preretinal Defects**

Age gradually depresses the visual field. Light-difference sensitivity decreases with age partly due to age-related loss of nerve fibers and increased condensation of the media. Abnormalities that interfere with media clarity reduce illumination and therefore depress the visual field; they also

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**Fig. 5.2:** Dilated examination revealed both eyes cystoid macular edem
Fig. 5.3: A 60-year-old woman diagnosed as glaucoma and referred; IOP 16; 12; Large CD ratio LE > RE. VF showed RE normal and LE showed an inferonasal defect. Careful examination revealed a superotemporal branch retinal vein occlusion which was laser ed in the left eye (below)
exaggerate existing visual field defects. Cataracts or media opacities produce a diffuse depression on the total deviation plot causing the visual fields to be severely depressed while the optic disc may be healthy (Fig. 5.5). Optically the posterior subcapsular area is behind the nodal point of the eye and an inferior opacity will translate as a superior field defect. In a glaucoma suspect such localized defects would be attributed to glaucomatous damage. Hence similar field defects occurring in patients under follow up for glaucoma could be mistaken for progression.

In glaucomatous optic neuropathy, severely depressed fields do not occur until and unless advanced optic neuropathy sets in with complete loss of ganglion cells. Media opacities causing such type of field defect have to be ruled out clinically before starting treatment.

**False Depressions**

Depression in the visual field can be due to some physiological phenomenon or some technical errors that we should keep in mind while interpreting the visual field.

**Inexperienced Patient**

Patient doing visual field for the first time may have visual field defects that are known as learning defects. These that mainly affect the mid peripheral lesions that do not correlate clinically (Fig. 5.6). These defects generally disappear on the sequential visual field testing or with the experience of the patient. A lot of patients experience a visual field defect owing to the learning curve. For this reason, a demonstration test may be run before the first test. The learning curve involves learning to respond consistently during the test. With experience, patients are noted to respond to more dim stimuli and to stimuli presented further away from the central fixation point. Therefore, the usual artefact from an initial test is an overall reduction in sensitivity of the visual field. Localized visual field defects which are typically seen relating to papilloedema and optic nerve head pathology are therefore unlikely to be artefacts. Probability plots will often allow detection of localised visual field loss despite over-riding reduction in sensitivity.

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**Fig. 5.4:** Visual field defects in a 45-year-old female are significant but obey the vertical meridian. The discs are normal and hence rule out a glaucomatous filed defect. Neuroimaging revealed a pituitary macroadenoma.
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Fig. 5.5: Visual field changes due to cataract may be misleading. Cataracts produce defects evident as a diffuse depression on the total deviation plot causing the visual fields to be severely depressed while the optic disc may be healthy.

Fig. 5.6: Seems laterally enlarged—could be resized
Hence, the first visual field should not be taken under consideration until or unless they clinically correlate. Patients should be subjected to a repeat visual field for the confirmation of field defect. Where suspicion exists regarding the reliability of the first test, the patient may be recalled for a second test at a later stage, and the second test taken as the baseline if felt to be more accurate.

**Fatigue**

As the test progresses, a long test strategy causes fatigue that mainly affects the mid-peripheral region. Hence the sensitivity of these points decreases as compared to surrounding points that appears as a scotoma in the visual field. To avoid these, a fast strategy should be adopted. Also we should follow the visual field of the same strategy on the subsequent follow up.

**Physiological/pathological Ptosis**

Glaucoma is a disorder of an elderly age group and due to aging, senile ptosis can occur. Other conditions like congenital ptosis or a case of third nerve palsy during testing may produce a superior artefact of the visual field.\textsuperscript{13-15} Ptosis produces an artefact with sudden reduction in sensitivity from normal values to 0 decibels in the superior field of vision.\textsuperscript{16} This may appear in both eyes if bilateral or just one eye, or the second eye tested if fatigue related. The lid can be taped open to prevent this (Figs 5.7 and 5.8).

**Use of Miotics**

Even use of miotic therapy can lead to a defective field loss involving the peripheral field hence there is a problem when assessing patients on miotics.\textsuperscript{5-8} Miosis depresses the visual field and can exaggerate the size and depth of existing visual field defects. Pupil diameter less than 2 mm produces visual field loss, as pupil constriction dims both the intensity of the stimulus and the intensity of the background.

**Low Reliability Indices**

Reliability indices are important factors to be considered for the interpretation of the visual field. However, such indices may on occasion be misleading.
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Fig. 5.8A

Single Field Analysis

Central 24-2 Threshold Test

Name: 
ID: 

Eye: Right
DOB: 

Fixation Monitor: Blind Spot
Fixation Target: Central
Fixation Losses: 1/15
False POS Errors: 3%
False NEG Errors: 2%
Test Duration: 07:18

Stimulus: III. White
Background: 31.5 ASB
Strategy: SITA-Standard
Pupil Diameter:
Visual Acuity: 20/20
RX: +5.00 DS DC X
Date: 28-03-2012
Time: 11:24 AM
Age: 50

Fovea: 25 dB

GHT
Outside Normal Limits

VFI 86%

MD -5.78 dB P < 0.5%
PSD 5.83 dB P < 0.5%

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HFA II 720-8247-4.2/5.0
Figs 5.8A and B: Superior visual field defect in a patient with ptosis and visual fields of the same patient in the same sitting, after taping the upper lid.
Fixation instability may certainly occur with poor fixation, but in addition, fixation instability may occur because of an ill-defined blind spot, presence of nystagmus or head movement during the test. These factors can be accounted for and, in fact, the visual field result is often reliable in many of these instances, particularly if the patient has been visually observed in addition to the catch trials.

Some reliability problems may relate to false negative responses. Throughout the test, a stimulus is projected at a level above threshold at a point which has already had a positive response to a certain decibel value. The patient should therefore respond to this; however, if there is no response, this is recorded as a false negative. Repeated high false negative responses have been found in patients already with visual field defects rather than normals, providing further evidence that false negative responses are more indicative of true defects than of poor patient reliability.  

High false negative scores may be seen in patients with early onset of visual loss, as there may be relative scotomas with varying visual responses in this area. High false negative scores may also be a sign of fatigue and allowing the patient a break during the test may alleviate this problem.

During the test, the projection device is at times moved, or clicks without presenting a stimulus. Should the patient respond despite the absence of a stimulus, this is recorded as a false positive. A high false positive score is often seen in ‘trigger happy’ patients who press the response button frequently despite not seeing stimuli. These patients also continue to respond to actual stimuli, with the result that stimuli are presented at consecutively higher sensitivities. This will continue beyond the upper limit of 51 decibels if the patient continues to press the response button. The mean deviation value shifts well into the positive area, producing artificial defects in the pattern deviation. Abnormally high sensitivity decibel values are thus achieved and visual field results are therefore unreliable.

**Lens Rim Defects**

Poorly positioned lenses often interfere with visual perception. Visual field defects related to a lens artefact are usually located between 25 and 30 degrees. Where possible, it is advisable to use the patient’s own single lens prescription unless these are small frames. Otherwise, wide aperture lenses should be used with the eye positioned as close to the lens as possible. A give-away as to the presence of a lens rim defect is the sudden drop of sensitivity at the tested point to less than 0 decibels where neighbouring points closer to fixation do not show such a drop in sensitivity.

**Observer Interpretation**

When interpreting the printout of the results, it may be tempting to interpret the grayscale only as this provides an immediate view of the visual field. However, by interpreting the grayscale only, some areas of localized loss in the visual field may not be noted where there is diffuse visual loss also, and further progression of an existing visual field defect may not be identified. A true indication of the extent of loss is not therefore obtained. Occasionally, interpretation of the grayscale only results in the false diagnosis of progressive visual field loss. It can be related to the use of a new printer ribbon/cartridge where the quality of the grayscale print is darker with the new cartridge, but the probability plots clearly indicate the same extent of visual loss.

**Points to Remember**

- Successful communication between perimetrist and patient are of utmost importance
- The patient needs to be comfortably and properly positioned. Activate the forehead rest alarm
- Comments by the operator on patient performance and accompanying circumstances are useful for interpretation
- Potential operator errors are listed in the field analyser manual and should be reviewed by the technician from time-to-time
- The greyscale is of limited use but distinctive patterns such as the Clover leaf suggest that test data is not reliable
- The foveal threshold measurement option should be switched on
- Use of the diamond fixation targets can help obtain reliable fields in patients with central vision defects (e.g. from macular degeneration)
- “Baseline fields” should be established as soon as possible and updated as needed
- Always consider the complete clinical picture including the role of coexisting conditions. Never interpret the visual fields in isolation.

**References**


