CHAPTER 4

Perimetry in Glaucoma

Overview

Introduction

The *visual field is defined as the area perceived simultaneously by a fixating eye*. Perimetry records the sum of all directions from which the eye may perceive visual stimulation at a defined moment in time and documents perception of this stimulation.

Using perimetry one can evaluate and quantify the visual field using targets of various sizes, illumination, and colors. *Perimetry depends upon responses provided by the patient, and is therefore a subjective test, with many variables.* The first fields recorded need to be interpreted with caution, as they appear to improve as the patient "learns" to respond more accurately to stimuli. Perimetry has advanced over the years to become more standardized, with as few variables as possible, as in automated static perimetry.

The ability to detect a spot of light against a uniformly illuminated background is called differential light sensitivity at a given point of the retina. It is highest at the macula and gradually decreases toward the periphery, with recordings across the retina forming a "hill of vision." It varies with the size and illumination of the spot and background, and is documented in numeroalphabetical notations or decibels (dB) (**Fig. 4.1a, b**). Perimetry is commonly done with a white target, but when recorded with a blue on yellow target it is about 10 degrees less and with a red on green target 20 degrees constricted as compared to a white target. These are necessary for patients having neuritis, toxic neuropathy, or chloroquine retinopathy.

Two techniques are commonly used:

- Kinetic: A target is slowly moved in front of the eye to map out the extended area where it is seen.
- Static: This is more standardized and graded, with stimuli of different luminance projected at the same position to *ascertain differential light sensitivity*, at points of the retina, with additional information of depth and area of the field.

Kinetic Perimetry

This is a simple and adaptable method of evaluating the visual field, in the hands of a trained operator. The patient has to be carefully explained the procedure as he/she may not understand what is required of him/her, or may find it difficult to respond.

Kinetic perimetry was initially described using a Bjerrum screen, and was further standardized by Goldmann using a half sphere with standard background illumination of 31.5 apostilbs, and a movable arm with a light of variable illumination and size.

The patient has one eye occluded, and is asked to keep his or her chin on the chin rest throughout the test. He or she is asked to fix on the central white dot/light with the eye under observation, and press a buzzer when the target is *clearly seen, not just a blur*. The target is moved from the periphery along a meridian until the patient responds (**Fig. 4.2**). A reverse movement from seeing to nonseeing can be used to more clearly delineate the edge of the visual field. Such points are recorded across all meridians, and represent points of a given retinal sensitivity. A line drawn through all these points is an isopter, designated by the size and illumination of the target used, e.g., I4e. *The largest and brightest target will have the largest isopter and the dimmest the smallest one.* Patients with good vision should have their field assessed with I4e target, while those with poor vision, up to 6/60, can have V4e utilized

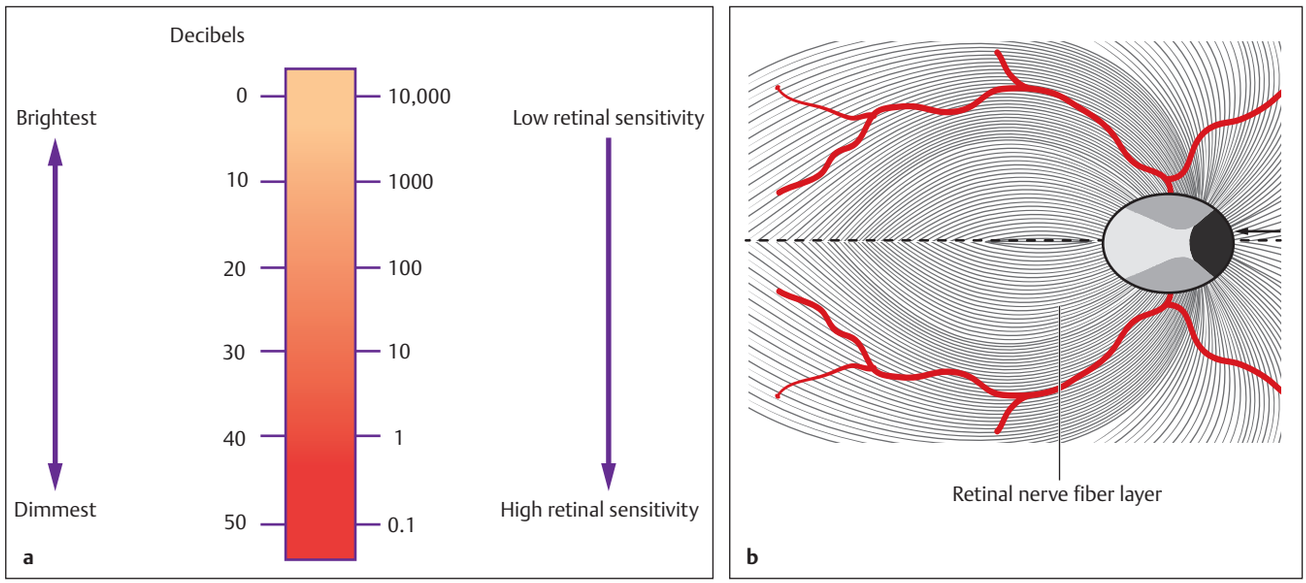


Fig. 4.1 **(a)** Relationship of retinal sensitivity to recorded values. **(b)** Arrangement of nerve fiber layers in the optic nerve and retina.

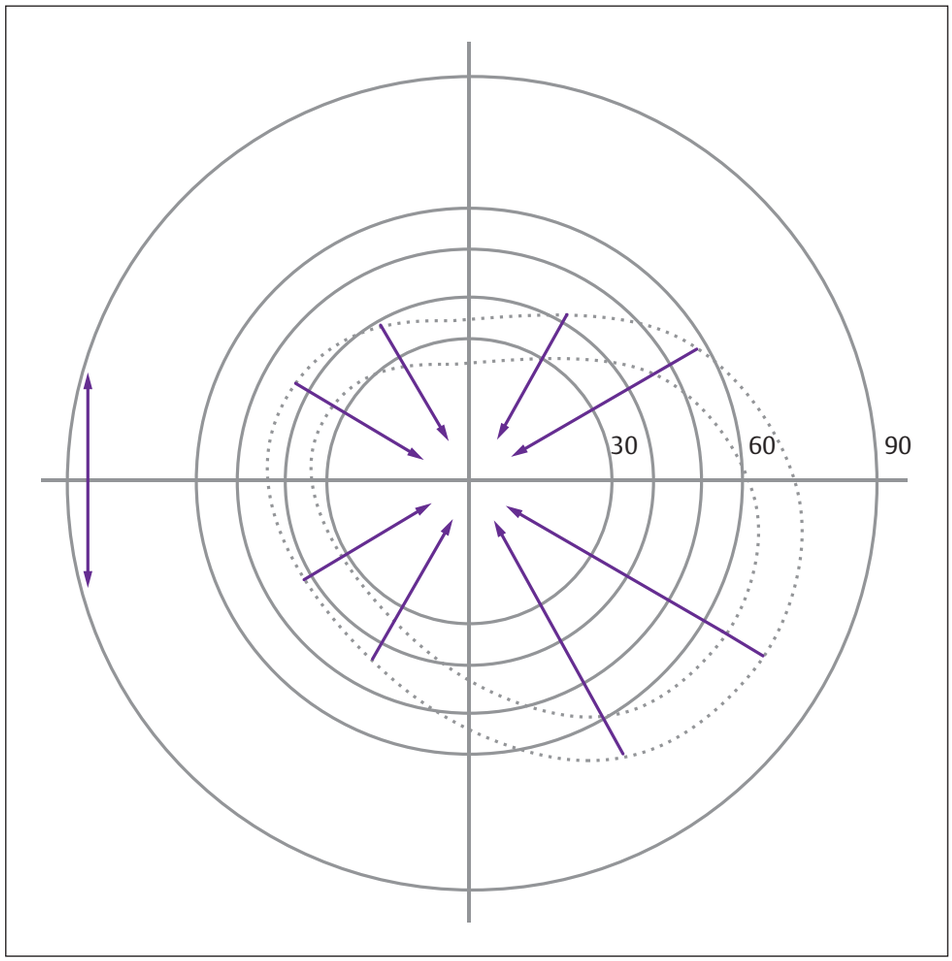


Fig. 4.2 Directions of movement of a target in kinetic perimetry for glaucoma, periphery to the center and across the nasal raphe.

so that the field can still be recorded. The white target should be moved up to fixation in all meridians to detect nonseeing areas within the field as well. These are again tested from seeing to nonseeing and the reverse to map out the scotomas. Absolute scotomas are detected by targets of all sizes, but relative scotomas are detected only with smaller and dimmer targets. Kinetic perimetry may fail to detect relative scotomas.

Static Perimetry

Targets of different luminance can be projected anywhere in the visual field in a random fashion, obviating false-positive responses, such as in kinetic perimetry where the sameor adjacent meridian is tested and the patient soon becomes aware of this. Randomization used in automated perimeters has made perimetry less dependent on trained technicians, and is more accurate and reproducible.

Automated perimeters allow a constant monitoring of fixation, retest abnormal points automatically, and can be customized to look at specific areas of the field of interest. *The most commonly used standard automated perimeter (SAP) uses a white-on-white stimulus.*

A number of strategies are possible, the most common being the following:

- *Suprathreshold for screening*: Targets of supranormal luminance, which would be visible to normal people, but would not be seen in areas having moderate to severe loss of sensitivity are presented. Points are recorded by the machine as "seen" or "not seen." This would not be able to detect mild loss of function.
- *Threshold strategy*: At each point, targets of increasing and decreasing luminance are randomly projected till just visible, to ascertain the differential light sensitivity at each locus. A *"staircase" strategy* increases light intensity in larger steps of 4 dB, and then fine tunes the sensitivity measurement by decreasing intensity in smaller steps of 2 dB. *Sensitivity measurements indicating that the patient has seen the stimulus 50% of the time are recorded.*

The algorithms test 50 to 100 spots, in grids that are 3 to 6 degrees apart, on or straddling the vertical and horizontal meridians.

- *Swedish interactive threshold algorithm* (SITA): On Humphrey field analyzer (HFA), it uses Bayesian statistics and predetermined normal and glaucomatous thresholds for each locus and interpoint correlations, so that the time for bracketing at each point is reduced. It dynamically monitors patient's responses and compares them with adjacent areas. SITA automatically postprocesses information to provide a likelihood of abnormality. Use of listening windows rather than repeat catch trials also helps decrease test duration.
- *Tendency oriented perimetry* (TOP): TOP, which is available on Octopus style perimeters, similarly estimates thresholds using information of adjacent loci and bracketing, to reduce duration of testing.

The patient is seated at a half sphere or screen with appropriate lens correction for near, on a chin rest, with one eye occluded. He or she is asked to fixate at a central light. In case of macular pathology, the patient can be asked to fixate at the center of a diamond of lights (**Fig. 4.3**). The patient is demonstrated a few targets in the field and is counseled to maintain constant central fixation. On perception of a light stimulus randomly presented at any point, a buzzer has to be pressed, to record sensitivity, and the next target can then be projected. The test can be paused in case the patient is fatigued.

The program starts with *4 seed locations in each quadrant, 13 degrees from fixation*, and then progresses randomly around the field. If the patient gets fatigued or inattentive, a clover leaf pattern is seen on the pattern deviation plot and grayscale (**Fig. 4.4**). The testing can be done for various extended areas of the visual field and with a larger or smaller number of stimuli and can also be customized (**Table 4.1**).

Fixation is monitored by different means in perimeters. In the Heijl-Krakau method, the stimulus is projected on the blind spot randomly. If the patient responds, it is because the eye has been moved, and this is recorded as a fixation loss. Gaze tracking monitors eye movements by monitoring the corneal reflection, and records even small movements over the test duration, providing a measure of the quality of fixation. The Octopus perimeter uses a video monitor display and an automatic eye tracking system. However, these do not quantify or identify the direction of fixation losses.

Once the test is complete, the sensitivity of the individual is compared to age-matched controls and a printout generated.

Reading a Single Field

Fig. 4.5 represents an example of Humphrey type perimeter single-field printout. **Flowchart 4.1** illustrates the algorithm for reading a single field.

Patient Parameters

First check that an *appropriate refractive correction for near* has been given and the patient has a *vision of at least 6/18.*

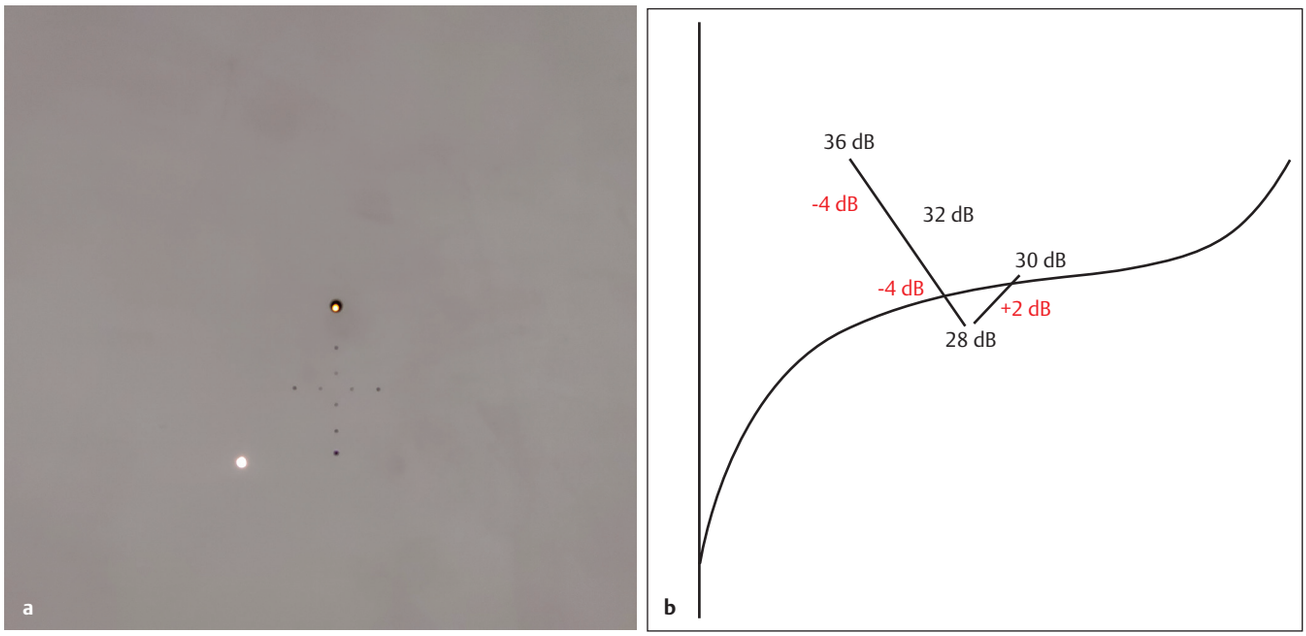


Fig. 4.3 (a, b) The patient is asked to fixate at the central spot, and respond when a stimulus is visible elsewhere.

Check that the date of birth is accurate as results are compared to age-matched normals. Pupils should be recorded as between 2 and 4 mm.

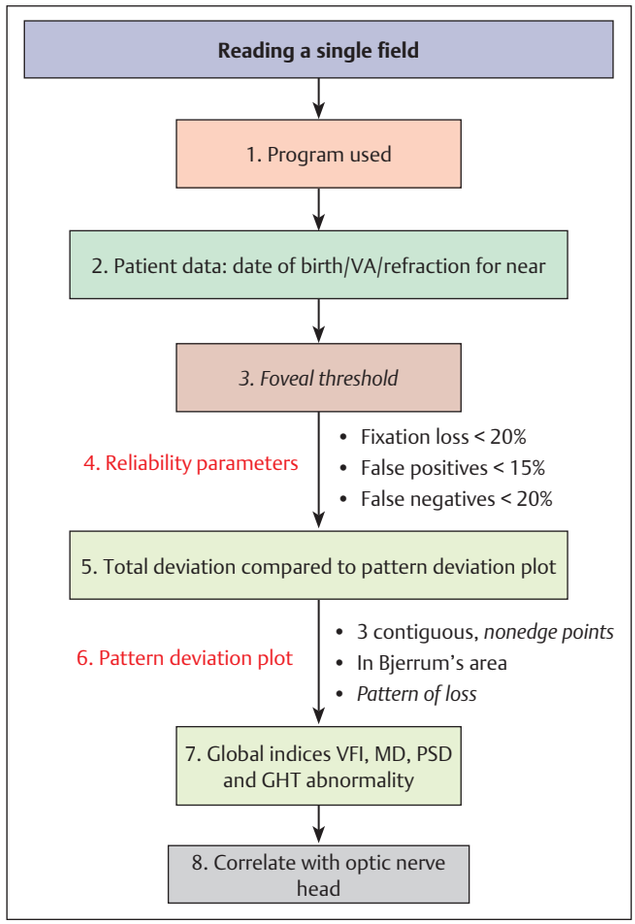
Test Parameters

The correct strategy should be chosen—30-2 or 24-2 for mild-to-moderate glaucoma and an additional 10-2 *is advised for all patients now to identify early involvement of the central field. In severe glaucoma with only a central island remaining, 24-2 and 30-2 test only 12 loci in the central 10 degrees, therefore a 10-2 program is used, and a macular threshold protocol may provide additional testing of 16 points in the central 5 degrees for very advanced glaucomas.*

Background illumination should be periodically calibrated. *Foveal threshold evaluation* provides a correlation with visual acuity, and a pointer to possible involvement of the central field.

Table 4.1 Testing strategies on Humphrey field analyzer

Threshold test	Extent of visual field tested	Number of loci tested
10-2	10 degrees	68-point grid
24-2	24 degrees	54-point grid
30-2	30 degrees	76-point grid
60-2	30–60 degrees	60-point grid
Full field 120	120 degrees	120 points



Flowchart 4.1 Algorithm for reading a single field. GHT, glaucoma hemifield test; MD, mean deviation; PSD, pattern standard deviation; VA, visual acuity; VFI, visual field index.

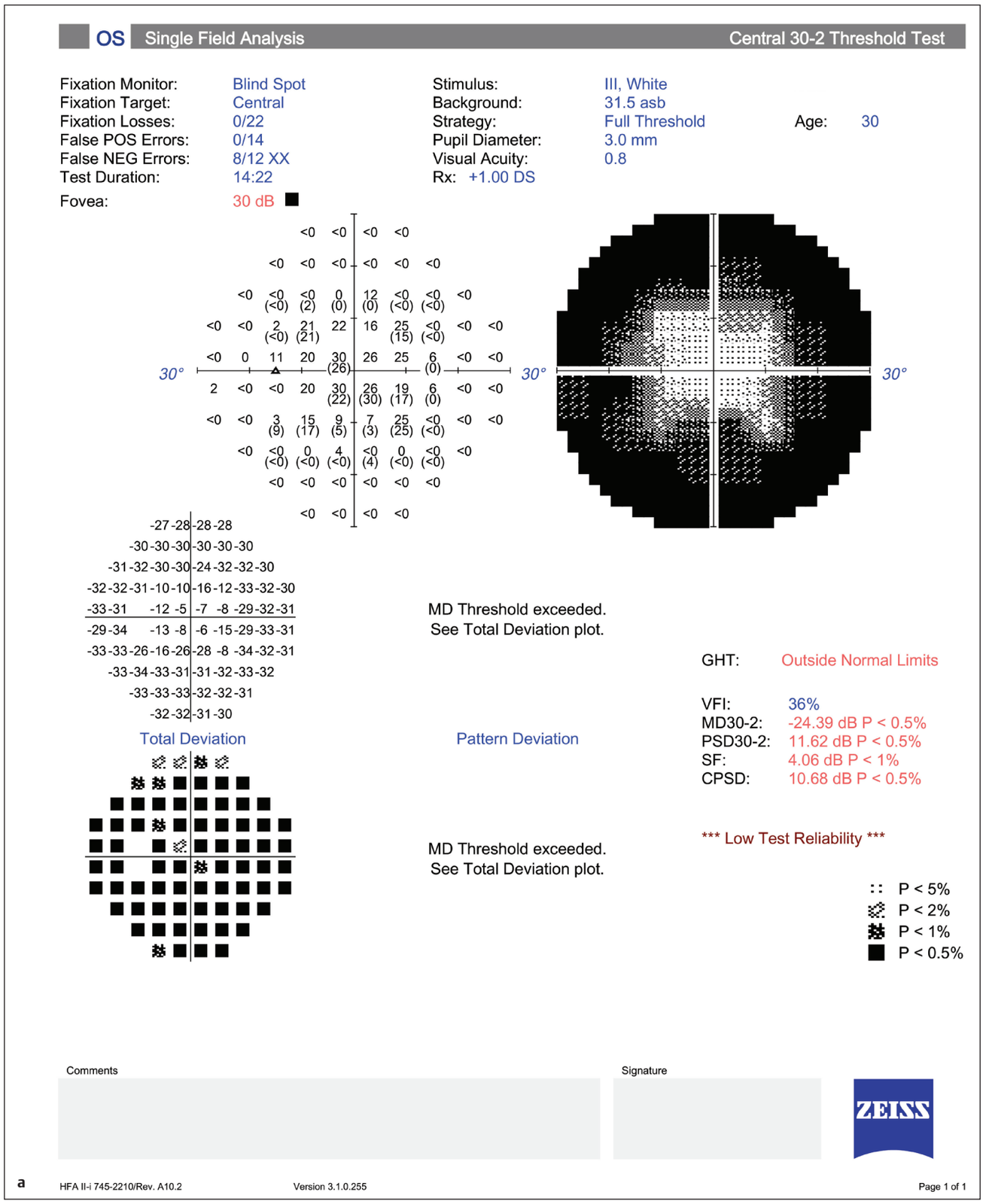


Fig. 4.4 **(a)** The initial 4 seed locations in the middle of three quadrants are grossly within normal limits, after which the patient appears to have become inattentive, leading to a clover leaf pattern on the pattern deviation plot and grayscale. *(Continued)*

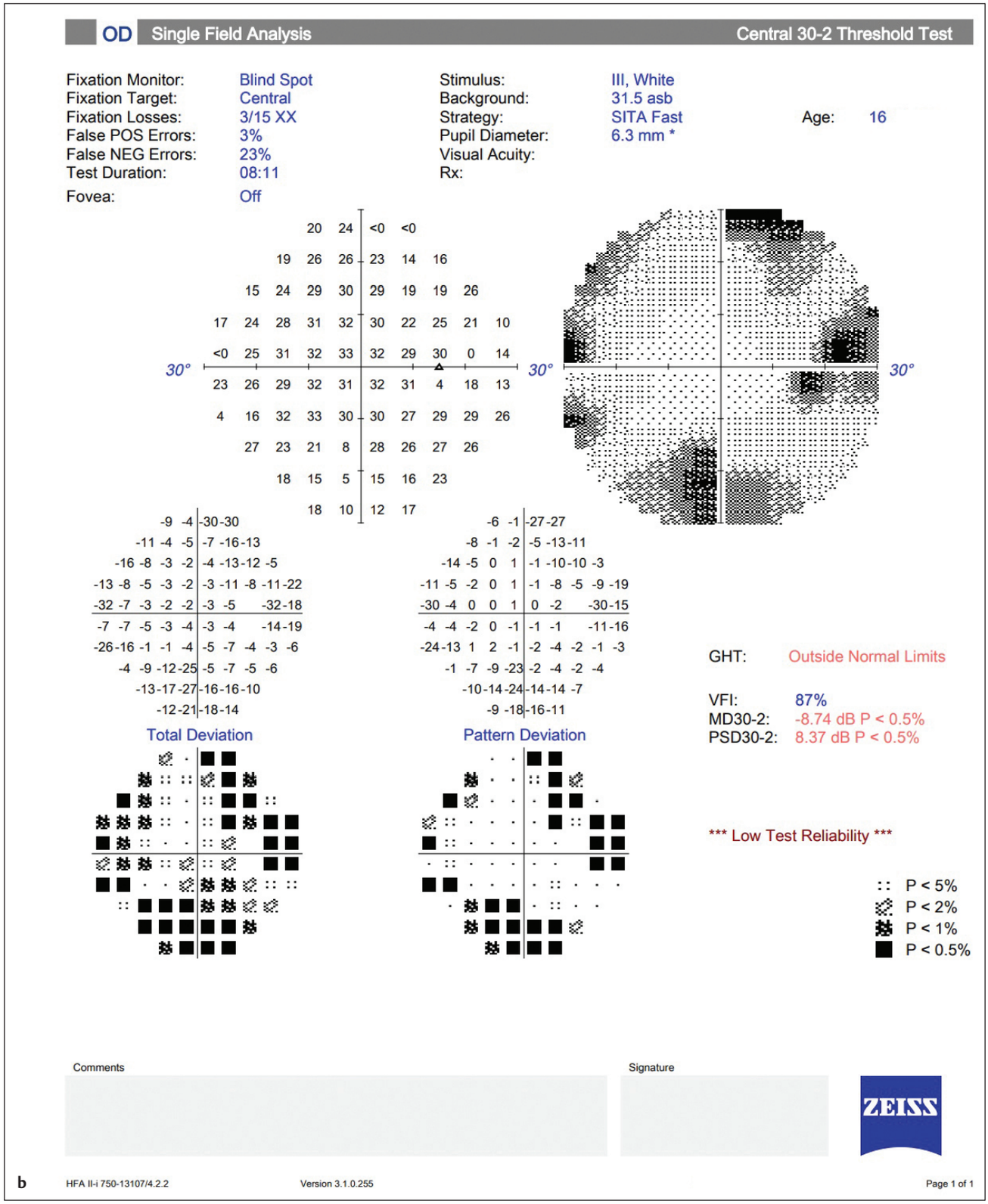


Fig. 4.4 *(Continued)* **(b)** Abnormal points are largely peripheral, and should not be considered in a 30-2 printout. There are high fixation losses and false negative responses, making this an unreliable field.

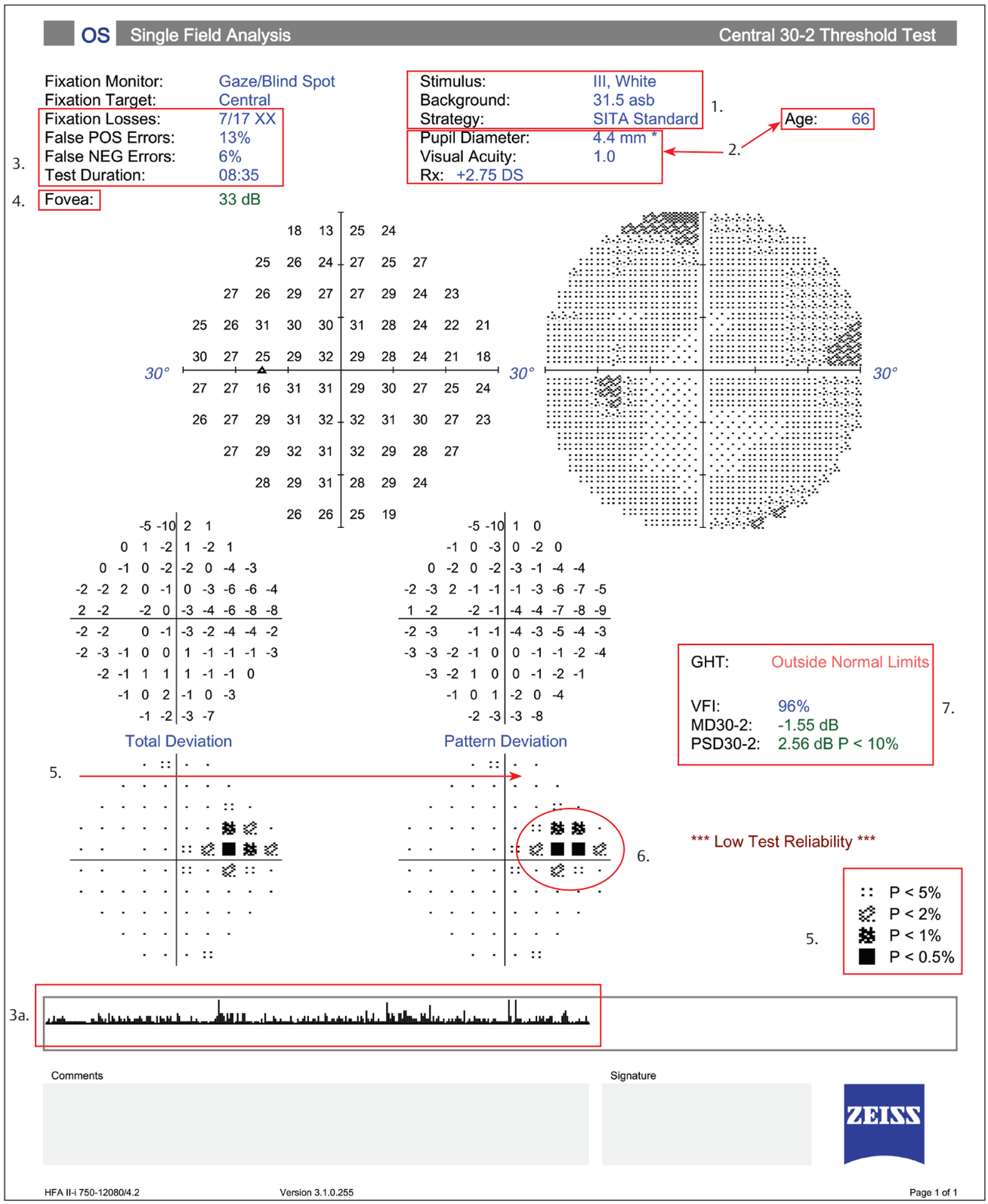


Fig. 4.5 A representative Humphrey field analyzer (HFA) single-field printout. Reliability criteria are met, and the visual acuity and foveal threshold correspond. A cluster of 5 nonedge, contiguous points with one having a probability of being seen in < 1% of age matched normals.

Reliability Parameters

Reliability of the field is quantified by reliability indices generated:

- Fixation losses of >20% render the field unreliable.
- False-positives: Patient responses in the absence of projected stimuli of >15% are marked with an xx as unreliable.
- False-negatives: If a patient records seeing the stimulus at a location initially, but fails to respond a second time to a brighter stimulus shown at the same location, by over 20%, this is considered an unreliable field. However, in advanced glaucoma this is more common and even >30% may still be considered for evaluation.

The test duration, if longer than average, may alert one to the possibility of inattentiveness or fatigue, and hence a less reliable field.

Total Deviation

Total deviation is the difference of a patient's retinal sensitivity at each location tested, compared to an age-matched normative database. The box plot presents one of a group of symbols, indicating whether the sensitivity is within age-adjusted normal limits or has a *probability of being seen in less than 5, 2, 1, or 0.5% of age-matched normal individuals*. This provides an immediate graphical representation of the locations that are abnormal and the degree to which they vary from normal.

Pattern Deviation

Pattern deviation shows retinal sensitivity levels, after the "average" or "overall" sensitivity loss has been subtracted, thereby revealing localized deviations compared to normal age-matched individuals. Pattern deviation plot values are calculated by subtracting the value of the 85th percentile of highest sensitivity deviation from all the values in the total deviation plot. This is achieved by subtracting all values on the total deviation by the 7th highest value, thereby adjusting the whole field. *The pattern of true visual field loss is best seen here by shape and location*. On the probability plot, solid black squares indicate a probability of being seen in less than 0.5% of the normal population, with less dense squares having a lower probability of being abnormal. If the deficit is predominantly localized, the total and pattern deviation plots look virtually identical. However, if the loss is widespread as in the presence of a cataract, abnormalities may be present on the total deviation plot, but the pattern deviation plot could be virtually normal.

Global Indices

Evaluation of perimetric damage is further aided by global indices provided on the printout.

Mean Deviation

Mean deviation on the HFA or mean defect on Octopus perimeters is the average deviation of sensitivity at each test location from age-adjusted normal population values. It indicates the degree of generalized or widespread loss present in the visual field, and is therefore less likely to pick up early, localized loss, and *is only good for assessing moderate-to-severe field loss, −6 to −12 dB.* Normal eyes have an mean deviation value of 0 to −2 dB.

Pattern Standard Deviation (PSD)

PSD on the HFA or loss variance (LV) on the Octopus system is a calculation of the average deviation of individual visual field sensitivity values from the normal slope of the visual field, after correcting for any overall sensitivity differences. It is the sum of the differences between absolute values recorded at each locus and the average sensitivity at each point, calculated by age-matched normal values + mean deviation. PSD is a measure of localized visual field loss or scotomas. A high value indicates an irregular field of vision, while a low value could signify either a smooth hill of vision, or severe visual field loss. *It is only useful in detecting early to moderate loss*.

Glaucoma Hemifield Test (GHT)

GHT compares sensitivity of five clusters of points above and below the horizontal midline which resemble the nerve fiber bundle pattern to identify any asymmetry, a common finding in glaucoma. The GHT summary could read:

- Outside normal limits (ONL): Lower sensitivity than seen in <1% of population.
- Borderline: Lower sensitivity than seen in <3% of population.
- Within normal limits (WNL): No significant difference.
- Abnormally high sensitivity: Higher sensitivity than seen in <0.5% of population.

Visual Field Index (VFI)

VFI provides a means of evaluating visual field loss as a percentage, relative to the sensitivity of an age patched reference group of healthy people. It expresses a comparison of the patient's field status as a percentage of a normal, age-adjusted visual field. *Decreased sensitivity at each locus compared to age-matched normative data is expressed as percentiles. There is greater weightage toward the central field, and the mean of all loci is expressed as a percentage.* Values range from 100% in an age-adjusted normal eye to *0% in one perimetrically blind.* VFI is less influenced by generalized loss seen with a cataract, and can be tracked over time as a measure of progression.

The index is calculated by considering the pattern deviation for defects up to −20 dB and the total deviation for more advanced visual field loss.

Grayscale: It has to be understood that this is an extrapolation of results, so that a general idea of a depression and its location can be seen. On the grayscale, areas of high sensitivity are denoted by a lighter color, and areas of low sensitivity by a darker color. *It cannot be used for diagnosis or assessment of the depth of visual field loss. The clinician should glance at it, but evaluate a field from total and pattern deviation records.*

Gaze monitor: At the bottom of the printout is a graphical representation of corneal movements, that is, loss of fixation or a movement of the head of even 1 to 2 degrees, as an upstroke and loss of pupil visibility, such as by blinking, as a downstroke.

Perimetry should always be correlated with the clinical picture, that is, the optic nerve head findings of the patient (**Fig. 4.6** and **Table 4.2**).

Printouts of Different Perimeters

These can be similarly read. Octopus type perimeter printouts (**Fig. 4.7**) provide the same data under slightly different terminology, with an additional Bebie or cumulative defect curve.

Octopus terminology and matching Humphrey equivalents:

- Catch trials: Reliability indices.
- Comparisons: Total deviation.
- Corrected comparisons: Pattern deviation.
- Mean defect: mean deviation.
- Mean sensitivity: Mean value of all data.
- Loss variance: PSD.
- Reliability factor provides an analysis from 1 to 15%.
- Bebie curve is a cumulative defect curve that ranks any deviation from normal values, providing an indicator of generalized depression of the field or extent of localized loss.

Diagnosing a Glaucomatous Scotoma on Standard Automated Perimetry

On evaluating a visual field, the first step is to determine whether there is a scotoma, and the second is to ascertain the possible causes of the field defect.

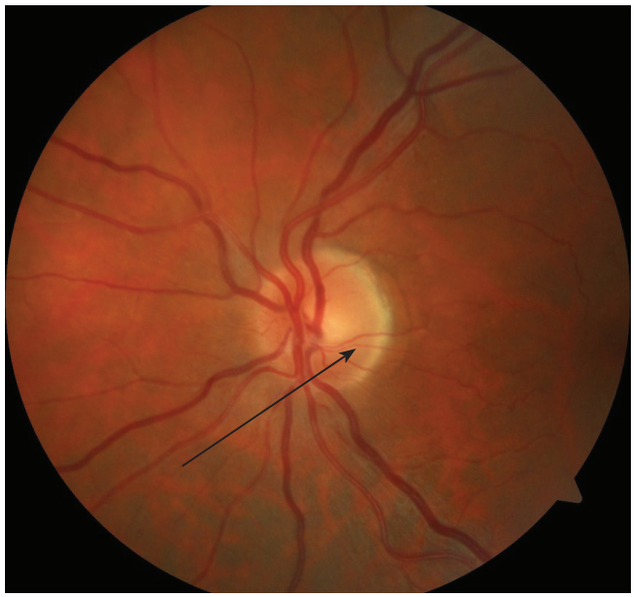


Fig. 4.6 Thinning of the inferior neuroretinal rim more than superior (*black arrow*), correlating with the superior nasal step in the field in **Fig. 4.5**.

Table 4.2 Commonly used perimeters

	Humphrey perimeter	Octopus perimeter
Background illumination	31.5 apostilbs (10 cd/m^2)	31.4 apostilbs (10 cd/m^2)
Luminance for 0 dB	10,000 apostilbs	4,000 apostilbs
Stimulus exposure time	200 ms	100 ms
Spacing of test locations	Equal spacing at 6-degree separation and off-set from vertical and horizontal meridian	Spacing is 2.8 degrees centrally and greater spacing toward the periphery
Strategy	SITA standard: 4-2 bracket process SITA fast: 3-1 bracket process	G-dynamic: 10-2 bracket process G-tendency-oriented perimetry: Interpolation process
Global indices recorded	Mean deviation Pattern standard deviation Fixation losses False-positives False-negatives	Mean sensitivity Mean deviation Standard loss variance Catch trials—positive/negative

Abbreviation: SITA, Swedish interactive threshold algorithm.

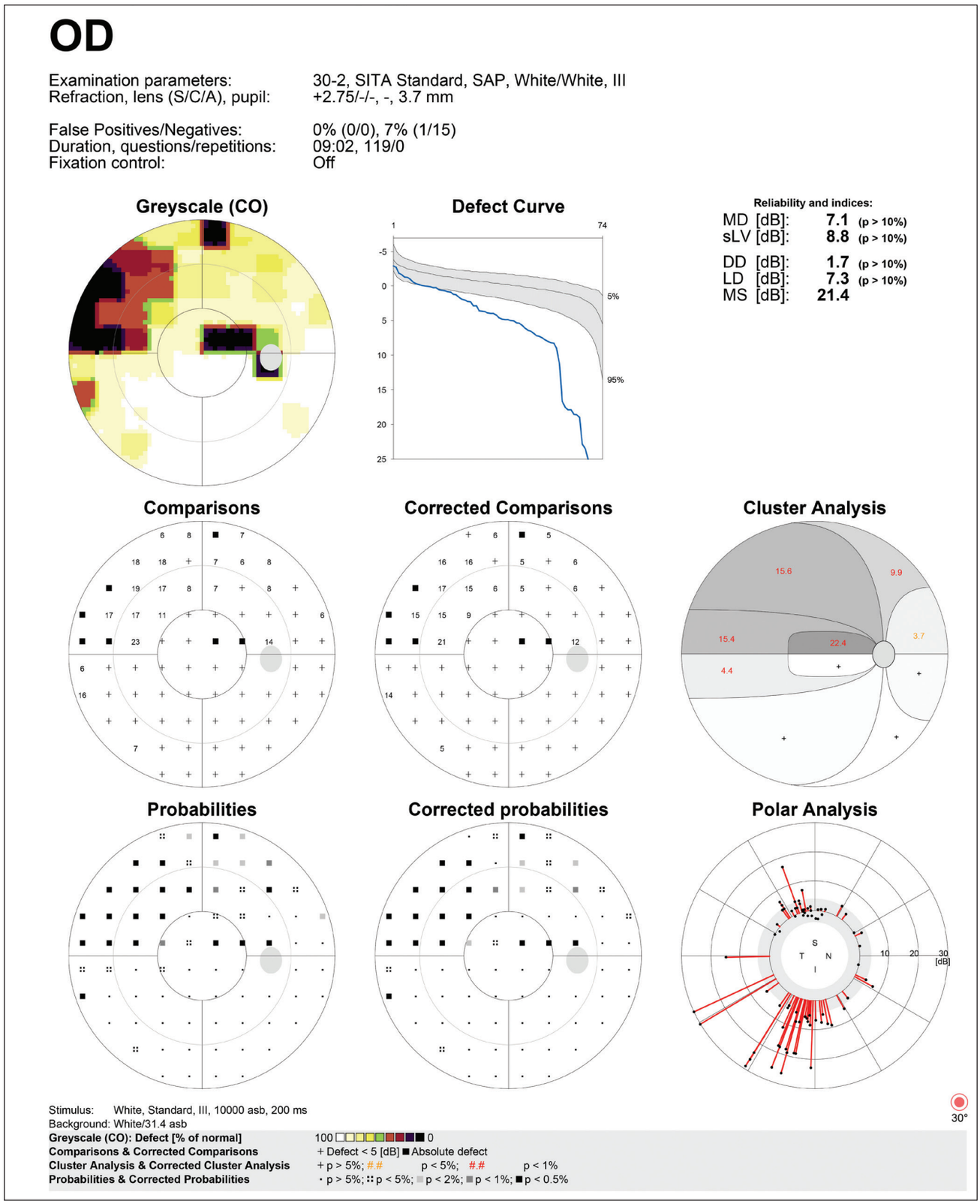


Fig. 4.7 An octopus perimeter single-field printout. False positives and negatives are 0%, with abnormal loci stretching from the blind spot to the superior nasal area. A superior arcuate scotoma is present, with a defect curve showing a largely localised loss. Polar analysis shows the expected loss of neuroretinal rim to be at both poles, inferior more than superior.

Anderson's criteria for the diagnosis of a scotoma is the presence of any of the three below, but the specificity increases if all are present and are reproducible on at least two consecutive fields:

- GHT should be marked as abnormal.
- Three contiguous, nonedge points on the pattern deviation plot within Bjerrum area have a probability of <5% of being seen in a normal population, one of which should have a probability of <1%.
- PSD should have a probability of <5%.

Patterns of Visual Field Loss Seen in Glaucoma

Visual field loss in glaucoma is due to loss of ganglion cells and their axons, which have a specific arrangement in the retina and the optic nerve. Loss of the axons is seen as thinning/notching of the neuroretinal rim, commonly inferotemporal and then superotemporal. *This results in a loss of function in Bjerrum area, that is, 5 to 20 degrees from fixation*. Loss of superficial axonal fibers causes a more central loss—paracentral scotomas—and extension of loss to deeper axons is probably related to formation of a nasal step. More extensive loss of the neuroretinal rim causes an expanding scotoma, arcuate or biarcuate with breakthrough to the periphery, finally leaving only central and temporal islands of vision (**Fig. 4.8**).

Relative paracentral scotomas: These are areas where smaller or dimmer targets are not visualized by the patient but larger or brighter targets are noticed, above or below fixation in Bjerrum area.

Nasal step: The appearance of a cluster of abnormal loci having a horizontal shelf in the nasal visual field is caused by an asymmetric nerve fiber loss at the two poles of the optic nerve.

Seidel scotoma is one that appears to start at a pole of the blind spot arching over the macula, without reaching the horizontal meridian nasally.

Arcuate scotomas also appear to start at the superior or inferior poles of the blind spot and arch over the macular area, widening as they curve down or up, to end at the horizontal meridian nasally.

Double arcuate or ring scotoma: Arcuate scotomas may occur in both hemispheres to form a ring-shaped loss in the midperipheral visual field.

End-stage or near-total field defect: Two arcuate scotomas expand to involve the entire peripheral visual field with only a central and residual temporal island of vision.

At least two consecutive, corroborative fields plotted on different occasions are required before a diagnosis of any glaucomatous loss can be made, as there is often a significant improvement in the field when plotted a second time, as patients become more familiar with the machine and test process, that is, the *learning effect*. *Clustering of perimetry, that is, performing field examinations frequently, initially permits the recognition of a learning effect, while determining reproducible defects, and also the rate of change in a given individual*. All results need to be considered together with clinical examination.

Artifacts on automated perimetry commonly appear as defects in the extreme periphery of a field, or a moth-eaten appearance of a field defect, or appear as diffuse abnormalities in the visual field (**Fig. 4.2**). *Glaucomatous defects are almost always dense and occur within Bjerrum area in defined patterns.*

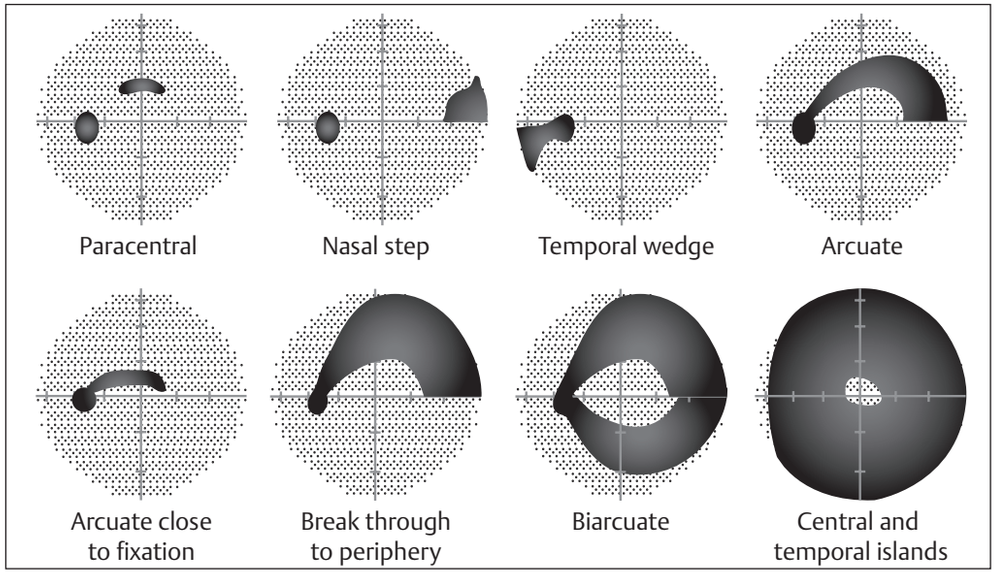


Fig. 4.8 Progression of glaucomatous visual field loss, starting with Bjerrum area in the superior field and progressing to the other hemisphere and peripherally, is frequently seen.

Perimetric Artifacts

Perimetric artifacts are often due to procedural problems or patient-related factors.

Procedural problems could be:

- Incorrect name.
- Incorrect date of birth.
- Patient's head not placed against the bar.
- Use of a lens that is not full field.
- Inappropriate refractive correction for near.
- Pupil not 2 to 4 mm.

Patient-related factors are as follows:

- Inattention over time leading to a "clover leaf" pattern.
- False-positives leading to supranormal thresholds being recorded as a "white-out" field or swiss-cheese pattern.
- Media opacification.
- Irregular refractive surfaces as in keratoconus and posterior staphylomas.

Other ocular or systemic pathology could also appear glaucomatous, such as:

- Medullated nerve fibers (**Fig. 4.9**).
- Chorioretinal scars.
- Diabetic retinopathy.

Nonglaucomatous Causes of an Arcuate Scotoma

An arcuate scotoma is considered to be definitive for glaucoma in the presence of corroborating changes on the optic nerve head and retinal nerve fiber layer. However, other ocular lesions and some along the optic pathway can also result in an arcuate scotoma (**Box 4.1**). These should be kept in mind if a discordance is seen between the field defect and optic nerve head picture.

Illustrating the Reading of a Single Visual Field

A 63-year-old underwent an HFA, 30-2 SITA standard test (**Fig. 4.10**). Visual acuity was 6/6, a near correction was used, and the pupil was 3 mm. Reliability indices showed 10% fixation losses. But the false-positives and false-negatives were nil. The Foveal threshold of 32 dB corresponds with visual acuity. Total deviation values and plot show a significant loss of sensitivity in the superior and inferior nasal area and superior paracentral loss. This is mirrored in the pattern deviation numbers and plot; therefore, there appears to be no significant media opacification, such as a cataract, etc.

Looking at the pattern deviation plot, in the superonasal area, there are three contiguous loci having a probability of being seen in the age-matched normal population of <5% with one likely to be seen in <1% of the age-matched normal population. This substantiates the presence of a scotoma. On identifying Bjerrum area, this scotoma falls within it, and GHT is "outside normal limits," making it likely to be glaucomatous. The pattern of the defect appears to be a definite superior nasal step, and some paracentral loss. The VFI is 91% and the mean deviation, PSD and corrected pattern standard deviation (CPSD), and short-term fluctuation (SF) are all significantly abnormal. These should correlate with the appearance of the optic nerve head in this patient, and will need to be confirmed on the next perimetry. Similarly read, **Figs. 4.11–4.13** show

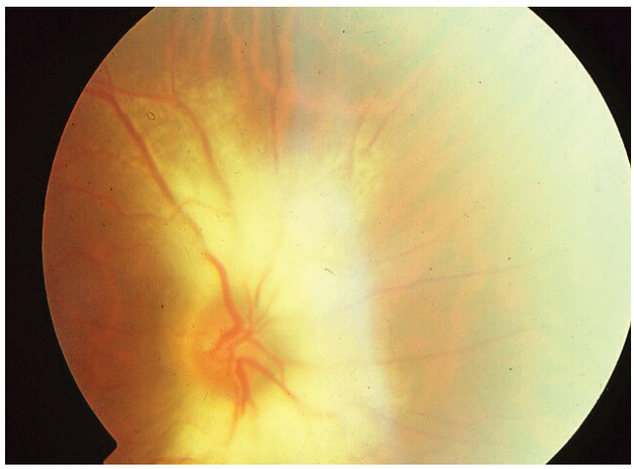


Fig. 4.9 Medullated nerve fibers that would cause an abnormal field.

Box 4.1 Nonglaucomatous causes of an arcuate scotoma

- **Retinal pathology**
  - ◊ Retinal branch vein occlusion
  - ◊ Retinal coloboma
  - ◊ Juxtapapillary choroiditis
- **Optic nerve head pathology**
  - ◊ Anterior and posterior ischemic optic neuropathy
  - ◊ Optic disc pit
  - ◊ Optic disc drusen
  - ◊ optic nerve head dysplasia
- **Central nervous system pathology**
  - ◊ Pituitary tumors
  - ◊ Meningioma—optic nerve, dorsum sella
  - ◊ Internal carotid aneurysms
  - ◊ Opticochiasmatic arachnoiditis

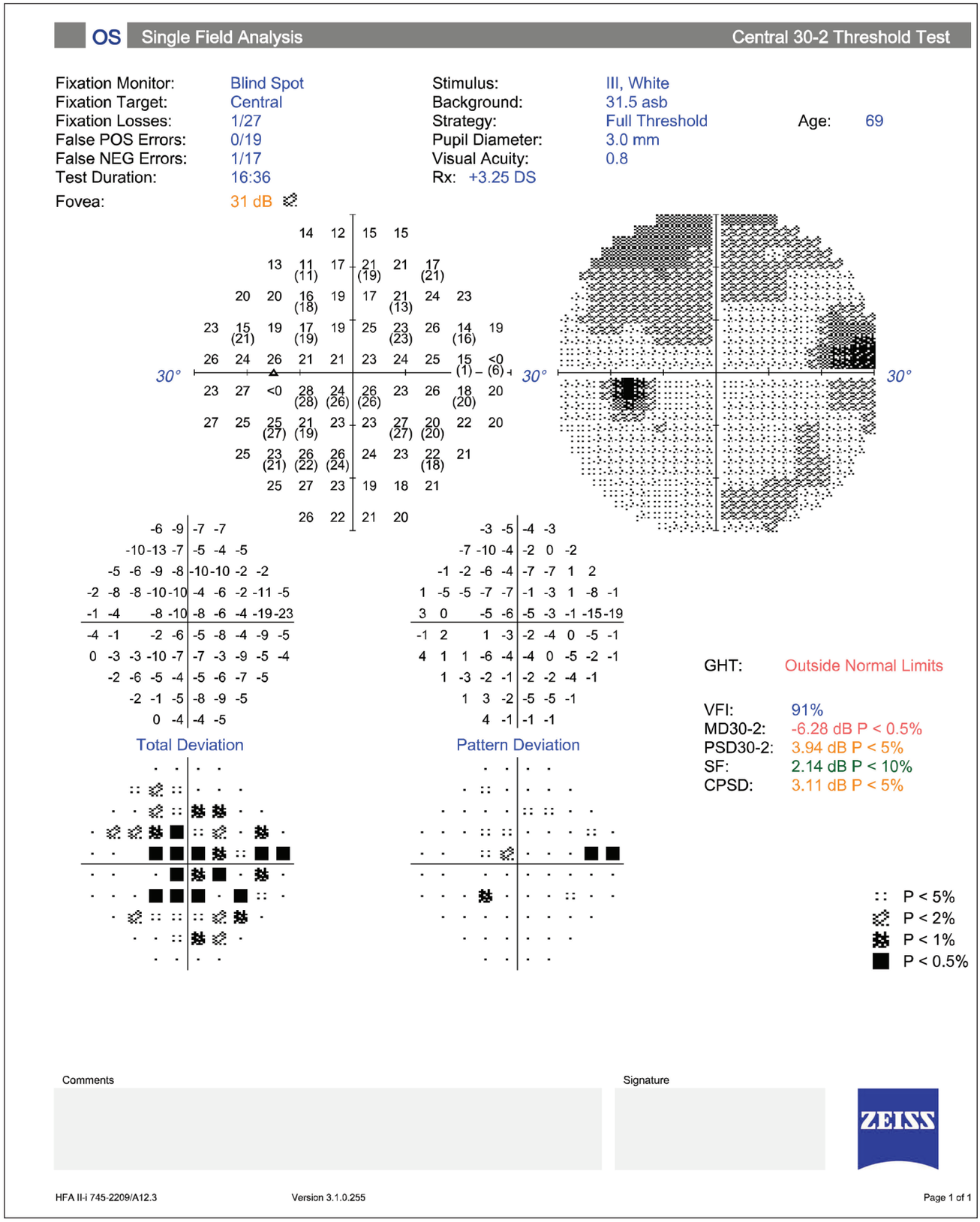


Fig. 4.10 Humphrey field analyzer (HFA). Fixation losses are 10%. Superior nasal step, with other scattered depressed loci in the paracentral area are seen. This needs to be reproduced in the next field done.

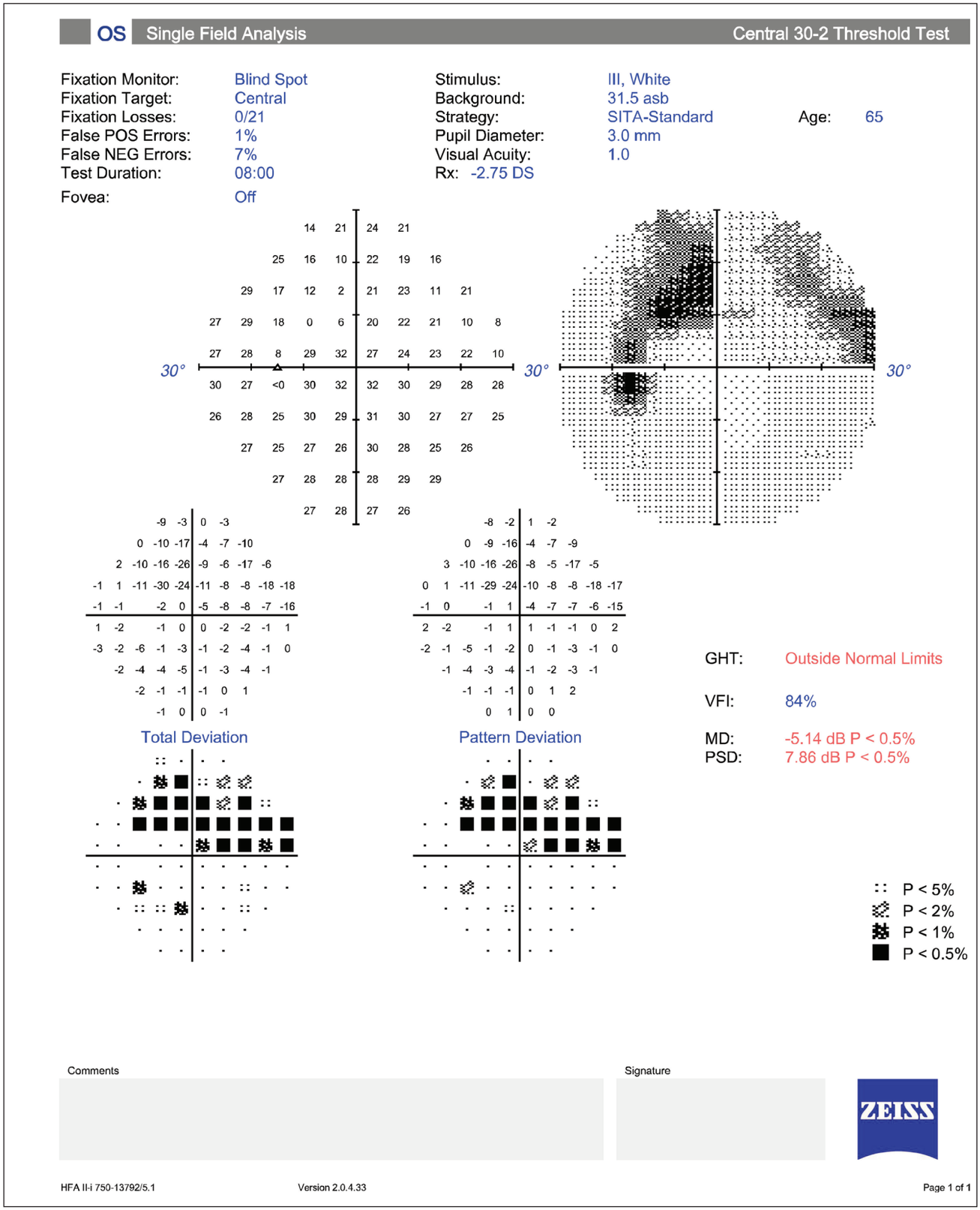


Fig. 4.11 Reliable field. Superior arcuate scotoma. An additional 10-2 field may provide information about any central loss.

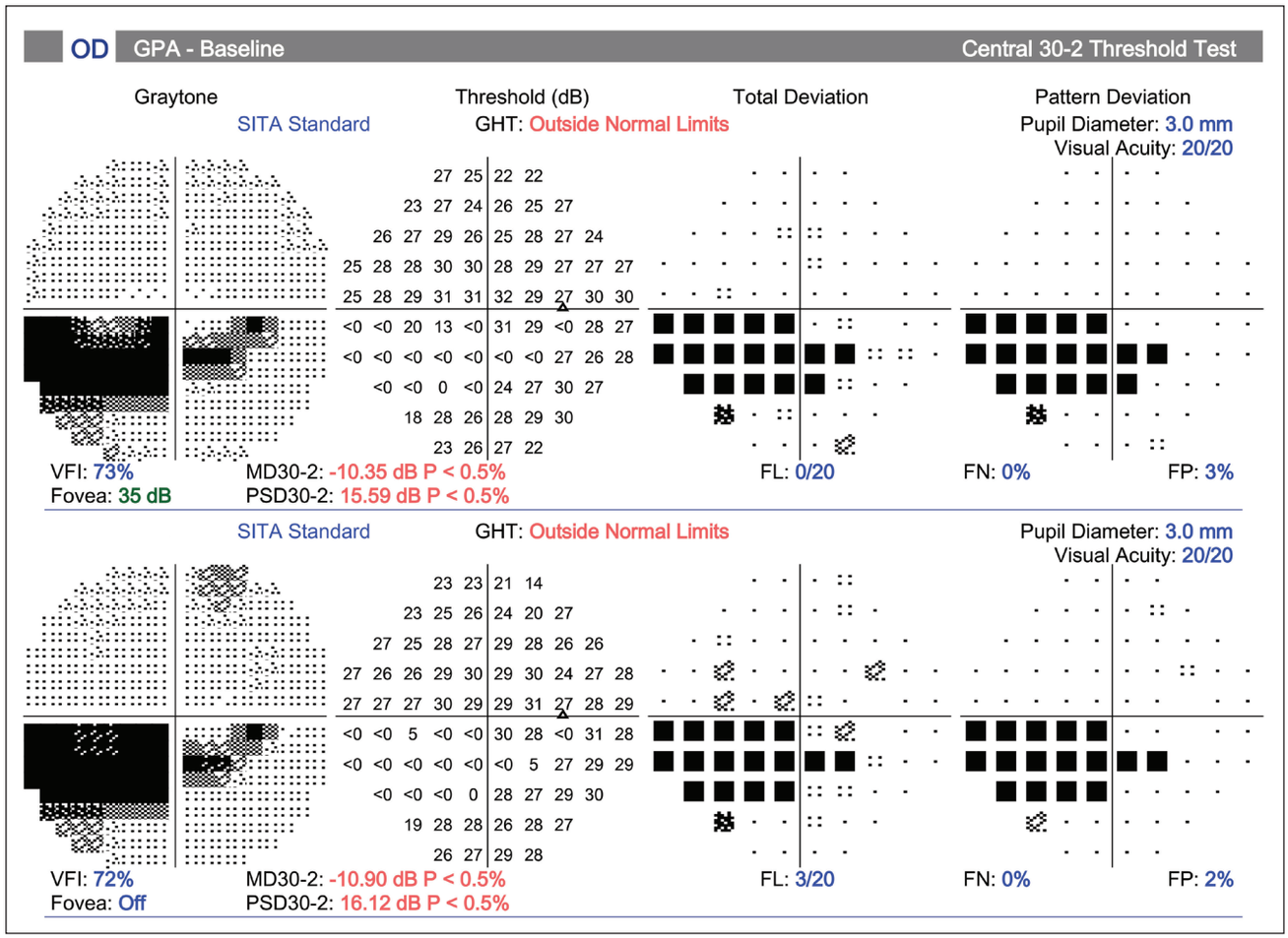


Fig. 4.12 Reliable field. Inferior arcuate scotoma encroaching central 5 degrees and extending to the periphery. This was reproduced on consecutive fields and should also have a 10-2 field done.

reliable and reproducible fields. **Fig. 4.14** shows the better appreciation of central 10 degree filed loss with a 10-2 or central 5 degrees with a macula program.

Newer perimetric techniques for glaucoma include microperimetry or fundus-tracked perimetry for the central field, perimeters that provide a standard automated field and optical coherence tomography confocal images at the same time to correlate changes, and a free iPad app, e.g., Melbourne Rapid Fields test, which uses a moving fixation target in order to increase the field area to test up to 30 degrees of field. Many inexpensive, lightweight, mobile virtual reality goggles, and software are also being evaluated.

Diagnosing progression on perimetry is very important, and will be discussed in the chapter on Progression.

Perimetry records a subjective response of the patient and could be influenced by fatigue, stress, and attentiveness of the patient. The search for an objective measure of visual function continues. Optical coherence tomography, multifocal visual-evoked potentials (VEPs), multifocal pupillographic objective perimetry, and a brain–computer interface using Goggle for objective assessment of the field are currently being evaluated. The advent of artificial intelligence and automated algorithms will dramatically change perimetry in the near future.

Currently, standard automated perimetry remains the gold standard for assessing and quantifying visual field loss, but it is commonly complemented by detection of optical coherence tomography changes. Some perimeters now provide a combined printout for glaucoma, including optical coherence tomography and fundus photography, separately and as an overlay.

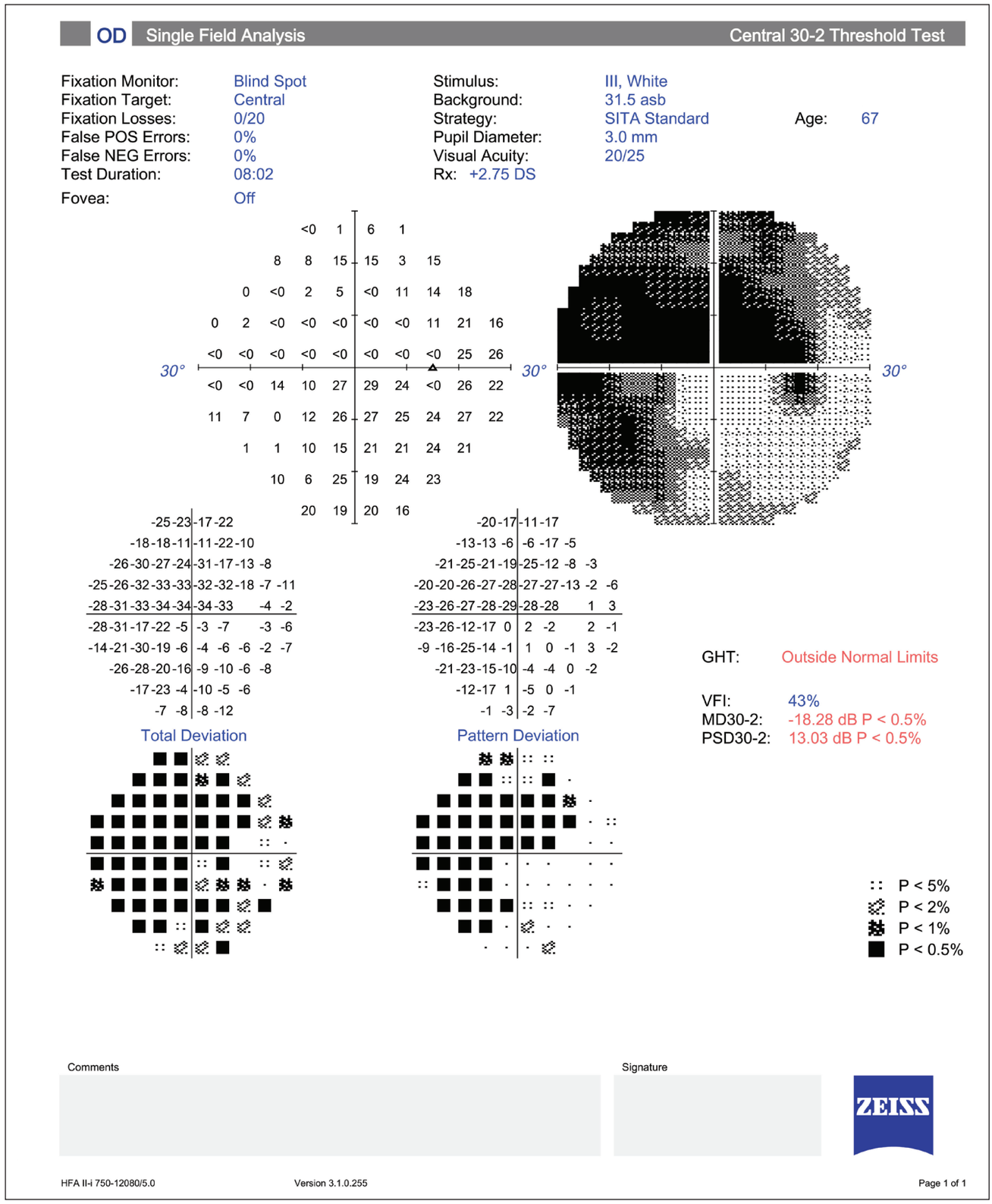


Fig. 4.13 Reliable field. Superior arcuate scotoma breaking into the periphery, with involvement of the central 5 degrees and a large inferior nasal step.

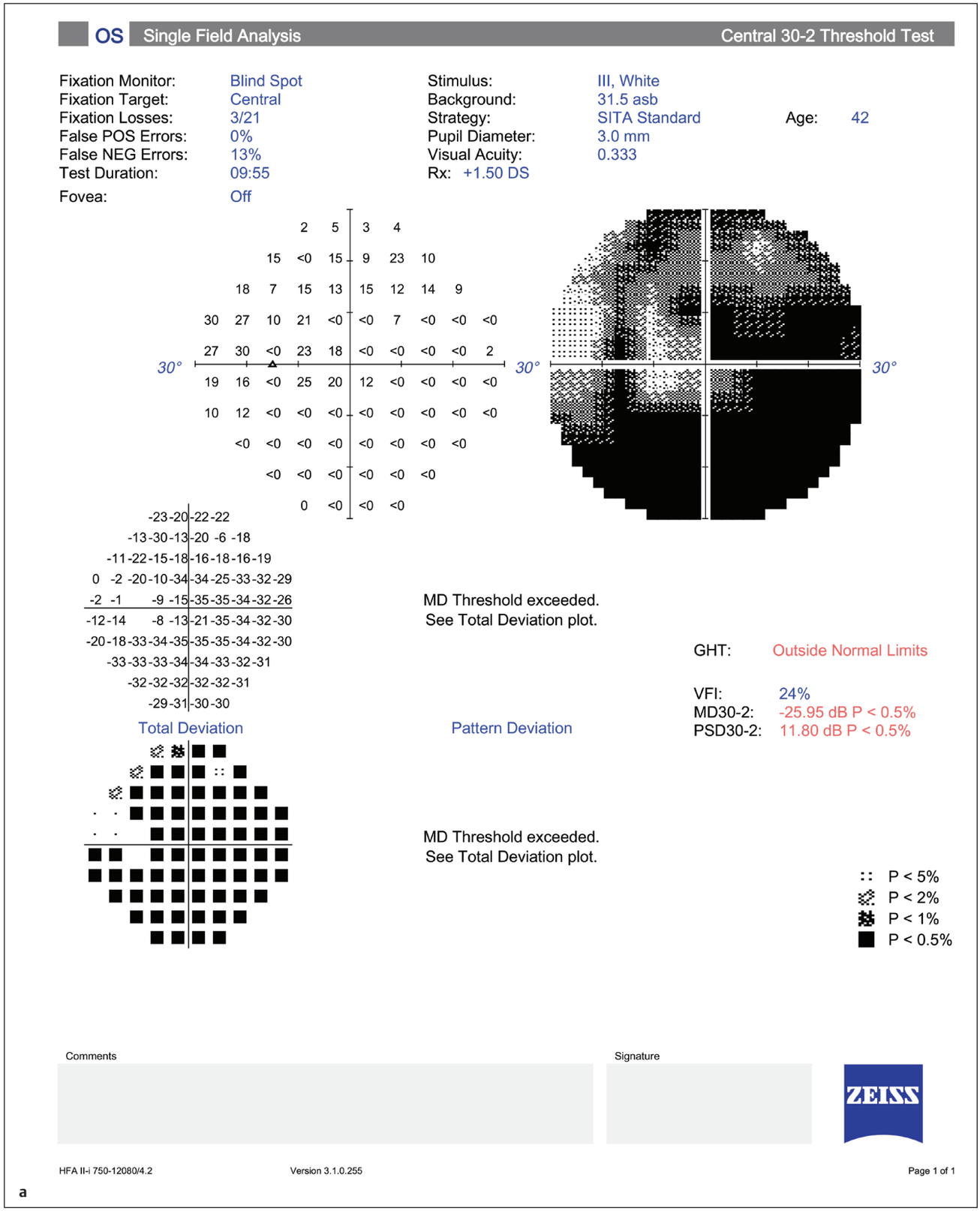


Fig. 4.14 **(a–c)** Better appreciation of central 10 degree field loss with a 10–2 or central 5 degrees with a macula program. *(Continued)*

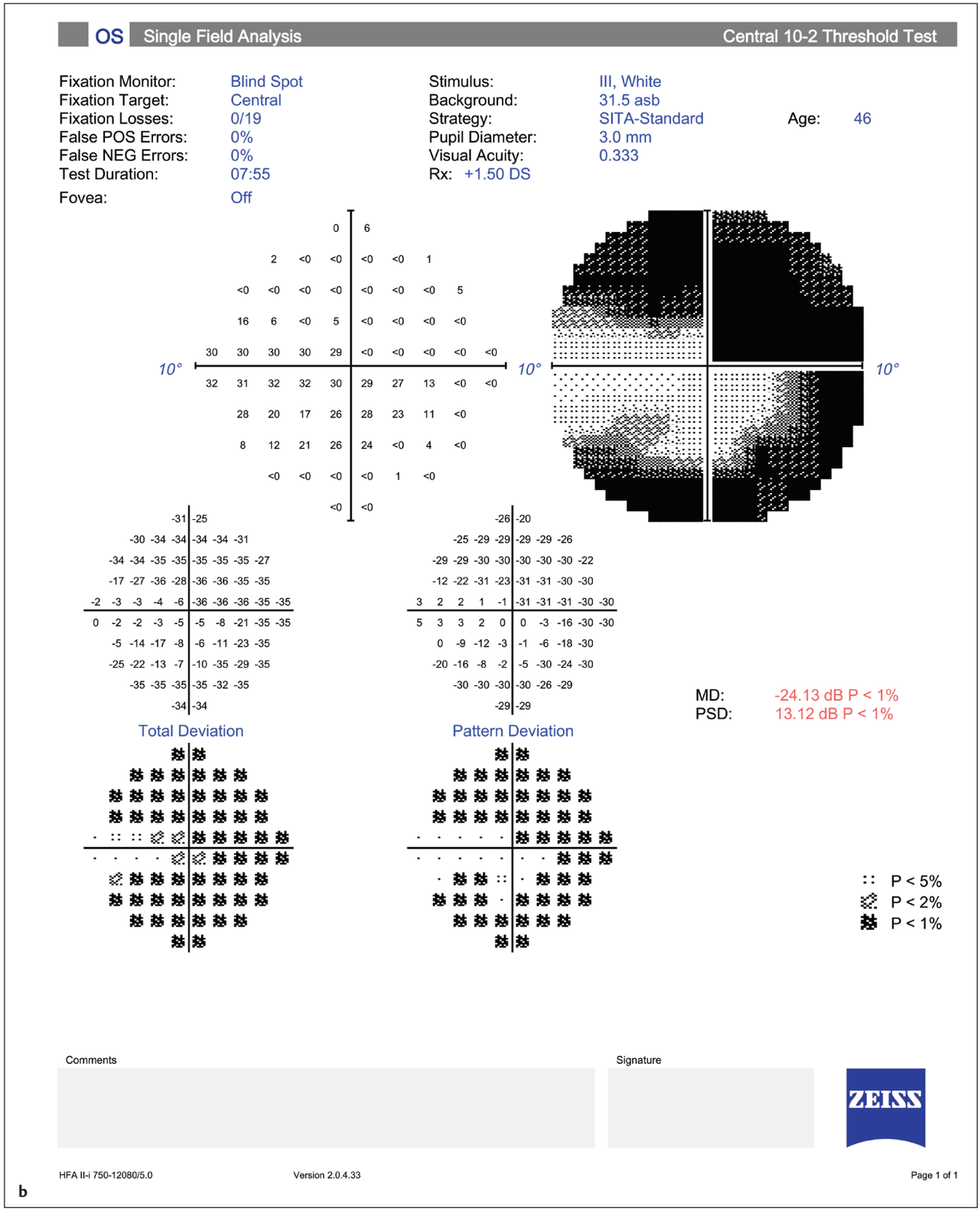


Fig. 4.14 *(Continued)* **(a–c)** Better appreciation of central 10 degree field loss with a 10–2 or central 5 degrees with a macula program.

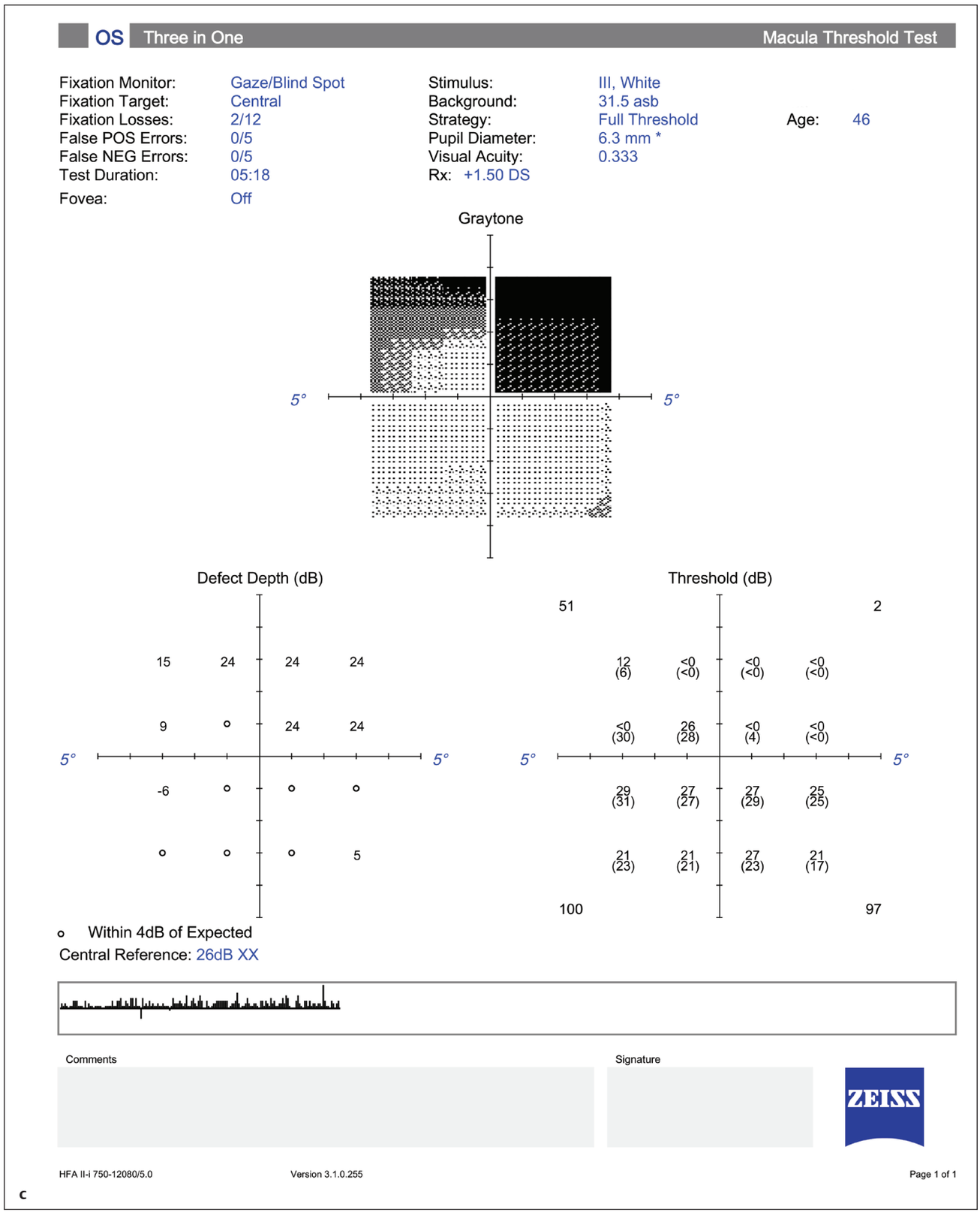
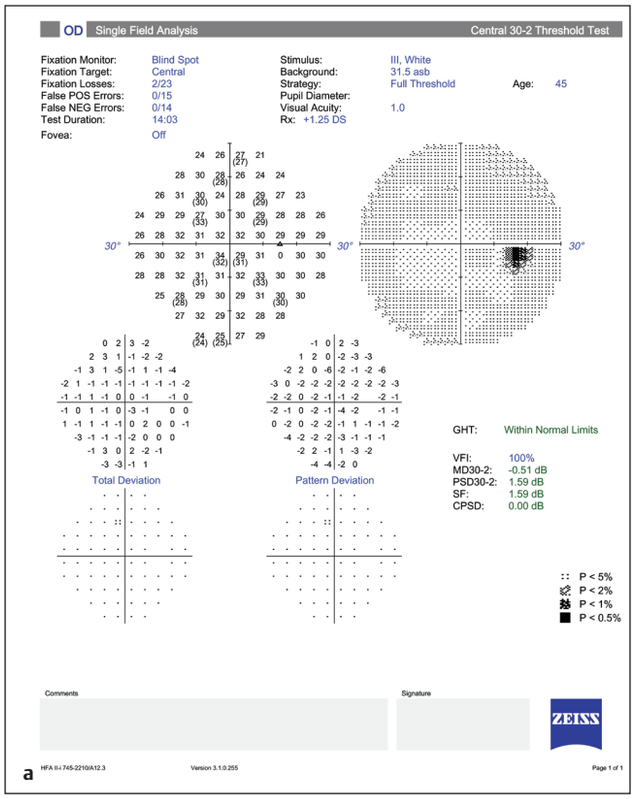


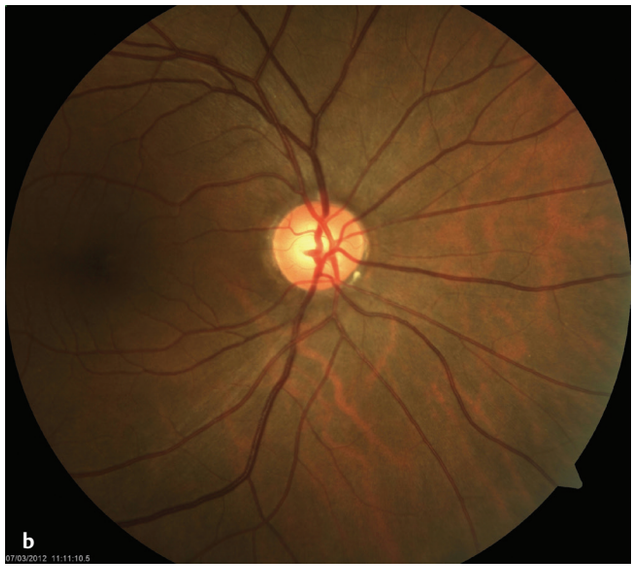
Fig. 4.14 *(Continued)* **(a–c)** Better appreciation of central 10 degree field loss with a 10–2 or central 5 degrees with a macula program.

Cases

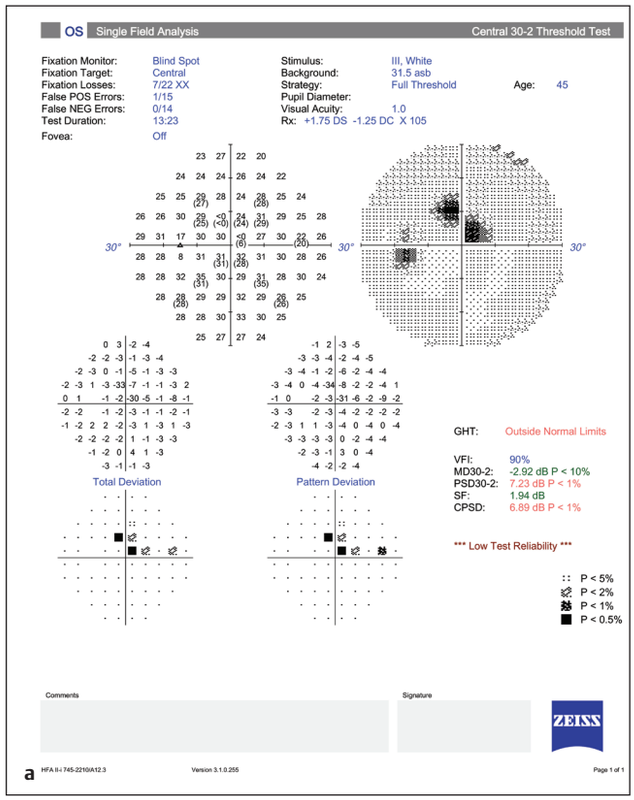
Case 1

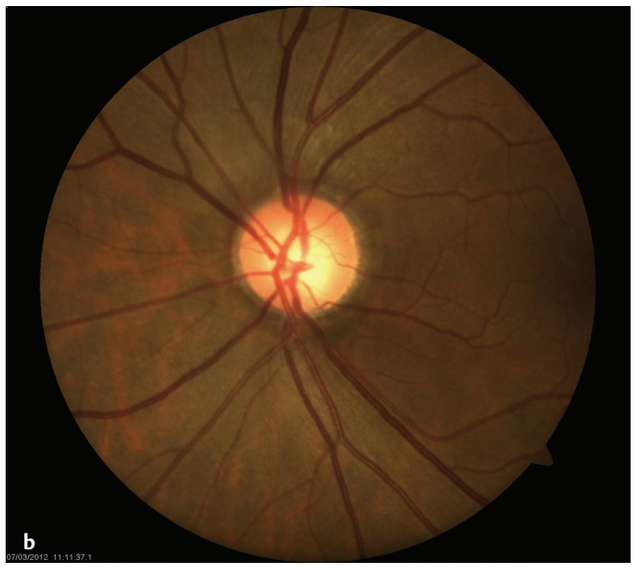
A 62-year-old patient with a suspicion of primary open-angle glaucoma (POAG) due to a cup:disc ratio of 0.6 and 0.7, and intraocular pressure (IOP) of 24/26 mm Hg, underwent perimetry. The right eye VFI is 100%, and mean deviation and PSD are within normal limits. There are no loci having a significant loss of sensitivity. This corresponds with the optic nerve head picture of thinning of the neuroretinal rim inferiorly but no focal or generalized loss (**Cases 1-1** and **1-2**).





Case 1-1 **(a, b)** Perimetry within normal limits corresponding to the optic nerve head picture of thinning of the neuroretinal rim without neuroretinal rim loss at any point.





Case 1-2 **(a, b)** Left eye of the same patient. Humphrey field analyzer (HFA) shows a superior arcuate scotoma, and the optic nerve head photograph reveals a corresponding loss of neuroretinal rim from 4 to 6 o'clock.

The other eye of the same patient has a significant Seidel or early arcuate scotoma on pattern deviation plot, VFI of 92%, mean deviation of −2.43, and PSD of 5.76. Even though it corresponds with the focal loss of neuroretinal rim between 5 and 6 o'clock positions, fixation losses are high. The field is therefore unreliable, and would need to be repeated to reach a final diagnosis.

Point to consider

- Always look at both ONHs, as an asymmetry of >0.2 in cup:disc ratio or a loss of neuroretinal rim in either eye is probably glaucomatous, and this would be reflected on perimetry.

Diagnosis and Management

The patient underwent a gonioscopy and the angle was found to be wide open with a normal trabecular meshwork. A diagnosis of POAG with mild visual field loss was made and a target IOP range of 15 to 17 mm Hg was decided upon.

Case 2

A 50-year-old lady with a cup:disc ratio of 0.6 in the right eye and 0.5 in the left underwent a perimetry on HFA. Her fields showed a severe loss on total deviation plot and a possible inferior nasal step on pattern deviation plot in the left eye (**Case 2-1**).

Point to consider

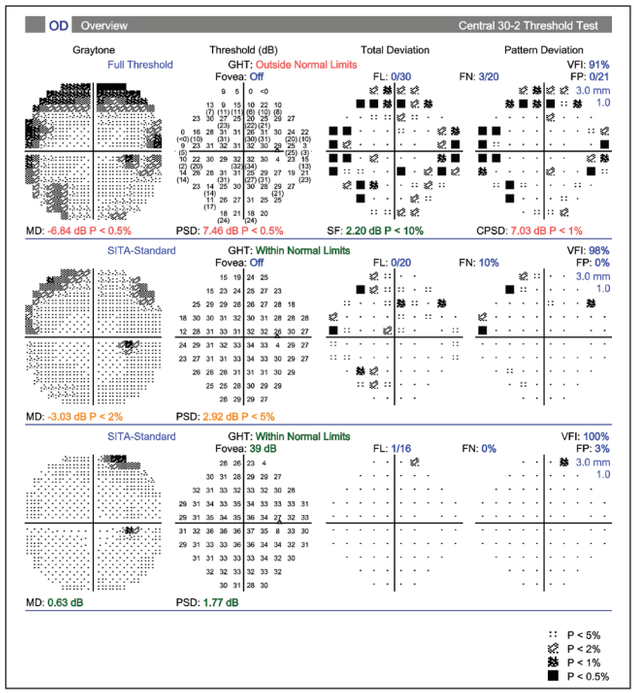
- As the left optic nerve head was grossly normal and did not correlate with the field, this was probably an artifact or "learning effect."

Diagnosis and Management

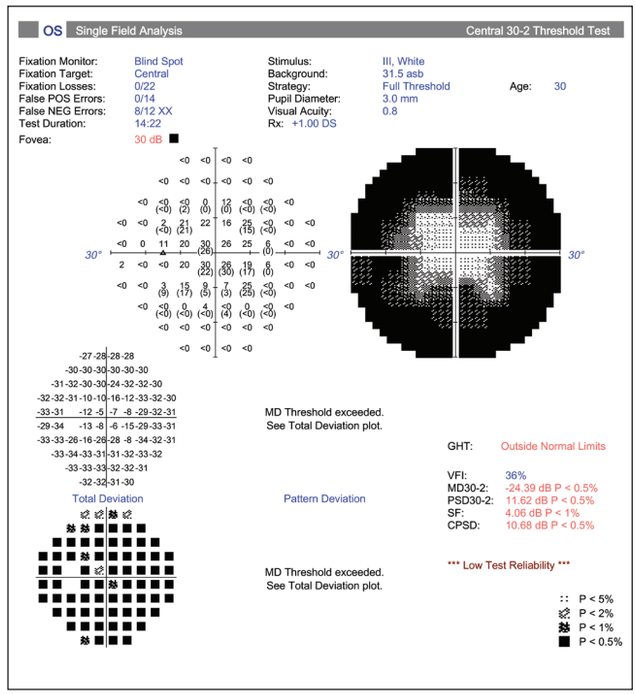
Perimetry was repeated twice and the last total and pattern deviation plots did not show any defect.

Case 3

A 59-year-old lady presenting with a gradual painless diminution of vision was found to have a normal anterior segment, cup:disc ratio of 0.7:1 in both eyes with inferior neuroretinal rim thinning, and an open angle. Diurnal phasing IOPs ranged from 14 to 22 mm Hg, and perimetry showed severely depressed points scattered and in the periphery of the 30-2 field of the left eye (**Case 3-1**).



Case 2-1 Humphrey visual fields—learning effect. **(a)** The first shows many points of decreased sensitivity on total deviation plot and few on the pattern deviation plot. **(b)** The second field had fewer depressed points on both total and pattern deviation plots, while the third field had no non edge depressed loci.



Case 3-1 Partial clover leaf pattern on perimetry, suggesting inattention after the first cardinal points were recorded and an unreliable field.

Points to consider

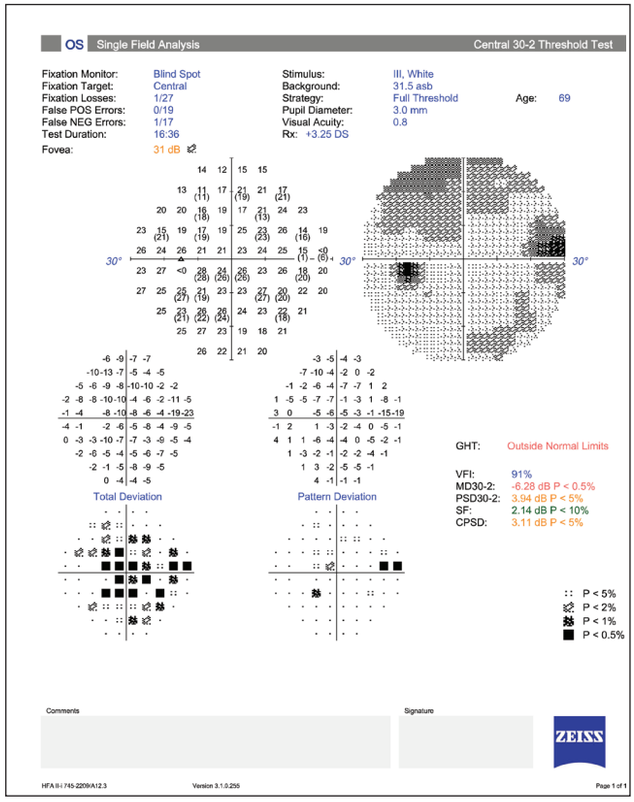
- Perimetric defects having scattered defects suggest inattention after the first four cardinal points were recorded.
- It was thought to be an unreliable field, and needs repitition.

Diagnosis and Management

A repeat perimetry revealed a "moth-eaten" appearance of peripheral defects not within Bjerrum area. A third perimetry in 1 to 2 months was advised, as all of the clinical parameters were within normal limits.

Case 4

A 70-year-old lady is being followed up for her POAG over the last 5 years. Her fields show an apparent progression, despite IOPs of 10 to 12 mm Hg (**Case 4-1**).



Case 4-1 A Humphrey field analyzer (HFA) single-field report total deviation plot showing a diffuse, moth-eaten appearance of depressed points, while the pattern deviation highlights a superior nasal step only. Diffuse loss due to a posterior subcapsular cataract was responsible for the discrepancy.

Point to consider

- The last field shows a total deviation plot depressed in significantly more loci than pattern deviation plot. This could mean that media opacification, probably a cataract, was causing the increased generalized depression of fields, and mistakenly diagnosed as progression.

Diagnosis and Management

On examination a posterior subcapsular cataract was seen. A repeat perimetry after cataract surgery showed an improvement in central points.

Case 5

A 12-year-old boy with a family history of glaucoma underwent perimetry. His fields showed scattered loci of significant abnormality in both total deviation plots (**Case 5-1**).

Point to consider

- There is no normative data for children in the Humphrey machine.

Diagnosis and Management

There were large areas of "white-out" in the fields, and the significant loci are highlighting difference between normal to supranormal responses. A kinetic perimetry was done, and was normal.

Case 6

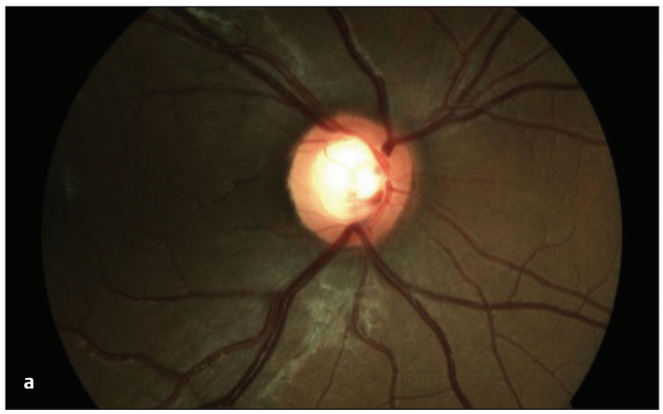
A 70-year-old male underwent cataract surgery, and was then diagnosed to have advanced glaucoma on perimetry. It showed a superior hemispheric loss with inferior nasal step in the right eye and an inferior arcuate scotoma with a superior paracentral defect in the left (**Case 6-1**). His children were concerned about his safety while driving.

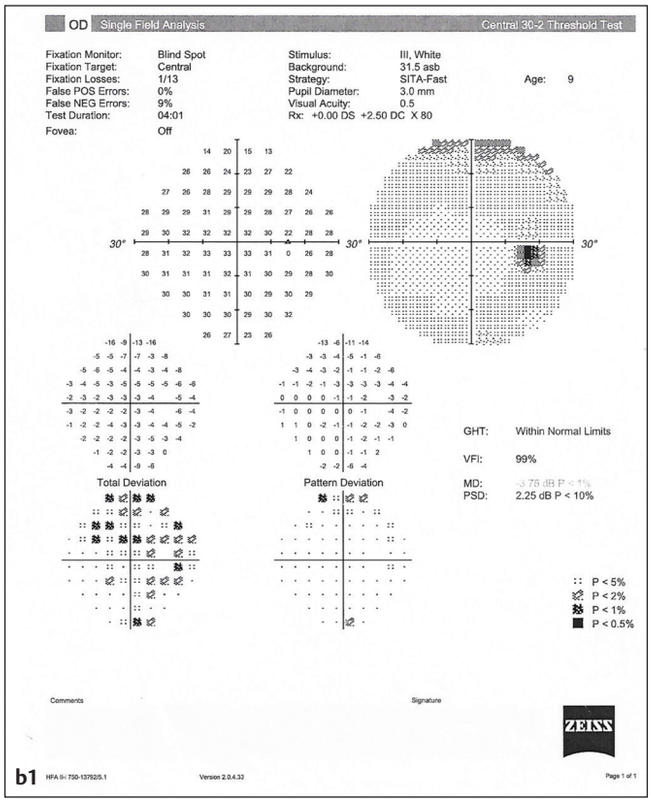
Point to consider

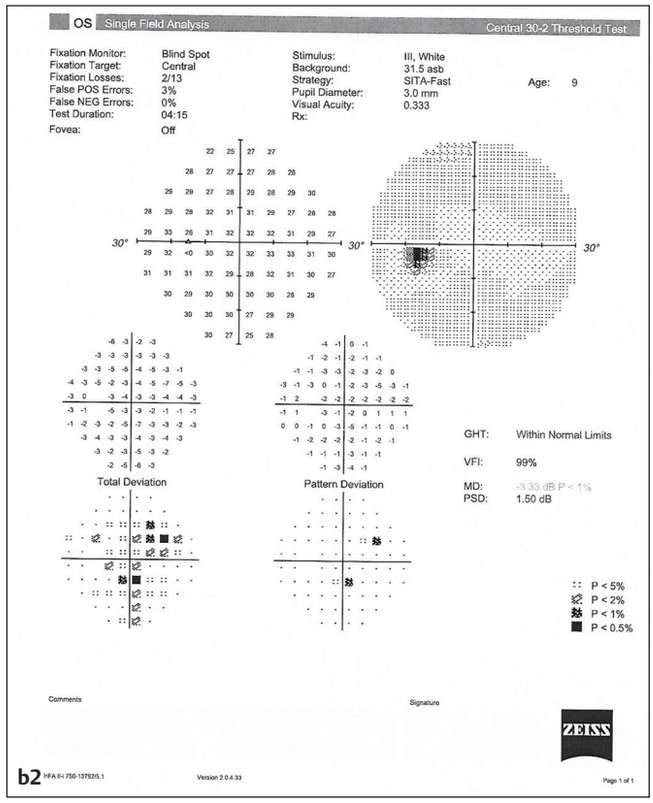
- There are severe defects in each eye which could affect visibility within the field of vision. However, uniocular fields overlap, and the binocular status could be almost normal.

Diagnosis and Management

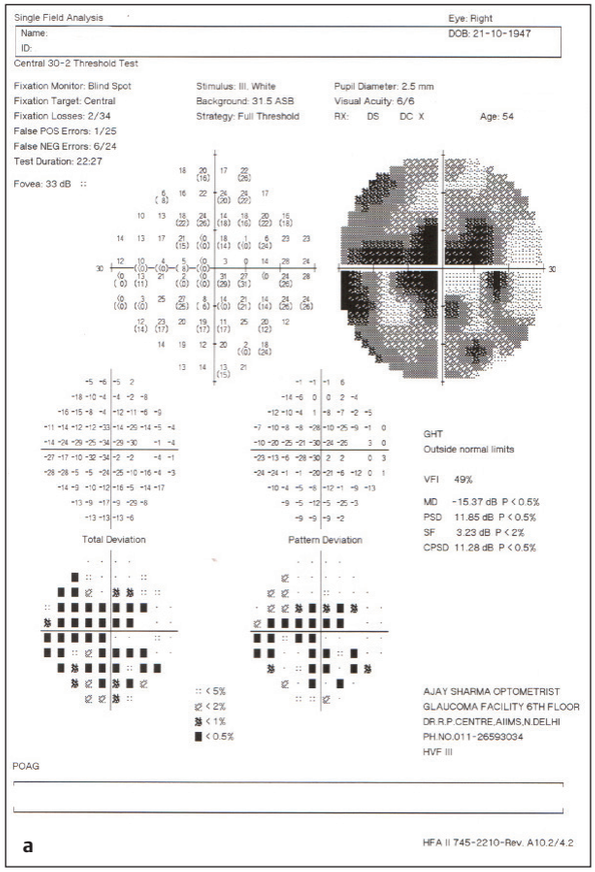
An Esterman binocular field was done and showed some defects, but only in the periphery, suggesting that the patient could be a safe driver for now.

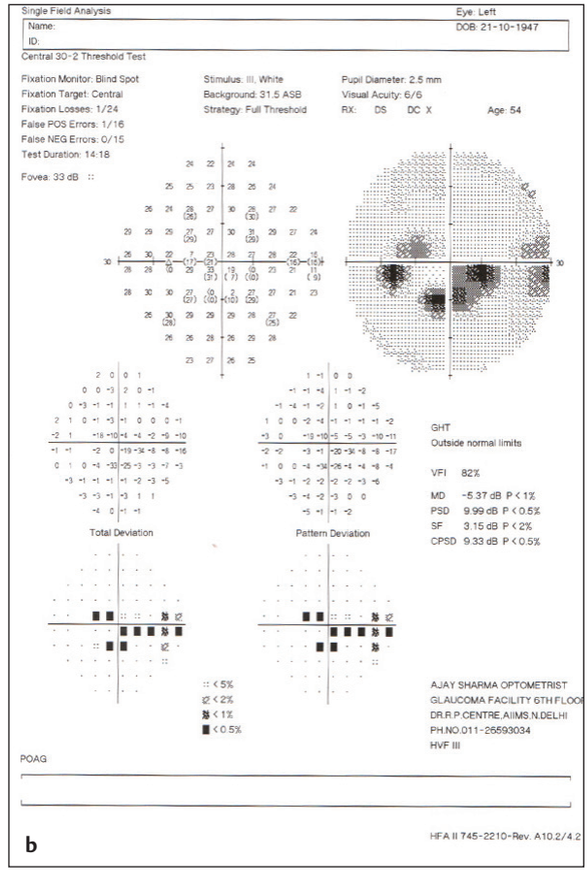


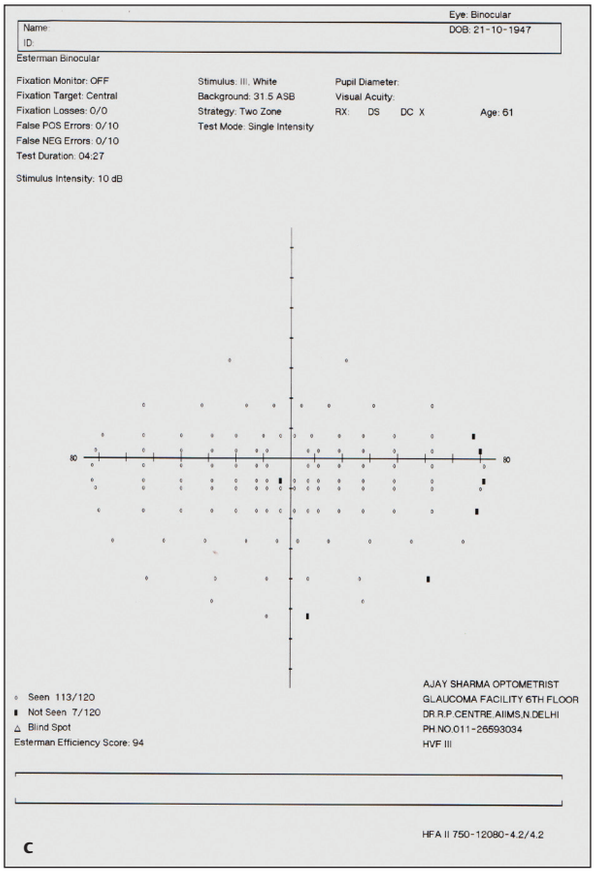




Case 5-1 **(a)** Fundus photo of the right eye showing a cup:disc ratio of 0.6 with a regular, normal colored neuroretinal rim. **(b)** Humphrey field analyzer (HFA) field showing scattered defects on total deviation plot but none on pattern deviation. The grayscale shows a central area of more widely spaced dots—"white-out" areas signifying supranormal sensitivity, with the patient pressing the buzzer even when stimulus was not seen, a "trigger happy" patient. There is no normative data for a 12-year-old.







Case 6-1 (a–c) The right eye field has a largely superior field loss, and the left eye has more defects inferiorly. The Esterman binocular field shows scattered areas of loss only in the periphery.

Suggested Readings

Bengtsson B, Heijl A. A visual field index for calculation of glaucoma rate of progression. Am J Ophthalmol 2008; 145(2):343–353

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