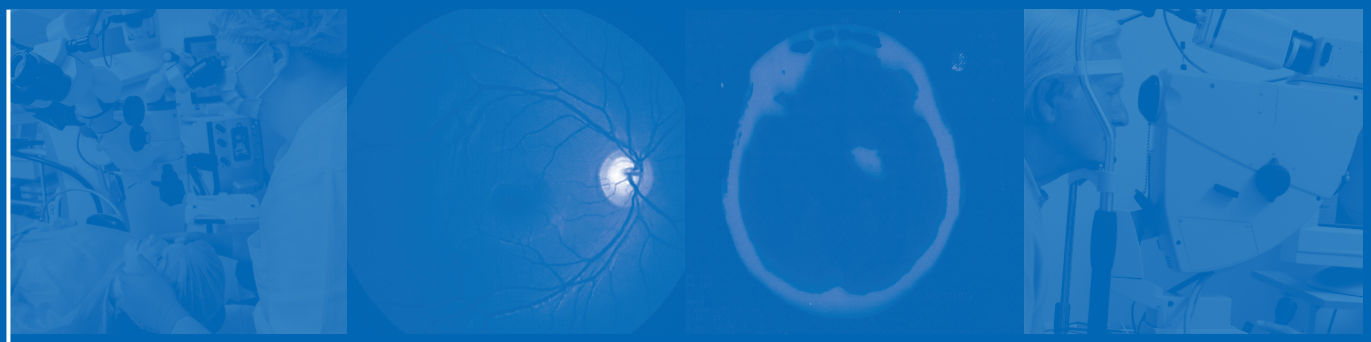

GLAUCOMA PRACTICE PEARLS

A Case-based Approach for Diagnosis and Management

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Preface

Dr. Ronnie George
Deputy Director,
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Glaucoma is a major cause for blindness in India. Given the limited resources available in diagnosing and managing the large number of those with undetected disease is a challenge. From many surveys done in the country that we know about, almost all persons with glaucoma are asymptomatic till late in disease. Therefore, every person who has an eye examination for any reason could potentially have the disease. The only thing that we might do to reduce the number of undetected cases would be by improving case detection rates in those who have an eye examination for any reason. The general ophthalmologist has a very important role in this regard since they are the first specialist the patient comes in contact with.

With this background, Allergan had launched an initiative that targeted a practical approach to the diagnosis and management of glaucoma. Instead of a top down approach of glaucoma specialists deciding on content a survey of general ophthalmologists across the country was done asking what specific areas in glaucoma management they would like to focus on. Since glaucoma specialists, who are actively involved with teaching and training, have valuable insights into the common questions asked at different meetings this was a group that was critical to working on these topics. To ensure that input was available from different regions of the country, zonal groups of glaucoma experts were made who recorded cases in their area. These clinical cases were then reviewed and refined by a core committee of glaucoma specialists in line with the overall objectives. This process required a number of workshops done across the country with active participation from many glaucoma specialists. In order to increase the reach and also provide a handy clinical reference a select group then worked on the material with extensive support from Springer Healthcare to convert this material to a book form. At every point a conscious effort was made to make the material clinically relevant with illustrative case scenarios.

This was only possible with extensive support from Allergan, both for the workshops and the content development. All the participants at every level contributed generously of their time, expertise and material in addition to help refine the process to achieve the objective. Special mentions to Dr. Nagaraj Malipatil who drove the entire process and made this project happen.

I hope the handbook proves to be a useful aid in helping manage our glaucoma patients.

SECTION 1

- Glaucoma Overview and Indian Scenario

1

Glaucoma Overview and Indian Scenario

TAKE HOME MESSAGES

- Elevated intraocular pressure is the precipitating factor for glaucoma.
- Glaucoma is usually asymptomatic in early stages and can be detected via a comprehensive eye examination.
- Glaucoma is diagnosed in only 8% cases and improving diagnosis and awareness can help in disease detection and compliance rates while reducing ocular morbidity.

GLAUCOMA: AN OVERVIEW

Glaucoma is a group of eye diseases, characterized by elevated intraocular pressure (IOP), in which optic nerve damage causes visual field (VF) loss and potentially permanent blindness; early diagnosis being crucial.

INTRAOCULAR PRESSURE AND GLAUCOMA

- The most important factor in glaucoma is elevated IOP.
- Normal IOP ranges between 10 mmHg and 21 mmHg, and in 50% cases of open-angle glaucoma (OAG), it is not unusual to see 'normal' baseline IOP.
- In primary OAG (POAG), though drainage angle appears anatomically normal, aqueous drainage is faulty.
- In angle-closure glaucoma (ACG), the drainage angle is visibly abnormal. An acute attack may present with severe pain, blurred vision, halos around lights, headache, nausea, or vomiting and requires immediate treatment, as blindness can occur within hours.
- There are other types of glaucoma like exfoliation glaucoma, pigmentary glaucoma, lens-induced glaucoma, neovascular glaucoma, and regardless of the cause and type, IOP reduction is as yet the only proven treatment to slow glaucomatous damage.

RISK FACTORS

It is important to note that, while some individuals may be at higher risk for glaucoma, no one is exempted from the risks. This is why regular eye examination is critical. Some common risk factors associated with glaucoma are mentioned in Table 1.

FACTS AND FIGURES

Glaucoma is the most common optic neuropathy, the second common cause of blindness, and the most common cause of preventable visual disability. Globally, there is disparity in distribution, as well as type of glaucoma (Table 2).

GLAUCOMA: THE INDIAN SCENARIO

Most studies in India have brought up different incidences in the rural and urban setting. Blindness is defined based on visual acuity (VA) rather than VFs, and so there is a chance that most surveys underestimate glaucoma blindness (Table 3).

Table 1: Risk factors for glaucoma.

Primary open-angle glaucoma	Angle-closure glaucoma
Age >60 years	Women
Hypertension	Older age
Type 2 diabetes	Asian descent
Hypothyroidism	Family history of myopia
Trauma to the eye	Small eyes
Severe myopia	Farsightedness
Previous eye surgery	

Table 2: Global prevalence of glaucoma.

- Global estimate for 2020 is 60.5 million for primary open-angle glaucoma (POAG) and 79.6 million for primary angle-closure glaucoma (PACG), respectively.
- Glaucoma causes 8.4 million cases of irreversible bilateral blindness.
- In the United States, 2.9 million people have glaucoma, accounting for 9–12% blindness.
- Half of the world's glaucoma population resides in China, India, and Pakistan.
- Primary open-angle glaucoma is the predominant glaucoma in North America, Europe, Australia, Tanzania, and South Africa.
- There is an equal prevalence of PACG and POAG in Mongolia, Singapore, China, and India.

Challenges in the Indian Setting

The Indian subcontinent faces some challenges which are unique to developing countries. Some of the commonly-faced challenges by the Indian doctors are mentioned below in Table 4. Better diagnosis and greater awareness about the disease could result in better disease detection rates and patient compliance.

A poll done during a conference has revealed interesting practice patterns among glaucoma specialists and non-glaucoma specialists (Table 5).

Table 3: The Indian context.

- The 2019 LV Prasad Eye Institute-Glaucoma Epidemiology and Molecular Genetics Study (LVPEI-GLEAMS), showed the prevalence of primary open-angle glaucoma (POAG) to be 1.07%, primary angle-closure (PAC) suspect 2.03% and PAC 1.77% and primary angle-closure glaucoma (PACG) 0.21%.
- As per the National Blindness Survey in 2001, glaucoma was accounted as the third major cause of blindness reporting 5.9% blind cases (Visual acuity [VA] <6/60). This was thrice the incidence in 1986.
- Approximately, 12 million Indians are affected by glaucoma, of which 1.2 million are blind from the disease.
- The Aravind Comprehensive Eye Survey (ACES) Study (2003) reported 1.7% patients >40 years of age with POAG in rural South India.
- The Chennai Glaucoma Study (2008) in urban South India reported an incidence of 3.5% glaucoma cases.
- The Chennai Glaucoma Study and ACES highlighted the problem of undiagnosis as 90% cases were diagnosed only at the time of survey (98.6%—The Chennai Glaucoma Study and 93%—ACES).

Table 4: Challenges in India.

- Glaucoma is largely managed by general ophthalmologists in India.
- Not all ophthalmologists have access to all the equipment in glaucoma diagnosis and management.
- Over 90% cases in India are undiagnosed as compared to 40–60% cases in developed nations.
- As per the ACES, only 45% undiagnosed patients have had an eye examination in the past.
- Awareness of glaucoma is very poor; only 1% rural population in The Andhra Pradesh Eye Diseases Survey (APEDS) was aware of glaucoma.
- Compliance rates for medication are poor.

Table 5: Practice patterns of ophthalmologists.

- Glaucoma specialists routinely use indentation gonioscopy (65%), non-Goldmann-style applanation tonometers (28%), and non-contact tonometry (17%).
- Fewer non-glaucoma specialists use Goldmann applanation tonometry (GAT) and four-mirror gonioscope.
- Glaucoma subspecialists use more glaucoma imaging than general ophthalmologists.
- Optical coherence tomography (OCT) is most preferred due to wider availability and greater versatility.
- Non-glaucoma specialists were less likely to perform laser iridotomy in primary angle-closure disease or use anti-fibrotics while performing filtration surgery.

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SECTION 2

- Glaucoma Diagnosis
- Intraocular Pressure Measurement
- Optic Disc Examination
- Gonioscopy
- Visual Field Examination
- Optical Coherence Tomography
- External Examination of the Eye

2

Glaucoma Diagnosis

TAKE HOME MESSAGES

- History should be an integral part of primary interaction with patient and must be revisited after clinical examination.
- A comprehensive eye examination, including slit-lamp, applanation tonometry, gonioscopy, and dilated evaluation of the optic nerve head is the basic process for a good glaucoma diagnosis.

Undetected glaucoma, followed by irreversible loss of vision, is a far greater cause for concern as compared to glaucoma *per se*. Although a positive family history of glaucoma is helpful in suspects, a negative history does not rule out the incidence of glaucoma, mostly due to the fact that 80% cases are usually undiagnosed. Specifically, questions regarding refractive error, systemic hypertension, migraine, pseudoexfoliation syndrome (PXF), diabetes, and smoking should be asked.

FOCUS ON HISTORY

- Glaucoma is a chronic condition and can be detected during routine eye examination.
- History should be an integral part of primary interaction with patients and must be revisited after clinical examination.
- Possible risk factors in history should be looked out for in case of a glaucoma suspect.

Clinical examination should focus on signs suggestive of mechanisms responsible for raised intraocular pressure (IOP) and/or optic nerve head (ONH) damage.

FAMILY BACKGROUND

- A positive family background in an individual with suspicious ONH or raised IOP, adds to the probability of glaucoma diagnosis.
- Enquire about glaucoma specifically using local terms for the same.
- Do not restrict only to parents and offspring but enquire about grandparents, siblings, and first degree relatives also.

MEDICAL HISTORY

- Conditions that have relative risk like diabetes mellitus (DM) and hypertension.
- Conditions that could explain progression like sleep apnea, Raynaud's disease, shock, hypotension, and migraine.
- Chronic illnesses requiring use of steroid drugs like rheumatoid arthritis (RA), asthma, allergic bronchitis, ocular or systemic allergies, autoimmune disorders, etc.
- Systemic conditions that may affect choice of treatment like cardiac and pulmonary disease.

DRUG HISTORY

- Drugs that may increase IOP, mainly steroids in any form, even in skin ointments or inhalers.
- Specifically enquire about the use of "alternative medicine" as they may contain steroids.
- Drugs that may cause pupillary block or forward shift of lens-iris diaphragm like sulfa drugs, alfa antagonists, antidepressants, anticonvulsants, etc.

OCULAR HISTORY

- Conditions which can elevate IOP as a consequence of inflammation like uveitis, trauma, previous ocular surgeries including cataract surgery, and retina surgery (silicone oil).
- History of refractive surgery

Content supported by Dr. Manish Panday, Director, Glaucoma, Ratan Jyoti Netralaya, Ophthalmic Institute and Research Centre, Gwalior

PERSONAL HISTORY

- Personal habits like yoga, pranayama, smoking, and alcoholism.
- Playing wind musical instruments like flute, clarinet, etc.

FOCUS ON CLINICAL EXAMINATION

The clinical diagnosis of glaucoma requires a comprehensive eye examination including slit-lamp, applanation tonometry, gonioscopy, and dilated evaluation of the ONH. Automated perimetry is suggested in case of glaucoma suspicion. Apart from evaluating any functional damage, it acts as a baseline for follow-up. Imaging may not be mandatory for diagnosis, but is definitely essential in following the case and monitoring treatment efficacy (Fig. 1).

Four Essential Elements of Clinical Examination in Glaucoma

1. Intraocular pressure measurement
2. Angle assessment
3. Slit-lamp examination
4. Disc assessment

Intraocular Pressure Measurement

- Intraocular pressure should be measured, preferably, by Goldmann applanation tonometry (GAT); if this is not available, 2–3 measurements should be taken with available tonometer at intervals to confirm IOP reading.
- Intraocular pressure varies at different times hence, time should be recorded.
- Central corneal thickness (CCT) should be measured in all cases, as it affects IOP reading.

Angle Assessment

- The Van Herick grading of anterior chamber (AC) indicates occludable angles but not angle status.
- Peripheral chamber thickness ≤1/4 corneal thickness indicates narrow angles.
- Gonioscopy is the only way to view and know status of angle (Fig. 2, Video 1).

Slit-lamp Examination

A comprehensive slit-lamp examination should be conducted, looking out for signs of conditions which could cause increased IOP:

- Signs of inflammation and trauma, like synechiae and subluxated lens.
- Krukenberg's spindles on corneal endothelium.
- Exfoliative material on pupillary border or anterior surface of lenticular capsule.
- Silicone oil in AC (Fig. 3).

Look Out For:

- Iris pattern and color.
- Pupil size and reaction, for any afferent pupillary defect.
- Anterior subcapsular opacities (Glaukomflecken) and subluxation.

Disc Assessment

- Dilated fundus examination is mandatory.
- Best tool for optic disc assessment is slit-lamp binocular microscopy.
- If available, colored and red-free fundus photos should be obtained.
- Physiological cupping and glaucomatous and non-glaucomatous discs should be differentiated (Fig. 4).

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Access Video 1: Basics of Gonioscopy

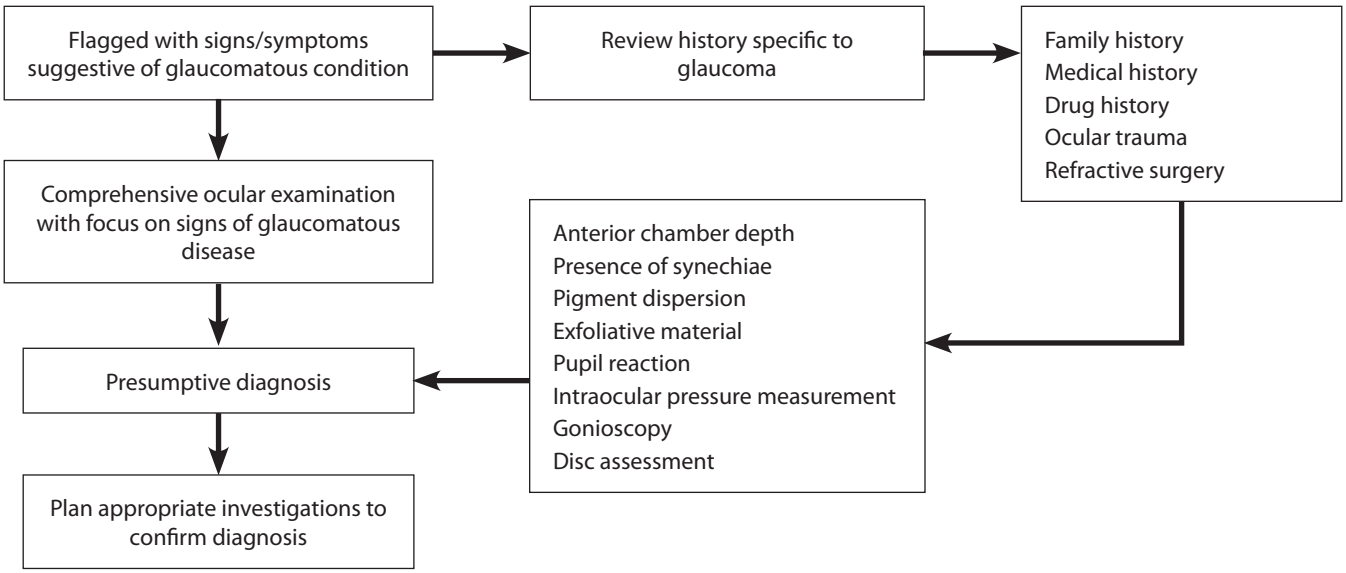

Fig. 1: Flowchart showing the diagnostic process of glaucoma.

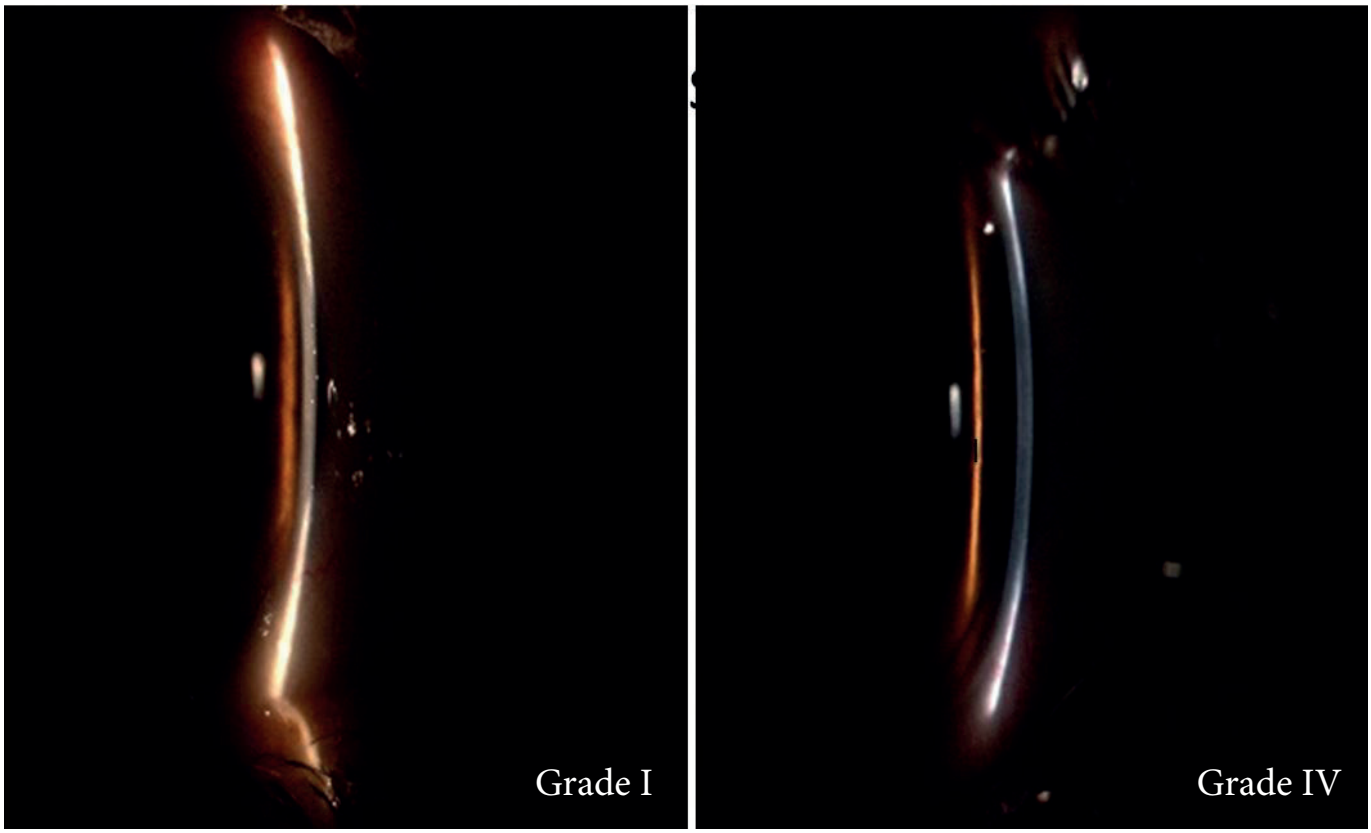

Fig. 2: Gonioscopy showing grades of angle.

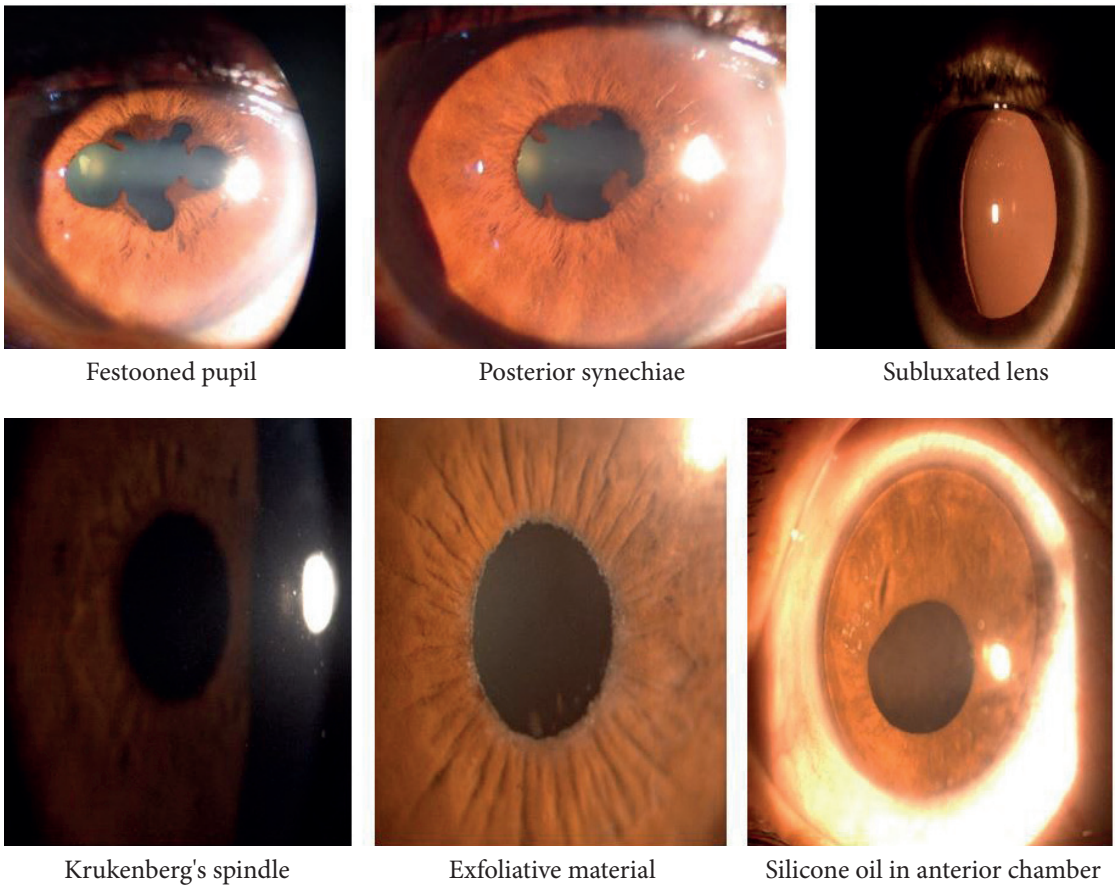

Fig. 3: Signs to look for during slit-lamp examination for increased intraocular pressure.

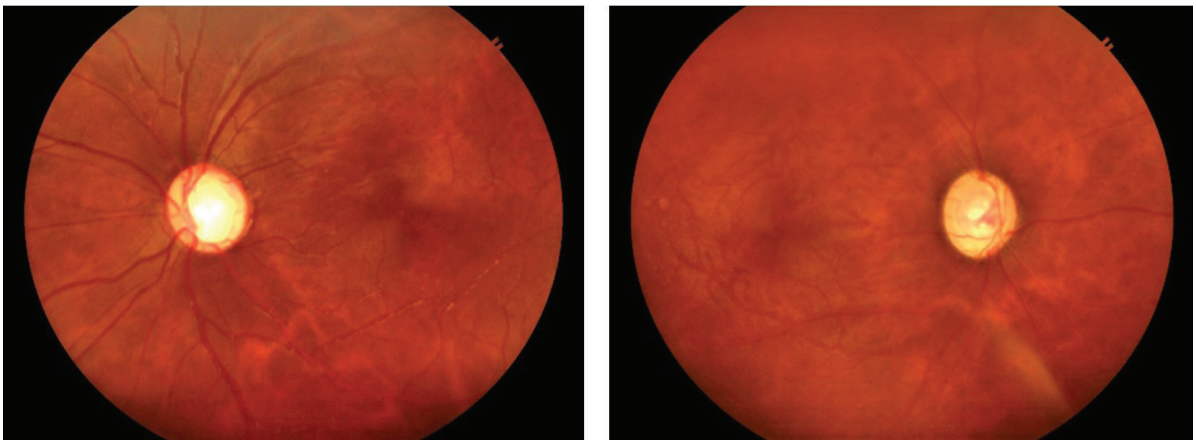

Fig. 4: Glaucomatous and non-glaucomatous cupping.

3

Intraocular Pressure Measurement

TAKE HOME MESSAGES

- Intraocular pressure should be measured at every visit.
- Goldmann applanation tonometer is the gold standard.
- A target intraocular pressure should be determined for each patient, based on disease stage, risk factors for progression, visual disability, and life expectancy.

INTRAOCULAR PRESSURE

Intraocular pressure (IOP) should be measured at every visit. While the current gold standard is the slit-lamp attached Goldmann applanation tonometer (GAT); hand-held Perkins instrument is also used. It is not recommended to use the Schiötz tonometer, routinely. Although the Tono-Pen®, Icare® rebound tonometer, and air puff tonometers are quite popular in top clinics, it is advisable to repeat and confirm abnormal values by GAT. The Pascal dynamic contour tonometer (DCT) is known to give better measurement of intracameral IOP and has least variability. Some points to consider are:

- A single reading cannot be relied on when there are no other signs of glaucoma.
- Measurement should be repeated when there is a suspicious disc, presence of other signs of, or if the patient falls in the high risk category due to positive family history.
- In some cases, dilating the pupil might reveal a true reading.
- In case of disc and field changes, if the IOP is "normal" or "low," multiple readings at different times of the day may be a good idea.
- Documenting baseline IOP is necessary not just to detect raised IOP but also as a guide for treatment.

METHODS OF TONOMETRY

Indentation

Schiötz Tonometer

Although the Schiötz tonometer does not make as precise measurements as others, it is inexpensive, simple to use, durable, low maintenance, does not require batteries, and is long lasting, making it suitable for screening at remote or mobile clinics.

Applanation

Applanation is the mechanical flattening of the cornea and can be of two types, constant area with variable force (e.g. GAT) and constant force with a variable area (e.g. Maklakov applanation tonometry).

Goldmann Applanation Tonometry

- Force is changed till defined area of flattening is achieved.
- The simple mechanics and relatively low cost makes it the gold standard.

Maklakov Applanation Tonometry

- A constant force is used which evaluates the amount of area flattened.
- It is not as accurate as GAT since the corneal flattening is not linear.

Pascal Dynamic Contour Tonometer

- There is an electronic strain gauge embedded in a contoured plastic tip.
- With corneal contact, the strain gauge measures IOP.
- It is more accurate than GAT in thinned laser-assisted in situ keratomileusis (LASIK) corneas.
- It is automated and only requires proper corneal alignment.

Content supported by Dr. Murali Ariga, Consultant, Swamy Eye Clinic, Chennai and Dr. Parul Sony, Senior Eye Consultant, Complete Eye Care, Gurugram

Tono-Pen®

- The Tono-Pen® is a descendant of the Mackay-Marg tonometer.
- The tip stabilizes the surrounding tissue and the central plunger behaves with uniformity.
- It has not demonstrated equivalent accuracy.

Model 30™ Pneumatonometer

- It is a dynamic form of tonometry, belonging to the GAT family.
- It has a silicone membrane cap as tip, attached by a semi-flexible tube to a metal tube that floats on an air bearing.
- It is useful after LASIK or penetrating keratoplasty; corneal scarring and astigmatism, nystagmus, kerato-prosthesis; young children, seated or supine position.
- It is expensive and needs training.

Ocular Response Analyzer

- The ocular response analyzer (ORA) measures the corneal elasticity or stiffness.
- It uses an air puff to measure the corneal response time from applanation to recovery.
- Corneal compensated IOP (IOPcc) is less affected by corneal properties.
- Corneal hysteresis (CH) is a measure of viscous damping in the cornea.
- Corneal resistance factor (CRF) measures overall rigidity of the cornea.
- Goldmann correlated IOP (IOPg) measures IOP traditionally for historical reference.

Icare® Rebound Tonometer

- No anesthetic is required; is handheld and portable.
- Minimal force needs to be applied to the eye.
- Rapid measurement (0.1 s) enables monitoring in non-compliant subjects.
- Beneficial where slit-lamp is not possible due to head positioning, or when topical preparations are to be avoided.

Ultrasonic Pachymetry

- Pachymetry readings are useful in glaucoma suspects and in established glaucoma patients.
- It measures corneal thickness, in a fast, portable, less expensive, and more consistent manner than optical pachymetry.
- A reading between 500 µm and 530 µm is questionable.
- A reading above 530 µm is a thick and safe cornea.
- A reading less than 500 µm suggests initiating treatment.
- In case of a reading ≥580 µm, an artificially increased reading may be seen, while in case of a thin cornea, artificially low pressure is measured.

Certain external as well as internal factors can affect IOP measurement as well as can cause errors. Some of them are tabulated in Tables 1 and 2.

Table 1: Factors affecting intraocular pressure measurement.

Factor	Mechanism
Circadian cycle	Normal diurnal variation is 3–6 mmHg and could vary with posture
Corneal factors	Thick cornea-artificially high intraocular pressure (IOP) Thin cornea-artificially low IOP In case of earlier corneal surgery, IOP could be greatly underestimated
Blood pressure (BP)	BP and IOP are correlated, but reducing BP does not reduce IOP
Intra-abdominal pressure	Valsalva maneuver increases IOP
Exercise	Exercise lowers IOP by 3 mmHg due to dehydration, yoga can increase IOP, while supine or prone position increases IOP

Table 2: Errors in intraocular measurement.

Error	Cause
Artificially low intraocular pressure (IOP)	Less fluorescein in tear film and microscopic corneal edema
Artificially high IOP	Too much fluorescein, blepharospasm causing eyelid pressure, breath holding, and tight collar
Difficulty in measurement	Scars, edema, keratoconus, nystagmus, small palpebral fissure, and tremors
In case of corneal astigmatism >4D	Holladay IOP measurements of 90° and 180° Goldmann red line adjusted to flat axis, then measure as usual

INTRAOCULAR PRESSURE MONITORING

As per the Asia-Pacific glaucoma guidelines, treatment targets can be based on risk categories for best possible outcomes. The likelihood of future visual disability, depending on disease stage, risk factors for progression, and patient's overall health status and life expectancy can be used as a guide (Table 3).

Target Intraocular Pressure

Target IOP is a dynamic pressure range estimated to slow or halt disease progression. It is determined using parameters like baseline IOP, stage, and progression of disease and life expectancy. Once target IOP is reached, additional monitoring of structural and functional changes needs to be done. Target IOP should be individualized and benefits versus risks have to be evaluated intermittently (Table 4).

Table 3: Risk stratification as per Asia-Pacific glaucoma guidelines.

Glaucoma with high 5-year risk for progression	Moderate 5-year risk for visual loss	Relatively lower risk for visual loss
Moderate to advanced glaucomatous optic neuropathy with field loss • Rapid rate of progression • Very high intraocular pressure • Bilateral visual field loss • Pseudoexfoliation glaucoma • Fixation threat • Young age with advanced disease • Primary angle-closure glaucoma	*Mild glaucomatous optic neuropathy with early field loss* • Fellow eye of established glaucomatous optic neuropathy • Ocular hypertension with thin central corneal thickness and high intraocular pressure • Primary angle-closure after Yttrium aluminum garnet peripheral iridotomy	• Ocular hypertension (intraocular pressure 21–28 mmHg) with thick corneas (>600 µm) • Primary angle-closure suspects–asymptomatic narrow angles • Steroid-induced intraocular rise after stopping steroid

Table 4: Setting target intraocular range.

Glaucoma with high risk for progressive visual loss or visual disability	Target pressure reduction of ≥40% or 1–2 standard deviation below the population mean (9–12 mmHg)
Glaucoma with moderate risk for visual loss or glaucoma suspect with high risk for visual loss	Target pressure reduction of >30%
Glaucoma suspect at moderate risk for visual loss	• Monitor closely for change or treat depending on risk and patient preferences • Treat if risk increases with target pressure reduction of ≥20% • The fellow eye of unilateral glaucoma may require the same target as the affected eye depending on risk and state
Glaucoma suspect with low risk for visual loss	Monitor, do not treat where benefit of treatment does not outweigh risks of vision loss
Other factors to monitor	• Central corneal thickness • Iridotomy to eliminate pupil block • Peripheral iridoplasty to flatten the peripheral iris • Lens extraction to reduce pupil block and/or displace the iris posteriorly • Treating predisposing diseases in secondary glaucoma

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TONOMETRY TIPS AND TRICKS

Intraocular Pressure—When and How?

- Intraocular pressure (IOP) check is a mandatory check-up, especially above 40 years of age.
- Applanation tonometer is the gold standard.
- If applanation tonometer is not available, use non-contact tonometry (NCT), Schiötz, or any other tonometer available.

Tips for Non-contact Tonometry

Non-contact tonometry is not advocated for glaucoma practice.

In case of high IOP (>21 mmHg)

- Take 2–3 readings.
- Ensure patient cooperation.
- Recheck with applanation tonometer.
- If applanation tonometer not available, take 3 readings with NCT or 2–3 readings with different weights with Schiötz.
- Careful slit-lamp evaluation
  - Anterior chamber depth
  - Pigment dispersion/pseudoexfoliation
  - Secondary glaucoma
  - Iris changes neovascularization
  - Pupillary ruff changes
  - Previous peripheral iridotomy
  - Lens thickness/position/cataract
- Fundus evaluation
  - Optic nerve head changes
  - Retinal nerve fiber layer changes

In case of normal IOP (<21 mmHg), if disc changes suggestive of glaucoma are seen

- Repeat IOP
- If first IOP readings are okay
  - Check previous records of IOP
  - Perform diurnal monitoring
  - Check for central corneal thickness

In case of thinner cornea or thicker cornea, avoid using fixed correction nomogram.

Tips for applanation tonometry

- Intraocular pressure measurements should be performed prior to gonioscopy.
- Anesthetize the cornea, stain the cornea with fluorescein dye, and use cobalt blue filter.
- Keep the knob with 5–10 mmHg of anticipated IOP and pay attention to mires.

In eyes with high astigmatism

- Measure in two axes, 90° to each other and take average of two readings, or
- Align the red mark on the knob with the steep axis.

4

Optic Disc Examination

TAKE HOME MESSAGES

- Good optic nerve head examination is crucial for glaucoma diagnosis
- Detecting optic nerve head changes and documenting it appropriately is critical for further management
- Assess disc size
- Assess the neuroretinal rim
- Follow inferior ≥ superior ≥ nasal ≥ temporal pattern
- Look for nerve fiber layer defects
- Check cup-to-disc ratio asymmetry
- Look for parapapillary atrophy and disc hemorrhage

OPTIC NERVE HEAD EVALUATION

Glaucoma is first and foremost an optic neuropathy, in which retinal ganglion cells (RGCs) are progressively lost, and manifests as neuroretinal rim (NRR) loss. Thus, evaluating the optic nerve head (ONH) is an essential aspect of managing glaucoma. The ONH can be examined by the following methods:

- Indirect ophthalmoscopy
- Direct ophthalmoscopy
- Slit-lamp biomicroscopy
- Fundus photography
- Stereo disc photography

In all glaucoma patients, dilated ONH examination should be done at baseline, 6-monthly, or annually depending on the stage of the disease and stability. At each examination, the following parameters need to be documented:

Intrapapillary Characteristics

- Disc size
- Disc shape
- Rim width and shape
- Cup/rim size in relation to disc size

Peripapillary Characteristics

- Disc hemorrhage
- Retinal nerve fiber layer (RNFL) defect
- Parapapillary atrophy (PPA)

It is essential to rule out non-glaucomatous optic neuropathies and also to differentiate conditions like compressive optic neuropathy (CON), anterior ischemic optic neuropathy (AION), and giant cell arteritis (GCA), from glaucoma, as they might present with similar cup and field defects. There are several ways by which the vertical cup-to-disc ratio (VCDR) can be measured:

- Adjust the vertical beam of a slit-lamp to the diameter of the optic disc.
- Use optic nerve imaging devices.
- Use the small size spot (5°) of a direct ophthalmoscope.
- A 60–90D indirect slit-lamp lens and stereoscopic view in a dilated (if safe) pupil gives best results.
- Use red-free illumination for assessment of RNFL (Fig. 1).

Disc size can vary in every patient; large discs have large VCDR despite having normal NRR area. A large VCDR may not be pathological and, at times, pathological rim loss could be missed in a small disc. If disc size between both eyes is symmetrical then asymmetry of VCDR of >0.2 between two eyes is a cause for suspicion (Fig. 2).

Cup-to-disc ratio (CDR), the ratio of cup diameter to disc diameter, normally ranges between 0.2 and 0.5, but could be almost 1 in glaucoma. NRR loss generally starts at superior and inferior margins, and VCDR is a better measure of deviation. In glaucoma, VCDR increases more rapidly than horizontally, causing the quotient of the horizontal to VCDR to be less than 1.0 (Fig. 3).

The following points should be checked out for cup configuration (Fig. 4):

- Stereoscopic evaluation
- Contour and color of the cup
- Blood vessels

Content supported by Dr. Reena Choudhary, Glaucoma, Squint & Anterior Segment, Ophthalmologist, ICARE Eye Hospital and Post Graduate Institute, Noida and Dr. Ronnie George, Deputy Director, Smt. Jadhavbai Nathamal Singhvee Glaucoma Services, Sankara Nethralaya, Chennai

Neuroretinal Rim: Inferior ≥ Superior ≥ Nasal ≥ Temporal Rule

There is a strong possibility of glaucoma in case of vertical CDR >0.7, or loss of rim outside the temporal sector, though a large or tilted disc may not follow this rule. The thickest to thinnest parts of the NRR of the optic disc are inferior ≥ superior ≥ nasal ≥ temporal (ISNT). Glaucomatous damage is indicated in case any variation to this is seen, although this variation might be seen in some normal discs too, so careful examination is warranted. The main factor of the ISNT rule is the T–in almost all normal eyes the narrowest part of the rim is in the temporal 60° (Fig. 5).

The rim is more important than the cup. The NRR width is the area from the inner border of the scleral ring to where the rim falls just below the level of the scleral ring. Loss of tissue from the inner edge of the rim is almost always diagnostic of glaucomatous optic neuropathy (Fig. 6).

The following signs indicate that glaucomatous damage has already occurred:

- Diffuse loss/notching of the rim
- Hemorrhage across the rim
- Undercutting of the rim
- Asymmetry of the rim width between both the eyes but no asymmetry in disc size
- A rim to disc ratio ≤0.1
- Significant asymmetry of rim width between superior and inferior sectors of the optic disc

Retinal Nerve Fiber Layer

- Retinal nerve fiber layer defects are localized or generalized as per disease stage.
- A localized defect is a wedge-shaped defect that runs towards or touches the optic disc border but does not occupy more than 60° disc circumference.
- Localized defects are usually rare in normal eyes but when present point towards definite optic nerve damage.
- Localized defects are not pathognomonic of glaucoma and can occur in other types of optic disc atrophies (Fig. 7).

Benefits of Classification and Staging

- To identify and distinguish abnormal changes.
- To document change in optic nerve appearance and determine progression.
- To group patients into disease categories (mild/moderate/advanced).
- To guide prognosis and treatment.

How to Document Optic Nerve Head

- Disc drawing
- Disc photographs
- Written description: e.g. VCDR noted with disc size/shape and description of NRR/nerve fiber layer (NFF), hemorrhage.
- Only CDR without NRR description can be confounding (Fig. 8).

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TIPS AND TRICKS FOR ASSESSING GLAUCOMA RISK

Who needs a glaucoma evaluation?

Everyone!

Impact of age on probability that the patient has glaucoma:

	Age 25 years	Age 75 years
Family history of glaucoma +	Low	High
Family history of glaucoma -	Minimal	Moderate

Who is at risk for glaucoma?

History

- Family history of glaucoma
- Steroid use (in any form)
- Trauma to the eye (any duration)
- Intraocular surgery

Demographics

Older age

Clinical examination

- Shallow anterior chamber
- Pseudoexfoliation
- Aphakia

Optic disc evaluation

Cup-to-disc ratio depends on disc size. A large disc has a large cup. A small disc may have minimal or no cupping.

- Small disc: <1.5 mm
- Medium disc: 1.5–2.5 mm
- Large disc: >2.5 mm

Pay attention to the neuroretinal rim

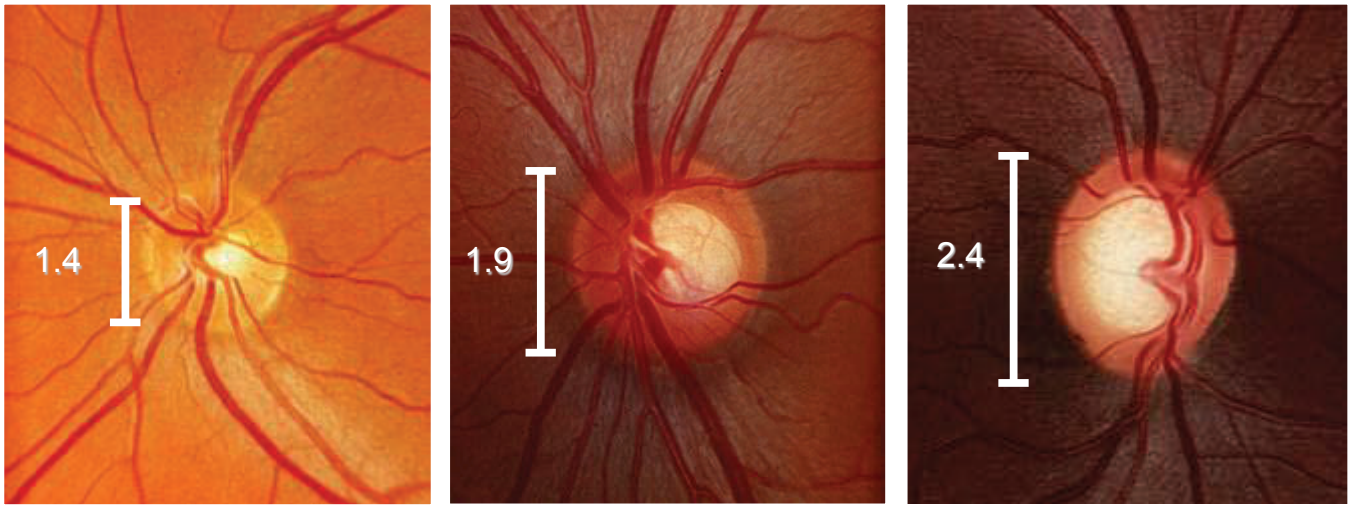
- Cardinal feature is loss of tissue from inner edge of rim.
- Thickness and shape are important.
- Position of vessel bending.
- Inferior ≥ superior ≥ nasal ≥ temporal (ISNT) rule should be considered.
- Look for pallor-suspect a neurological cause.

Disc hemorrhage

- Occurs in 2–23% glaucoma cases.
- Could indicate disease progression.
- It usually resolves in 6 weeks.

Peripapillary chorioretinal atrophy

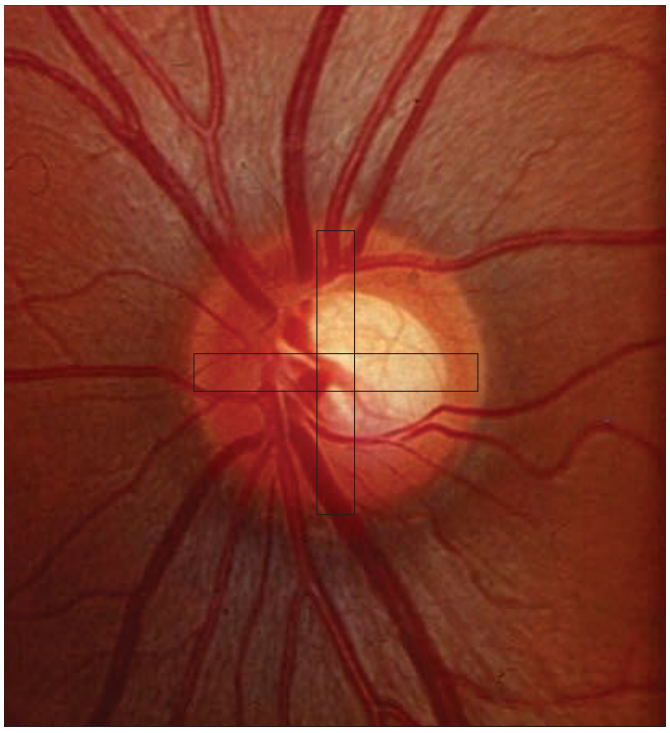
- Beta zone-visible sclera and choroidal vessels and retinal pigment epithelium atrophy.
- Alfa zone-peripheral hypo- and hyperpigmentation and thinning of chorioretinal tissue layer.



Small | Average | Large

Large disc with large cup can be physiological
Small disc with a small cup-to-disc ratio can be glaucomatous

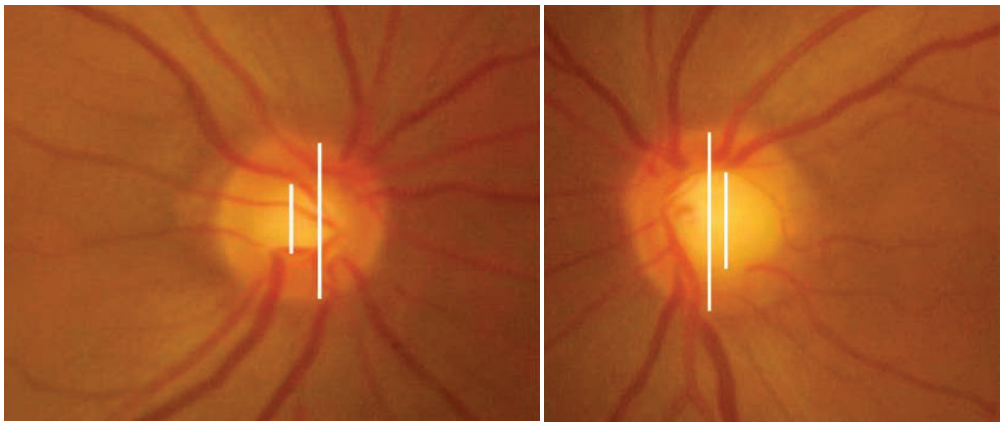
Fig. 1: Effect of disc size on cup size.



Measure length of slit beam
Correction factors
Volk 60D – x 1.0
Volk 78D – x 1.1
Volk 90D – x 1.3

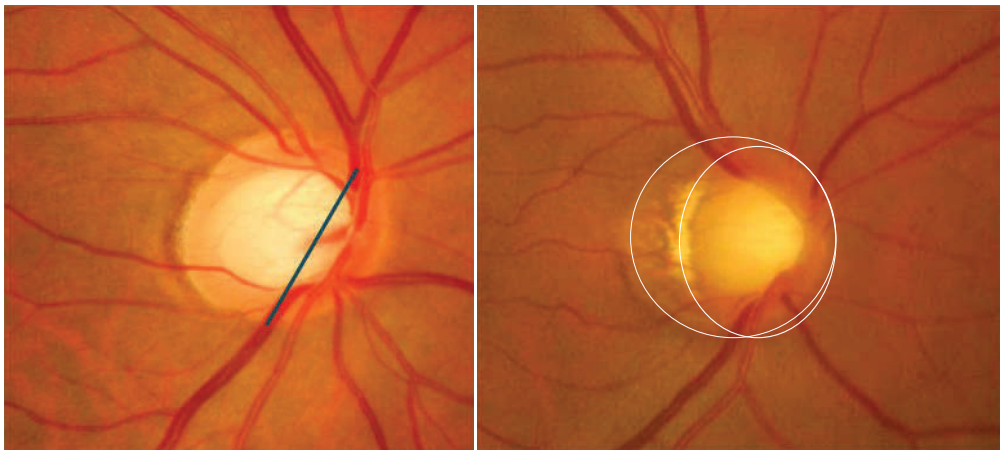
Rough estimation of disc size often used in clinical practice

Fig. 2: Measurement of optic disc size.



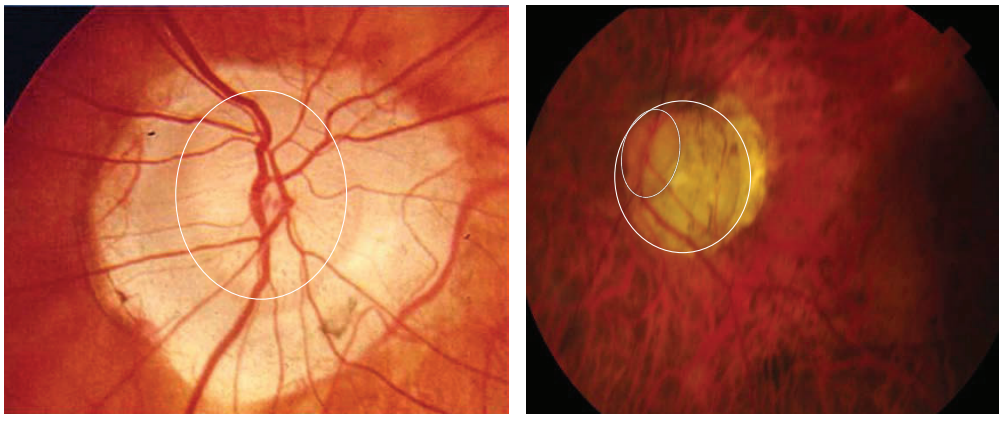
Difference in disc size between the two eyes of the same patient with physiological asymmetry in cupping

(a)



Torted disc | Tilted disc

(b)



Delineate the disc margin correctly

Fig. 3: (a) Some disc images that are commonly encountered. (b) Some challenging situations.

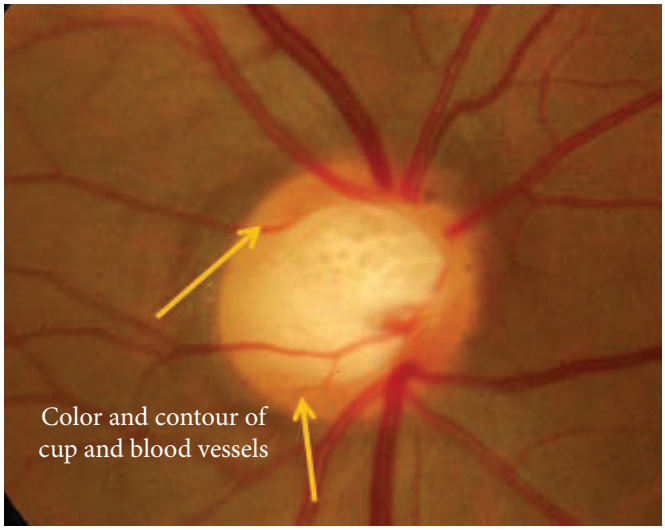


Fig. 4: Cup configuration.

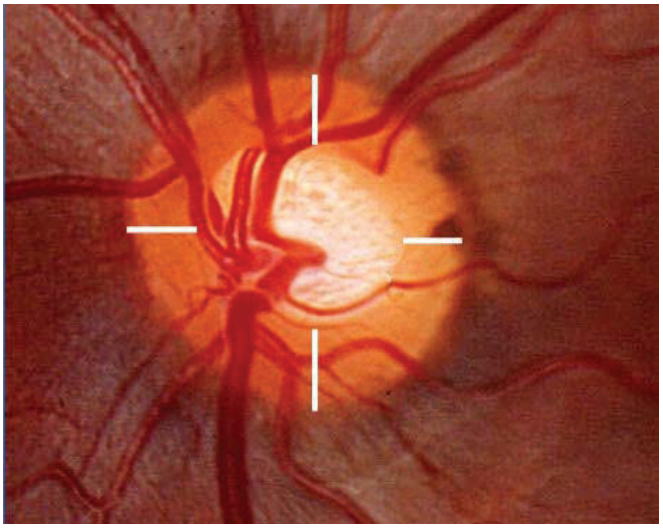
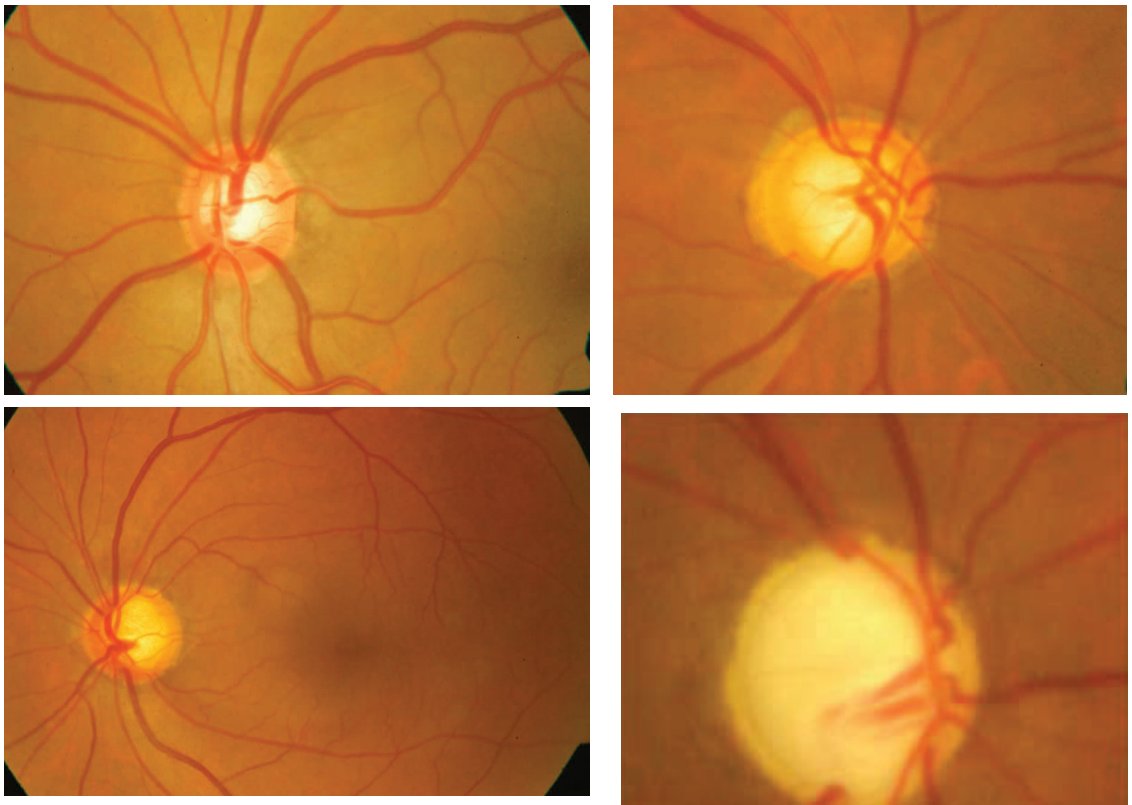


Fig. 5: The inferior ≥ superior ≥ nasal ≥ temporal rule.



Neuroretinal rim: In glaucoma, loss of tissue from the inner edge of the rim.
IT (inferior-temporal) and ST (superior-temporal) regions are the first to be involved.

Fig. 6: The neuroretinal rim.

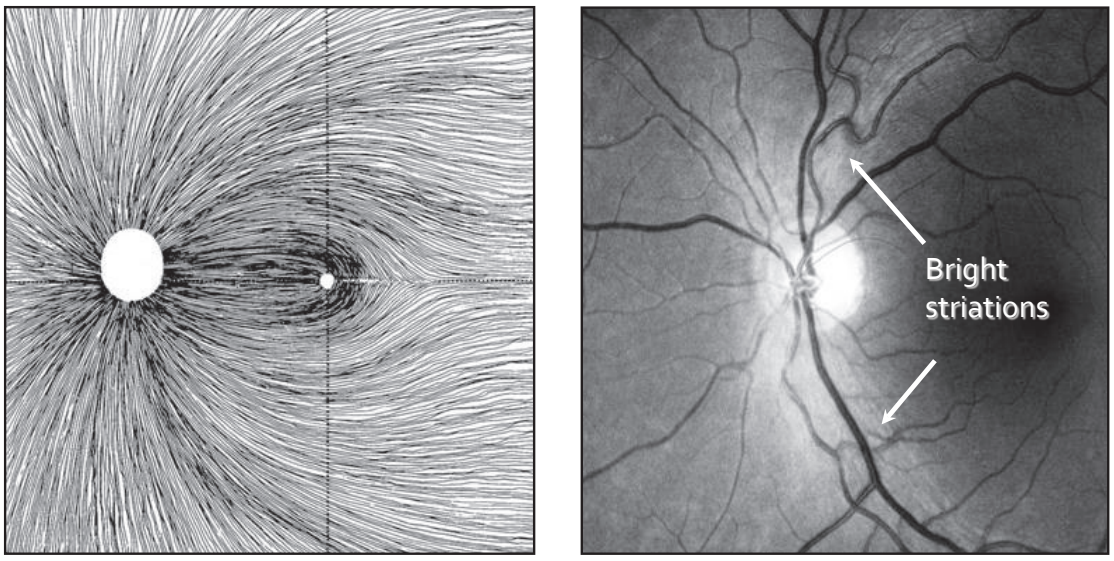
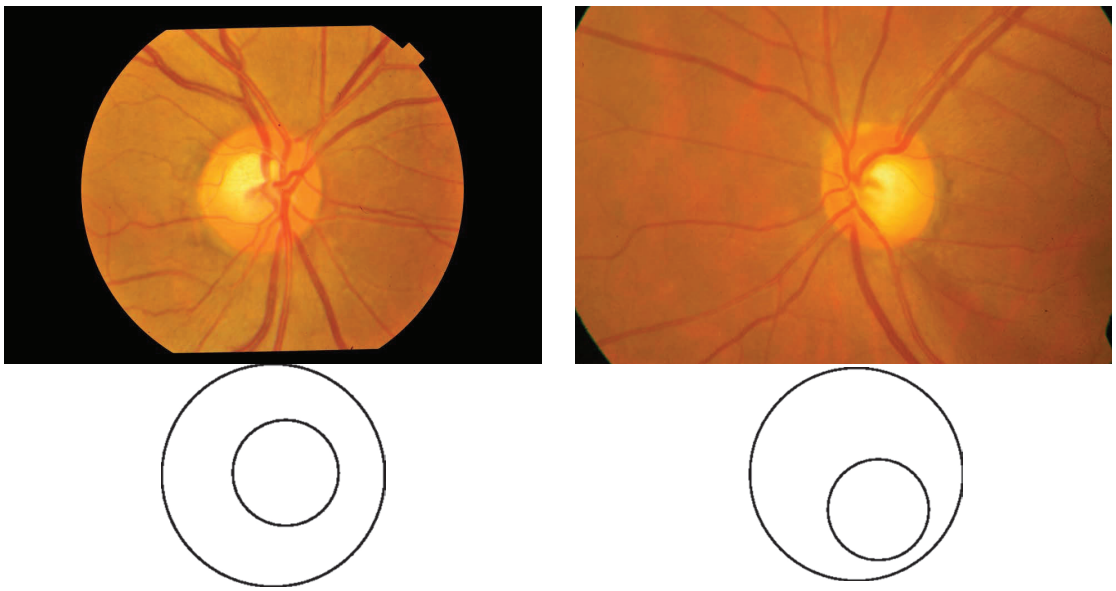


Fig. 7: Retinal nerve fiber layer.



0.5 CDR with normal NRR

0.5 CDR with glaucomatous inferior rim loss

Fig. 8: Documenting optic nerve head.
NRR: neuroretinal rim; CDR: cup-to-disc ratio

5

Gonioscopy

TAKE HOME MESSAGES

- Gonioscopy should be done in all glaucoma patients.
- A four-mirror lens and indentation are the best methods.
- Findings must be recorded for future use and comparison.
- Gonioscopy is not a one-time examination.
- A patient with primary open-angle glaucoma can develop angle-closure over time.
- Gonioscopy should be repeated annually, if the signs of the disease change.
- It is also recommended after interventions like iridotomy or trabeculectomy.

Examination of the angle of the anterior chamber (AC) is best done by the gonioscope, using the indentation method and a four-mirror gonioscope (Fig. 1). In case a four-mirror gonioscope is not available, the procedure can be manipulated using indentation and a two-mirror gonioscope (Table 1).

Goldmann Lens (Fig. 2)

- Ask the patient to look down.
- Place the lens edge at inferior limbus.
- Rotate lens onto cornea.
- Ask the patient to look straight.

Zeiss/Sussman 4-mirror Lens (Fig. 3)

- Ask the patient to look straight ahead.
- Insert lens gently to touch tear strip.
- Any pressure would indent the angle open.

In an ideal situation, the room should be dimly lit, with the slit-lamp at minimal intensity, and low slit-beam height in order for the light to not impinge on the pupil and taking care to not exert undue pressure on the eye with the gonioscope. After 30–45s of pupil dilatation, in case the posterior trabecular meshwork is not visible, the patient is instructed to look toward the mirror, which allows an "over the (iris) hill view" of the angle. If more than 180° of the meshwork is seen with this maneuver without any pressure on the eye, the angle is considered open else, he is diagnosed as primary angle-closure suspect (PACS) (Table 2, Fig. 4). Points to look for during gonioscopy:

- Angle grading: An anatomical system of grading as developed by Dr. Madanmohan eliminates subjective assessment of the angle entry from interfering with the grading system (Fig 5).
- Is the angle closed/occludable?
- How much can it open?
- Any secondary features?

Landmarks

- Schwalbe's line (Fig. 6a)
- End of Descemet's membrane identified by following the corneal parallel-piped.

Table 1: Slit-lamp adjustments for gonioscopy.

For up and down:
- Vertical slit beam
- Illumination tilted to one side
- Microscope straight

Side adjustment:
- Horizontal slit beam
- Illumination and microscope straight
- Illumination tilted to aim beam upwards by about 15° to give parallax

Table 2: Peeping over the hill (without indenting).

- Tilt goniolens slightly.
- The peripheral iris convexity into the angle can be seen.
- With a 3-mirror, an open angle can be missed.
- Large diameter lens allows less movement.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru and Dr. Thomas George, Senior Consultant Ophthalmologist, Cosmopolitan Hospital, Thiruvananthapuram

Schlemm's Canal

- Not seen often
- Seen as a pink line in middle of trabecular meshwork if blood has refluxed into it.
- Trabecular meshwork has a granular appearance (color and pigmentation can vary a lot) (Fig. 6b).

Scleral Spur and Ciliary Body

- Glistening white line at posterior edge of trabecular meshwork.
- Behind this the grey ciliary body band may be seen followed by the brown root of iris (Fig. 6c).

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TIPS AND TRICKS FOR GONIOSCOPY

Gonioscopy detects and measures iridotrabecular contact:

- It detects angle-closure, secondary glaucomas, and angle width, respectively.
- It should be done initially in all patients and done more often in those with detected angle-closure.
- It needs a dark room with a small slit-lamp beam minimizing light falling on the pupil.
- In case of appositional closure, indentation can detect peripheral anterior synechiae.
- The position of the mirror can be altered in order to see the angle over a convex iris.

If angle structures are not found, a bright wide slit at low magnification is recommended. Once found, illumination should be turned down, the slit should be shortened and narrowed, and change in iris/angle configuration should be looked for.

Angle-closure signs

- Peripheral anterior synechiae
- Pigment patches over trabecular meshwork
- Iris insertion above scleral spur

Abnormal open-angles

- Trabecular meshwork pigmentation, new vessel formation, and abnormal iris processes
- Angle recession and cyclodialysis cleft
- Blood reflux in Schlemm's canal

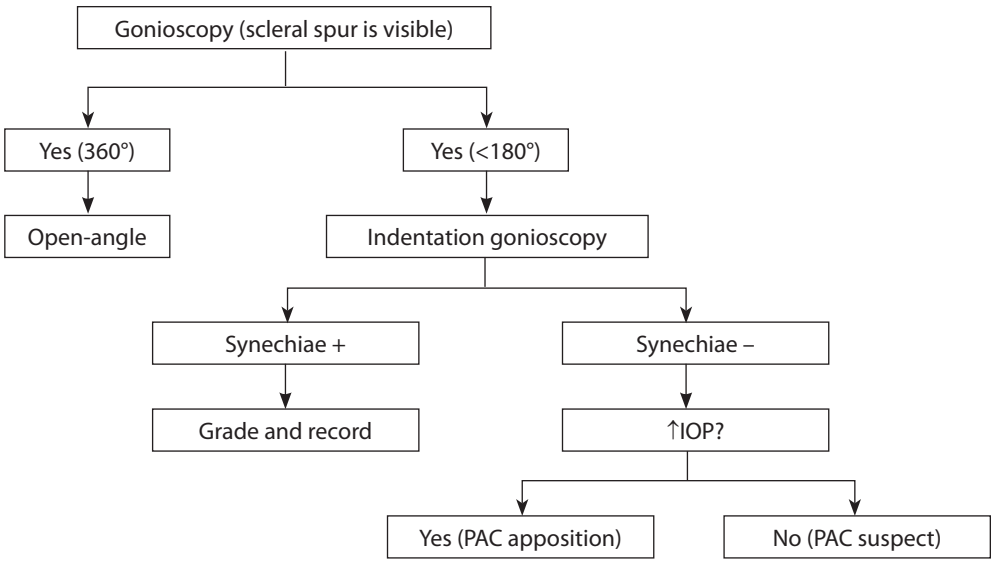

Fig. 1: Gonioscopy examination to diagnose primary-angle closure.
IOP: intraocular pressure; PAC: primary-angle closure

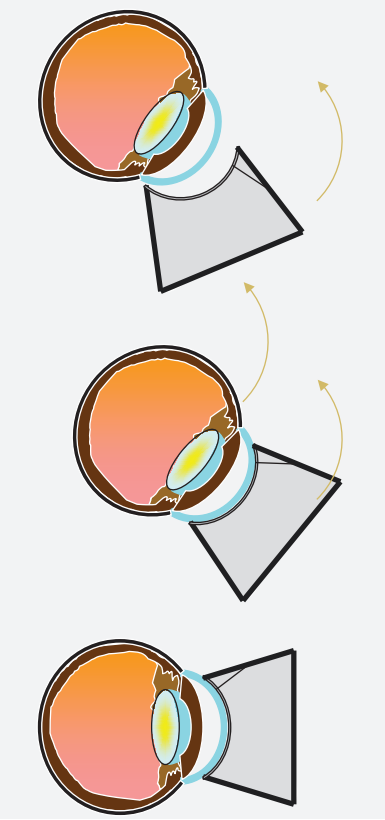

Fig. 2: Goldmann lens.

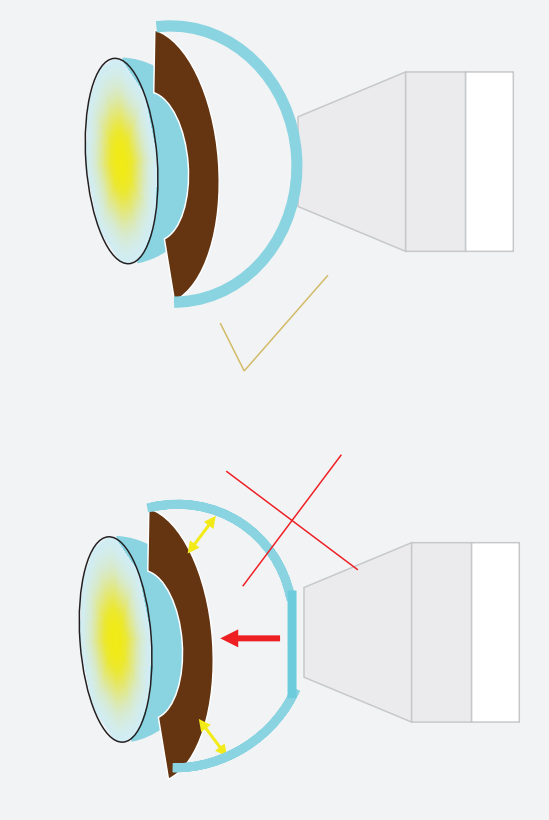

Fig. 3: Zeiss/Sussman 4-mirror lens.

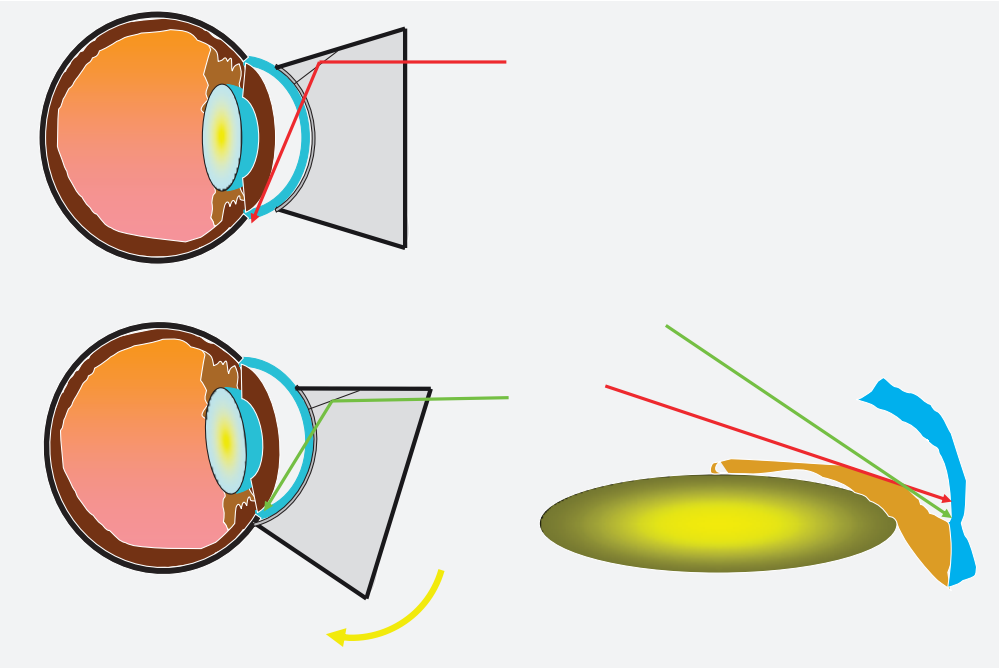

Fig. 4: Peeping over the hill.

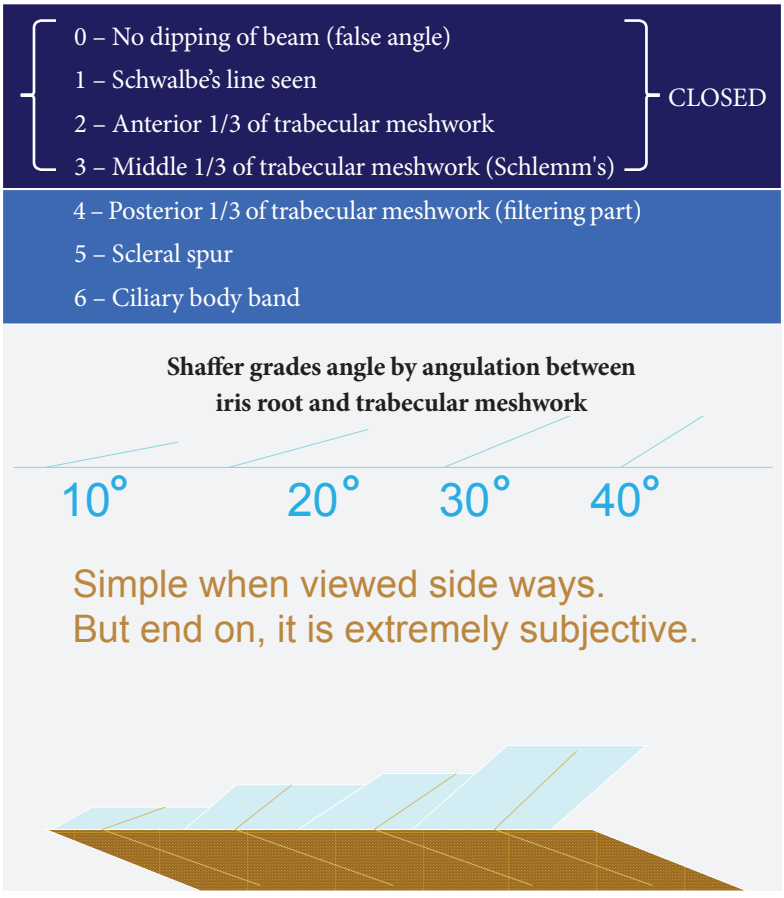

Fig. 5: Madanmohan's angle grading.

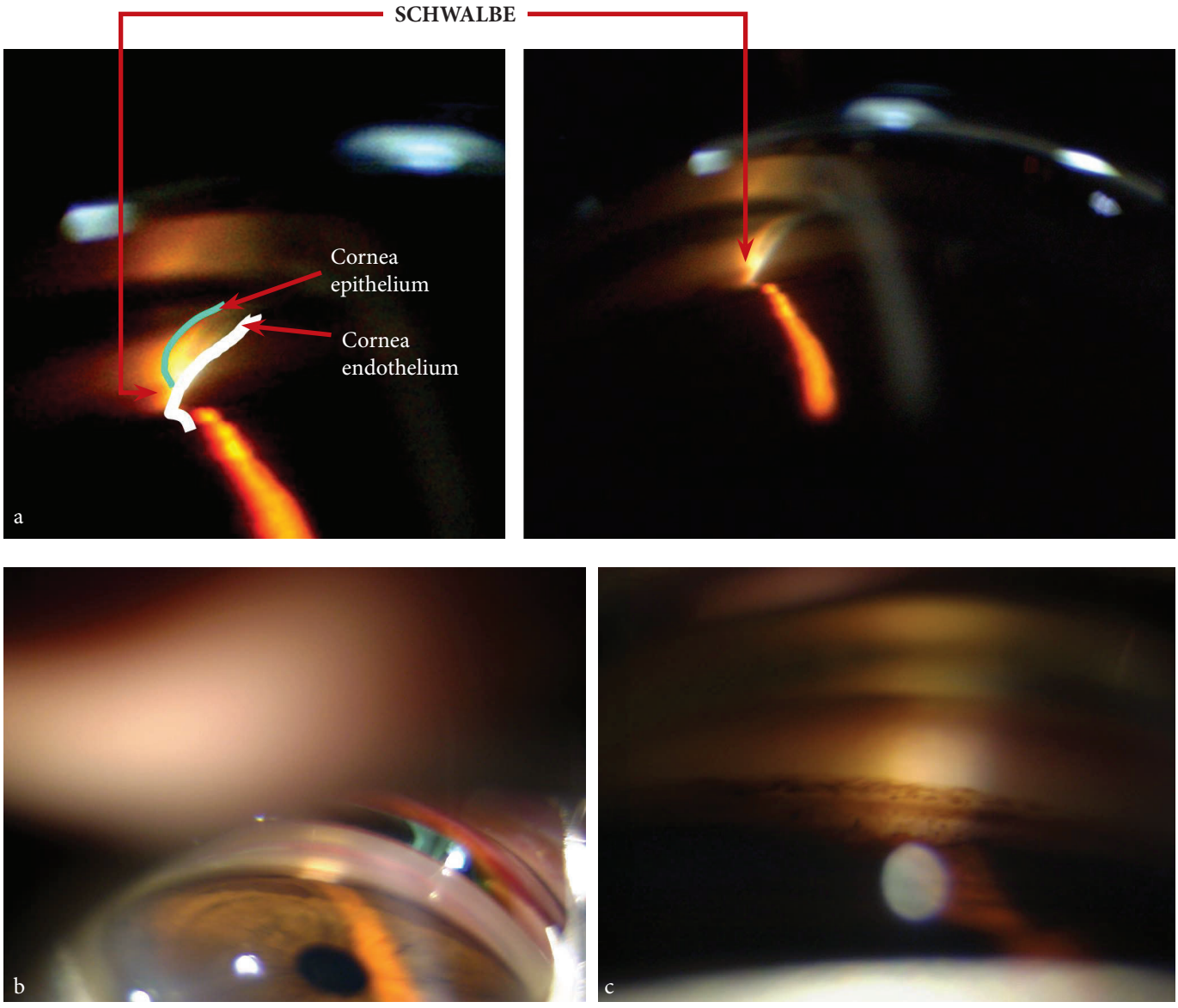

Fig 6: Gonioscopy landmarks. (**a**) Schwalbe's line. (**b**) Schemm's canal. (**c**) Scleral spur and ciliary body.

Supplementary material: see page 165

6

Visual Field Examination

TAKE HOME MESSAGES

- Automated perimetry is the method of choice to detect visual field defects.
- It should be done in case of any suspicion of glaucoma.
- It should be repeated at regular intervals to monitor disease progression.
- Correct method and familiarity with the perimetry readings is essential for correct analysis.

Testing the visual fields (VFs) examines the state of optic nerve function and also defines if glaucoma is progressing or not. Standard automated perimetry (SAP) remains the preferred VF testing method for glaucoma. In case of a suspicion of glaucoma during a clinical examination, an early perimetry is recommended.

Of the various perimeters available and used, the standard white-on-white perimetry using the Humphrey field analyzer (HFA) is the commonest and preferred one, with the Swedish interactive thresholding algorithm (SITA) strategy being proven the best. However, accuracy in performing and analyzing the reports is quite essential.

Points to note:

- Visual field testing is subjective and responses vary.
- Fluctuations are seen among patients and increase with disease severity.
- Visual field defects usually manifest after considerable cell loss.

Frequency Doubling Technology

- The frequency doubling technology (FDT) perimetry detects frequency doubling stimulus by using contrast sensitivity.
- It is portable and easier to use.
- The test is faster than SAP.

Short-wavelength Automated Perimetry

- The short-wavelength automated perimetry (SWAP) uses narrow-band blue-light stimulus with yellow background illumination.
- It uses SITA strategy, thereby, reducing the overall duration of the test.
- Short-wavelength automated perimetry is more sensitive than SAP and detects early functional glaucoma defects.
- Short-wavelength automated perimetry defects may be present 3–5 years before detection by SAP and hence, is indicated in younger glaucoma suspects.

Frequency doubling technology and short-wavelength automated perimetry are preferred when SAP is normal but glaucomatous damage is suspected.

Rarebit or Microdot Perimetry

- The rarebit or microdot perimetry (RBP) technique uses a computer LCD monitor and presents very small stimuli with a dark background.
- The microdots evaluate density within central 30° of the VF.
- Micro-defects aggregate in VF defects; and are denser in deeper defects.

GLAUCOMATOUS FIELD DEFECTS

- Follow retinal nerve fiber layer (RNFL) pattern.
- Rarely cross the horizontal midline.
- Are located in mid-periphery (early/moderate cases) (5°–25° from fixation).
- Are not attributable to other pathology.
- Correlate with the appearance of the optic disc and RNFL.

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Content supported by Dr. Sushma Tejwani, Consultant and Head of Glaucoma Services, Narayana Nethralaya-2, Bengaluru

TIPS AND TRICKS FOR BETTER VISUAL FIELD EXAMINATION

Tips to improve quality

- Goal of the test should be explained to the patient.
- Performance improves over two to three tests so the most reliable one may be used.
- Pupil size and change should be noted.
- Near vision correction should be used.
- In case of test repetition on the same day, the patient should be rested for at least half an hour between tests.

Tips for optimum perimetry

- Appropriate controls on the field analyzer should be used.
- Current refraction should be used.
- Patient should be comfortable, so feet and back should be supported.
- Forehead must touch the holding band easily so, chin rest must be adjusted.
- Other eye should be covered completely.
- A quiet atmosphere must be maintained.

Simple instructions for the patient

- This is a test that will enable to know where and how much damage is there.
- The test is not difficult but needs to be done in a particular manner.
- Look straight ahead always and let the light come to him/her rather than going looking for it.
- The light may be seen several times and may not be seen at times.
- The button must be pressed only when the light is seen, whether dim or bright.
- Blink as and when necessary, but preferably while pressing the button, so as not to miss any lights.
- Holding the button down will pause the machine and the patient can rest.
- Releasing the button will resume the test.

Patient support during the test

- The patient must not be abandoned during the test and must be checked on intermittently.
- If the patient cannot cope, the test may be rescheduled.
- Patience is the key.

Common artifacts could prevail due to

- Hypermetropia could affect the central field and threshold sensitivities.
- In high myopia, 'refraction scotoma' might mimic glaucomatous changes.
- Cataract and other opacities in cornea or vitreous could influence visual field (VF).
- Small pupil may exaggerate VF abnormalities when associated with cataract.
- Droopy lids, deep eyes, or prominent nose could affect the test.
- Multifocal intraocular lens could affect results.

Supplementary material: see page 172

7

Optical Coherence Tomography

TAKE HOME MESSAGES

- Optical coherence tomography is an increasingly valuable diagnostic modality in glaucoma.
- It has anterior as well as posterior segment evaluation benefits.
- It can diagnose suspects, as well as early stage glaucoma.
- It is helpful in follow-up and prognostication of glaucoma.

Optical coherence tomography (OCT) has given the glaucoma specialist a better understanding and approach to glaucoma. Assessing the retinal nerve fiber layer (RNFL) is now an integral approach towards diagnosing glaucoma. The swept source OCT (SS-OCT), enhances optic nerve head (ONH) evaluation as well as deeper tissues like the lamina cribrosa (LC) and choroid. OCT has both, anterior and posterior segment applications and has made diagnosing and prognostication of glaucoma a breeze. Some ocular structures where OCT is commonly used in glaucoma are mentioned below:

POSTERIOR SEGMENT

- Two different imaging techniques, enhanced depth imaging OCT (EDI-OCT) and swept source OCT (SS-OCT), are used commonly to examine ocular structures.
- With EDI-OCT, the spectral-domain OCT (SD-OCT) device is pushed closer to the eye, which creates an inverted fundus image, by which the choroid can be visualized and measured better.
- Swept source OCT has a longer center wavelength (1040–1060 nm instead of 840 nm), with less scatter, due to which there is better tissue penetration and better visualization of the choroid.
- Enhanced depth imaging OCT has shown better visibility for the anterior and posterior laminar borders and laminar pores; while intrascleral vessels and the choroid were better visualized with SS-OCT.

LAMINA CRIBROSA

- Swept source OCT enables good visualization of the anterior lamina cribrosa (LC).
- Lamina cribrosa shape changes correlate with disease progression.
- Focal LC defects are associated with structure, function, and visual field (VF) defects.
- Focal LC defects are also associated with glaucomatous optic neuropathy.

CHOROID

- Swept source OCT enhances choroid visualization and measures choroidal and retinal thickness.
- Automated measurements of choroidal and retinal thickness are precise and repeatable.

RETINAL NERVE FIBER LAYER

- The thickness of the macular ganglion cell complex (mGCC) and the macular ganglion cell inner plexiform layer (mGCIPL) are reduced in glaucomatous compared to healthy eyes.
- Both, SS-OCT and SD-OCT have similar accuracy in detecting glaucoma and circumpapillary RNFL.
- Early glaucoma can also be effectively diagnosed.

ANTERIOR SEGMENT

- Gonioscopy remains the clinical gold standard for angle visualization and measurement, but anterior segment OCT (AS-OCT) is proving more valuable in this situation.
- The scleral spur, Schwalbe's line, and the Schlemm's canal (SC) are well-visualized.
- Variability of angle measurements using SS-OCT is very low.
- Presence of peripheral anterior synechiae (PAS) is also detected.
- Due to its non-contact nature, OCT is better than gonioscopy and it gives more accurate PAS measurement.
- Iridotrabecular contact (ITC), PAS, and appositional angle closure, in eyes with shallow peripheral anterior

is also better diagnosed with SS-OCT as compared to biomicroscopy.

- A more thorough evaluation of the iris and its volume is possible with SS-OCT rather than with time-dominant OCT.
- Swept source OCT potentially does a complete evaluation of structural changes in glaucoma.

The 2016 World Glaucoma Association (WGA) consensus on glaucoma diagnosis states: "OCT measurement of RNFL thickness may be the best among the currently available digital imaging instruments for detecting and tracking optic nerve damage in glaucoma".

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TIPS AND TRICKS TO GET THE MOST OUT OF OPTICAL COHERENCE TOMOGRAPHY

Optical coherence tomography (OCT) can help diagnose and monitor glaucoma, especially those with early or moderate disease. Get the most out of OCT by:

- Monitoring scan signal quality, alignment and centration of the scan.
- Watching out for opacities and segmentation errors.
- Looking at the entire readout, not just one or two numbers.
- Looking for focal change, not just overall change.
- Accounting for the aging effect.
- Using trend-based analysis whenever possible.

TAKE HOME MESSAGES

- Imaging is a useful complement to a good clinical examination.
- Imaging is important in glaucoma suspect eyes to rule in or rule out early disease.
- Imaging is not very useful in advanced glaucoma.
- Imaging is important to document and follow-up preperimetric disease.
- Rely on thickness map analysis whenever available to avoid overdiagnosis of glaucoma on optical coherence tomography.

CASE 1

INTRODUCTION

A 65-year-old male patient presented for eye examination. There was family history of glaucoma (elder brother).

EXAMINATION

- Intraocular pressure (IOP) was 23 mmHg in both eyes.
- On gonioscopy, both angles were open.
- Disc in the left eye showed inferior notch with 2 distinct retinal nerve fiber layer (RNFL) defects in the inferotemporal peripapillary region (Fig. 1).
- Humphrey field analyzer (HFA) showed a correlating defect in superior hemifield. The defect also involved the central 10° field (Fig. 2).
- Optical coherence tomography (OCT) showed RNFL thinning in the inferior peripapillary region in the RNFL thickness map, deviation map, and the clock hour map; correlating with the clinical and HFA examination, respectively (Fig. 3).

Field defect involving the central 10° correlated with the inner retinal layer thinning found on the macular scan (on the thickness, deviation, and sector maps) (Fig. 4).

CONCLUSIONS

Imaging is used to document and, objectively, quantify the structural damage in glaucoma eyes; like the perimetry for functional damage.

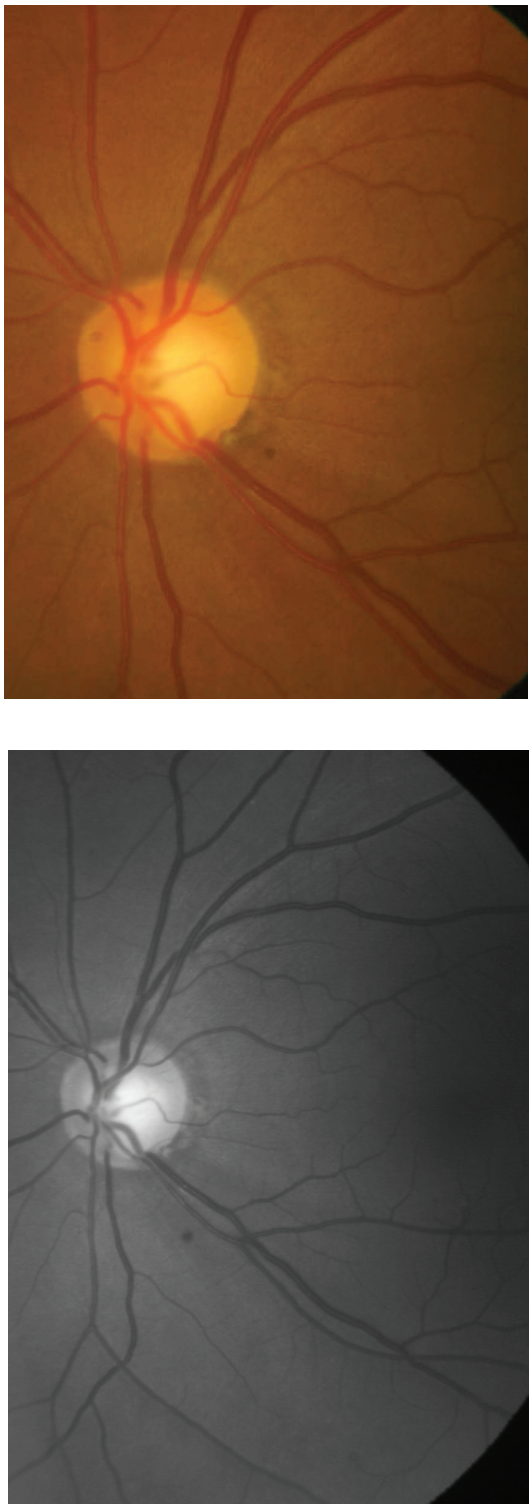

Fig. 1: Disc examination.

Content supported by Dr. Harsha BL Rao, Glaucoma Consultant, Narayana Nethralaya, Bengaluru

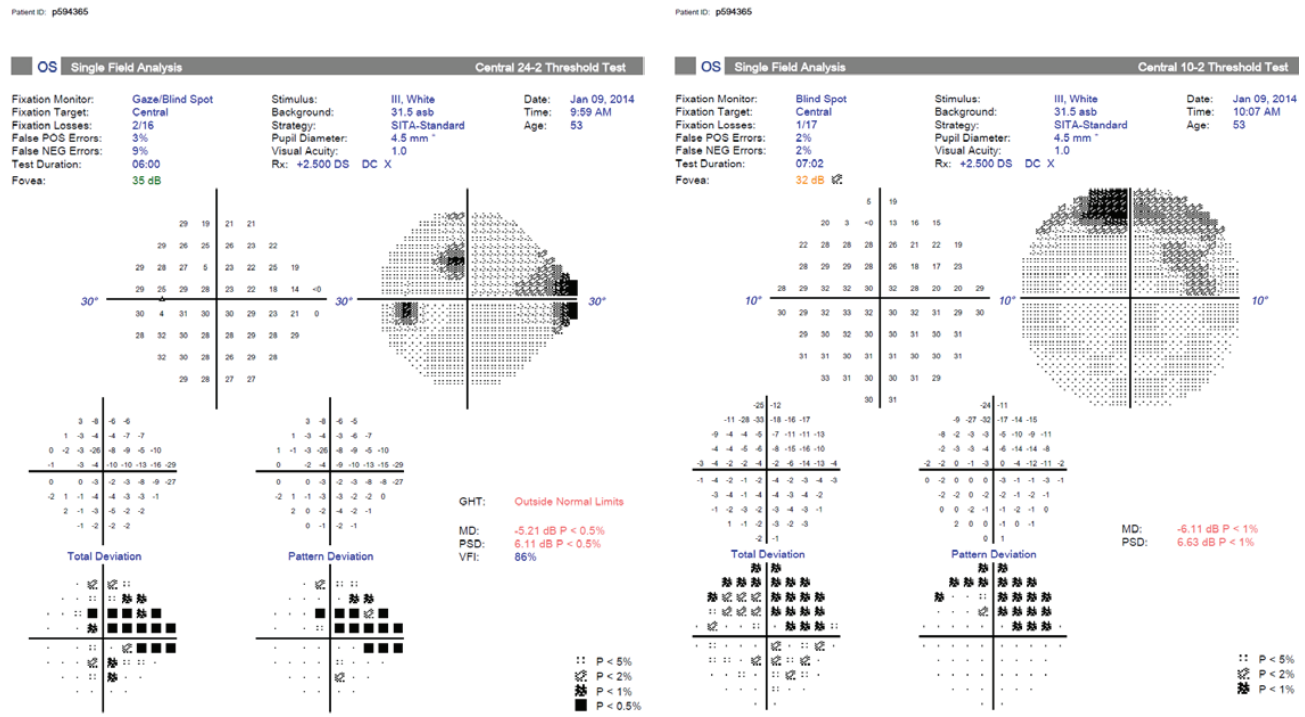

Fig. 2: Humphrey field analyzer examination.

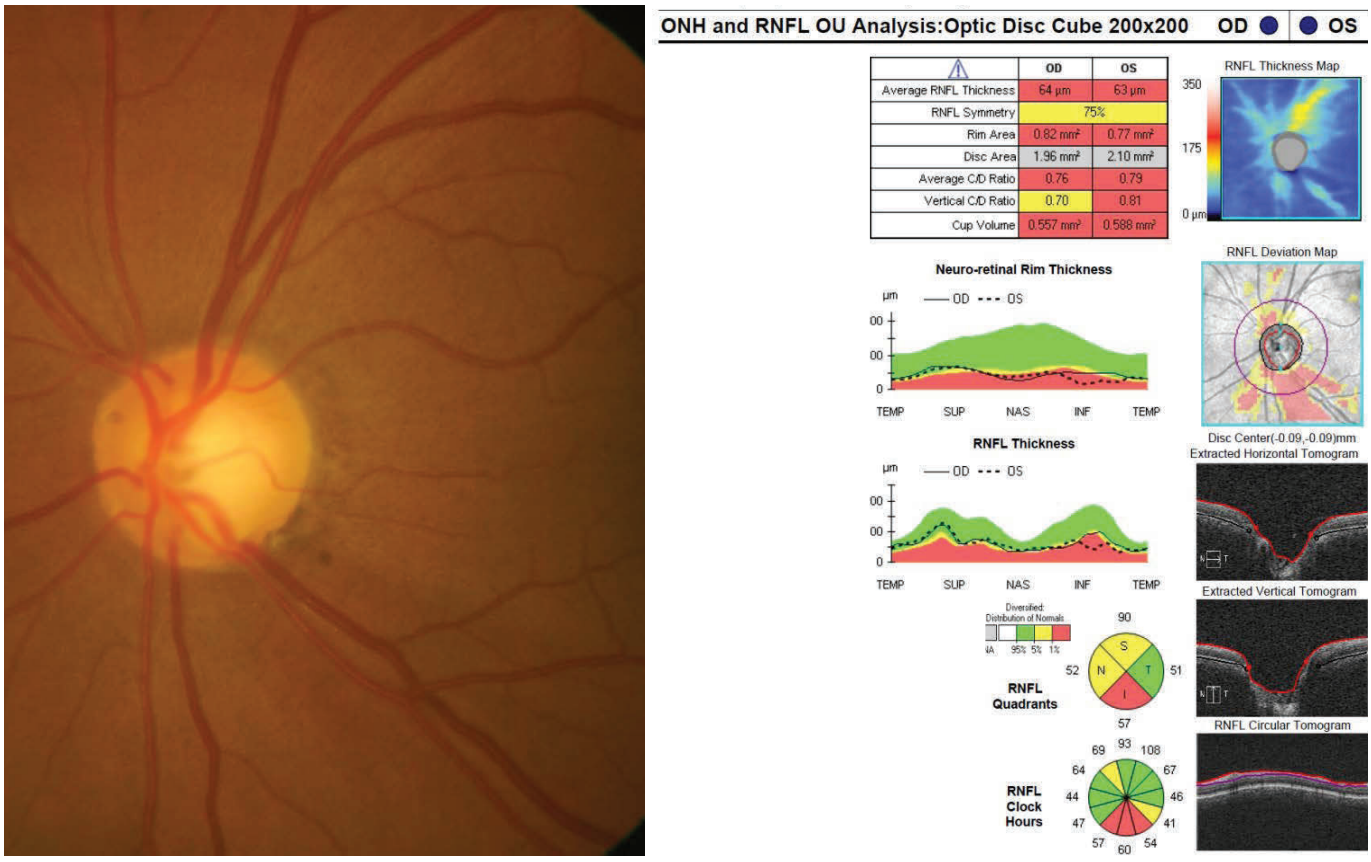

Fig. 3: Optical coherence tomography examination.

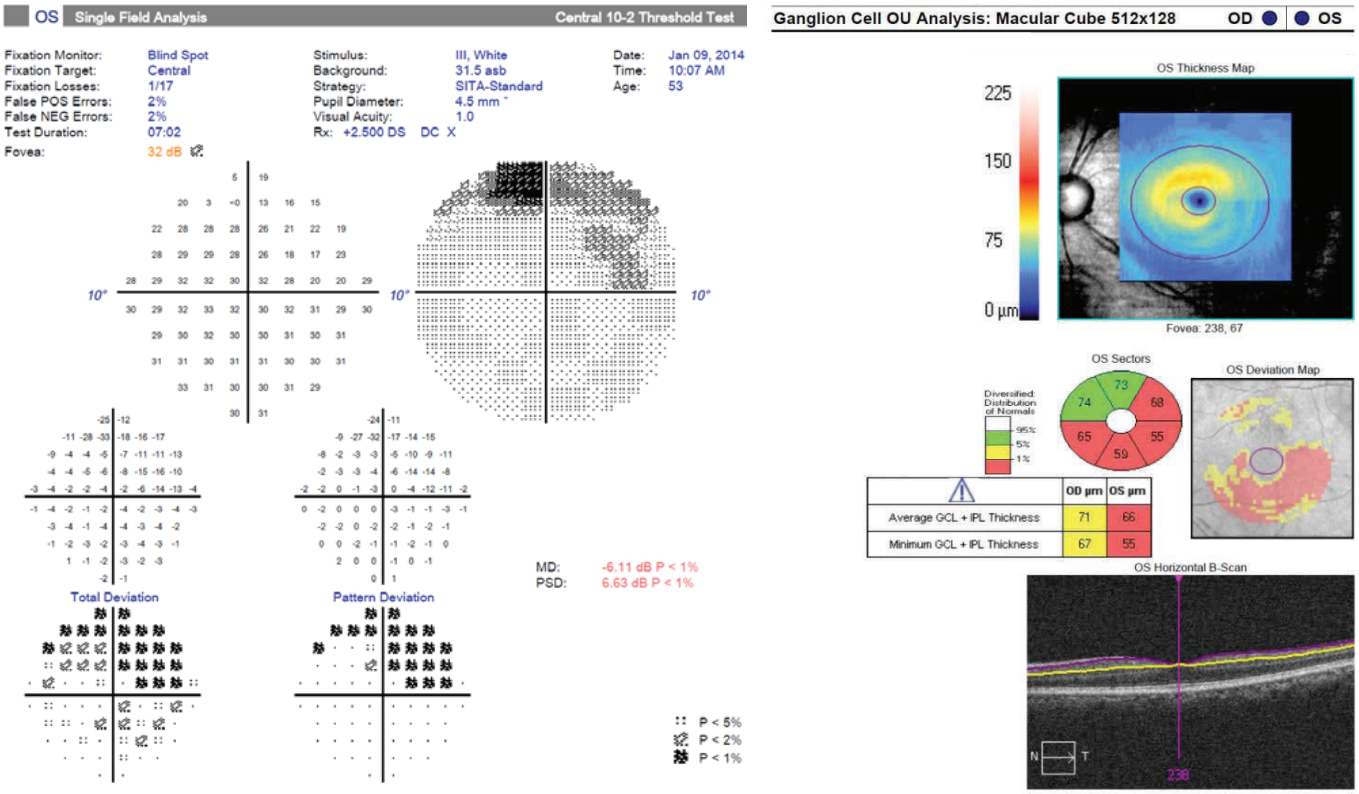

Fig. 4: Correlation of field defect and retinal nerve fiber layer.

CASE 2

INTRODUCTION

A 60-year-old male patient presented for a routine eye examination. There was no family history of glaucoma.

EXAMINATION

- Intraocular pressure (IOP) was 16 mmHg in both eyes.
- Gonioscopy showed open angles.
- Examination of the right optic disc showed inferior neuroretinal rim (NRR) thinning with an inferotemporal nerve fiber layer (NFL) defect (Fig 1).

The first test recommended was visual fields (VFs). VF showed normal results (Fig. 2).

- Optical coherence tomography in this situation showed retinal nerve fiber layer (RNFL) thinning in the inferotemporal region on the RNFL thickness, deviation, and clock hour maps, respectively (Fig. 3).

CONCLUSIONS

Imaging is important to document and follow-up preperimetric disease.

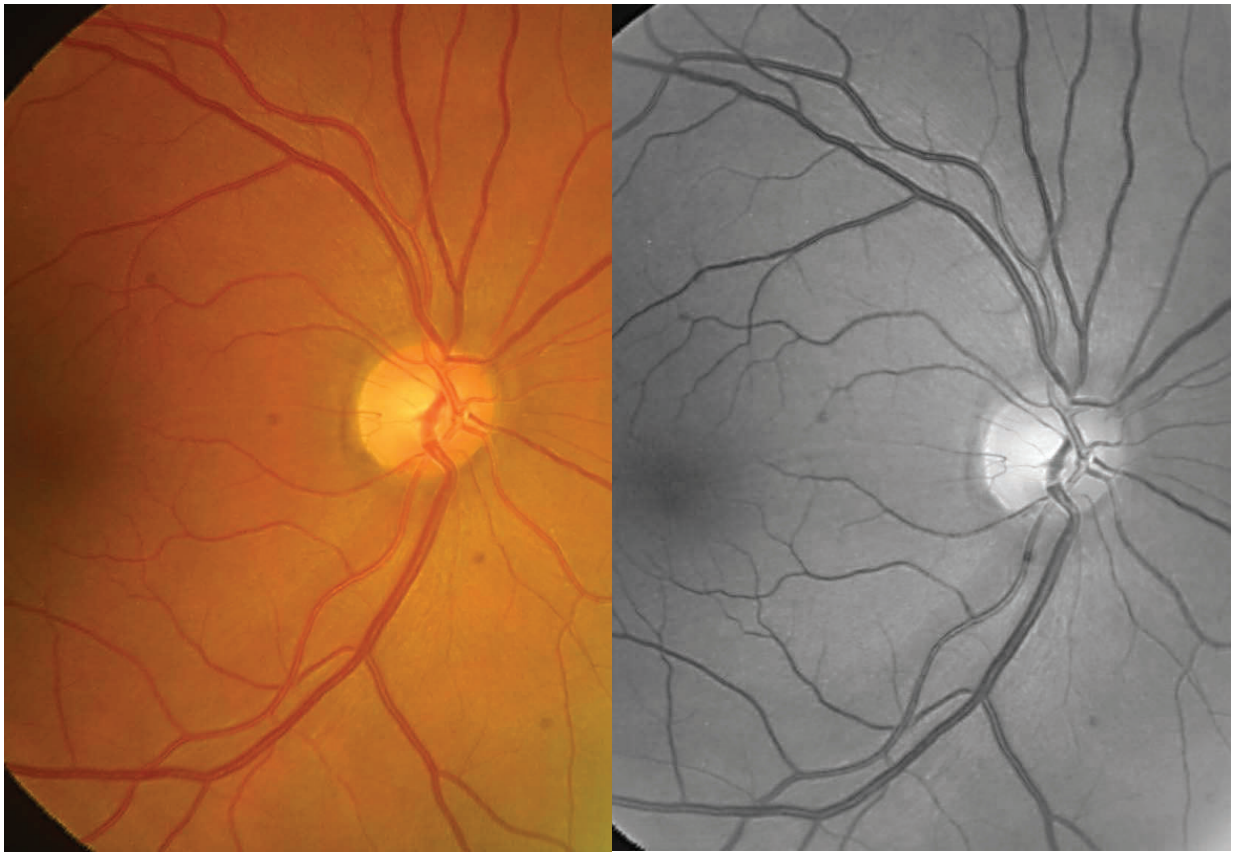

Fig. 1: Disc examination.

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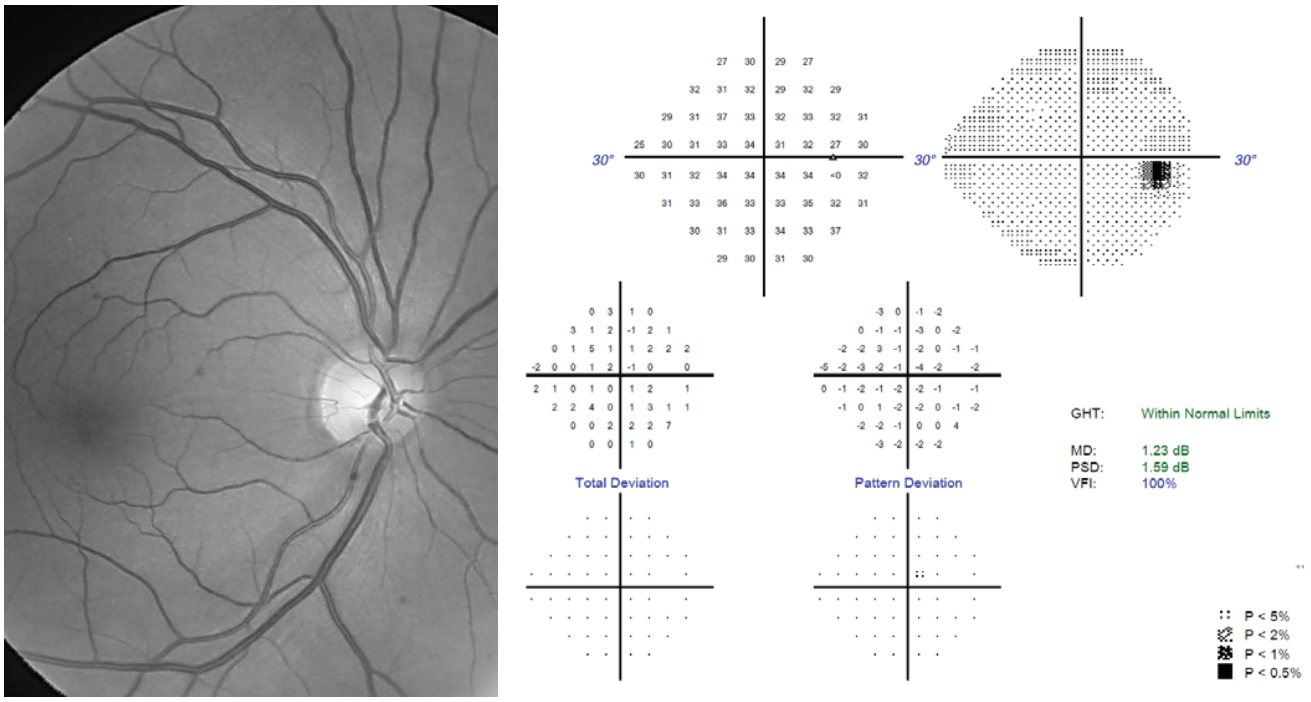

Fig. 2: Humphrey field analyzer examination.

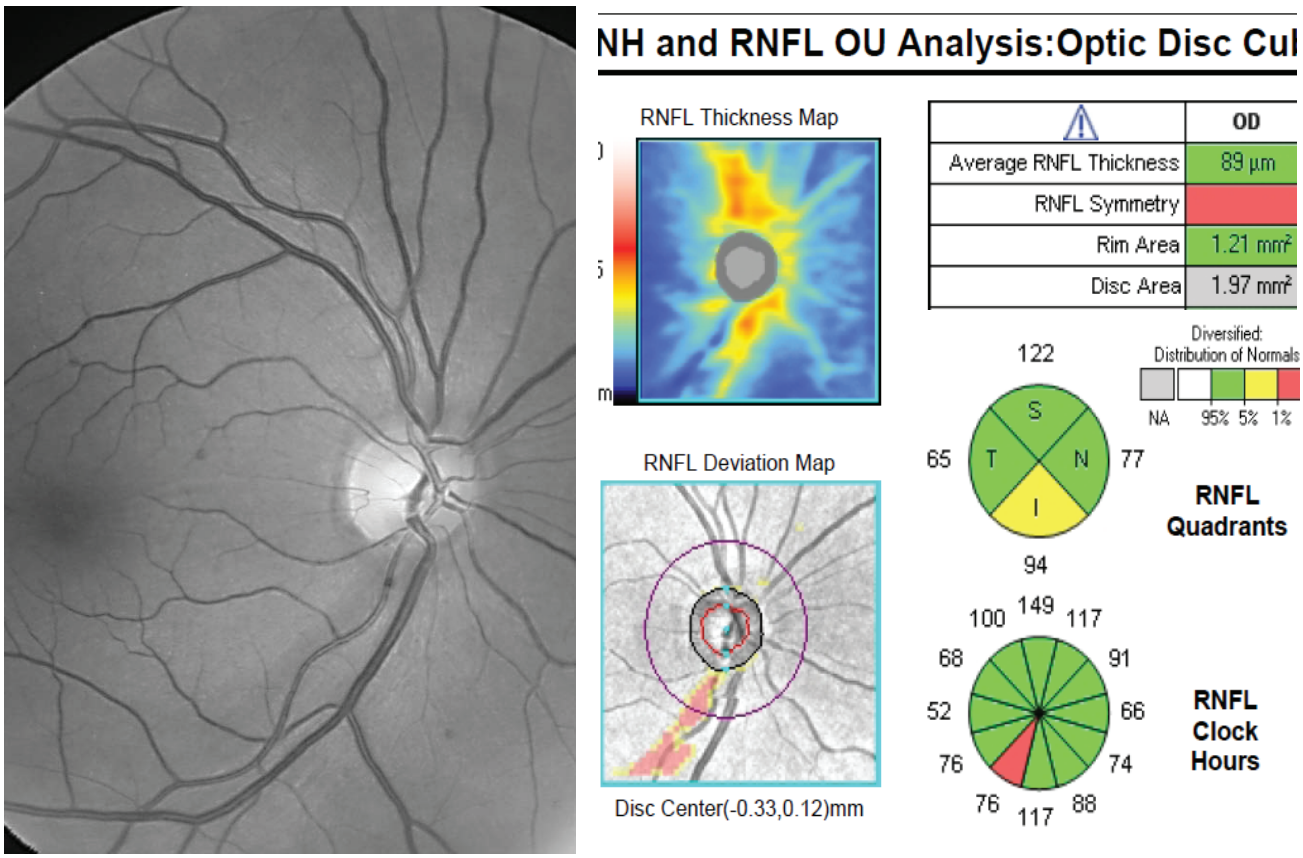

Fig. 3: Optical coherence tomography examination.

CASE 3

INTRODUCTION

A 65-year-old male patient presented for routine examination. There was no family history of glaucoma.

EXAMINATION

- Intraocular pressure (IOP) was 16 mmHg in both eyes.
- Gonioscopy showed open angles.
- Optic disc in left eye, which is tilted, showed suspicious findings of glaucoma and there was inferior rim thinning. However, no obvious abnormality of retinal nerve fiber layer (RNFL) was seen (Fig. 1).
- Humphrey field analyzer (HFA) showed a nasal defect. However, it was difficult to say if this defect was true or an artifact (Fig. 2).
- Optical coherence tomography (OCT) of the eye showed inferotemporal RNFL thinning noted in thickness and deviation map. Clock-hour map was normal (Fig. 3).
- Careful examination of the red-free fundus photo showed the RNFL defect which was difficult to recognize on the color photo due to the tessellated retinal background (Fig. 4).

CONCLUSIONS

Imaging is important in glaucoma suspect eyes to rule in or rule out early disease. Clock-hour maps can miss detecting structural defects.

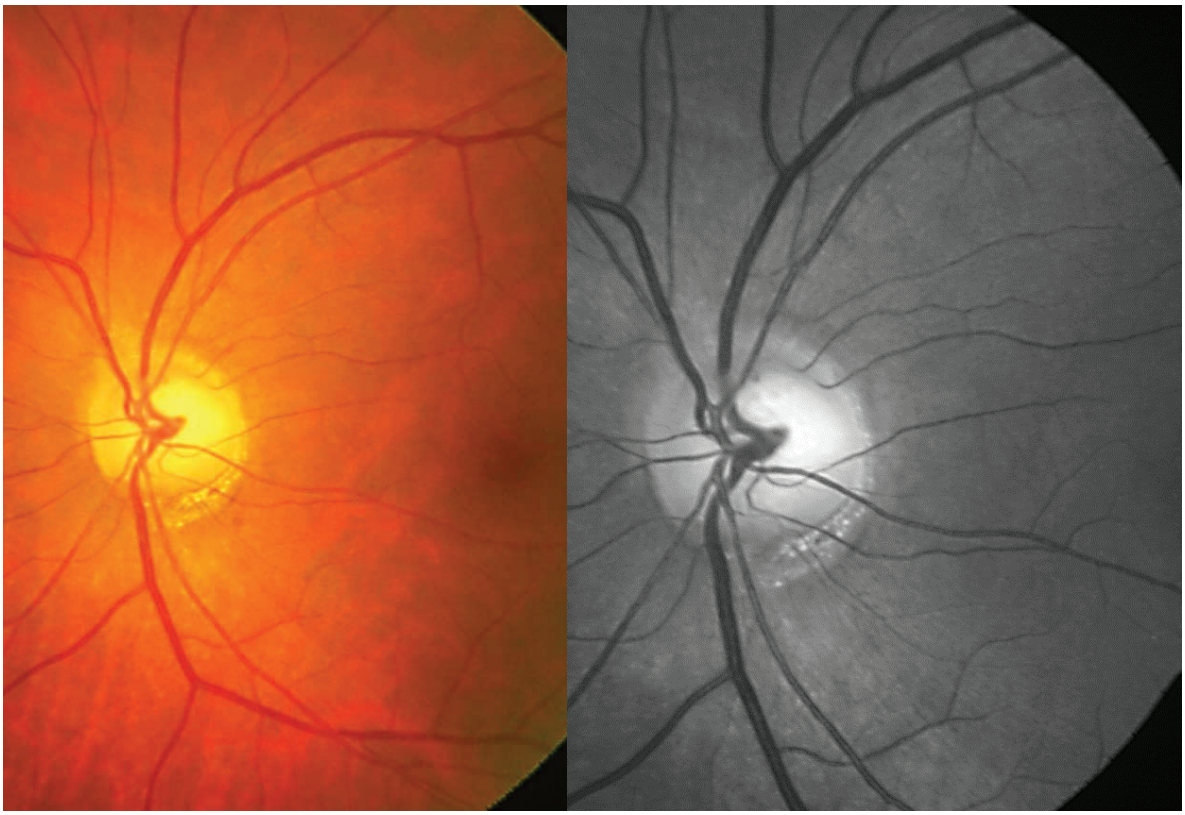

Fig. 1: Disc examination.

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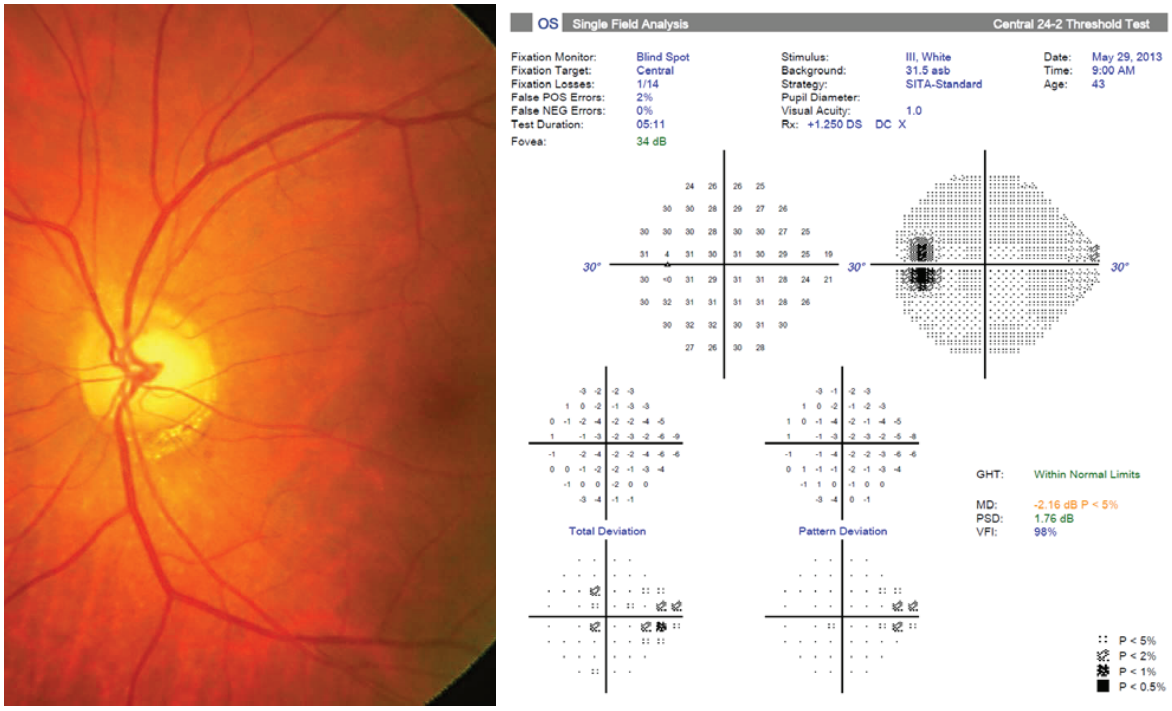

Fig. 2: Humphrey field analyzer examination.

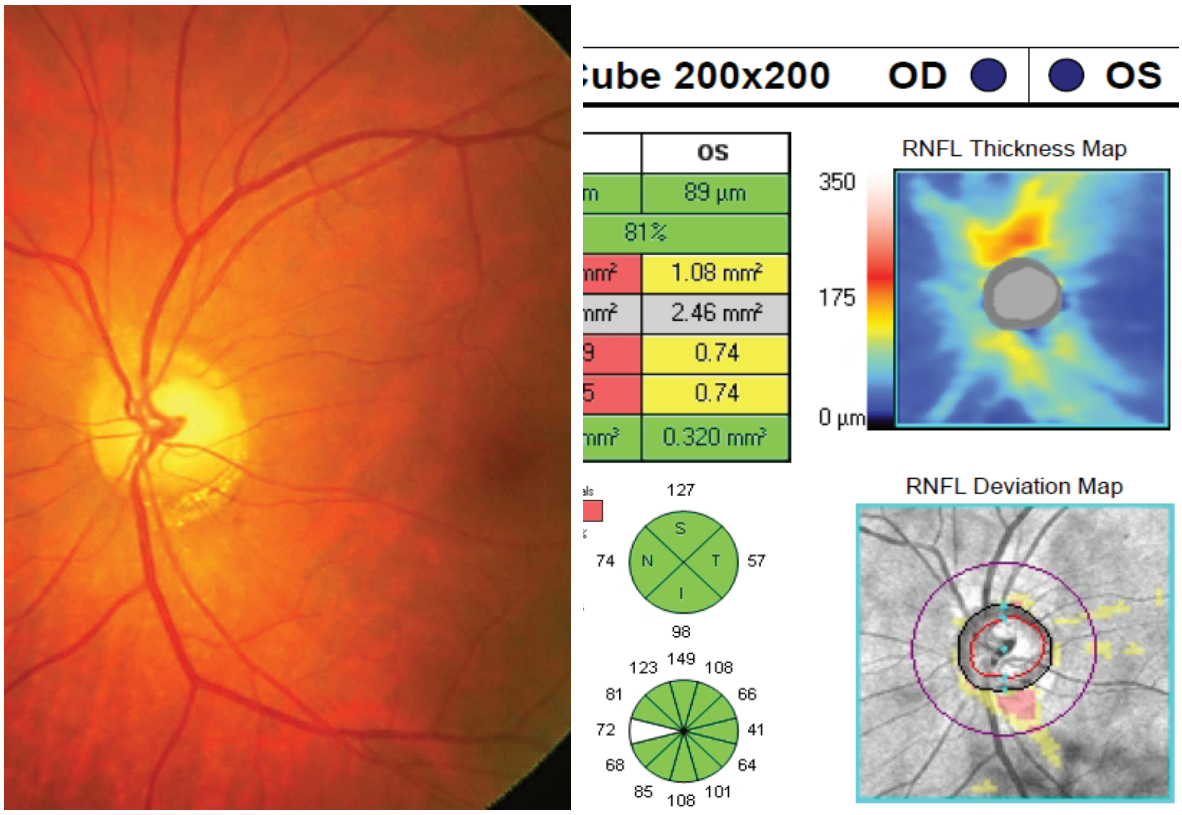

Fig. 3: Optical coherence tomography examination.

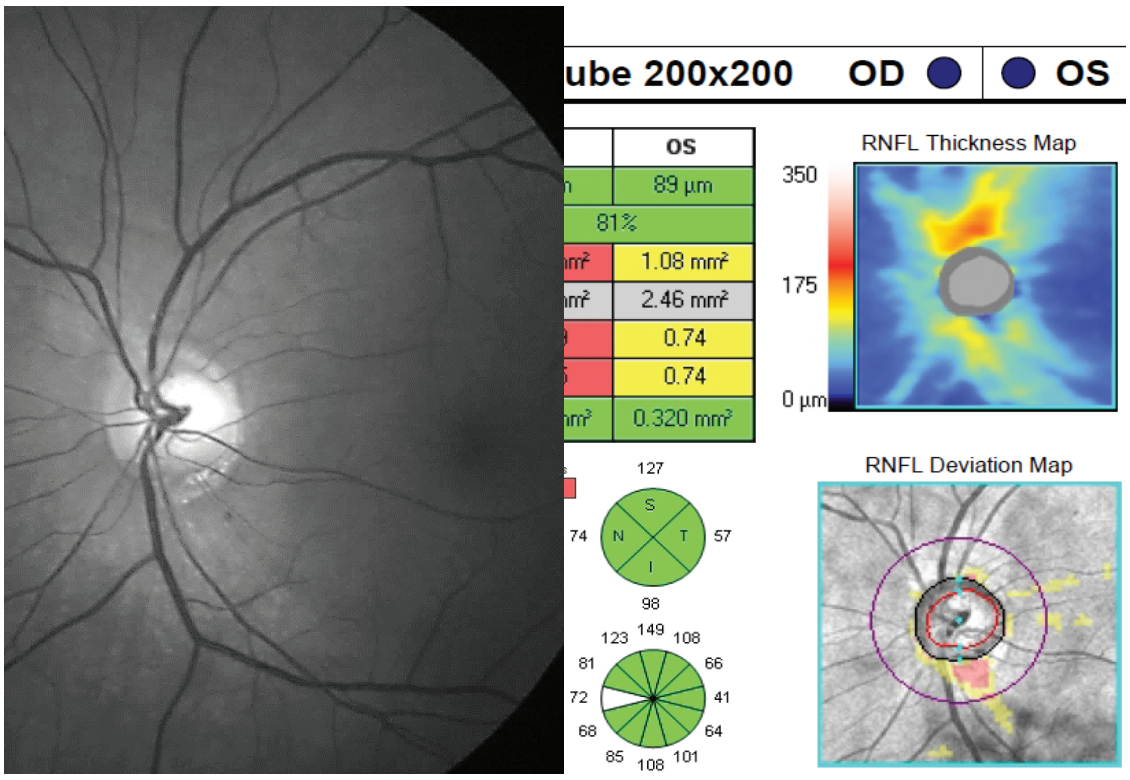

Fig. 4: Red-free fundus imaging.

CASE 4

INTRODUCTION

A 55-year-old male patient presented for routine examination. There was a family history of glaucoma.

EXAMINATION

- Intraocular pressure (IOP) was 22 mmHg in both eyes.
- Gonioscopy showed open angles.
- Right optic disc showed thinning in superior pole. The humphrey field analyzer (HFA) showed normal results (Fig. 1).
- Optical coherence tomography (OCT) showed infero-temporal retinal nerve fiber layer (RNFL) thinning in thickness and deviation maps. Note that the clock-hour map once again showed no abnormality (Fig. 2).
- Careful examination of the red-free photograph showed RNFL abnormality in the inferior region (Fig. 3).

CONCLUSIONS

Imaging is important in glaucoma suspect eyes to rule in or rule out early disease. Clock-hour maps can miss detecting structural defects.

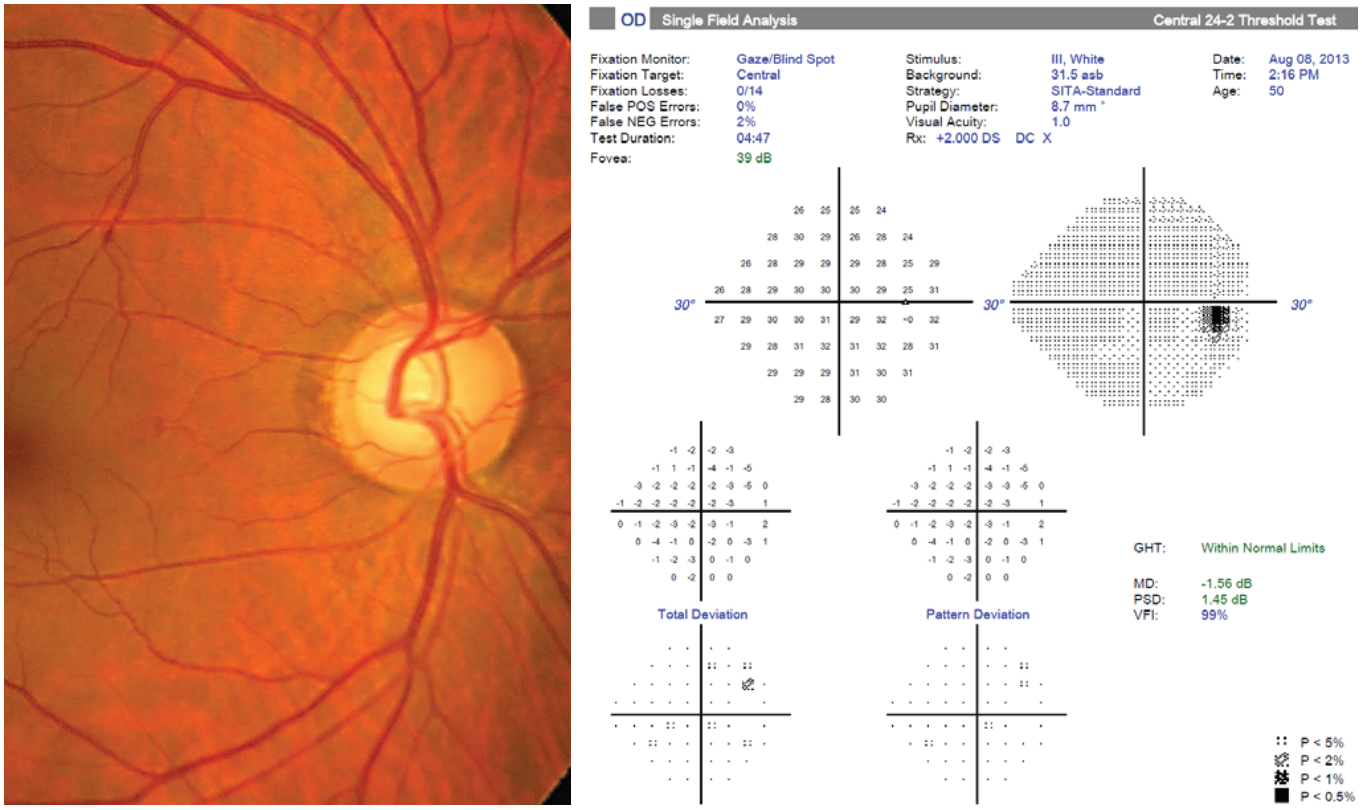

Fig. 1: Humphrey field analyzer examination.

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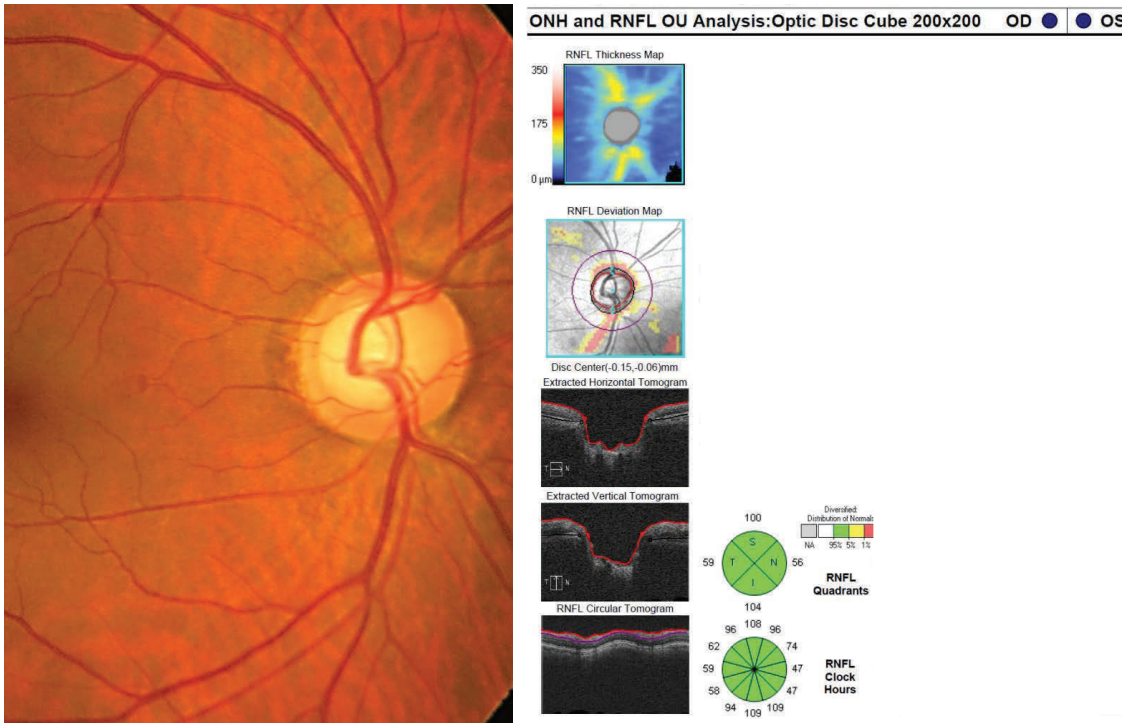

Fig. 2: Optical coherence tomography examination.

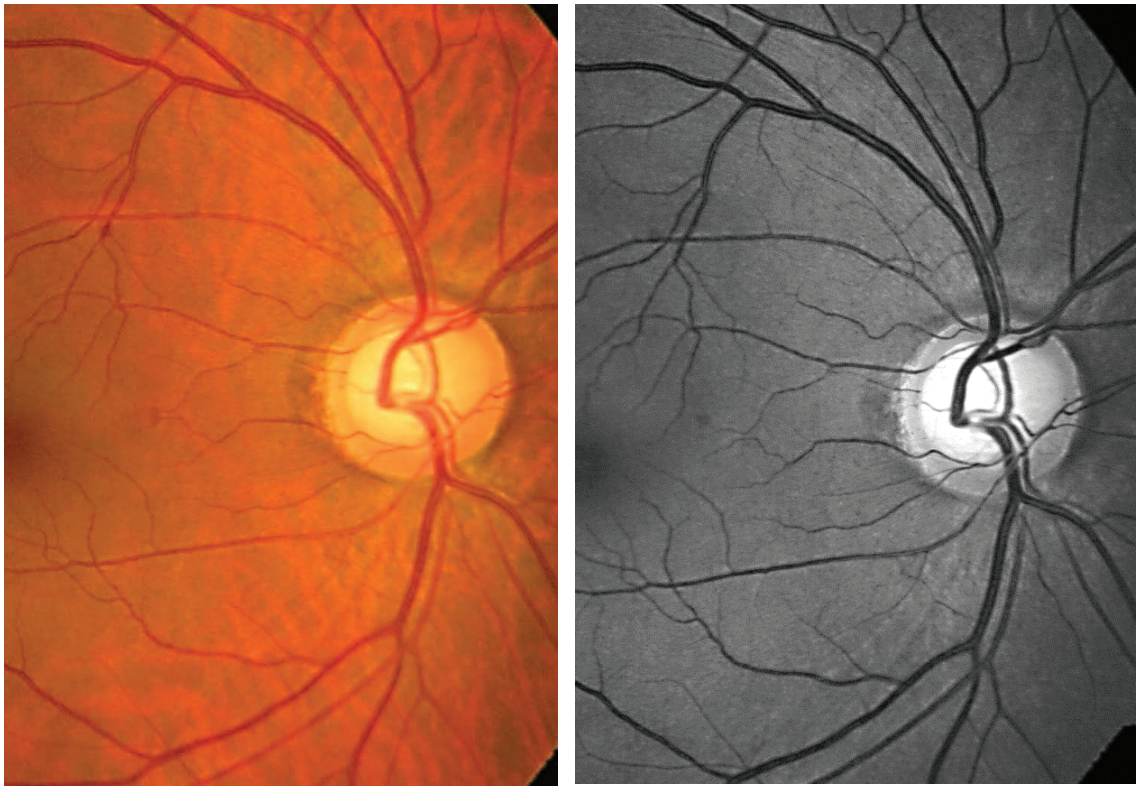

Fig. 3: Red-free fundus imaging.

CASE 5

INTRODUCTION

A 55-year-old female patient presented as a primary angle-closure suspect (PACS). There was no family history of glaucoma.

EXAMINATION

- Intraocular pressure (IOP) was 14 mmHg and the patient was not on anti-glaucoma medication.
- Disc in right eye showed intact rims and normal retinal nerve fiber layer (RNFL). Visual acuity (VA) showed normal results which are normal for a decade (Fig. 1).

However, optical coherence tomography (OCT) showed RNFL thinning, coded as red in the inferior region and yellow in the superior region (Fig. 2).

CONCLUSIONS

- Beware of "red" disease; OCT showing RNFL thinning on reference database comparison maps.
- Rely on thickness map analysis whenever available to avoid overdiagnosis of glaucoma on OCT.

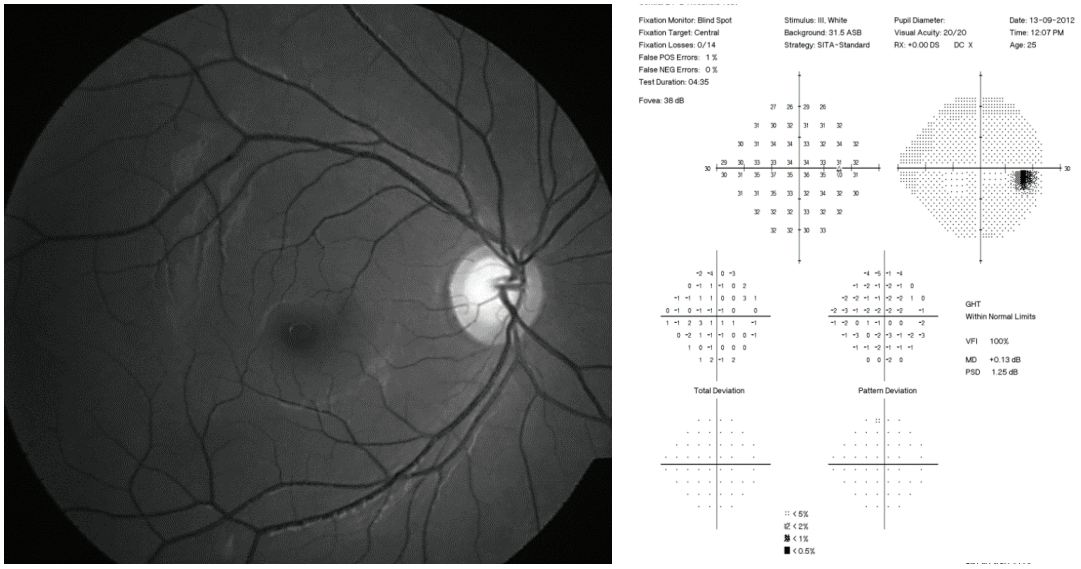

Fig. 1: Humphrey field analyzer examination.

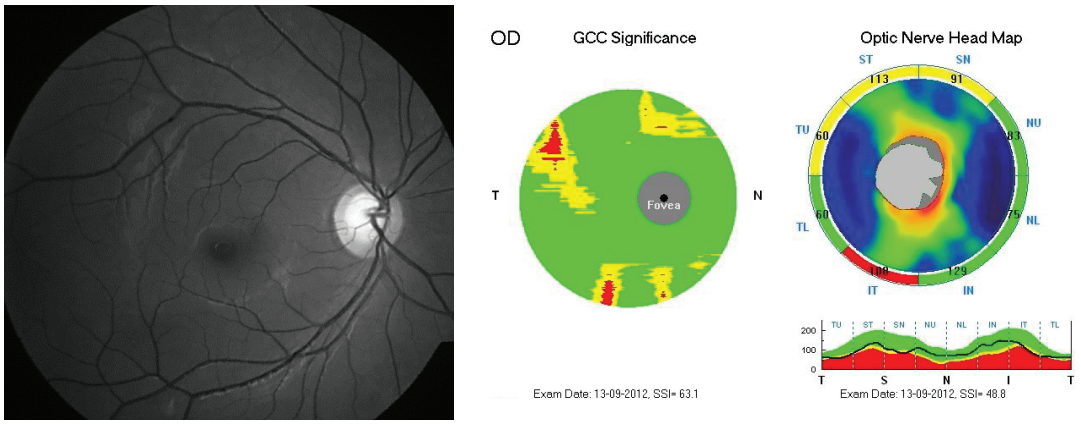

Fig. 2: Optical coherence tomography examination.

Content supported by Dr. Harsha BL Rao, Glaucoma Consultant, Narayana Nethralaya, Bengaluru

CASE 6

INTRODUCTION

A 65-year-old female patient with history of primary angle-closure glaucoma presented for examination.

EXAMINATION

- Intraocular pressure (IOP) was 22–28 mmHg under medical management. The patient was poorly-compliant to medicine dosage.
- Visual field (VF) showed a fast progression in the left eye. However, retinal nerve fiber layer (RNFL) maps showed no evidence of deterioration (Fig. 1).

CONCLUSIONS

Imaging is not very useful in advanced glaucoma.

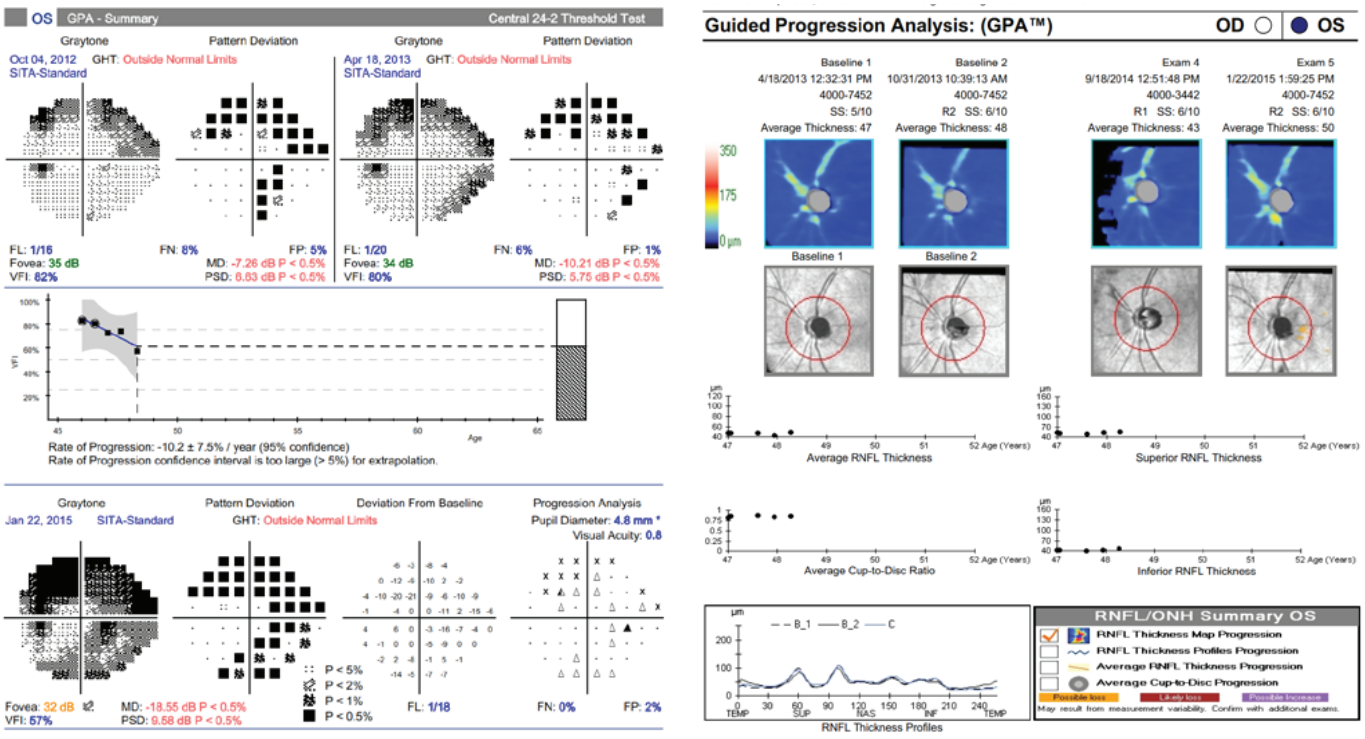

Fig. 1: Visual fields and retinal nerve fiber layer map.

Content supported by Dr. Harsha BL Rao, Glaucoma Consultant, Narayana Nethralaya, Bengaluru

8

External Examination of the Eye

TAKE HOME MESSAGES

- A good external examination is imperative to detect glaucoma in a blindness-preventable stage.
- Significant signs can be detected by a torch examination and a slit-lamp assessment.

A comprehensive eye examination including tonometry, gonioscopy, and a disc and field examination is the key to diagnosing glaucoma. However, the significance of a good external examination should not be underestimated. Visual acuity (VA), refraction, external examination, ocular motility, pupillary examination (for a relative afferent pupillary defect [RAPD]), and slit-lamp biomicroscopy must all be done thoroughly and documented for future reference. While intraocular pressure (IOP), gonioscopy, optic disc, and visual field (VF) testing are imperative in a good glaucoma investigation, these are not to be performed in isolation, but rather as a package along with a basic external ocular examination.

An external examination can detect signs like a hemangioma or dilated episcleral veins that could be due to a reason other than glaucoma whereas finding ciliary conjunctival congestion could be attributed to acute angle-closure (AAC).

Examining ocular motility could reveal any underlying amblyopia or sensory exotropia which could have a bearing on the future management.

Pupillary examination can reveal several hidden secrets. Glaucoma is usually not symmetrical in both eyes and detecting an RAPD is an important sign and helps in prognosis as well. In case of angle-closure, a dilated pupil may be seen.

Slit-lamp examination should be done in non-dilated and dilated eyes, which could show if there is any pseudoexfoliation (PFX), pigment dispersion, uveitis, or trauma. In case of a normal IOP but an edematous cornea, the readings would need to be repeated. The pupil could be distorted in case of posterior synechiae. Corneal endothelium or iris examination could also indicate a secondary cause. An earlier glaucoma attack could explain the Glaucomflecken on the anterior lens surface.

Glaucoma is a disease which, if detected in initial stages, can definitely prevent blindness. A thorough external examination can detect suspicious cases, which could then be examined by other modalities for a confirmation.

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TIPS AND TRICKS FOR GOOD EXTERNAL EXAMINATION

Vision
- Refraction
- Best corrected visual acuity
- Visual acuity should be documented at each visit

External eye
- Routine examination
- Ptosis if present, can have bearing on fields

Torch light examination
- Circumcorneal congestion

Pupils
- Size, shape, and reaction
- Bilateral glaucoma is usually asymmetric so relative afferent pupillary defect is generally present.

Oblique flashlight test
- Anterior chamber depth—shallow or deep

Cornea
- Edema, keratic precipitates, and others
- Anterior chamber
- Depth uniformity
- Van Herick's grading
- Signs of uveitis

Iris
- Pupil centration, size, and sphincter atrophy
- Polycoria
- Iris atrophy
- Pseudoexfoliation

Lens
- Subluxation, intumescence, shape and stage of cataract

Content supported by Dr. Thomas George, Senior Consultant Ophthalmologist, Cosmopolitan Hospital, Thiruvananthapuram

SECTION 3

- General Principles of Glaucoma Management
- Primary Open-angle Glaucoma
- Primary Angle-closure Glaucoma
- Ocular Hypertension
- Normal Tension Glaucoma
- Glaucoma Suspect
- Secondary Glaucoma
- Pediatric Glaucoma
- Medical Management of Glaucoma
- Miscellaneous

9

General Principles of Glaucoma Management

TAKE HOME MESSAGES

- A thorough diagnosis is essential for optimal glaucoma management.
- An individualized holistic approach should be adopted for management of glaucoma.
- Medical therapy is the most preferred option.
- Monitoring and follow-up are essential components of glaucoma management.

Glaucoma is one of the leading causes of vision loss worldwide, and is associated with significant long-lasting adverse consequences. It impairs patients' quality of life attributable to progressive vision loss, inconvenience due to side-effects, and cost of therapy.

GENERAL CONSIDERATIONS IN GLAUCOMA MANAGEMENT

- As glaucoma is a debilitating condition, it is imperative that attending ophthalmologists consider several important factors while managing a patient of glaucoma (Table 1).
- The fundamental aims of glaucoma management are to preserve vision and improve the quality of life lost due to the disease.
- Taking into account the main treatment goals, it is prudent to devise a holistic management approach that is tailored according to patients' needs, preferences, and general health condition.
- The rationale for this approach is to ensure that patients are able to adhere to the therapy for desired outcomes.

PRINCIPLES OF GLAUCOMA MANAGEMENT

- The challenges related to comprehensive glaucoma management are numerous. Hence, it is important to adopt and observe basic principles for optimal outcomes:
  - Establish a robust diagnosis.
  - Set a target intraocular pressure (IOP).
  - Medical therapy is the preferred treatment option.
  - Monitor and follow-up patients.
  - Choose advanced therapeutic options, when necessary.
- Early and appropriate diagnoses is important to prevent visual impairment and to plan an appropriate treatment strategy.
- Management approach should consider targeting a variety of mechanisms underlying pathogenesis of glaucoma; these include but are not limited to increased IOP, ischemia, genetic factors, and oxidative damage.
- Wealth of data indicates that strategies used for glaucoma management principally slow the progression of disease and its complications such as vision loss.
- Despite role of several mechanistic pathways in glaucoma, numerous studies have shown IOP lowering as a valuable option in both patients, with or without raised IOP. Thus, lowering of IOP to a preset target pressure range individualized according to patients' needs is advisable.
- Several treatment options are currently available for glaucoma management including medicines, laser therapy, and surgical options. However, clinical evidences indicate the role of pharmacotherapy aiming at lowering IOP as the mainstay.
- Among currently available drugs, five main classes of medicines commonly used in glaucoma treatment include:
  - Prostaglandin analogs
  - Cholinergic agonists

Table 1: General considerations in glaucoma management.

- Prevent loss of vision.
- Minimize adverse effects of therapy.
- Preserve and improve patients' quality of life.
- Optimize cost of therapy.
- Consider patients' compliance while prescribing therapy.

  - Adrenoceptor agonists
  - Carbonic anhydrase inhibitors
  - Beta-adrenoceptor antagonists
- Other agents include hyperosmotic drugs and combination therapeutics.
- Prostaglandin analogs constitute as the first-line agents, with similar popularity for beta-adrenoceptor antagonists. If first-line agents provide inadequate therapeutic response, it is advisable to change to other classes of drugs such as alfa-adrenergic agonists and carbonic anhydrase inhibitors.
- Ideally, monotherapy should be instituted as initial treatment protocol.
- Therapy in glaucoma is usually implemented in an upward fashion; in events when monotherapy fails to produce desired results, another agent may be added till the desired outcomes are achieved.
- However, a specialist must resort to alternative and advanced therapeutic options in case medical therapy proves to be inadequate for achieving required clinical outcomes, side-effects of therapy outweigh the benefits, cost of the therapy is exuberant, or patient is unable to adhere to the prescribed regimen.
- Monitoring treatment outcome and checking for progressive damage is important to ensure the success of treatment.

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10

Primary Open-angle Glaucoma

TAKE HOME MESSAGES

- Intraocular pressure lowering is the primary target in primary open-angle glaucoma.
- Medical management with agents such as prostaglandin analogs, beta-blockers, carbonic anhydrase inhibitors, and alfa-agonists is effective for intraocular pressure lowering.
- Treatment of primary open-angle glaucoma is carried out in a step-wise manner.
- If medical management fails, laser and surgical options can be explored.

- Primary open-angle glaucoma (POAG), being the most frequently-encountered subtype of glaucoma, merits special emphasis, and vigorous treatment strategy.
- Medical management with aim to lower intraocular pressure (IOP), the primary underlying pathology, forms the foundation of an appropriate therapeutic regimen.
- Rationale for lowering IOP in POAG relies on the findings that elevation of IOP promotes degenerative changes in optic nerve. It has also been proven that extent of nerve impairment is proportional to extent of IOP increase. However, owing to advancements in diagnosis and knowledge of disease process, other pathological pathways enlisted in Table 1 may also be explored and targeted.
- Since IOP lowering is a cornerstone approach, it is imperative to establish a therapeutic goal termed as target IOP range to monitor the effectiveness of therapy instilled.
- Target IOP is considered as a level at which progressive optic nerve damage or visual field defect is not expected (Table 2).
- There are mainly two pathways that pharmacologic agents target in order to reduce IOP; reduction of aqueous humor production and promotion of drainage of aqueous humor through conventional and unconventional pathways. Conventional pathway includes drainage through trabecular meshwork or Schlemm's canal whereas unconventional pathway includes drainage through uveoscleral outflow passage.
- The chief classes of drugs used for pharmacotherapeutic management of POAG include prostaglandin analogs, beta-blockers, carbonic anhydrase inhibitors, and alfa-agonists.
- Prostaglandin analogs such as Latanoprost are extensively used in POAG. It is expected that one drop of this agent, once-daily, may help in reducing IOP by almost 30%. Prostaglandin analogs produce superior ocular hypotensive results when used in combination with beta-blockers, adrenergic and cholinergic agonists, or carbonic anhydrase inhibitors.
- Topical beta-blockers are another group of agents useful for reduction of IOP. Two types of beta-blockers are currently in use, nonselective that target beta-1 and beta-2 adrenoceptors, and cardioselective that target only beta-2 adrenoceptors. Timolol, levobunolol, and betaxolol are few examples of beta-blockers used for ocular purposes.
- Carbonic anhydrase inhibitors such as Dorzolamide and Brinzolamide have also been well-accepted for treatment

Table 1: Treatment targets in primary open-angle glaucoma.

- Intraocular pressure
- Oxidative stress
- Vascular dysfunction
- Retinal cell apoptosis
- Immune dysregulation
- Protein misfolding
- Excitotoxicity

Table 2: Optimal target intraocular pressure in primary open-angle glaucoma.

Disease stage	Target intraocular pressure (IOP)*
Mild	15–17 mmHg
Moderate	12–15 mmHg
Severe	10–12 mmHg

*Note:

- Target IOP may be reassessed after 6 months based on baseline IOP, age, vascular perfusion outcomes, or change in perimetry/imaging outcomes.
- In case of progression or systemic disease, further lowering of IOP is suggested.

of glaucoma. They show IOP lowering effect equivalent to beta-blockers but are less effective than prostaglandin analogs. These agents can be readily used with other drugs due to their additive potential when used in combination.

- Alfa-agonists are another class of agents used in glaucoma management, but are mainly second-line of therapy. These agents can be prescribed as monotherapy or in combination with beta-blockers. Brimonidine is commonly used due to its better tolerability and efficacy.
- Primary open-angle glaucoma management is carried in a step-wise approach (Fig. 1). Initially monotherapy is started, followed by combination therapy, with laser therapy or surgery as secondary options in case of inadequate treatment response. Wealth of data substantiates the effectiveness of medical therapy in POAG. The ideal characteristics of a medical agent are enlisted in Table 3.

Table 3: Characteristics of an ideal intraocular pressure lowering agent.

- Efficacious with long-term protective action
- Fewer local and systemic side-effects
- Good tolerability profile
- Need for lesser dose instillation to improve compliance
- Use in different subgroups of patients
- Cost-effective

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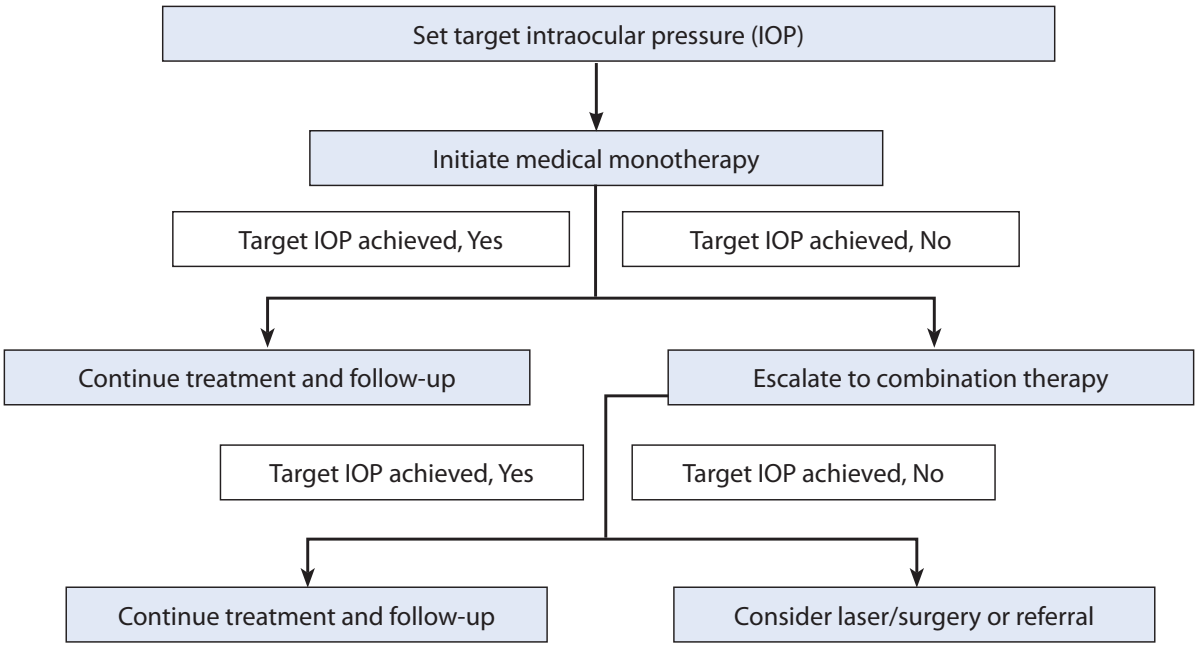

Fig. 1: Treatment flowchart for primary open-angle glaucoma.

CASE 1

EARLY PRIMARY OPEN-ANGLE GLAUCOMA

TAKE HOME MESSAGES

- Establishing target intraocular pressure is necessary.
- Risk factors must be considered during the management of primary open-angle glaucoma.

INTRODUCTION

A 32-year-old male presented for routine check-up. His medical history was negative for diabetes or any other systemic illness.

On enquiring about his family, it was revealed that his mother and sister both had glaucoma. While his sister was on medical therapy, his mother underwent surgery in both the eyes but unfortunately lost vision in one eye.

He was apprehensive and worried due to his condition, and feared vision loss.

EXAMINATION

- Best corrected visual acuity (BCVA)
  - Right eye (OD): 6/9, n6
  - Left eye (OS): 6/9, n6
- Anterior segment examination (OD and OS): Normal, Van Herick (VH)>1/2 corneal thickness
- Pupil (OD and OS): 3 mm, round and regular, reacting to light (rrr)
- Gonioscopy showed open angles
- Intraocular pressure (IOP)
  - OD: 22 mmHg
  - OS: 24 mmHg (applanation)
- Diurnal IOP
  - OD: 22–26 mmHg
  - OS: 24–28 mmHg
- Optic disc examination (Figs. 1a, b): Right eye showed thinning of superior and inferotemporal neuroretinal rim (NRR) and slit-like retinal nerve fiber layer (RNFL) defect. Left eye showed an inferotemporal notch and NFL defect.
- Visual field examination was normal for the right eye; generalized as well as steep localized loss in superotemporal field was noted in the left eye (Figs. 2a, b).
- Nerve fiber layer thickness analysis (Fig. 3): Right eye was normal whereas left eye showed inferotemporal NFL loss

DIAGNOSIS

After necessary assessment, patient was diagnosed with early primary open-angle glaucoma (POAG) with definitive glaucomatous optic nerve changes and corresponding vision loss.

MANAGEMENT

Considering high risk of blindness owing to contributory family history, early age of onset and defect close to fixation, early IOP lowering by at least 30% (14–18 mmHg) was set as the target IOP.

CONCLUSIONS

Patient was diagnosed with early POAG, and IOP lowering by 30% was considered appropriate.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru

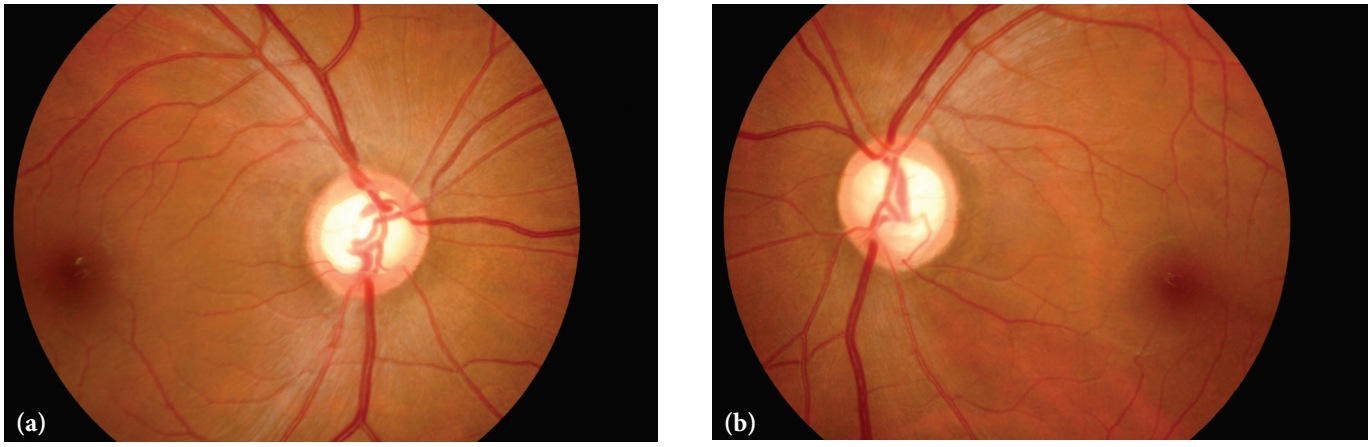

Fig. 1: Optic disc examination. (**a**) The optic disc of the right eye is slightly large in size and shows some thinning of the superior and inferotemporal neuroretinal rim, and superior temporal and inferior slit-like retinal nerve fiber layer defects. (**b**) The optic disc of the left eye shows an inferotemporal notch, cup-to-disc ratio 0.75 with slit-like nerve fiber layer defects superiorly.

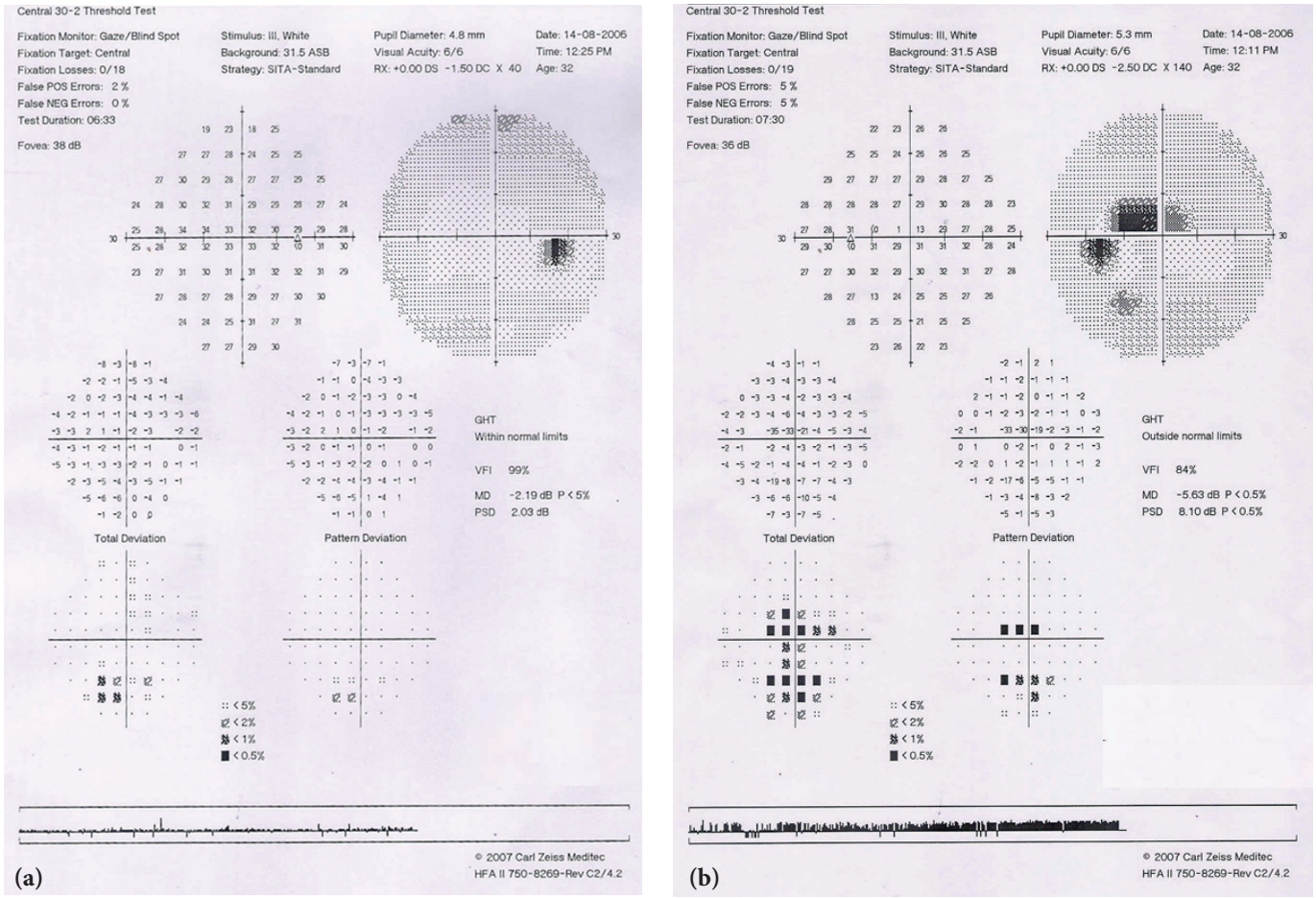

Fig. 2: Visual field examination: (**a**) Right eye visual fields are normal. (**b**) Left eye visual fields show mild generalized and steep localized loss in the superotemporal field that respects the horizontal meridian.

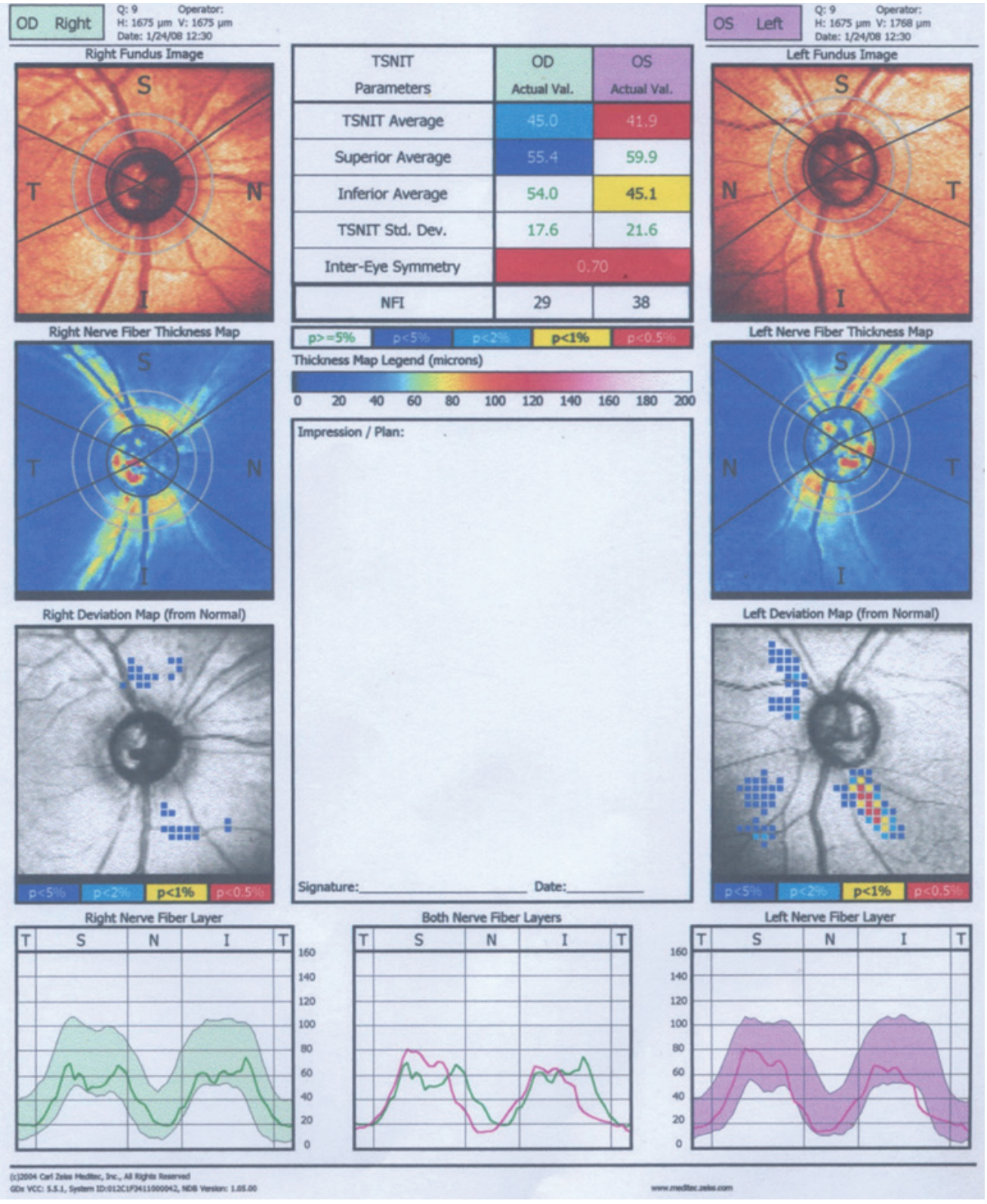

Fig. 3: Nerve fiber layer thickness analysis of the right eye is within normal limit, left eye shows inferotemporal nerve fiber layer loss.

CASE 2

SEVERE/ADVANCED PRIMARY OPEN-ANGLE GLAUCOMA

TAKE HOME MESSAGES

- Intraocular pressure reduction by 30% is usually considered appropriate in primary open-angle glaucoma.
- In case of failure with monotherapy, step-wise approach for management must be adopted and combination must be prescribed.
- Follow-up is necessary to monitor treatment response and check for progression.

INTRODUCTION

A 45-year-old male driver reported with disturbed vision since past few months. He was previously diagnosed with glaucoma and was undergoing treatment with Latanoprost 0.005% eye drops left eye. He had no systemic illness. His family history was significant since his sister was also diagnosed with glaucoma.

EXAMINATION

- Visual acuity (VA) test
  - Right eye (OD): 6/6
  - Left eye (OS): 6/9
- Anterior segment
  - OD: Within normal limit (wnl)
  - OS: Relative afferent pupillary defect (RAPD)–positive; anterior segment–wnl
- Gonioscopy showed open angles in both eyes.
- Intraocular pressure
  - OD: 23 mmHg
  - OS: 28 mmHg
- Central corneal thickness (CCT)
  - OD: 490 µm
  - OS: 500 µm
- Anterior segment slit-lamp analysis of the right and left eye showed dilated pupil (pharmacological) (Figs. 1a, b).
- Optic disc examination was significant for inferior NFL defect in the right eye and peripapillary atrophy (PPA) in the left eye (Figs. 2a, b).
- Visual field (VF) examination showed superior arcuate type of field defect in the right eye, and advanced field loss with a preserved temporal island in the left eye (Figs. 3a–c).

DIAGNOSIS

After thorough check-up, he was diagnosed with severe POAG associated with disc change and VF loss in OD and advanced disc changes associated with VF loss and threatened fixation in OS.

MANAGEMENT

After considering younger age and positive family history, reduction in IOP by at least 30% from baseline in the right eye and to near episcleral venous pressure in the left eye was planned.

CONCLUSIONS

Reduction of IOP in POAG patients is the most important therapeutic approach.

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Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru

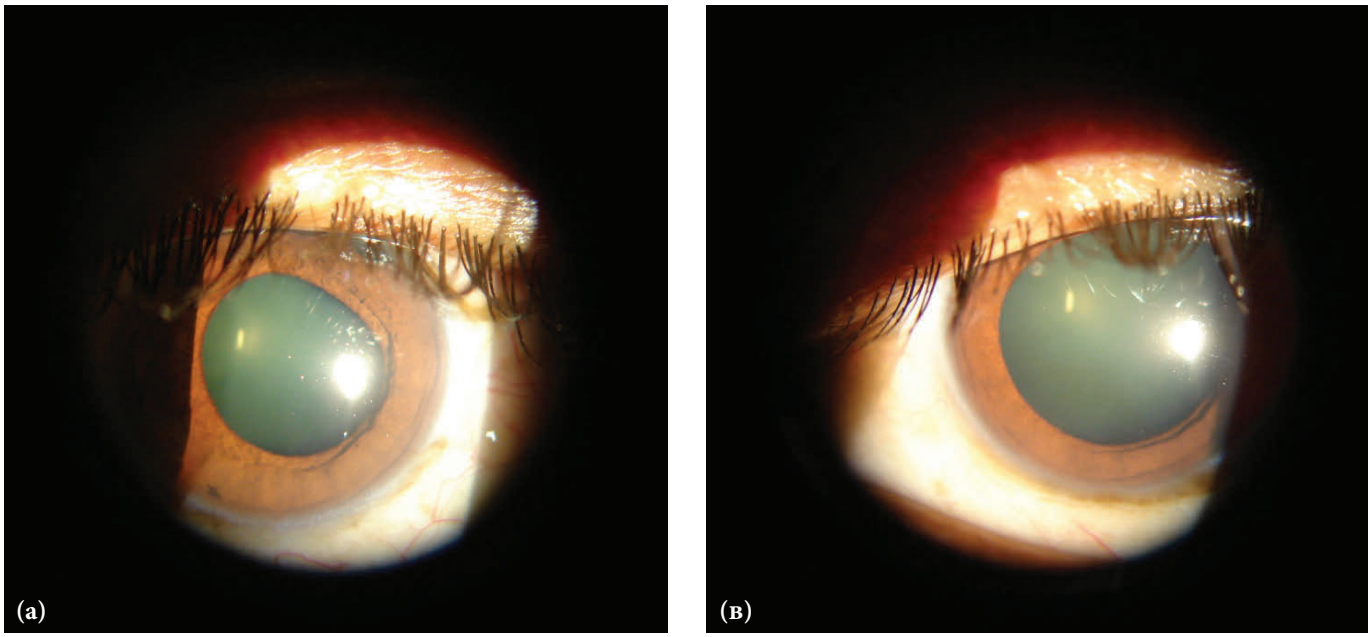


Fig. 1(a, b): Slit-lamp examination showing dilated pupil (pharmacological).

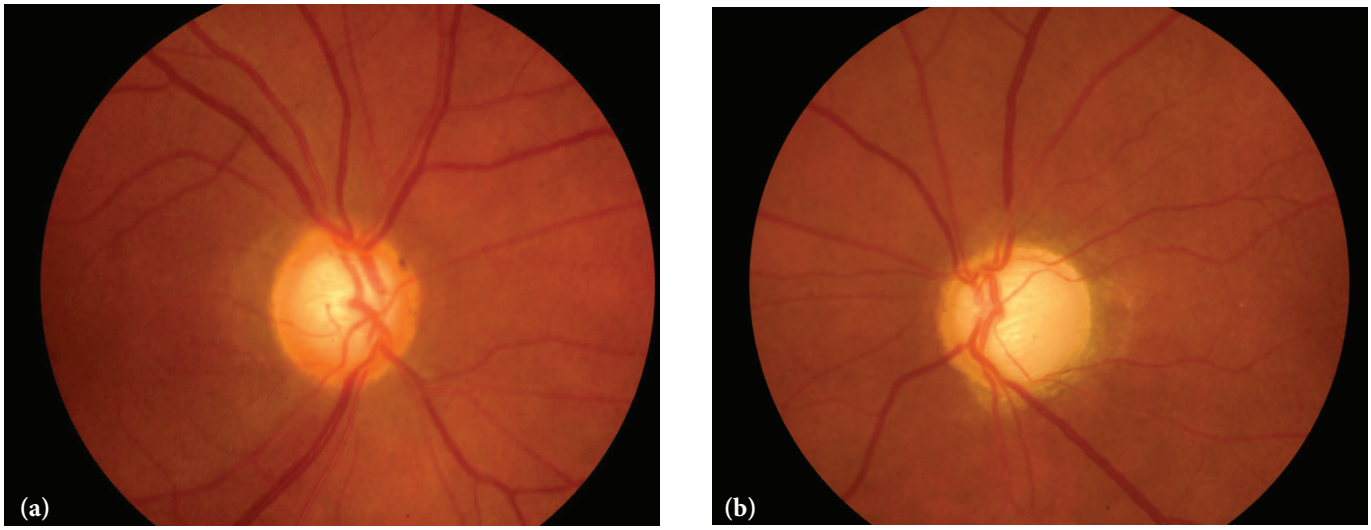
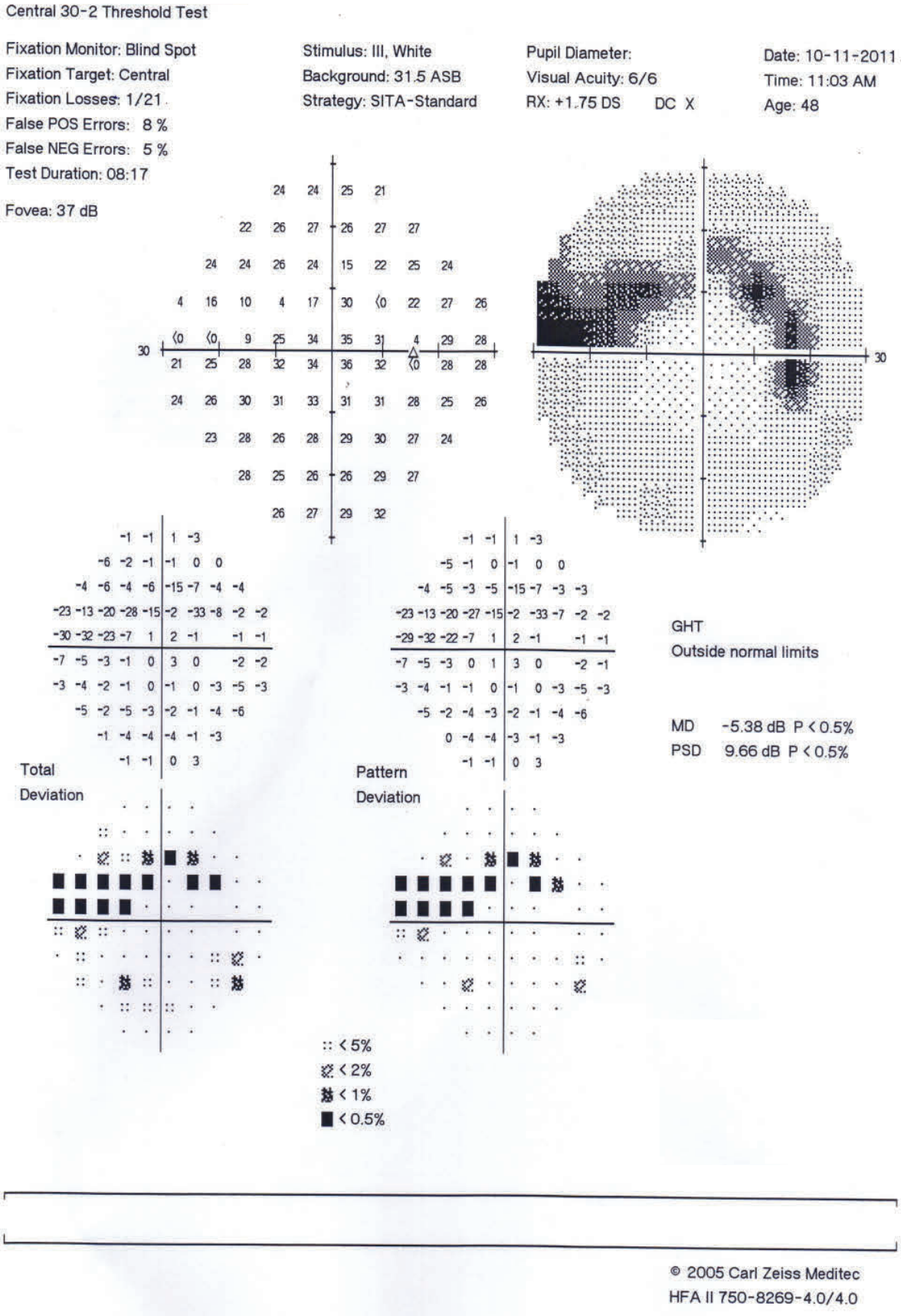


Fig. 2: Optic disc examination. (**a**) Optic disc of the right eye showing cup-to-disc ratio (CDR) of 0.8 and concentric enlargement of cup with thin neuroretinal rim (NRR) inferiorly, and peripapillary atrophy (PPA). Inferior nerve fiber layer defect is also seen. (**b**) Disc of the left eye showing 0.9 CDR, with thin NRR all round and PPA.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False NEG Errors: 5 %
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Background: 31.5 ASB
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RX: +1.75 DS DC X
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GHT
Outside normal limits
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PSD 9.66 dB P < 0.5%
Total Deviation
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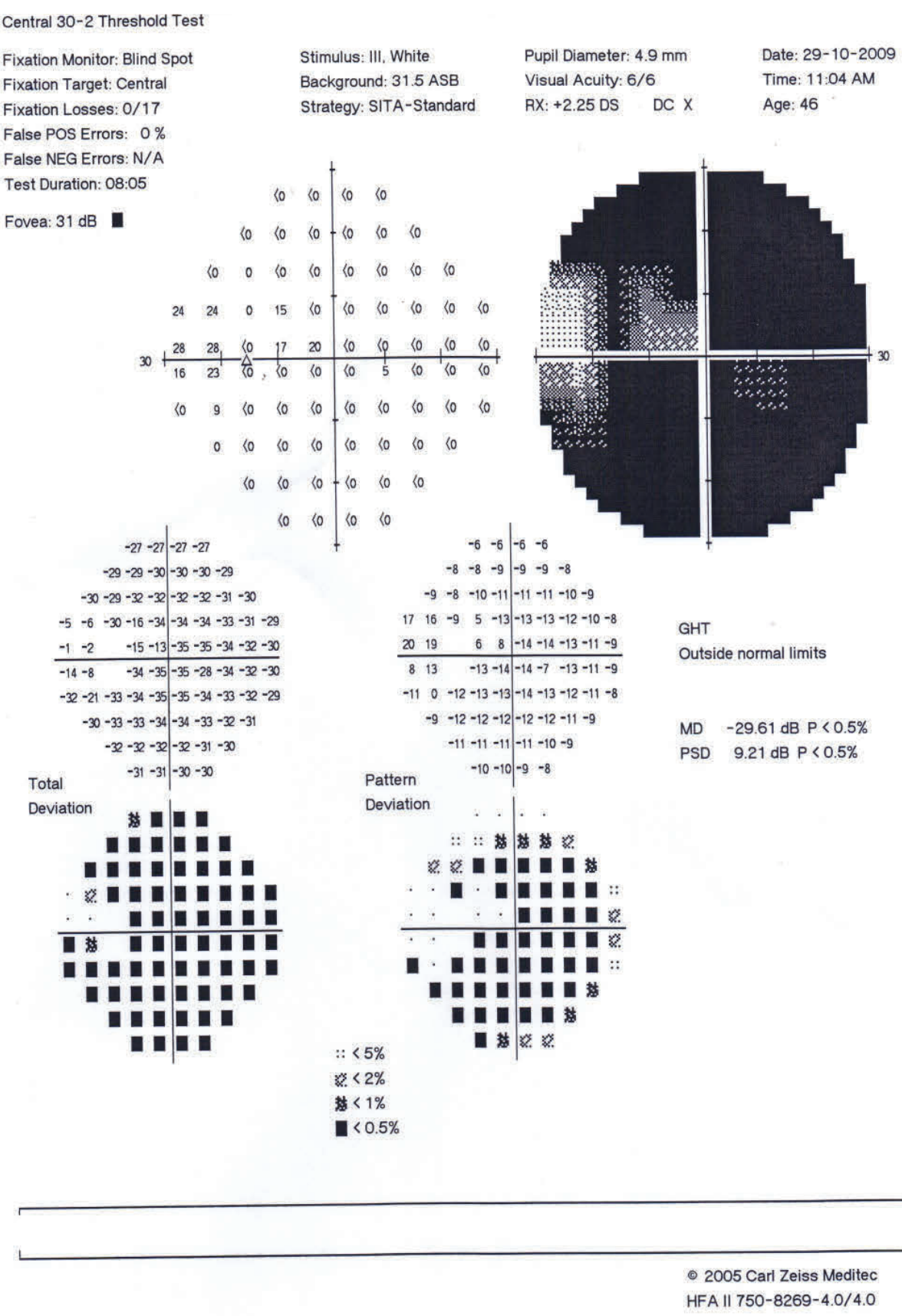
(a)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GHT
Outside normal limits
MD -29.61 dB P < 0.5%
PSD 9.21 dB P < 0.5%
Total Deviation
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(b)

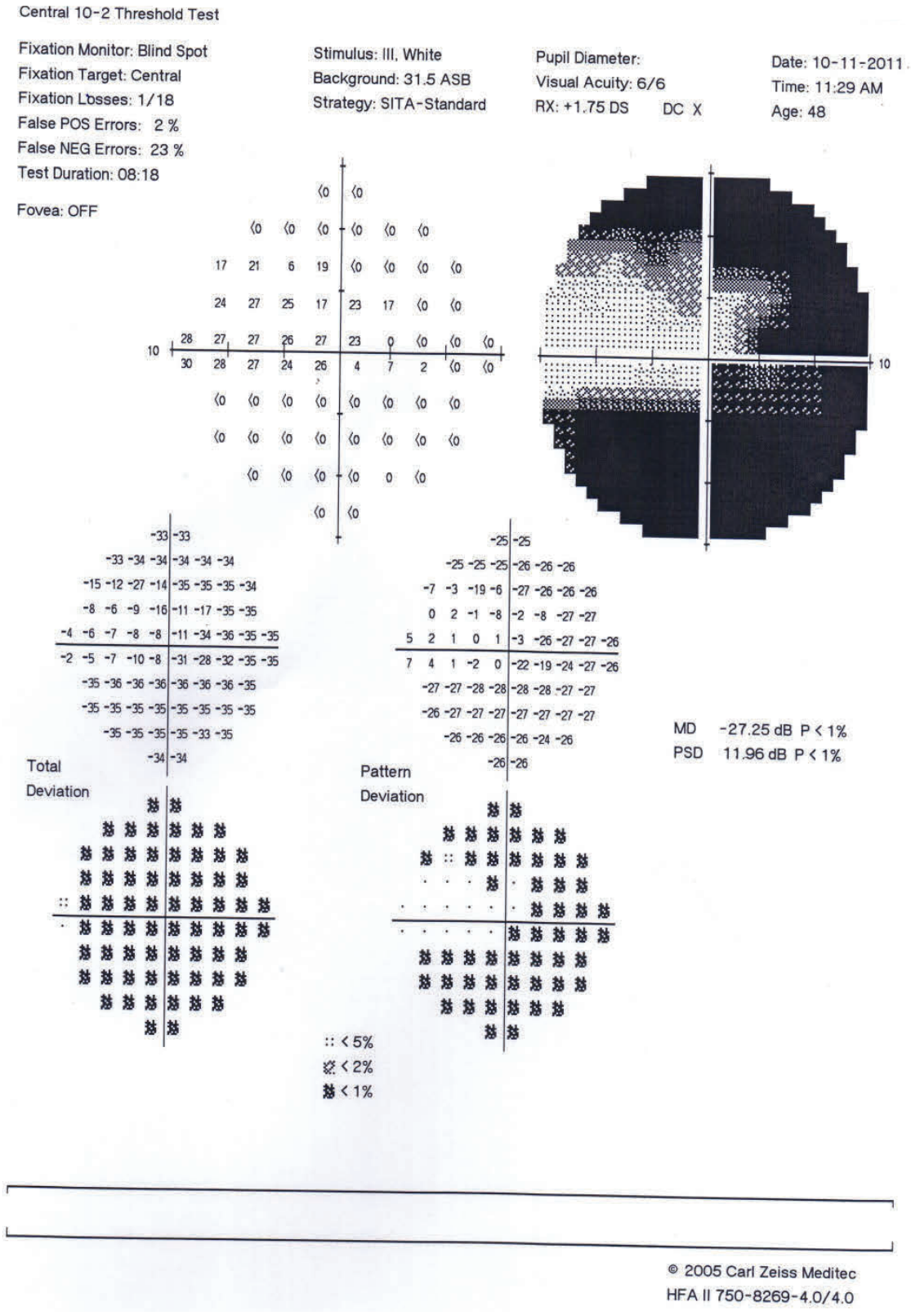

Fig. 3: Visual field examination. (**a**) Visual fields of the right eye showing superior arcuate type of field defect. (**b**) Visual field (30-2) of the left eye showing advanced field loss with a preserved temporal island. (**c**) Central (10-2) visual fields of the left eye showing small island of preserved retinal sensitivity.

11

Primary Angle-closure Glaucoma

TAKE HOME MESSAGES

- Detection/screening for angle closure should be conducted in all patients above 40 years of age and with a family history of primary angle-closure glaucoma.
- Periodic verification of gonioscopy is necessary even after laser peripheral iridotomy.
- Medical treatment should not be used as a substitute for laser iridotomy or surgical iridectomy in patients with primary angle closure or primary angle-closure glaucoma.

Primary angle-closure glaucoma (PACG) is widespread in India and Asian countries. The magnitude of the problem is large hence, it is important to understand various management regimens to effectively treat the disease, reduce the burden, preserve vision, and improve patients' quality of life.

- A comprehensive management relies on the following factors:
  - Clinical presentation
  - Correct diagnosis: primary angle-closure suspect (PACS), primary angle-closure (PAC) or PACG
  - Identification of underlying pathological process
  - Appropriate therapy
- Treatment options in PACG include
  - Medical management: oral, topical, and intravenous agents
  - Laser management: Argon and neodymium-doped (Nd): yttrium-aluminum-garnet (YAG) peripheral iridotomy
  - Surgical management: in eyes showing inadequate response to medical/laser therapy for PAC and PACG
- Medical therapy is to be used in conjunction with laser or surgical options.
- The management protocol for angle closure has been summarized in Fig. 1.

MANAGEMENT OF PRIMARY ANGLE-CLOSURE SUSPECT

- Medical therapy must be instituted before prophylactic laser iridotomy to induce pupil miosis and iris stromal thinning so that it is easy to perform laser procedure.
- Intraocular pressure (IOP) spike before and after laser therapy may be avoided using alfa-agonists.
- Post-laser inflammation can be treated with topical steroids.

MANAGEMENT OF ACUTE PRIMARY ANGLE-CLOSURE

- Intraocular pressure lowering using medical therapy is important as immediate management protocol.
- Subsequent to sufficient IOP lowering, pilocarpine should be instilled to restore aqueous outflow except in some cases such as phacomorphic, pseudoexfoliation, aqueous misdirection, and secondary to lens-induced mechanisms.
- Systemic status of the patient should be assessed for diseases like asthma, diabetes, cardiovascular disorders, allergic disorders, hypertension, allergy to drugs, use of anticoagulants, and renal status.
- Use of intravenous mannitol (20%) and/or oral acetazolamide tablets and/or glycerol syrup (not to be used in diabetes) is advisable for lowering IOP depending on systemic status.
- While awaiting definitive therapy, topical steroid can be given to alleviate inflammation, and analgesics to alleviate pain.
- Yttrium aluminum garnet peripheral laser iridotomy or peripheral iridoplasty, constitute as definitive management options.
- Prophylactic YAG peripheral iridotomy may be considered for high-risk patients after gonioscopy assessment.

MANAGEMENT OF PRIMARY ANGLE-CLOSURE GLAUCOMA AND CHRONIC PRIMARY ANGLE CLOSURE

- Laser iridotomy or iridoplasty should be performed for management purposes.

Content supported by Dr. Manish Panday, Director, Glaucoma, Ratan Jyoti Netralaya, Ophthalmic Institute and Research Centre, Gwalior

- Intraocular pressure lowering agents may be advised for long-term control of IOP in patients with inadequate control.

LASER MANAGEMENT

- Laser iridotomy is the mainstay and suggested in all cases of PAC and PACG. However, in PACS, it is indicated in narrow angles in the fellow eye with acute angle closure glaucoma, confirmed family history of PACG and is relatively indicated when follow-up is not possible, and patient needs frequent dilatation for retinal evaluation.
- Lasers target pupillary block as the primary underlying patho-mechanism.
- Yttrium aluminum garnet lasers are most commonly used.
- Appropriate power and time of exposure according to iris thickness and extent of iris pigmentation are essential to produce desired outcomes.
- It is less effective in advanced stages of PACG.

SURGICAL MANAGEMENT

- Surgical management is chosen when medical and laser therapy produce inadequate response or when progressive visual field defect or optic nerve damage are evident.
- Surgical management may also be selected in non-compliant patients, intolerance to medical therapy, and uncooperative patients.
- Iridectomy, lens extraction, goniosynechialysis, and trabeculectomy are few surgical options.

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TIPS AND TRICKS

- Intraocular pressure (IOP) alone cannot be used as a tool for diagnosis. IOP can be within normal range in primary angle-closure glaucoma.
- A suitable combination of power and time of laser exposure appropriate to the iris thickness and degree of iris pigmentation, is critical to produce the desired effect in laser iridotomy.
- Laser iridotomy may fail in case of very high IOP, greater extent of peripheral anterior synechiae, and glaucomatous optic disc. Trabeculectomy is selected in such cases.
- There is no consensus on usefulness of clear lens extraction as a treatment option in angle-closure glaucoma.

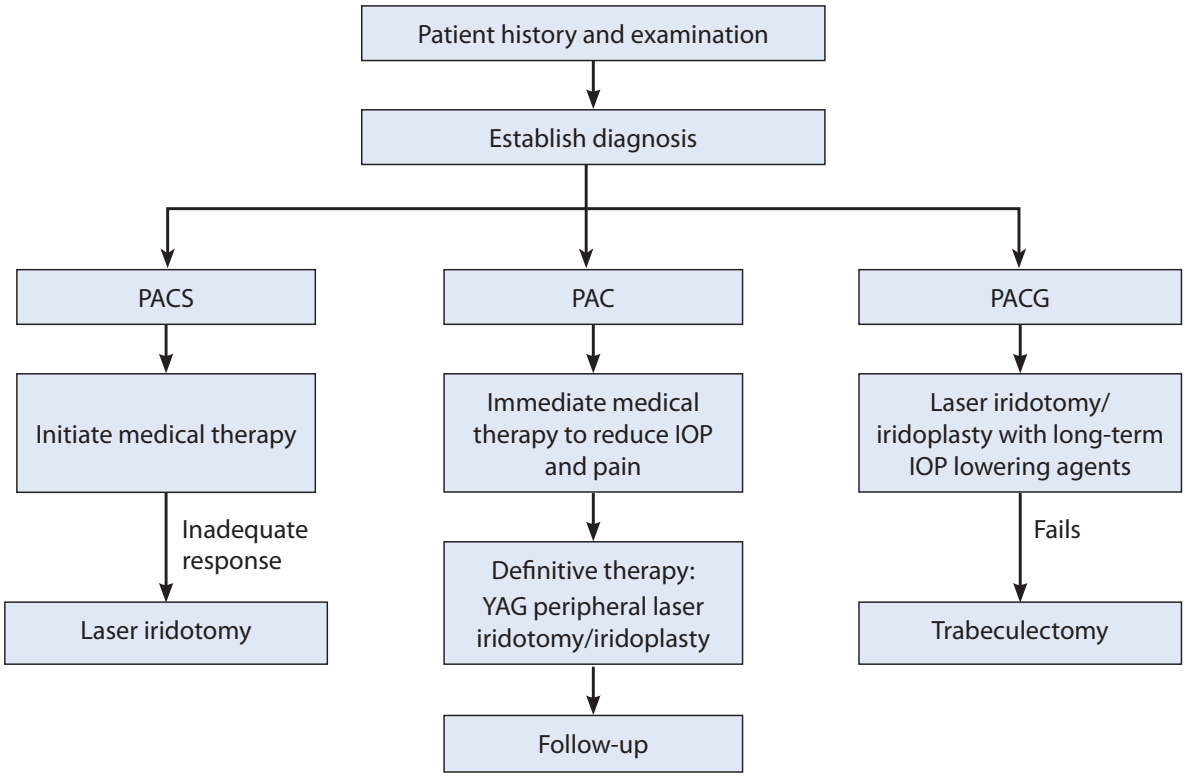


Fig. 1: Flowchart showing management plan for angle-closure.

PACS: primary angle-closure suspect; PAC: primary angle closure; PACG: primary angle-closure glaucoma; IOP: intraocular pressure; YAG: Yttrium aluminum garnet

CASE 1

TAKE HOME MESSAGES

Laser iridotomy is the treatment of choice in primary angle-closure glaucoma.

INTRODUCTION

A 63-year-old female reported with reduction in vision in her left eye. Her medical history was insignificant for any systemic illness.

EXAMINATION

- Visual acuity (VA) test
  - Right eye (OD): 6/6, n6
  - Left eye (OS): 6/18, n10
- Anterior segment examination
  - OD: Within normal limit (wnl), pupil 3 mm round, regular and reactive to light (rrr)
  - OS: pupil 4 mm, relative afferent pupillary defect (RAPD)–positive
- Intraocular pressure (IOP)
  - OD: 16 mmHg
  - OS: 24 mmHg
- Gonioscopy showed closed angles in both eyes, opens to grade 1–2 on indentation.
- Anterior segment slit-lamp examination (Figs. 1a, b)
  - There is anisocoria, with left pupil larger than the right one.
- Visual field (VF) examination (Figs. 2a, b)
  - OD: Normal
  - OS: Showed a preserved central island of vision on the 30-2, with macular fields
- Optic disc examination (Fig. 3)
  - Optic disc of the left eye showed advanced disc changes with 0.9 cup-to-disc ratio (CDR) and peripapillary atrophy (PPA)

DIAGNOSIS

- OD: Primary angle-closure
- OS: Primary angle-closure glaucoma (PACG) with advanced disc and VF loss

MANAGEMENT

Patient underwent laser iridotomy in both eyes, followed by treatment of the left eye with medications. The target IOP was set to <12 mmHg.

CONCLUSIONS

The patient was diagnosed with PACG. Laser iridotomy was considered appropriate and performed.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru

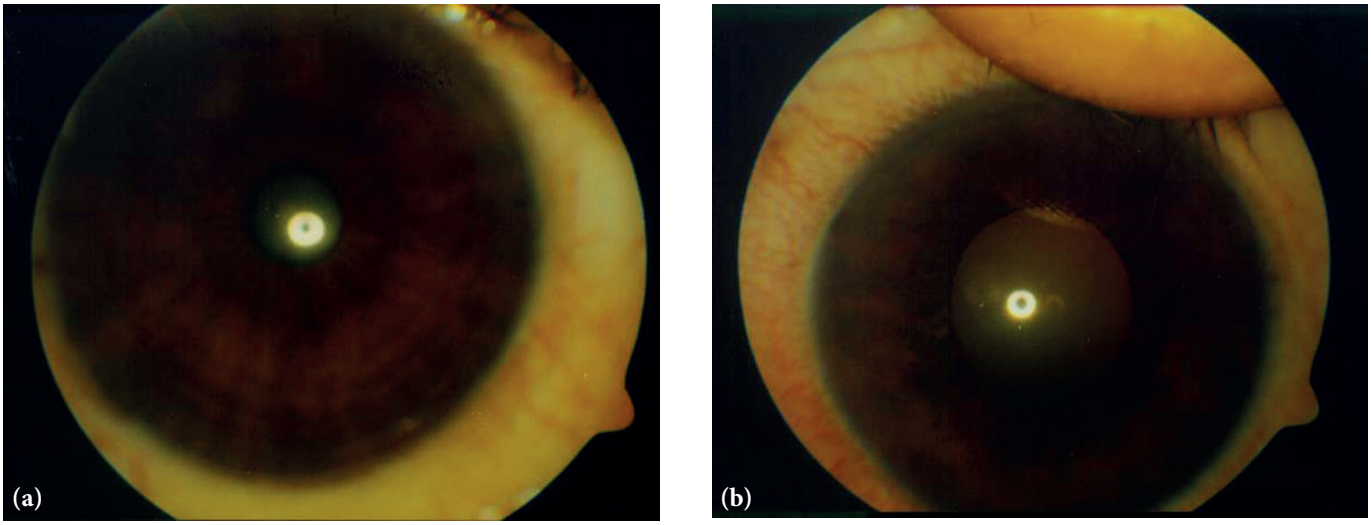
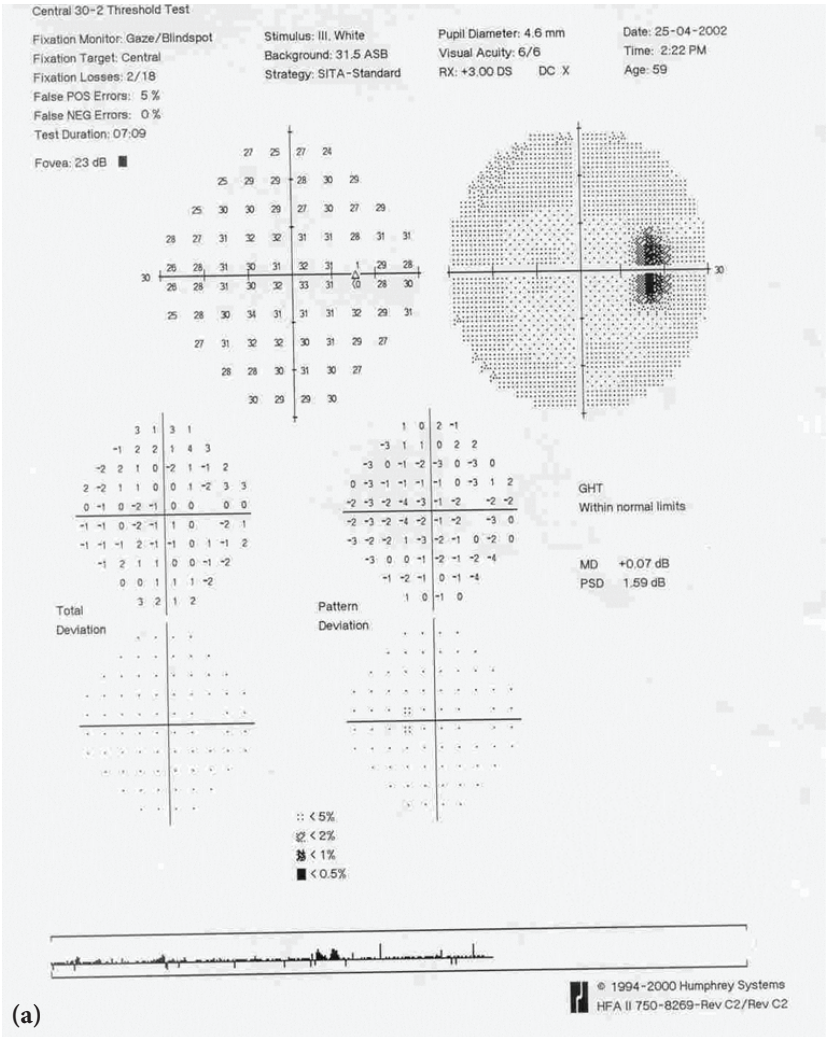


Fig. 1: Slit-lamp examination. (**a**) Normal right eye. (**b**) Left eye showing anisocoria with larger pupil.



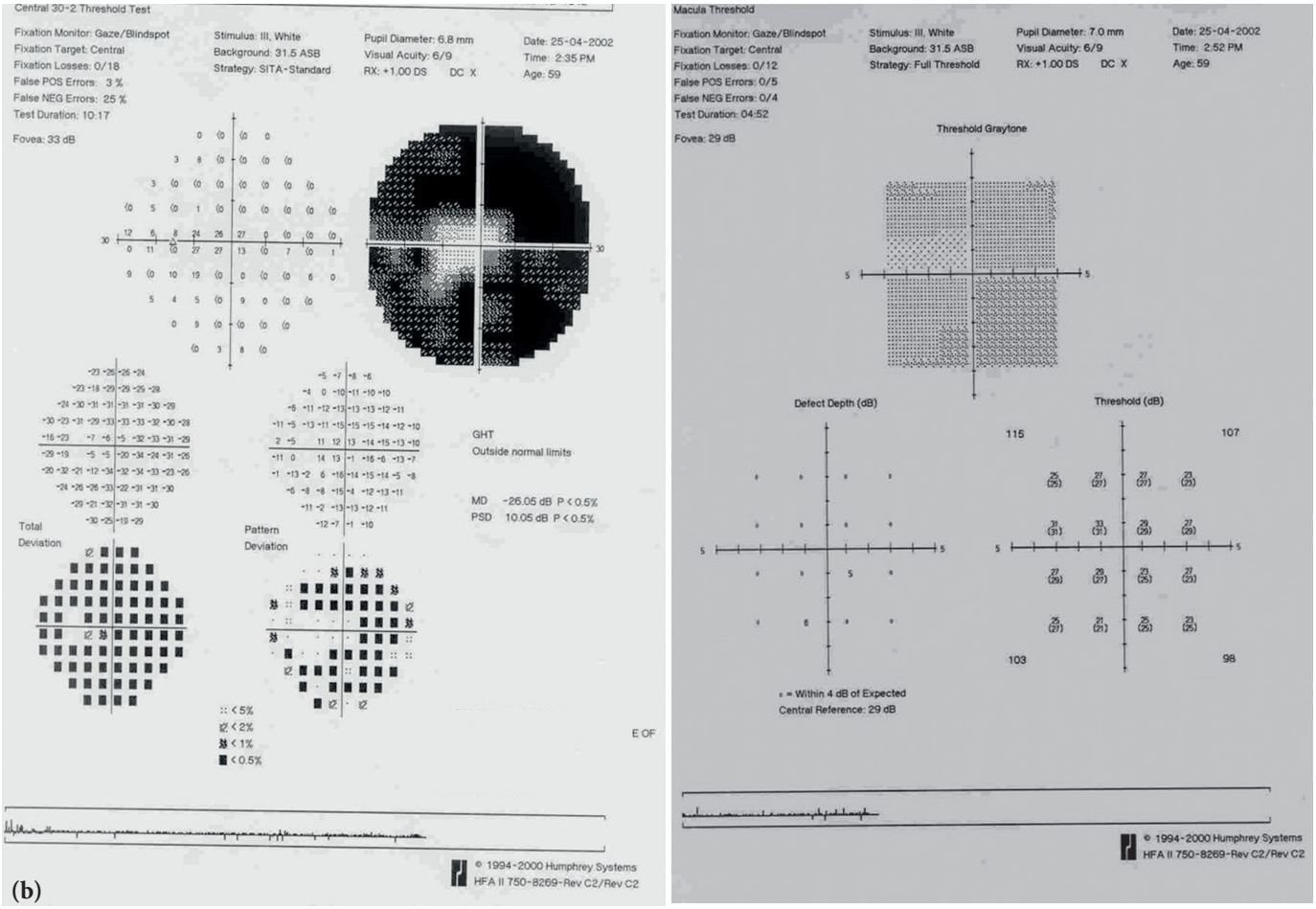


Fig. 2: Visual field examination. (**a**) Disc and field of the right eye are normal. (**b**) Disc and field of the left eye show preserved central island of vision on the 30-2, with normal macular field.

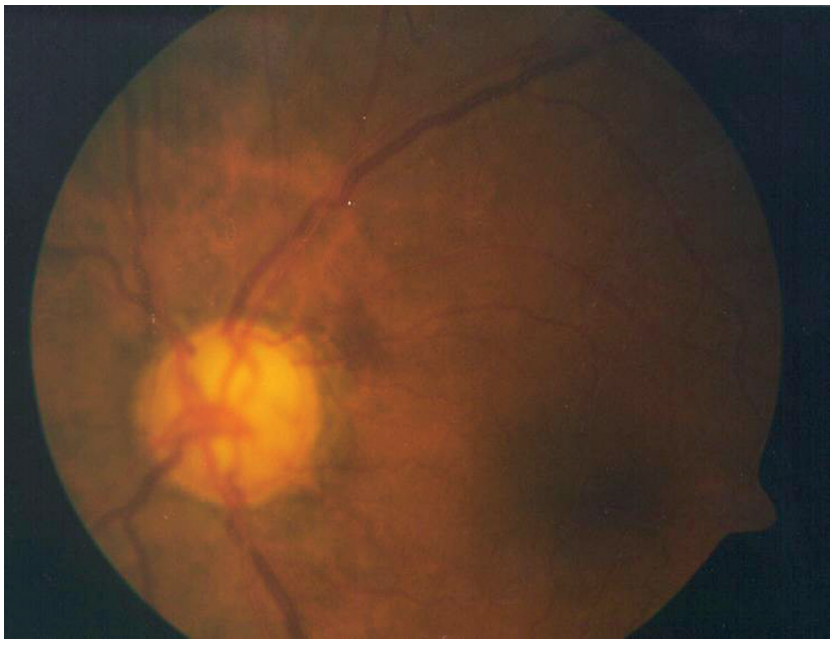


Fig. 3: Optic disc examination of the left eye showing advanced disc changes, 0.5 cup-to-disc ratio, and peripapillary atrophy.

12

Ocular Hypertension

TAKE HOME MESSAGES

- Individualized risk assessment is useful in clinical decision making and dictates frequency of examination, tests, treatment options, and preventive measures.
- Periodic re-evaluation of target intraocular pressure, optic nerve anatomy and function is necessary.
- Ocular hypertension is the only modifiable factor for primary open-angle glaucoma.
- Early treatment reduces chances of primary open-angle glaucoma.
- Accuracy of applanation tonometry may be influenced by central corneal thickness.

Ocular hypertension (OHT) is observed in 3–10% individuals over 40 years of age. It is assumed that more than 10% patients with OHT develop glaucoma within 5–10 years. Since, OHT can progress to glaucoma; it is vital to treat it for the prevention of sequelae.

WHEN TO SUSPECT A PATIENT HAS OCULAR HYPERTENSION?

- Intraocular pressure (IOP) >21 mmHg evidenced by applanation tonometry twice or even more
- No optic nerve damage
- No visual field defect on perimetry
- Gonioscopy showing normal/open angles
- No systemic causes of increased IOP

WHOM TO TREAT?

- Risk of progression is suspected as in case of high IOP, increasing age, family history of glaucoma, and systemic vascular disorder
- Young patient
- One-eyed patient
- Non-compliant patient
- Patient in whom optic disc cannot be visualized
- Patient with history of retinal vascular occlusion

WHEN TO TREAT?

- High risk patients definitively need treatment.
- Moderate risk patients should be closely monitored with follow-up every year and treatment should be initiated at the first sign of glaucomatous change.
- Low risk patient should be followed-up every 2 years.

WHAT CONSTITUTES HIGH RISK?

- Retinal nerve fiber layer (RNFL) abnormality
- Parapapillary alterations
- Intraocular pressure >30 mmHg
- Intraocular pressure >26 mmHg with central corneal thickness (CCT) <555 µm
- Vertical cup-to-disc ratio (VCDR) of 0.4:1 or more, with CCT <555 µm.

WHAT IS A MODERATE RISK?

- Intraocular pressure between 26 mmHg and 29 mmHg without RNFL abnormality.
- Intraocular pressure between 22 mmHg and 25 mmHg with CCT <555 µm.
- Vertical cup-to-disc ratio of 0.4:1 or more, with CCT between 555 µm and 558 µm.
- High myopia
- Family history of primary open-angle glaucoma (POAG).

WHAT CONSTITUTES LOW RISK?

- Intraocular pressure between 22 mmHg and 23 mmHg with CCT >588 µm.
- Vertical cup-to-disc ratio of 0.4:1 or more with CCT >558 µm.

Content supported by Dr. Jimmy Mittal, Senior Consultant (Glaucoma Services), Department of Ophthalmology, Vivekananda Polyclinic and Institute of Medical Sciences, Lucknow

IMPORTANT CONSIDERATIONS FOR TREATMENT DECISION IN OCULAR HYPERTENSION

- Treatment may not be cost-effective in all patients.
- Long-term medical management may have potential adverse effects.
- Compliance may be an issue as long-term management is required.

Treatment Target

Lowering IOP by at least 20%.

TREATMENT OF CHOICE IN OCULAR HYPERTENSION

- Beta-blockers and prostaglandin analogs are the preferred medical therapeutics.
- It is ideal to initiate monotherapy with maximum of two medications at any given time.
- If treatment response is inadequate, selective laser trabeculoplasty is considered
- Aggressive therapy in OHT patients should be avoided

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CASE 1

TAKE HOME MESSAGE

Baseline, circadian, and normal intraocular pressure, population mean, and standard intraocular pressure for normal eyes, central corneal thickness, severity of disease, extent and rate of disease progression, patient's life expectancy, family history, race, systemic illness, treatment adverse effects, and cost must be considered while deciding target intraocular pressure for a patient.

INTRODUCTION

A 46-year-old female presented with discomfort in both eyes since past few days. She had visited earlier when air puff tonometry was performed which revealed intraocular pressure (IOP) readings of 28 mmHg in the right eye and 26 mmHg in the left eye. She was then advised Latanoprost 0.005% right eye and Timolol 0.5% BD, for both the eyes. Her family history was negative for glaucoma. She was a diabetic on oral hypoglycemic agents.

EXAMINATION

- Best corrected visual acuity (BCVA)
  - Right eye (OD): 6/6, n6
  - Left eye (OS): 6/6, n6
- Anterior segment examination
  - OD: Normal, Van Herick (VH) >½ corneal thickness
  - OS: Normal, VH >½ corneal thickness
- Pupil (right and left eye): 3 mm, round, regular, and reacting (rrr)
- Gonioscopy: open to scleral spur
- Intraocular pressure (applanation tonometry)
  - OD: 20 mmHg
  - OS: 18 mmHg
- Central corneal thickness (ultrasound pachymetry)
  - OD: 600 µm
  - OS: 598 µm
- Optic disc examination (Figs. 1a, b)
  - Right eye showed normal-sized disc with healthy neuroretinal rim (NRR) and left eye showed large disc with healthy NRR.
- Visual field (VF) examination (Fig. 2)
  - Normal VF, both eyes
- Nerve fiber layer (NFL) thickness (Fig. 3)
  - Normal

DIAGNOSIS

She was diagnosed with ocular hypertension (OHT) on basis of the following findings:

- Normal anterior segment with open angles
- Intraocular pressure >22 mmHg
- Normal optic nerve head (ONH)
- Normal VFs (threshold automated perimetry)
- Normal imaging

MANAGEMENT

Considering low risk for vision loss due to glaucoma in this patient, no treatment was initiated and she was advised continuous monitoring and follow-up.

CONCLUSIONS

Patient was diagnosed with low risk OHT and monitoring and follow-up is the best way to check for disease progression.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru

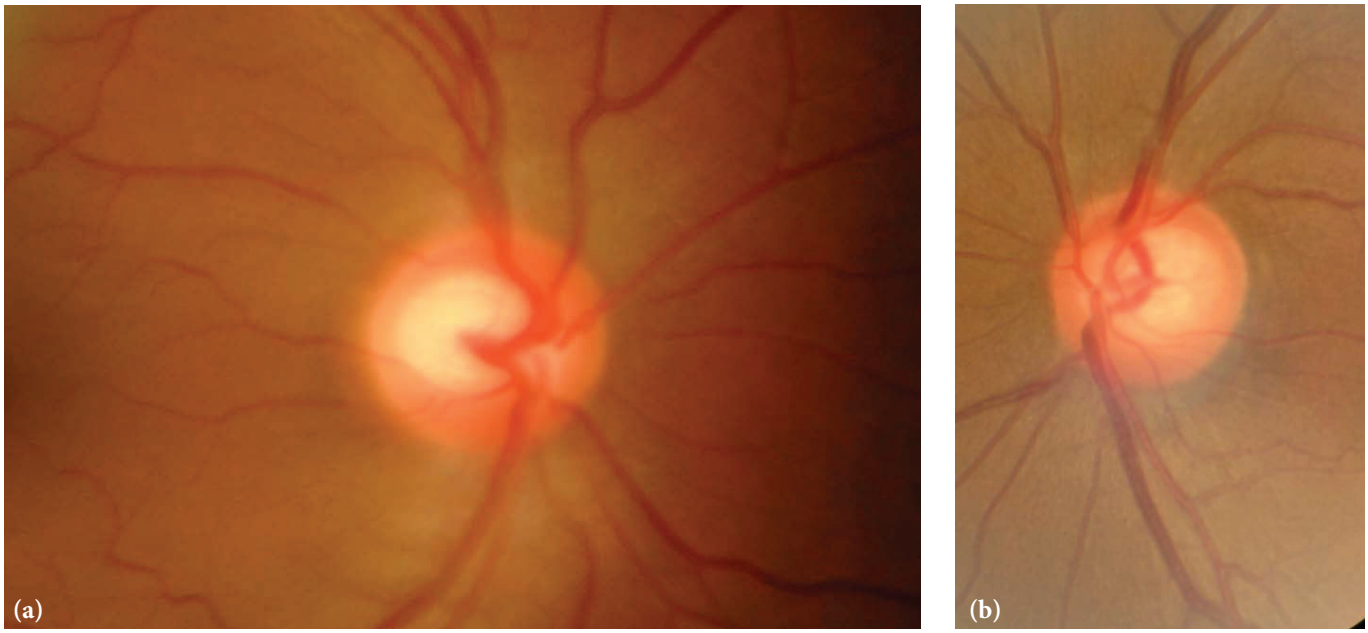

Fig. 1: Optic disc examination. **(a)** Disc of the right eye is normal in shape and size with cup-to-disc ratio 0.5 and healthy neuroretinal rim. **(b)** Disc of the left eye is slightly larger than right eye with, cup-to-disc ratio 0.65 and healthy neuroretinal rim.

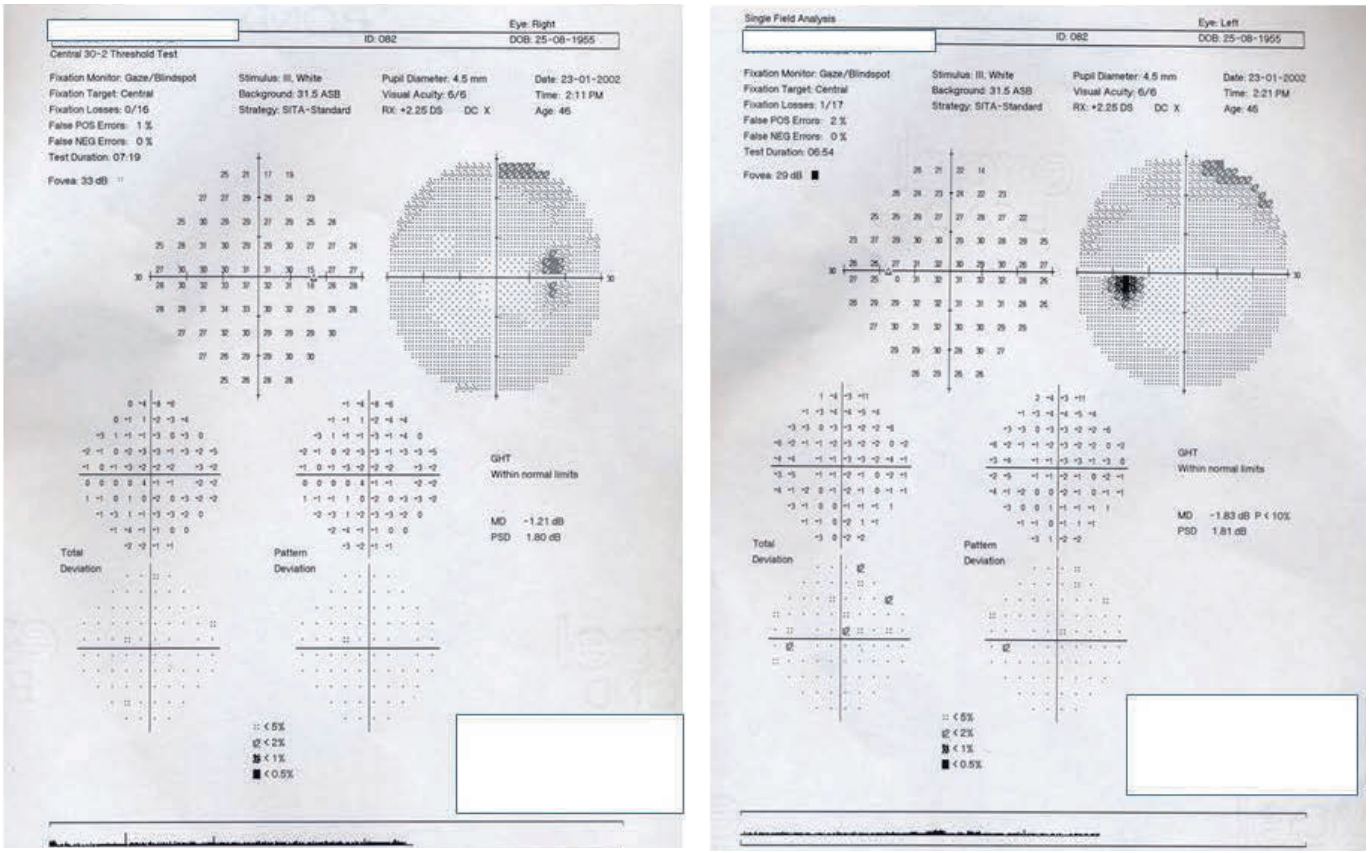

Fig. 2: Visual field examination. Threshold [Swedish Interactive Testing Algorithm (SITA)-standard] 30-2 fields are normal for both eyes.

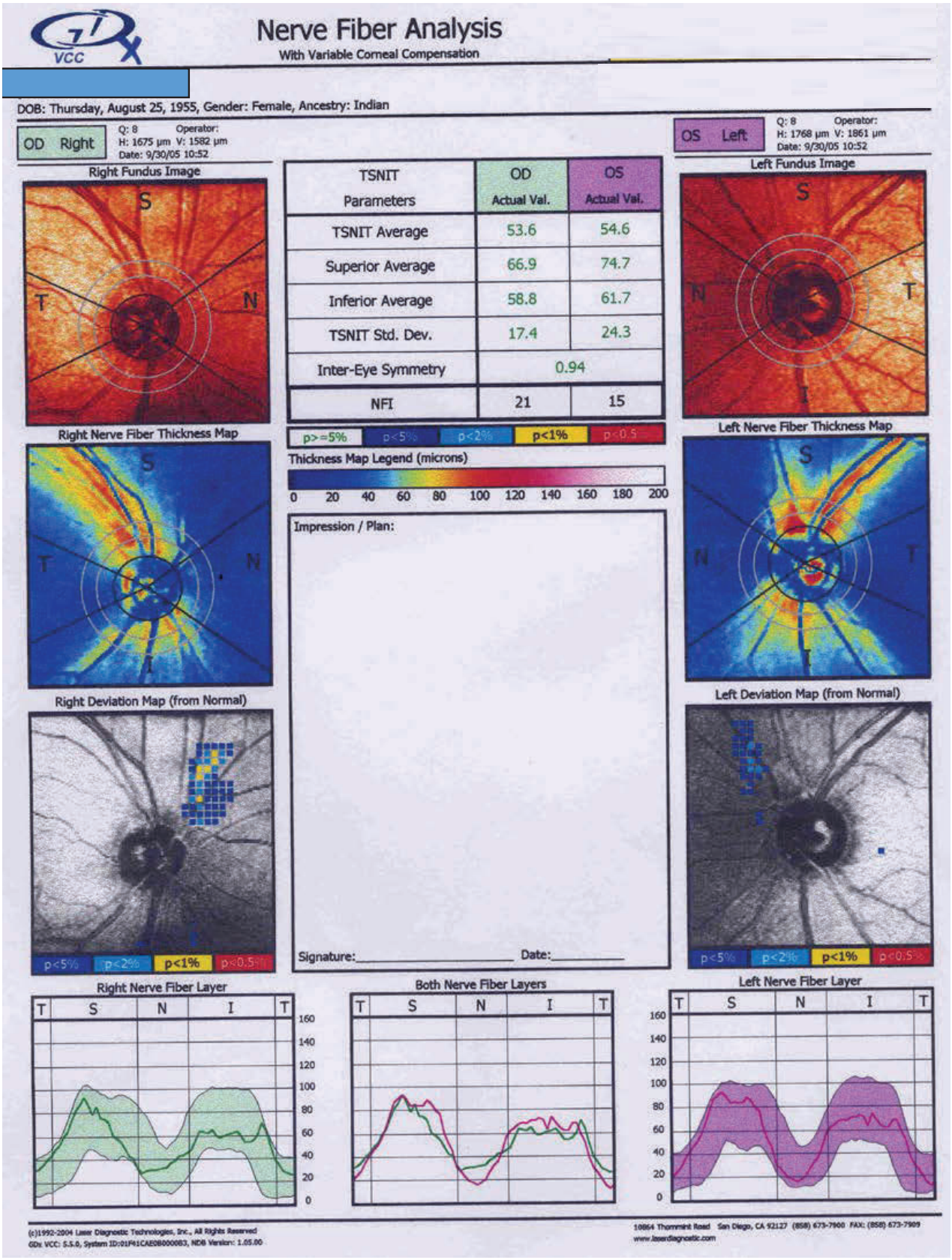

Fig. 3: Nerve fiber layer thickness by GDx VCC within normal range for both eyes.

13

Normal Tension Glaucoma

TAKE HOME MESSAGES

- Despite intraocular pressure lowering, disease progression may be evident.
- Intraocular pressure-dependent and -independent therapies, may be future treatment options in normal tension glaucoma.

Normal tension glaucoma (NTG) is a cause of concern due to its remarkable overlapping presentation with primary open-angle glaucoma (POAG). This subtype of glaucoma presents without increase in intraocular pressure (IOP).

HOW TO IDENTIFY NORMAL TENSION GLAUCOMA?

- Glaucomatous changes
- Intraocular pressure consistently ≤21 mmHg
- Open angles on gonioscopy
- Optic nerve head damage
- Progressive retinal fiber changes
- Visual field (VF) defect
- Absence of secondary cause for glaucoma
- Progression of glaucomatous changes

WHO IS AT RISK OF NORMAL TENSION GLAUCOMA?

- Advancing age
- Females
- Individuals with lesser central corneal thickness (CCT)
- Individuals with vascular diseases or ischemia
- Individuals with migraine
- Individuals with cold extremities as in Raynaud's phenomenon
- Nocturnal systemic hypotension
- Overtreated systemic hypertension
- Non-IOP related cardiovascular conditions such as systemic hypertension and hypotension, and cardiac arrhythmia, respectively

DIAGNOSTIC TECHNIQUES

- Goldmann applanation tonometry (GAT)
- Gonioscopy
- Slit-lamp biomicroscopy
- Optical coherence tomography (OCT)
- Visual field analysis

MANAGEMENT OF NORMAL TENSION GLAUCOMA

- Substantial IOP reduction to prevent vision loss is the prime objective in NTG.
- Intraocular pressure reduction by 30% should be the treatment target.
- Prostaglandin analogs are the most effective agents for lowering IOP. They are effective for optimal diurnal control.
- A 24-hour monitoring of blood pressure is also considered important in the management of NTG.
- Treatment of underlying cardiovascular abnormality is an important component of the comprehensive management.
- Neuroprotection using calcium channel blockers that enhance bloodflow to optic disc may also be considered.
- Laser trabeculoplasty is also useful for diurnal control in NTG in comparison to medical therapy.
- In case both medical and laser therapy fail, glaucoma filtering surgery can be performed.

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TIPS AND TRICKS

- Disc hemorrhages and beta zone parapapillary atrophy may be significant in normal tension glaucoma (NTG) and associated with poor prognosis.
- Fixation, deep, and more focal visual field defects can be seen in NTG.
- Systemic side-effects of topical beta-blockers must be considered while using these agents.

14

Glaucoma Suspect

TAKE HOME MESSAGES

- Glaucoma suspects progress to true glaucoma when classic visual field defects not attributable to any other optic neuropathies are evident.
- During examination, both eyes should always be compared.

GLAUCOMA SUSPECTS: WHEN TO SUSPECT GLAUCOMA?

Patients who do not have evident disease, but are at high risk of developing the disease in future taking into account various factors:

- Patients with ocular hypertension (OHT)
- Suspicious but not diagnostic disc appearance
- Suspicious but not diagnostic visual field (VF) changes
- Patients with family history
- Patients with disc hemorrhage
- Patients with pseudoexfoliation
- Patients with pigment dispersion
- Patients with angle recession and anatomically narrow angle
- Risk factors include age, ethnicity and thin central cornea thickness, myopia, individuals with migraine/peripheral vasospasm, and vascular disease

CLUES FOR THE DIAGNOSIS OF GLAUCOMA SUSPECT

- Comprehensive diagnostic evaluation is useful in glaucoma suspects.
- The necessary components of a comprehensive diagnosis include
  - History: Ocular, family, systemic, and medical history.
  - Ophthalmic evaluation: Visual acuity test, pupil examination, anterior segment examination, intraocular pressure (IOP) assessment, gonioscopy, optic nerve head (ONH) and retinal nerve fiber layer (RNFL) examination, and fundus examination.
  - Tests such as central corneal thickness (CCT) assessment, VF evaluation and ONH, and RNFL imaging.

TREATMENT DECISIONS IN GLAUCOMA SUSPECT

- Treatment decision in suspects is complex and depends on ocular, systemic, medical, and psychosocial factors.
- For appropriate clinical decision, progressive vision loss must be matched against patients' life expectancy, treatment-related side-effects and impact on quality of life.
- Glaucoma suspects may be treated in case
  - Optic nerve deterioration is evident.
  - Subtle optic disc and RNFL abnormalities are identified.
  - New VF defect is seen
  - Patient has very high IOP, and nerve damage is expected.

Clinicians can use risk calculators to determine the future risk of glaucoma in suspected cases.

- Treatment mainly consists of IOP control, and can be tailored based on the risk categorization for a glaucoma suspect patient (Table 1).
- It is appropriate to choose IOP target 20% lower than baseline IOP measure.
- Regular yearly monitoring is suggested for patients at low risk, and 6 monthly follow-up monitoring is suggested for patient at moderate to high risk.
- Prostaglandin analogs are most apposite as initial agents for glaucoma suspects due to following advantages
  - Once-daily instillation

Table 1: Risk categorization based on intraocular pressure assessment and treatment needs.

Intraocular pressure	Risk	Treatment
30 mmHg–>40 mmHg	High	Initiate treatment
22 mmHg–30 mmHg	Moderate	Initiate treatment depending on other factors

Content supported by Dr. Surojit Chakraborti, Ophthalmologist, Priyamvada Birla Aravind Eye Hospital, Kolkata

  - Effective IOP-lowering ability
  - Minimal side-effects
- Alfa 2-agonists, beta-blockers, carbonic anhydrase inhibitors, and other fixed dose combinations can be considered additional to prostaglandin analogs.
- In case topical therapy is inadequate, argon laser trabeculoplasty or selective laser trabeculoplasty should be considered.

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CASE 1

TAKE HOME MESSAGES

- Signal strength must be assessed before interpretation of retinal nerve fiber layer analysis to avoid abnormal results.
- Myopes have low average nerve fiber layer thickness.
- Significant proportion of myopic eyes will be classified as outside normal limits when compared to normative database.

INTRODUCTION

A 46-year-old male myope presented for regular check-up. There was no family history of any systemic illness or ophthalmologic conditions.

EXAMINATION

- Mean diurnal intraocular pressure (IOP)
  - Right eye (OD): 22 mmHg
  - Left eye (OS): 21 mmHg
- Central corneal thickness (CCT)
  - OD: 590 µm
  - OS: 598 µm
- Retinal nerve fiber layer (RNFL) analysis by optical coherence tomography (OCT) (Fig. 1).
- Optic disc examination and RNFL (Figs. 2a, b)
  - Discs of both the eyes seemed suspicious but did not correspond to OCT findings, clinically.
- Repeat OCT-RNFL (Fig. 3).
- Humphrey field analyzer (HFA) 24-2 test (Fig. 4).

DIAGNOSIS

The patient is a high myope and had a mean diurnal IOP of 22/21 mmHg, with CCT 590 µm/598 µm, in left and right eye respectively. Although there is no family history of glaucoma, he is considered a glaucoma suspect.

MANAGEMENT

It is important to observe signal strength before confirming the RNFL analysis to be "abnormal". "Cleavage in RNFL" should be considered in myopes, which is not seen in emmetropic or hypermetropic patients, and is usually not associated with visual field dysfunction. This patient is managed as a glaucoma suspect, and should be monitored for the progression of disease.

CONCLUSIONS

In glaucoma suspects in order to avoid abnormal results in RNFL analysis signal strength must be checked.

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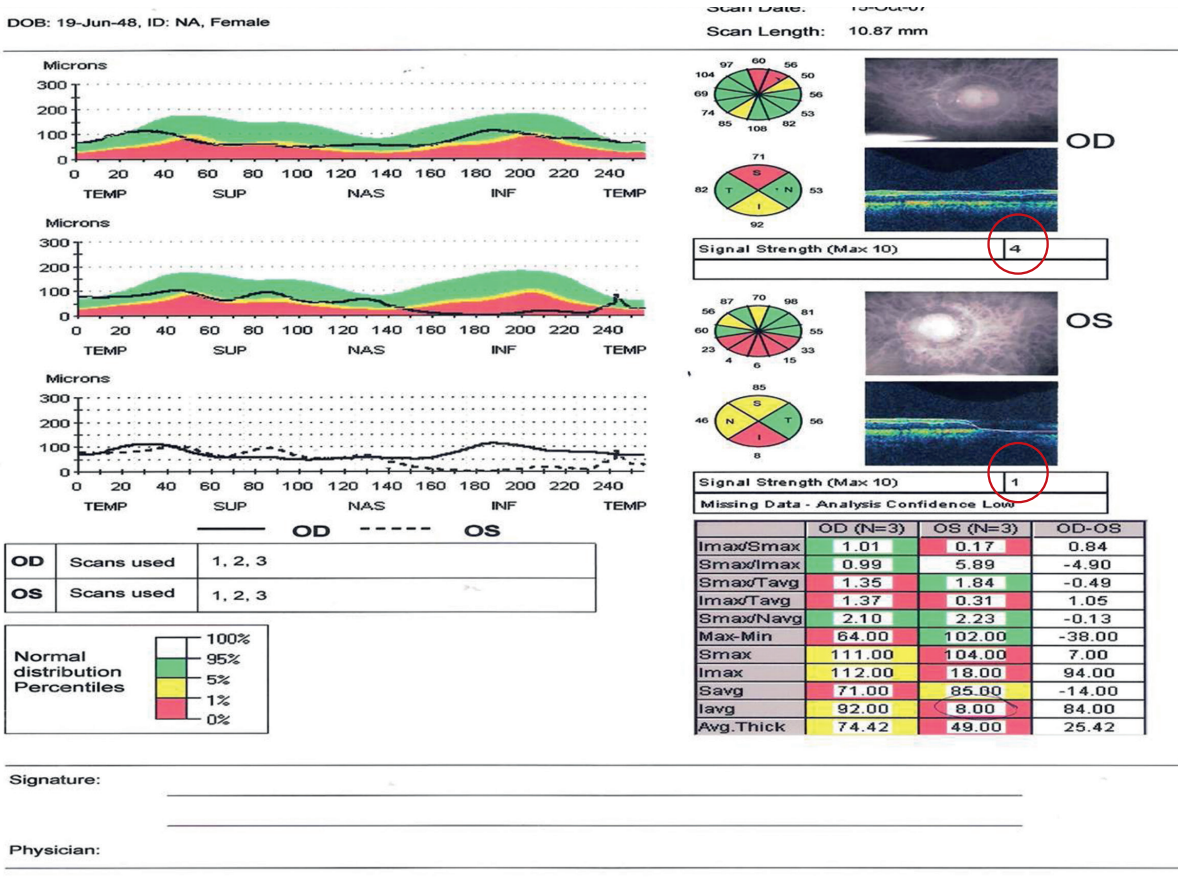

	OD (N=3)	OS (N=3)	OD-OS
Imax/Smax	1.01	0.17	0.84
Smax/Imax	0.99	5.89	-4.90
Smax/Tavg	1.35	1.84	-0.49
Imax/Tavg	1.37	0.31	1.05
Smax/Navg	2.10	2.23	-0.13
Max-Min	64.00	102.00	-38.00
Smax	111.00	104.00	7.00
Imax	112.00	18.00	94.00
Savg	71.00	85.00	-14.00
Iavg	92.00	8.00	84.00
Avg.Thick	74.42	49.00	25.42

Fig. 1: The optical computed tomography results indicate either poor and unreliable signal strength or advanced retinal nerve fiber layer damage.

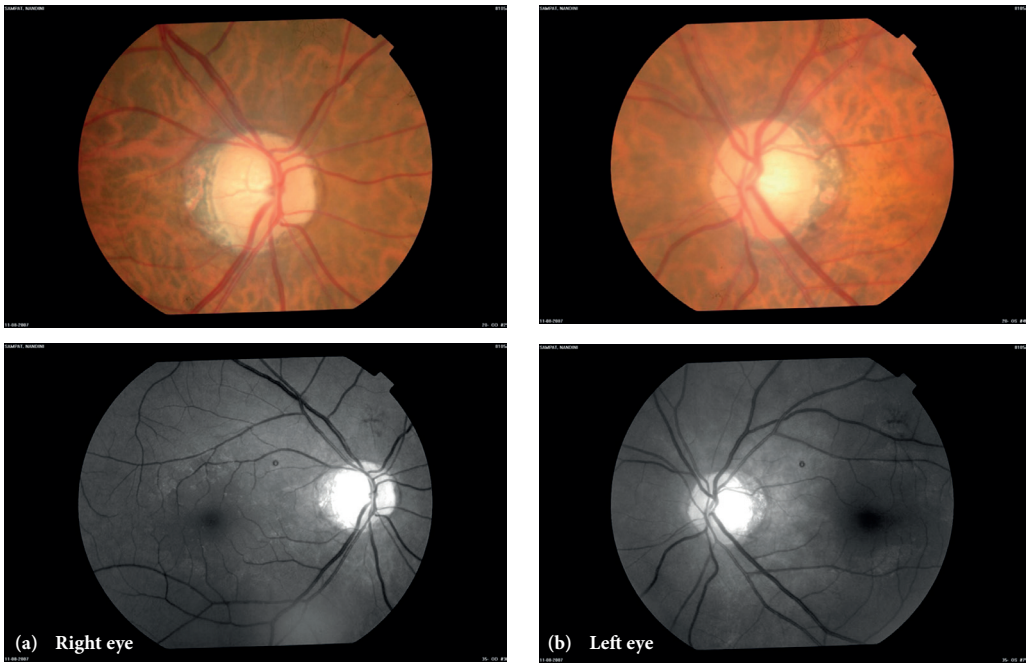

Fig. 2(a, b): Discs of left and right eye look suspicious but do not clinically correspond to the optical coherence tomography findings.

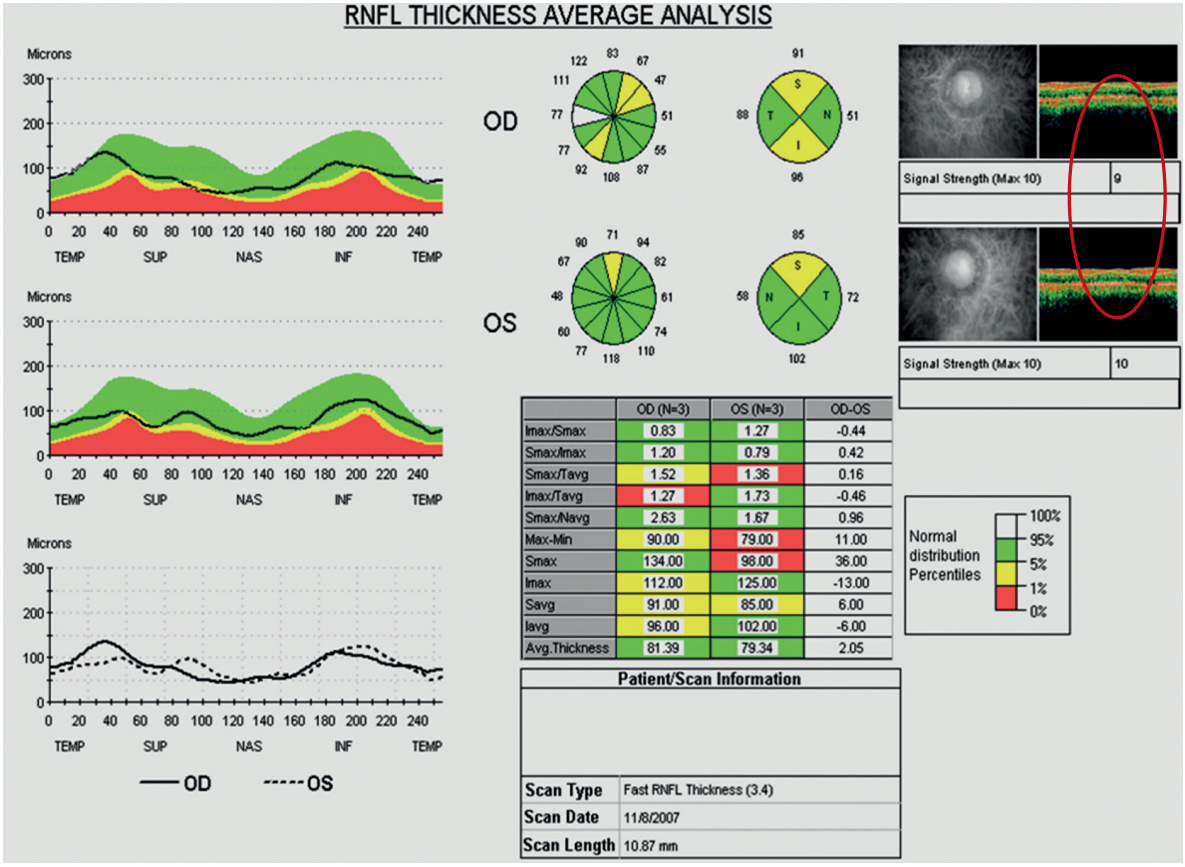

Fig. 3: Optical coherence tomography with better signal strength and reliable findings.

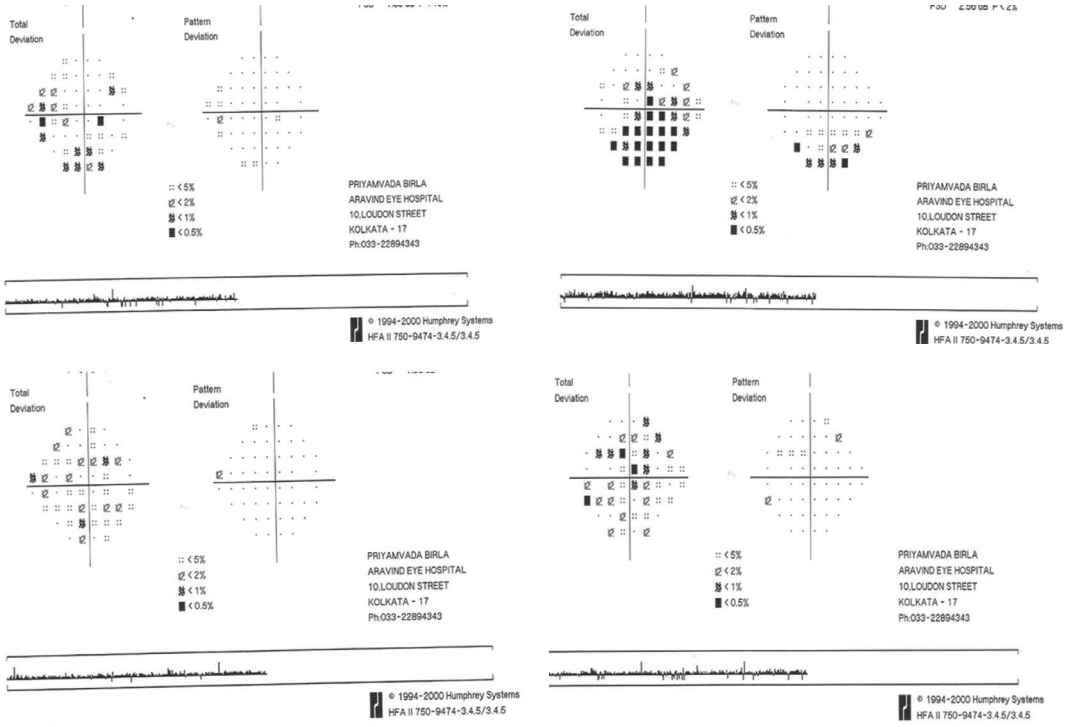

Fig. 4: Repeat Humphrey field analyzer (HFA) test also showing better performance.

CASE 2

TAKE HOME MESSAGE

Retinal nerve fiber layer analysis by optical coherence tomography can be normal in presence of documented field defect.

INTRODUCTION

A middle-aged woman reported for routine check-up. Her past medical history was positive for diabetes. She had no family history of glaucoma.

EXAMINATION

- Mean diurnal intraocular pressure (IOP)
  - Right eye (OD): 18 mmHg
  - Left eye (OS): 19 mmHg
- Central corneal thickness (CCT)
  - OD: 510 µm
  - OS: 500 µm
- Gonioscopy revealed open angles
- Fundoscopy (Figs. 1a, b)
  - Retinal nerve fiber layer (RNFL) hemorrhage and RNFL defect were observed in both the eyes.
- Retinal nerve fiber layer analysis by optical coherence tomography (OCT) (Fig. 2)
  - Nothing abnormal detected
- Visual field (VF) assessment (Fig. 3)
  - Early glaucomatous changes were visualized in both the eyes.

DIAGNOSIS

Glaucoma suspect

MANAGEMENT

The patient should be monitored, and she will no longer be considered a suspect if the disease progression is evident in terms of structural or functional changes.

CONCLUSIONS

Retinal nerve fiber layer analysis by optical coherence tomography can be normal in presence of documented field defect. Hence, patient monitoring is important to check disease progression.

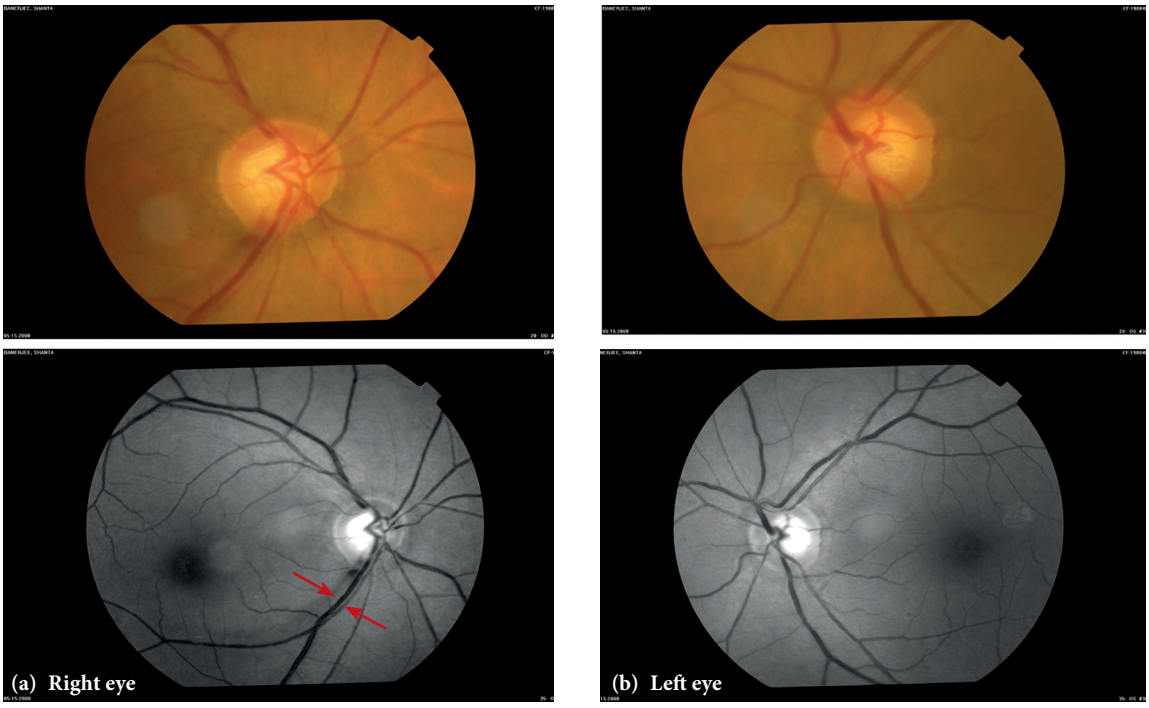

Fig. 1(a, b): Retinal nerve fiber layer (RNFL) hemorrhage with RNFL defect in both the eyes.

Content supported by Dr. Surajit Chakraborty, Ophthalmologist, Priyamvada Birla Aravind Eye Hospital, Kolkata

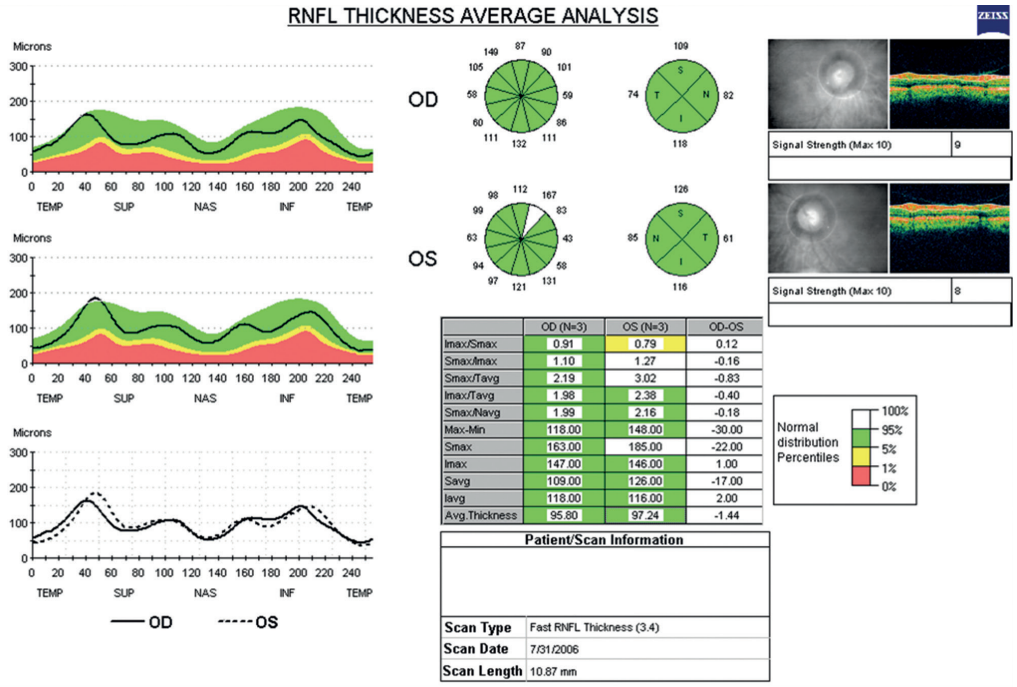

Fig. 2: Optical coherence tomography did not show any obvious defects in the retinal nerve fiber layer.

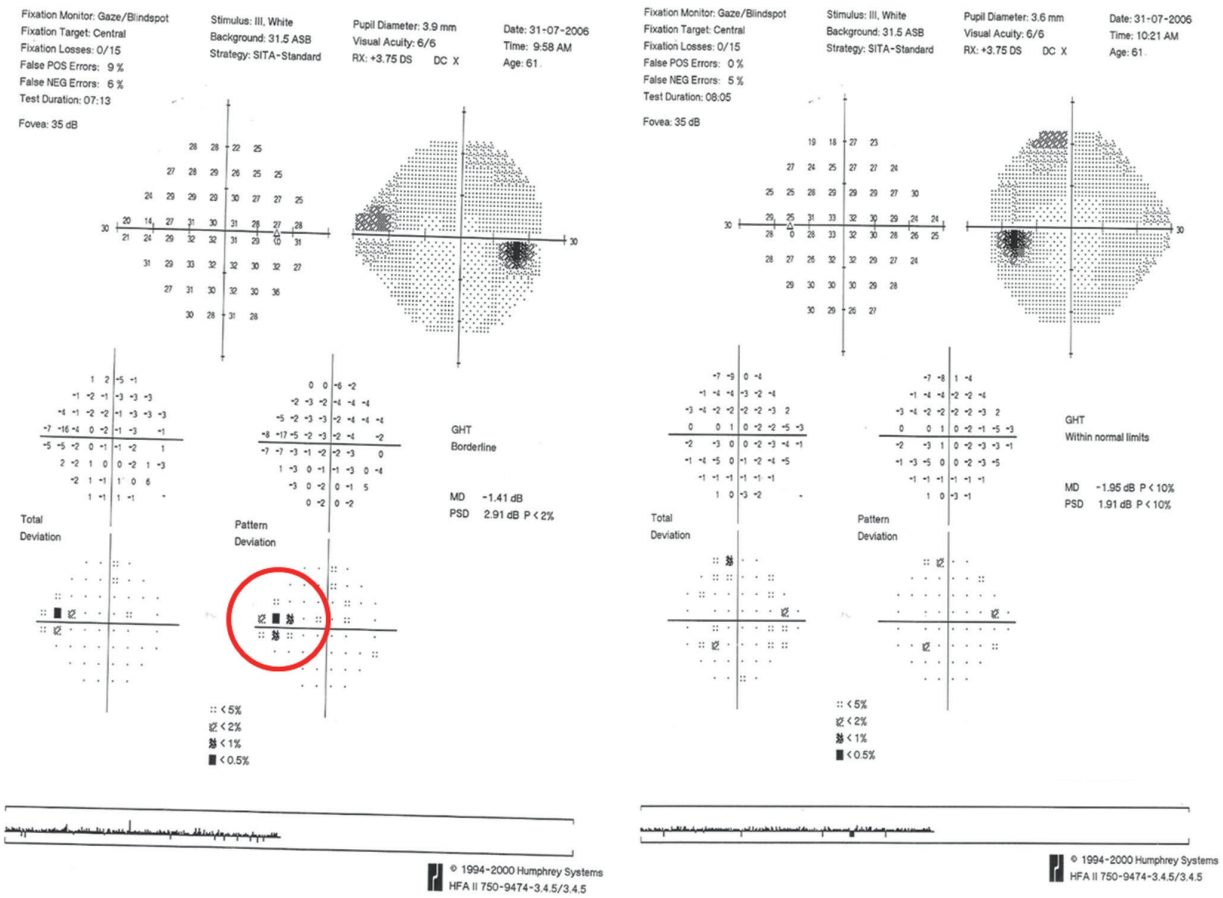

Fig. 3: Visual field assessment showing early glaucomatous defect in both the eyes.

CASE 3

TAKE HOME MESSAGE

Disorders associated with optic disc damage or abnormalities of visual field must be considered during examination.

INTRODUCTION

A 60-year-old female reported for her regular check-up. Her medical history revealed that she was using Latanoprost for the last 2 years.

EXAMINATION

- Scanning laser polarimetry (GDx) and optical coherence tomography (OCT) (Fig. 1)
  - Right eye (OD): normal
  - Left eye (OS): retinal nerve fiber layer (RNFL) thinning
- Fundus examination (Fig. 2)
  - No RNFL defect or neuroretinal rim thinning was detected in both the eyes.
- Visual field (VF) assessment (Fig. 3)
  - Homonymous quadrantanopia defect was observed in the right eye.
- For further investigations on clinical suspicion, she was advised computed tomography (CT) scan, which revealed a lesion near basal ganglia (Fig. 4).

DIAGNOSIS

Glaucoma suspect

MANAGEMENT

Patient is considered as a glaucoma suspect and should be monitored for progression. Due to the lesion seen on CT scan, patient was advised neurology consult and treated further for the same.

CONCLUSIONS

This case of a 60-year-old female treated with Latanoprost for two years could have been a pseudo RNFL defect, possibly due to the associated basal ganglia lesion. She is still considered a glaucoma suspect and should continue to be monitored for the same.

Content supported by Dr. Surojit Chakraborti, M P Birla Eye Hospital, Kolkata

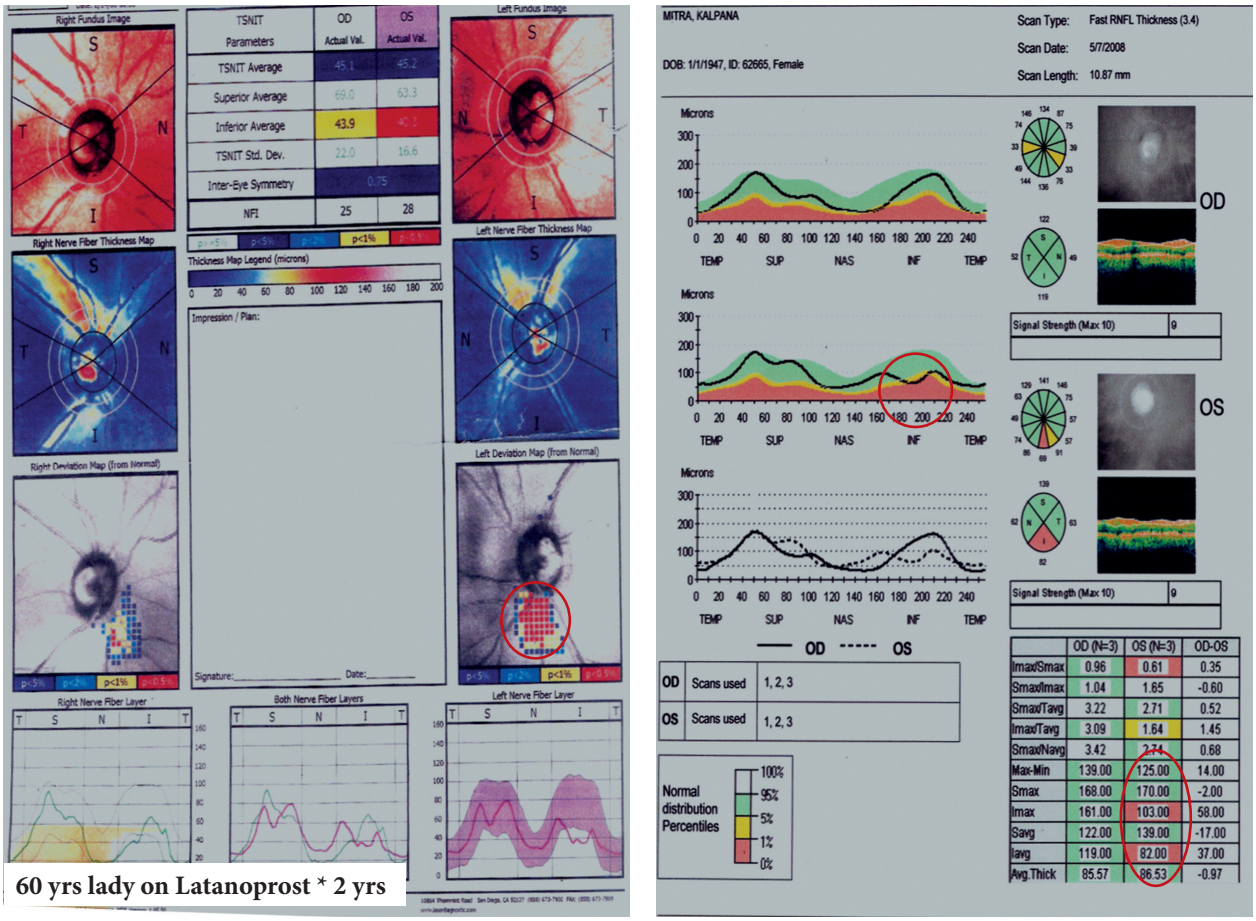

Fig. 1: Left inferior retinal nerve fiber layer thinning detected on scanning laser polarimetry (GDx) and optical coherence tomography.

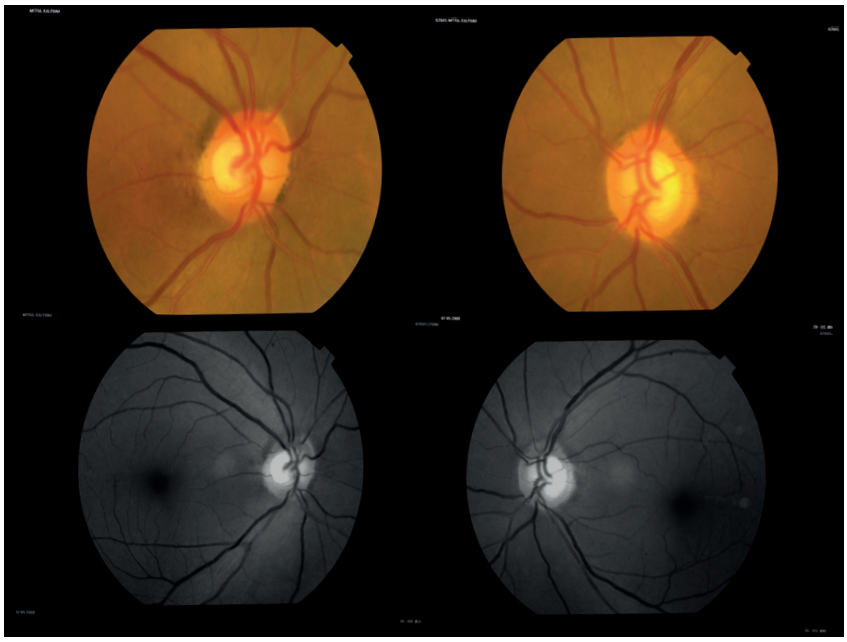

Fig. 2: Fundus examination showing no clinically detectable retinal nerve fiber layer defect or neuroretinal rim thinning.

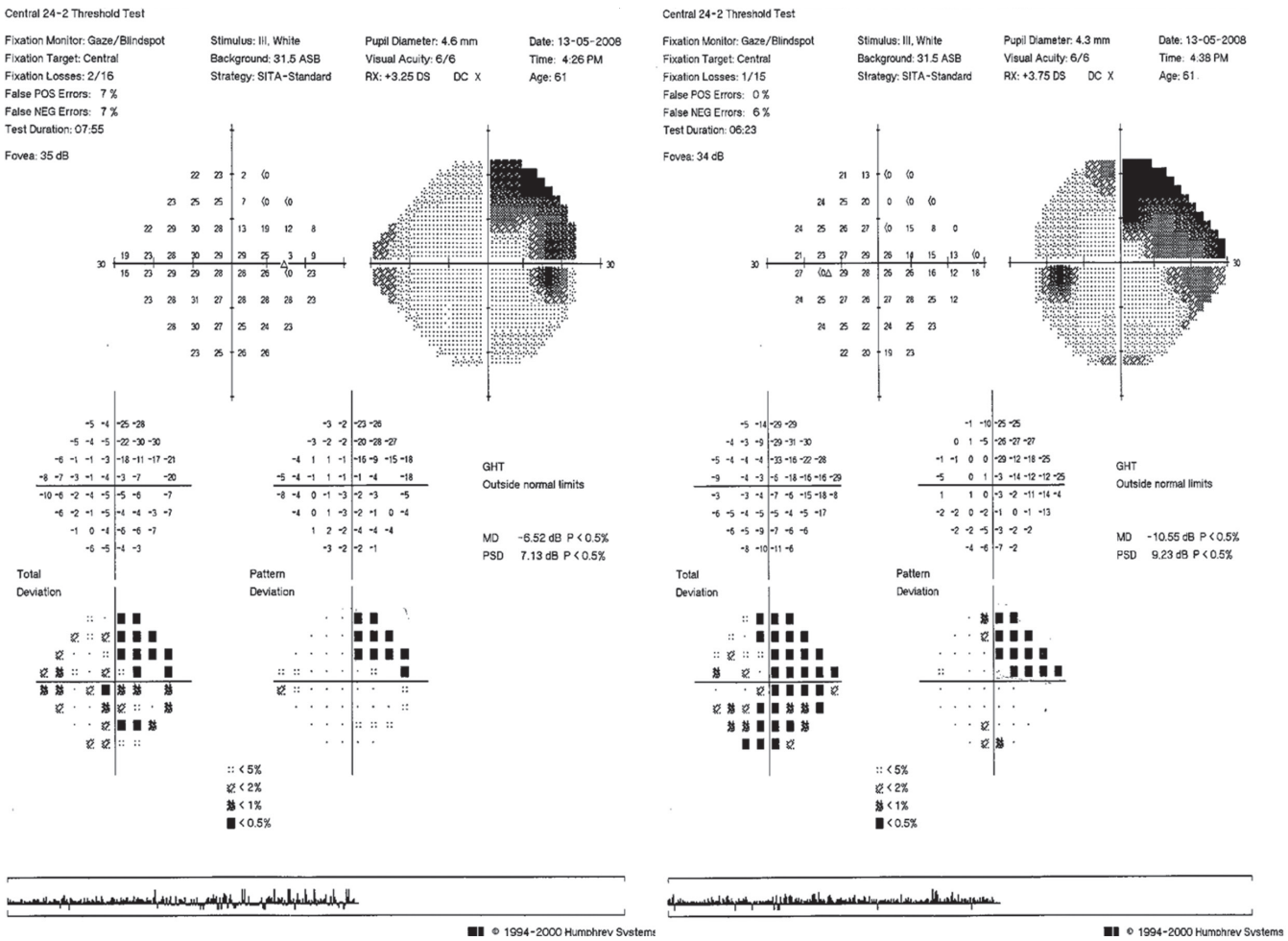

Fig. 3: Visual field assessment showing homonymous quadrantanopia defect in right eye.

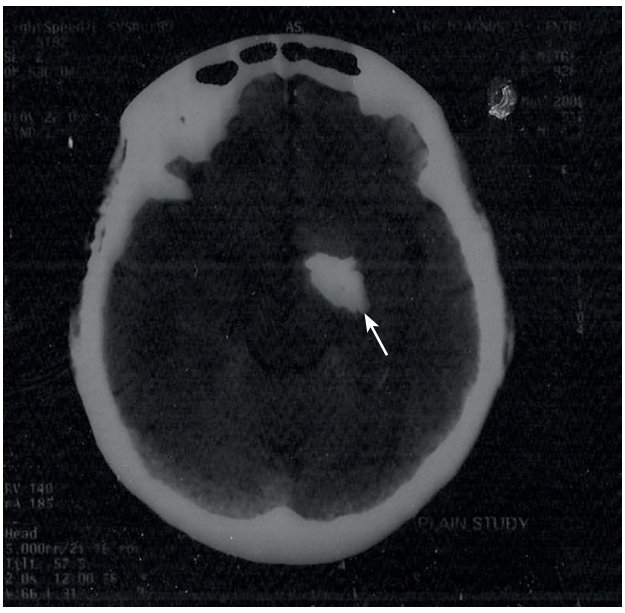

Fig. 4: Computed tomography scan showing lesion near basal ganglia.

CASE 4

TAKE HOME MESSAGES

- When progression occurs in terms of structural and functional changes, it is no longer a glaucoma suspect.
- Retinal nerve fiber layer thinning cannot confirm the diagnosis of glaucoma in patients with high myopia.

INTRODUCTION

A 33-year-old male with high myopia reported for his routine check-up. His previous records revealed that his father was a primary open-angle glaucoma (POAG) suspect.

EXAMINATION

- Automated perimetry
  - Humphrey visual field 24-2: Normal
  - Short wavelength automated perimetry: Normal
- Diurnal intraocular pressure (IOP) variation (Table 1)
- Fundus examination (Fig. 1)
  - Retinal nerve fiber layer (RNFL) defect alongside the superotemporal retinal vessels in right eye.
- Optical coherence tomography (OCT) (Fig. 2)
  - Superior and inferior RNFL thinning in both the eyes.

Table 1: Diurnal intraocular pressure variation.

	Right eye	Left eye
Maximum	21 mmHg	20 mmHg
Minimum	16 mmHg	16 mmHg

DIAGNOSIS

Glaucoma suspect

MANAGEMENT

The RNFL defect on OCT was not diagnostic of glaucoma as the patient was a myope, therefore, he was considered a glaucoma suspect and was monitored for progression.

CONCLUSIONS

Patient is no longer considered a glaucoma suspect when there is structural and functional progression.

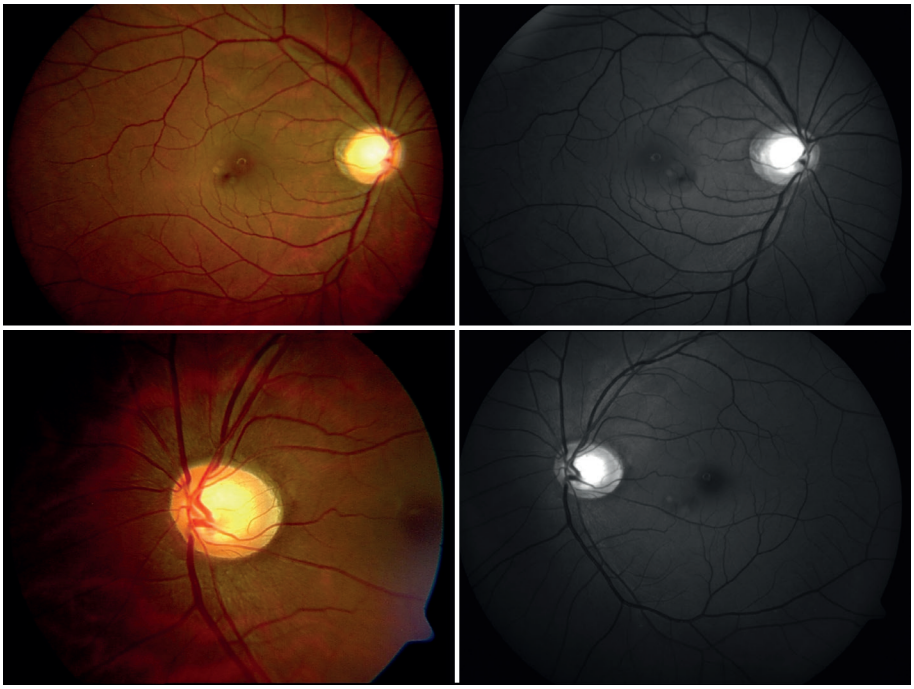

Fig. 1: Fundus examination showing retinal nerve fiber layer defect in the right eye.

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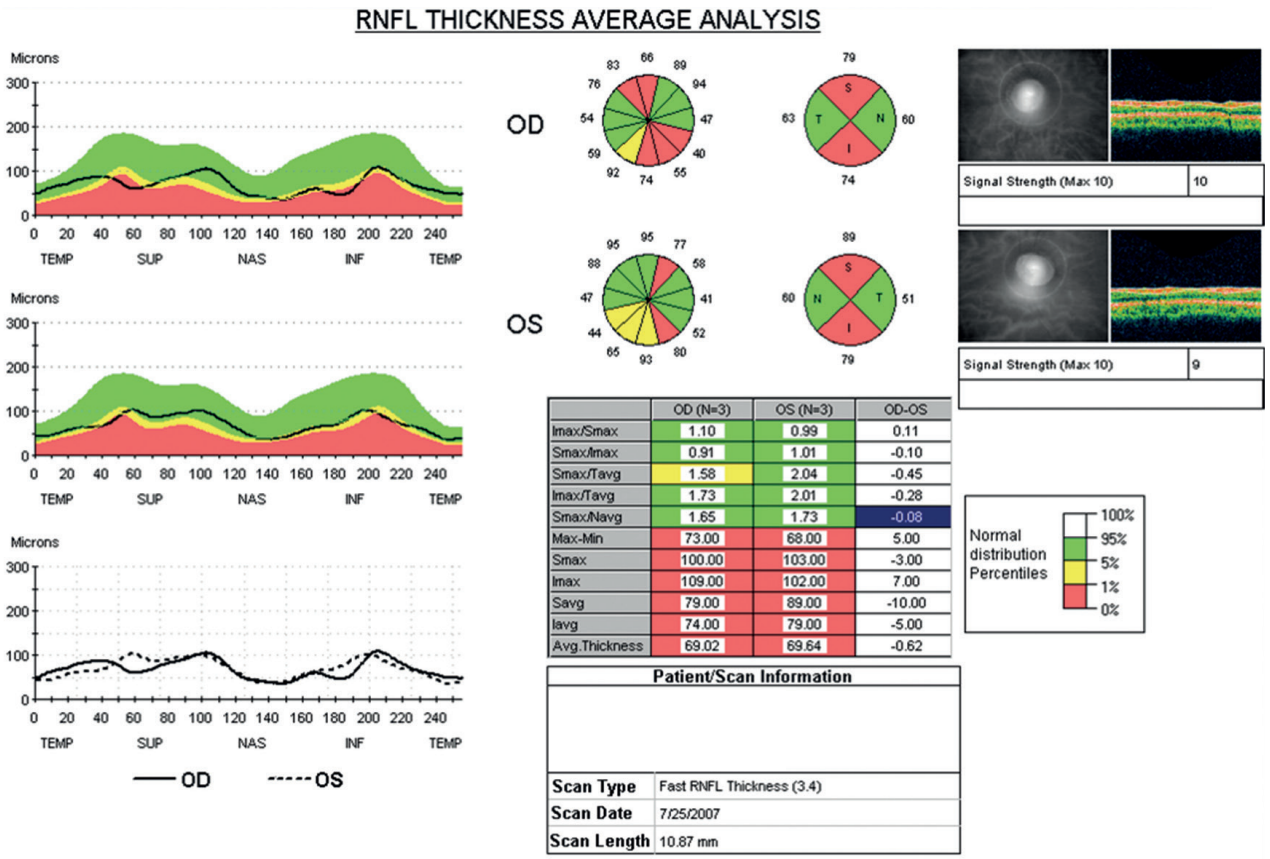

Fig. 2: Optical coherence tomography showing superior and inferior retinal nerve fiber layer thinning in both eyes.

CASE 5

TAKE HOME MESSAGES

- Intraocular pressure is the only parameter that can be modified in glaucoma suspects.
- The decision related to intraocular pressure reduction is intricate, and usually involves ophthalmologist's view on examination findings, risk factors, future risks, and patient preference.

INTRODUCTION

A 68-year-old female reported for routine check-up. Her past medical history was insignificant.

EXAMINATION

- Visual acuity test
  - Right eye (OD): 6/6, n6
  - Left eye (OS): 6/6, n6
- Anterior segment examination
  - OD: Normal, Van Herick (VH) >½ corneal thickness
  - OS: Normal, VH >½ corneal thickness
- Pupil
  - OD: 4 mm round, regular, reacting to light (rrr)
  - OS: 4 mm rrr
- Intraocular pressure (IOP) by applanation tonometry
  - OD: 22 mmHg
  - OS: 28 mmHg
- Gonioscopy revealed open angles in both eyes.
- Fundoscopy (Figs. 1a, b)
  - OD: Normal disc and healthy neuroretinal rim (NRR)
  - OS: Inferior NRR thinning with inferior nerve fiber layer (NFL) defect
- Visual fields (VFs): Normal in both the eyes
- Pachymetry
  - Central corneal thickness (CCT)
    - OD: 501 µm
    - OS: 500 µm
  - Retina nerve fiber layer assessment (Fig. 2)
    - OD: Normal
    - OS: Decreased thickness of inferior NFL

DIAGNOSIS

- Glaucomatous disc with normal VF
- Moderate risk of VF loss

MANAGEMENT

Patient was monitored closely and IOP reduction by at least 20% was considered.

CONCLUSIONS

Intraocular pressure can be modified in glaucoma suspects. Hence, patient monitoring and IOP reduction must be considered.

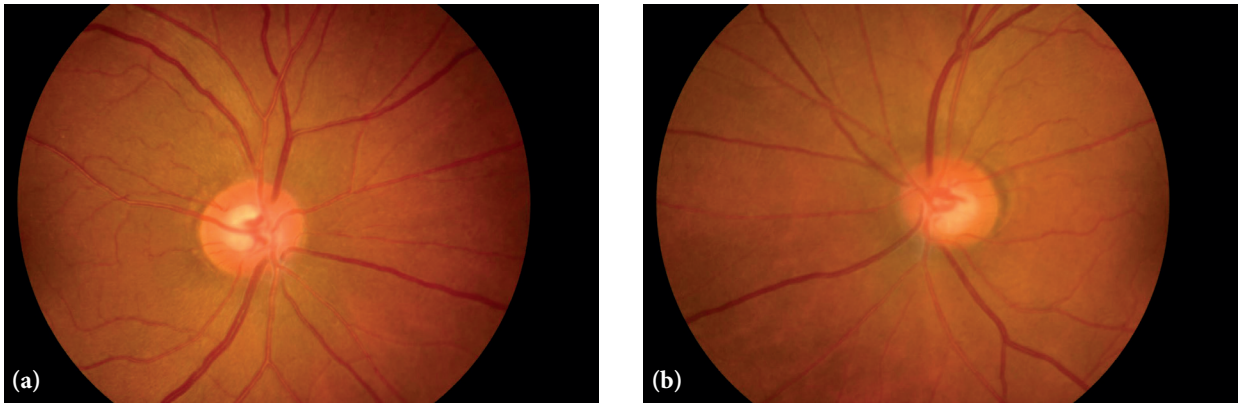

Fig. 1: (a) Right eye optic disc is normal in shape and size with a cup-to-disc ratio of 0.3 and healthy neuroretinal rim. (b) Left eye optic disc shows inferior neuroretinal rim thinning with cup-to-disc ratio of 0.6 and an inferior nerve fiber layer defect.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru

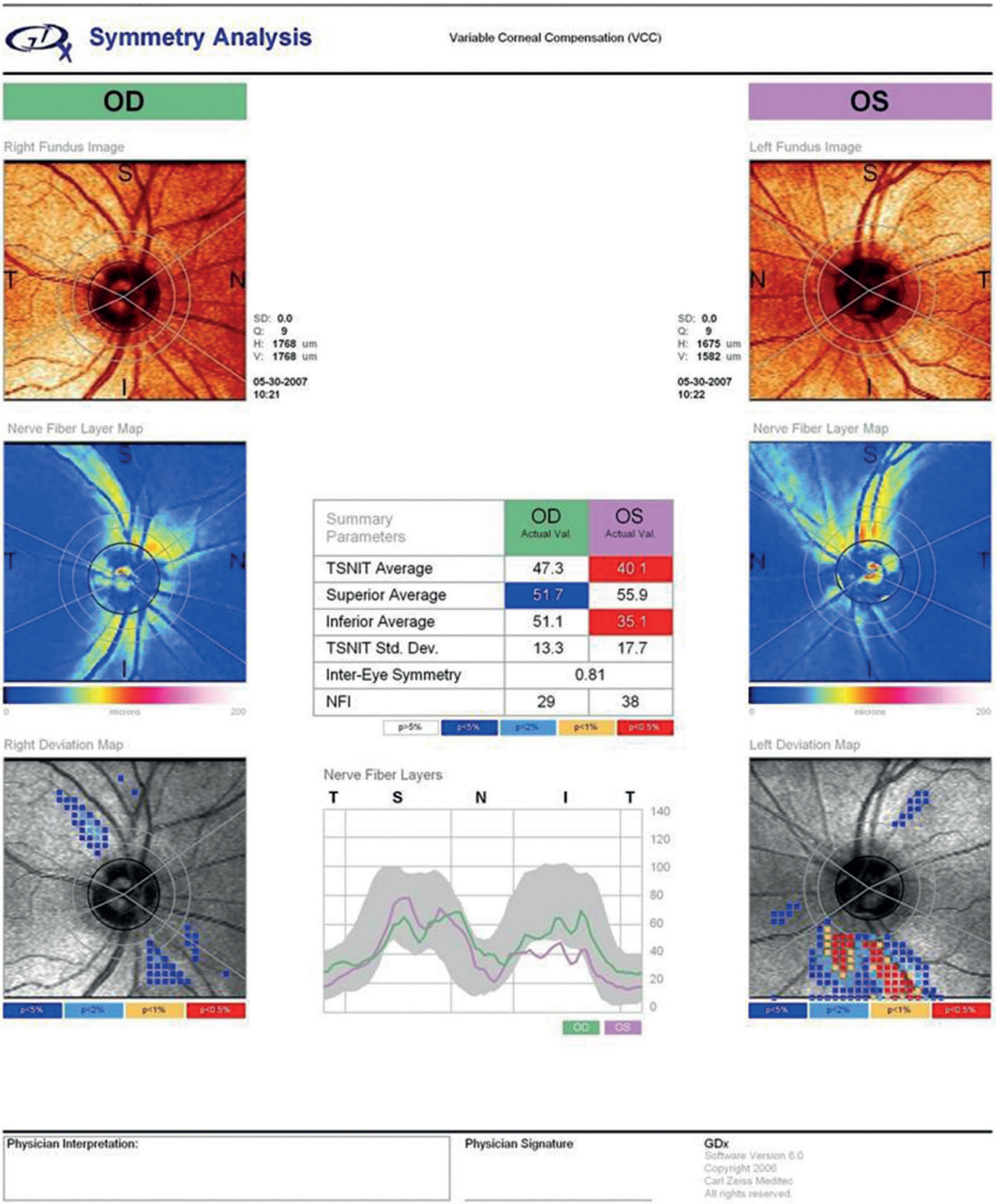

Fig. 2: Retinal nerve fiber layer thickness in the right eye is normal and the left eye shows decreased thickness of inferior nerve fiber layer.

CASE 6

TAKE HOME MESSAGES

- Patients with physiological cupping must be considered as glaucoma suspects.
- Both eyes must be compared for proper diagnosis.

INTRODUCTION

A 48-year-old male presented for routine check-up. His medical and family history were insignificant for any diseases.

EXAMINATION

- Gonioscopy: Open angles in both eyes
- Pachymetry: Central corneal thickness (CCT) 540 µm both eyes
- Fundoscopy examination (Fig. 1): Increased cup-to-disc ratio (CDR) with healthy neuroretinal rim (NRR)
- Visual fields (VFs) (Fig. 2): Normal in both the eyes

DIAGNOSIS

Glaucoma suspect

MANAGEMENT

Patient was kept under observation with annual follow-ups

CONCLUSIONS

A patient without any significant medical or family history presented for routine check-up. Despite a healthy NRR, due to increased CDR, he was considered a glaucoma suspect and yearly follow-up for progression is the best option.

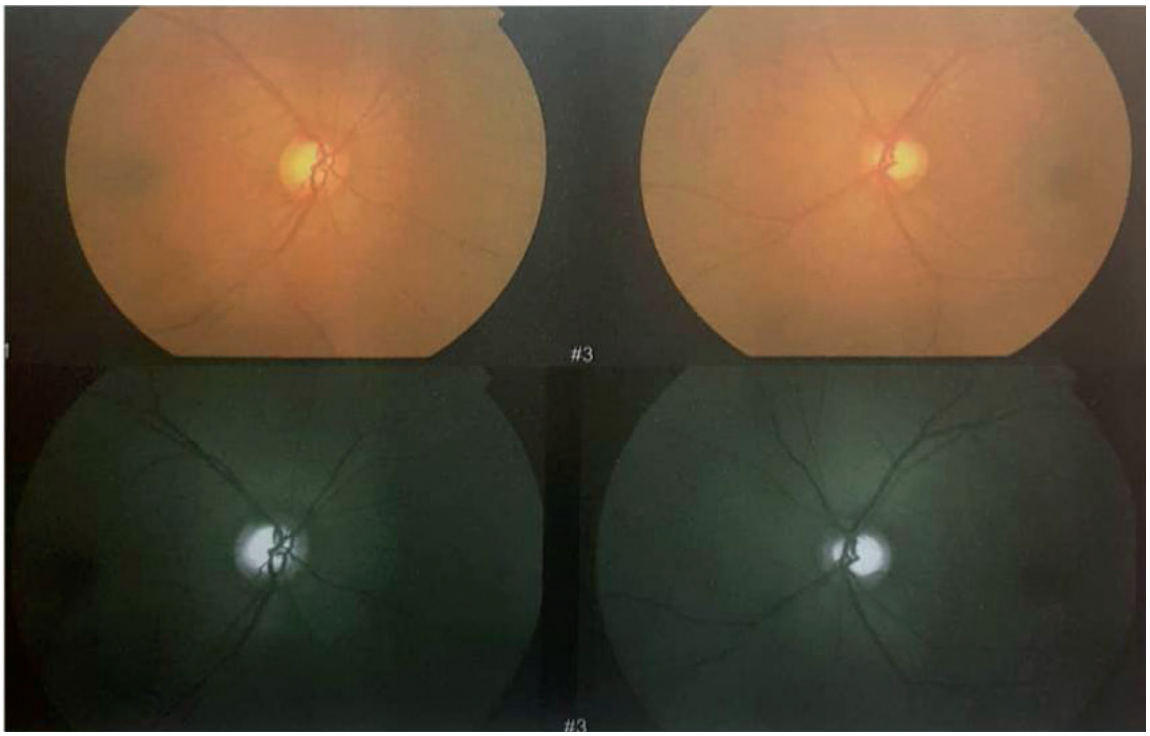

Fig. 1: Fundoscopy examination showing increased cup-to-disc ratio with healthy neuroretinal rim.

Content supported by Dr. Shweta Tripathi, Senior Consultant, Glaucoma Services, Indira Gandhi Eye Hospital and Research Centre, Lucknow

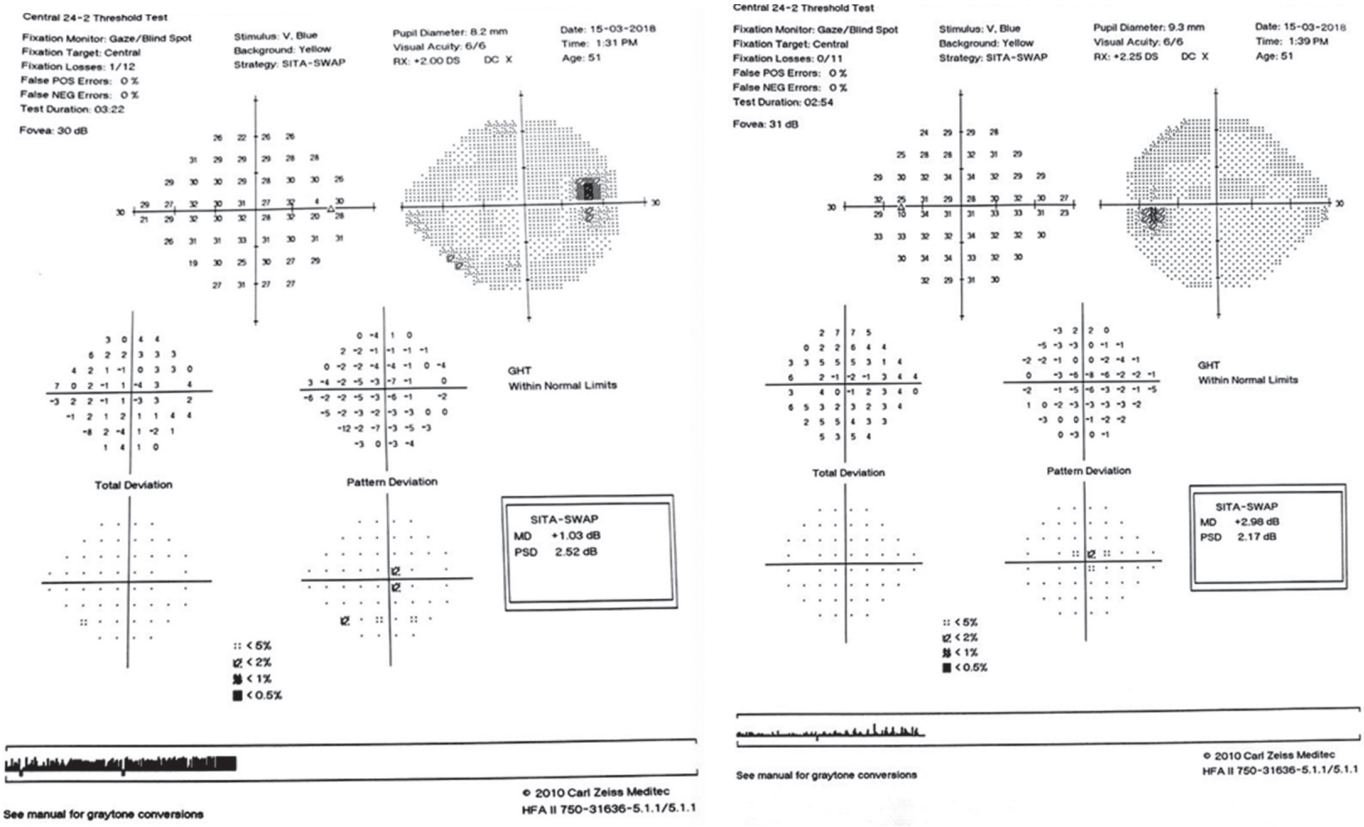

Fig. 2: Visual fields were normal in both eyes.

15

Secondary Glaucoma

TAKE HOME MESSAGES

- Secondary glaucoma, although presents in a smaller percentage of patients, causes considerable ocular morbidity and vision loss.
- Early diagnosis is vital for prevention of vision loss.
- Trauma is a major cause of secondary glaucoma in age group below 20 years.
- Treatment in secondary glaucoma is often based on intraocular pressure lowering, and removal of underlying cause.

SECONDARY GLAUCOMA

- Owing to discomforting symptoms such as reduction in visual acuity (VA), pain, and ocular discomfort, patients with secondary glaucoma self-visit ophthalmologists.
- Secondary glaucoma is always a result of primary pathology hence careful treatment of primary pathology can avert development of secondary glaucoma.
- Early detection is the key to optimal management in secondary glaucoma.
- Patients with secondary glaucoma frequently have an underlying systemic disorder and poor intraocular pressure (IOP) control; it is likely to miss the underlying disorder, hence meticulous diagnosis is of prime importance.

COMMON CAUSES OF SECONDARY GLAUCOMA

- Lens-induced
- Neovascular
- Pseudophakic
- Post-vitrectomy
- Uveitic
- Traumatic
- Steroid-induced
- Corneoiridic scar
- Unknown etiology

Pigmentary Glaucoma

- Pigmentary glaucoma is a common type of secondary glaucoma.
- Risk factors include younger age, Caucasian males, and myopia.
- It is characterized by
  - Mid peripheral iris transillumination defects
  - Krukenberg's spindles
  - Heavily pigmented trabecular meshwork
- Underlying pathophysiology includes
  - Rubbing between iris pigment epithelium and lens zonules.
  - Aqueous flow obstruction attributable to accumulation of pigment in trabecular meshwork.
  - Denudation, collapse, and sclerosis of trabecular beams.
- During the course of disease, IOP may raise owing to progressive trabecular meshwork impairment leading to ocular hypertension and subsequently glaucoma.
- Condition becomes apparent in the third or fourth decade of life.
- Anterior segment structures such as corneal epithelium, zonule, lens, and trabecular meshwork are involved, hence, anterior segment analysis is crucial for diagnosis.
- Management is based on early intervention to prevent pigmentation.
- Therapeutic regimens include anti-glaucoma medication, laser trabeculoplasty and filtering surgery.

Uveitic Glaucoma

- High IOP and aggressive nerve damage are classical features of uveitic glaucoma.
- This subtype of glaucoma necessitates management of both uveitis and glaucoma.
- Interplay of complex mechanisms may be the underlying cause of raised IOP in uveitic glaucoma.
- Etiological factors for development of uveitic glaucoma include:
  - Rheumatoid arthritis-associated iridocyclitis

  - Fuchs' heterochromic iridocyclitis
  - Sarcoidosis
  - Herpes simplex keratouveitis
  - Zoster uveitis
  - Lyme-related uveitis
  - Cancer-associated uveitis
  - Juvenile idiopathic arthritis
  - Behçet's disease
  - Pars planitis
  - Sympathetic ophthalmia
  - Syphilis
- Patients often present with remarkably high IOP fluctuations.
- Diagnostic methods include thorough clinical evaluation of optic nerve and retinal nerve fiber layer (RNFL) analysis including optical coherence tomography (OCT) and optic disc imaging.
- Owing to complex disease process, a comprehensive management including specialist care is necessary for treatment.
- The goal of management is to preserve structural anatomy and prevent optic nerve damage.
- Treatment considerations must incorporate management of uveitis and reduction in IOP along with control of inflammation.
- Surgery is often the mainstay therapeutic strategy owing to intricate disease process causing ocular inflammation.

Neovascular Glaucoma

- It is usually associated with poor prognosis.
- It is a potentially blinding condition refractory to medical and surgical management.
- Aqueous humor outflow obstruction attributable to new vessel formation over the iris and the iridocorneal angle, and subsequent increase in IOP with sequelae of posterior segment ischemia are features of neovascular glaucoma.
- Neovessel growth is related to disturbance in homeostasis between pro-angiogenic factors and anti-angiogenic factors.
- It is mostly associated with an underlying disease such as diabetic retinopathy, ischemic central retinal vein occlusion (CRVO), ocular ischemic syndrome, central retinal artery occlusion (CRAO), branch RVO, Eales' disease, sickle cell retinopathy, intraocular neoplasms, chronic retinal detachment and severe intraocular inflammation.
- Treatment aim is to prevent/reduce posterior segment ischemia.
- Management consists of IOP lowering, laser, photocoagulation or other surgical procedures such as cyclodestructive techniques.
- Filtration or shunt surgery is necessary when significant synechial angle-closure is observed.
- Recently, anti-vascular endothelial growth factor (VEGF) agents are being tested for usefulness in neovascular glaucoma.

Steroid-induced Glaucoma

- Steroids are frequently prescribed for numerous autoimmune and inflammatory conditions.
- Ocular steroid exposure can be iatrogenic or associated with self-prescribed over the counter steroid-based ocular agents.
- Steroid exposure can be topical, periocular, intraocular, intranasal, inhalational, or systemic.
- Intraocular pressure increase is commonly seen in the first few weeks of steroid use. Nevertheless, it may take days or even years in some cases.
- Intraocular pressure often normalizes within 1–4 weeks after steroid discontinuation.
- Pathognomonic process in steroid-induced glaucoma is believed to involve increase in resistance to outflow of aqueous humor in trabecular network and subsequent increase in IOP. Trabecular meshwork possesses glucocorticoid receptors, and steroids may alter cell migration and phagocytosis thereby decreasing the cellularity of trabecular meshwork and increasing the extracellular matrix culminating to resistance and IOP increase.
- Risk factors for steroid-induced glaucoma are primary open-angle glaucoma (POAG), family history of glaucoma, type 1 diabetes, myopia, rheumatoid arthritis, increasing age, children <6 years of age, and penetrating keratoplasty for Fuchs' dystrophy and keratoconus.
- Signs and symptoms may include watering, blepharospasm, photophobia, raised IOP, optic disc cupping, visual field defect, increase in corneal thickness and corneal ulcer.
- A proper diagnosis should include taking a thorough history for use of steroids; post-ophthalmologic condition or underlying illness. Diagnostic tests include VA test, tonometry, visual field (VF) test, gonioscopy, and OCT.
- The primary step in steroid-induced glaucoma management is discontinuation of steroid, or dose reduction if discontinuation is not feasible.
- Subsequent step is addition of IOP lowering agent. Beta-blockers constitute as first-line agent in this condition.

- If medical therapy fails, laser trabeculoplasty must be considered.
- Surgical therapy is often the last resort, when both, medical and laser therapy fail.

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TIPS AND TRICKS

- Pigmentary glaucoma: Peripheral laser iridotomy may prevent progression and reverse backward bowing of the iris.
- Uveitic glaucoma: Management of inflammation is imperative.
- Neovascular glaucoma: Vision is extremely compromised usually and limited to counting fingers to hand movements, and IOP is ranges between 40 mmHg and 60 mmHg or more.
- Steroid-induced glaucoma: Diagnosis is confirmed by decrease in IOP after steroid discontinuation. Severity of disease depends on frequency of use, strength of steroid used, and duration of use.
- Prostaglandin analogs are relatively contraindicated in cases of steroid-induced glaucoma.

CASE 1

NEOVASCULAR GLAUCOMA

TAKE HOME MESSAGES

- Neovascularization of iris and angle occurs in response to a stimulus.
- Most common causes include
  - Retinal ischemia
  - Proliferative diabetic retinopathy
  - Ischemic retinal vein occlusion
  - Ocular ischemic syndrome

INTRODUCTION

A 72-year-old male presented with decreased vision in right eye. He had a history of diabetes since 35 years and was on insulin and oral hypoglycemic agents. He also had hypertension for the last 30 years and was taking Telmisartan for the same.

EXAMINATION

- Visual acuity (VA) test: 6/9, n6 in both eyes
- Anterior segment examination:
  - Right eye (OD) (Fig. 1): Cornea clear, anterior chamber flare+/normal depth, pupil 3 mm round, and reactive to light (rrr), neovascularization of the iris present (NVI+), and intraocular pressure (IOP) 18 mmHg
  - Left eye (OS): Normal
- Gonioscopy (Fig. 2)
  - Neovascularization of angle (NVA).
- Fundus examination (Fig. 3)
  - Proliferative diabetic retinopathy (PDR) with pre-retinal hemorrhage and neovascularization of the disc (NVD).

DIAGNOSIS

- OD: Senile immature cataract (SIMC), NVI, NVA, and PDR
- OS: SIMC, severe non-PDR

MANAGEMENT

- Pan retinal photocoagulation of the right eye was performed in 3 sittings.
- Intraocular pressure was closely monitored to document any deterioration.
- Left eye was also closely monitored.

CONCLUSIONS

In neovascular glaucoma cases close monitoring of IOP is necessary to check for deterioration.

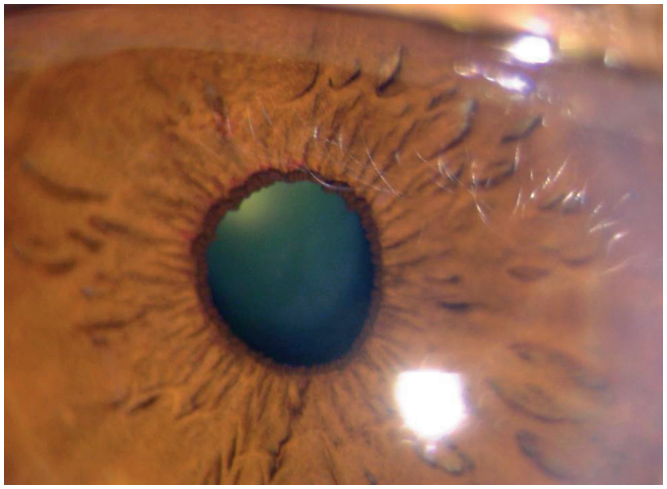

Fig. 1: Anterior segment of the right eye showing slightly irregular pupil and neovascularization of iris from 9 o'clock to 1 o'clock positions.

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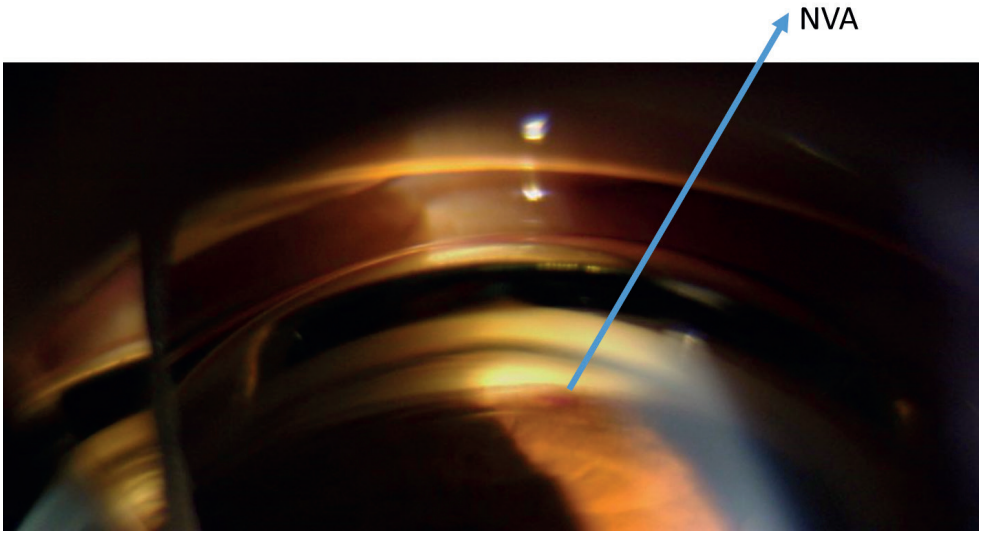

Fig. 2: Gonioscopy showing neovascularization of angle (NVA).

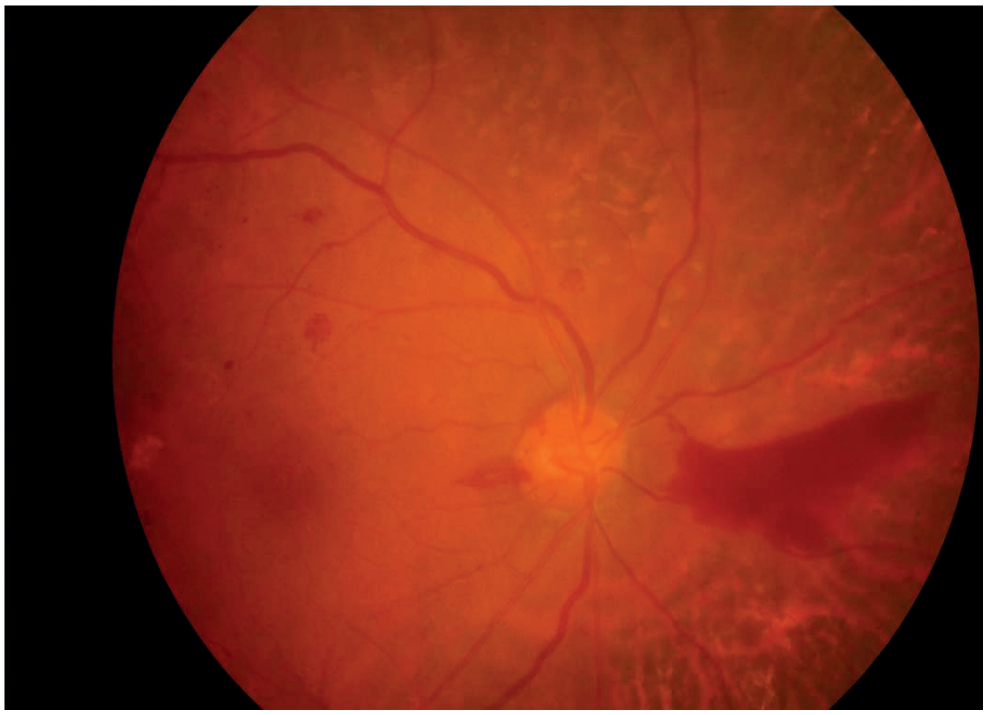

Fig. 3: Fundus of the right eye showing proliferative diabetic retinopathy with pre-retinal hemorrhage and neovascularization of disc.

CASE 2

NEOVASCULAR GLAUCOMA

TAKE HOME MESSAGES

- It is not advisable to delay treatment in neovascular glaucoma, as prompt further intervention is important to preserve vision.
- Refer to glaucoma specialist immediately, if intraocular pressure is not controlled with maximal medical therapy.
- Surgical options include trabeculectomy with maximal medical therapy and Ahmed glaucoma valve implant.

INTRODUCTION

A 65-year-old female reported with pain, redness, and decreased vision in the left eye. Her past history revealed phacoemulsification cataract surgery with intraocular lens (IOL) implantation in both eyes 4 months back. Her medical history was significant for diabetes mellitus since 15 years, hypertension since 18 years, and ischemic heart disease since 5 years. She was taking oral hypoglycemic agents and Amlodipine.

EXAMINATION

- Best corrected visual acuity (BCVA)
  - Right eye (OD): 6/6, n6
  - Left eye (OS): 6/12, n6
- Anterior segment examination (Fig. 1)
  - OD: Within normal limit (wnl)
  - OS: Pupillary ruff and neovascularization of iris (NVI)
- Intraocular pressure (IOP)
  - OD: 17 mmHg
  - OS: 32 mmHg
- Gonioscopy (Fig. 2)
  - OD: Open angles
  - OS: Synechiae-neovascularization of the angle (NVA) in 2 quadrants
- Fundus examination (Fig. 3): Showed proliferative diabetic retinopathy (PDR)

DIAGNOSIS

- OD: Pseudophakia and severe non-proliferative diabetic retinopathy (NPDR)
- OS: Pseudophakia, PDR, and neovascular glaucoma (NVG)
- Good VA
- Elevated IOP
- Partial synechial angle-closure

MANAGEMENT

- Underlying pathology was managed with intravitreal anti-vascular endothelial growth factor (VEGF).
- Pan retinal photocoagulation in 3 sittings was planned.
- For IOP reduction, aqueous suppressants such as Timolol, Brimonidine, and Dorzolamide; eye drops systemic acetazolamide, and topical atropine, and dexamethasone were prescribed.
- Post anti-VEGF, after maximal medical therapy, IOP remained between 34–40 mmHg. Hence, pan retinal photocoagulation 3 (PRP 3) was performed.

CONCLUSIONS

In neovascular glaucoma cases, early treatment is advisable to prevent vision loss.

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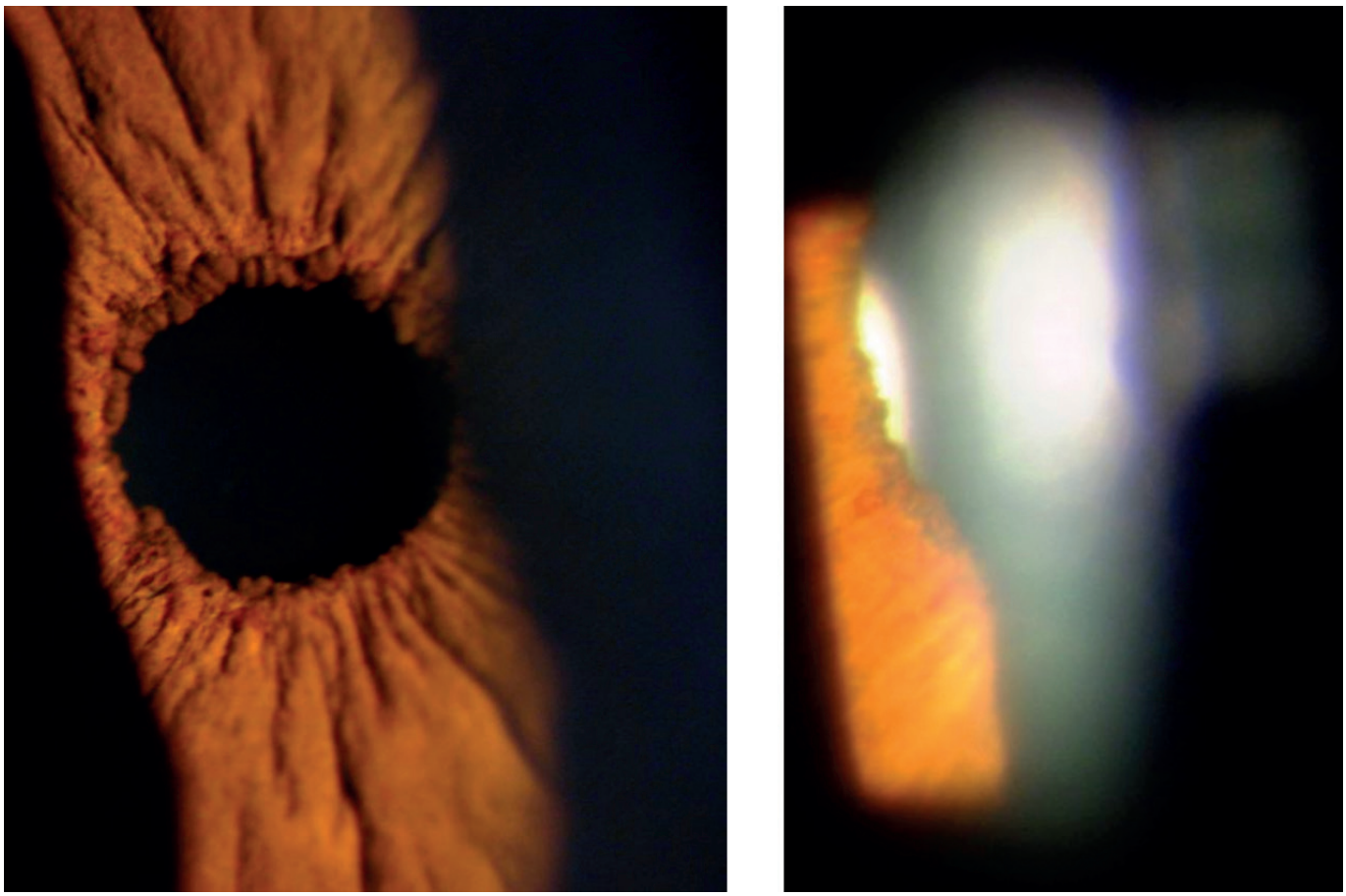

Fig. 1: Anterior segment of the left eye showing loss of pupillary ruff and neovascularization of the iris.

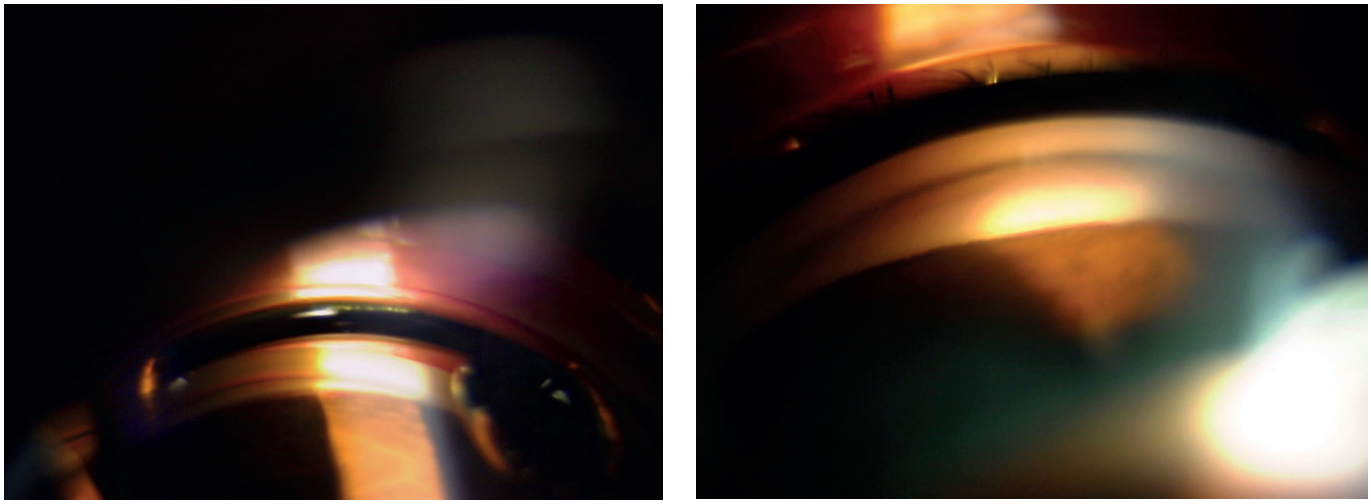

Fig. 2: Gonioscopy of the left eye showing synechial angle-closure.

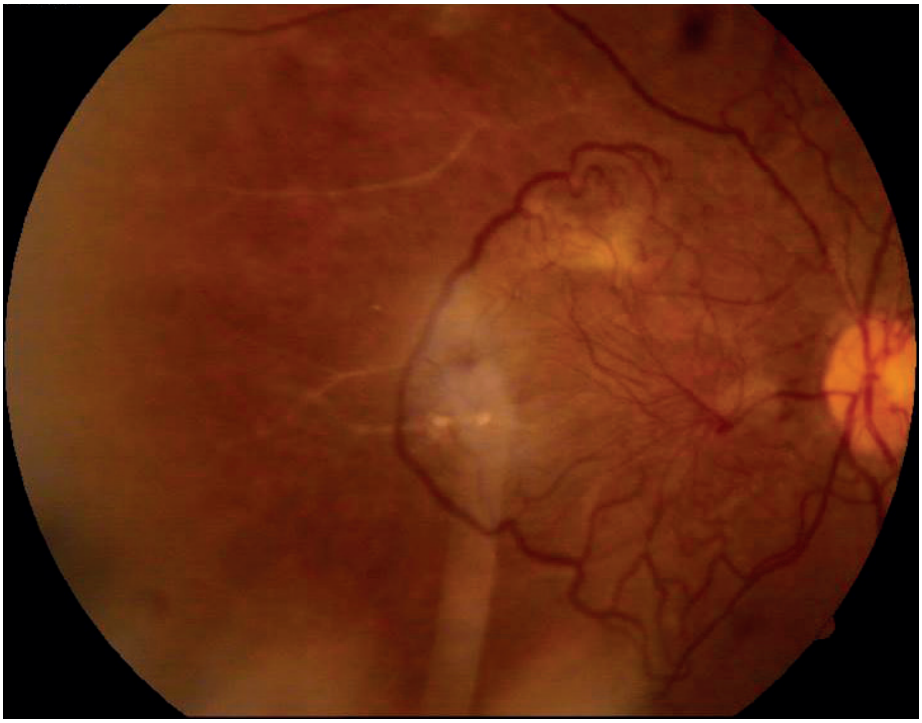

Fig. 3: Fundus of the right eye showing proliferative diabetic retinopathy and florid neovascularization elsewhere.

CASE 3

NEOVASCULAR GLAUCOMA

TAKE HOME MESSAGES

- Early diagnosis and prompt treatment is vital for the prevention of retinal ischemia.
- Anti-vascular endothelial growth factor therapy must be considered in case of
  - Regression of neovascularization of iris and angle
  - Prevention of peripheral anterior synechiae
  - Until definitive management can be done
  - Fewer complications with glaucoma surgery
- Medical management with prostaglandin analogs and pilocarpine must be avoided while awaiting surgery.
- Definitive surgical management includes trabeculectomy with maximal medical therapy, valves, transscleral cyclophotocoagulation/endoscopic cyclophotocoagulation.

INTRODUCTION

A 69-year-old male patient presented with pain and vision loss in the right eye, and one-sided headache. Past medical history revealed that he had diabetic retinopathy in both eyes and received anti-vascular endothelial growth factor (VEGF) intravitreal injection 1 year back, followed by laser therapy. Systemic illness included diabetes mellitus since 25 years, nephropathy (on dialysis), hypertension, and ischemic heart disease.

EXAMINATION

- Visual acuity (VA)
  - Right eye (OD): No perception of light (NPL), intraocular pressure (IOP) 52 mmHg
  - Left eye (OS): 6/24
- Anterior segment analysis
  - OD (Fig. 1)
    - Corneal edema
    - Irregular pupil
    - Ectropion uveae
    - Florid neovascularization of iris (NVI)
  - OS (Fig. 2)
    - Ectropion uveae, no NVI
    - Mid-dilated pupil
    - Senile immature cataract (SIMC)
    - Intraocular pressure: 18 mmHg on Timolol and Dorzolamide
    - Gonioscopy: Open angle, patchy peripheral anterior synechiae (PAS), no neovascularization of angle (NVA)
- Fundus examination
  - OD: Hazy view
  - OS: Signs of previous pan retinal photocoagulation (PRP) stable

DIAGNOSIS

- OD: Absolute neovascular glaucoma, proliferative diabetic retinopathy (PDR), signs of previous PRP
- OS: Regressed NV/SIMC, PDR signs of previous PRP, secondary open-angle glaucoma

MANAGEMENT

Medical management with aqueous suppressants, topical steroids, and cycloplegics was initiated. Transscleral cyclophotocoagulation (TSCPC)/cyclocryotherapy was planned for the right eye.

CONCLUSIONS

To prevent retinal ischemia early diagnosis and management is advisable.

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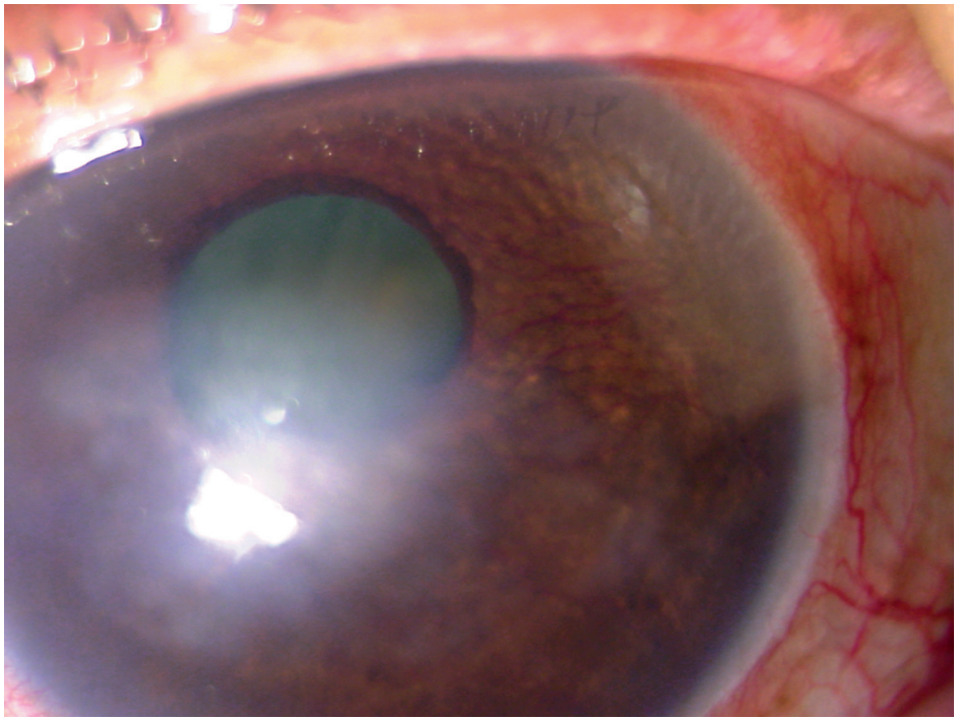


Fig. 1: Anterior segment of the right eye showing hazy cornea due to corneal edema, irregular pupil and ectropion uveae, and florid neovascularization of iris.

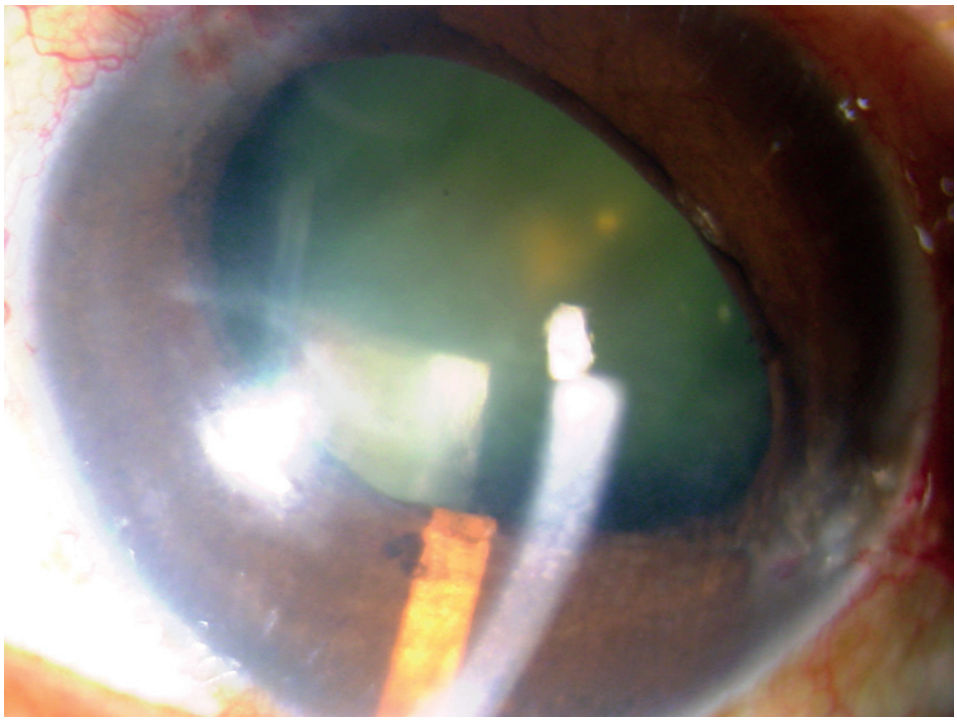


Fig. 2: Anterior segment of the left eye showing ectropion uveae, mid-dilated irregular pupil, and senile immature cataract.

CASE 4

PIGMENTARY GLAUCOMA

TAKE HOME MESSAGES

- Drugs of choice:
  - Prostaglandin analogs
  - Target the uveoscleral pathway
  - Not the clogged trabecular meshwork
- Laser peripheral iridotomy may be beneficial only if iridozonular contact is seen on the ultrasound biomicroscopy.
- Vigorous physical exercise can cause pigment dispersion.
- Trabeculectomy is associated with high risk of hypotony.

INTRODUCTION

A 37-year-old male presented for routine out patient evaluation. He neither had history of trauma or ocular surgery nor any contributory systemic illness or family history of glaucoma.

EXAMINATION

- Visual acuity (VA) test
  - Right eye (OD): 6/6 n6, refractive error -1.50/+1.50 D cylinder at 180°
  - Left eye (OS): 6/6/ n6, refractive error -2.50 D
- Slit-lamp evaluation (Fig. 1)
  - Ocular surface normal
  - Van Herick (VA) test: Grade 4 in both eyes
- Intraocular pressure (IOP) (Goldmann applanation tonometry [GAT])
  - OD: 36 mmHg
  - OS: 32 mmHg
- Gonioscopy showed densely pigmented trabecular meshwork (Figs. 2a–c).
- Optic disc evaluation (Figs. 3a–c, 4a–c)
  - OD: Large disc with a sloping inferior rim and inferior peripapillary atrophy (PPA).
  - OS: Large disc with loss of the inferior rim and thinning of the superior rim and diffuse retinal nerve fiber layer (RNFL) loss.
- Visual field (VF) analysis (Figs. 5a, b)
  - OD: Within normal limit
  - OS: Corresponded to the disc changes in the left eye
  - Humphrey visual field (OS) (Figs. 5c)
    - With central damage on 24-2 performing a 10-2 helps to monitor central progression
- Ultrasound biomicroscopy (UBM) (Fig. 6)
  - Showed irido-zonular contact

DIAGNOSIS

Pigmentary glaucoma

MANAGEMENT

After thorough examination and diagnostic testing, patient was started on prostaglandin analog. The IOP reduced to 16 mmHg in both the eyes and was stable at last follow-up.

CONCLUSIONS

Prostaglandin analogs are a treatment of choice for reduction of IOP in pigmentary glaucoma.

Content supported by Dr. Ronnie George, Deputy Director, Smt. Jadhavbai Nathamal Singhvee Glaucoma Services, Sankara Nethralaya, Chennai

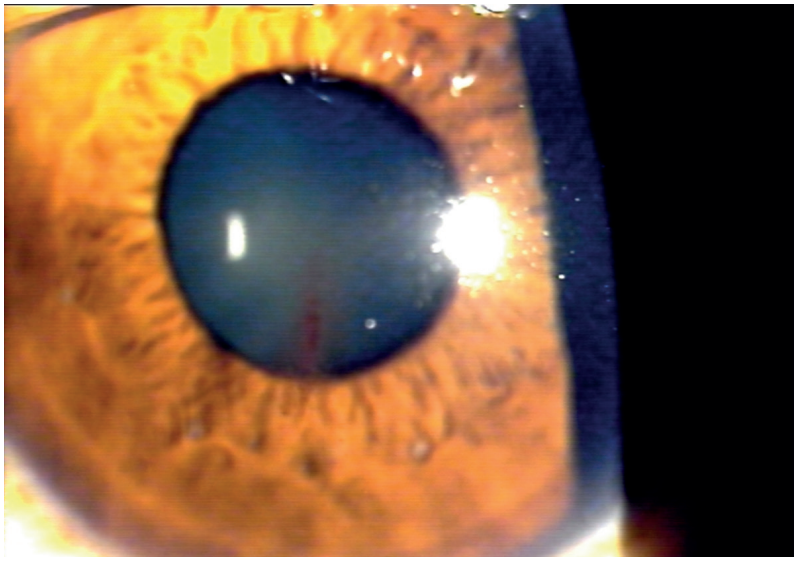


Fig. 1: Slip-lamp showing Krukenberg's spindle.

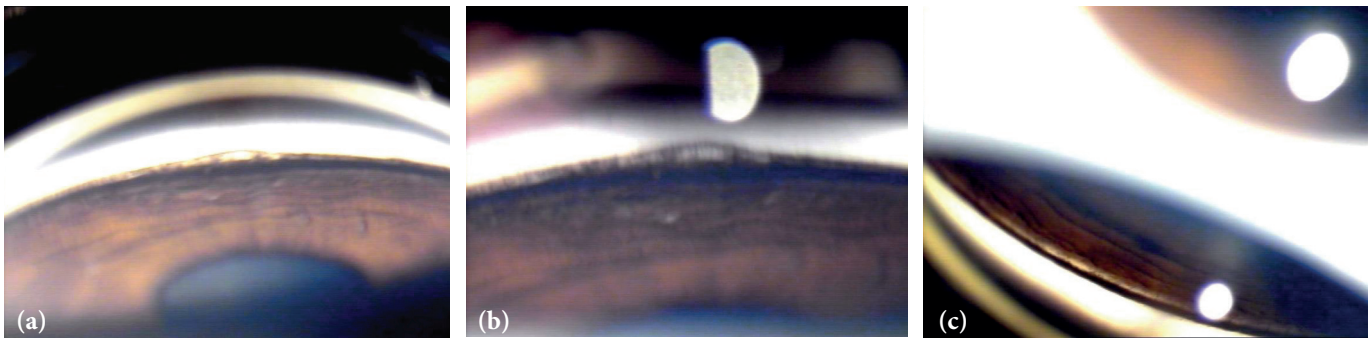


Fig. 2(a–c): Gonioscopy showing densely pigmented trabecular meshwork.

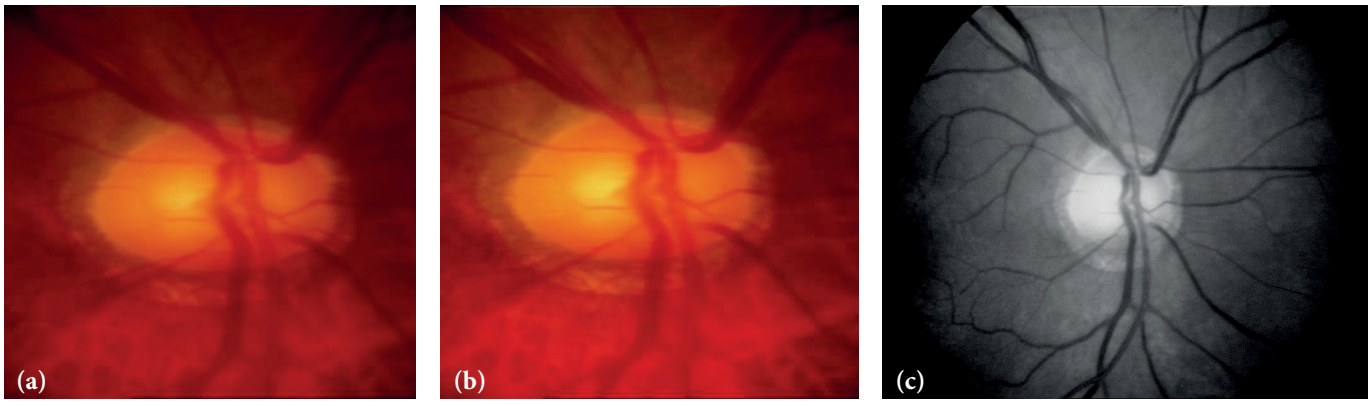


Fig. 3(a–c): Optic disc examination showing large disc with a sloping inferior rim and inferior peripapillary atrophy in right eye.

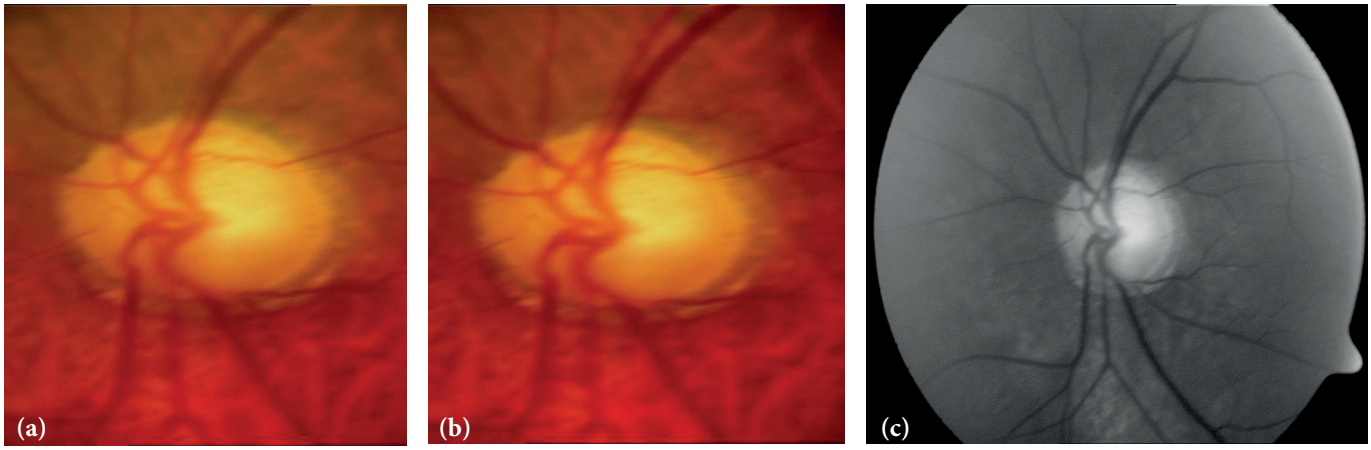
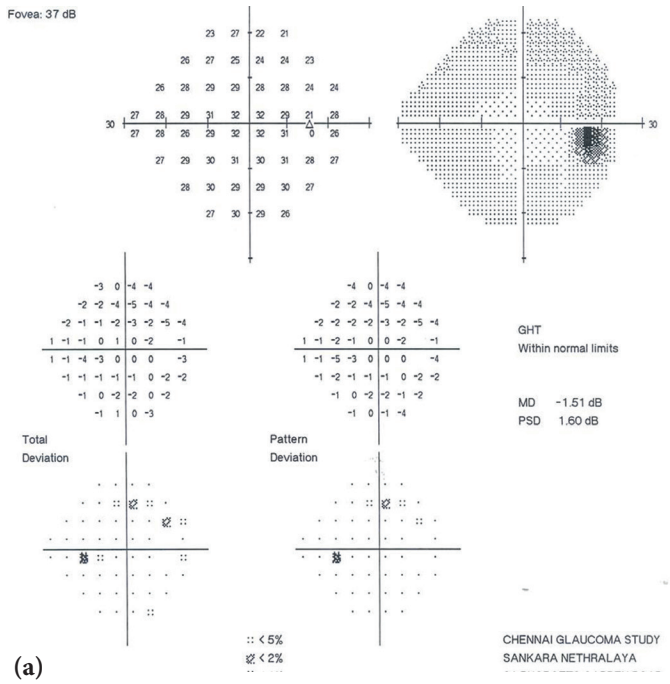
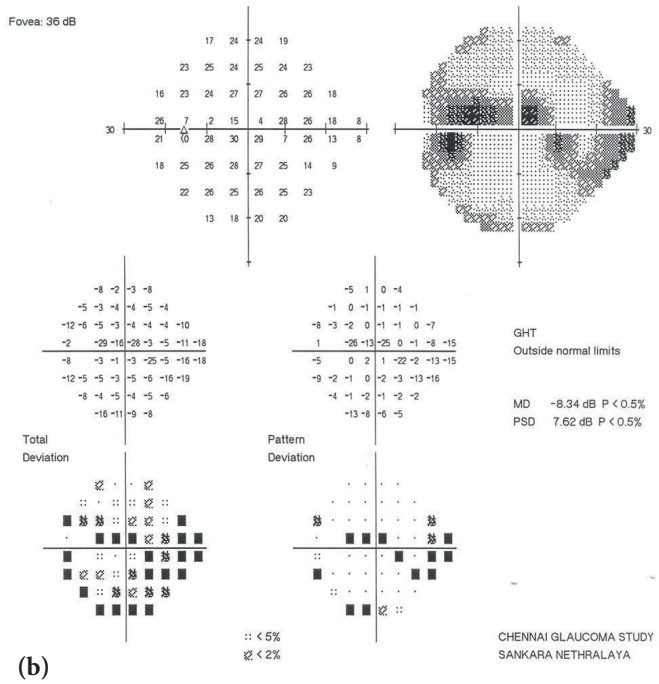


Fig. 4(a–c): Large disc with loss of the inferior rim and thinning of the superior rim and diffuse retinal nerve fiber layer loss in left eye.





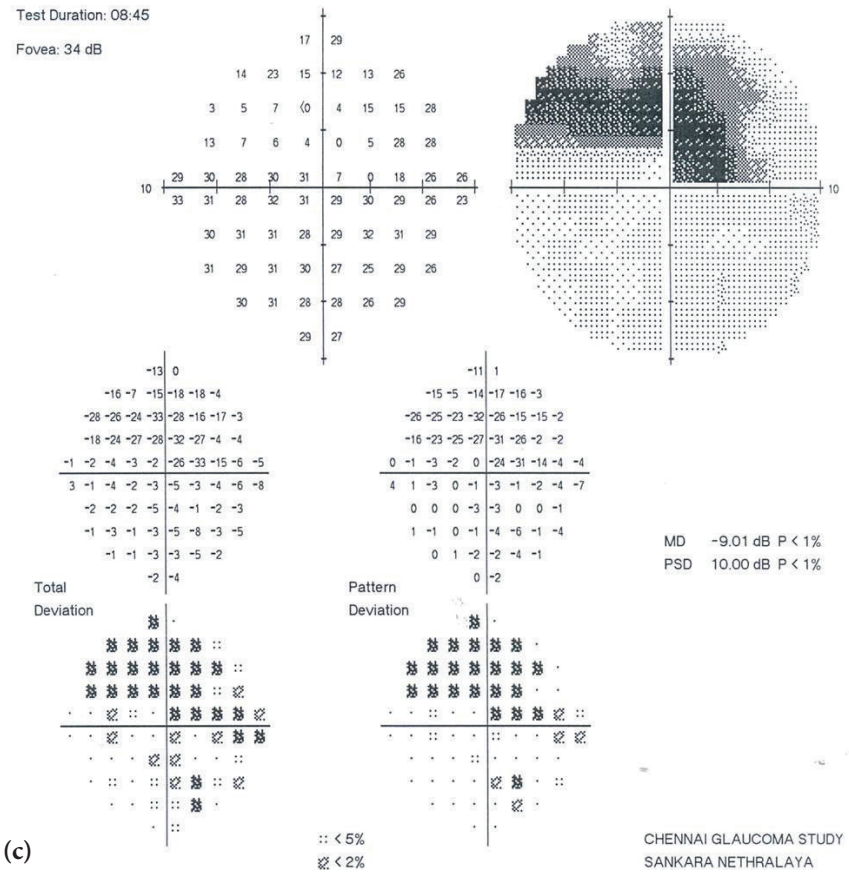


Fig. 5: Visual field analysis. **(a, b)** Right eye was within normal limit and field defect corresponding to disc changes were evident in the left eye. **(c)** Visual field (left eye) with central damage on 24-2; performing a 10-2 helps monitor central progression.

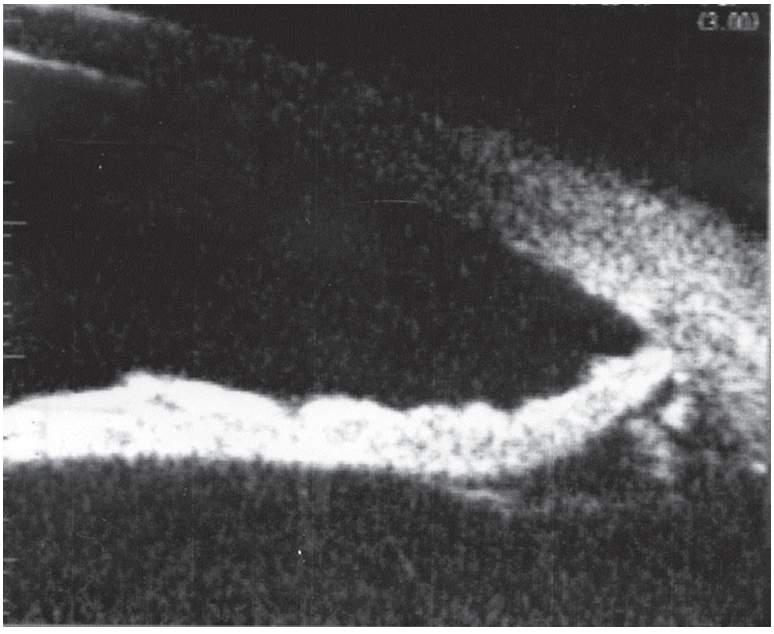


Fig. 6: Ultrasound biomicroscopy showing irido-zonular contact.

CASE 5

UVEITIC GLAUCOMA

TAKE HOME MESSAGES

- Treatment of the underlying cause is necessary.
- It is important to manage the inflammation.
- Identify the etiological factors such as
  - Trabeculitis
  - Steroid response: Common and quick with topical steroids but can happen with oral steroids too which may take longer to manifest
  - Secondary angle-closure
- Gonioscopy is mandatory for proper diagnosis.

INTRODUCTION

A 48-year-old female presented with gradual and progressive vision diminution in the left eye since 6 months. She also had mild redness and photophobia. She was referred following treatment for repeated episodes of redness.

She had a history of seven attacks of redness and blurred vision in left eye in the last 3 years. She is currently not on any medications.

EXAMINATION

- Visual acuity (VA) (Table 1)
- Anterior segment examination (Table 2)
- In view of patient's history including anterior inflammation, it was ascertained that trabeculitis was causing intraocular pressure (IOP) spike.
- Hence, she was investigated for uveitis, however, no cause was found. Patient was then advised topical steroids, Timolol, and Brimonidine eye drops for IOP control.
- Patient returned after 3 months and reported 3 recurrent episodes.
- Slit-lamp examination (Figs. 1a, b): Keratic precipitates on the endothelium in the left eye.
- Gonioscopy
  - Right eye (OD) (Fig. 2a): Open angle till scleral spur
  - Left eye (OS) (Fig. 2b): Open 360° with synechiae inferiorly
- Fundus examination (Table 3)
- Pachymetry
  - OD: 499 µm
  - OS: 500 µm
- Visual field (VF) examination (Figs. 3, 4)

DIAGNOSIS

Uveitic glaucoma

MANAGEMENT

Inflammation was under control, there was peripheral anterior synechiae in angle with trabecular meshwork scarring. Patient was considered as a steroid responder. Steroid was slowly tapered and topical Dorzolamide was added along with few days course of acetazolamide. Follow-up one year later showed persistence of redness, pain and peripheral anterior synechiae, and IOP of 38 mmHg.

CONCLUSIONS

Gonioscopy is mandatory for proper diagnosis of uveitic glaucoma.

Content supported by Dr. Ronnie George, Deputy Director, Smt. Jadhavbai Nathamal Singhvee Glaucoma Services, Sankara Nethralaya, Chennai

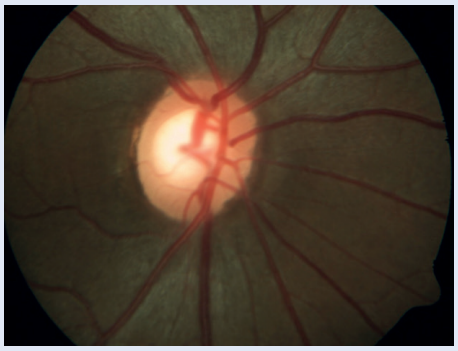
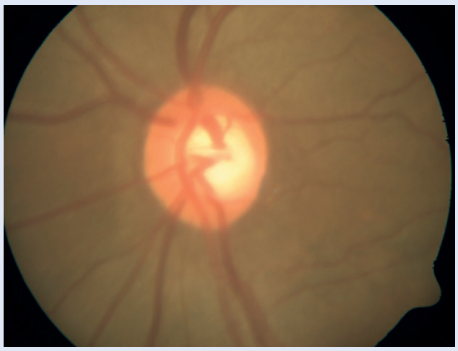
Table 1: Visual acuity examination.

	Right eye	Left eye
Distant	6/6 (0.75 DS)	6/6 (-8.00 DS)
Near	N6 (+2.00 DS)	N6 (+2.00 DS)

Table 2: Anterior segment examination.

	Right eye	Left eye
Conjunctiva	Clear	Circumcorneal congestion
Sclera	Normal	Normal
Cornea	Clear	Few large pigmented keratic precipitates inferiorly
Anterior chamber	Normal depth, quiet	Normal depth, cells +++
Iris	Normal color, pattern	Normal color, pattern
Pupil	Round, regular, reactive	Round, regular, reactive
Lens	Early cataract	Dense posterior subcapsular cataract
Intraocular pressure	14 mmHg	40 mmHg

Table 3: Fundus examination.

	Right eye	Left eye
		
Media	Clear	Hazy due to posterior subcapsular cataract
Disc	0.6 cup-to-disc ratio	0.6 cup-to-disc ratio
Neuroretinal rim	Healthy	Healthy
Macula	Normal	Normal
Peripheral retina	Normal	Normal

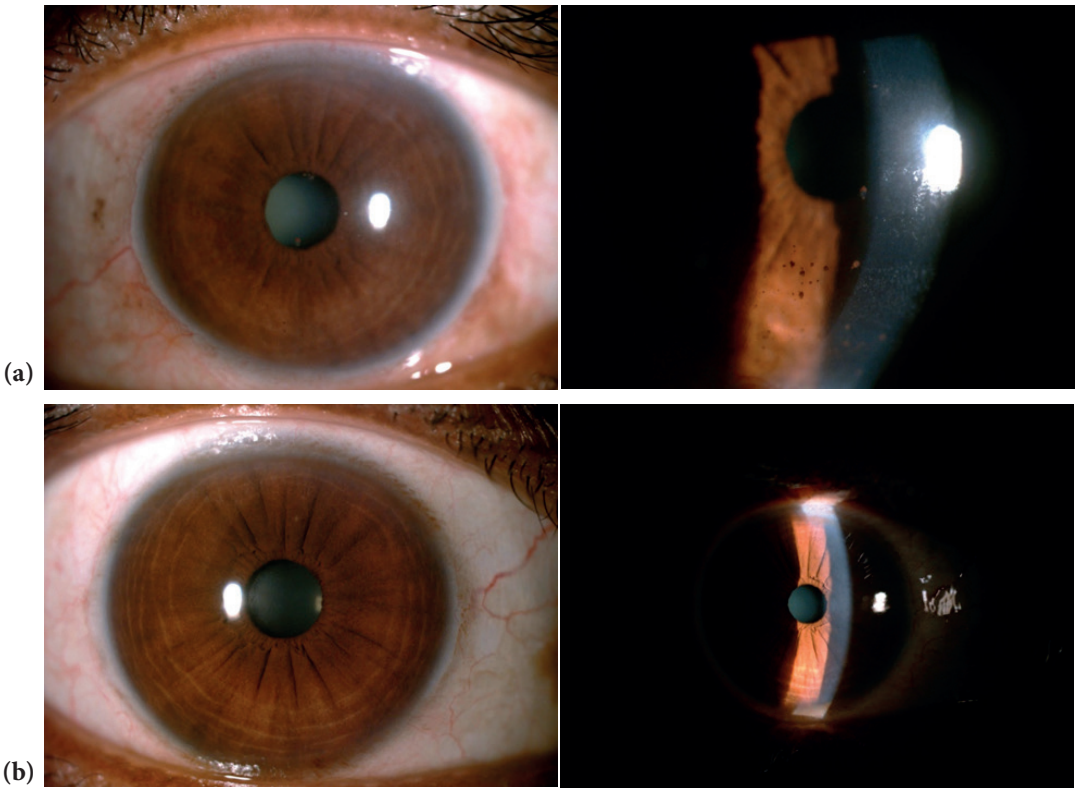


Fig. 1: (a) Slit-lamp examination (right eye) normal. (b) Keratic precipitates on the endothelium in the left eye on slit-lamp examination.

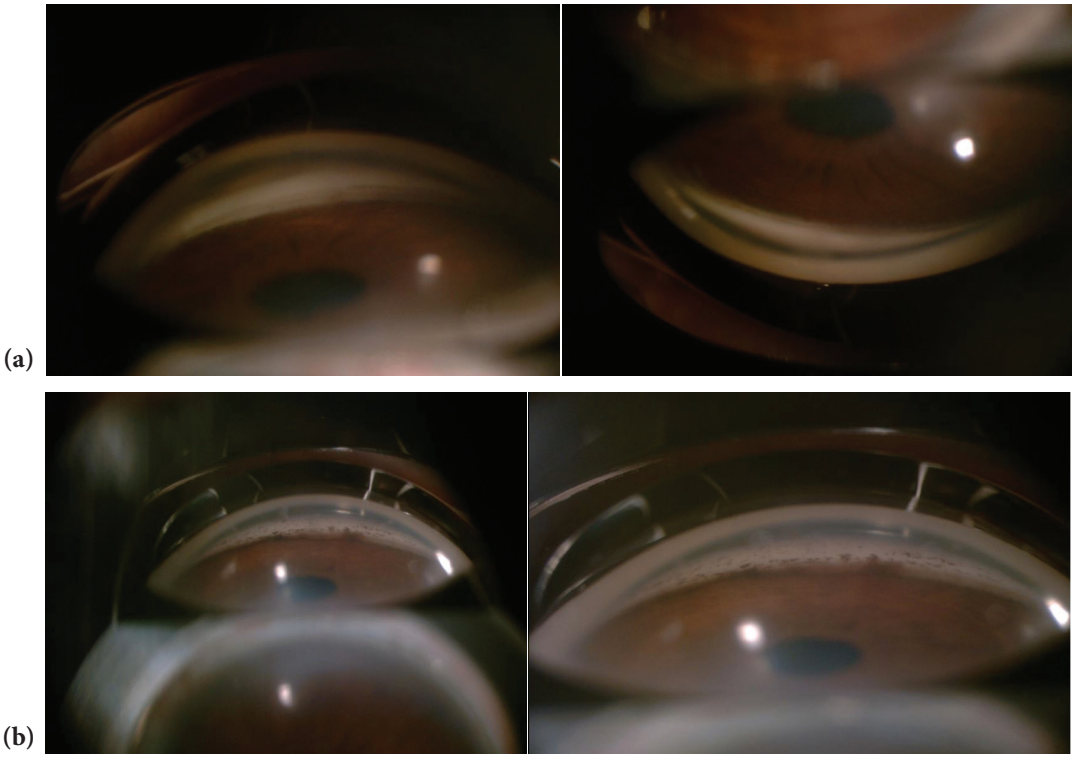


Fig. 2: (a) Gonioscopy right eye showing open angle till scleral spur. (b) Gonioscopy left eye showing open angle 360° with focal synechiae inferiorly.

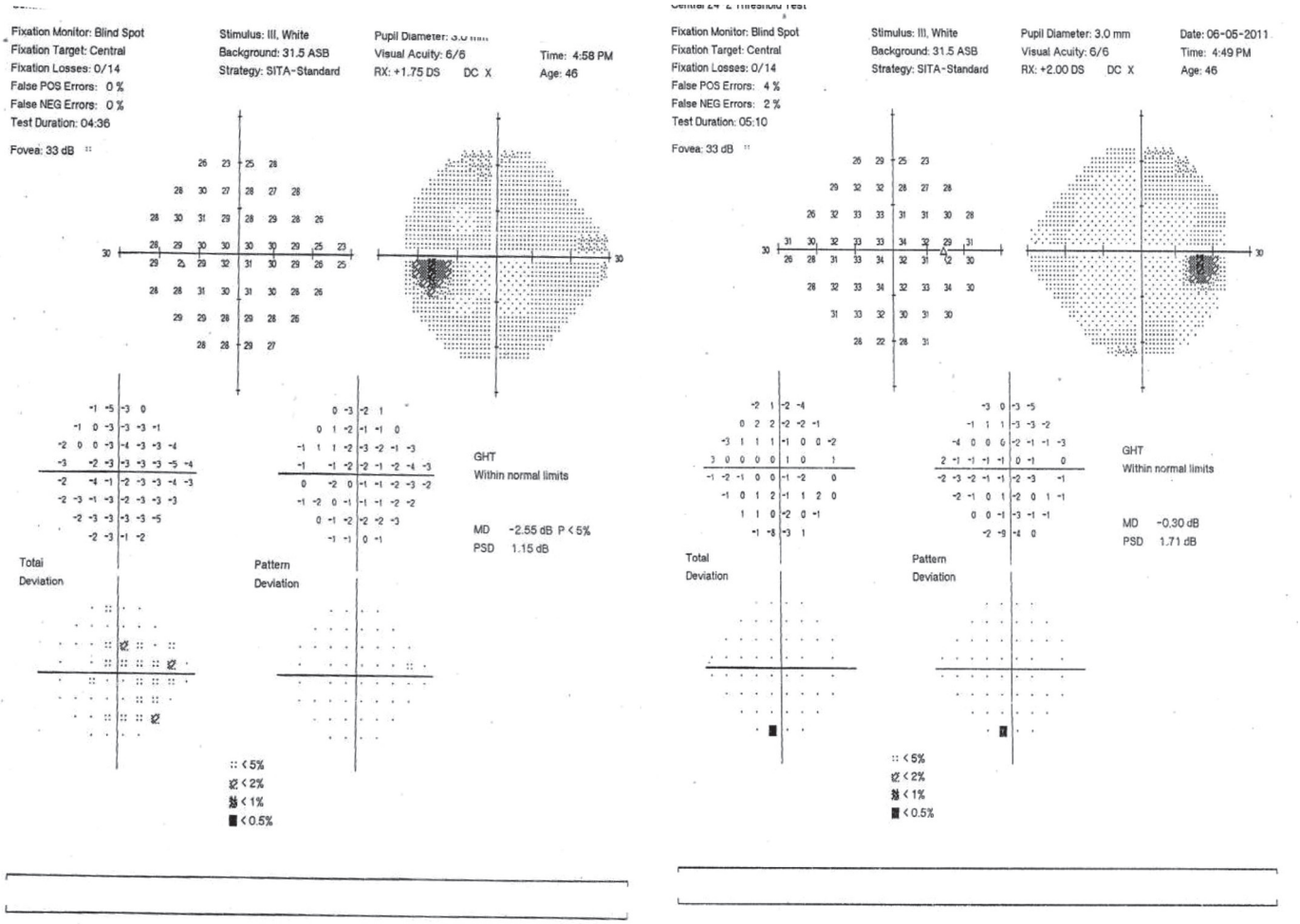


Fig. 3: Visual fields within normal limits in 2011.

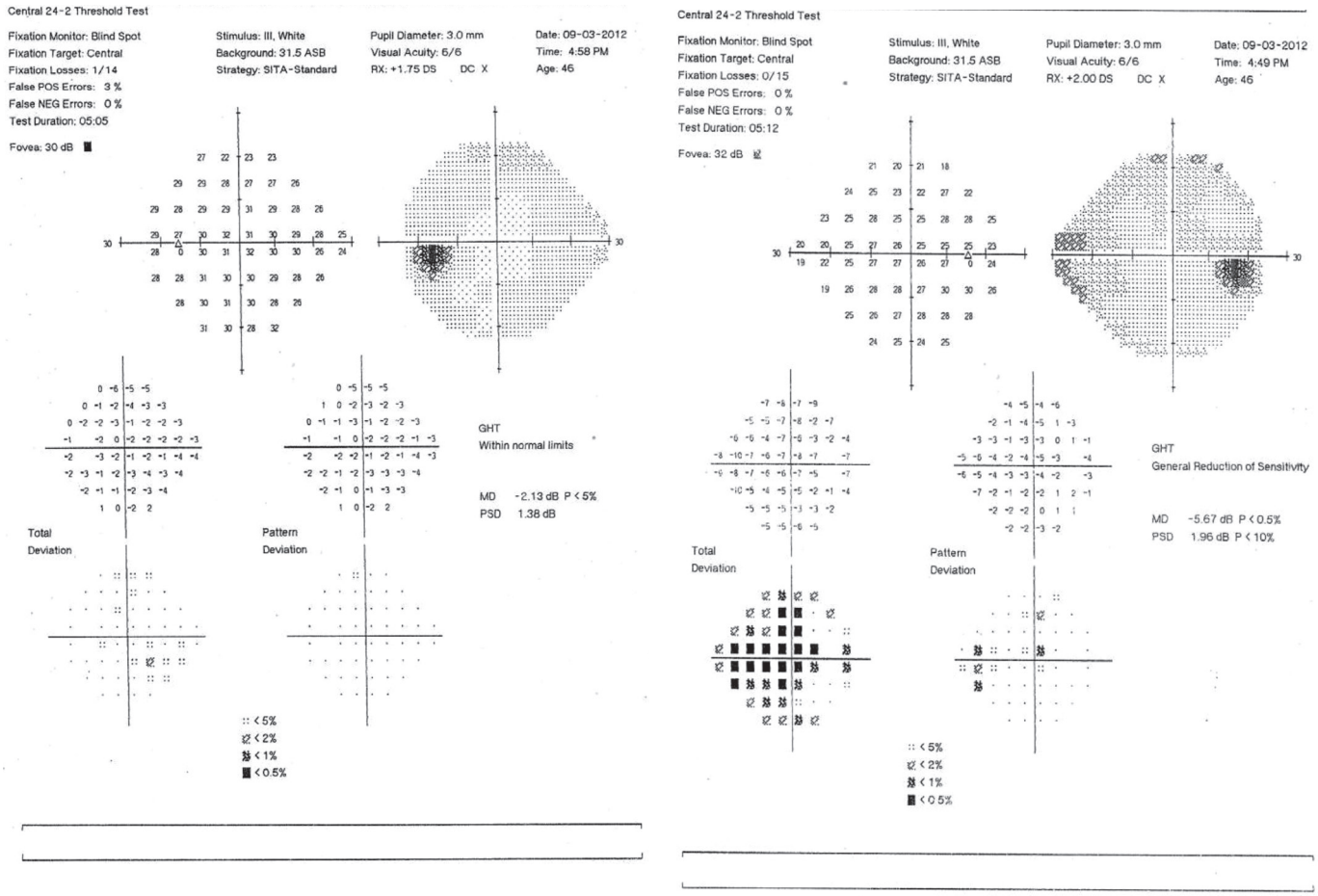


Fig. 4: Visual fields within normal limits in 2012.

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Pediatric Glaucoma

TAKE HOME MESSAGES

- Periodic follow-up and assessment is an integral part of pediatric glaucoma management.
- Timely referral and appropriate counseling of parents before surgery is a very important.
- Selection of appropriate surgery at an appropriate time is the key to success.
- Refractive correction, amblyopia therapy, and visual rehabilitation are essential elements of management.

UNDERSTANDING PEDIATRIC GLAUCOMA

- Pediatric glaucoma can be classified as primary, secondary or that associated with syndromes.
- Primary pediatric glaucoma is further classified as congenital, infantile, and juvenile glaucoma.
- Secondary pediatric glaucoma may be related to inflammation due to trauma, tumors, or lenticular causes.
- Syndrome associated with glaucoma development include Axenfeld-Rieger syndrome, Rubinstein-Taybi syndrome, and Sturge-Weber syndrome, among others.

PRESENTATION

- Epiphora
- Photophobia
- Corneal haze
- Blepharospasm
- Buphthalmos

DIAGNOSIS AND EVALUATION

- Sound diagnosis depends on appropriate understanding of the signs, symptoms, and underlying condition.
- The diagnostic evaluation includes
  - Visual assessment
  - Retinoscopy, if media haze allows
  - Anterior segment evaluation with handheld slit-lamp
  - Corneal diameter and keratometry
  - Intraocular pressure (IOP) assessment
  - Fundus evaluation
  - Fields (over 5 years of age)
  - Cornea status
  - B-scan (ophthalmic ultrasound)

VARIATIONS BETWEEN PEDIATRIC AND ADULT GLAUCOMA

- Pediatric glaucoma is a clinical challenge wherein medical treatment has limited role.
- Surgical management differs from adults owing to variations in anatomy, varied pathophysiological mechanisms, aggressive healing response, and unpredictable postoperative course.
- Monitoring progression of the disease is different.
- In addition to IOP and disc evaluation, corneal diameter, axial length, and refraction are to be monitored.
- Treatment of co-existing refractive error and amblyopia are prudent for favorable outcomes.
- Postoperative follow-up is difficult as children are less co-operative.
- Long-life expectancy, anticipating future surgery, or re-intervention needs must be considered for pediatric patients.

THERAPEUTIC OPTIONS

- The management in pediatric glaucoma is frequently surgical with medical therapy playing a supplementary role.
- The aim of management is preservation of vision.
- Various surgical options for management include
  - Goniotomy
  - Viscocanalostomy/trabeculotomy
  - Trabectome surgery
  - Trabeculectomy
  - Glaucoma shunt surgery
  - Cycloablation with diode laser (limited transscleral cyclophotocoagulation)

Content supported by Dr. Sushma Tejwani, Consultant and Head of Glaucoma Services, Narayana Nethralaya-2, Bengaluru

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TIPS AND TRICKS

- Prognosis depends on severity of ocular pathology, and it is good in primary congenital glaucoma.
- Reduction in vision is usually associated with amblyopia and uncontrolled glaucoma.

CASE 1

TAKE HOME MESSAGES

- Trabeculotomy is useful to remove obstruction to aqueous outflow.
- Trabeculectomy is useful to bypass episcleral venous system.
- Treatment of coexisting refractive error and amblyopia are advisable for favorable outcomes.

INTRODUCTION

A one-month-old baby girl was brought to the hospital by parents for swelling and redness in the left eye since birth. Her medical history was significant for seizures since the 12th day of birth and she was prescribed phenobarbital syrup.

EXAMINATION

- Intraocular pressure (IOP)
  - Right eye (OD): 10 mmHg
  - Left eye (OS): 22 mmHg
- Left eye corneal haze
- Corneal diameter
  - OD: 10 mm
  - OS: 12 mm
- Fundus examination: Left eye showed choroidal hemangioma.
- In view of findings and her medical history; seizures and hemangioma, magnetic resonance imaging (MRI) was advised.
- Magnetic resonance imaging showed cortical and subcortical calcification in the occipital, parietal, and temporal regions with large enhancing pial and leptomeningeal angioma.

DIAGNOSIS

Sturge-Weber syndrome Type 1 with secondary glaucoma, left-sided port wine stain and choroidal hemangioma with cerebral hemangioma, brain ischemia, and cortical and subcortical calcification.

MANAGEMENT

- Surgical management was considered prudent.
- Trabeculotomy and trabeculectomy were performed under general anesthesia in the left eye (Fig. 1).

FOLLOW-UP

- Early postoperative period:
  - Vision: Baby was following light.
  - Retinoscopy showed a refractive error of -6.00DS.
  - Intraocular pressure was 10 mmHg both eyes.
  - Bleb was diffused with well-formed anterior chamber (AC).
  - Fundus showed presence of choroidal angioma with no fluid and pigment deposits.
  - Specialist advised glasses and occlusion therapy to treat amblyopia.
  - Choroidal hemangioma was monitored for any change in size or any fluid collection but no active treatment was performed for the same.
- Late postoperative period:
  - Last follow-up was at 2.5 year after surgery.
  - Vision
    - OD: 20/84
    - OS: 20/130
  - Intraocular pressure
    - OD: 11 mmHg;
    - OS: 16 mmHg
  - Well-formed diffused bleb.
  - Choroidal hemangioma reduced in size and the child was stable.

CONCLUSIONS

Trabeculotomy and trabeculectomy are useful in treatment of pediatric glaucoma followed by correction of co-existing refractive error and amblyopia.

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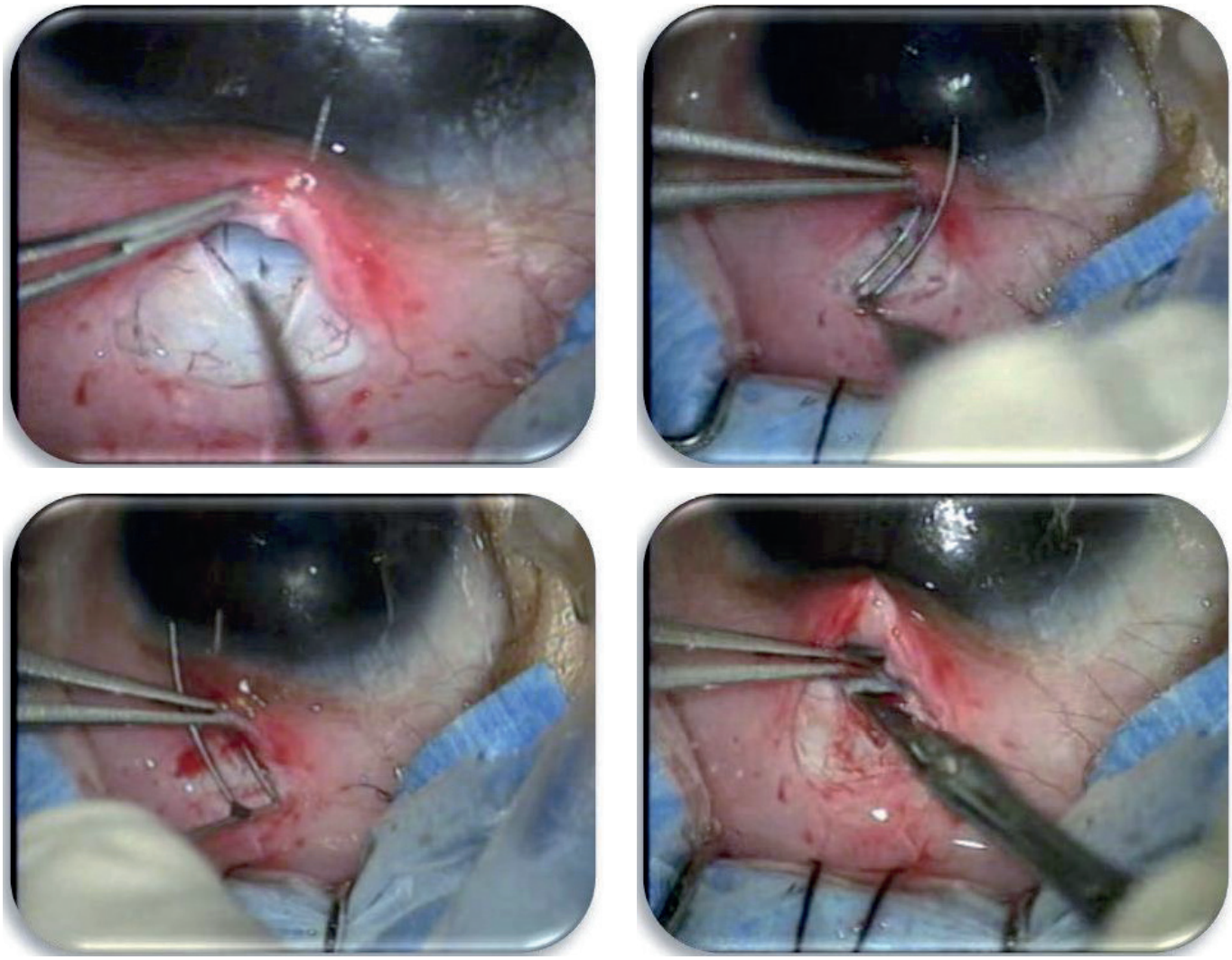

Fig. 1: Trabeculotomy and trabeculectomy in left eye.

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Medical Management of Glaucoma

TAKE HOME MESSAGES

- Setting target intraocular pressure is necessary for optimal medical management.
- Fixed dose combinations have an advantage over monotherapy for management of glaucoma.
- If medical management fails, surgical options must be explored.

AIM OF MEDICAL THERAPY

Medical therapy must aim to:

- Decrease intraocular pressure (IOP) to a level that will minimize optic nerve damage
- Maintain visual function
- Maintain quality of life
- Treatment-related
  - Minimal treatment-related inconvenience
  - Minimal side-effects
  - Treatment should be cost-effective
  - Good compliance

SETTING TARGET INTRAOCULAR PRESSURE

- Ocular hypertension/early glaucoma
  - 20% reduction from baseline IOP or set to achieve 18–20 mmHg
- Normal tension glaucoma
  - 30% reduction from baseline IOP
- Moderate glaucoma
  - 30% reduction from baseline IOP or set to achieve 13–15 mmHg
- Advanced glaucoma
  - 40–50% reduction from baseline IOP or set to achieve <12 mmHg

MONOTHERAPY VERSUS FIXED COMBINATIONS IN GLAUCOMA

- Monotherapy
  - Insufficient response to reach target IOP.
  - Patients may require instillation of more than 1 agent, hence, affects compliance.
- Fixed combination
  - Better compliance.
  - Reduction in overall preservative exposure.
  - Ease of remembering and convenience of use.
  - Improvement in adherence.
  - Possibly cost-effective.

MEDICAL AGENTS USED IN GLAUCOMA MANAGEMENT

Various pharmacological agents used for lowering IOP include:

- Prostaglandin analogs
- Carbonic anhydrase inhibitors
- Alfa 2-adrenergic agonists
- Cholinergic agonists
- Beta-blockers

Prostaglandin Analogs

- Mechanism of action: Improvement in the uveoscleral outflow of aqueous humor (Fig. 1).
- Contraindications: Pregnancy.
- Side-effects: Headache, joint and muscle ache, local adverse effects like blurred vision, hyperemia, eye discomfort, permanent iridial pigmentation, macular edema, and thickening of eyelashes.
- Advantages: May help to achieve up to 25–35% reduction in IOP according to Marais A, *et al.*; once daily dosing, diurnal, and nocturnal IOP control; lowers IOP beyond 24 hours.
- Disadvantages: Ocular adverse effects.

Content supported by Dr. Deven Tuli, Consultant Glaucoma, Kailash Nursing Home & Eye Care, New Delhi

- Examples: Latanoprost 0.005%, Travoprost 0.004%, and Bimatoprost 0.01%, 0.03%
- Combinations: Travopost 40 µg/mL + Timolol 5 mg/mL; Bimatoprost 0.3 mg/mL + Timolol 5 mg/mL; Latanoprost 50 µg/mL + Timolol 5 mg/mL

Carbonic Anhydrase Inhibitors

- Mechanism of action: Reduction in production of aqueous humor; few agents reduce rate of aqueous humor flow, and few agents improve ocular blood flow (Fig. 1).
- Contraindications: Hypersensitivity to components.
- Side-effects: Ocular irritation, dry eyes, blurred vision, and bitter taste. Acetazolamide specific-paresthesia, nausea, diarrhea, loss of appetite and dose-related systemic acidosis.
- Advantages: Also possess diuretic mode of action; helps in IOP reduction by 15–20% from baseline according to Marais A, *et al.*
- Disadvantages: Acetazolamide has limited use due to systemic side-effects.
- Examples: Acetazolamide 250 mg tabs, Dorzolamide 2%, and Brinzolamide 1%.
- Combinations: Brinzolamide 10 mg/mL + Timolol 5 mg/mL; Dorzolamide 20 mg/mL + Timolol 5 mg/mL

Alfa 2-adrenergic Agonists

- Mechanism of action: Selective alfa 2-receptor agonist; limits aqueous humor production, and increases uveoscleral flow (Fig. 1).
- Contraindications: Cerebral or coronary insufficiency, postural hypotension, and renal or hepatic failure.
- Side-effects: Systemic adverse effects include central nervous system (CNS) and respiratory system side-effects. Local side-effects with topical use include hypersensitivity reactions, ocular irritation, eyelid edema, foreign body sensation, and dry eyes.
- Advantages: Baseline IOP reduction by at least 20–30% according to Marais A, *et al.*
- Disadvantages: Systemic side-effects.
- Examples: Brimonidine 0.15%, 0.2%, 0.1%, 0.025%.
- Combinations: Brimonidine 2 mg/mL + Timolol 5 mg/mL.

Cholinergic Agonists

- Mechanism of action: Increase trabecular meshwork aqueous outflow (Fig. 1).
- Contraindications: Neovascular glaucoma, uveitis, cataract, and worsening papillary block, age >40 years.
- Side-effects: Ciliary muscle spasm, myopia, and altered vision.
- Advantages: Pilocarpine administration can constrict pupil and open angle for better visualization, hence, useful for preoperative administration.
- Disadvantages: Poor tolerability.
- Examples: Pilocarpine 1%, 2%, 4%.

Beta-blockers

- Mechanism of action: Reduction in aqueous humor production (Fig. 1).
- Contraindications: Asthma, chronic obstructive pulmonary disease, and bradycardia.
- Side-effects: Ocular irritation and dry eyes.
- Advantages: 15–25% decrease in IOP according to Marais A, *et al.*, and does not cause miosis or accommodation disturbances.
- Disadvantages: Significant systemic side-effects, minimal nocturnal IOP lowering.
- Examples: Betaxolol 0.25%, 0.5%, Timolol 0.25%, 0.5%, and Levobunolol 0.25%, 0.5%.
- Combinations: Travopost 40 µg/mL + Timolol 5 mg/mL; Bimatoprost 0.3 mg/mL + Timolol 5 mg/mL; Latanoprost 50 µg/mL + Timolol 5 mg/mL; Brinzolamide 10 mg/mL + Timolol 5 mg/mL; Brimonidine 2 mg/mL + Timolol 5 mg/mL; Dorzolamide 20 mg/mL + Timolol 5 mg/mL.

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TIPS AND TRICKS

- Monotherapy escalated to maximum dose should be followed by combination therapy to maximum dose.
- If no response is observed with combination, up to 3 agents may be used for optimal response.

Increase in aqueous drainage via uveoscleral outflow:

- Prostaglandin analogs—Latanoprost, Bimatoprost, and Travoprost
- Alfa 2 adrenergic agonists—Apraclonidine and Brimonidine

Reduction in aqueous production:

- Carbonic anhydrase inhibitors—systemic (Acetazolamide); topical (Brinzolamide and Dorzolamide)
- Adrenergic agonists—Apraclonidine and Brimonidine
- Adrenergic antagonist (beta-blockers)—non selective-Timolol; selective β1 blocker-Betaxolol

Increase in aqueous outflow via trabecular meshwork:

- Cholinergic agents direct acting—Pilocarpine; indirect acting-Carbachol

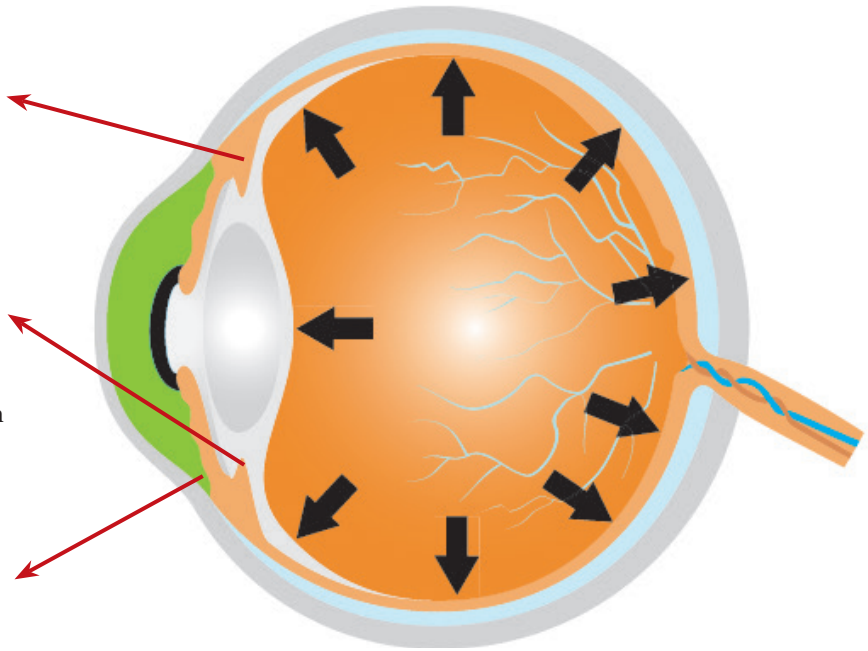

Fig. 1: Mechanisms of action of anti-glaucoma medications.
Image courtesy: Shutterstock

CASE 1

MEDICAL MANAGEMENT OF GLAUCOMA

TAKE HOME MESSAGES

- Intraocular pressure lowering potential by various groups
  - Prostaglandins: 30–35%
  - Others: 18–25%
- In case of pseudophakia, pilocarpine 2% should be considered in place of topical carbonic anhydrase inhibitor.

INTRODUCTION

A 74-year-old female patient with a history of glaucoma came for routine examination. Patient was already receiving Travoprost, Brimonidine, and Timolol for both the eyes as three separate bottles. She was pseudophakic in both eyes. Clinically, she had hyperemia and blepharitis (Fig. 1).

EXAMINATION

- Intraocular pressure (IOP) readings at presentation
  - Right eye (OD): 24 mmHg
  - Left eye (OS): 20 mmHg
- Fundus examination (Fig. 2)
  - Showed worsening of the left optic disc and increased cup-to-disc ratio (CDR)
- Optical computed tomography (OCT)
  - Left disc changes
- Retinal nerve fiber layer (RNFL) analysis (Fig. 3)
  - Showed RNFL deterioration.

MANAGEMENT

- After thorough history and examination, it was assumed that she probably had an allergy to either Travoprost or Brimonidine.
- Diagnosis of exclusion was considered appropriate for this case; initial discontinuation of Brimonidine followed by reassessment was planned.
- If condition improved on discontinuation of Brimonidine, Travoprost, and Timolol in single bottle fixed combination was to be continued, with addition of topical carbonic anhydrase inhibitor (CAI) like Dorzolamide or Brinzolamine as second bottle to lower IOP.
- Since she was pseudophakic, Pilocarpine 2% could have been used instead of topical CAI as second bottle.
- In case of no improvement, Travoprost was to be replaced with Latanoprost or Bimatoprost 0.01% and clinical condition was to be reassessed for further action.

CONCLUSIONS

Diagnosis of exclusion must be considered in cases where patient report allergies to medical therapy advised for lowering IOP.

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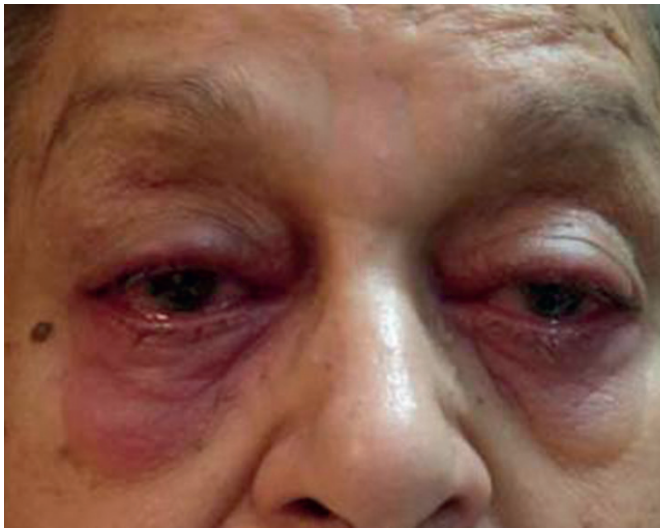

Fig. 1: Significant hyperemia and blepharitis.

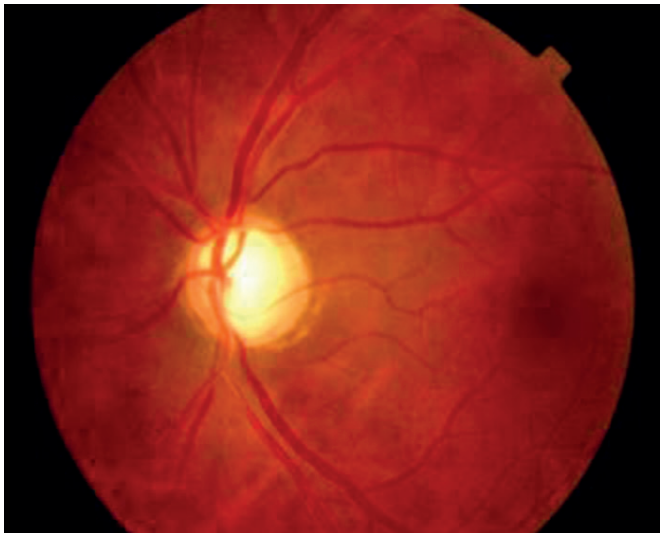

Fig. 2: Fundoscopy showing increased cup-to-disc ratio.

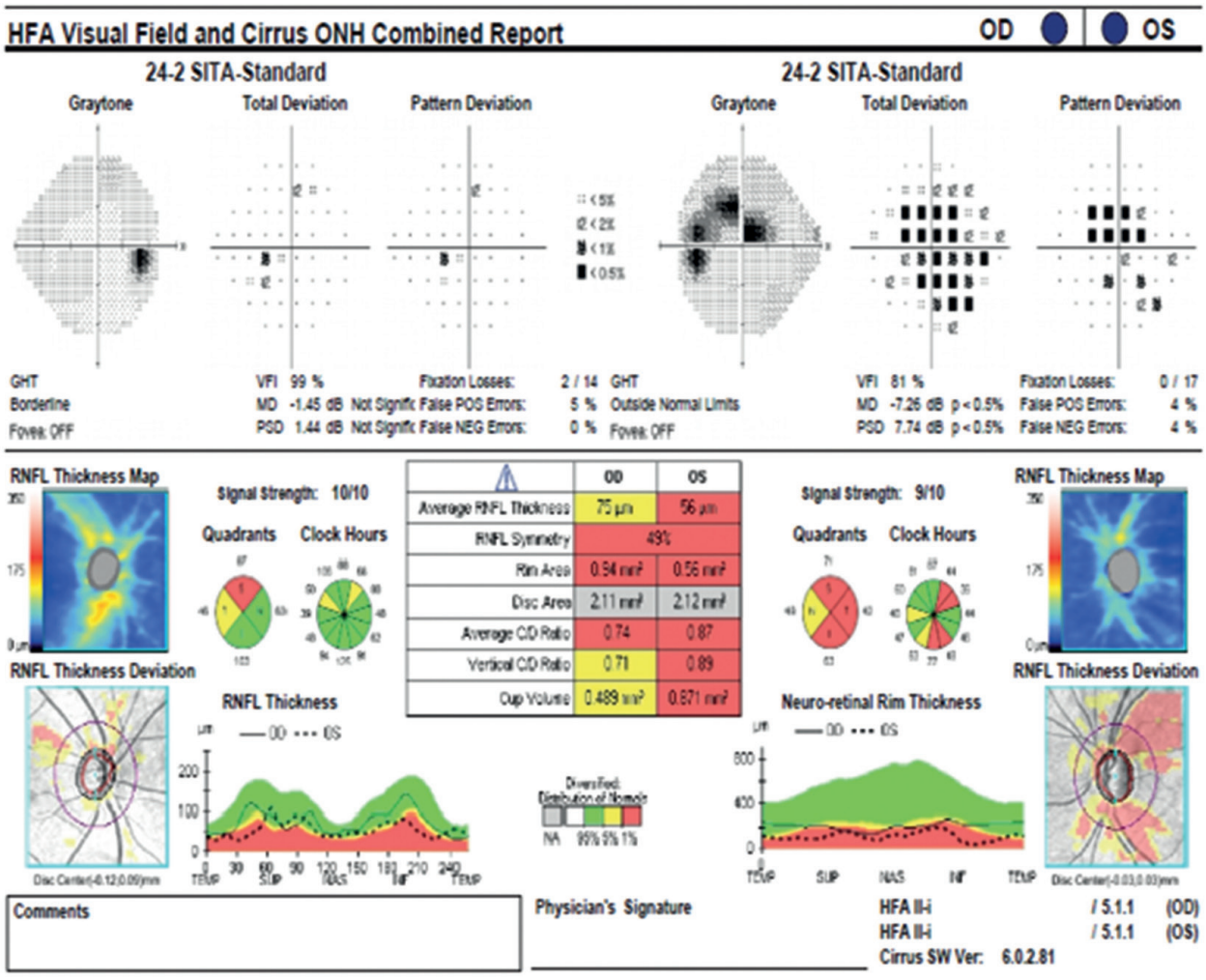

Fig. 3: Retinal nerve fiber layer analysis showing deterioration of visual fields and defect.

CASE 2

MEDICAL MANAGEMENT OF JUVENILE GLAUCOMA

TAKE HOME MESSAGES

- Prostaglandins are the preferred choice due to
  - Single nighttime dosing regimen leading to better compliance.
  - Minimal ocular or systemic side-effects leading to better adherence.
  - 24-hours day and nighttime control of intraocular pressure ensuring maximum optic nerve protection
- Combination therapy is not recommended as first-line of management. It is difficult to understand which agents are effective or causing side-effects in a combination therapy.
- Target intraocular pressure is the range of acceptable intraocular pressure levels at which eye being treated will be safe.
  - Ocular hypertension/early glaucoma: 20% reduction or keep 18–20 mmHg
  - Normal tension glaucoma 30% reduction
  - Moderate glaucoma 30% reduction or keep 13–15 mmHg
  - Advanced glaucoma 40–50% reduction or keep <12 mmHg

INTRODUCTION

A 34-year-old patient with a history of juvenile glaucoma reported for examination.

EXAMINATION

- Fundus examination (Figs. 1a, b):
  - Right eye (OD): 0.7 vertical CDR and 0.6 horizontal CDR; irregular rim with disc hemorrhage.
  - Left eye (OS): Asymmetric disc; 0.4 CDR
- Intraocular pressure (IOP)
  - OD: 23 mmHg
  - OS: 19 mmHg
- Visual field (VF) examination (Fig. 2)
  - Right eye shows nasal step defect.

MANAGEMENT

- In view of the findings, target IOP was set to be reduced by 25%.
- For medical therapy, the following options are available
  - Brinzolamide
  - Brinzolamide/Timolol combination
  - Prostaglandin
- It is preferable not to start with a combination, as it is difficult to know which drug is working and which is causing the side-effect, if any.
- Hence, either Brinzolamide or prostaglandins alone must be chosen.
- In case of any disease progression, the next step in management could be prostaglandin/Timolol combination.
- Prostaglandin is the preferred choice, due to better compliance, leading to better adherence, and optimal optic nerve protection.

CONCLUSIONS

Prostaglandins must be considered for initial treatment of juvenile glaucoma.

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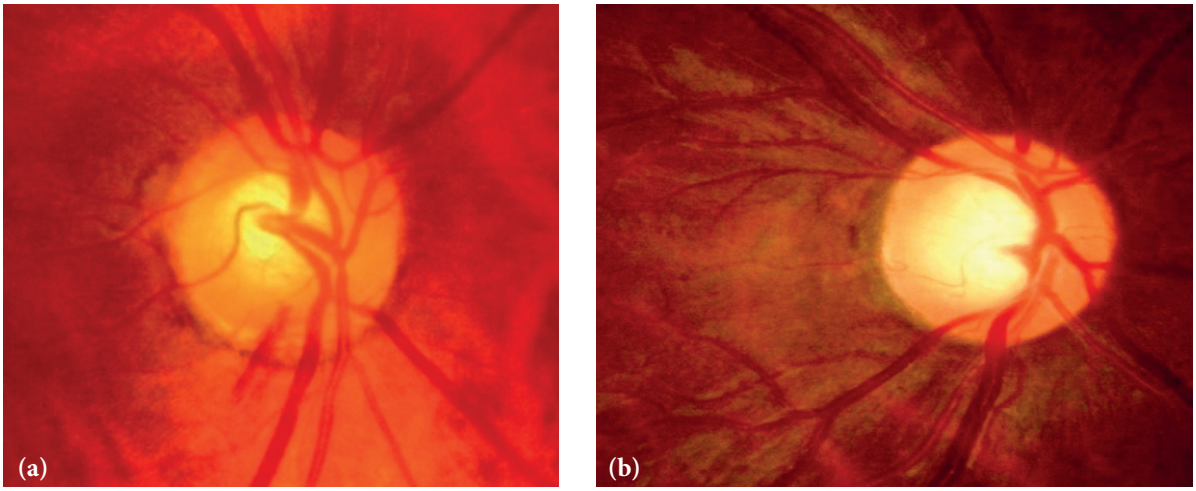

Fig. 1: (**a**) Left eye showing asymmetric disc and cup-to-disc ratio of 0.4. (**b**) Right eye showing irregular rim with disc hemorrhage, 0.7 vertical and 0.6 horizontal cup-to-disc ratio.

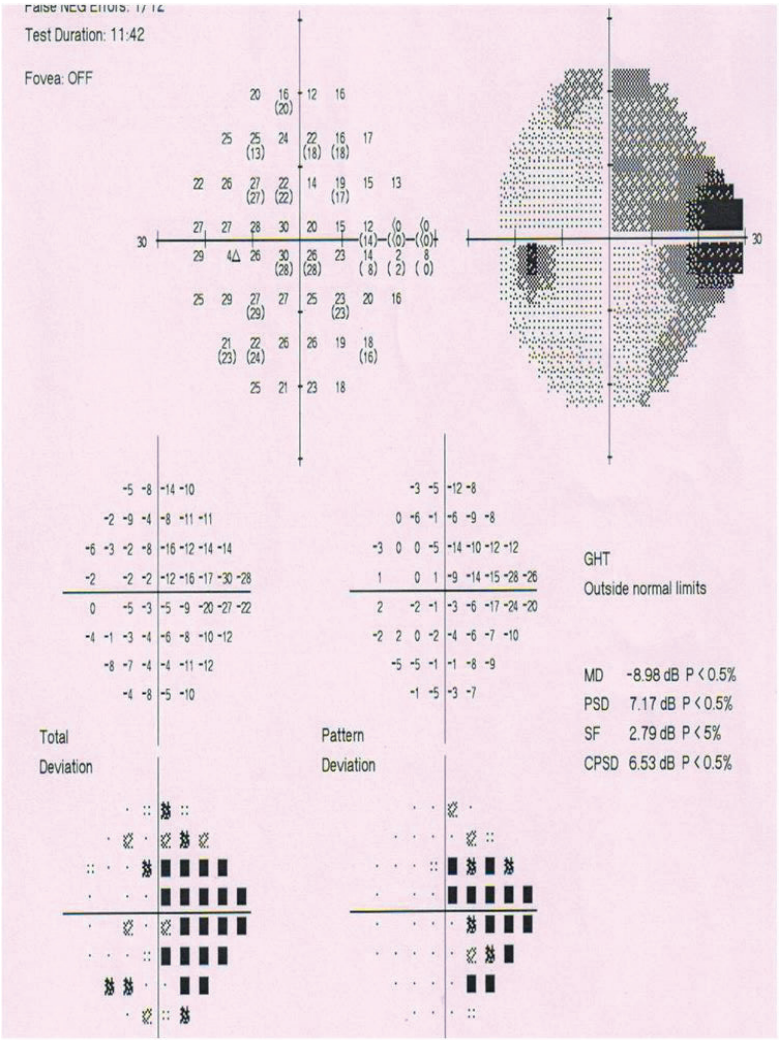

Fig. 2: Nasal step observed in the right eye.

CASE 3

MEDICAL MANAGEMENT OF ADVANCED GLAUCOMA

TAKE HOME MESSAGES

- In case of progression, prostaglandin/Timolol combination along with Brimonidine and Brinzolamide combination must be considered.
- The following are the therapeutic consideration with regard to maximum tolerable therapy
  - Use only 3–4 drugs in maximum of 2 eye drop bottles.
  - Multiple drugs may have ocular side-effects hence patient adherence may reduce.
  - Using more than 2 bottles of eye drops may reduce patient compliance.
- Laser trabeculoplasty or trabeculectomy is recommended in case of insufficient response to medications.
- Advantages of fixed combination are
  - Compliance is better.
  - Reduced overall preservative exposure.
  - Ease of remembering.

INTRODUCTION

A 64-year-old female with history of primary open-angle glaucoma (POAG) reported for routine check-up.

EXAMINATION

- Intraocular pressure (IOP): 34 mmHg in both the eyes.
- Visual field (VF) examination revealed double arcuate scotoma in both the eyes.

MANAGEMENT

- Optic discs show deep cupping in both eyes (Fig. 1).
- The target IOP was decided to be reduced by almost 45% for both eyes.
- Patient was recommended prostaglandin HS and Brimonidine/Timolol combination in both eyes.
- Intraocular pressure reduced to 17–18 mmHg in both eyes after medications.
- Patient was instructed for regular follow-up for continuous monitoring.
- Follow-up included disc examination and field analysis.

CONCLUSIONS

Fixed-dose combinations should be used due to their advantages in advanced glaucoma.

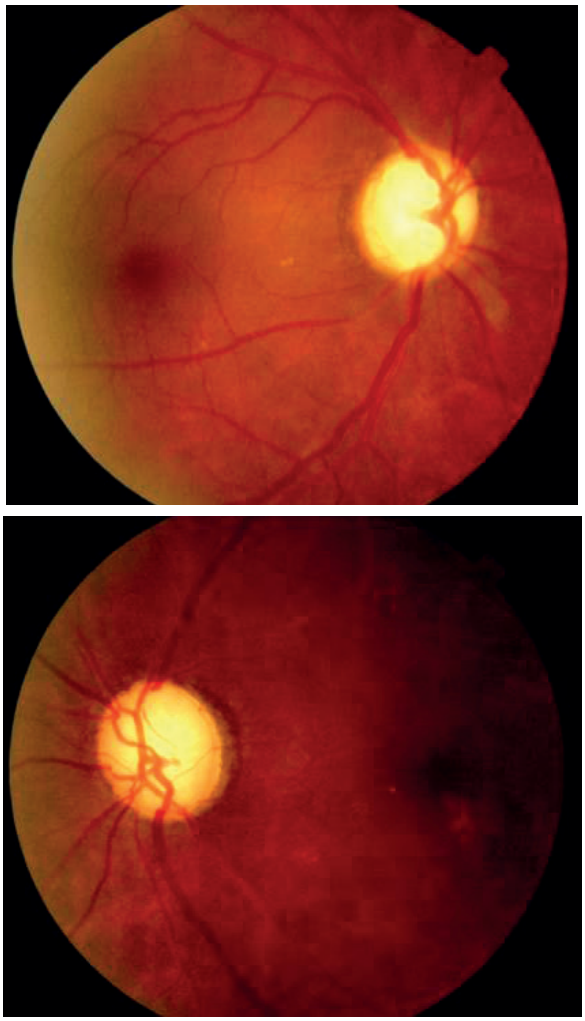

Fig. 1: Deep cup in both eyes, showing cup-to-disc ratio of 0.9.

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Miscellaneous

CASE 1

GLAUCOMA MASQUERADE

TAKE HOME MESSAGES

- During glaucoma examination, non-glaucomatous causes of optic neuropathy must be considered.
- Non-glaucomatous optic neuropathies may be misdiagnosed as glaucoma, thus, delaying the actual diagnosis, missing underlying systemic illness, or initiation of inappropriate treatment.

INTRODUCTION

A 53-year-old patient reported with redness and watering in both the eyes since past few days. The patient's past medical history was positive for normal tension glaucoma (NTG). His current medications included Brimonidine, Dorzolamide, and Bimatoprost. He was advised bilateral trabeculectomy.

EXAMINATION

- Visual acuity (VA) test
  - Right eye (OD): 6/6
  - Left eye (OS): 6/9
- Intraocular pressure (IOP) (Goldmann applanation tonometry [GAT])
  - OD: 16 mmHg
  - OS: 17 mmHg
- Gonioscopy showed open angles in both the eyes
- Torch examination
  - OD: normal
  - OS: pupil was sluggish and ill-sustained
- Slit-lamp examination: Grade 2 meibomian gland dysfunction
- Both lenses were clear
- Fundus examination (Figs. 1a, b)
  - OD: Cup-to-disc ratio (CDR) 0.7; inferior rim more than the superior rim and temporal pallor of disc were observed.
  - OS: CDR 0.5 healthy neuroretinal rim (NRR) and temporal pallor of disc.
- Review of old perimetry reports (Figs. 2a–d) revealed bitemporal hemianopia.
- Central corneal thickness (CCT) (pachymetry)
  - OD: 535 µm
  - OS: 530 µm
- Humphrey visual field (HVF) analysis (24-2): bitemporal hemianopia in both the eyes

MANAGEMENT

- All anti-glaucoma medications were stopped. Patient was advised warm compress with eyelid massage. He was advised tear substitutes for symptomatic relief, and neurosurgeon's opinion was recommended. Neurosurgeon further advised magnetic resonance imaging, which showed pituitary adenoma (Figs. 3a, b).
- Hence, neurosurgical procedure for the excision of adenoma was performed. The recovery was uneventful. Patient was advised to follow-up 3 months after the surgery. Postoperative GAT revealed IOP of 14 mmHg and 16 mmHg in the right and left eye, respectively. VA score was 6/6 in right eye and 6/9 in left eye, vision was stable and color vision was normal. Patient was recommended repeat HVF. At 6 months follow-up visit, his IOP was remarkably raised; right eye 26 mmHg and left eye 28 mmHg. Patient's medication history was significant for oral corticosteroid for hormonal replacement. Steroid-induced glaucoma was suspected.

CONCLUSIONS

Non-glaucomatous optic neuropathies may be misdiagnosed as glaucoma. Hence, caution is advised.

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Content supported by Dr. Alokesh Ganguly, Ophthalmologist, Priyamvada Birla Aravind Eye Hospital, Kolkata

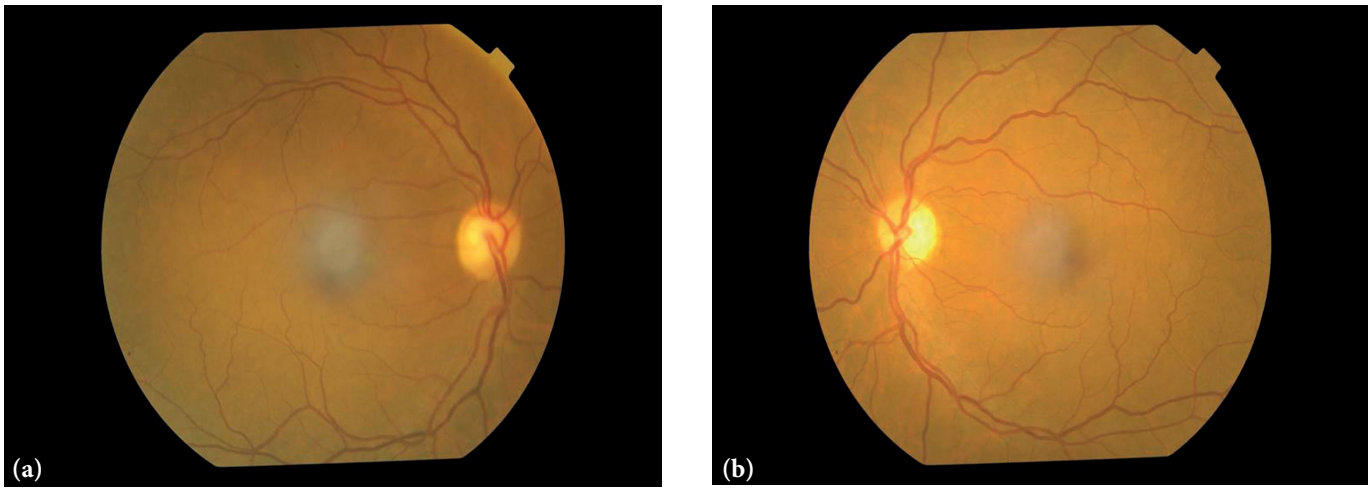
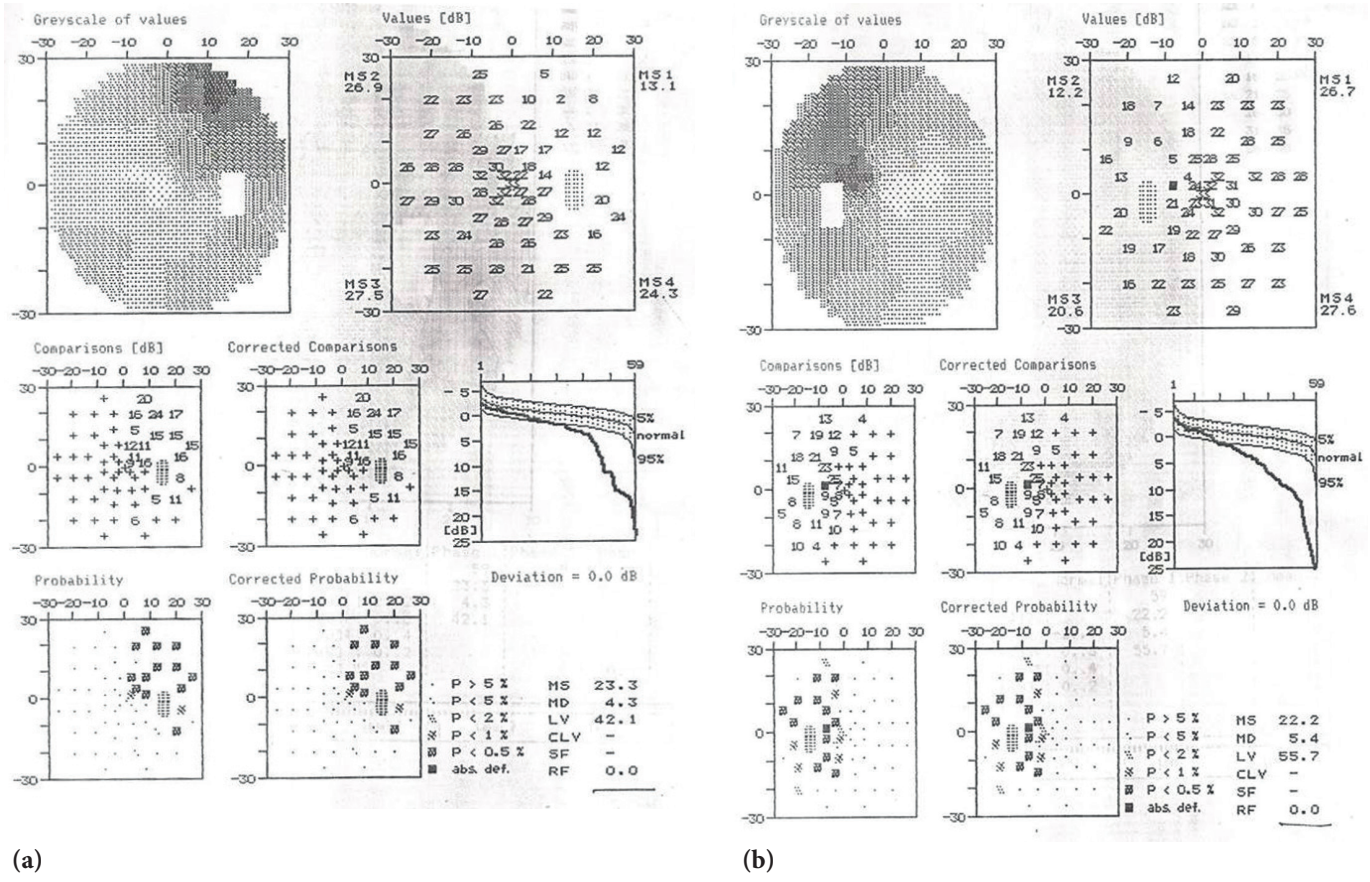


Fig. 1: (a) Fundoscopy right eye showing cup-to-disc ratio 0.7:1; inferior rim > superior rim and temporal disc pallor. (b) Fundoscopy left eye showing cup-to-disc ratio 0.5:1, healthy neuroretinal rim and temporal disc pallor.



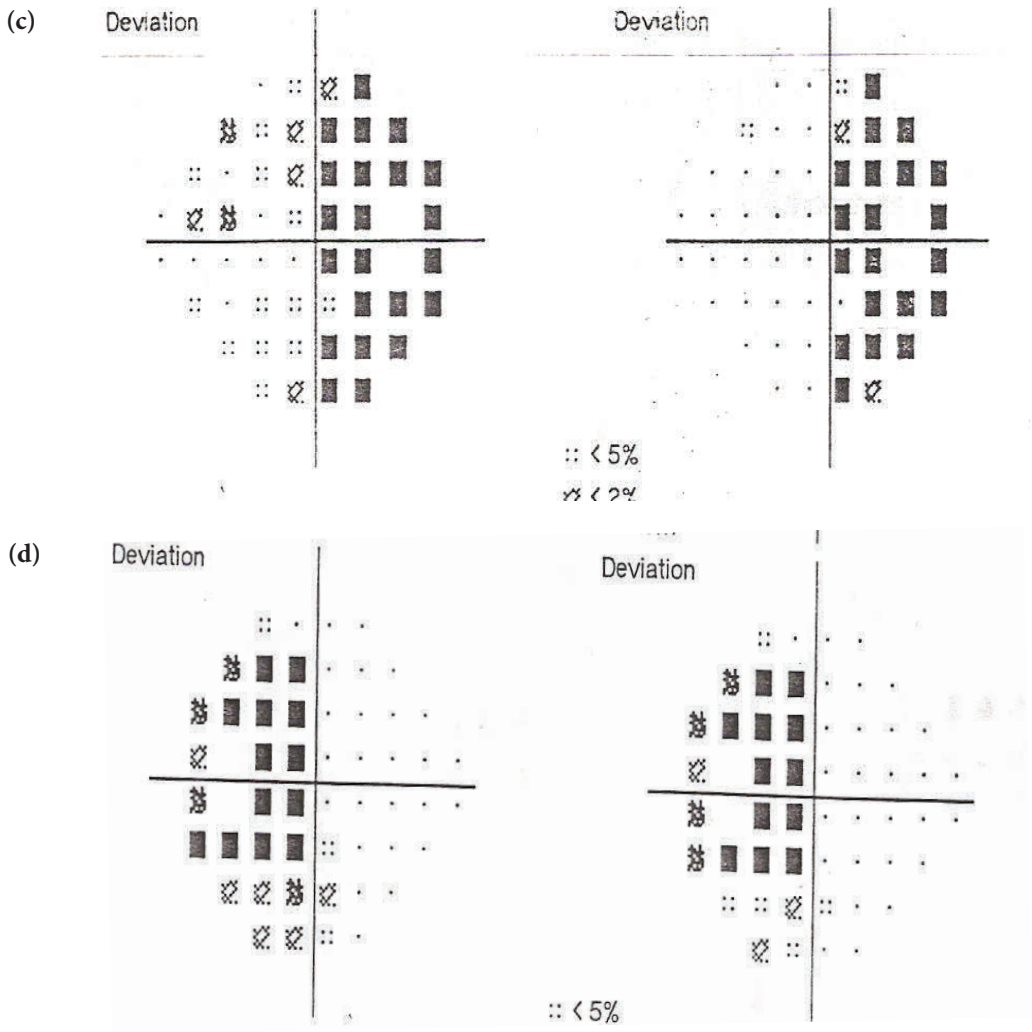


Fig. 2: (**a, b**) Review of old perimetry reports showing bitemporal hemianopia. (**c, d**) Visual fields showing bitemporal hemianopia.

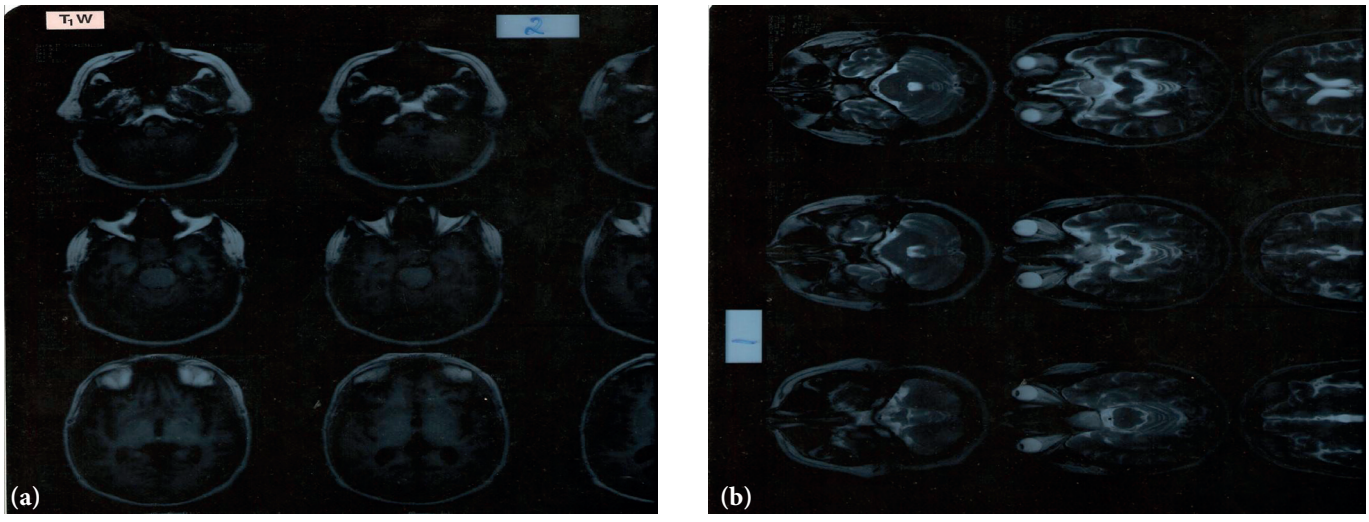


Fig. 3(a, b): Pituitary adenoma on magnetic resonance imaging.

CASE 2

PSEUDO RETINAL NERVE FIBER LAYER DEFECT

TAKE HOME MESSAGES

- Suspect retinal nerve fiber layer defect in patients with family history, high myopes, mild myopes, hyperopes, and patients with ocular hypertension.
- In high myopes, optical coherence tomography normative database does not include refractive values above -6 DSph hence, erroneous values are possible.
- Literature search shows that in high myopes the internal surface area of the globe is much more, that the normal density of axons cannot fully cover and thereby give rise to these pseudo retinal nerve fiber layer defects.

INTRODUCTION

A 33-year-old male ophthalmologist reported for clinical examination. The patient is a high myope and his father had primary open-angle glaucoma (POAG), hence, he requested for indirect ophthalmoscopy.

EXAMINATION

- Best corrected visual acuity (BCVA)
  - Right eye (OD): 6/6 with -12.0 DS/-1.00 cylinder at 1600
  - Left eye (OS): 6/6 with -10.0 DS
- Intraocular pressure (IOP) (applanation tonometry)
  - OD: 20 mmHg
  - OS: 18 mmHg
- Central corneal thickness (CCT)
  - OD: 590 µm
  - OS: 594 µm

Table 1: Day diurnal intraocular pressure variation.

	Right eye	Left eye
Maximum	21 mmHg	20 mmHg
Minimum	16 mmHg	16 mmHg

- Slit-lamp examination
  - Nothing abnormal detected
- Gonioscopy showed open angles
- Automated perimetry
  - Humphrey visual field (HVF) 24-2: Normal
  - Short wavelength automated perimetry (SWAP): Normal
- Day diurnal IOP variation (Table 1)
- Optical coherence tomography (OCT) (Figs. 2a, b)

DIAGNOSIS

Pseudo retinal nerve fiber layer (RNFL) defect

MANAGEMENT

Patient was advised follow-up every 6 months for continuous monitoring. Serial fundus examination was done. Change analysis through regular serial visual field examination and OCT was suggested.

CONCLUSIONS

Continuous monitoring and follow-up are suggested in pseudo RNFL defect.

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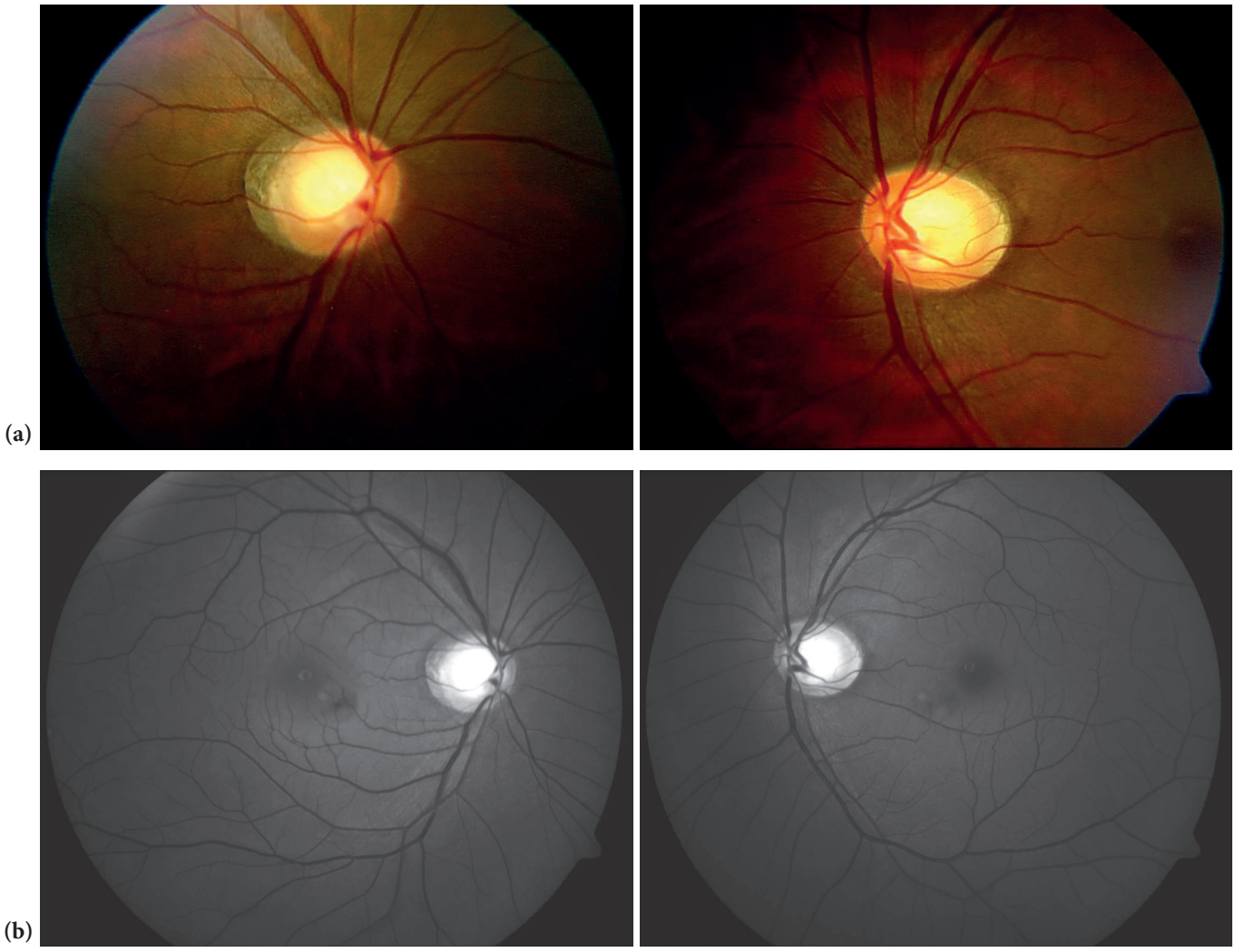
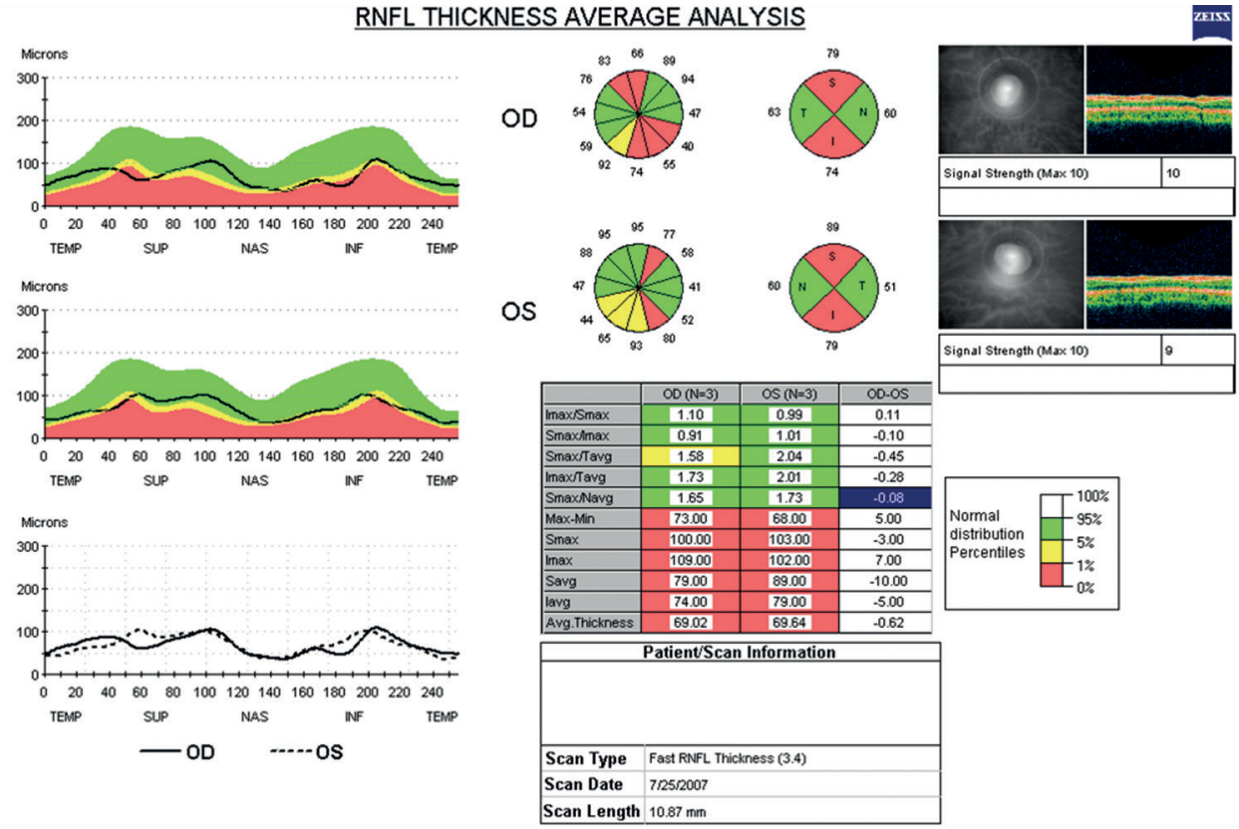


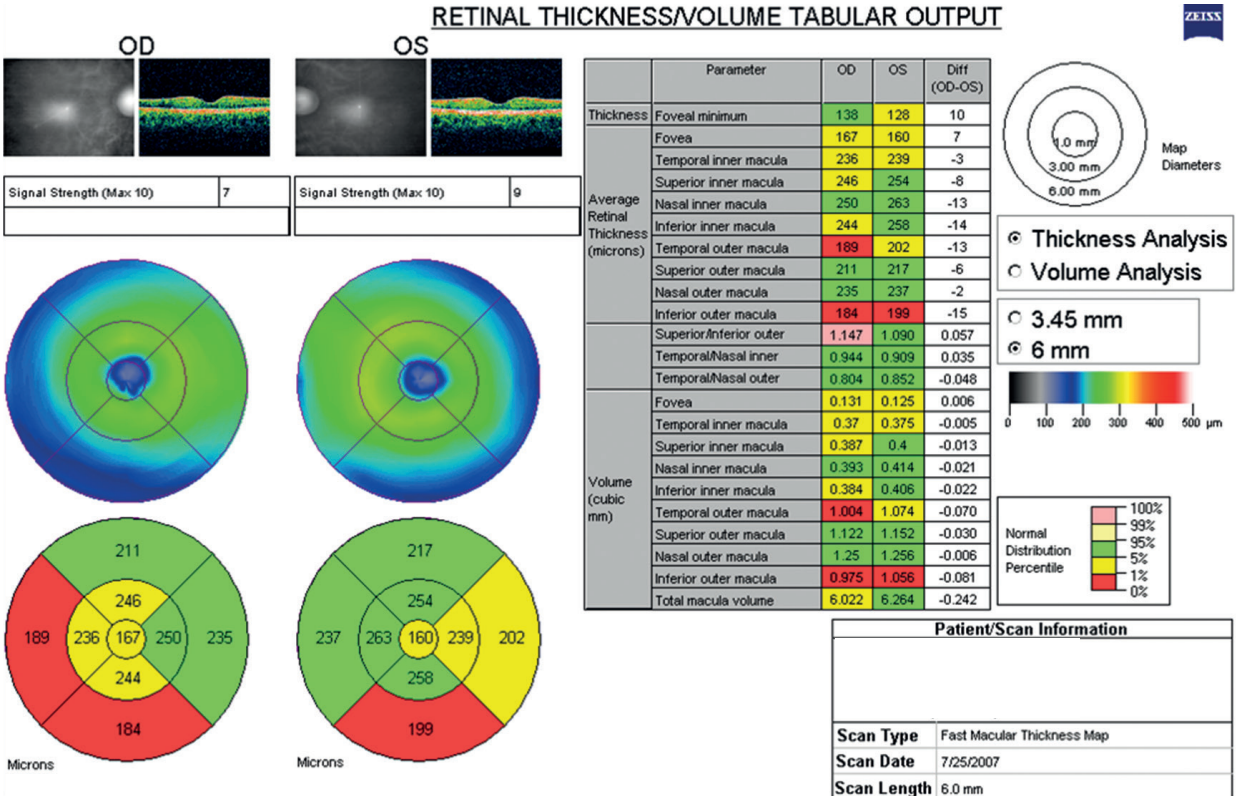
Fig. 1: (**a**) Fundus in both eyes showing uniform neuroretinal rim, cup-to-disc ratio 0.7 and braid-like retinal nerve fiber layer defects seen along major blood vessels, mainly superior temporal, more prominent in the right eye. (**b**) Prominent retinal nerve fiber layer defect seen with red-free photography.

(a)



	OD (N=3)	OS (N=3)	OD-OS
Imax/Smax	1.10	0.99	0.11
Smax/Imax	0.91	1.01	-0.10
Smax/Tavg	1.58	2.04	-0.45
Imax/Tavg	1.73	2.01	-0.28
Smax/Navg	1.65	1.73	-0.08
Max-Min	73.00	68.00	5.00
Smax	100.00	103.00	-3.00
Imax	109.00	102.00	7.00
Savg	79.00	89.00	-10.00
Iavg	74.00	79.00	-5.00
Avg.Thickness	69.02	69.64	-0.62

(b)



	Parameter	OD	OS	Diff (OD-OS)
Thickness	Foveal minimum	138	128	10
Average Retinal Thickness (microns)	Fovea	167	160	7
	Temporal inner macula	236	239	-3
	Superior inner macula	246	254	-8
	Nasal inner macula	250	263	-13
	Inferior inner macula	244	258	-14
	Temporal outer macula	189	202	-13
	Superior outer macula	211	217	-6
	Nasal outer macula	235	237	-2
	Inferior outer macula	184	199	-15
	Superior/Inferior outer	1.147	1.090	0.057
	Temporal/Nasal inner	0.944	0.909	0.035
	Temporal/Nasal outer	0.804	0.852	-0.048
Volume (cubic mm)	Fovea	0.131	0.125	0.006
	Temporal inner macula	0.37	0.375	-0.005
	Superior inner macula	0.387	0.4	-0.013
	Nasal inner macula	0.393	0.414	-0.021
	Inferior inner macula	0.384	0.406	-0.022
	Temporal outer macula	1.004	1.074	-0.070
	Superior outer macula	1.122	1.152	-0.030
	Nasal outer macula	1.25	1.256	-0.006
	Inferior outer macula	0.975	1.056	-0.081
	Total macula volume	6.022	6.264	-0.242

Fig. 2(a, b): Generalized thinning of retinal nerve fiber layer of both the eyes.

CASE 3

BILATERAL ACUTE ANGLE-CLOSURE

TAKE HOME MESSAGES

- Bilateral acute angle-closure in a young patient is a red flag.
- Gross myopic shift should be a cause of suspicion.
- A proper medication history must be obtained.
- Ultrasound biomicroscopy is confirmatory.

INTRODUCTION

A 23-year-old female, presented with sudden blurring of vision, redness, and photophobia in both eyes since past one day. There was no family history of glaucoma, but she had migraine attacks on and off for the last three years.

EXAMINATION

- Unaided visual acuity (VA) test: 3/36; N6 improved to 6/9 with glasses
- Previously emmetropic with VA of 6/6, N6 (BE)
- Refraction: Myopic shift
  - Right eye (OD): -4.00DS/-1.50 cylinder at 100°
  - Left eye (OS): -3.50DS/-0.50 cylinder at 120°
- Slit-lamp biomicroscopy showed circumciliary congestion with uniformly shallow anterior chamber (AC). Iris and lens were normal (Fig. 1)
- Intraocular pressure (IOP)
  - OD: 55 mmHg
  - OS: 44 mmHg
- Gonioscopy showed closed angles 360° (Fig. 2)
- Ultrasound biomicroscopy (UBM) showed shallow AC and supraciliary effusion (Fig. 3)

MANAGEMENT

On specifically asking, the patient revealed that she was on topiramate treatment since 3 weeks. Considering this to be the cause of glaucoma, she was treated with the following protocol:

- Intravenous mannitol
- Anti-glaucoma medications
- Topical steroids/cycloplegic
- Discontinue the causative drug

The patient responded well to the treatment and was well-controlled (Figs. 4, 5).

CONCLUSIONS

A proper medication history is mandatory to confirm the cause of glaucoma.

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Fig. 1: Slit-lamp biomicroscopy showing circumciliary congestion and shallow anterior chamber.

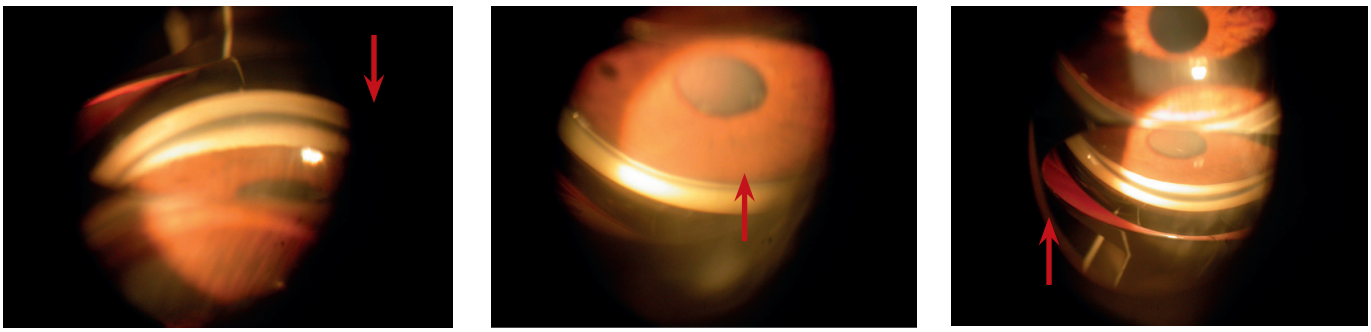

Fig. 2: Gonioscopy shows 360° closed angles.

Shallow anterior chamber

Supraciliary effusion

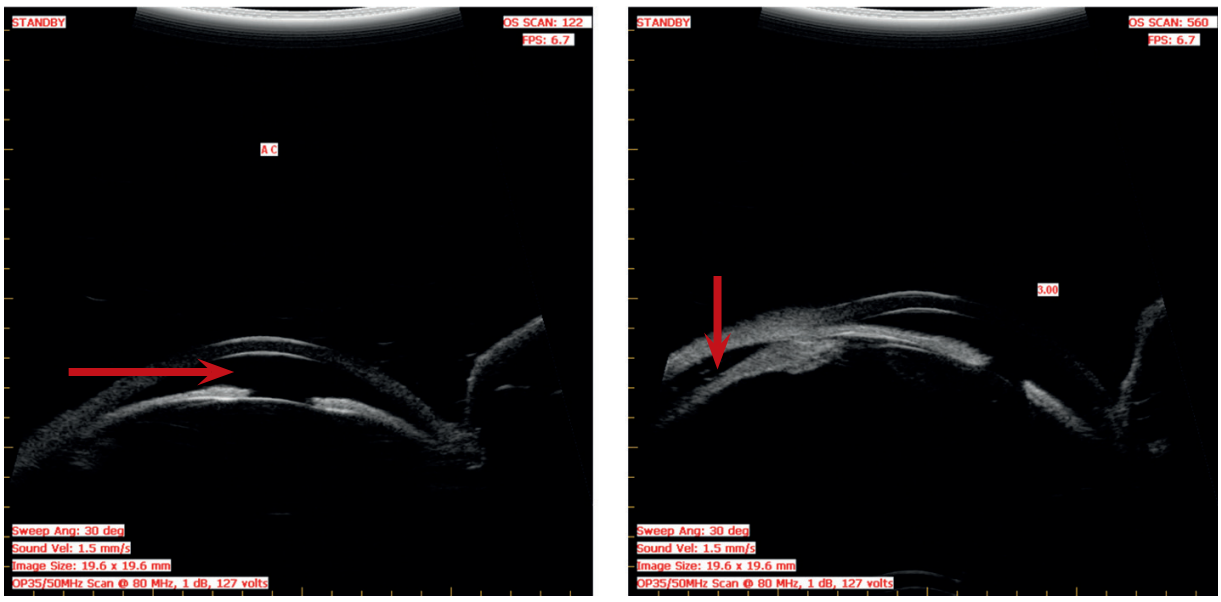

Fig. 3: Ultrasound biomicroscopy.

Deepened anterior chamber

Widened angle

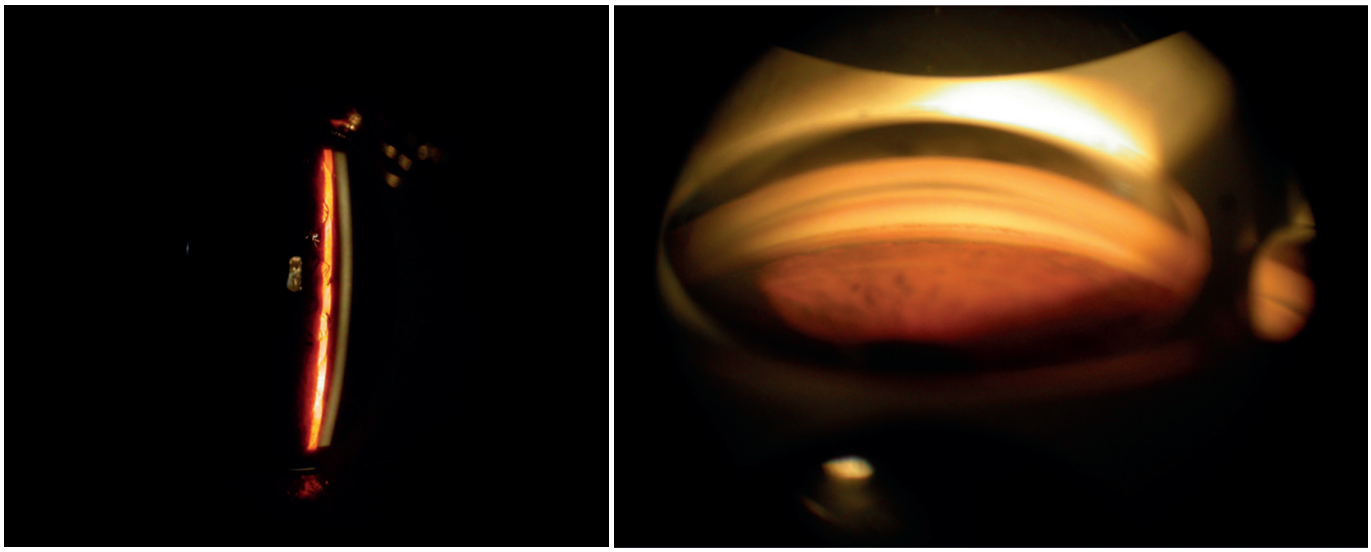

Fig. 4: Response to treatment.

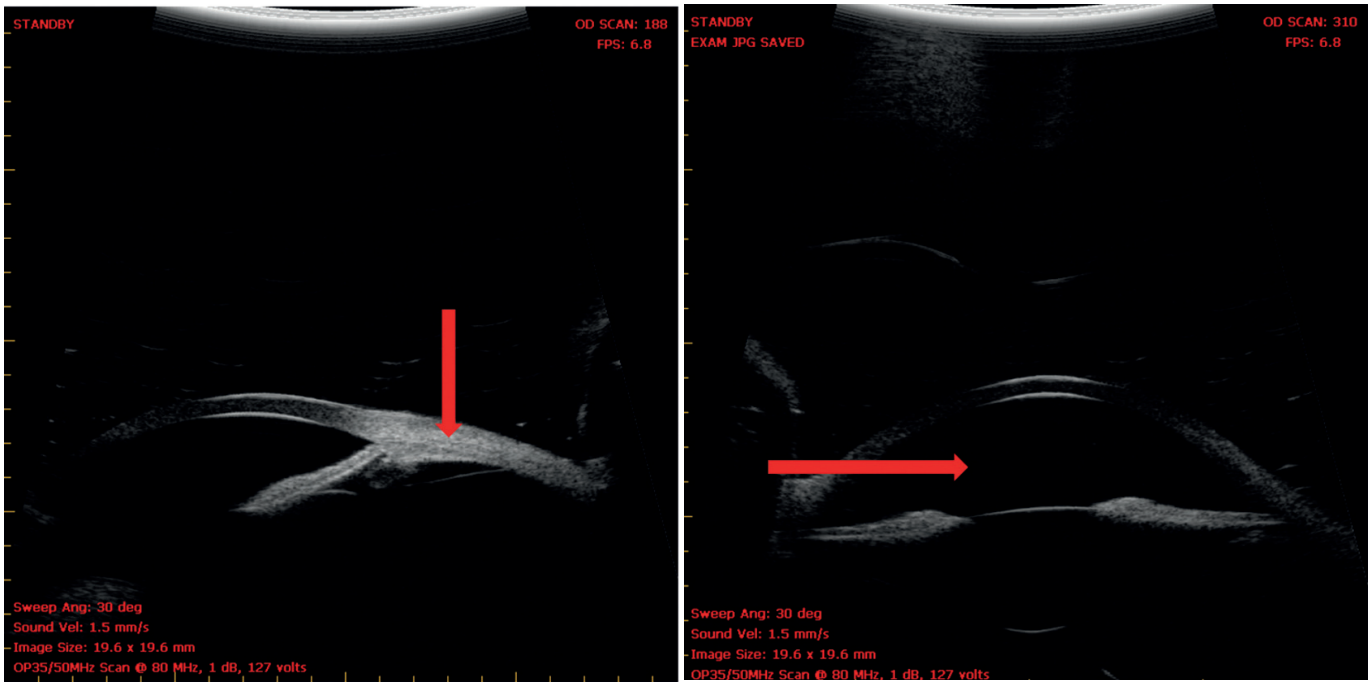

Fig. 5: Post treatment ultrasound biomicroscopy.

CASE 4

ATYPICAL PROGRESSION OF GLAUCOMA

TAKE HOME MESSAGES

- Any atypical presentation with well-controlled intraocular pressure needs to be seen with caution.
- Neuroimaging must be considered in case of any progression not correlating with disc findings.

INTRODUCTION

A patient with hypertension and primary open-angle glaucoma (POAG) reported for consultation in 2012.

EXAMINATION

- Vision acuity (VA) test
  - Right eye (OD): 6/18 N8
  - Left eye (OS): No perception of light (PL); lost after fungal endophthalmitis post cataract surgery
- There was nuclear sclerosis (NS II) + posterior subcapsular cataract (PSC) seen in the right eye, while left eye was phthisical.
- Intraocular pressure (IOP) by applanation tonometry (AT)
  - OD: 12 mmHg (Baseline IOP OD: 25 mmHg) (using Timolol and Brimonidine combination once daily)
  - OS: Soft
- Fields showing superior defect (Fig. 1)
- Gonioscopy showed open angles
- Pachymetry reading was 550 μm
- Disc showed mild inferior thinning (Fig. 2)

MANAGEMENT

Cataract surgery was performed. It was uneventful and postoperative vision in right eye was 6/6, N6. IOP by AT was 14 mmHg (Timolol and Brimonidine). He was lost to follow-up and presented again in February 2013. On examination, vision OD was 6/6 N6; and IOP by AT was 11 mmHg; fields were not evaluated.

At the next check-up in June 2013, he complained of decreased vision in his right eye. On examination, vision OD was 6/9 N6; and IOP by AT was 10 mmHg (Latanoprost).

Patient had progression of symptoms despite having normal IOP (Fig 3); hence, further evaluation was done:

- Office diurnal IOP: 9–12 mmHg
- Cardiac evaluation: Normal
- Carotid Doppler (Fig 4): Calcified plaque was noted in internal carotid artery along with flow obstruction but as per the cardiologist that was not clinically significant.
- Blood lipid profile: Normal
- Blood sugar levels: Borderline diabetes and, hence, a diabetologist's opinion was taken
- Blood pressure monitoring: Normal

In the scenario of atypical worsening of symptoms and field progression, neuroimaging was suggested and magnetic resonance imaging showed suprasellar mass with optic nerve and optic chiasma compression (granuloma) (Fig. 5). He was then referred to a neurologist, who performed cerebrospinal fluid analysis, considering a tuberculous cause or a fungal etiology. Tests turned out negative for tuberculosis and a final diagnosis of fungal granuloma was made.

CONCLUSIONS

In a patient showing atypical progression on well-controlled IOP which is not correlating with disc findings, neuroimaging must be considered.

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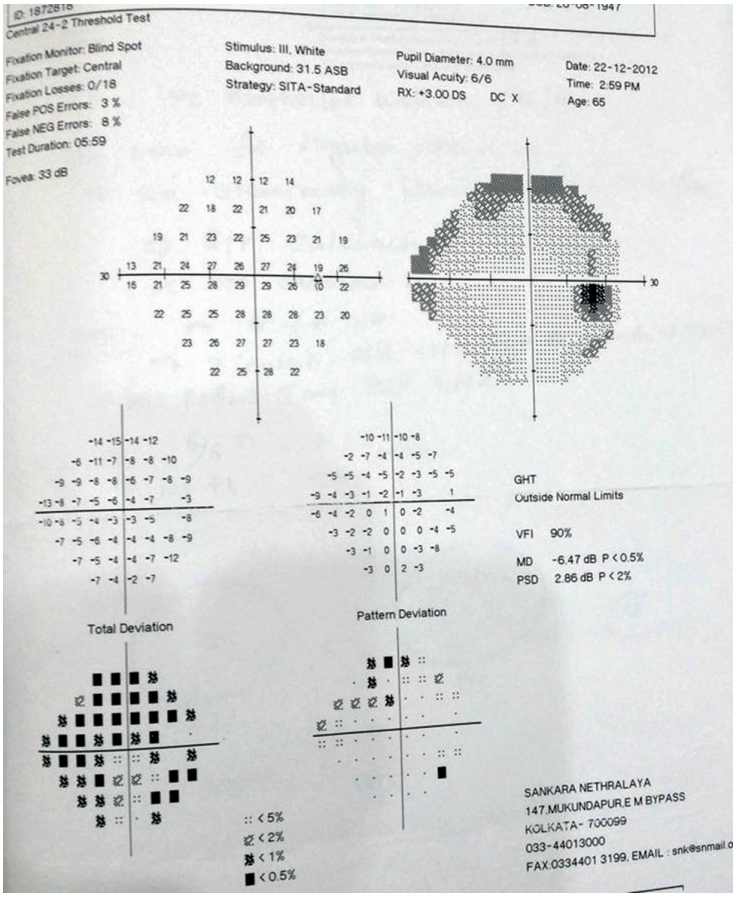


Fig. 1: Fields showing superior defect.

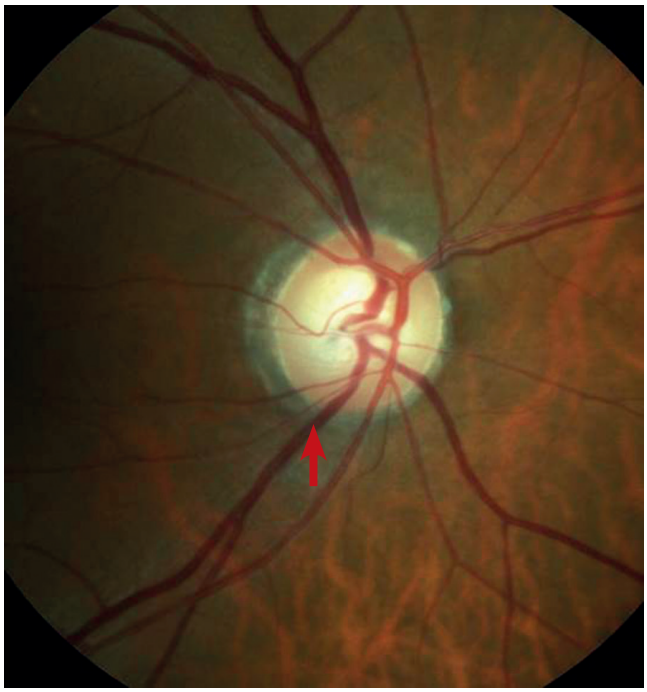
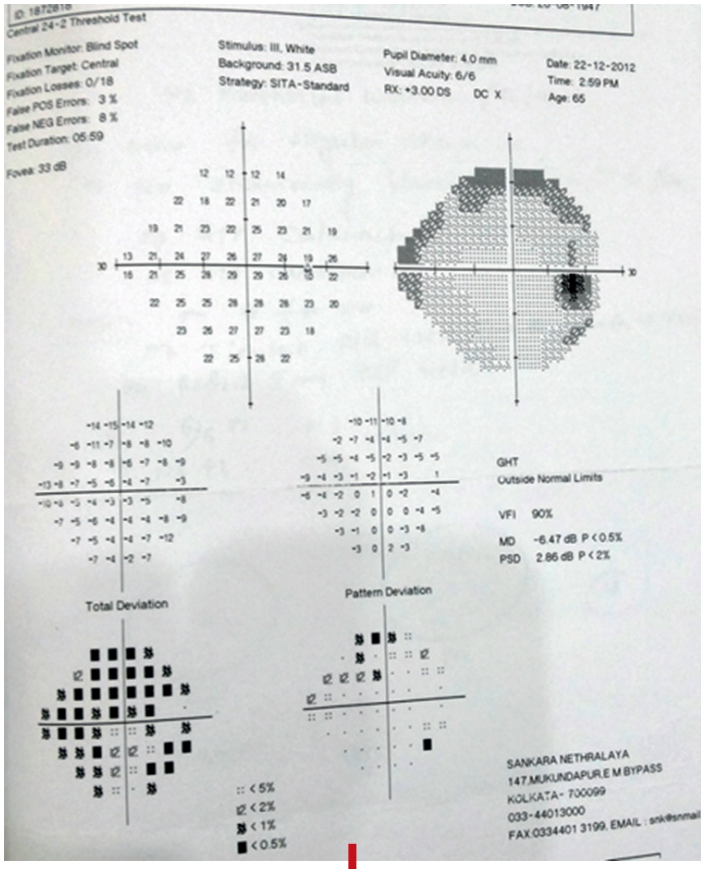


Fig. 2: Optic disc showing mild inferior rim thinning with minimal pallor.

December 2012



June 2013

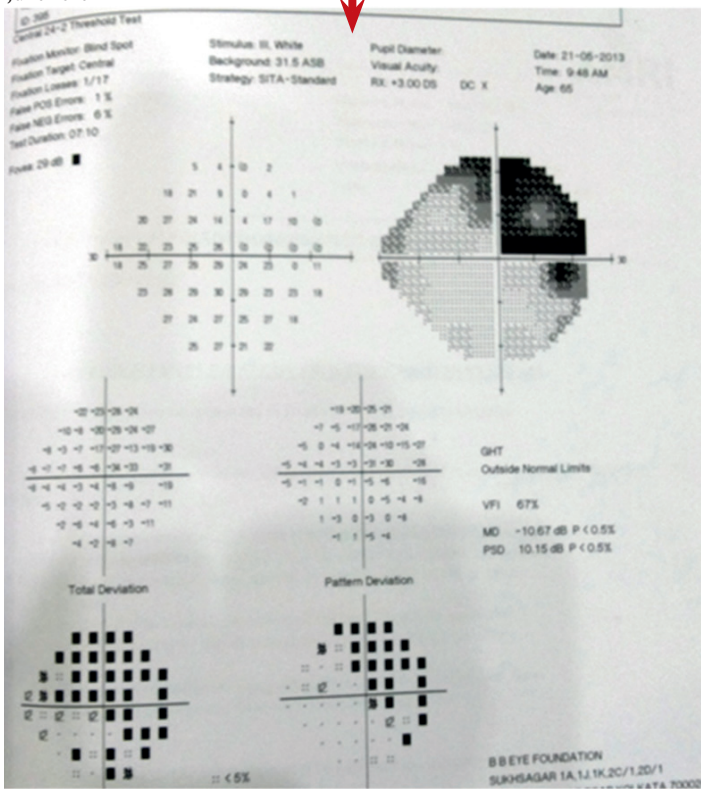


Fig. 3: Visual fields showing significant progression.

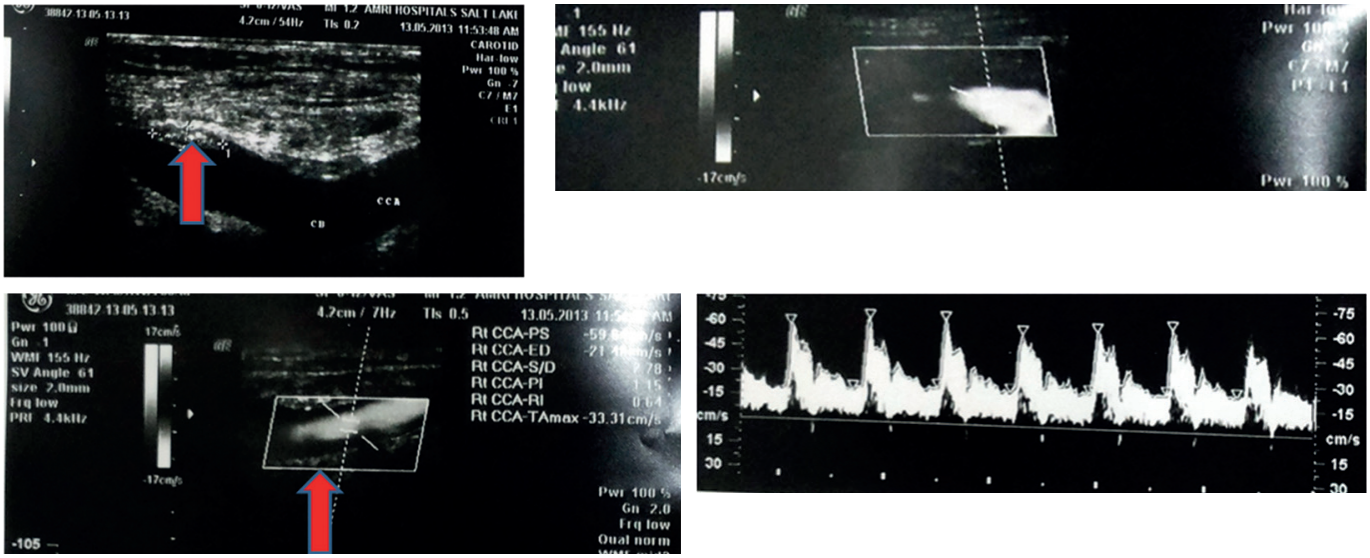


Fig. 4: Carotid Doppler showing calcified plaque and flow obstruction.

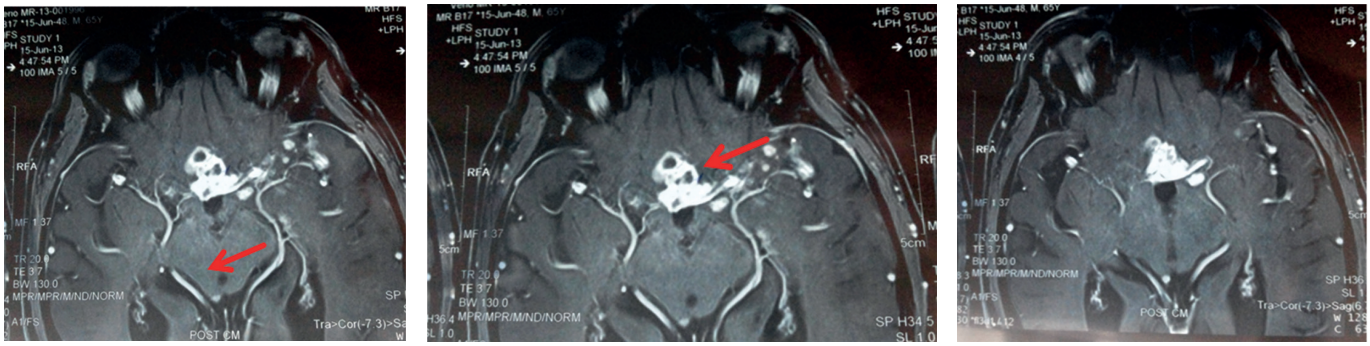


Fig. 5: Magnetic resonance imaging showing suprasellar mass with optic nerve and optic chiasma compression.

CASE 5

SHALLOW ANTERIOR CHAMBER POST TRABECULECTOMY

TAKE HOME MESSAGES

- Detailed history is important to prevent misdiagnosis.
- Causes of raised intraocular pressure include angle invasion of the tumor, seedling of the angle, associated choroidal detachment or hemorrhage, angle compression, and neovascularization of the angle.
- Ocular metastasis
  - Rare and spreads through hematogenous route.
  - Choroidal metastasis is most common often associated with subretinal fibrosis and retinal detachment.
  - Ultrasonography B-scan is useful for the diagnosis.
  - Primary sources are breast (most common), lung, and gastrointestinal tract, respectively.
  - Treatment is usually radiotherapy and chemotherapy.

INTRODUCTION

A 64-year-old female presented with sudden vision loss, severe redness, and pain in the right eye (Fig. 1). She had hypertension and diabetes. She underwent phacotrabeculectomy in the right eye 6 months ago. As per her previous records from 2 months ago, her vision was 6/9, N6 (both eyes) and intraocular pressure (IOP) was 18 mmHg. She also underwent yttrium-aluminum-garnet (YAG) peripheral iridotomy 2 years ago in her left eye due to primary angle-closure.

EXAMINATION

- Slit-lamp examination (Figs. 2a, b)
  - Right eye was pseudophakic with shallow anterior chamber (AC) (axial shallowing) and Grade 3 cells.
- Intraocular pressure (IOP)
  - Right eye (OD): 48 mmHg
  - Left eye (OS): 16 mmHg
- Gonioscopy
  - OD: Closed angles
  - OS: Open angles (post laser peripheral iridotomy)
- Fundus examination (Figs. 3a, b): Vitreous hemorrhage in the right eye and healthy disc of left eye.
- Ultrasonography (USG) B-scan (Figs. 4a, b): Lesion in vitreous in the right eye.
- Other relevant finding: detailed systemic history was also obtained, which revealed that patient was taking homeopathic medication for breast lump and nipple discharge since past 3 months. This was not revealed by the patient initially. Taking into account this aspect of history, patient was advised breast computed tomography (Fig. 5) and whole body scintigraphy (Fig. 6).

DIAGNOSIS

Ocular metastasis from breast cancer resulting in vitreous hemorrhage, shallow chamber, and secondary IOP increase.

MANAGEMENT

She was advised:

- Topical steroids and atropine eye drops for control of pain and inflammation
- Oral analgesics
- Anti-glaucoma medication for IOP control
- Consultation with oncologist/oculoplasty surgeon for radiotherapy

CONCLUSIONS

The patient had ocular metastasis as underlying cause for ophthalmologic condition. Therefore, ocular metastasis should be considered as differential diagnosis for a patient presenting with shallow AC and high pressure.

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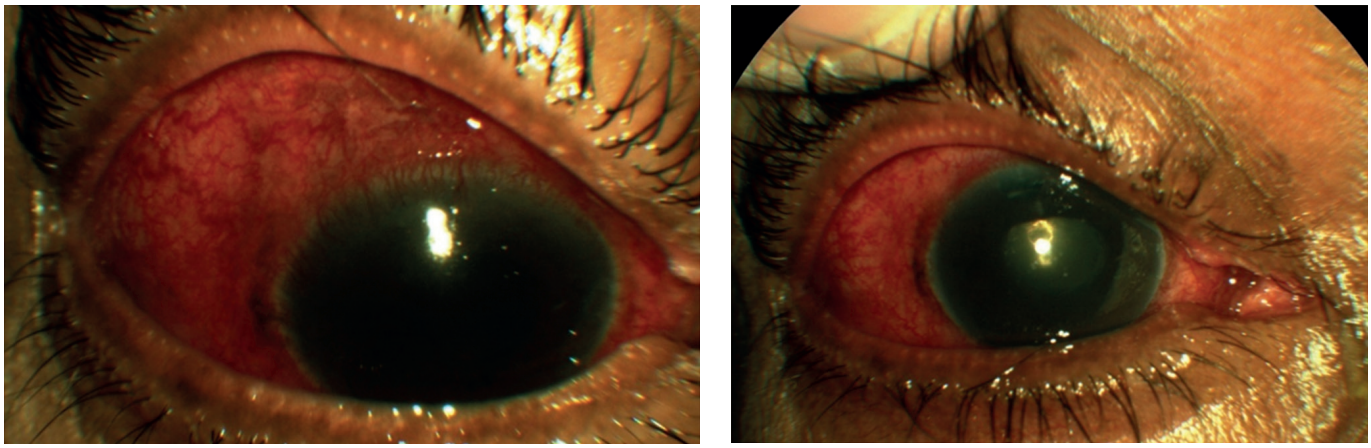

Fig. 1: Right eye showing redness and trabeculectomy bleb.

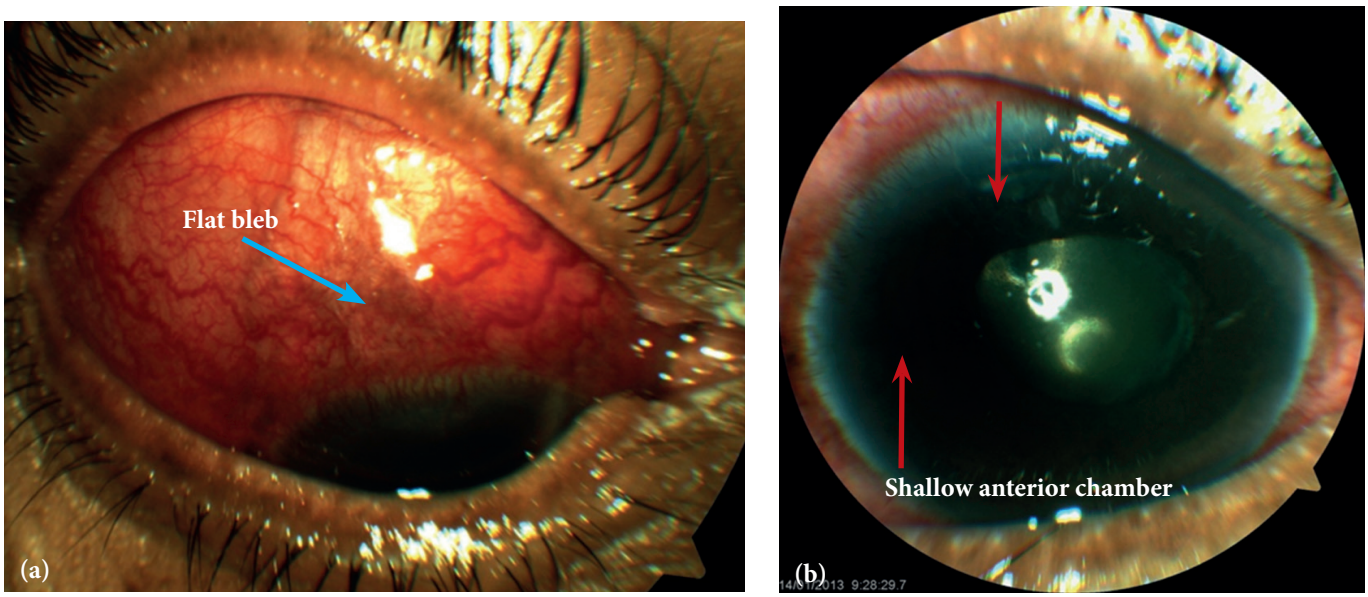

Fig. 2: (**a**) Pseudophakic right eye with congestion and flat bleb. (**b**) Pseudophakic right eye with shallow anterior chamber (axial shallowing) and Grade 3 cells.

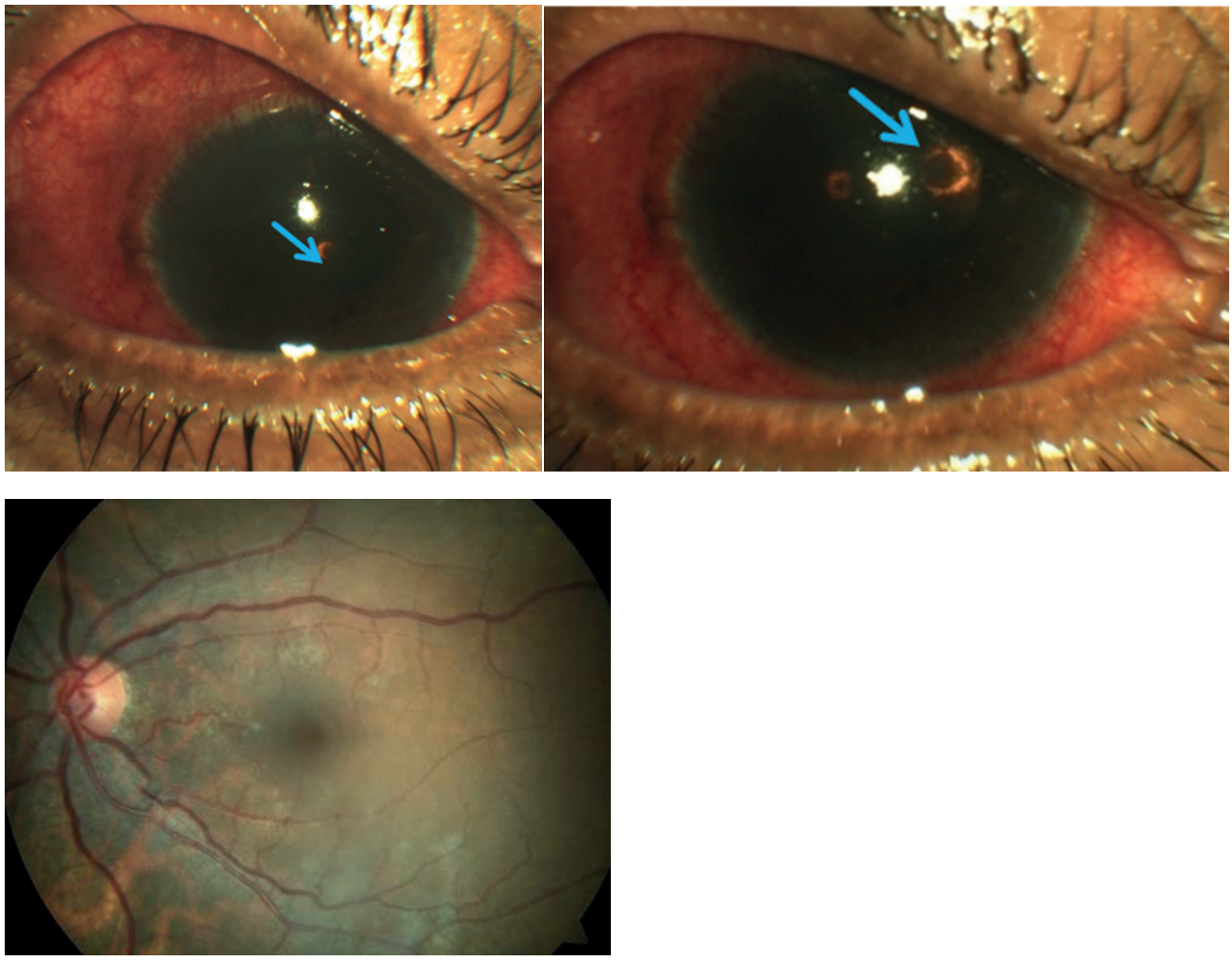

Fig. 3: (a) Right eye showing red fundal glow. (b) Left eye showing healthy optic disc.

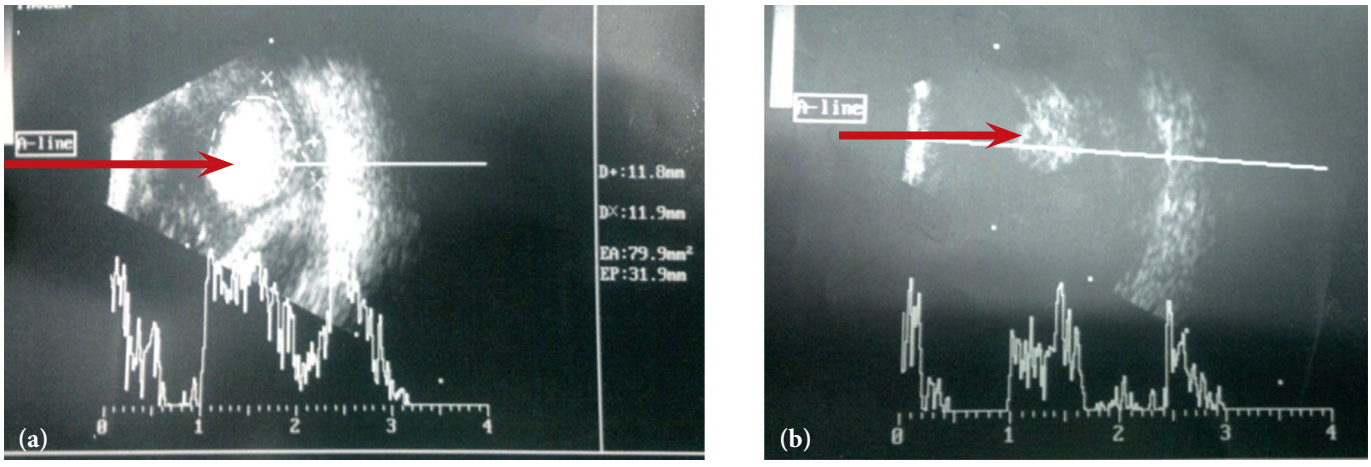

Fig. 4(a, b): Right eye USG B-scan shows mass lesion in vitreous.

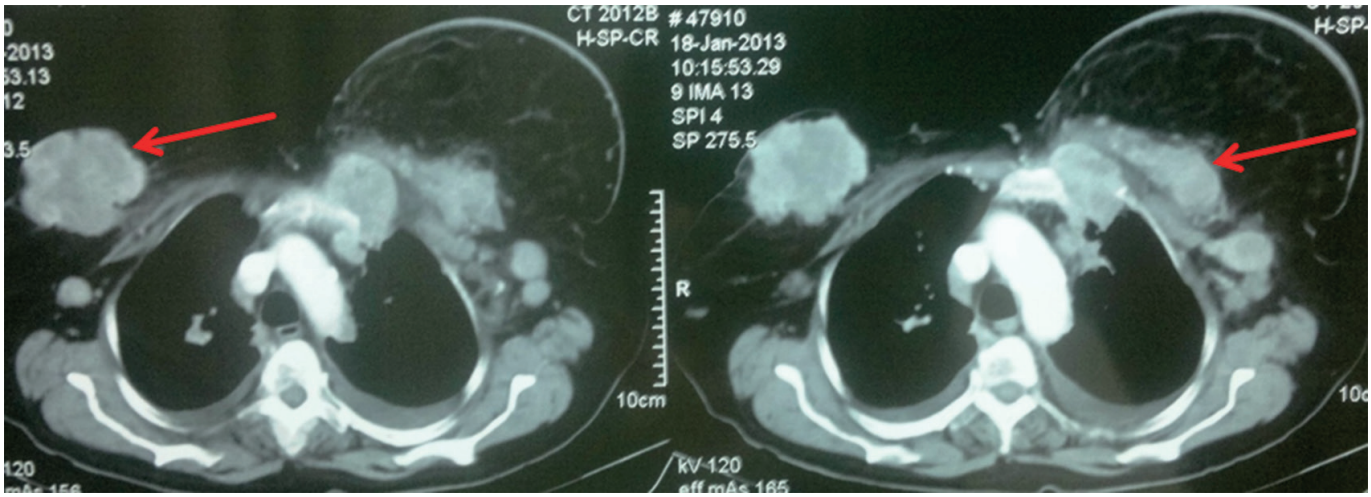

Fig. 5: Computed tomography scan showing calcified mass in breast.

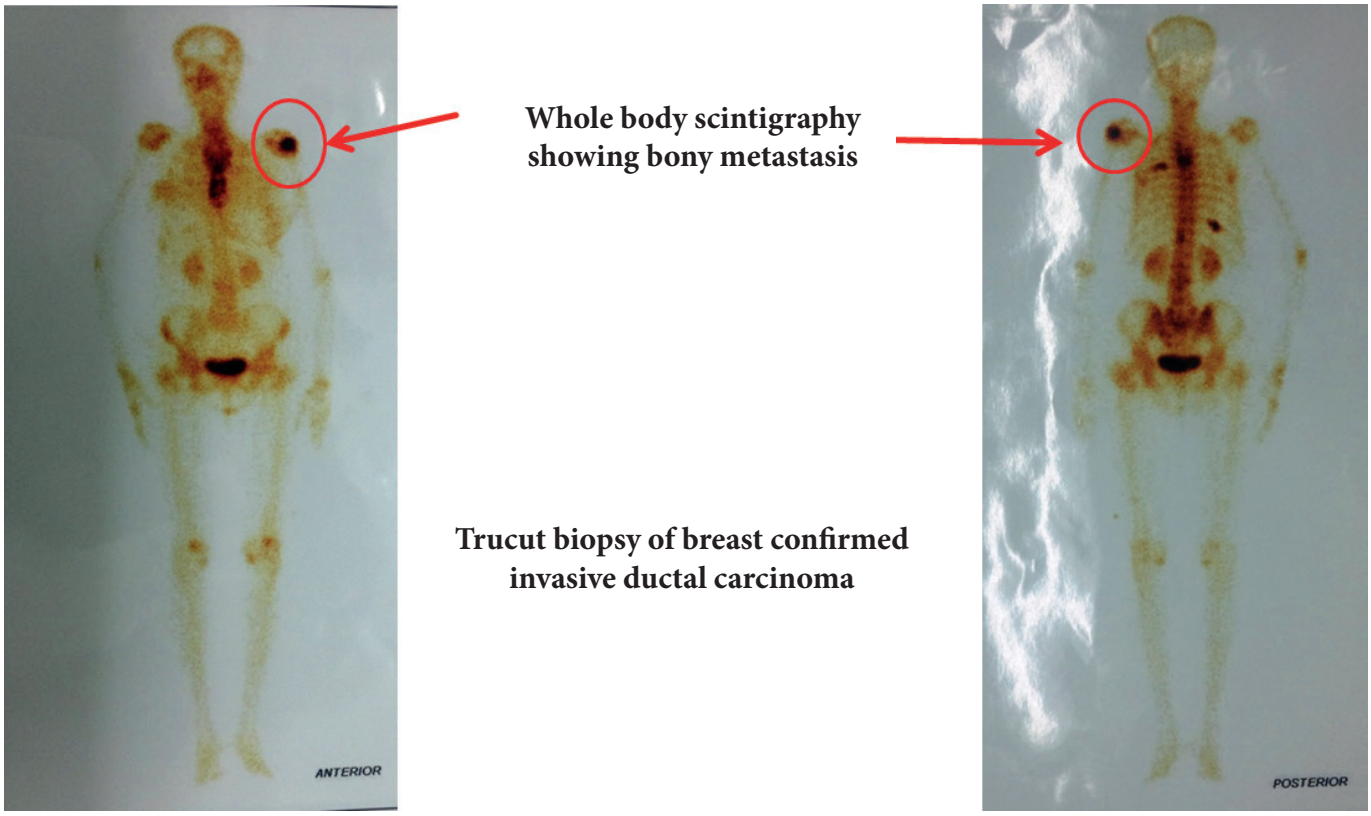

Fig. 6: Whole body scintigraphy showing metastasis.

CASE 6

PHYSIOLOGICAL CUPPING

TAKE HOME MESSAGES

- Most patients have learning phase in perimetry.
- It is pronounced between first and second visual field examinations.
- Field defects should correlate clinically and should be reproducible.
- Whenever there is doubt repeat the field examination; bizarre field defects and unreliable fields should be discarded.

INTRODUCTION

A 66-year-old male suspected with glaucoma reported for second opinion.

EXAMINATION

- Intraocular pressure (IOP) with Goldmann applanation tonometry (GAT)
  - Right eye (OD): 19 mmHg
  - Left eye (OS): 19 mmHg
- Angles open on gonioscopy
- Central corneal thickness (CCT): 562 µm both eyes
- Disc cupping
  OD: 0.65
  OS: 0.75
- Optic disc examination (Fig. 1a, b): optic disc size asymmetry was evident. Left eye disc was slightly larger in size, due to which the cup in left eye was slightly bigger as well. Both discs were healthy.
- Visual field (VF) examination (Fig. 2a, b)
- On disc and field comparison, discs of both eyes did not correlate with the fields.

DIAGNOSIS

Physiological cupping

MANAGEMENT

In cases where disc and fields do not correlate, treatment should not be initiated until IOP is high. It is prudent to repeat VF test to exclude artifacts (Fig. 3).

CONCLUSIONS

In patients diagnosed with physiological cupping treatment should not be initiated unless IOP is high.

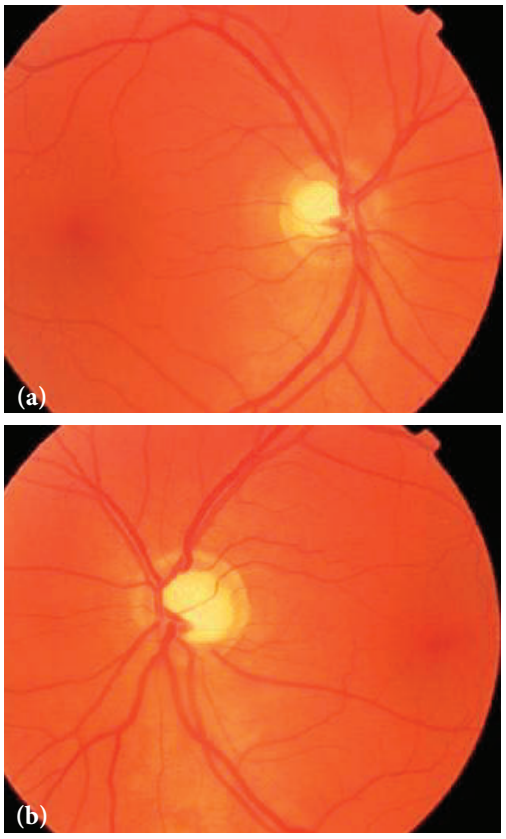

Fig. 1: (a) Disc showing uniform neuroretinal rim. (b) Disc showing uniform neuroretinal rim with no rim thinning

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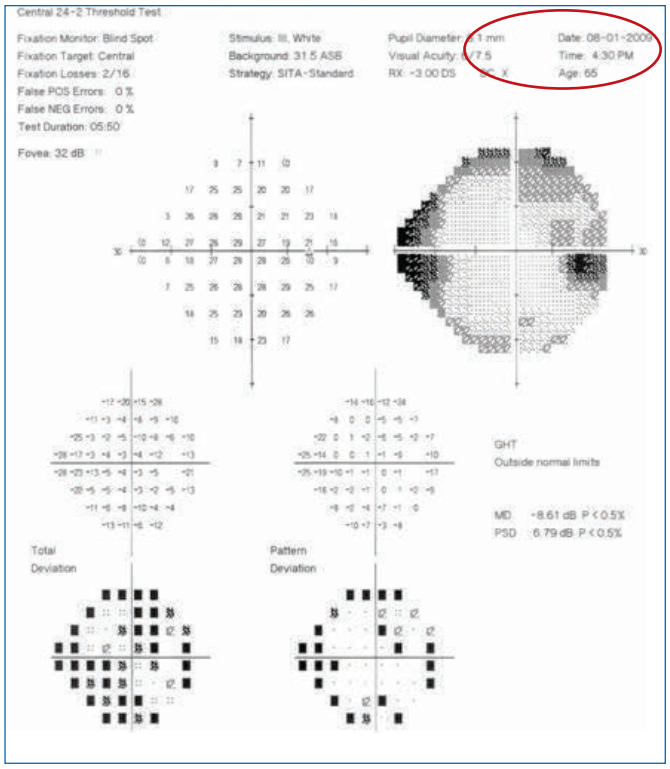

Fig. 2: (a) Right eye showing superior and nasal defects. (b) Left eye showing superior and inferior defects.

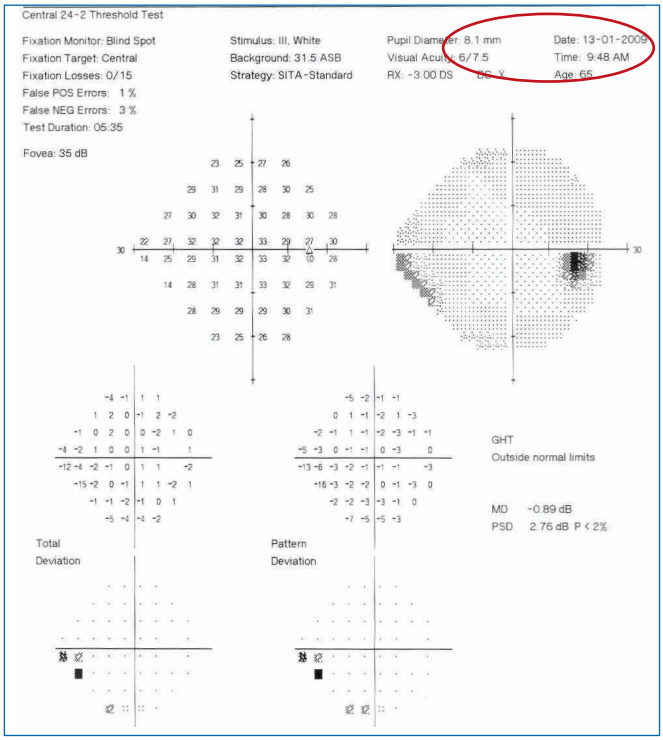

Fig. 2: Normal repeat field test.

SECTION 4

- Lasers in Glaucoma Management
- Surgical Management of Glaucoma
- Management of Coexisting Cataract and Glaucoma

19

Lasers in Glaucoma Management

TAKE HOME MESSAGES

- Lasers have wide application in glaucoma management.
- Almost all kinds of glaucoma can be managed using different kinds of lasers.
- Lasers act via different mechanisms—increasing aqueous flow, increasing angle width, or reducing aqueous humor production.
- Lasers also have postoperative application.

Laser treatments have seen a lot of utility in management of all types of glaucoma, viz., angle-closure glaucoma with pupil block (iridotomy), en plateau irises (iridoplasty), open-angle glaucoma (trabeculoplasty), neovascular or refractory glaucoma (cyclophotocoagulation of the ciliary body) among others. Lasers have value even after glaucoma surgery to control postoperative intraocular (IOP) after trabeculectomy (suture lysis) or after canaloplasty (perforation of the Descemet membrane).

LASERS TO INCREASE AQUEOUS OUTFLOW

Argon Laser Trabeculoplasty

Introduced in 1979, argon laser trabeculoplasty (ALT), reduces IOP but scars the trabecular meshwork, making retreatment difficult (Table 1).

Efficacy

- As per the Glaucoma Laser Trial (1991), in primary open-angle glaucoma (POAG), while Timolol 0.5% reduced IOP by 7 mmHg, ALT reduced IOP by 9 mmHg.
- After 2 years, no further intervention was required in 44% ALT-treated eyes as against 30% in those on medication.
- After 7 years, IOP and visual fields (VFs) were controlled in the ALT group as against the medication group.

Selective Laser Trabeculoplasty

First described in 1995, selective laser trabeculoplasty (SLT) uses frequency-doubled (Q-switched) Neodymium-doped Yttrium Aluminum Garnet (Nd: YAG) laser that specifically acts on trabeculate melanoctyes using only 1% energy, thus, causing less scarring, making retreatment feasible (Table 2).

Efficacy

- By one year, Wong MO, *et al.* found that IOP reduction is 7% in newly-diagnosed glaucoma and 36% in patients on maximum anti-glaucoma medications.
- Regarding IOP reduction, SLT is non inferior to ALT and topical anti-glaucoma medication.

Table 1: Argon laser trabeculoplasty.

Anesthesia	Topical; gonioscopy lens
Laser application	180° (anterior half) trabecular meshwork is treated with 40–50 laser spots
Spot size	50 µm at 800 mW
Postoperative	Topical steroids for the first week
	Intraocular pressure is checked again after 4–6 weeks and, if required, the other half of trabecular meshwork is treated

Table 2: Selective laser trabeculoplasty.

Anesthesia	Topical; gonioscopy lens
Energy	Frequency-doubled (Q-switched) Nd:YAG
Laser application	180°–360° of the trabecular meshwork
Power	0.8 mJ
Spot size	400 µm non-overlapping spots
Duration	3 ns
Postoperative	Weak topical steroid/nonsteroidal anti-inflammatory drops may/may not be initiated

Nd:YAG: Neodymium-doped Yttrium Aluminum Garnet

MicroPulse® Laser Trabeculoplasty and Titanium-sapphire Laser Trabeculoplasty

MicroPulse® laser trabeculoplasty (MLT) is delivered via diode or laser while the titanium-sapphire laser trabeculoplasty (TLT) uses pulsed near-infrared (IR) energy. Both, MLT and TLT, neither destroy nor scar the trabecular meshwork (Table 3).

Efficacy

- Gossage D. found that patients receiving 1000 mW showed decrease in IOP by 30% after 4 months and 24% after 2 years.
- According to them, titanium-sapphire laser trabeculoplasty showed 32% IOP reduction as compared to 25% by ALT.

LASERS TO INCREASE ANGLE WIDTH

Laser Peripheral Iridotomy

Peripheral iridotomy allows aqueous humor to flow from the posterior to the anterior chamber (AC), bypassing the pupil. Surgical iridectomy has now become obsolete with laser peripheral iridotomy (LPI) taking its place (Table 4).

Table 3: Laser trabeculoplasty.

MicroPulse® laser trabeculoplasty	
Anesthesia	Topical; gonioscopy lens Primed to deliver 10 confluent laser shots/clock hour over 360°
Energy	810 nm (diode) or 532 nm/577 nm laser
Power	1000 mW (15%-on/85%-off cycle)
Exposition time	300 ms
Spot size	300 µm
	Anti-inflammatory medications are not required
Titanium-sapphire laser trabeculoplasty	
Energy	790 nm near-infrared
Power	30–90 mJ
Exposition time	5–10 ms pulses
Spot size	200 µm
Spot number	50 shots to 180°of the pigmented trabecular meshwork; non overlapping
	The endpoint is the formation of bubbles/pigment bursts from the trabecular meshwork

Argon Laser Iridoplasty

In an acute situation, argon laser iridoplasty (ALP) can open an appositionally closed angle. ALP is quite beneficial in case

Table 4: Laser peripheral iridotomy.

Power	3–10 mJ
Exposition time	30 ns–20 ps
Spot number	1–2
Spot target	Beyond the inner 2/3rd and outer 1/3rd of pupillary border and limbus distance
Indications	• Acute primary angle-closure • Occludable fellow eye in acute primary angle-closure glaucoma • Angle-closure with peripheral anterior synechia • Glaucomatous optic neuropathy with primary angle-closure • Angle-closure in half of trabecular meshwork • Phacomorphic glaucoma • Pigment dispersion syndrome
Contraindications	• Corneal edema • Iridocorneal contact • Rubeosis of iris • Anticoagulant therapy

Table 5: Argon laser iridoplasty.

Anesthesia	Topical; Abraham/Weiss iridotomy contact lens Pilocarpine 1–4 % thrice over 10–30 min
Power	200–400 MW
Spot size	500 µm
Exposition time	0.5 s
Spot number	1–2
Spot target	• The beam is aimed at the peripheral iris near the limbus and large contracting burns are created • Applications should be 1–2 spot sizes apart, with no overlapping • In case of bubble formation or popping noises, power is reduced
Postoperative	• Brimonidine 0.2%/Apraclonidine 0.5% right after laser application • Steroid drops 4–6 times/day for a week • Intraocular pressure should be checked half an hour after the procedure
Indications	• Acute angle-closure glaucoma • Acute phacomorphic glaucoma • Uncontrolled primary open-angle glaucoma • Chronic angle-closure, plateau iris syndrome, nanophthalmos, peripheral anterior synechia, lens-related angle-closure • Drug intolerance • Inadequate patient compliance
Contraindications	• Narrow or closed angle • Advanced glaucoma with damage • Low pressure glaucoma • Steroid-induced glaucoma

of a cloudy cornea, shallow AC, or inflamed eye. Any future course of management may be contemplated by the surgeon after the situation subsides (Table 5).

LASERS TO REDUCE AQUEOUS HUMOR PRODUCTION

Transscleral Photocoagulation

Described in 1970, transscleral laser photocoagulation uses ruby laser and Nd:YAG laser with fiber optic delivery probe for delivery. Transscleral diode cyclophotocoagulation (TCP) is quite popular due to good penetration and absorption by pigmented ciliary body (Table 6).

Efficacy

- In 2013, Ishida K, *et al.* found that 66–92% patients achieved IOP ≤21 mmHg within a couple of years.
- Cheng J, *et al.* and colleagues concluded that the outcome is not as predictable as other glaucoma surgeries and 20–40% might require retreatment after a year.

Endocyclophotocoagulation

Described in 1992, endoscopic diode cyclophotocoagulation (ECP) is nothing but photocoagulation of the ciliary processes under endoscopic guidance and is usually performed along with cataract or vitreoretinal surgery. It is, however, not very effective in reducing IOP (Table 7).

Efficacy

- As per Kaplowitz K, *et al.* mean IOP decreased by 31% after 2 years.
- In secondary glaucoma, the mean decrease in IOP was 50% after 2–5 years.

Table 6: Transscleral photocoagulation.

Anesthesia	Retrobulbar block or general anesthesia
Laser	Nd: YAG
Power	4–9 W
Exposition time	0.5–0.7 s
Spot target:	1–2 mm posterior to limbus
Laser	810 nm Diode laser
Power	1500 mW
Exposition time	2 s
Spot target	17–20 applications, 1.2 mm posterior to limbus
	"Pop" sound indicates over treatment
Postoperative	Atropine, steroid drops, and pre-laser glaucoma medications

Nd:YAG: Neodymium-doped Yttrium Aluminum Garnet

- Lima FE, *et al.* showed a high failure rate in congenital glaucoma (78%) at 5 years.
- Intraocular pressure <21 mmHg was seen in 79% of patients after 5 years.
- Regeneration of the ciliary epithelium calls for laser reapplications.

POSTOPERATIVE LASER PROCEDURES

Suture Photolysis

Argon laser is used to do photolysis of the suture that closes the scleral flap of trabeculectomy. A Hoskins lens is used postoperatively:

- Without anti-metabolites within one week.
- With 5-fluorouracil (5-FU) within 2 weeks.
- With mitomycin-C (MMC) within 4 weeks (Table 8).

Neodymium-doped Yttrium Aluminum Garnet Laser Goniopuncture

Neodymium-doped Yttrium aluminum garnet laser facilitates aqueous humor flow from the AC to the decompression chamber, thus, converting a non-perforating procedure into a perforating one (Table 9).

Table 7: Endocyclophotocoagulation.

Anesthesia	Retrobulbar block or general anesthesia
Power	0.3–0.9 W
Probe size	18–20 gauge
	Energy is applied with shrinkage and whitening as endpoint
Spot target	• Limbal approach at 270°–360° • Anterior vitrectomy allows safe accessibility to ciliary processes in case of pars plana approach
Indications	• Refractory glaucoma • Painful blind eye (aphakic or pseudophakic glaucoma and neovascular glaucoma, post-keratoplasty glaucoma)

Table 8: Suture photolysis.

Anesthesia	Retrobulbar block using Hoskins lens
Energy	Argon laser
Power	200–400 mW
Spot size	50 μm
Time	0.2 s
Indications	Suture cutting at the scleral flap during trabeculectomy

Table 9: Neodymium-doped Yttrium Aluminum Garnet laser goniopuncture.

Pre-procedure	2% pilocarpine drops after using the gonioscopy lens avoids iris involvement
Energy	Nd:YAG
Power	1–8 mJ
Spot size	• Pulsed 2–10 spots • Beam is aimed at the Descemet window • After canaloplasty, the prolene thread inserted during surgery should be avoided
Indications	Postoperative hypertonia following non-perforating procedures (deep sclerectomy and canaloplasty)
Postoperative	Topical steroid therapy for a week

Nd:YAG: Neodymium-doped Yttrium Aluminum Garnet

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20

Surgical Management of Glaucoma

TAKE HOME MESSAGES

Different types of surgeries in glaucoma

- Penetrating filtering surgery
  - Trabeculectomy
  - Trabeculectomy with antimetabolites
- Non-penetrating surgery
  - Viscocanalostomy
  - Deep sclerectomy
  - Canaloplasty
- Glaucoma drainage devices
- Goniosynechialysis
- Minimally-invasive glaucoma surgery

Surgeries in different types of glaucoma

- Open-angle glaucoma
  - Penetrating filtering surgery
  - Non-penetrating filtering surgery
  - Glaucoma drainage devices
  - Minimally-invasive glaucoma surgery
  - Ex-Press® glaucoma shunt
- Angle-closure glaucoma
  - Iridectomy
  - Trabeculectomy
  - Lens extraction
  - Laser peripheral iridoplasty
  - Goniosynechialysis
  - Glaucoma drainage devices

Surgery is indicated in glaucoma management in order to lower intraocular pressure (IOP) in eyes where topical medications or laser application have not proven satisfactory, or in case of poor patient compliance. Surgery could either be penetrating or non-penetrating and antimetabolites or devices may be used to improve outcomes.

PENETRATING FILTERING SURGERY

Trabeculectomy

This is a time-tested surgery, which has had a lot of success over the years. Two kinds of approaches are possible based on the initial conjunctival incision. Antimetabolites are routinely used with this procedure (Tables 1 and 2).

Trabeculectomy with Antimetabolites

Trabeculectomy outcomes may be enhanced by the use of antimetabolites, which act on tissue healing. Younger age, previous conjunctival surgery, and inflammation can lead to bleb failure, in which case, a higher dose of antimetabolite is recommended (Tables 2 and 3).

NON-PENETRATING SURGERY

Non-penetrating glaucoma surgery is an extraocular surgery performed without penetrating the eye. These include viscocanalostomy, canaloplasty, and deep sclerectomy and may be combined with phacoemulsification. They are usually preferred in cases where the IOP reduction target is not very low (Tables 4 and 5).

Viscocanalostomy

Viscocanalostomy was developed to avoid scarring-related issues. It has two advantages over the trabeculectomy:

- Failure due to scarring is avoided as there is no filtering bleb.
- Less chances of hypotonia, inflammation, and cataract as the anterior chamber (AC) is not opened.

Viscoelastic injection into the canal dilates the Schlemm's canal (SC) as well as disrupts its walls and trabecular layers, thus, enhancing trabecular outflow facility. Viscocanalostomy can be combined with phacoemulsification, and a temporal or superior position can be used as decided by the alternate approach used for phacoemulsification (Table 5).

Table 1: Trabeculectomy flaps.

	Limbal-based conjunctival flap	Fornix-based conjunctival flap
Incision	Incision is in the fornix and base at the limbus	Incision is at the limbus and base in the fornix
Technical aspect	• Easier and less time consuming • Good exposure • Good visualization • Releasable sutures can be used • Smaller area of dissection	• More difficult and time consuming • Exposure is difficult • Poor visualization • Releasable sutures cannot be used • Larger area of dissection
Repeat surgery	Easier	Difficult due to scarring
Use of anti-fibrotic sponges	Difficult	Easier
Bleb	Diffuse in shape Drainage posteriorly	Cystic blebs and "ring of steel" Drainage anteriorly
Leaks	Higher chance	Less chance

Table 2: Tips for better trabeculectomy outcomes.

- Traction sutures
- The scleral flap thickness that provides resistance to aqueous flow
- Larger antimetabolite treatment area
- Permanent, releasable, or adjustable scleral sutures
- Meticulous conjunctival closure
- Postoperative suture lysis if required

Table 3: Anti-scarring agents applied to bleb site.

	5-fluorouracil (25 or 50 mg/mL)	Mitomycin-C (0.2–0.5 mg/mL)
Duration	2–5 min	1–5 min
Mechanism of action	Growth arrest	Cell death
Level of control on arrest	Moderate	Moderate

Table 4: Indications and contraindications of non-penetrating surgery.

Indications	Relative contraindications	Absolute contraindications
• Early primary open-angle glaucoma—to prevent long-term topical medication toxicity. • Pseudoexfoliative glaucoma—high and irregular intraocular pressure fluctuations. • High myopia—increased risk of complications. • Uncontrolled aphakic glaucoma—difficult to manage surgically. • Open-angle uveitic glaucoma—inflammatory cells cause scarring. • Sturge-Weber syndrome-risk of choroidal effusion or expulsive hemorrhage. • Congenital glaucoma.	• Angle-closure glaucoma • Previous laser trabeculoplasty	• Neovascular glaucoma • Iridocorneal endothelial syndrome • Rubeosis iridis • Chronic closed-angle glaucoma • Traumatic angle recession
Pros and cons of non-penetrating glaucoma surgery		
Advantages	**Disadvantages**	
• Fewer postoperative complications • Faster ambulation • Faster visual recovery • Less postoperative inflammation and infection • Less chance of cataract formation	• More difficult to perform • More time consuming • Goniopuncture with Nd:YAG might be needed • Increased cost	

Nd:YAG: Neodymium-doped Yttrium Aluminum Garnet

Canaloplasty

In this surgery, there is no creation of alternative pathway for aqueous humor drainage; however, the efficiency of the trabecular meshwork is improved. It is a form of viscocanalostomy with additional steps:

- A catheter dilates the SC.
- After stretching the canal, a permanent suture is placed (Table 5).

Deep Sclerectomy

Deep sclerectomy differs from viscocanalostomy as it facilitates filtration of the aqueous humor into the intrascleral lake and then into the sub-Tenon's space. It has fewer complications, and using antimetabolites and implants can improve efficacy. It can be performed alone or combined with phacoemulsification, with better results as compared to trabeculectomy (Table 5).

Table 5: Techniques of non-penetrating glaucoma surgery.

Viscocanalostomy	Canaloplasty	Deep sclerectomy
• Create a fornix-based conjunctival flap • Make a 200 µm thick, 5 x 5 mm outer parabolic flap • Create inner 4 x 4 mm scleral flap beneath this • Dissect and de-roof SC • Cannulate the two ostia of SC • Dilate entire canal length via a microcatheter and release VES • Pass a 10-0 polypropylene suture inside the canal and distend the trabecular meshwork inward • Pull the inner scleral flap upwards, and the floor of the Descemet's membrane down, to create a trabeculo-descemetic window • Excise the inner scleral flap • Seal the lake with 10-0 nylon • Inject VES beneath the flap • Suture the conjunctiva	• Create scleral lake • Dilate SC ostias with a cannula and inject VES through a microcatheter • While retracting, inject VES again • Release and suture the prolene 10.0 • Close the superficial flap, check filtration and close conjunctiva	• Use superotemporal intracorneal suture to expose the upper quadrant • Dissect a 5 x 5 mm superficial scleral flap and extend it 1–2 mm into clear cornea • Create another 4 x 4 mm deep scleral flap • Detach Descemet's membrane from corneal stroma • Make two radial corneal cuts • Peel the endothelium of SC and juxtacanalicular trabeculum • After aqueous humor percolates, remove the deep scleral flap • Place implant in the scleral bed • Close the superficial scleral flap, Tenon's capsule, and conjunctiva
Complications after non-penetrating glaucoma surgery		
Intraoperative	**Early postoperative**	**Late postoperative**
• Perforation of trabeculo-Descemet's membrane • Iris prolapse	• Hypotony • Inflammation • Shallow anterior chamber • Hyphema • Wound and bleb leaks • Blebitis • Keratitis	• Late rupture of trabeculo-Descemet's membrane • Peripheral anterior synechiae • Iris prolapse • Cataract progression • Corneal astigmatism • Bleb fibrosis

SC: Schlemm's canal; VES: Viscoelastic substance

Table 6: Glaucoma drainage devices.

	Type of device	Smallest plate surface area (mm^2)	Largest plate surface area (mm^2)
Ahmed device	Valved	96 (pediatric model)	364
Baerveldt implant	Non-valved	250	350
Krupin implant	Valved	–	180
Molteno implant	Non-valved	133	265

Table 7: Glaucoma drainage devices-techniques.

- In a two stage procedure, in the first stage, sew the plate into place, but do not insert the tube. After 6–8 weeks, a fibrotic capsule forms around the plate and the tube can be inserted in the second stage.
- Resistance is provided by the fibrous capsule, which prevents over-filtration and hypotony.
- In case of a single stage surgery, place the non-valved implant in the eye but block the flow via a releasable suture to avoid hypotony.

GLAUCOMA DRAINAGE DEVICES

Tube shunts were initially indicated in cases of low visual prognosis, failed trabeculectomy, or scarring. They are now being used as a primary intervention in many types of glaucoma. They could be valved and non-valved and each has its own unique feature. For instance, the Baerveldt implant is more effective than the Ahmed valve in IOP reduction, but is associated with more vision threatening complications than the latter. The choice of glaucoma drainage implant must, hence, be considered on a case-to-case basis (Tables 6–8).

The Krupin-Denver valve tube was made of plastic and due to scarring around, it had limited effect. Molteno added a plastic plate at the end of the tube for better long term outcomes; larger the plate, lower the final IOP. Despite fibrosis, the surface area increased and aqueous humor could drain. However, these devices use tubes with 300 µm inner diameter, which doesn't cause much resistance to aqueous flow (Tables 8 and 9).

Table 8: Glaucoma drainage devices.

Postoperative course		
	Valved	**Non-valved**
Aqueous humor flow	Immediate 8–18 mmHg	Not immediate and is variable
	Ocular hypertension may be seen	Hypotony may be seen
Postoperative follow-up	Hypertensive phase could occur 4–16 weeks after surgery	In two stage procedure preoperative medication should be continued till second surgery
	Aqueous humor suppressant may be needed to prevent hypertensive phase	Weekly follow-up from 5–6 weeks to check ligature opening after which glaucoma medications can be discontinued
Complications		
• Uncontrolled intraocular pressure • Hypotony • Choroidal effusion • Corneal decompensation • Peripheral anterior synechiae		• Cataract • Blockage of tube by blood, vitreous, or fibrin • Tube/plate erosion • Endophthalmitis • Aqueous misdirection

Table 9: Tips for better outcomes with glaucoma devices.

- Valved devices provide more reliable pressures in the early postoperative period.
- Intraocular pressure results are comparable to trabeculectomy in less complicated glaucomas.
- At 5 years, failure rate is lower and additional glaucoma surgery is not required with tube shunts.
- Monitoring is essential in early postoperative period to detect and manage hypotony or inflammation.
- Tube shunts are preferred in aphakes who wear contact lens.
- Pars plana insertion can be performed in aphakia.

Table 10: Technique of goniosynechialysis.

- Visualize the gonioscopic angle under topical anesthesia
- Make side port/paracentesis incisions
- Use cholinergic to constrict pupil
- Fill anterior chamber with viscoelastic substance
- Lyse peripheral iris adhesions
- Remove viscoelastic substance
- Ensure watertight wound

GONIOSYNECHIALYSIS

Goniosynechialysis is done to remove peripheral anterior synechiae (PAS) from the trabecular surface in the angle in order to facilitate access to the trabecular meshwork. It is combined with cataract surgery in case of phacomorphic or primary angle-closure glaucoma (PACG). Since, it does not touch the conjunctiva, subsequent trabeculectomy can be performed if needed (Table 10).

MINIMALLY-INVASIVE GLAUCOMA SURGERY

Popular procedures recently being performed are trans-trabecular microbypass aqueous humor shunting to SC (iStent)®, endolaser cyclophotocoagulation, and *ab interno* trabeculotomy (trabectome). Minimally-invasive glaucoma surgery reduces IOP with a better safety profile than conventional glaucoma surgery. They can increase aqueous outflow by several ways:

- The Ex-Press® mini glaucoma shunt diverts aqueous humor from the AC to the subconjunctival space forming a filtration bleb.
- The iStent® and trabectome are trabecular bypass techniques that improve access of aqueous humor from the AC to the SC and later to the collector channels.
- The CyPass® is a choroidal shunt and increases aqueous humor drainage into suprachoroidal space.

Ex-Press® Mini Glaucoma Shunt

The Food and Drug Administration (FDA) approved Ex-Press® glaucoma filtration device is a 400 µm stainless steel glaucoma implant with a flow-modulating MRI compatible design. The shunt reduces IOP by diverting aqueous humor from the AC to the subconjunctival space to form a filtration bleb. Mitomycin-C (MMC) is recommended to prevent scarring. It is, currently, the procedure of choice in primary, secondary, pseudophakic, and refractory glaucoma because:

- Outcomes are dependable due to uniformly-sized outflow path for aqueous flow.
- It is accurate, repeatable, and a safer alternative to trabeculectomy.
- Being biocompatible, there is less incidence of inflammation (Table 11).

Trans-trabecular Micro Bypass Shunt

The iStent® is an FDA-approved device for mild-to-moderate glaucoma for combined surgery. The trabecular meshwork

Table 11: Ex-Press® mini glaucoma shunt at a glance.

Indications	Contraindications	Advantages
• Refractory open-angle glaucoma • Open-angle glaucoma after a failed filtration procedure • Combined surgery-for faster visual recovery • Aphakic glaucoma-as no iridectomy is required • Sturge-Weber syndrome due to lower rate of postoperative hypotony	• Narrow-angle glaucoma, unless the lens is removed • Congenital or juvenile glaucoma • Aniridia and anterior segment dysgenesis syndromes • Neovascular glaucoma • Microphthalmos	• Neither a sclerostomy nor an iridectomy is needed • Outcomes are more predictable since the flow through the device is always the same • Releasable or laserable sutures may be used on the scleral flap • There are fewer complications like hyphema, hypotony, and choroidal detachment • Erosion of the device is extremely rare if placed under a scleral flap

Technique of Ex-Press® mini glaucoma shunt

- Create a scleral flap similar to that in trabeculectomy after using mitomycin-C.
- Enter the anterior chamber (AC) underneath the scleral flap at the gray line with a 25-gauge needle parallel to the iris.
- Introduce the inserter, preloaded with the Ex-Press® shunt in the mid AC.
- Press the inserter firmly to release the shunt.
- Ensure watertight closure of conjunctiva.

bypass supplements ablation, and boosts outflow pathways. The conjunctiva is not affected which provides for future trabeculectomies and aqueous shunts.

Ab Interno Trabeculectomy–Trabectome™

The Trabectome™ first used in 2005, is now an accepted replacement for laser trabeculoplasty or filtering surgery in eyes with open-angle glaucoma that do not respond to medical therapy. It has an electric spark that ablates the trabecular meshwork and inner wall of SC via gonioscopic route.

- It is a preferred first line therapy with/without cataract surgery.
- Complications are rare, commonest being hyphema.
- Subsequent filtering procedures can be performed successfully in case of an unsuccessful trabectome.
- It is very safe in mild-to-moderate glaucoma, and in pediatric angle surgery instead of goniotomy or *ab externo* trabeculotomy.

Suprachoroidal Devices

The CyPass® Micro-Stent is a biocompatible polyamide stent (300 µm lumen; 6.35 mm length with 76 µm fenestrations, distally) placed *ab interno* via a clear corneal incision. The iStent® SUPRA (4 mm length, 165 µm lumen) is heparin-coated combination of titanium and polyethersulfone and is placed *ab interno* via a clear corneal incision. The SOLX gold shunt moves fluid from the AC to the suprachoroidal space using an *ab externo* approach.

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21

Management of Coexisting Cataract and Glaucoma

TAKE HOME MESSAGES

- Mitomycin-C and not 5-fluorouracil, is a better adjunctive antifibrosis agent in combined surgery.
- Considering other factors at par, two-site, rather than single-site surgery, is preferred.
- Phacoemulsification, rather than nuclear expression is the method of choice.

Managing glaucoma and cataract is becoming more frequent due to increasing longevity. In recent years, phacoemulsification has virtually replaced extracapsular cataract extraction (ECCE) and temporal clear cornea incisions have replaced scleral incisions. Better results in this complicated patient population are seen due to following factors:

- There is better visualization in difficult cases like small pupils or pseudoexfoliation
- Conjunctiva is spared for future filtration
- Complication rate has reduced
- Small pupils are better managed
- Filtration surgery has evolved
- Antimetabolites are usually used
- Success in lowering intraocular pressure (IOP) and creating filtration blebs has improved
- Argon laser suture lysis and releasable sutures allow titration of early filtration

There is now a choice of performing cataract surgery and trabeculectomy simultaneously or in stages.

Cataract extraction is more hazardous in the glaucomatous eye possibly due to poor pupillary dilation caused by the use of miotics and exfoliation which diminishes zonular integrity. The ultimate goal should be to target IOP, better quality of life, improved vision, and reduced anti-glaucoma medications. The therapeutic options have been presented in Table 1.

CLINICAL RECOMMENDATIONS

Good evidence

- Long-term IOP control is greater with combined surgery than with cataract extraction alone

Fair evidence

- Trabeculectomy alone lowers long-term IOP more than combined ECCE and trabeculectomy.

Weak evidence

- Cataract extraction in glaucoma patients lowers IOP by 2–4 mmHg.
- Trabeculectomy alone lowers IOP more than combined surgery.
- Combined surgery lowers IOP by 8 mmHg in individuals over 1–2 years.
- Extracapsular cataract extraction and trabeculectomy lowers IOP by 6–8 mmHg in individuals over 1–2 years.

Insufficient evidence

- Mitomycin-C (MMC) during combined surgery results in lower IOP.
- The use of 5-fluorouracil (5-FU) during combined surgery does not show similar IOP lowering results.
- Separate cataract and glaucoma incisions lowers IOP more than performing both at the same site.

Content supported by Dr. Suneeta Dubey, Anterior Segment & Glaucoma, Head Glaucoma Services, Dr. Shroff's Charity Eye Hospital, New Delhi

Table 1: Suggested therapeutic options to manage glaucoma with co-existing cataract.

Cataract surgery alone	Sequential surgery-trabeculectomy followed by cataract surgery	Combined glaucoma and cataract surgery
Indications		
• Primary open-angle glaucoma well-controlled on medical therapy having visually significant cataract • Ocular hypertensives having cataract • Primary angle-closure glaucoma with mild-to-moderate damage well-controlled with medications • Phacomorphic glaucoma with short history	• Advanced glaucomatous damage requiring intraocular pressure (IOP) in low teens • Uncontrolled IOP with maximum tolerable medical therapy • Moderate glaucomatous damage with visually insignificant cataract • Risk factors for filtration failure	• Mild/moderate/severe glaucoma with borderline/uncontrolled IOP on maximum tolerable medical therapy with visually significant cataract • Advanced glaucomatous optic atrophy at risk of damage due to postoperative IOP spikes • Moderate/severe glaucoma, with controlled IOP, where there is an urgent need for visual recovery • Non-compliance to anti-glaucoma medication, allergies, side-effects, or unsustainable expenses
Advantages		
• Cataract removal alone lowers IOP by 2–4 mmHg in both normal and glaucomatous eyes • There is a 41% reduction in anti-glaucoma medication after cataract surgery due to: ▪ Anatomic or dynamic changes in aqueous humor ▪ Enhanced aqueous outflow via the trabecular meshwork or uveoscleral pathway ▪ Could be reduction in aqueous humor production	• Reduced inflammation • Less surgical manipulation • Better wound integrity • Adjunctive antifibrotic medications can help	• Eliminates the risk of two invasive procedures • Early visual rehabilitation as compared to sequential surgery • Favored in elderly patients • Better patient satisfaction, compliance, and economy
Disadvantages		
• Cataract surgery alone does not produce a reliable long-term lowering of IOP • There could be postoperative pressure spikes after cataract surgery • IOP could rise to 30 mmHg possibly due to trabecular meshwork block by retained viscoelastic material, inflammatory cells, or lens debris	• Need for two separate surgical procedures • Trabeculectomy can accelerate cataract formation • Subsequent cataract surgery hampers bleb functioning • Early cataract surgery can scar the conjunctiva reducing the success of a subsequent trabeculectomy	• Relatively lesser decrease in IOP and lower long term bleb success (31% versus 48%) • Poor filtration bleb as compared to trabeculectomy alone • Increased intra-operative manipulations, time, corneal endothelial damage and postoperative inflammation, and hyphema • Higher risk of endophthalmitis

- In combined surgery, IOP is lowered more if phacoemulsification is used rather than nuclear expression.

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4 TIPS AND TRICKS FOR COMBINED GLAUCOMA AND CATARACT SURGERY

Intra-operative

- A clear corneal temporal incision is preferred over scleral tunnel.
- Pupillary dilatation may be achieved by stretching, iris hooks, or sphincterotomy.
- Extra care must be taken to remove all the viscoelastic material at the end of the procedure.
- Intracameral pilocarpine is advised.
- Topical apraclonidine is recommended at the conclusion of the surgery.

Postoperative

- Postoperative intraocular pressure spikes (oral acetazolamide may be given) should be looked out for.
- Preoperative anti-glaucoma medications should be continued.
- Steroids should be used cautiously especially in steroid responders.
- In case of complicated surgery with vitreous loss, prostaglandin analogs should be avoided.

One site versus two sites

Due to recent trend towards clear corneal phacoemulsification, the temporal incision is preferred for cataract extraction and a superior approach for conventional trabeculectomy.

Two sites

Advantages

- Clear corneal approach minimizes conjunctival manipulation.
- More comfortable phacoemulsification position for majority.
- Good for against-the-rule astigmatism.

Disadvantages

Longer operative time than combined surgery.

TAKE HOME MESSAGES

- Cataract surgery helps in lowering IOP in both normal and glaucomatous eyes.
- Combined glaucoma and cataract surgery diminishes the need for two invasive procedures and aids in early visual rehabilitation.
- Each case needs to be considered on individual basis and managed accordingly.

CASE 1

INTRODUCTION

A 50-year-old male, presented with vision in right eye: 6/9, N8 and left eye: 6/6, N6.

INVESTIGATIONS

- Intraocular pressure (IOP)
  - Right eye (OD): 28 mmHg on maximum medical therapy
  - Left eye (OS): 20 mmHg
- Lens: Nuclear sclerosis with early cortical changes
- Gonioscopy: Open angles in both eyes
- Optic nerve
  - OD: 0.9, inferior rim loss >180°
  - OS: 0.7
- Visual field (VF) analysis
  - OD: biarcuate scotoma
  - OS: Incomplete superior arcuate defect

DIAGNOSIS

Advanced primary open-angle glaucoma (POAG) right > left with early immature senile cataract in both eyes.

CONSIDERATIONS

Uncontrolled IOP; vision not compromised; Young age.

RECOMMENDED MANAGEMENT PLAN

Glaucoma surgery alone.

CONCLUSIONS

In young patients with uncontrolled IOP and compromised vision surgery may be considered.

Content supported by Dr. Suneeta Dubey, Anterior Segment & Glaucoma, Head Glaucoma Services, Dr. Shroff's Charity Eye Hospital, New Delhi

CASE 2

INTRODUCTION

A 56-year-old female, presented with vision in right eye: 6/18, N8 and left eye: 6/24, N12.

INVESTIGATIONS

- Intraocular pressure (IOP)
  - Right eye (OD): 16 mmHg on one anti-glaucoma medication
  - Left eye (OS): 14 mmHg
- Lens: Nuclear sclerosis II/III with posterior subcapsular cataract
- Gonioscopy: Open angles in both eyes
- Optic nerve
  - OD: 0.6 with inferior rim thinning
  - OS: 0.4
- Visual field (VF) analysis
  - OD: Incomplete superior arcuate scotoma
  - OS: Superior nasal step.

DIAGNOSIS

Immature senile cataract with primary open-angle cataract.

CONSIDERATIONS

Controlled IOP on one anti-glaucoma medication and compromised vision.

RECOMMENDED MANAGEMENT PLAN

Cataract surgery alone-preferably temporal approach phacoemulsification.

CONCLUSIONS

Cataract surgery helps in lowering IOP.

Content supported by Dr. Suneeta Dubey, Anterior Segment & Glaucoma, Head Glaucoma Services, Dr. Shroff's Charity Eye Hospital, New Delhi

CASE 3

INTRODUCTION

A 65-year-old male, presented with vision in right eye: 6/36, N8 and left eye: 6/60, N12.

INVESTIGATIONS

- Intraocular pressure (IOP)
  - Right eye (OD): 22 mmHg on three anti-glaucoma medications
  - Left eye (OS): 24 mmHg
- Lens: Nuclear sclerosis grade 3; posterior subcapsular cataract
- Gonioscopy: Open angles in both eyes
- Optic nerve (Both eyes): 0.8, with inferior rim thinning
- Visual field (VF) analysis: Both eyes: Superior arcuate scotoma with inferior nasal step

DIAGNOSIS

Advanced immature senile cataract with advanced primary open-angle glaucoma in both eyes.

CONSIDERATIONS

Uncontrolled IOP on anti-glaucoma medications; compromised vision.

RECOMMENDED MANAGEMENT PLAN

Cataract surgery combined with glaucoma surgery

Or,

Glaucoma surgery first, followed by cataract surgery or vice versa. However, patient needs to be counseled about the need for two surgeries.

CONCLUSIONS

Combined surgeries may be considered for early visual rehabilitation.

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CASE 4

INTRODUCTION

A 65-year-old male, presented with vision in right eye: 6/9, N8 and left eye: 6/9, N6.

INVESTIGATIONS

- Intraocular pressure (IOP)
  - Right eye (OD): 24 mmHg on maximum medical therapy
  - Left eye (OS): 18 mmHg on prostaglandin analogs
- Lens: nuclear sclerosis 2+ in both eyes.
- Gonioscopy: Closed angles in both eyes; 270° peripheral anterior synechiae (PAS) in right eye and superior PAS in left eye.
- Optic nerve: OD: 0.9, inferior rim loss >180°, OS: 0.7, with inferior neuroretinal rim thinning.
- Visual field analysis
  - OD: Biarcuate scotoma
  - OS: Superior nasal step.

DIAGNOSIS

OD: Advanced primary angle-closure glaucoma (PACG)
OS: Early PACG

CONSIDERATIONS

OD: Uncontrolled IOP; shallow anterior chamber, nuclear sclerosis
OS: Nuclear sclerosis

RECOMMENDED MANAGEMENT PLAN

OD: Combined surgery
OS: Cataract surgery alone

CONCLUSIONS

Treatment plan must be individualized.

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SECTION 5

- Monitoring Glaucoma

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Monitoring Glaucoma

TAKE HOME MESSAGES

- Glaucoma monitoring is required to detect structural and functional changes in the eye.
- Standard automated perimetry should be used for monitoring of functional progression, around 2–3 times per year.
- Loss of visual field in glaucoma can be diffuse but isolated defects are common.
- A single intraocular pressure measurement does not reflect the entire intraocular pressure profile of a patient with glaucoma.
- A 24-hour ambulatory intraocular pressure monitoring technology has been made available recently.
- Adults showing findings, consistent with an increased risk for glaucoma development in at least one eye are glaucoma suspects.
- Three or four intraocular pressure measurements scattered throughout typical office hours (e.g. at 10:00 pm, 2:00 pm, and 6:00 pm, respectively) should be conducted before the commencement of therapy.

WHY TO MONITOR GLAUCOMA PROGRESSION?

Glaucoma progresses slowly, but the glaucomatous visual field (VF) does develop or progress in approximately half of patients during the follow-up. Even though the rate of glaucoma progression and development of blindness is low, monitoring is required to detect:

- Structural changes
- Functional changes

MONITORING STRUCTURAL AND FUNCTIONAL PROGRESSION: HOW AND WHAT TO LOOK FOR?

- Standard automated perimetry (SAP) should be used for appropriate monitoring of functional progression.
- The suggested frequency of examination is 2–3 per year, depending on the patient's stage and progression rate.
- Look for changes in the optic nerve head (ONH).
  - Enlargement of cup-to-disc ratio (CDR).
  - Increased neuroretinal rim (NRR) thinning.
  - Rim notching.
- Look for retinal nerve fiber layer (RNFL) changes:
  - Increased width or depth of RNFL defect.
  - Appearance of new RNFL defect.
- Optical coherence tomography (OCT) is a newer and widely used method to effectively monitor glaucoma progression.
- Be cautious to properly differentiate intersession variability from progression while using OCT.
- Thickness change exceeding the cut-off variance of each OCT parameter can be regarded as progression.
- Changes in the average RNFL thickness exceeding 6.5 μm and in the average ganglion cell-inner plexiform layer (GCIPL) thickness exceeding 4.0 μm are more likely to be the signs of progression rather than of long-term test-retest variability.

Risk Factors for Progression

- Intraocular pressure (IOP)-dependent risk factors
  - Insufficient IOP reduction
  - Large IOP fluctuation
- Intraocular pressure-independent risk factors
  - Autonomic dysfunction
  - Low nocturnal blood pressure (BP)
  - Low ocular perfusion pressure (OPP)
  - Large fluctuation of OPP
- Disc hemorrhage
- Myopia

VISUAL FIELD ASSESSMENT IN GLAUCOMA

Loss of VF can be diffuse (as with cataract or corneal opacification). But, isolated defects are common. Mostly, there are

non-specific VF defects in glaucoma. Relatively specific glaucomatous VF defects include:

- A nasal step defect obeying the horizontal meridian.
- A temporal wedge defect.
- The classic arcuate defect, which is a comma-shaped extension of the blind spot.
- A paracentral defect 10°–20° from the blind spot.
- An arcuate defect with peripheral breakthrough.
- Generalized constriction (tunnel vision).
- Temporal-sparing severe VF loss.
- Total loss of field.

INTRAOCULAR PRESSURE MONITORING

- Intraocular pressure is not fixed. It varies during
  - 24-hour cycle
  - Consecutive visits
- A single IOP measurement does not reflect the entire IOP profile of a patient with glaucoma.
- Ideal situation is a 24-hour assessment of IOP which is not always practical.
- Clinical picture of patient should mainly decide about the method of IOP monitoring.
- Ocular hypertension patients require a single IOP measurement, which is appropriate in early to moderately stable glaucoma patients.
- Patients with functional or anatomical progression require a diurnal or ideally a 24-hour IOP monitoring.

The 24-hour Intraocular Pressure Measurement

- The 24-hour ambulatory IOP monitoring technology has been made available recently.
- It correlates with chronobiology of aqueous humor production and the outflow system.
- It identifies deleterious IOP patterns in glaucomatous patients.
- The relevant determinants of glaucoma development and progression include:
  - Time course and amplitude of peak IOP
  - Frequency of spontaneous spikes
  - Fluctuations
  - Magnitude and duration of the nocturnal IOP rise and morning fall

Impact of Continuous 24-hour Intraocular Pressure Monitoring

- Early detection of disease
- Individualized treatment
- Improved adherence to therapy
- Evaluation of effect of behaviors/activities on individuals' IOP
- Facilitate alternative treatment strategies
- Progression of glaucoma can be prevented

Intraocular Pressure Monitoring in Glaucoma Suspects

Adults showing findings consistent with an increased risk for glaucoma development in at least one eye are glaucoma suspects. Findings arousing suspicion of glaucoma include:

- An enlarged cup (taking into account optic disc size)
- Asymmetric cup-to-disc ratio
- Notching or narrowing of the NRR
- Visual field changes commensurate with glaucoma
- Intraocular pressure readings above the statistically accepted upper limit (over 21 mmHg)

Best Intraocular Pressure Monitoring Strategy in Primary Open-angle Glaucoma

- Three or four IOP measurements scattered throughout typical office hours (e.g. at 10:00 am, 2:00 pm, and 6:00 pm, respectively) before the commencement of the therapy.
- This schedule provides important information for the particular patient's initial IOP characteristics over an appreciable part of the 24-hour cycle.
- Post initiation of treatment, diurnal curve offers valuable information on the quality of pressure control over a significant time period.
- Full 24-hour compliance curve is needed in patients with erratic pressure profiles such as those found in exfoliation or narrow-angle glaucoma, or in progressive glaucoma despite apparently adequate diurnal IOP control and good compliance.
- Complete 24-hour curve is also important in patients with very advanced damage and high risk for further progression.

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Annexure 1

SAMPLE GLAUCOMA WORKSHEET

Name: ..... Age: ..... ID No: .....

Presenting complaints:

History of presenting illness:

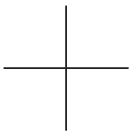
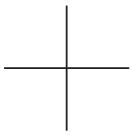
Past history:

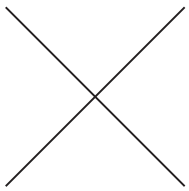
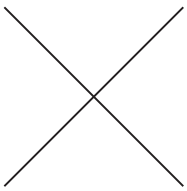
Family history:

Systemic history and risk factors:

Content supported by Dr. Ronnie George, Deputy Director, Smt. Jadhavbai Nathamal Singhvee Glaucoma Services, Sankara Nethralaya, Chennai

Examination

	Right eye	Left eye
Unaided vision Distance Near		
Refraction		
Best corrected vision/vision with pin hole		
External eye		
Torch light findings		
Congestion		
Oblique flashlight test		
Pupils Size Shape Polycoria Position Relative afferent pupillary defect (RAPD)		

Slit-lamp examination	Right eye	Left eye
Cornea		
Anterior chamber Van Herick Inflammation Other		
Iris Pupil centration Atrophy Pseudoexfoliation Neovascularization Other		
Lens Cataract Position		
Intraocular pressure Applanation		
Gonioscopy		

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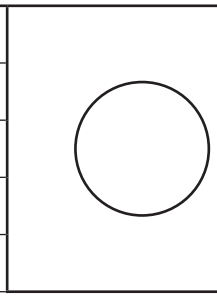
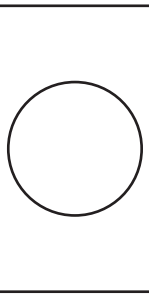
Lens +90/78/60D</td><td>Eye</td><td rowspan="5">  </td><td>Eye</td><td rowspan="5">  </td></tr>
<tr><td>Lens</td><td>Lens</td></tr>
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<tr><td colspan="2">Neuroretinal rim (NRR)</td><td colspan="2">Neuroretinal rim (NRR)</td></tr>
<tr><td colspan="2">Retinal nerve fiber layer (RNFL)</td><td colspan="2">Retinal nerve fiber layer (RNFL)</td></tr>
<tr><td>Notch</td><td></td><td>Notch</td><td></td></tr>
<tr><td>Hemorrhage</td><td></td><td>Hemorrhage</td><td></td></tr>
<tr><td>Other</td><td>Impression</td><td>Other</td><td>Impression</td></tr>
<tr><td>Other retinal findings</td><td colspan="2"></td><td colspan="2"></td></tr>
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<tr><td>Impression</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Working diagnosis:

Management plan:

Treatment advice:

Follow-up schedule:

Annexure 2

Glaucoma—Intervene to Make a Difference

Glaucoma has a notorious character and could either be very much underdiagnosed or overtreated.

The main goal in glaucoma treatment is to keep asymptomatic glaucoma, asymptomatic, throughout life, or to contain the progression of symptomatic glaucoma. The following pointers can be kept in mind for the holistic management of glaucoma:

- Regular assessment and follow-up cannot be stressed more.
- Rather than getting too rigid with intraocular pressure (IOP), the optic nerve should be focused on.
- What's progressive should be arrested or slowed down and what's static can be safely observed.
- The pros and cons should be measured in every patient's case prior to initiating treatment.
- Intervention is advocated when things appear progressive, expected life-span is enhanced, and the case is absolutely unambiguous.
- More observation and less unnecessary treatment should be the motto.
- Serial follow-up is the key for everything; starting treatment at the earliest suspicion is secondary.

With current generation of imaging modalities and awareness of preperimetric glaucoma, caution is warranted. In case of lack of sophisticated instruments, taking a disc photo and serially following it up, is the best option. Also, overdiagnosis is common with these machines, especially due to the different disc sizes and shapes and limited database of the machines. The general opinion is that doctors are either over treating at initial stage or undertreating at later stages, where it really matters. Regular assessment and judicious treatment at initial stages and advanced treatment at later stages is required.

It is important to note that glaucoma is a costlier disease than cataract. Cost required for initial work-up, regular medications, leave from job for regular follow-up, cost of follow-up investigations, disability due to glaucoma and subsequent loss of wages, and surgeries at later stages (multiple)—everything add up.

The psychological impact in few patients is also high. Fear of impending blindness, especially when someone familiar to the patient is already in the advanced stage, can be very disturbing for the patient. It is important to convey the correct information to the patient, so that they learn to live with glaucoma just like any other chronic disease such as diabetes and systemic hypertension. Irrespective of their complaints at the eye care set-up, glaucoma screening with optic disc examination should be done in each patient. Good 90 D examination, close watch for Van Herick, and cross-checking of IOP with applanation method goes a long way in identifying obvious glaucoma cases and also those having risk of developing glaucoma. So, it is not surprising if a patient takes legal action against his eye specialist for not detecting the disease at the right time.

PATHOPHYSIOLOGY OF DOCTOR-PATIENT CONFLICTS IN OPHTHALMOLOGY

Recently, there have been incidences of violence against doctors in wake of adverse results after the treatment and it is increasing day by day. Having spent almost about a decade in

Content supported by Dr. Pankaj Bendale, Chief of Glaucoma Services & Adult Cataract Consultant, National institute of Ophthalmology, Pune

the profession, I can very well say that there are certain situations when these incidences can take place.

Firstly, exaggerating results of treatment in wake of heavy competition, down-playing the dark side of every procedure then failing to achieve these goals is unscientific. For e.g., cataract surgery is just a 10-min job after which you immediately get clear vision; there is no need for glasses and the recovery is immediate. But in reality, there are various grades of cataract. Each eye is unique and everybody's visual needs are different. Pre-existing cylindrical number also matters and even with multifocal intraocular lens (IOL), some may still need glasses for near vision. Amount of money spent on the surgery should be directly proportional to a better or best outcome after the surgery. This, sometimes, creates conflicts. If cataract surgery does not go smooth for various reasons like weak zonules and vitreous loss then that delays visual recovery and the patient may need additional interventions and despite best efforts, visual outcome can be subnormal from mild to severe grade. All these issues are not highlighted due to fear of losing the patient. Heavy investment, intense competition, rapidly changing technology platforms, changing dynamics of marketing in medical fields, and professional rivalry affects the clinical scenario and practice patterns of every eye specialist resulting in varied management opinions. This situation can be extremely confusing for patients leading to ambiguity and loss of faith in the healthcare system.

Well-balanced communication is the key for every situation and there is no substitute for it. Before signing consent for surgery, the patient and his relatives should be fully aware of all the factors related to it. This should be the main focus of counseling rather than paying attention on the mode of payment, cost of surgery, etc. which mars the discussion agenda.

TEST YOURSELF

1) Which previous test gives the best assessment about glaucoma progression after current examination in diagnosed- and on-treatment glaucoma patients?
   a. Baseline disc photo
   b. Baseline perimetry
   c. Baseline optical coherence tomography (OCT)
   d. Baseline ganglion cell complex (GCC) analysis

2) How to stage severity of glaucoma in clinical practice?
   a. Clinical disc examination
   b. Perimetry
   c. Optical coherence tomography
   d. Intraocular pressure

3) When can stop-trial of anti-glaucoma medications (reverse therapeutic trial) given?
   a. Efficacy of particular molecule is in doubt
   b. Optic nerve and perimetry stable for long time without progression to reassess baseline IOP and titrate therapy
   c. Allergic reaction to particular molecule suspected
   d. All of the above

4) How to conduct first counseling for glaucoma patient?
   a. You can skip your meal but not drops otherwise you will go blind
   b. Henceforth, regular lifelong check-up and adjustment to treatment is required
   c. This drop should be used lifelong
   d. This is a chronic disease just like hypertension and diabetes. Do not panic. You will need regular medication and reassessment. At the same time, the patient should not take this disease casually as it can cause irreversible damage to the eye sight. Most patients can be easily treated with eye drops. Timely surgeries also help in this disease but not after the end stage of the disease.

Answers: 1 (b), 2 (a), 3 (d), 4 (d)

GONIOSCOPY

The illumination and slit height are increased to constrict the pupil, and "indentation" is performed with the gonioscope to study the angle further. Peripheral anterior synechiae (PAS), trauma, old hemorrhage, inflammation, or new vessels might be detected. If other signs are absent, angles are open and considering disc and/or field changes, primary open-angle glaucoma (POAG) is confirmed (Figs. 1–12).

Fig. 1: Grade 0-Schwalbe's line not seen.

Content supported by Dr. Gowri J Murthy, Senior Consultant, Glaucoma Services, Prabha Eye Clinic and Research Centre; Vittala International Institute of Ophthalmology, Bengaluru and Dr. Thomas George, Senior Consultant Ophthalmologist, Cosmopolitan Hospital, Thiruvananthapuram.

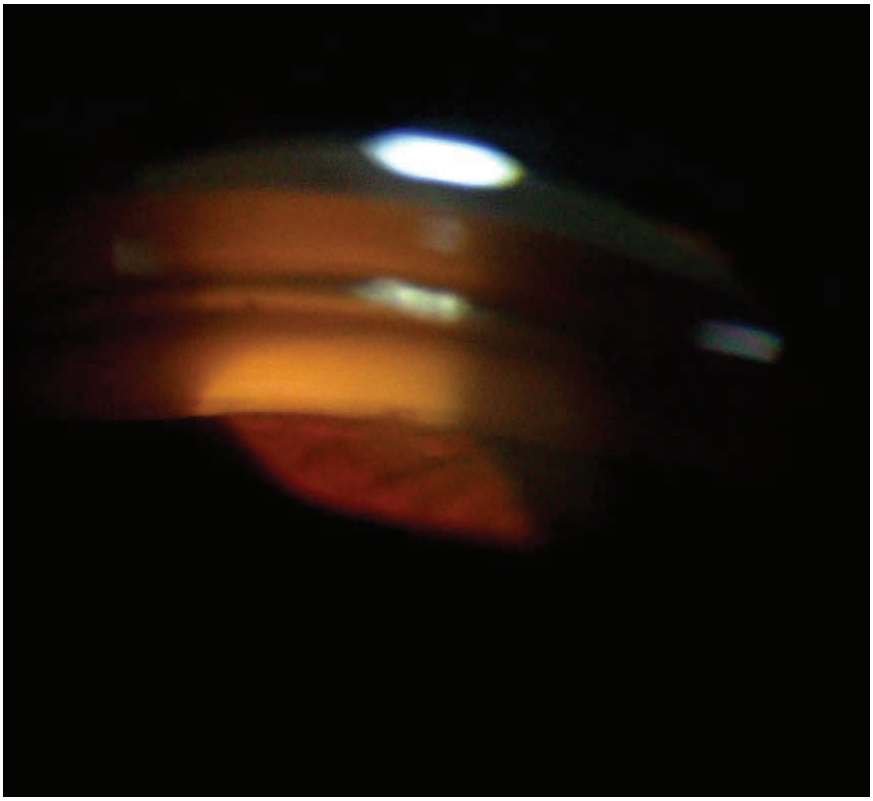


Fig. 2: Grade 2-anterior trabecular meshwork seen.

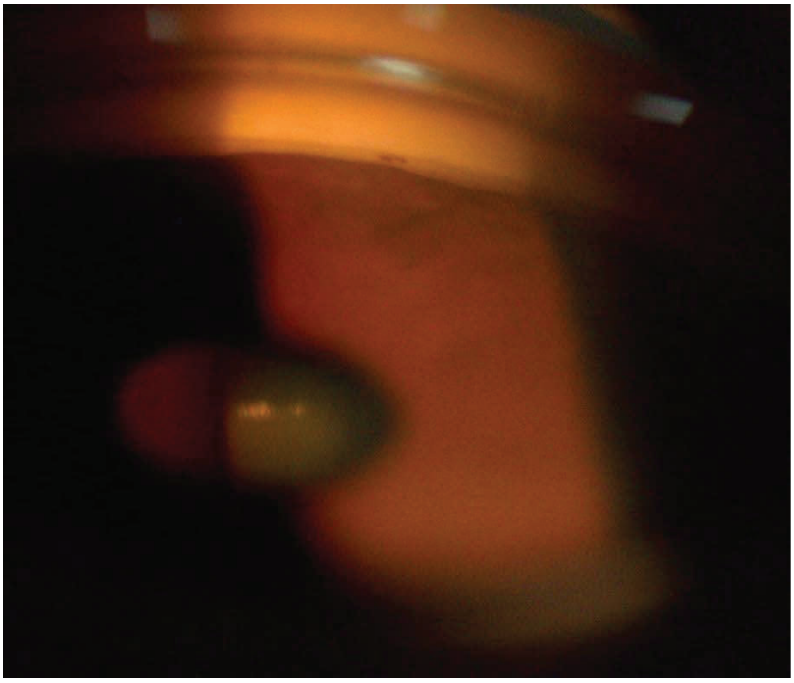


Fig. 3: Grade 3-mid trabecular meshwork seen.

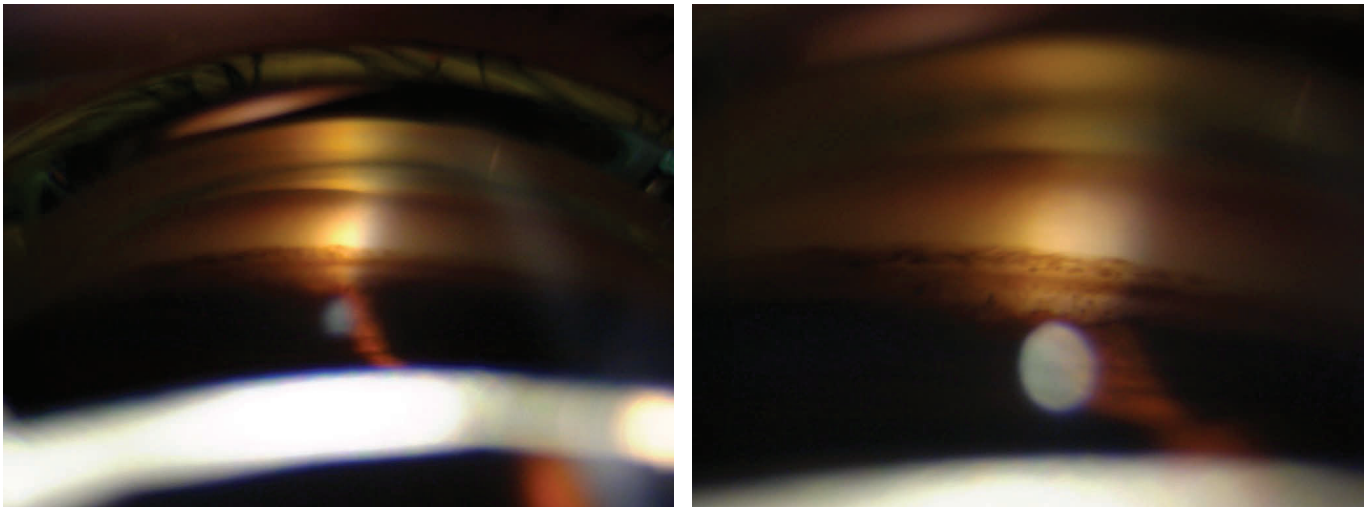


Fig. 4: Open-angle with pigmentation.

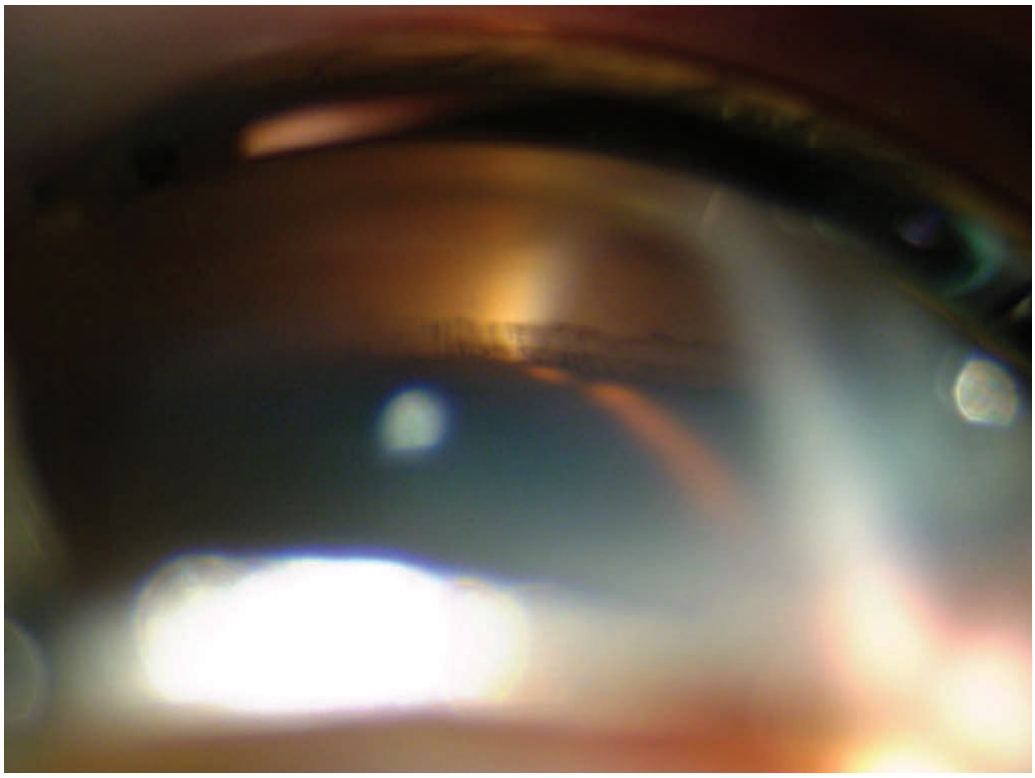


Fig. 5: Blotchy pigmentation in angle-closure glaucoma.

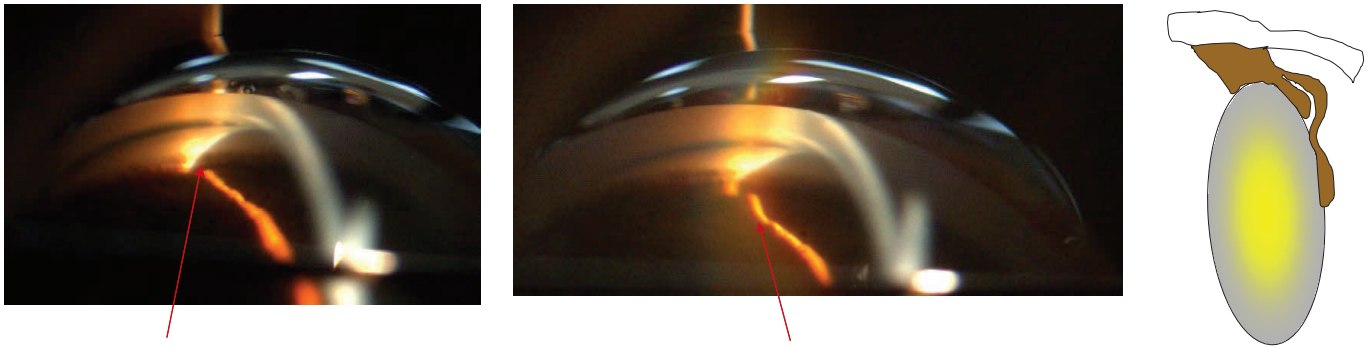
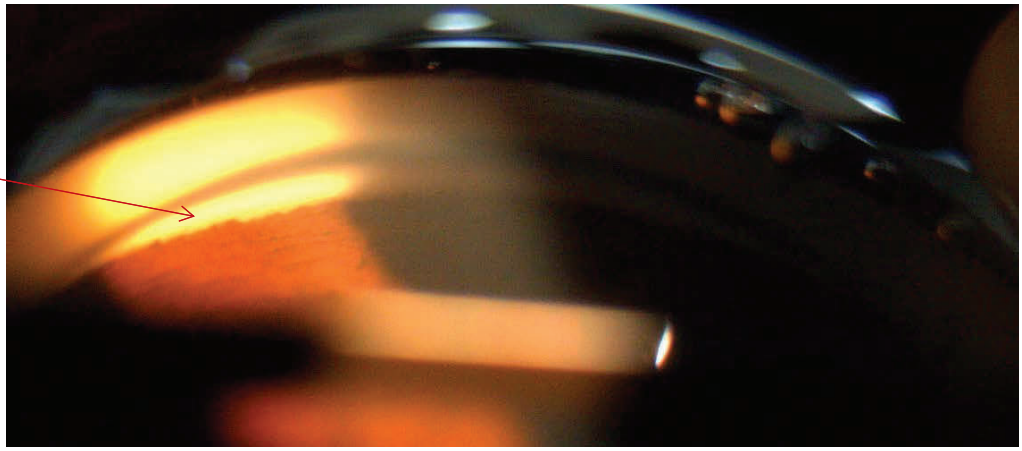


Fig. 6: Plateau iris configuration.

- Inflammatory
  - Irregular
  - More inferiorly



- Differentiate from iris processes (normal)

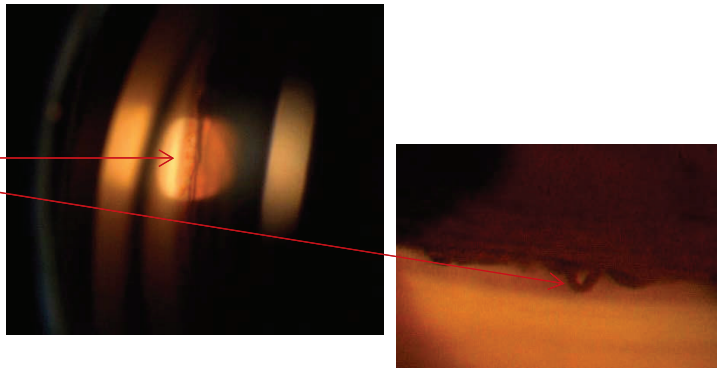


Fig. 7: Synechiae.

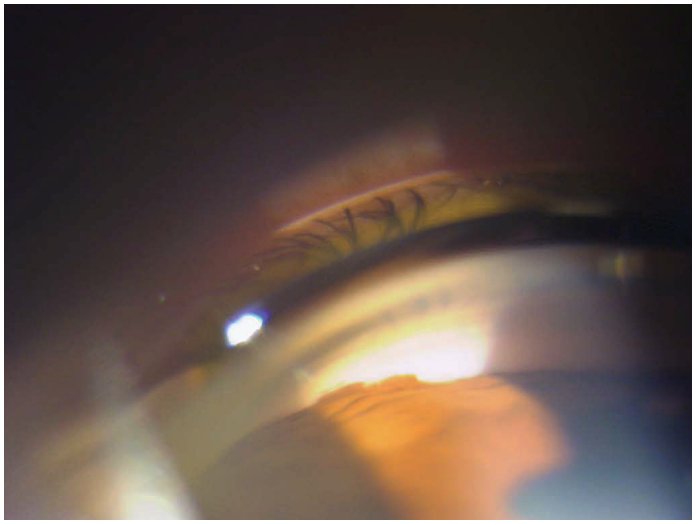


Fig. 8: Peripheral anterior synechiae on indentation.

- Recession
  - Wide ciliary body band
  - Torn iris processes

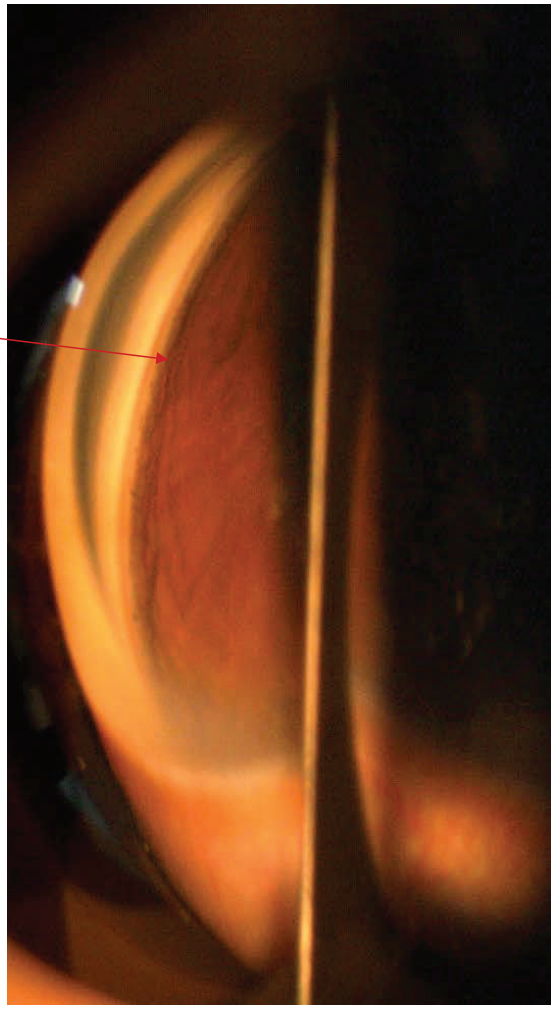


Fig. 9: Recession after trauma.

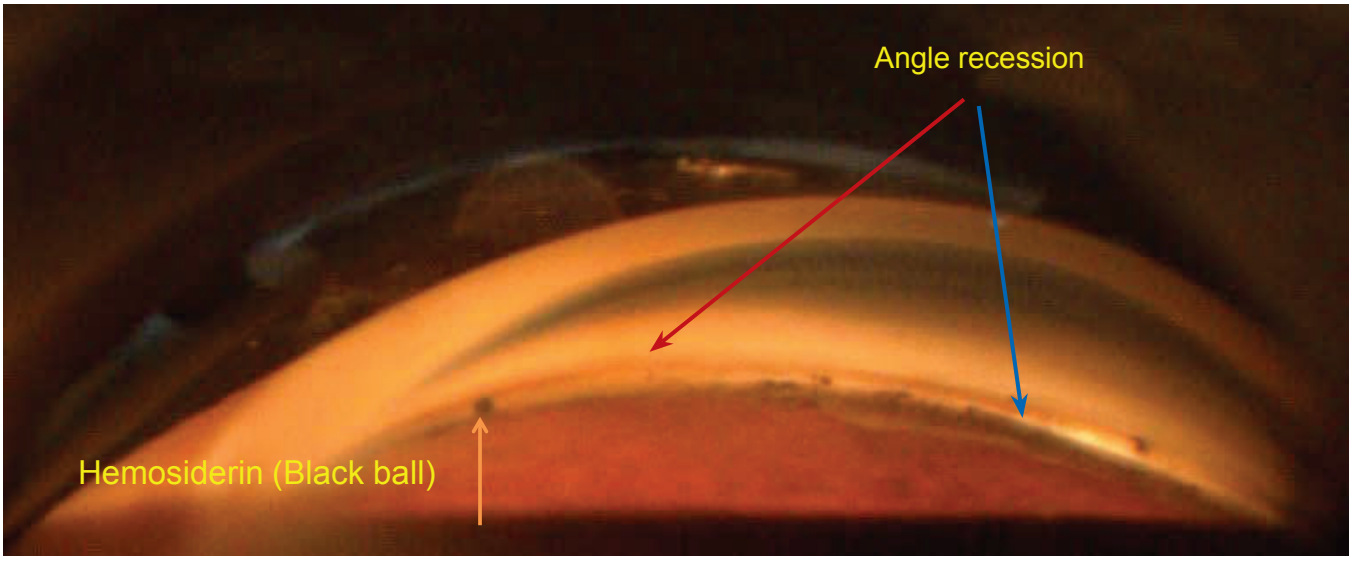


Fig. 10: Remnants of hyphema.

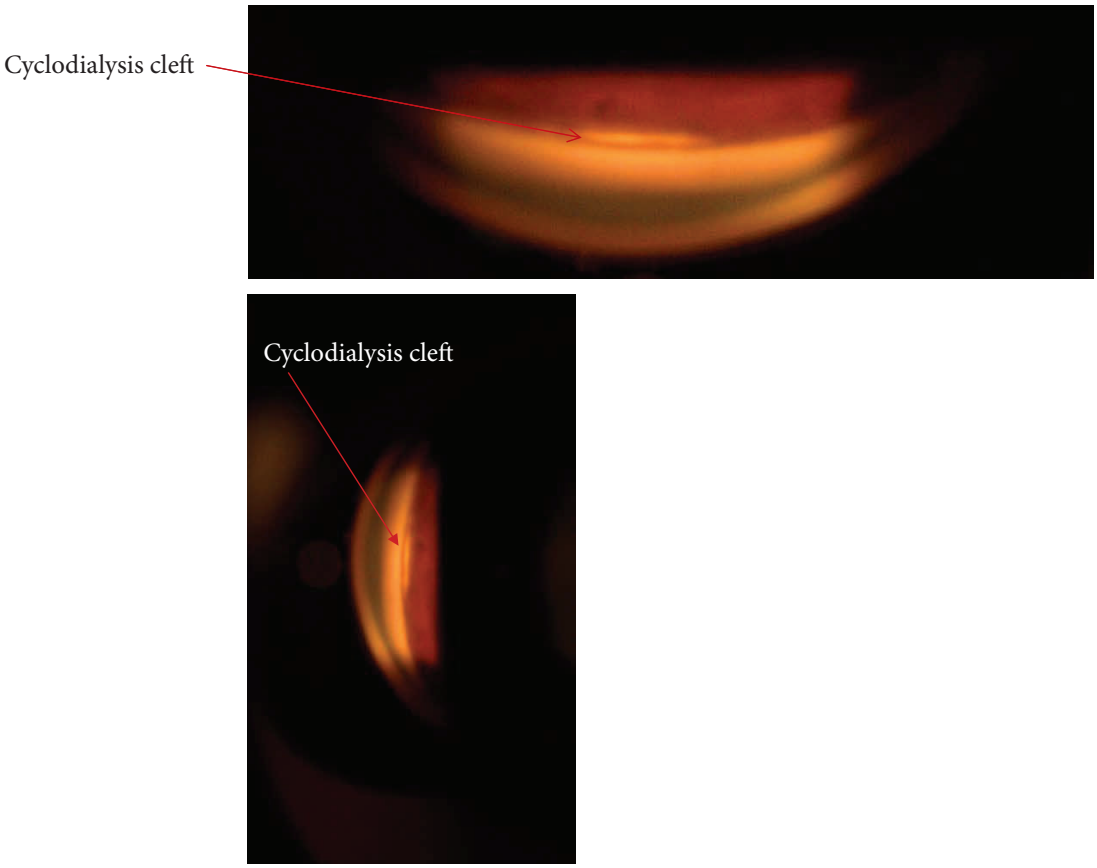


Fig. 11: Cyclodialysis cleft.

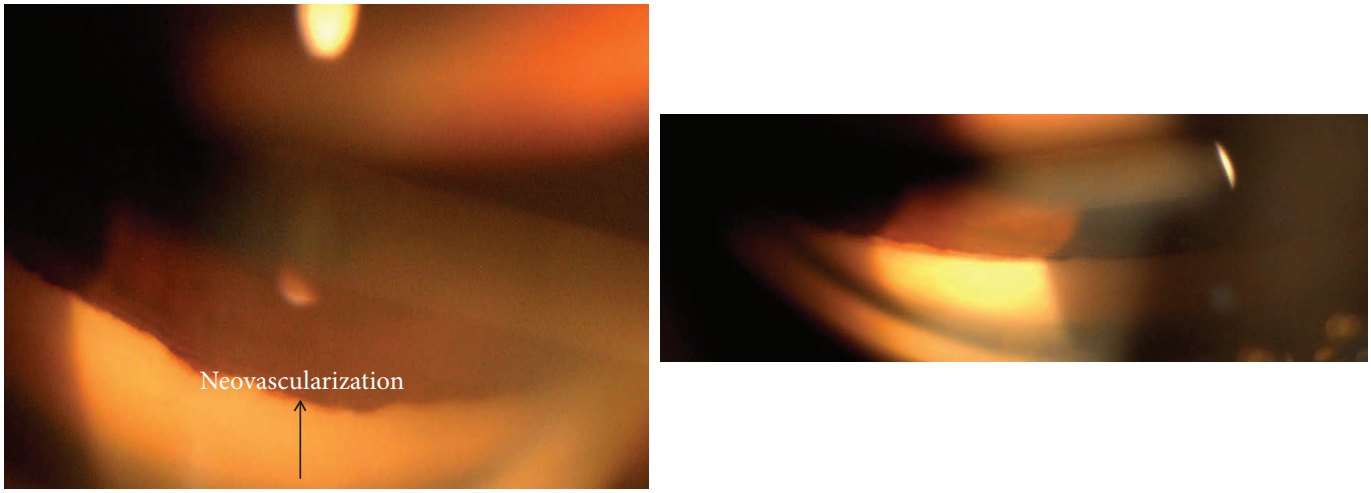


Fig. 12: Neovascular glaucoma.

SUPPLEMENTARY MATERIAL

Visual Field Examination

PERIMETRY FOR PRACTITIONERS-DECODING A PERIMETRY ANALYSIS

Zone 1: Patient Data and Test Data (Fig. 1)

- Patient data
- Name of the patient
- Date of birth-age
- Pupil diameter
- Visual acuity (VA)
- Refractive error correction

Test Data

- Fixation monitor-blind spot
- Fixation target-central
- Background illumination
- Stimulus size
- Test pattern
- Test strategy

Zone 2: Did the Patient Perform Well?

- Foveal threshold
- Reliability indices

Fixation Monitor: Gaze/blind Spot

- Fixation target: central
- Fixation losses: 2/14
- False positive errors: 0%
- False negative errors: 0%
- Test duration: 4:40

Foveal Threshold (FT)

- Checked at the beginning of the test.
- Importance—VA: good, FT: reduced suggests improper refractive correction.

Fixation Losses

- During the test: 5% of the stimuli are presented to the blind spot.
- Patient's response to these stimuli is due to a loss/shift of fixation.

Heijl-Krakau Method

- Central fixation check-presents stimuli at the center of the grid 8 dB brighter than the measured central threshold value; no response: recorded as false.
- Fixation losses >20%—unreliable.

False-positive Response (Fig. 2)

- Patient presses the response button to a non-projected stimulus.
- Patient responds to sound without an accompanying light stimulus.
- Up to 20% is considered acceptable.
- >30% false positive rate: 'XX'.
- White scotomas—areas of abnormally high retinal sensitivity.

False-negative Response (Fig. 3).

- Failure to respond to the brightest stimulus in an area previously determined to have some sensitivity.
- >20% false negatives is considered abnormal but the machine defaults up to 33%.
- Can happen due to fatigue and lack of attentiveness.
- Fields should not be considered unreliable only based on a high false-negative rate.
- Especially in patients with advanced glaucomatous damage—>50% false-negative responses.
  - Small shifts in fixation

Content supported by Dr. Sushma Tejwani, Consultant and Head of Glaucoma Services, Narayana Nethralaya-2, Bengaluru

Clover-leaf defect

Sometimes perimetry shows significantly advanced damage that does not correlate (Fig. 4a). Patients responded to the initial part of the test, hence, the central points that are checked first are mapped well and later patient losses attention and the points appear as blind spots (Fig. 4c).

No blind spot!!

Unreliable fields (Fig. 4b) are suggestive of poor fixation by the patient and, thereby, give falsely better fields; happens usually when patient is following the light stimuli (Table 1).

At times, there is indication of poor fixation by the patient which could lead to falsely better fields, which happens usually when patient is following the light stimuli. (Fig. 4d)

Table 1: Potential source of errors.

Technician criteria	Patient criteria
1) Age not correctly entered 2) Refractive error correction not used 3) Pupil size <3 mm 4) Improper positioning of the patient's head 5) Foveal threshold not measured at the beginning	1) High fixation losses 2) High false-positive errors 3) High false-negative errors 4) Poor gaze tracking 5) White scotomas 6) Clover-leaf 7) Rim artifact 8) Learning curve

Zone 3: Raw Data (Fig. 1)

Exact retinal sensitivity at selected points

- The values can be compared with normal to judge depressed retinal sensitivity.
- Scotoma determined by comparing with the surrounding points.

Zone 4: Gray Scale (Fig. 5)

- Gross representation of the visual field (VF).
- Decreased sensitivity is represented by darker tones.
- Each change in gray scale tone corresponds to a 5 dB change in threshold.

Zone 5: Total Deviation Plot (Fig. 6)

Point by point difference from the expected value for age-related normal. Pay attention to the number and pattern of the symbols.

Zone 6: Pattern Deviation Plot (Fig 7)

This reveals focal defects after adjusting for the overall sinking or elevation for the hill of the vision.

Zone 7: Global Indices with Visual Field Index

Global indices	
Visual field index (VFI)	100%
Mean deviation (MD)	-0.11 dB
Pattern standard deviation (PSD)	1.36 dB

All the information from all the points tested is reduced to single numbers.

Zone 8: Glaucoma Hemifield Test (Fig. 8)

Machine compares points on either side of horizontal meridian in these zones and presents the results that are indicative for glaucoma.

Anderson's Criteria for Glaucomatous Defects (Fig. 15)

- Pattern deviation plot
  - Three or more non-edge points with p <5%
  - One point p <1%
  - Cluster in arcuate area
- Corrected pattern standard deviation (CPSD) or pattern standard deviation (PSD) <5%
- Abnormal glaucoma hemifield test (GHT)

For examples of normal and defective visual fields, refer to Figures 9–23.

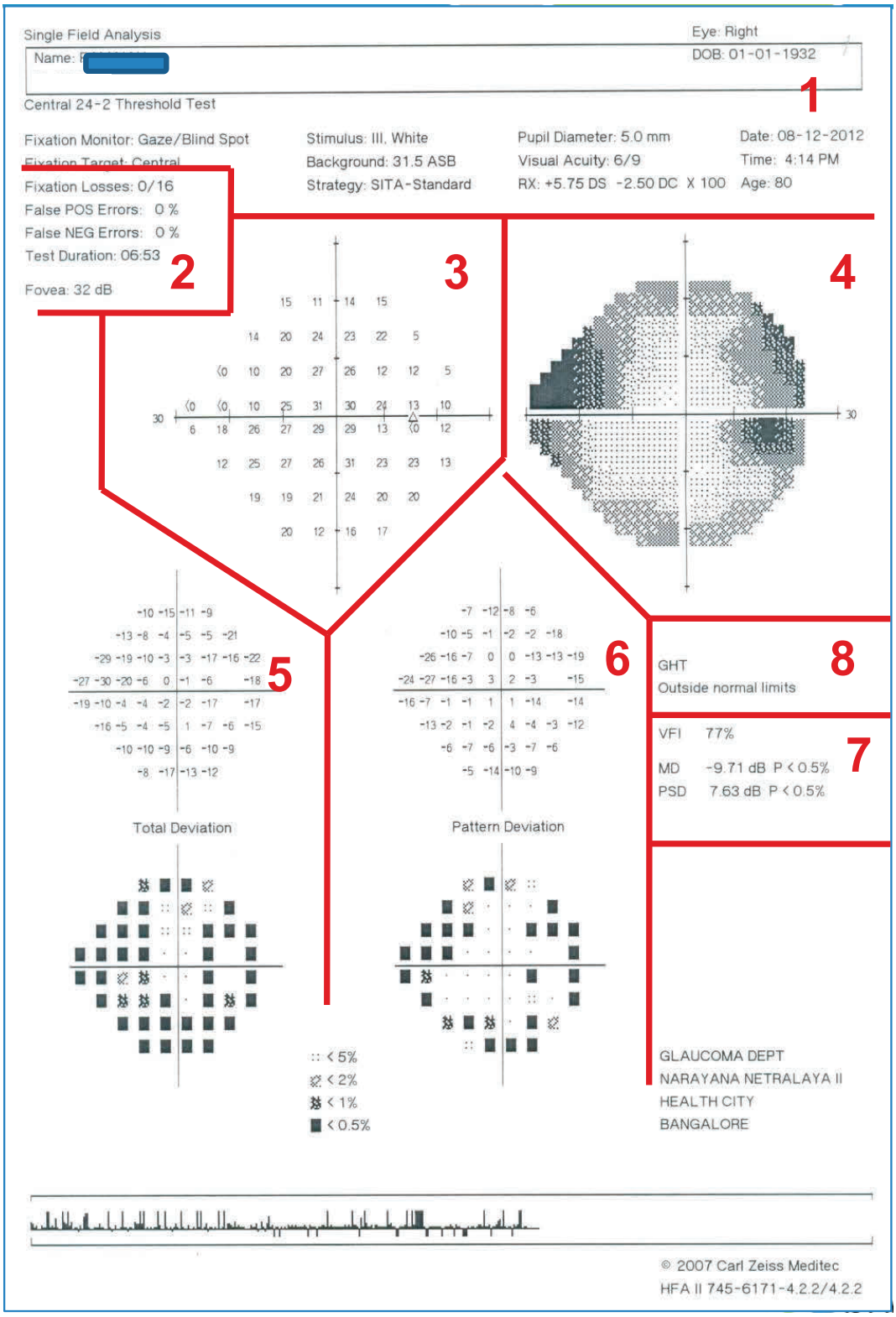
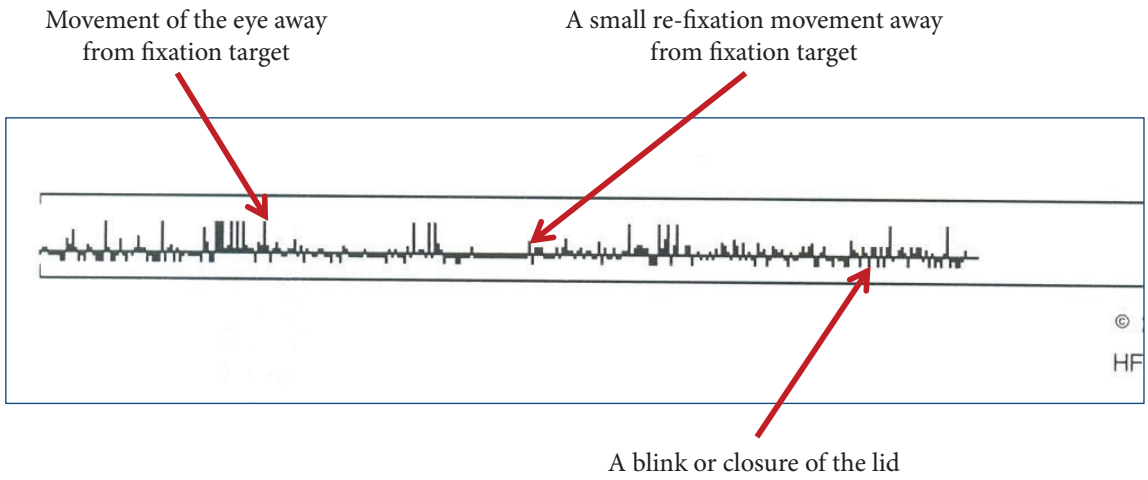
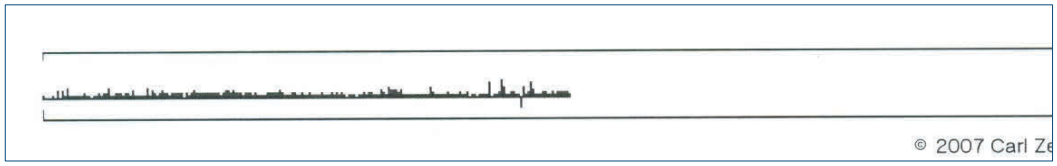
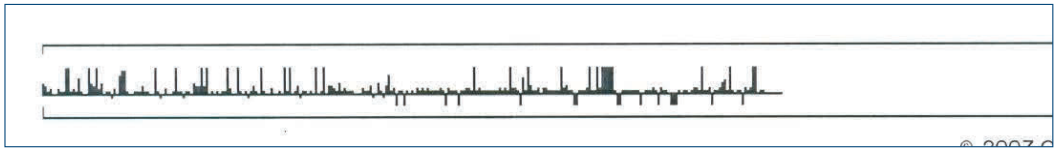


Fig. 1: Decoding a perimetry analysis.

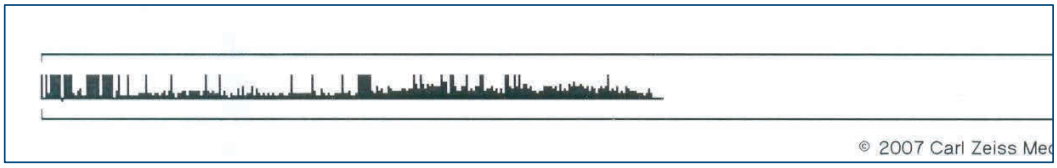




Exemplary

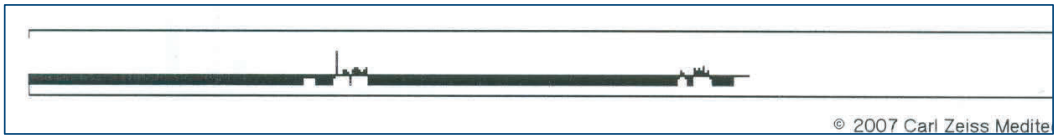


Mostly okay



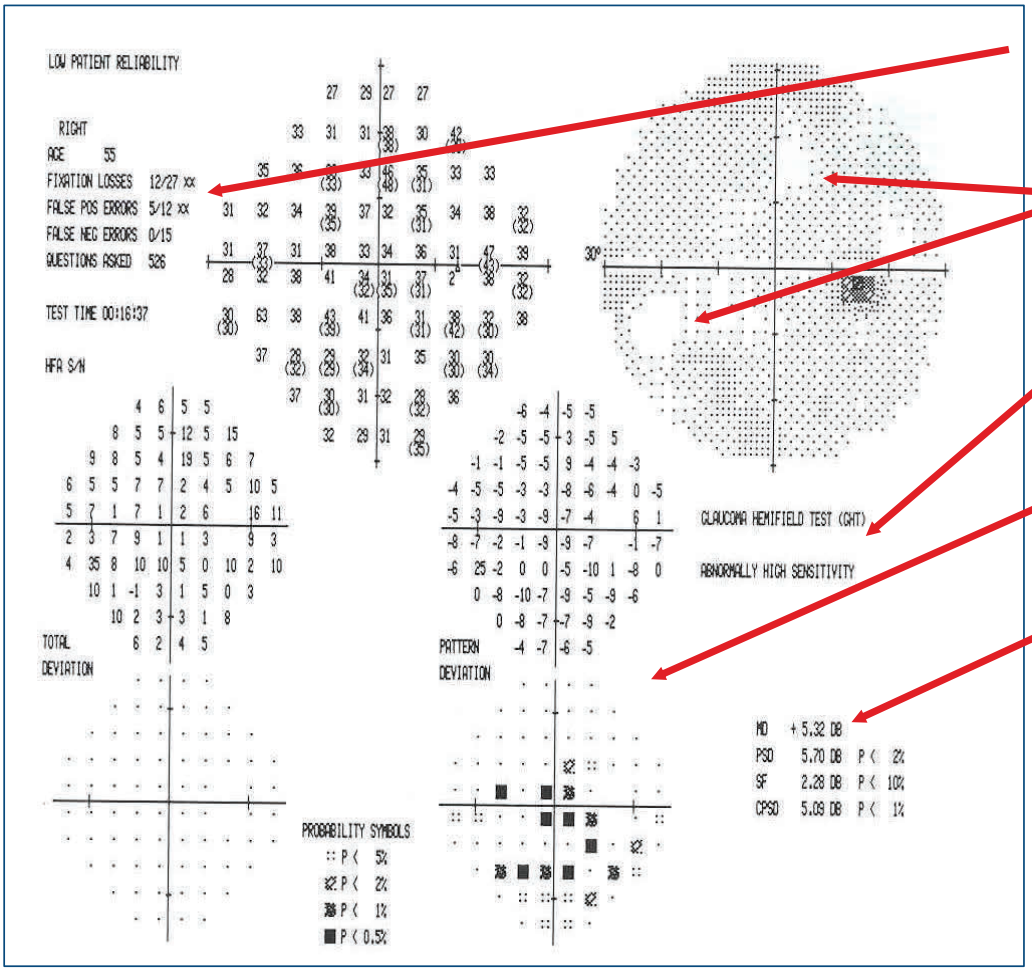
Initially shaky and then acceptable

Fixation losses throughout the test



Patient performing fields in dreams

Fig. 2: Gaze track monitor.



Elevated false-positive (FP) catch trials

White scotomas

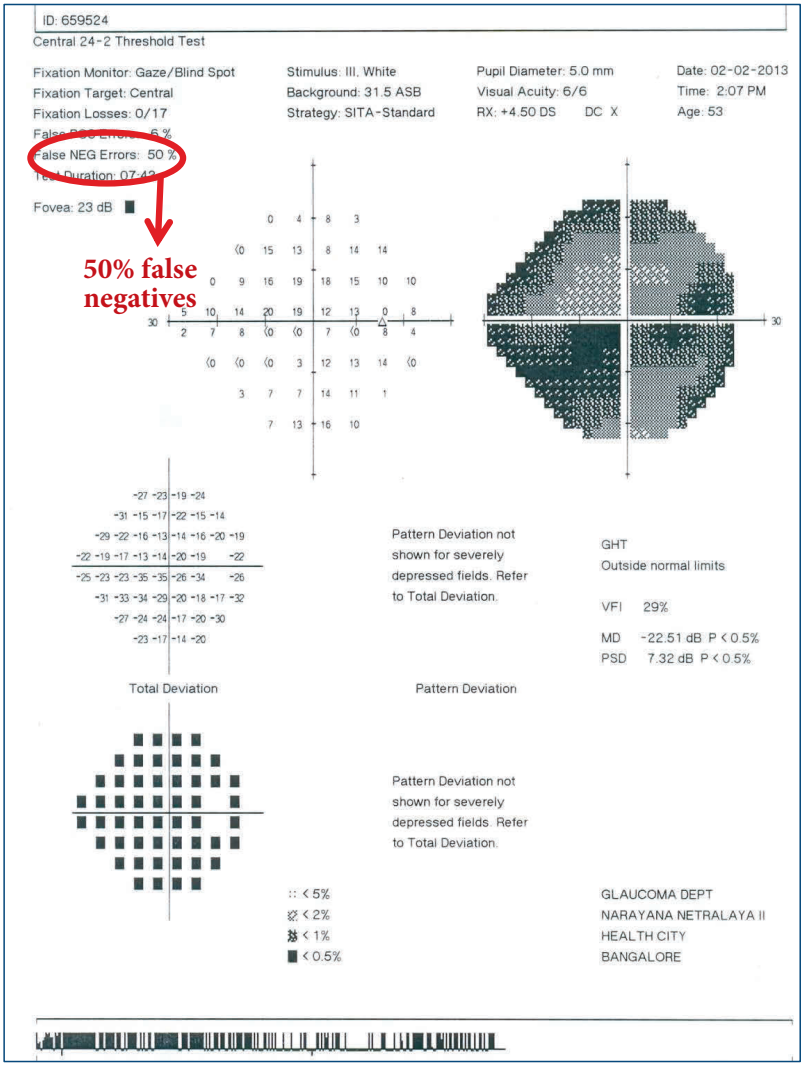
Glaucoma hemifield test (GHT) positive

Pattern deviation (PD) worse than total deviation (TD)

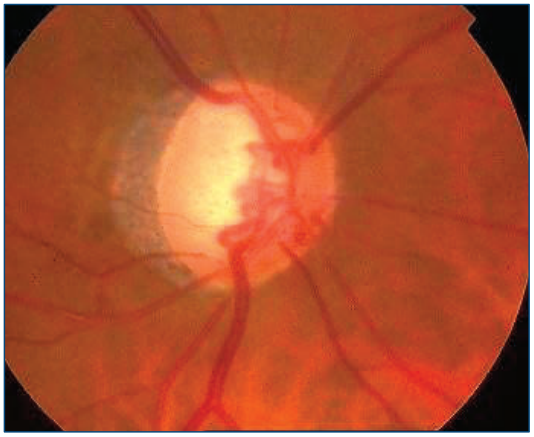
High positive mean deviation (MD)

Implication:
Useless result
Plan: Re-instruct; re-test

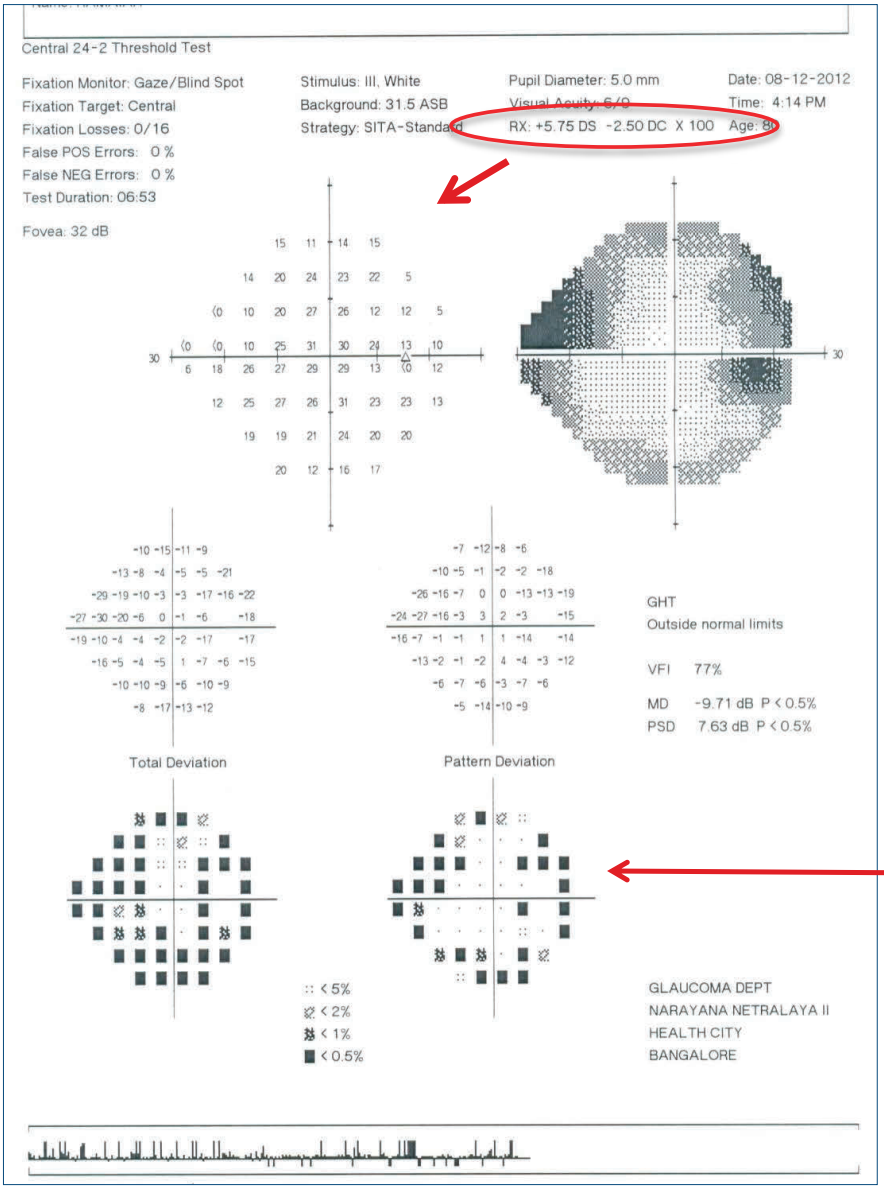
Fig. 3: High false positive responses.



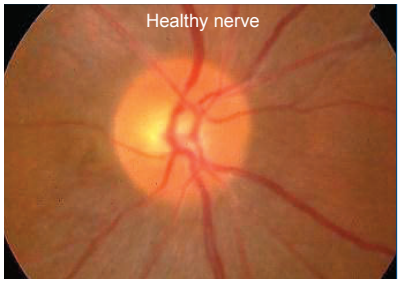
(a)



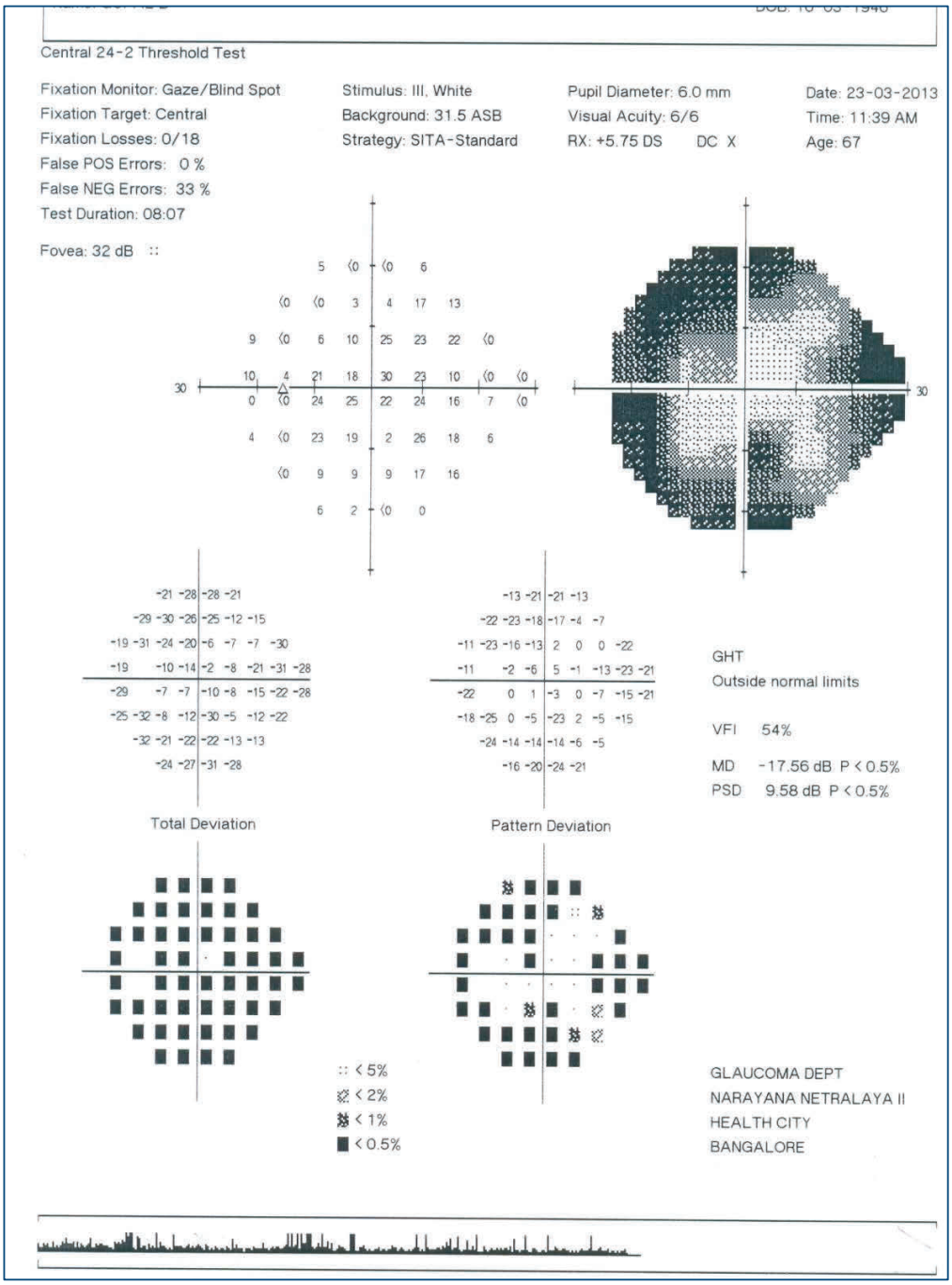
Disc shows a cup-to-disc ratio (CDR) of 0.7 with sloping inferior and superior rims.



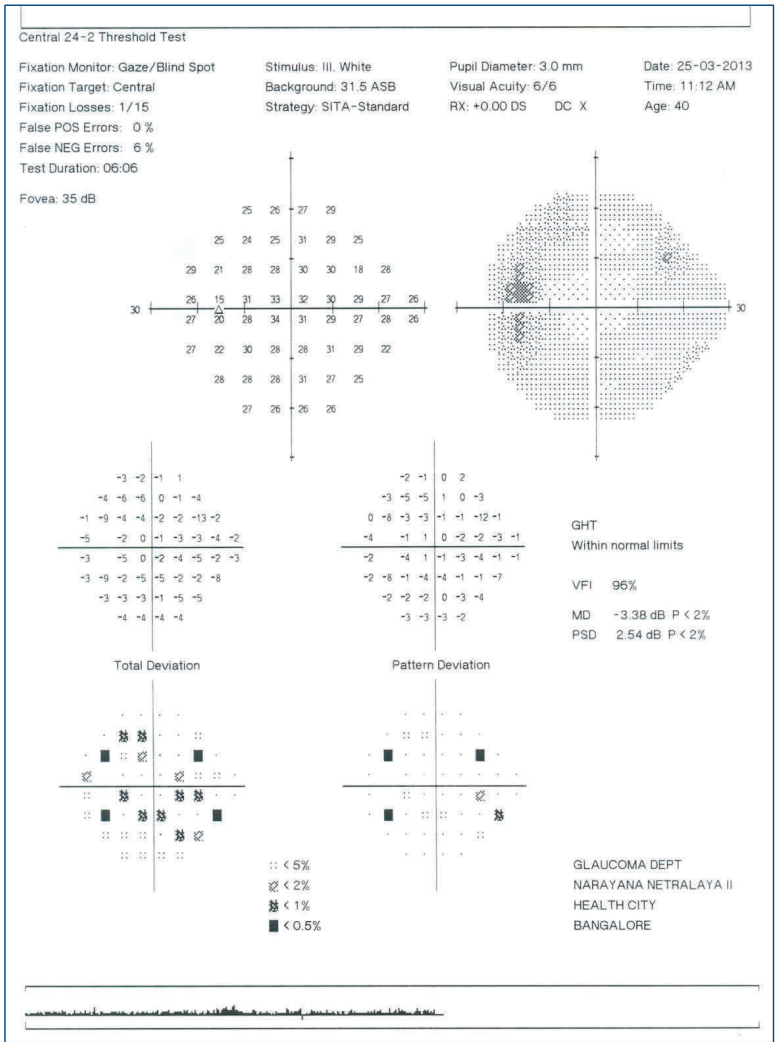
Rim artifact



(b)


Central 24-2 Threshold Test
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 0/18
False POS Errors: 0 %
False NEG Errors: 33 %
Test Duration: 08:07
Fovea: 32 dB ::
Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard
Pupil Diameter: 6.0 mm
Visual Acuity: 6/6
RX: +5.75 DS DC X
Date: 23-03-2013
Time: 11:39 AM
Age: 67
GHT
Outside normal limits
VFI 54%
MD -17.56 dB P < 0.5%
PSD 9.58 dB P < 0.5%
Total Deviation
Pattern Deviation
:: < 5%
< 2%
< 1%
< 0.5%
GLAUCOMA DEPT
NARAYANA NETRALAYA II
HEALTH CITY
BANGALORE

(c)



(d)

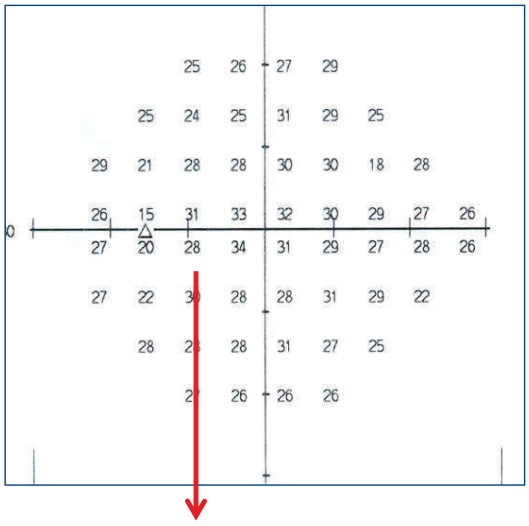


Fig. 4: (a) Unreliable fields. (b) Unreliable fields: rim artifact. (c) Unreliable fields: Clover-leaf defect. (d) Unreliable field: no blind spot.

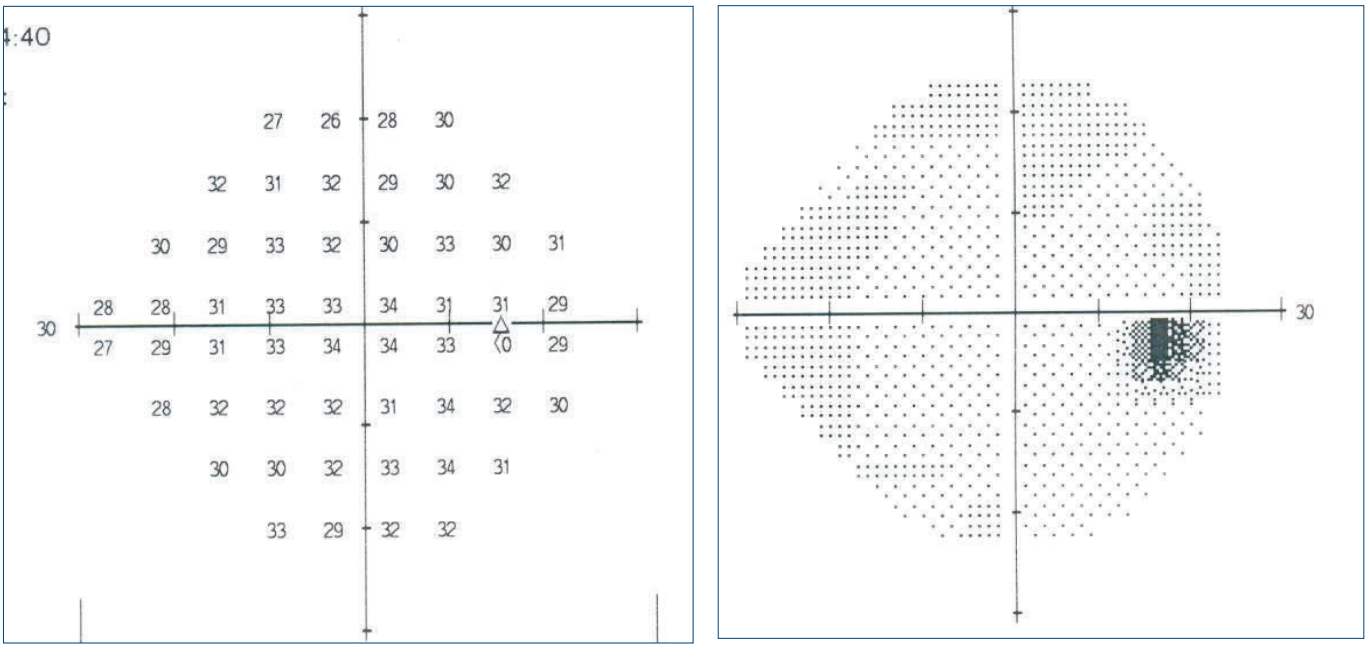


Fig. 5: Zone 4: Gray scale.

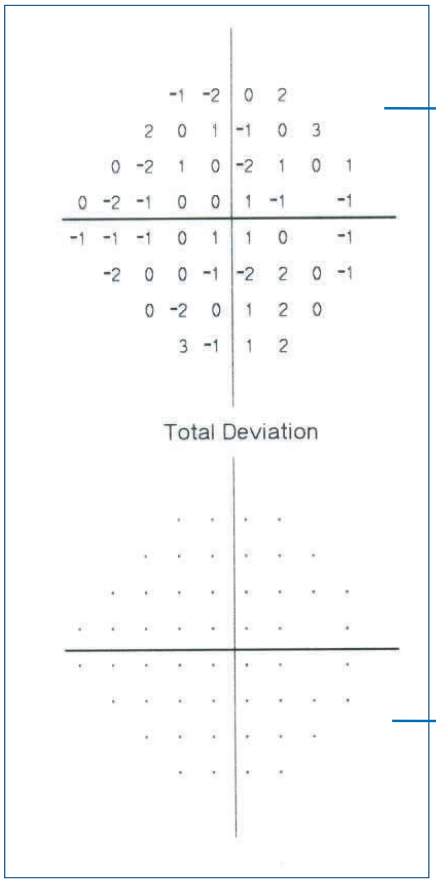


Fig. 6: Zone 5: Total deviation plot.

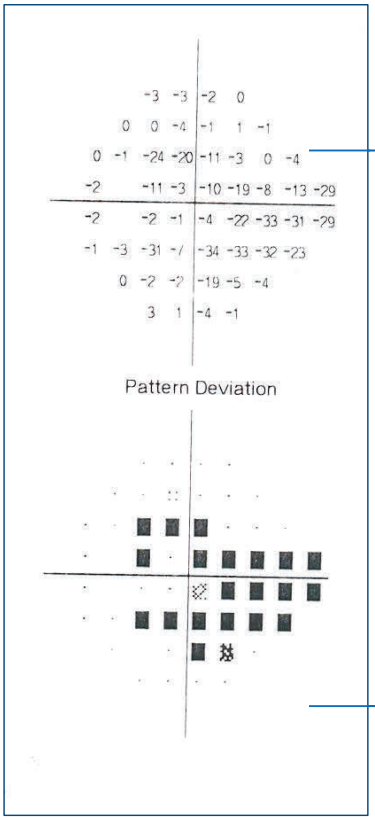


Fig. 7: Zone 6: Pattern deviation plot.

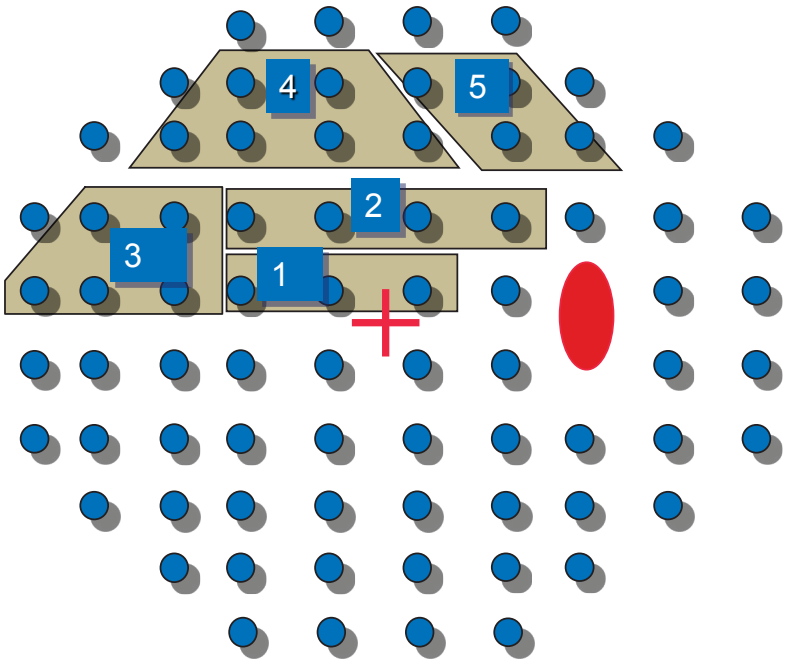
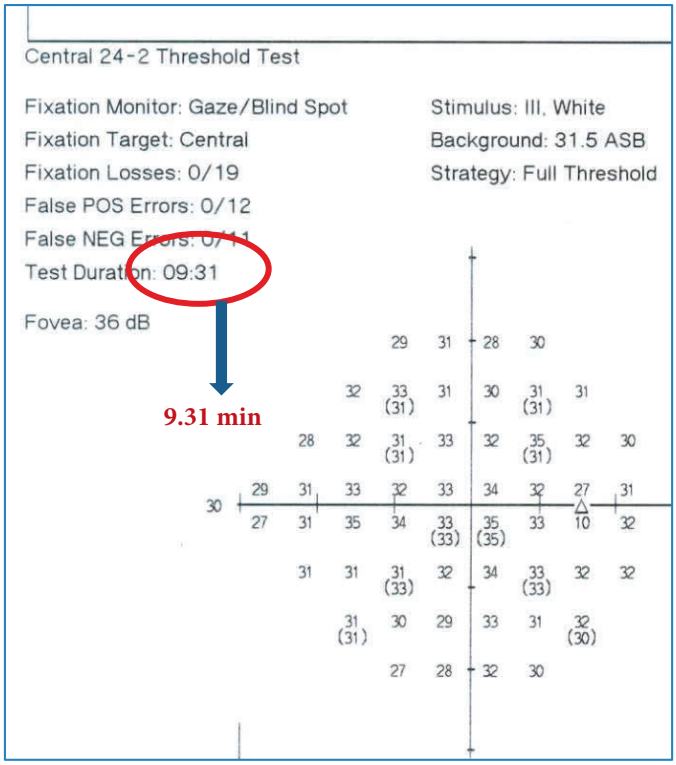
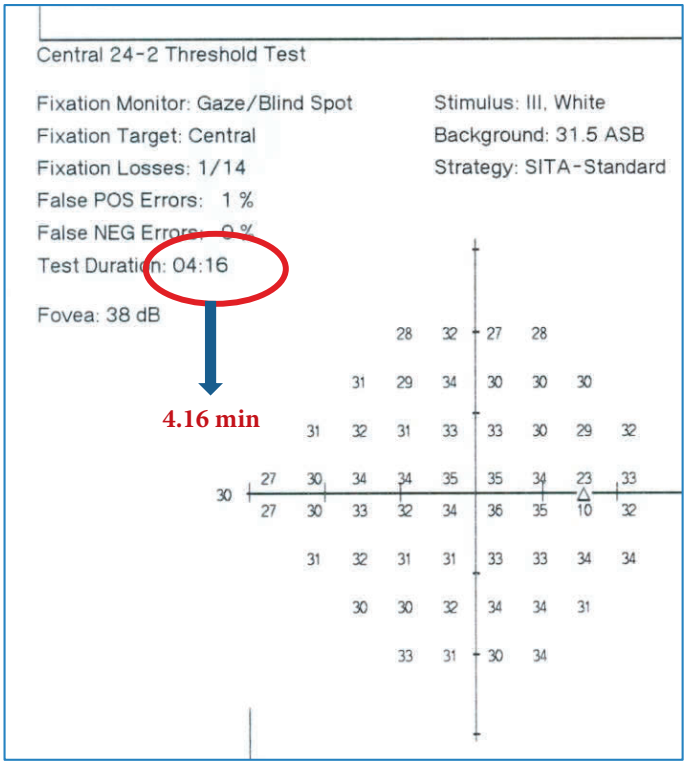


Fig. 8: Zone 8: Glaucoma hemifield test.

Full threshold



SITA standard



SITA fast

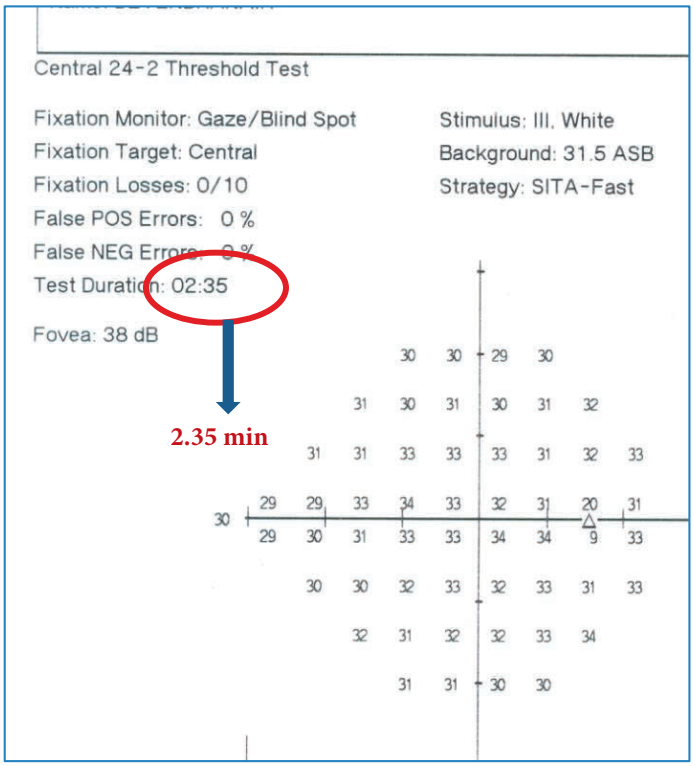


Fig. 9: Time for fields for the same patient with different strategies.

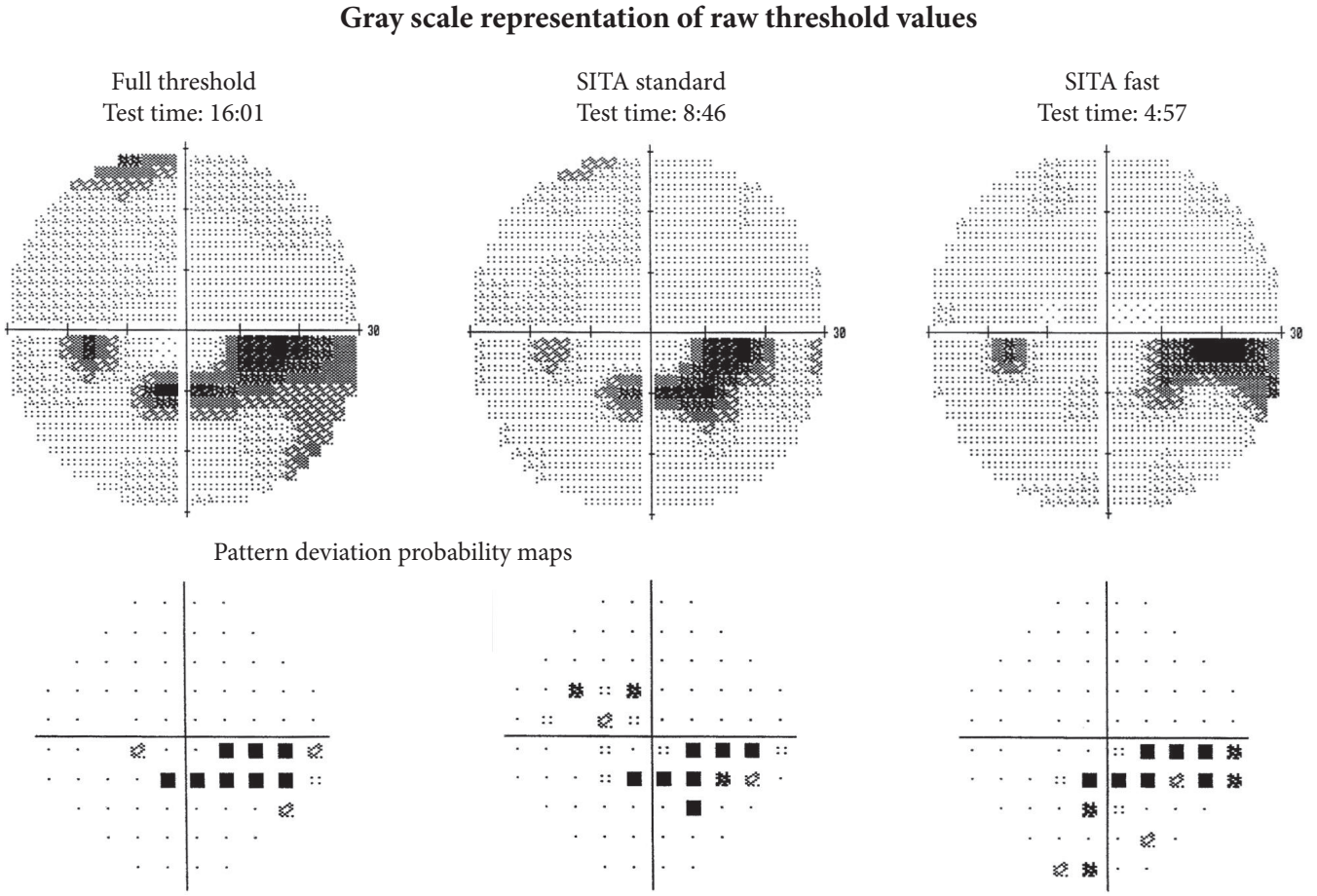
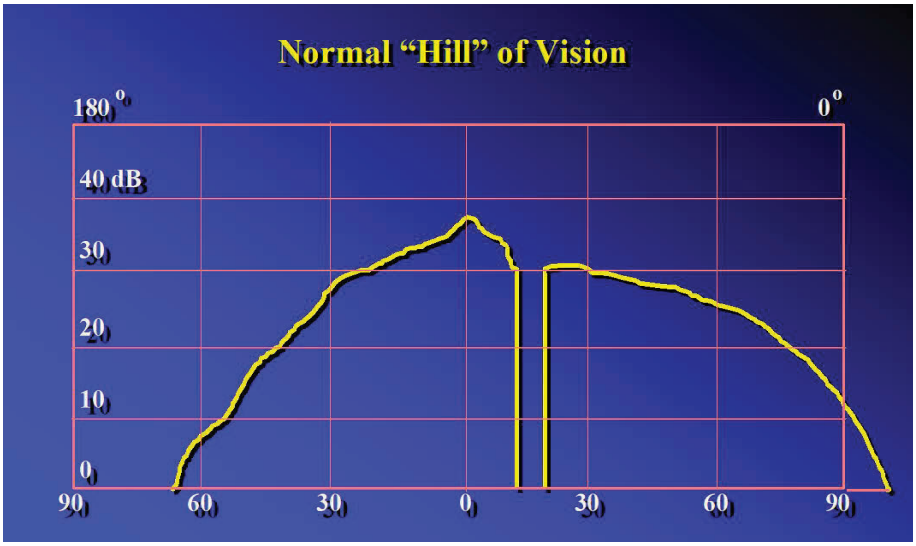


Fig. 10: Same eye: different test programs.



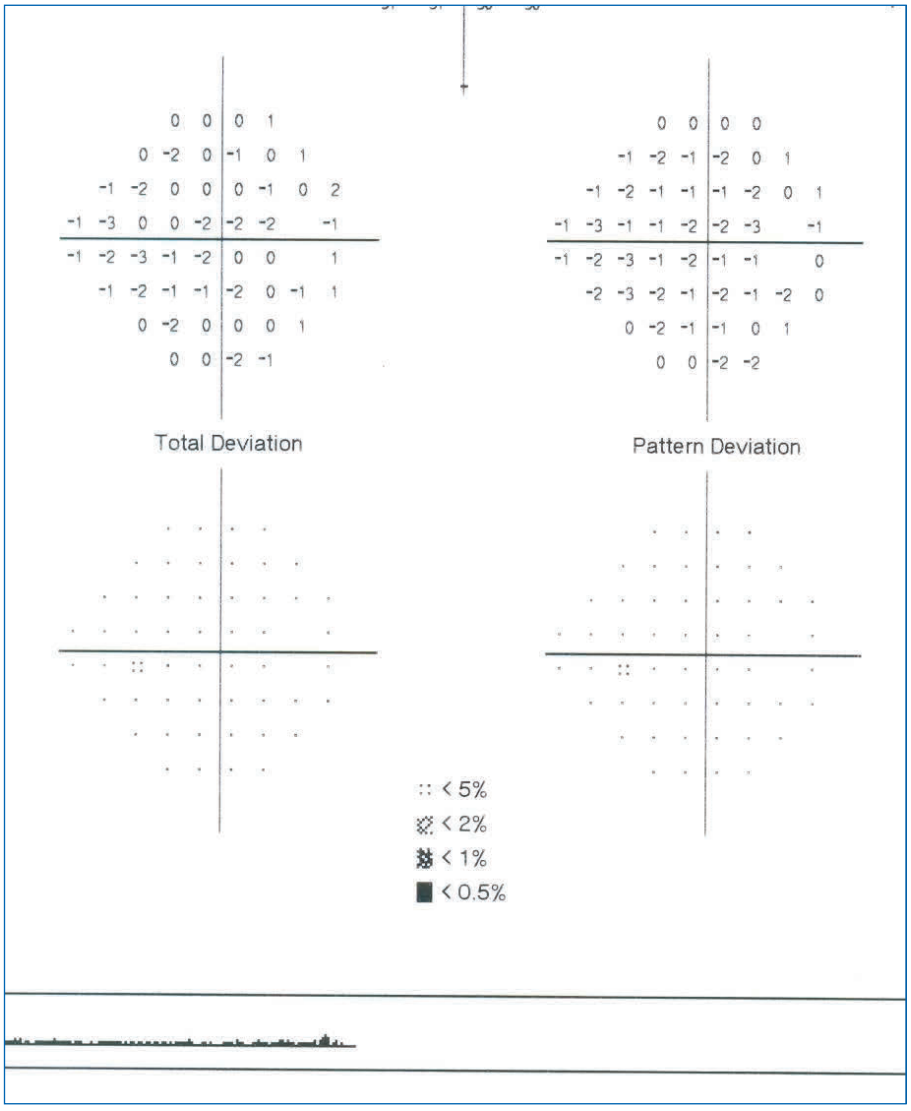
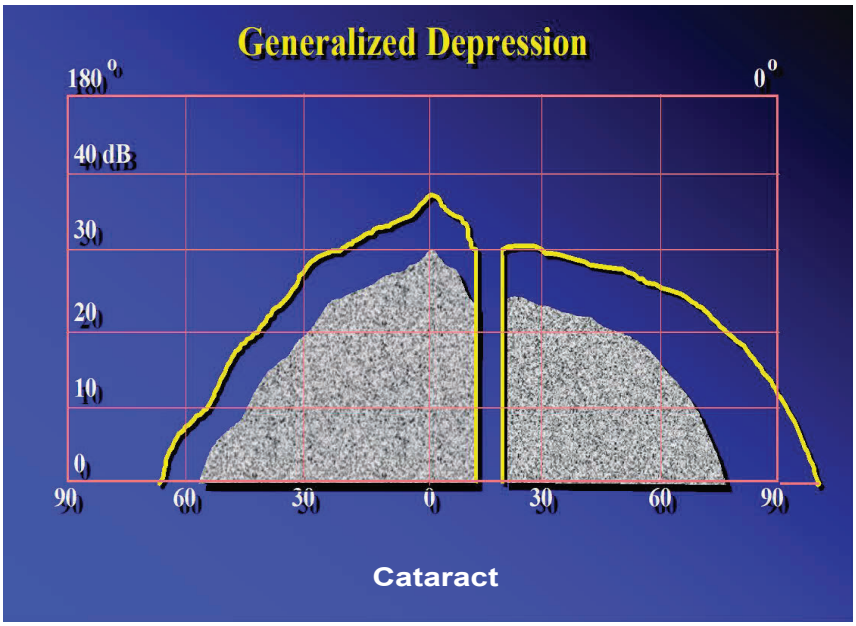


Fig. 11: Normal fields.



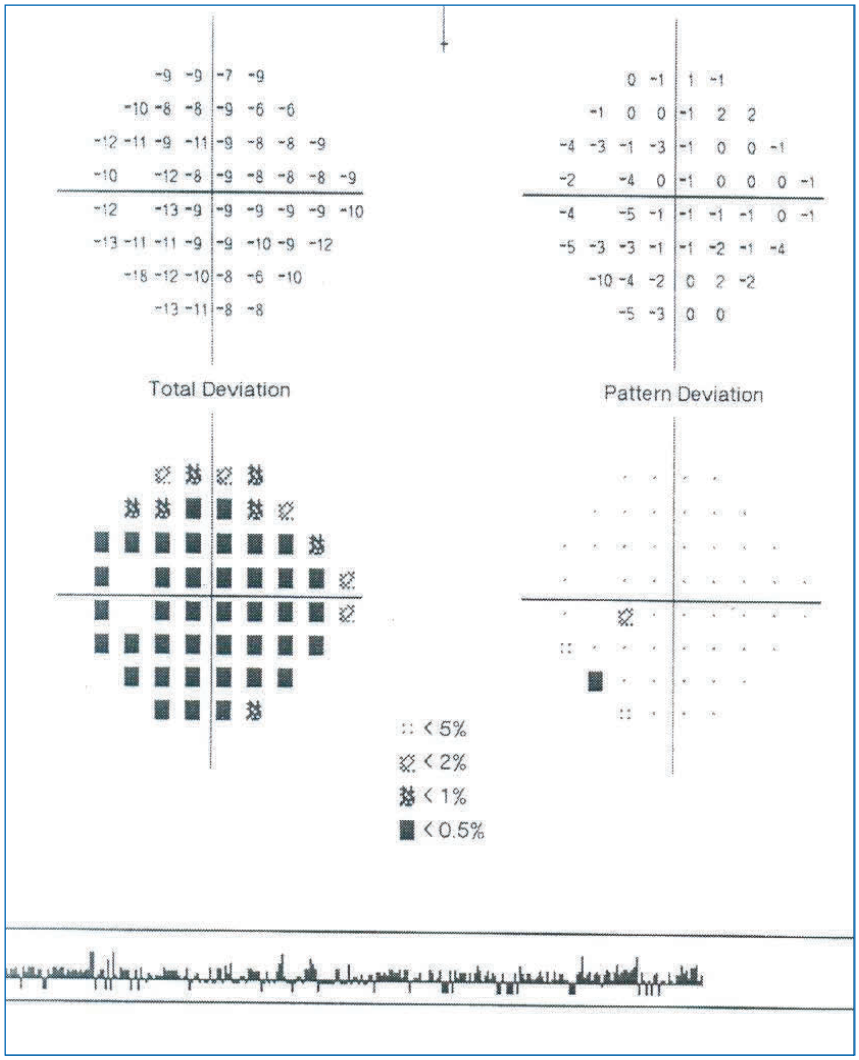
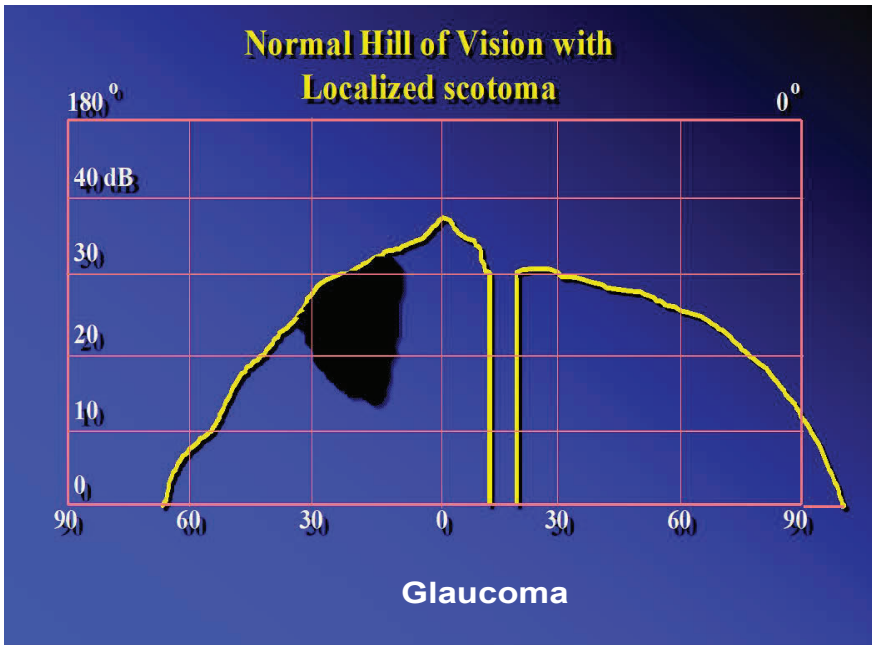


Fig. 12: Generalized depression.



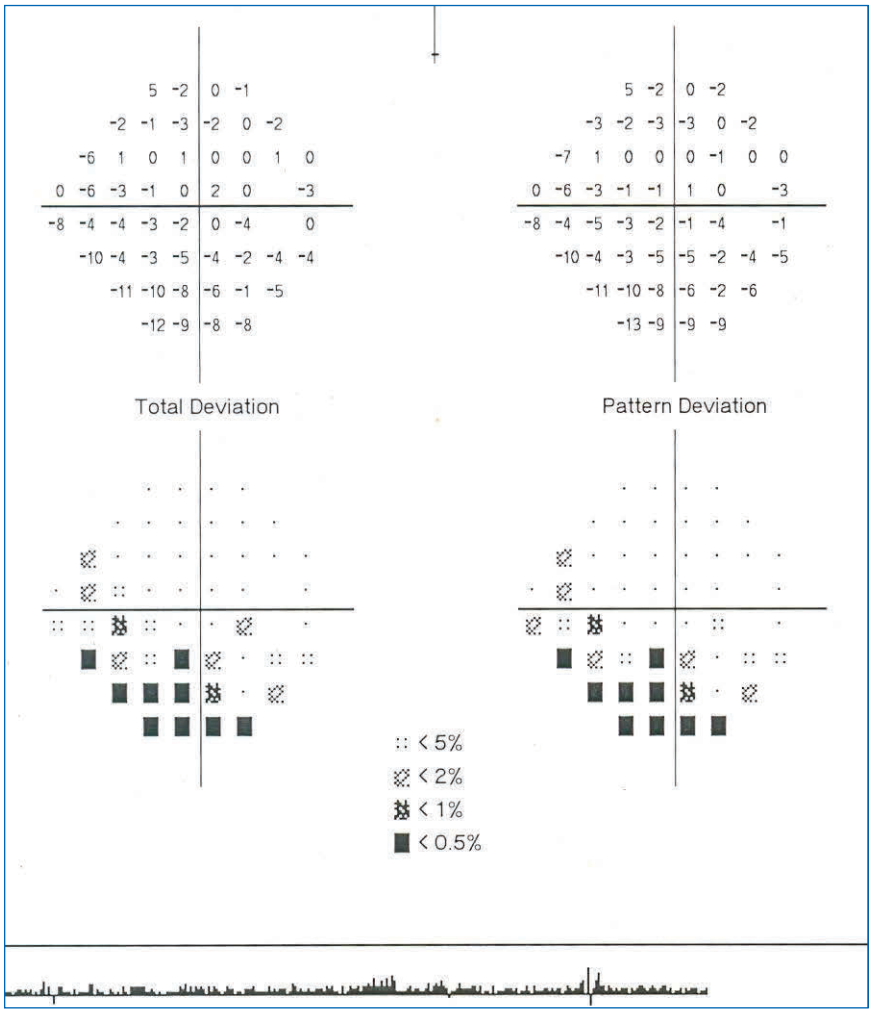


Fig. 13: Localized depression.

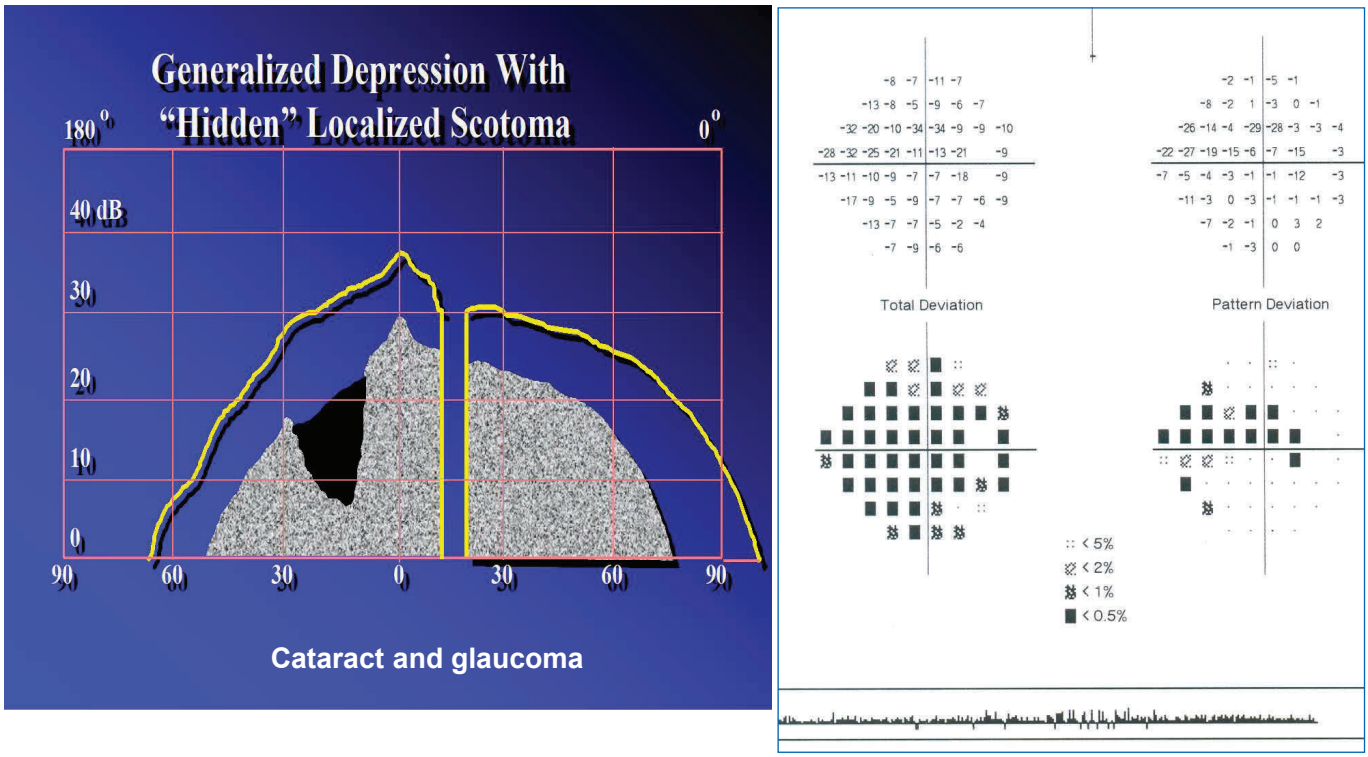


Fig. 14: Generalized depression with "hidden" localized scotoma.

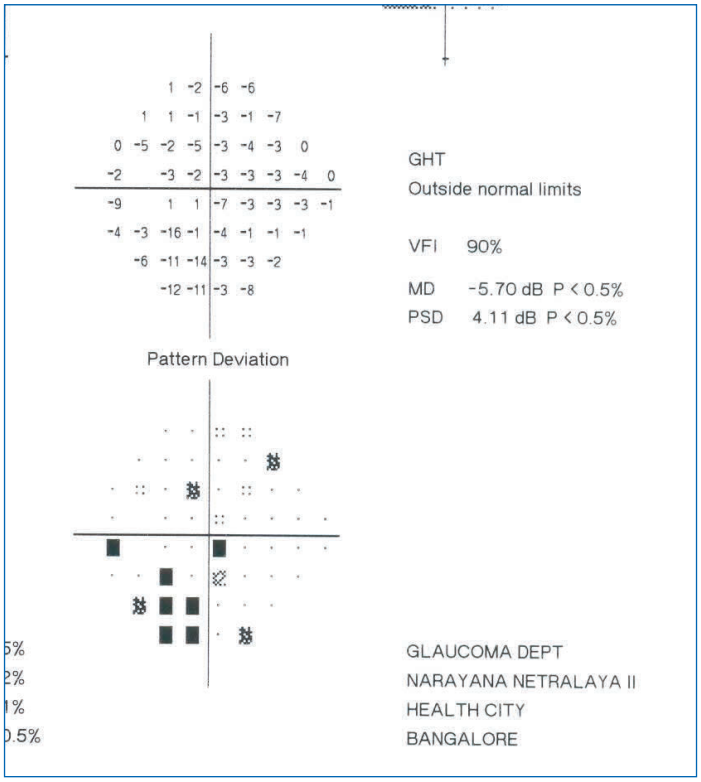
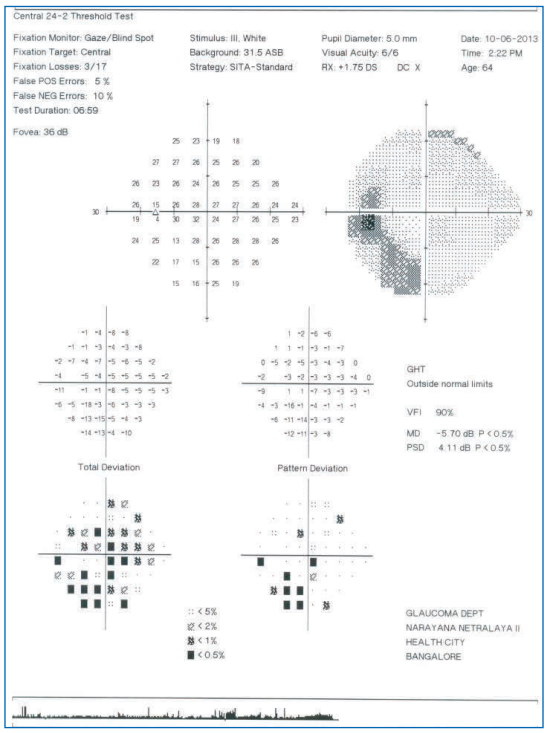
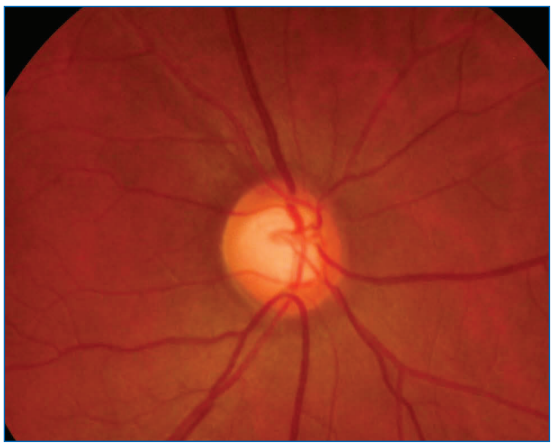


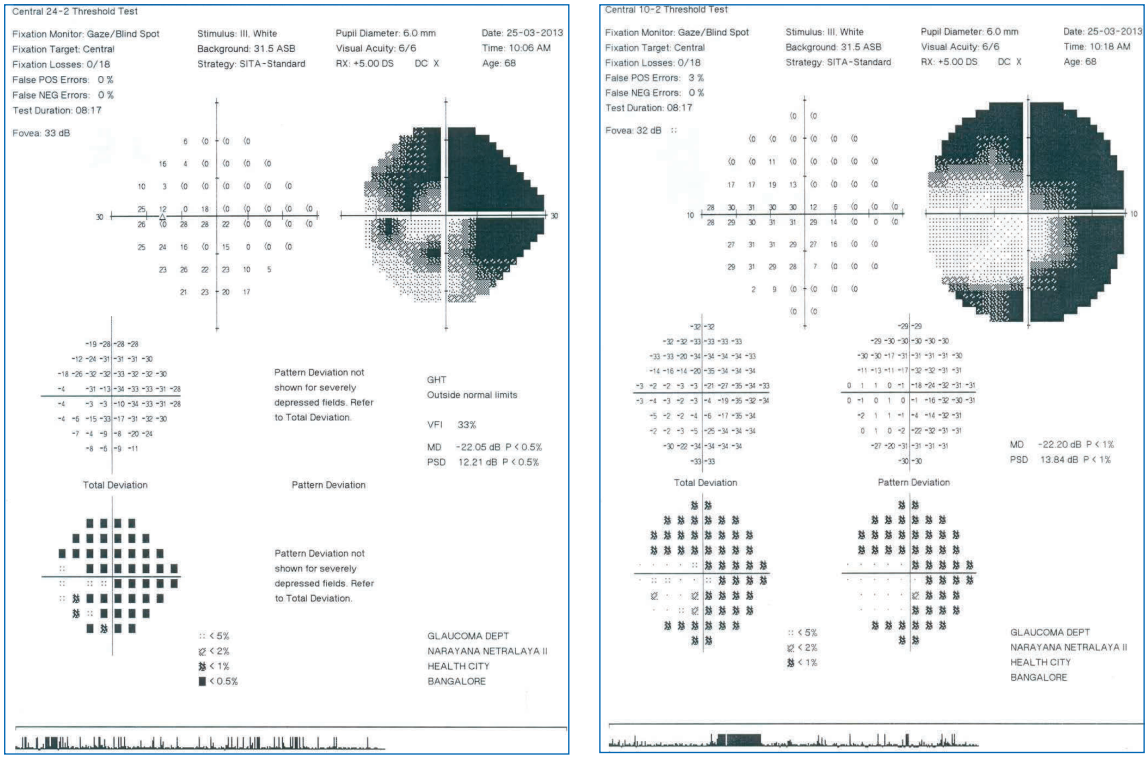
Fig. 15: Anderson's criteria for glaucomatous defects.





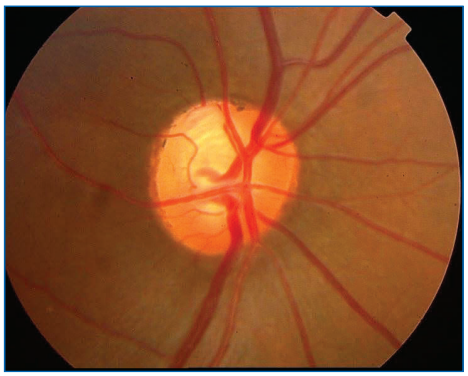
Superior nerve fiber layer (NFL) defect correlating with inferior depressed points

Fig. 16: Early glaucoma.



Significantly depressed sensitivity in field with advanced damage precludes points in pattern deviation plot
Such patients can be monitored on central fields (10-2)

Fig. 17: Significantly depressed field sensitivity.



Superior notch correlating with inferior arcuate scotoma

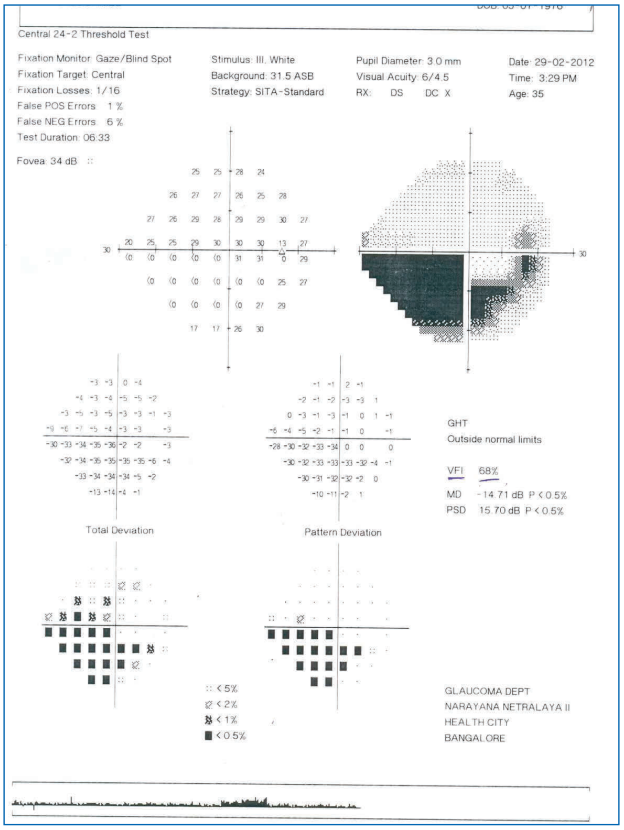
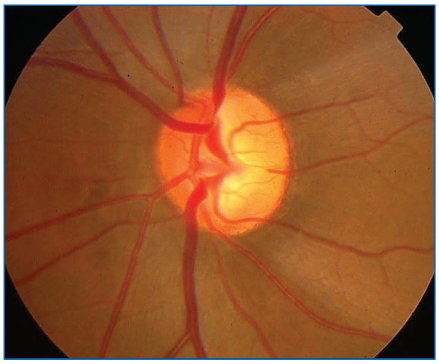


Fig. 18: Inferior arcuate scotoma.



Superior and inferior nerve fiber layer (NFL) defects with biarcuate scotoma

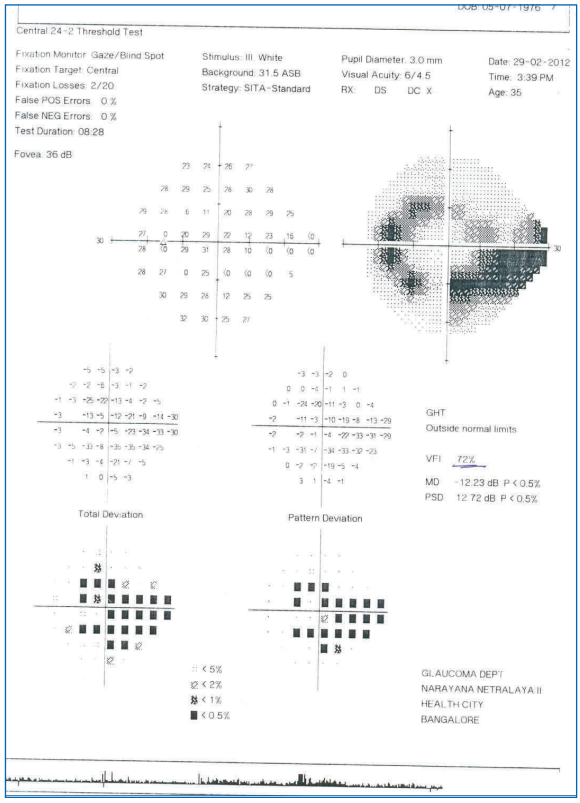
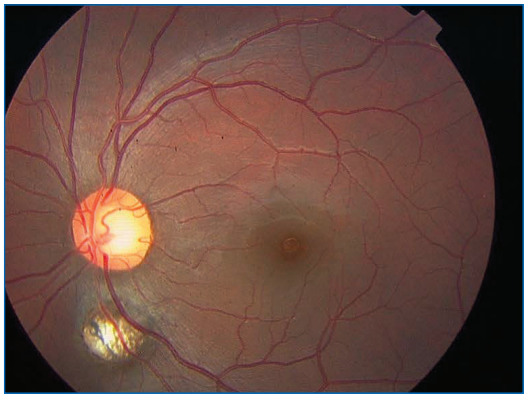


Fig. 19: Biarcuate scotoma.



Defects related to choroidal coloboma

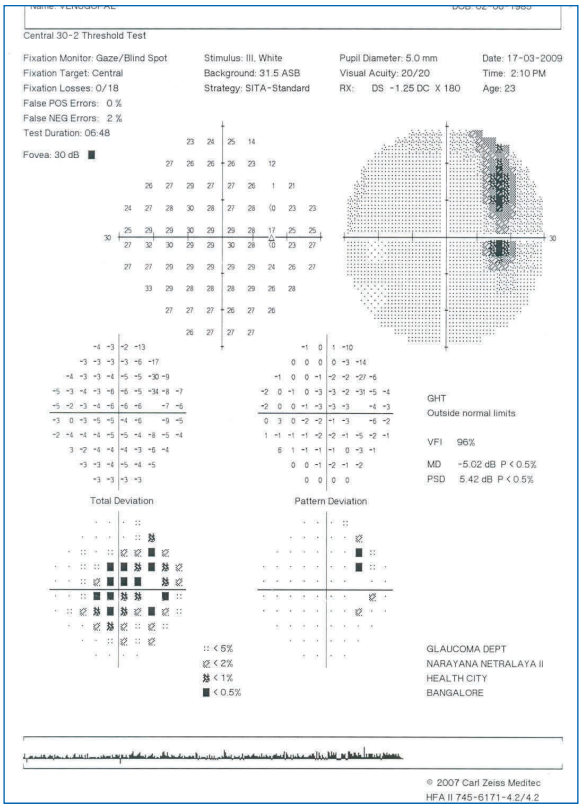
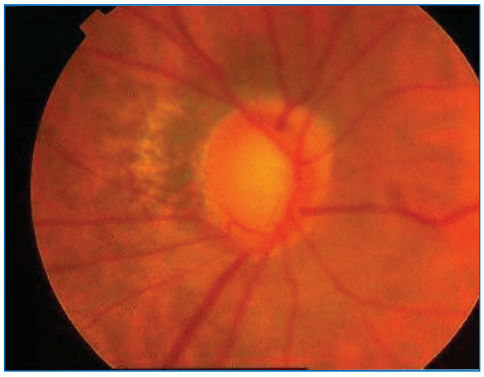


Fig. 20: Choroidal coloboma defect.



Myopic crescent with enlargement of blind spot

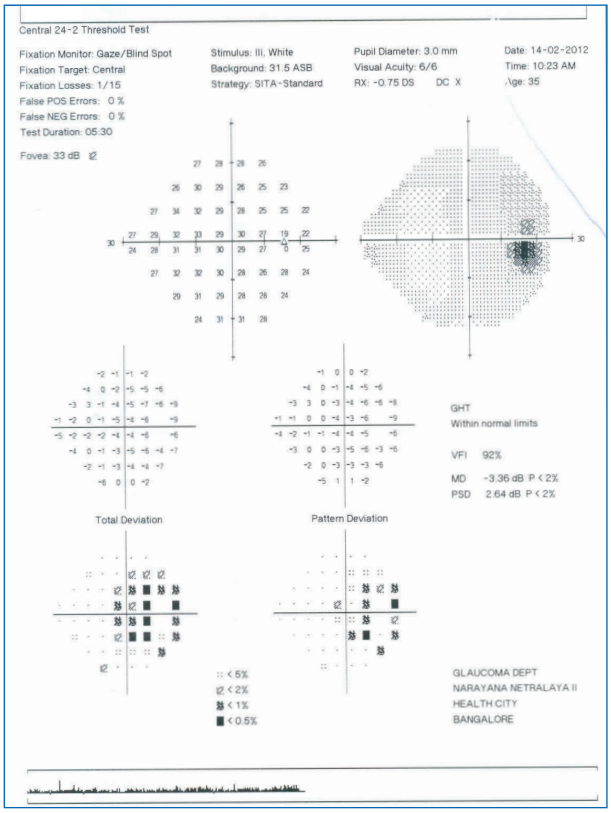


Fig. 21: Crescent with enlarged blind spot.

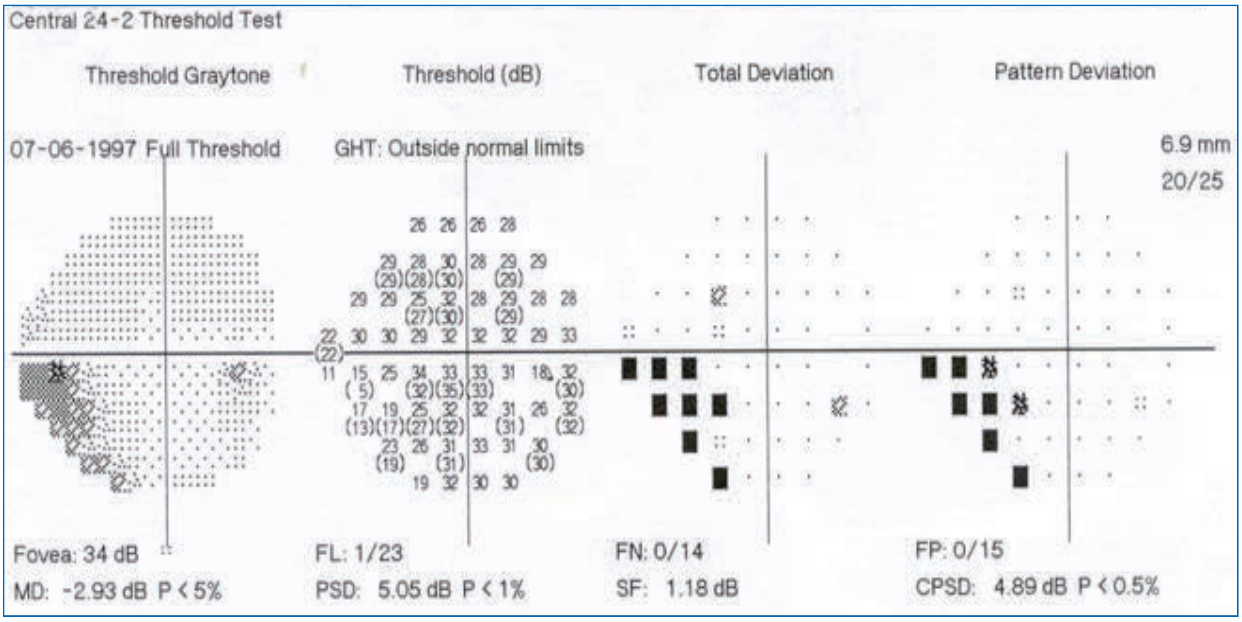
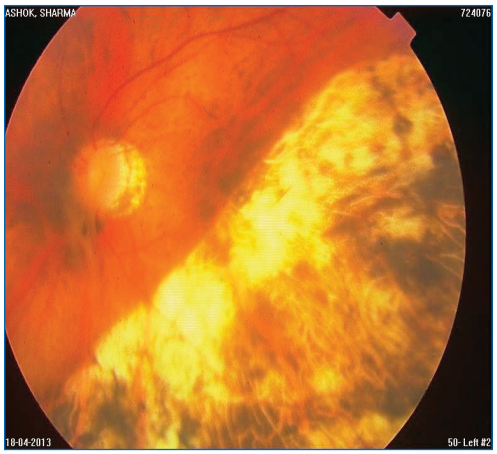


Fig. 22: Fields showing typical glaucoma.



Fields using size 5 stimulus as patient's visual acuity is less than 6/36, showing scotoma corresponding to retinal pathology

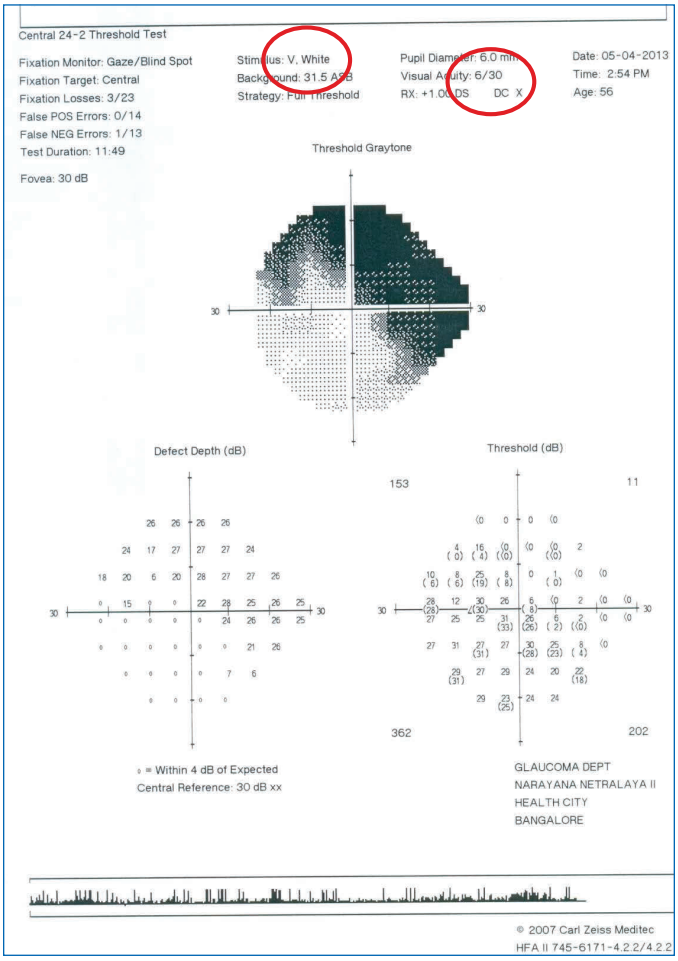


Fig. 23: Retinal pathology scotoma.

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