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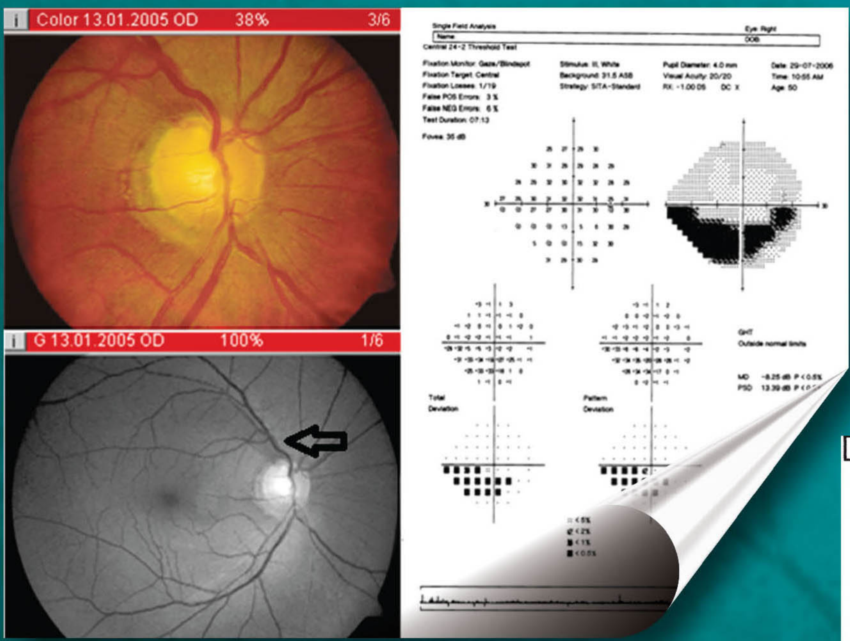
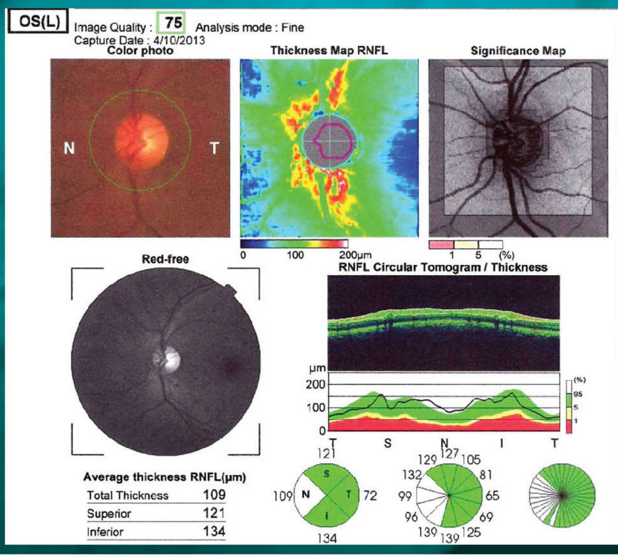
Practical Perimetry





2nd Edition

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JAYPEE

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CHAPTER

2 Choice of Perimeters—A Comparison

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INTRODUCTION

Evaluation of the visual field is the cornerstone for management of glaucoma, and is an important tool in the assessment of patients with ocular and neurological diseases. Automated static perimeters are the most commonly used for this purpose and common perimeters in use today include the Humphrey field analyzer (HFA), Octopus perimeter, Oculus, Opto, Dicon, and many others.[1-12]

HUMPHREY FIELD ANALYZER

The HFA is probably the most commonly used perimeter and has been in use for >25 years in research, and clinics alike. Most of the large-scale glaucoma clinical trials, including Advanced Glaucoma Intervention Study (AGIS), Early Manifest Glaucoma Trial (EMGT), Normal Tension Glaucoma Study (NTGS), and Ocular Hypertension Treatment Study (OHTS), have used the HFA for perimetry for both diagnosis and progression analysis. The GPA, or the Glaucoma Progression Analysis software is the only FDA-approved perimetry progression software, and is compatible with electronic medical record (EMR) systems **(Fig. 1)**.[1,2,5-7]

Humphrey perimeters have different models available which are designed depending on the kind of practice one has. The Humphrey 740*i* is the basic model but caters to comprehensive testing. The 720*i* is designed for low volume practices. The Humphrey 754*i* has all the features of 740*i* with additional Swedish interactive testing algorithm–short-wavelength automated perimetry (SITA-SWAP) software. The Humphrey 750*i* has all the advanced features. Newer models now available are 830, 840, 850, and 860, with additional features which are enumerated in the **Table 1**.

OCTOPUS

The Octopus **(Figs. 2A to C)** was the world's first automated perimeter which has gained popularity because it

Fig. 1: Humphrey's field analyzer
Source: https://www.zeiss.com/content/dam/Meditec

incorporates all three important glaucoma perimetry standards, namely, (1) standard perimetry, (2) SWAP, and (3) flicker testing. It does not require a dark room for optimal test results and has a fast strategy that reduces the time for visual field testing to as less as two and a half minutes. The perimeter also provides fixation control and automated gaze tracking, making the test easier and more reliable. The networkability of the octopus involves both, an ethernet connection and EMR interface.[1-3,5-7]

This chapter aims to provide a comparison of each of the attributes of the two perimeters **(Tables 1 and 2)**.[1-12] The main differences are elucidated below.

Measuring Range and Scale of Sensitivities

In Humphrey perimeters, the background illumination is the same as Octopus but the maximum stimulus luminance is higher. In Humphrey visual field (HVF), 40 dB corresponds to 1 abs and 0 dB to 10,000. As a result, the normal values in HVF

TABLE 1: Comparison of characteristics of different models of Humphrey.

Technical specifications	***HFA 720i***	***HFA 740i***	***HFA 745i***	***HFA 750i***	***HFA3 830***	***HFA3 840***	***HFA3 850***	***HFA3 860***
Maximum temporal range (degrees)	89	89	89	89	90	90	90	90
Stimulus duration	200 ms	200 ms	200 ms	200 ms	200 ms	200 ms	200 ms	200 ms
Visual field-testing distance	30 cm	30 cm	30 cm	30 cm	30 cm	30 cm	30 cm	30 cm
Background illumination	31.5 asb	31.5 asb	31.5 asb	31.5 asb	31.5 asb	31.5 asb	31.5 asb	31.5 asb
Stimulus size	Goldmann III	Goldmann I–V	Goldmann I–V	Goldmann I–V	Goldman I-V	Goldmann I–V	Goldmann I–V	Goldmann I–V
Foveal threshold testing	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Automatic pupil measurement	No	No	No	No	No	Yes	Yes	Yes
Threshold test library								
24-2, 30-2, 10-2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macula	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
60-4, Nasal step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test methods								
SAP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SWAP	No	No	Yes	Yes	No	No	Yes	Yes
SITA Standard, Fast, Full threshold	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SITA SWAP			Yes	Yes			Yes	Yes
Fixation control								
Heijl–Krakau method	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Video eye monitor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gaze tracking		Yes	Yes	Yes		Yes	Yes	Yes
Head tracking				Yes		Yes	Yes	Yes
Vertex monitoring				Yes			Yes	Yes
Remote video eye monitor capability	Yes	Yes	Yes	Yes				
Liquid Trial Lens								Yes
Automatic pupil measurement						Yes	Yes	Yes
RelEYE eye review							Yes	Yes
Software features								
Glaucoma hemifield test (GHT)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Visual field index (VFI)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guided progression analysis (GPA)		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serial field overview		Yes	Yes	Yes	Yes	Yes	Yes	Yes
networking	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FoRUM connectivity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DICoM connectivity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Easyconnect RCT/HFA-NET pro	Yes	Yes	Yes	Yes				

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Figs. 2A to C: Octopus 300; (B) Octopus 600; (C) octopus 900
Sources:
- https://www.haag-streit.com/haag-streit-diagnostics/products/perimetry/
- http://www.haag-streit.com/products/perimetry/octopusr-600.html
- http://www.haag-streit.com/products/perimetry/octopusr-900

are 3–4 dB higher than Octopus and thus we cannot directly compare the measured sensitivities of the two instruments.

In Octopus 300, the maximum stimulus luminance and the background are brighter than Octopus 101. But the normal value expressed in decibels is the same, i.e., 40 dB corresponds to 0.1 asb and 0 dB to 1,000 abs in Octopus 300 and this has a background luminance of 31.4 abs. 40 dB corresponds to 0.48 abs and 0 dB to 4,800 abs in Octopus 101 with background luminance of 4 asb.

Octopus 101 and HVF 700 have a spherical bowl as compared to Octopus 300 which uses a direct projection system. The newer models of both are compared in the **Tables 1 and 2**.

Stimulus Size and Duration

The stimulus size Goldmann I to V are available in Octopus 101 and HVF 700 whereas Octopus 300 has size III and V.

The stimulus duration in the Octopus is 100 ms compared to 200 ms in Humphrey. This is sufficiently high to reach temporal summation yet below the reaction time of the fixation. So, the patient can see the stimulus yet not move his eyes toward it.

Measurement Strategies

Humphrey uses the 4-2 dB bracketing strategy whereas the Octopus uses the 4-2-1 dB bracketing strategy to determine the retinal sensitivity at a point. So, the threshold is crossed twice in Humphrey compared to three times in Octopus. This is applicable in full threshold strategies.

The perimetric test can be long leading to fatigue and if the procedure is prematurely stopped all data may be lost with no conclusive result. To avoid this Octopus has provision of running the examination in modular steps. In each stage, a predetermined subset of locations is tested and results saved as separate examinations. This helps to choose the critically important locations to be tested first when the patient is not fatigued. In case, the fields appear severely depressed or perfectly normal the test can be terminated after second or third stages also instead of completing all four. After each stage, the test can be restarted, continued, or saved.

The defect level indicator is available in Octopus which gives a real time display to allow the operator to judge if the fields are normal, borderline, or depressed even when the tests is in progress.

The staging and phasing concept is unique to Octopus and not available in Humphrey. It helps to make the test shorter without compromising on the information gathered. This also helps to set priorities to diagnostic relevant areas.

The newer models of HVA 3 have added features which include SITA faster and 24-C program. This machine allows mixed glaucoma progression analysis between SITA standard, SITA Fast, and SITA faster so all tests need not have been done on the same strategy.

It also has a Liquid Trial Lens so that one single lens is needed and by pressure changes in the liquid it adapts to all refractive corrections.

Individual Strategies: How to Choose

Humphrey perimeters use the full threshold strategy with the 4-2 bracketing to derive the retinal sensitivity at each test location. It also checks the short-term fluctuation where ten points are rechecked. This can be time consuming and to decrease this without compromising on the test quality other strategies like SITA were developed. SITA strategies are not only fast and accurate, but also friendly to the patient. These utilize the patient response and reaction time to pace the test timing so in a way the patient runs the perimeter rather than the machine ruling the test.

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TABLE 2: Comparison of characteristics of different models of Octopus.

Technical specifications	***Octopus 300 basic***	***Octopus 300 pro***	***Octopus 600 basic***	***Octopus 900 basic***	***Octopus 900 pro***
Threshold test library					
Peripheral range (distance)	30° (infinite)	30° (infinite)	30° (infinite)	180° (30 cm radius Goldmann bowl)	180° (30 cm radius Goldmann bowl)
Stimulus generation	Direct projection system	Direct projection system	TFT monitor	Mirror projection system	Mirror projection system
Stimulus duration	100 ms, 200 ms, and 500 ms	100 ms, 200 ms, and 500 ms	SAP: 100; Pulsar: 500	100, 200, 500, 1,000, and infinite	100, 200, 500, 1,000, and infinite
Background illumination	31 asb	31/314	SAP: 10 cd/m^2; Pulsar: 32 cd/m^2	0/4/31/314	0/4/31/314
Stimulus size	III, V	III, V	SAP: 0.43 (Size III); Pulsar: 5	Goldmann I-V	Goldmann I-V
24-2, 30-2, 10-2	Yes	Yes	Yes	Yes	Yes
Macula	M Program	M Program	M Program	M Program	M Program
60-4, Nasal step					
General/glaucoma 30° (G1-Program, 32)	Yes	Yes	Yes	Yes	Yes
Test methods					
SAP	Yes	Yes	Yes	Yes	Yes
SWAP	With package	Yes		With package	Yes
Flicker	With package	Yes		With package	Yes
Pulsar			Yes		
Goldmann kinetic				with package	Yes
Top	Package	Yes	Pulsar	Package	Yes
Dynamic	Yes	Yes	Yes	Yes	Yes
Fixation control					
Blink control	Yes	Yes	Yes	Yes	Yes
Pupil position control	Yes	Yes	Yes	Yes	Yes
Automated eye tracking	Yes	Yes		Yes	Yes
Contact control	Yes	Yes	Yes		
Dart control			Yes		
Software features					
FoRUM connectivity					
DICoM connectivity	Yes	Yes		Yes	Yes
EMR	Yes	Yes		Yes	Yes
Ethernet	Yes	Yes	Yes	Yes	Yes
Global progression MD, sLV	Yes	Yes	Yes	Yes	Yes
Cluster trend, polar trend	Yes	Yes	Yes	Yes	Yes

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Swedish interactive testing algorithm testing strategies available on the HFA II-*i*:

- *SITA Standard:* A threshold testing method which collects the same amount of information in half the time as the original Humphrey® Full Threshold standard algorithm. This is done without compromising test reproducibility.
- *SITA Fast:* A threshold testing method that collects the same amount of information in half the time as FASTPAC, without compromising test reproducibility.

Octopus perimeters have the following strategies:

- *Normal strategy:* This utilizes the 4-2-1 bracketing standard perimetry. It takes time because of thresholding at each location and is recommended in early and shallow defects in young individuals.

- *Low vision strategy:* It uses the 4-2-1 bracketing but starts with the brightest stimulus and steps up thus reducing time to reach threshold and is recommended in end stage diseases.
- *Dynamic test strategy:* The FOSc (frequency-of-seeing curve) determines the step sizes. As the depth of defect increases the stimulus luminance can take larger decibels steps to decrease the testing time. This is indicated in early detection of field loss especially where focal defects are expected.
- *Tendency oriented perimetry:* It is a method which takes into account that threshold values of neighboring locations are correlated. It is a systematic method and not based on disease pathology so it can be extended to other perimetric methods like blue on yellow and flicker perimetry. This is useful for older patients and those with depressed fields as time taken is lesser.
- *Two level testing:* This is a qualitative test and gives a rough estimation of test being normal, relative, or absolute defect.
- *One level test:* It is used in legal testing procedures and just indicates normal or not normal qualitatively.

Special Perimetric Methods

Humphrey visual fields 30-2 program tests 76 points placed 6° apart within the central 30° region. The 24-2 program tests 54 points by omitting the outer ring points of 30-2 except the 2 nasal points. This saves time and is clinically sufficient as the edge points of 30-2 are often not considered in diagnostic criteria.

In Octopus, the program 32 is similar to the 30-2 of HVF. Due to the wide spacing of locations and no correlation with retinal topography, two different programs were introduced. Program G1 tests 59 points in central 30° and program G2 has additional 14 peripheral test locations in the 30–60° area. These test locations are specially designed for glaucoma with attention to the paracentral test locations. The macula area resolution is 2.8° compared to the 6° in program 32.

Differences while Conducting the Tests

The newer models of Humphrey like HFA II-*i* have better monitoring of the eye and head positions during the test. Earlier models had gaze tracking and used the Heijl–Krakau method to judge fixation.

- Gaze tracking records the fixation of the patient while each stimulus is presented. This is recorded at the base of the printout.
- Head tracking ensures proper alignment of the head and eye relative to the trial lens holder.
- Video eye monitoring helps to position the test eye in the center of the trial lens holder and monitor the patient during testing.
- Vertex monitoring uses the distance between two corneal reflexes to determine if the patient has moved too far back from the trial lens. The software flags the movement and asks the operator to realign the patient or reinitialize the system.

Octopus on the other hand uses the picture of the corneal reflex as the baseline and any deviation due to gaze shift makes the machine stop the test. This eliminates fixation losses altogether from the final analysis of the visual fields, making the reliability better.

Differences in Printouts

The HVF printout is a seven in one printout with demographic parameters including the test specifications. Reliability indices include fixation loss, false positive, and negative. In Octopus, these are called catch trials. There is no fixation loss in Octopus because the machine takes a picture of the corneal light reflex at the beginning of the test and any deviation is associated with pausing the test and restarting when the reflex is centered.

The raw data and grayscale of HVF is similar to values and grayscale of values in Octopus and these represent the actual retinal sensitivities in decibels.

Total deviation of HVF represents the deviation from the expected normal at each point and this is called comparisons in Octopus. Pattern deviation is called probability.

The corrected comparisons show the localized defects after discounting for the generalized depression. Similarly, the corrected probability is the statistical evaluation of the probability or significance of the defect.

Global indices in HVF are the mean deviation (MD), pattern standard deviation (PSD), short-term fluctuations, and corrected PSD. The corresponding indices in Octopus are mean defect, loss variance (LV), short-term fluctuations, and corrected LV, respectively. Additionally, a reliability factor is also calculated in the Octopus which indicates the patients' cooperation. This is calculated from the catch trials.

In HVF, there is GHT which compares five weighted zones in the superior hemisphere to their mirror images in the inferior hemisphere. In Octopus, there is the cumulative defect curve called the Bebie curve which shows the defects sorted in order of increasing depth.

Another additional feature in HVF is the visual field index which is a summary measurement of the patient's visual field status, expressed as a percentage of the normal age-adjusted visual field **(Figs. 3 and 4)**.

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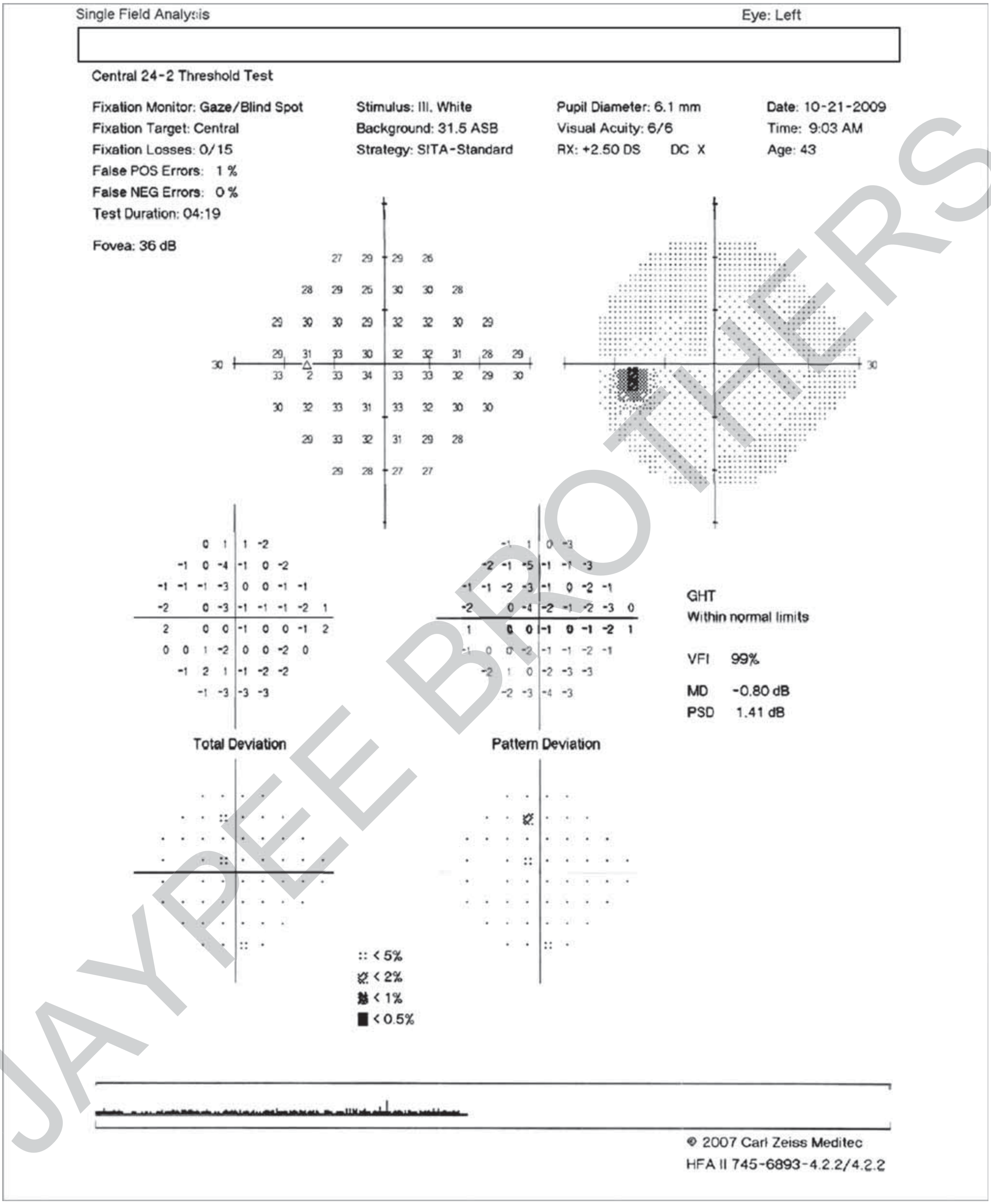

Fig. 3A

Source: Dr Shroff's charity eye hospital

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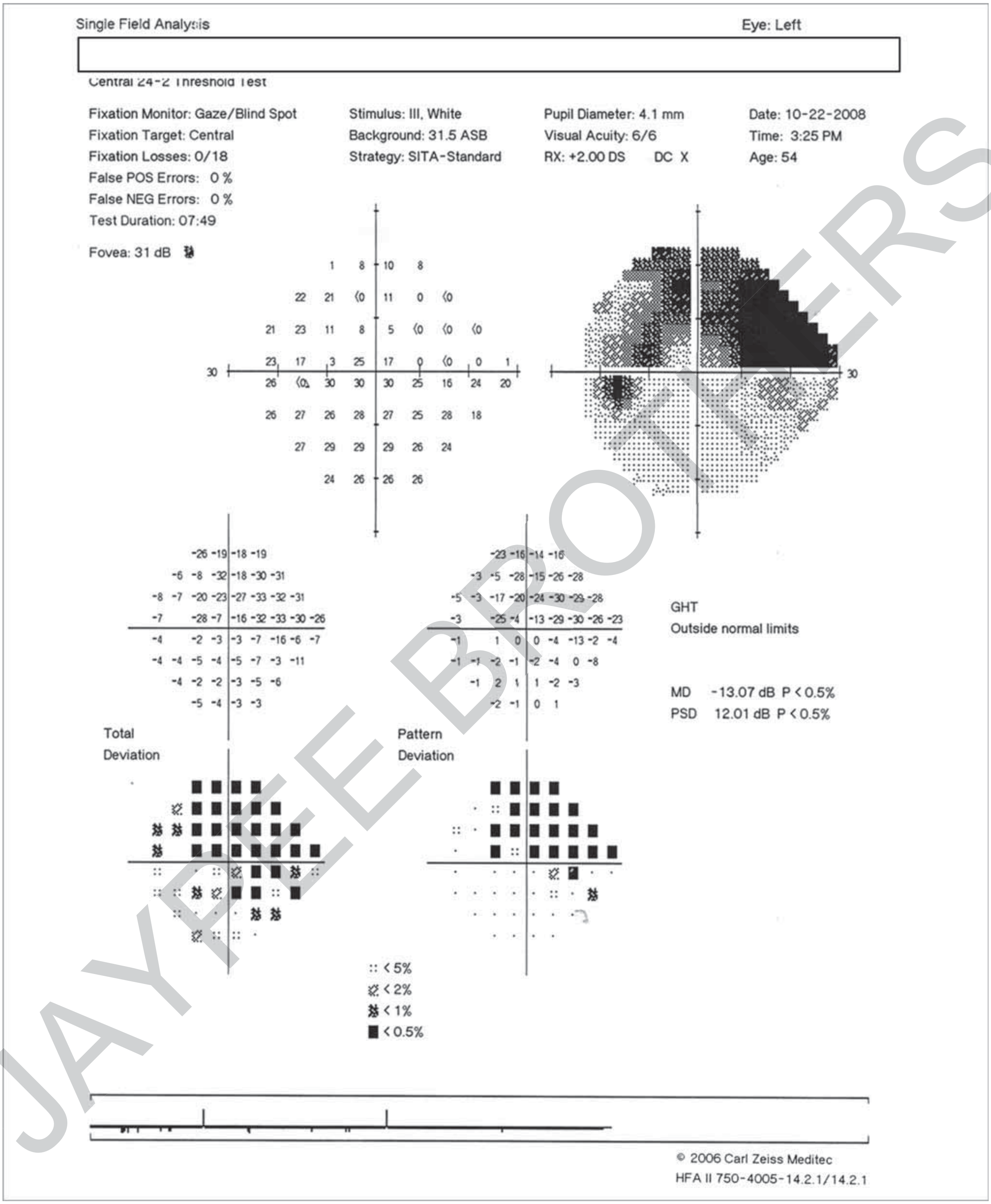

Fig. 3B

Source: Dr Shroff's charity eye hospital

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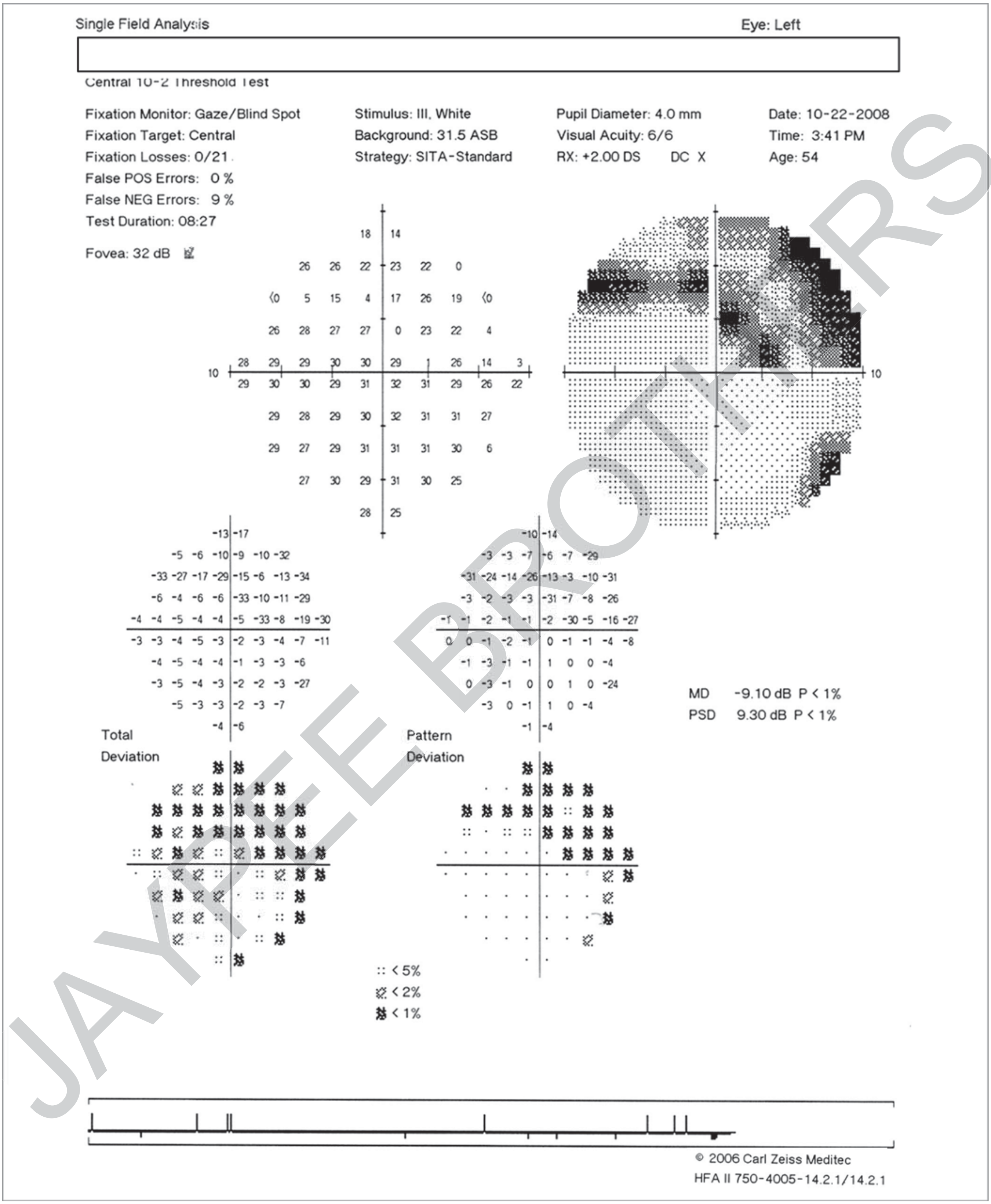

Fig. 3C

Figs. 3A to C: (A) Normal Humphreys visual field 24–2; (B) Abnormal Humphreys visual field 24–2; and (C) Abnormal Humphreys visual field 10-2 of the same patient as same patient as in **Figure 3B**. This will be more informative for follow-up of this patient.

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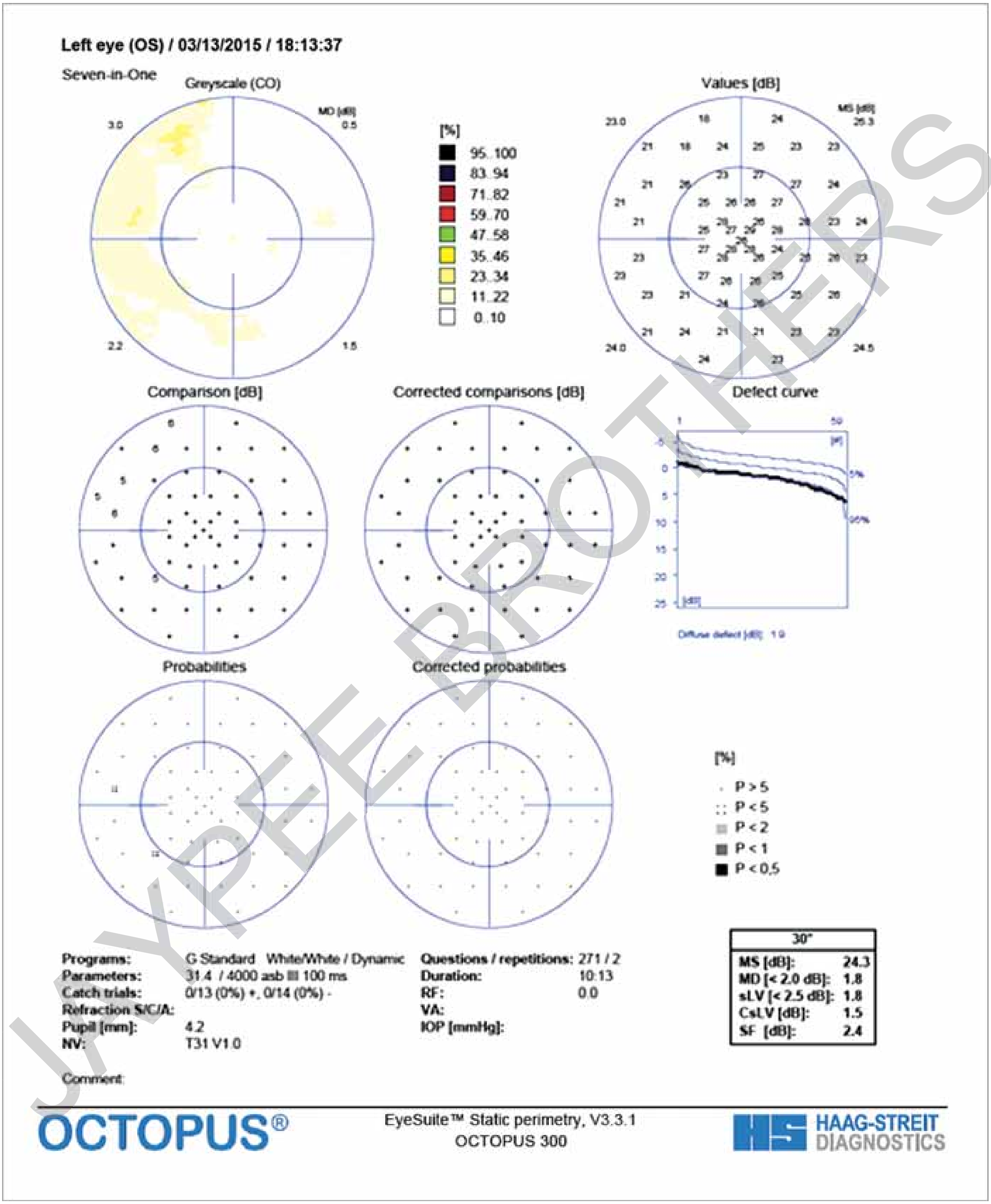

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Fig. 4A

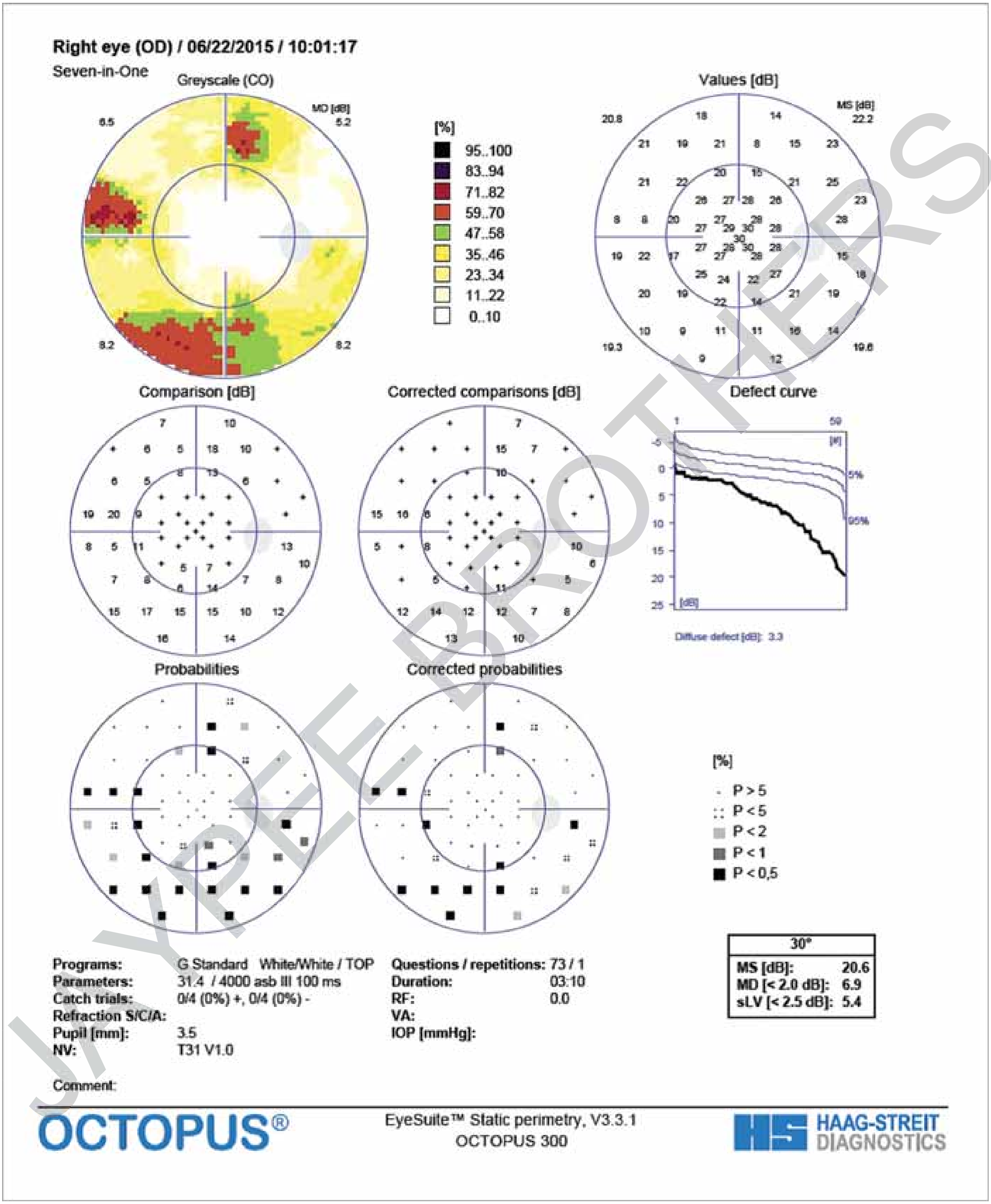

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Fig. 4B

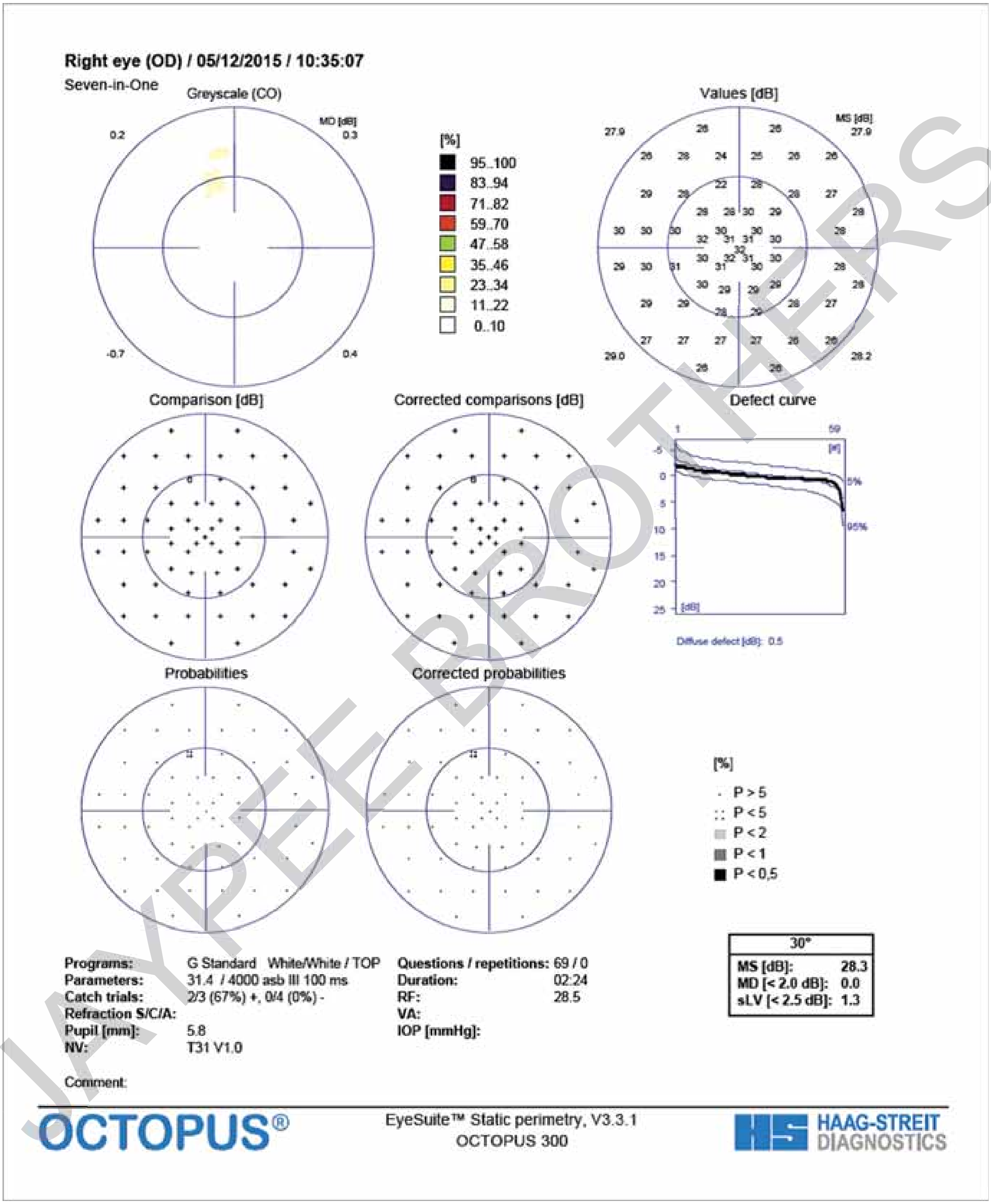

Fig. 4C

Figs. 4A to C: (A) Normal visual field (Octopus). Left eye of a 74-year-old patient tested with G Standard Dynamic Program; (B) Abnormal visual field (Octopus) right eye of a 52-year-old patient with inferior arcuate defect. Note the Babie curve depressed below the normal range; (C) Normal Octopus visual field, tendency-oriented perimetry.

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CORRELATION OF FIELDS BETWEEN THE TWO PERIMETERS

Repeat visual field assessment is invaluable for confirming presence of visual field deficit, aiding localization of pathological lesion, and for recording improvement, stabilization, or deterioration of the underlying condition. Therefore, it is important that the same perimeter be used in the serial evaluation of a patient overtime. Even though the parameters of visual field loss show a good correlation between the two kinds of perimeters, the values from each may not be used interchangeably in the serial monitoring of patients.

With patients shifting between practices with different machines, it is important to have a general idea of intraperimeter comparisons. When interpreting progression by interpreting fields done on the two different perimeters, it is essential to keep in mind the effect of differing bracketing strategies, background illuminations on threshold values which impacts MD and PSD/(LV indices).[1-12]

Fig. 5: Humphrey visual field connected to FORUM and electronic health record (HER). It can also connect to networked devices without Digital Imaging and Communications in Medicine (DICOM). *Source:* https://www.zeiss.com/content/dam/Meditec

NETWORKING AND COMPATIBILITY

The Humphrey machine can be connected to the office network and other Zeiss machines through FORUM eye care management systems **(Fig. 5)**. This establishes centralized data storage management and retrieval thereby increasing efficiency. It can be connected to the electronic health records to store data also.

The EyeSuite software with Octopus has the capability of connecting the machine to the other Haag strait machines such that the patient data can be accessed anywhere in the busy OPD **(Fig. 6)**. The software is compatible with standardized interfaces such as GDT and Digital Imaging and Communications in Medicine (DICOM) and can be transferred to EMRs thus reducing time and eliminating transcription errors.

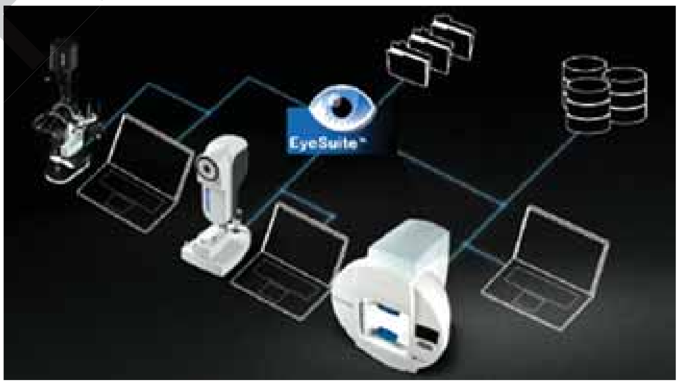

Fig. 6: Integration of EyeSuite with the Octopus 900.
Source: http://www.haag-streit.com/products/perimetry/octopusr-900

MERITS AND DEMERITS

The Humphrey perimeter is used more extensively, and more ophthalmologists have been trained to read HFA visual fields, and therefore, find it easier to interpret. Also, as patients shift between practices, serial follow-up is easier if the next doctor has the same machine, even though a fresh baseline will need to be established to monitor progression. The Octopus perimeter is easier to use since the time taken for the field is less, and it does not require a dark room for perimetry. Fixation losses are not a concern during visual fields with the Octopus machines as stimulus projection is stopped when there is fixation loss and the perimetrist encourages the patient to refixate before testing is restarted. The direct projection system of the 300 series machines implies that no near correction has to be added during perimetry. It is a compact machine and therefore requires less table space. Features unique to the Octopus include Polar diagram, cluster analysis and EyeSuite Trend analysis (all these features are discussed in detail in the preceding chapters on Octopus perimetry.

OCULUS PERIMETERS

The Oculus Easyfield is the smallest full-fledged perimeter on the market. It is designed for use as a visual field screener and as a threshold perimeter for immediate reexamination of any abnormal findings. Ideal for all common examinations of the

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central visual field up to 30°. It has an adjustable double chin rest and uses translucent eye shields for maximum patient comfort.

The Centerfield® 2 Perimeter has proven itself to be an invaluable instrument in the occupational health area. The unit performs static perimetry up to 70° eccentricity. It also meets the requirements of the German Ophthalmological Society's (DOG) Road Traffic Commission for conducting visual field testing in accordance with the regulations for the issuance of driver's licenses.

The Twinfield 2 Oculus device measures the full field of vision using both automatic, static perimetry, and automatic or manual kinetic examinations.

CONCLUSION

The best perimeter for your practice is the one you have. As long as it is used judiciously, and appropriate caution is exercised when interpreting the visual field report, the performance of each of the perimeters is comparable to the other. It is important that the same perimeter be used in the serial evaluation of a patient over time, especially to utilize the progression software of the device.

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Practical Perimetry

Practical Perimetry is a collective effort of clinicians and glaucoma specialists 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 clinicians 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 clinician-scientist 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.

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Printed in India

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ISBN 978-93-5696-311-5

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